Administration and Performance Guide

Adaptive Server® IQ

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Contents

About This Book

This book, *Adaptive Server IQ Administration and Performance Guide*, presents administrative concepts and procedures and performance tuning recommendations for Sybase Adaptive Server IQ, a high-performance decision support server designed specifically for data warehouses and data marts.

Audience

This guide is for system and database administrators or for anyone who needs to set up or manage Adaptive Server IQ or understand performance issues. Familiarity with relational database systems and introductory user-level experience with Adaptive Server IQ is assumed.

How to use this book

The following table shows which chapters fit a particular interest or need.

Table 1: Guide to using this book

To learn how to...	*Read this chapter...*
Understand the role of an Adaptive Server IQ administrator	Chapter 1, “Overview of Adaptive Server IQ System Administration”
Start and stop an IQ database server, and set up user connections	Chapter 2, “Running Adaptive Server IQ”
Create an Adaptive Server IQ database	Chapter 3, “Working with Database Objects”
Select Adaptive Server IQ indexes	Chapter 4, “Adaptive Server IQ Indexes”
Load data into your database	Chapter 5, “Moving Data In and Out of Databases”
Create procedures and batches	Chapter 6, “Using Procedures and Batches”
Add users and assign them privileges	Chapter 10, “Managing User IDs and Permissions”
Specify constraints on the data in your tables	Chapter 7, “Ensuring Data Integrity”
Understand how transactions work	Chapter 8, “Transactions and Versioning”
Set up your database for the language you work in	Chapter 9, “International Languages and Character Sets”
Back up and restore databases	Chapter 11, “Backup and Data Recovery”
Tune Adaptive Server IQ for maximum performance	Chapter 12, “Managing System Resources”; see also performance tuning hints for specific features in all chapters
Monitor and tune performance	Chapter 13, “Monitoring and Tuning Performance”

Related documents

Documentation for Adaptive Server IQ:

- *Introduction to Adaptive Server IQ*

  Read and try the hands-on exercises if you are unfamiliar with Adaptive Server IQ, with the Sybase Central database management tool, or with Interactive SQL.

- *Adaptive Server IQ Reference Manual*

  Read for a full description of the SQL language, utilities, stored procedures, data types, and system tables supported by Adaptive Server IQ.

- *Adaptive Server IQ Troubleshooting and Error Messages Guide*

  Read to solve problems, perform system recovery and database repair, and understand error messages, which are referenced by by SQLCode, SQLState and message text.

- *Adaptive Server IQ Installation and Configuration Guide*

  Read the edition for your platform before and while installing Adaptive Server IQ, when migrating to a new version of Adaptive Server IQ, or when configuring Adaptive Server IQ for a particular platform.

- *Adaptive Server IQ Multiplex User's Guide*

  Read if you are using the multiplex feature, which lets you manage a very large data warehouse consisting of a write server and multiple query servers.

- *Adaptive Server IQ Release Bulletin*

  Read just before or after purchasing Adaptive Server IQ for an overview of new features. Read for help if you encounter a problem.

Note Because Adaptive Server IQ is an extension of the Adaptive Server Anywhere product, IQ and Anywhere support many of the same features. The IQ documentation set refers the reader to Anywhere documentation where appropriate.

Documentation for Adaptive Server Anywhere:

- *Adaptive Server Anywhere User's Guide*

  Intended for all users of Adaptive Server Anywhere, including database administrators and application developers, this book describes in depth how to use Adaptive Server Anywhere.

- *Adaptive Server Anywhere Programming Interfaces*

  Intended for application developers writing programs that directly access the ODBC, Embedded SQL, or Open Client interfaces, this book describes how to develop applications for Adaptive Server Anywhere.

CHAPTER 1

Overview of Adaptive Server IQ System Administration

About this chapter

This chapter provides a brief introduction to Adaptive Server IQ and an overview of IQ system administration.

Introduction to Adaptive Server IQ

Adaptive Server IQ is a high-performance decision support server designed specifically for data warehousing. This cross-platform product runs on Windows NT as well as on Sun Solaris (SPARC), HP 9000/800 HP-UX, IBM RISC System/6000 AIX, Silicon Graphics IRIX, and Compaq Tru64 systems.

Adaptive Server IQ is part of the Adaptive Server family that includes **Adaptive Server Enterprise** for enterprise transaction and mixed workload environments and **Adaptive Server Anywhere**, a small footprint version of Adaptive Server often used for mobile and occasionally connected computing.

Sybase database architecture

Sybase database architecture provides a common code base for Adaptive Server IQ and Adaptive Server Anywhere, with workload optimized data stores. You use the IQ Store for data warehousing. You can also use Adaptive Server Anywhere for transaction processing. These products share a common command syntax and user interface, allowing easier application development and user access.

Rapid access to many data sources

Adaptive Server IQ can integrate data from diverse sources—not just IQ databases, but other databases in the Adaptive Server family, as well as non-Sybase databases and flat files. You can import this data into your IQ database, so that you can take advantage of IQ's rapid access capabilities. You can also query other databases directly, using Adaptive Server IQ's remote data access capabilities.

Note Some of these capabilities are currently available on Windows NT only. See your *Adaptive Server IQ Installation and Configuration Guide* for more information.

Data warehousing and Adaptive Server IQ

Data warehouses are collections of data designed to allow business analysts to analyze information. They are typically distinct from production databases, to avoid interrupting daily operations. Data warehouses are often used as data stores on which to build decision support systems (DSS). A **decision support system** is a software application designed to allow an organization to analyze data in order to support business decision making.

All of Adaptive Server IQ's capabilities are designed to facilitate DSS applications. A unique indexing system speeds data analysis. Query optimization gives you rapid responses, even when results include thousands or millions of rows of data. Concurrent data access for multiple query users, and the ability to update the database without interrupting query processing, provide the 24–hour, 7–day access that users expect.

Learning more about Adaptive Server IQ

This book explains how you manage an Adaptive Server IQ system, and gives pointers for tuning your system for maximum performance. It is intended for database administrators, and others who need to understand performance issues. You may also want to refer to the other documentation described in "About This Book":

System administration tasks

Typically, the database administrator (DBA) is responsible for the tasks listed on the left side of the following table. Look at the right side of the table to see where these tasks are explained in this or other manuals.

Table 1-1: Administrative tasks

If you want to know how to...	*Look in...*
Install and configure Adaptive Server IQ for your platform	*Adaptive Server IQ Installation and Configuration Guide*
Start and stop the database server, and set up user connections	Chapter 2, “Running Adaptive Server IQ”
Create an Adaptive Server IQ database	Chapter 3, “Working with Database Objects”
Determine appropriate indexes for your users' queries	Chapter 4, “Adaptive Server IQ Indexes”
Load data into your database	Chapter 5, “Moving Data In and Out of Databases”
Add users and assign them privileges	Chapter 10, “Managing User IDs and Permissions”
Ensure the integrity of data in your tables	Chapter 7, “Ensuring Data Integrity”
Understand how transactions impact concurrency	Chapter 8, “Transactions and Versioning”
Set up your database for the language you work in	Chapter 9, “International Languages and Character Sets”
Back up and restore databases	Chapter 11, “Backup and Data Recovery”
Tune Adaptive Server IQ for maximum performance	Chapter 12, “Managing System Resources”; see also performance tuning hints for specific features in all chapters
Monitor IQ performance	Chapter 13, “Monitoring and Tuning Performance”
Set up and manage a multiplex configuration	*Adaptive Server IQ Multiplex User's Guide*

Security overview

The DBA is responsible for maintaining database security. Adaptive Server IQ provides security controls by means of the privileges you can assign to users.

Types of users

Adaptive Server IQ recognizes three categories of users for each IQ database:

- The database administrator, or *DBA*, has complete authority to perform all operations on that database. This guide is addressed primarily to the DBA, who typically carries out most administrative tasks.
- The user who creates a particular database object is its *owner*, and can perform any operation on that object.
- All other users are considered *public users*. The owner of an object is considered a public user for objects owned by other users.

Granting permissions

Except for the DBA, who can perform any task, users must be granted the authority to perform specific tasks. For example, you need the proper authority to:

- Connect to a database.
- Create database objects, such as a database, table, or index.
- Alter the structure of database objects.
- Insert or delete data.
- Select (view) data.
- Execute procedures.

The DBA can grant any type of authority to any user. Sometimes other users can grant authority as well. For more information on what users can do, and how the DBA manages users, see Chapter 10, “Managing User IDs and Permissions”.

Tools for system administration

To help you manage your database, Adaptive Server IQ provides two primary tools:

- **Sybase Central** is an application for managing Sybase databases. It helps you manage database objects and perform common administrative tasks such as creating databases, backing up databases, adding users, adding tables and indexes, and monitoring database performance. Sybase Central has a Java-based graphical user interface, and can be used with any operating system that allows graphical tools.
- **DBISQL**, also called Interactive SQL, is an application that allows you to enter SQL statements interactively and send them to a database. DBISQL has a window-like user interface on all platforms.

The *Introduction to Adaptive Server IQ* explains how to use Sybase Central and DBISQL to perform simple administrative tasks. If you are not already familiar with these tools, you should read about them in the *Introduction to Adaptive Server IQ* and use the tutorials provided there.

In addition to these tools, Adaptive Server IQ provides a number of stored procedures that perform system management functions. See “Stored procedures” for more information. You can also create your own procedures and batches.

A few administrative tasks, such as selecting a collation, rely on command-line utilities. These utilities are discussed in other chapters of this book, and described in the *Adaptive Server IQ Reference Manual*.

The database server

The **database server** is the “brain” of your Adaptive Server IQ system. Users access data through the database server, never directly. Requests for information from a database are sent to the database server, which carries out the instructions.

Catalogs and IQ

An Adaptive Server IQ database is a joint data store consisting of three parts:

- The permanent IQ Store
- The Temporary Store

- The Catalog Store

When you create an IQ database, all three stores are created automatically. You create IQ databases using the procedures described in Chapter 3, “Working with Database Objects”.

The IQ Store

The **IQ Store** is the set of Adaptive Server IQ tables. You can have one or more permanent IQ Stores, each in a separate database. Each IQ Store includes a set of tables that organize your data. The table data is stored in indexes, which are structured so as to allow rapid response to various types of analytical queries on very large quantities of data.

The Temporary Store

The **Temporary Store** consists of a set of temporary tables. The database server uses them for sorting and other temporary processing purposes; you cannot store your data in them directly.

The Catalog Store

The **Catalog Store** contains all of the information required to manage an IQ database. This information, which includes system tables and stored procedures, resides in a set of tables that are compatible with Adaptive Server Anywhere. These tables contain the **metadata** for the IQ database. Metadata describes the layout of the IQ tables, columns, and indexes. The Catalog Store is sometimes referred to simply as the Catalog.

Adaptive Server Anywhere and Adaptive Server IQ

The Catalog Store closely resembles an Adaptive Server Anywhere store. Adaptive Server Anywhere is a relational database system that can exist with or without IQ. You may have Adaptive Server Anywhere-style tables in your Catalog Store along with your IQ tables, or you may have a separate Adaptive Server Anywhere database.

Anywhere tables have a different format than IQ tables. While the commands you use to create objects in an Anywhere database are the same as those for an IQ Store, there are some differences in the features you can specify in those commands. *Always use the command syntax in this book or the Adaptive Server IQ Reference Manual for operations in the IQ Store.*

This book explains how you manage your IQ Store and its associated Catalog Store. If you have an Anywhere database, or if you have Anywhere-style tables in your Catalog Store, see the Adaptive Server Anywhere documentation for details of how to create, maintain, and use them.

Concurrent operations

Adaptive Server IQ allows multiple users to query a database at the same time, while another user inserts or deletes data, or backs up the database. Changes to the structure of the database, such as creating, dropping, or altering tables, temporarily exclude other users from those tables, but queries that only access tables elsewhere in the database can proceed.

Adaptive Server IQ keeps your database consistent during these concurrent operations by maintaining multiple versions of table data. To understand this approach, see Chapter 8, “Transactions and Versioning”.

Stored procedures

Adaptive Server IQ **stored procedures** help you manage your system. Stored procedures give you information about your database and users, and carry out various operations on the database. This section briefly describes the stored procedures. For more information, see the *Adaptive Server IQ Reference Manual*.

A stored procedure typically operates on the database in which you execute it. For example, if you run the stored procedure sp_addlogin in the asiqdemo database, it adds a user to asiqdemo.

You can also create your own stored procedures. See Chapter 6, “Using Procedures and Batches” for details.

Note Statements shown in examples generally use the asiqdemo database, a sample database installed as part of Adaptive Server IQ. For a diagram of this database’s structure, see *Introduction to Adaptive Server IQ*.

Adaptive Server IQ stored procedures

The following procedures work specifically on the IQ Store. They are owned by the DBA user ID.

Note Stored procedures that produce size information assume that the database was created with the default block size, as described in “Block size”. If a database was created with a non-default block size, the output from the following stored procedures is inaccurate: sp_iqestjoin, sp_iqestdbspaces, sp_iqestspace.

Table 1-2: Stored Procedures for the IQ Store

Procedure name	*Purpose*
sp_iqcheckdb	Checks the validity of the current database and repairs indexes
sp_iqcommandstats	Gives statistics on execution of various commands
sp_iqdbsize	Gives the size of the current database
sp_iqdbstatistics	Reports results of the most recent sp_iqcheckdb
sp_iqestjoin	Estimates the space needed to create join indexes for the tables you specify
sp_iqestdbspaces	Estimates the number and size of dbspaces needed for a given total index size
sp_iqestspace	Estimates the amount of space needed to create a database, based on the number of rows in the underlying database tables.
sp_iqindex	Lists indexes and information about them. Omitting the parameter lists all indexes in the database. Specifying the *table_name* parameter lists indexes for this table only.
sp_iqindexsize	Gives the size of the specified index
sp_iqjoinindexsize	Gives the size of the specified join index
sp_iqstatus	Displays miscellaneous status information about the database
sp_iqtable	Lists tables and information about them. Omitting the parameter lists all tables in the database. Specifying the *table_name* parameter lists columns for this table only.
sp_iqtablesize	Gives the size of the specified table

Adaptive Server Enterprise system and catalog procedures

Adaptive Server Enterprise provides system and catalog procedures to carry out many administrative functions and to obtain system information. Adaptive Server IQ has implemented support for some of these procedures.

System procedures are built-in stored procedures used for getting reports from and updating system tables. Catalog stored procedures retrieve information from the system tables in tabular form.

Note While these procedures perform the same functions as they do in Adaptive Server Enterprise and pre-Version 12 Adaptive Server IQ, they are not identical. If you have preexisting scripts that use these procedures, you may want to examine the procedures. To see the text of a stored procedure, run

```
sp_helptext procedure_name
```

You may need to reset the width of your DBISQL output to see the full text, by clicking Command→Options and entering a new Limit Display Columns value.

Adaptive Server Enterprise system procedures

The following Adaptive Server Enterprise system procedures are provided in Adaptive Server IQ. These stored procedures perform important system management tasks.

System procedure	Description
sp_addgroup	Adds a group to a database
sp_addlogin	Adds a new user account to a database
sp_addmessage	Adds user-defined messages to SYSUSERMESSAGES for use by stored procedure PRINT and RAISERROR calls
sp_addtype	Creates a user-defined data type
sp_adduser	Adds a new user to a database
sp_changegroup	Changes a user's group or adds a user to a group
sp_dboption	Displays or changes database options
sp_dropgroup	Drops a group from a database
sp_droplogin	Drops a user from a database
sp_dropmessage	Drops user-defined messages
sp_droptype	Drops a user-defined data type
sp_dropuser	Drops a user from a database
sp_getmessage	Retrieves stored message strings from SYSMESSAGES and SYSUSERMESSAGES for PRINT and RAISERROR statements.

System procedure	Description
sp_helptext	Displays the text of a system procedure or view
sp_password	Adds or changes a password for a user ID

Adaptive Server Enterprise catalog procedures

Adaptive Server IQ implements all the Adaptive Server Enterprise catalog procedures with the exception of the sp_column_privileges procedure. The implemented catalog procedures are described in the following table.

The following list describes the supported Adaptive Server Enterprise catalog procedures.

Catalog procedure	Description
sp_column_privileges	Unsupported
sp_columns	Returns the data types of the specified column
sp_fkeys	Returns foreign key information about the specified table
sp_pkeys	Returns primary key information for a single table
sp_special_columns	Returns the optimal set of columns that uniquely identify a row in a table
sp_sproc_columns	Returns information about a stored procedure's input and return parameters
sp_stored_procedures	Returns information about one or more stored procedures
sp_tables	Returns a list of objects that can appear in a FROM clause

Catalog stored procedures

In addition to the Adaptive Server Enterprise Catalog stored procedures, there are other system and catalog stored procedures. The following table lists the ones you are most likely to use. For a complete list, see Chapter 14, "System Procedures" in *Adaptive Server IQ Reference Manual*.

Procedure name	Purpose
sp_remote_columns	List remote tables columns and their data types
sp_remote_tables	List tables on a remote server

Procedure name	Purpose
sp_servercaps	Display information about a remote server's capabilities

System tables and views

Adaptive Server IQ system tables contain all of the information the database server needs to manage your IQ system. The system tables reside in the Catalog Store, and are sometimes called catalog tables. For some system tables there are also views that make it easier to display the information in the table. The SYS user ID owns the system tables.

Among the information in the system tables is:

- Database characteristics
- Table characteristics, including table definitions and information about the size and location of each table
- Information about indexes
- Current settings for database and DBISQL options

System tables include:

System table	Description
DUMMY	A table with exactly one row, useful for extracting information from the database
SYSARTICLE	Describes an article in a SQL Remote publication
SYSARTICLECOL	Describes columns in each article in a SQL Remote publication
SYSCOLLATION	Contains the complete collation sequences available to Adaptive Server IQ
SYSCOLLATIONMAPPINGS	Lists the collation sequences available in Adaptive Server IQ and their GPG and JDK mappings
SYSCOLUMN	Describes each column in every table or view

System table	Description
SYSDOMAIN	Lists the number, name, ODBC type, and precision of each predefined data type
SYSFILE	Lists operating system files and dbspace names for the database
SYSFKCOL	Associates each foreign key column with a primary key column
SYSFOREIGNKEY	Contains general information about each foreign key
SYSGROUP	Describes a many-to-many relationship between groups and members
SYSINDEX	Describes indexes in the database
SYSINFO	Describes database characteristics
SYSIQBACKUP	Lists backups and restores
SYSIQCOLUMN	Lists information on columns in every table or view in the IQ Store
SYSIQFILE	Lists information on operating system files for the database
SYSIQINDEX	Lists internal information on indexes in the database
SYSIQINFO	Lists additional database characteristics
SYSIQJINDEX	Describes join indexes in the database
SYSIQJOINIXCOLUMN	Describes columns that participate in join indexes
SYSIQJOINIXTABLE	Lists the tables that participate in each join index in the database
SYSIQTABLE	Describes each table or view in the IQ Store
SYSIXCOL	Describes each index for each column in the database
SYSJAR	Describes each jar file associated with the database
SYSJARCOMPONENT	Describes each jar component associated with the database
SYSJAVACLASS	Contains all information related to Java classes

System table	Description
SYSLOGIN	Lists User Profile names that can connect to the database with an integrated login
SYSOPTION	Lists current SET OPTION settings for all users including the PUBLIC user
SYSPROCEDURE	Describes each procedure in the database
SYSPROCPARM	Describes each parameter to every procedure in the database
SYSPROCPERM	Lists each user granted permission to call each procedure in the database
SYSPUBLICATION	Describes each SQL Remote publication
SYSREMOTETYPE	Contains information about SQL Remote
SYSREMOTEUSER	Describes user IDs with REMOTE permissions and the status of their SQL Remote messages
SYSSQLSERVERTYPE	Contains information relating to compatibility with Adaptive Server Enterprise
SYSSUBSCRIPTION	Relates each user ID with REMOTE permissions to a publication
SYSTABLE	Describes one table or view in the database
SYSTABLEPERM	Describes permissions granted on each table in the database
SYSSQLSERVERTYPE	Contains information on compatibility with Adaptive Server Enterprise
SYSUSERMESSAGES	Lists user-defined error messages and their creators
SYSUSERPERM	Lists characteristics of each user ID. Because it contains passwords, you need DBA permissions to select from this table
SYSUSERTYPE	Describes each user-defined data type

System views present the information from their corresponding system tables in a more readable format. In some cases, they omit password information so that they can be accessible to all users. System views include:

System view	Description
SYSCATALOG	Lists all tables and views from SYSTABLE
SYSCOLAUTH	Presents column update permission information from SYSCOLPERM
SYSCOLUMNS	Presents a readable version of the table SYSCOLUMN
SYSFOREIGNKEYS	Presents foreign key information from SYSFOREIGNKEY and SYSFKCOL
SYSGROUPS	Presents group information from SYSGROUP
SYSINDEXES	Presents index information from SYSINDEX and SYSIXCOL
SYSOPTIONS	Displays option settings contained in the table SYSOPTION
SYSPROCPARMS	Lists all the procedure parameters from SYSPROCPARM
SYSREMOTEUSERS	Lists the information in SYSREMOTEUSER
SYSTABAUTH	Presents table permission information in SYSTABLEPERM
SYSUSERAUTH	Displays all the information in the table SYSUSERPERM except for user numbers. Because it contains passwords, this system view does not have PUBLIC select permission
SYSUSERLIST	Presents all information in SYSUSERAUTH except for passwords
SYSUSEROPTIONS	Display effective permanent option settings for each user
SYSUSERPERMS	Contains exactly the same information as the table SYS.SYSUSERPERM except the password is omitted
SYSVIEWS	Lists views and their definitions

For a complete description of system tables and views and their contents, see the *Adaptive Server IQ Reference Manual*.

Commands and Functions

All Adaptive Server IQ commands are SQL statements. SQL stands for Structured Query Language, a language commonly used in database applications. Adaptive Server IQ SQL uses the same syntax as Adaptive Server Anywhere SQL; the only differences are for certain product capabilities that are supported only for IQ or for Anywhere. Adaptive Server IQ SQL also offers a high degree of compatibility with Transact-SQL, the SQL dialect used by Adaptive Server Enterprise.

This section introduces the types of commands and functions you can use. Other chapters of this book tell you about the commands you use to perform various administrative tasks. For complete details of supported commands and functions, see the *Adaptive Server IQ Reference Manual.*

Types of SQL statements

You use three basic types of SQL statements:

- DDL (Data Definition Language) statements let you define and modify your database schema and table and index definitions. Examples of DDL statements include CREATE TABLE, CREATE INDEX, ALTER TABLE, and DROP.
- DML (Data Manipulation Language) statements let you query your data, and move data into and out of the database. Examples of DML statements include SELECT, SET, and INSERT.
- Program control statements control the flow of program execution. They do not operate directly on your IQ tables. Examples include IF, CALL, and ROLLBACK.

Functions

Functions return information from the database. They are allowed anywhere an expression is allowed. Adaptive Server IQ provides functions that:

- Aggregate data (for example, AVG, COUNT, MAX, MIN, SUM)
- Manipulate numeric data (for example, ABS, CEILING, SQRT, TRUNCATE)
- Manipulate string data (for example, LENGTH, SOUNDEX, UCASE)

- Manipulate date and time data (for example, TODAY, DATEDIFF, DATEPART, MINUTES)
- Convert retrieved data from one format to another (CAST, CONVERT)

Message logging

A message log file exists for each database. The default name of this file is *dbname.iqmsg*. The message log file is created when the database is created.

By default, Adaptive Server IQ logs all messages in the message log file, including:

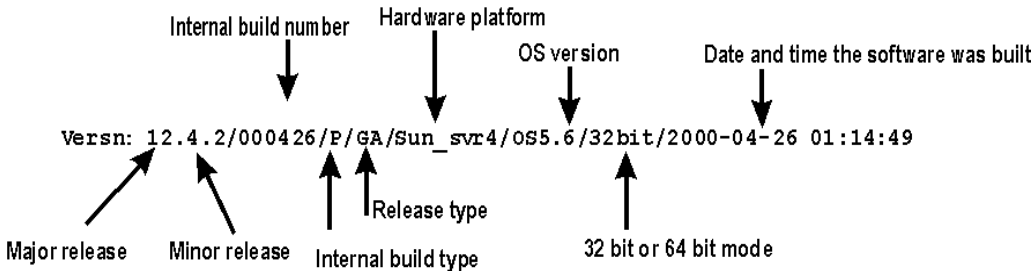
- Error messages
- Status messages
- Insert notification messages

You can examine this file as you would any other text file. At the start of the file you see output like the following:

```
2000-03-07 17:20:50 0000 OpenDatabase Completed

2000-03-07 17:20:50 0000 IQ cmd line srv opts:

2000-03-07 17:20:50 0000 DB: r/w, Buffs=1913, Pgsz=4096/512blksz/8bpc

2000-03-07 17:20:50 0000 DB: Frmt#: 23F/2T/1P (FF: 03/18/1999)

2000-03-07 17:20:50 0000 DB: Versn: 12.4.2/(32bit mode)/MS Windows NT 4.0/EBF
0000/Mar 02 2000, 02:17:37 2000-03-07 17:20:50 0000 DB: Name:  C:\Program
Files\Sybase\ASIQ12\scripts\asiqdemo.db
```

The fourth line of the file contains version information:

Figure 1-1: Version string in message log



The date and time of the software build appears in the version string in ISO datetime format: `YYYY-MM-DD hh:mm:ss` where

YYYY	4-digit year
MM	2-digit month number (0-12)
DD	2-digit day of month number (0-31)
hh	2-digit numbmer of complete hours that have passed since midnight (00-23)
mm	2-digit number of complete minutes that have passed since the start of the hour (00-59)
ss	2-digit number of complete seconds that have passed since the start of the minute (00-59)

The message log continues to exist until you drop the database. If your message log ever becomes too large, you can archive it while no users are connected to the database, and then create a new, empty *dbname.iqmsg* file before allowing another user to connect.

The utility database

The utility database is essentially a database that never holds data. The database server uses it at times when it needs a database to connect to, but either no real database exists, or none should be running. Adaptive Server IQ installation creates the utility database automatically.

Be sure you do not delete this database. You need it to do any of these things:

- Start the database server using the START ENGINE command with no database specified
- Create or drop a database when you have no other database to connect to
- Start the database server or connect to a database when any other databases you have are either corrupt or unavailable due to media failure
- Restore a database

By default, the utility database has the user ID dba and the password sql. You can change these to other values during installation, or later by editing the connection parameters in the *util_db.ini* file in your executable directory.

For more information on the utility database, see Chapter 3, "Configuring Client/Server Communications" in your *Adaptive Server IQ Installation and Configuration Guide*.

Compatibility with earlier versions

Version 12 of Adaptive Server IQ differs markedly from earlier versions of IQ. It offers many important new features, including the ability to update the database concurrently with query use, Transact-SQL and Java support, additional query and view support, and better front end support. It offers syntactic compatibility with Adaptive Server Anywhere, allowing Anywhere users to build on their existing knowledge base as they begin to use IQ. It also includes a new, more efficient database format.

These last two features have special implications for users migrating from pre-version 12 Adaptive Server IQ. When you migrate to version 12, you must:

- Examine any scripts, applications, and procedures for differences in syntax, and make the necessary changes.
- Reload your IQ database, using the special migration procedure.

See the *Adaptive Server IQ Installation and Configuration Guide* and the *Adaptive Server IQ Release Bulletin* for your platform for migration details.

CHAPTER 2

Running Adaptive Server IQ

About this chapter

Three steps are required for you to start using Adaptive Server IQ:

- The database server must be started.
- The database must be started.
- You must connect to the database.

Adaptive Server IQ gives you great flexibility in performing these three steps. This chapter explains various options for accomplishing each of these steps, and gives suggestions for which to choose, depending on your situation.

With Adaptive Server IQ you will run in a client/server environment, in which many users can connect to a database server across a network. You may have multiple databases on a given database server. Likewise, you may be able to connect to more than one database server. The server startup and connection options you choose must take into account these factors.

Starting the database server

The first step in running Adaptive Server IQ is to start the database server.

You can start the server in all of these ways:

- Type a server startup command at the operating system prompt. See “Server command lines” on page 22, as well as the section specific to your operating system.
- Start the server from the Windows NT Start menu. See “Starting the server from the NT Start menu” on page 26.
- Start the server with the Sybase-provided utility, start_asiq, that runs the server as a UNIX background process. See “Starting the server on UNIX” on page 23.

- Start the server and the sample database with a Sybase-provided configuration file. See “Starting the asiqdemo database” on page 47.
- Place a server startup command in a shortcut or desktop icon.
- Include a server startline in an ODBC data source. See “Creating and editing ODBC data sources” on page 65.
- Include a server startline in a utility command.
- Issue a SQL command from Interactive SQL to start an additional server. See “Starting a server from DBISQL” on page 40.

Note If you will be using remote data access capabilities to insert data from other databases or to issue queries to other databases, see the *Adaptive Server IQ Release Bulletin for Windows NT* for special startup requirements.

Server command lines

The general form for the server command line is as follows:

asiqsrv12 [*server-switches*] [*database-file*
[*database-switches*], ...]

The elements of this command line are as follows:

- *server-switches* include the database server name and other options that control the behavior of the server, for all databases that are running on that server.
- *database-file* is the file name of the Catalog Store. You can omit this option, or enter one or more database file names on the command line. Each of these databases is loaded and available for applications. If the starting directory contains the database file, you do not need to specify the path; otherwise, you must specify the path. If you do not specify a file extension in database-file, the extension *.db* is assumed.
- *database-switches* are options that you can specify for each database file you start, that control certain aspects of its behavior.

In examples throughout this chapter where there are several command-line options, we show them for clarity on separate lines, as they could be written in a configuration file. If you enter them directly on a command line, you must enter them all on one line (that is, without any carriage returns).

You can choose from many command-line options or switches to specify such features as permissions required to start a database or stop the server, and the network protocols to use. The command-line switches are one means of tuning Adaptive Server IQ behavior and performance.

There are slight variations in the basic command for different operating systems, as well as a startup utility that runs this command automatically. See the sections that follow for details.

Starting the server on UNIX

This section describes two methods for starting the database server that are specific to UNIX platforms:

- Use the startup utility start_asiq. This is the preferred method.
- Enter the server startup command and the appropriate parameters (see below).

You can also use any of the generic methods described elsewhere in this chapter, *provided that you set startup parameter defaults for each platform to the settings used in* start_asiq. These settings are listed in the *Adaptive Server IQ Installation and Configuration Guide*.

Normally, you should always use the start_asiq utility to start the server on UNIX platforms. If you do not, among the tasks you must do which the utility normally does for you are:

- Remove all limits, and then set limits on the stack size and descriptors. To do so, go to the C shell and issue these commands:

```
% unlimit
% limit stacksize 8192
% limit descriptors 4096
```

Note Be aware that unlimit affects soft limits only. You must change any hard limits by setting kernel parameters.

- Set all server parameters appropriately in the asiqsrv12 command.

Note the server starting directory

Note what directory you are in when you start the server. The server startup directory determines the location of any database files you create with relative pathnames. If you start the server in a different directory, Adaptive Server IQ cannot find those database files.

Any server startup scripts should change directory to a known location before issuing the server startup command.

Using the startup utility

For most situations, the easiest way to start a database server on UNIX is by using the startup script that Sybase provides. Using this script ensures that all required parameters are set correctly, except in special situations described later in this chapter.

❖ **To start the server on UNIX using the startup utility:**

1 Change to a writable directory.

2 Run the start_asiq utility at the system prompt. The simple form of this command is:

start_asiq *servername* [*database*]

You can also include server switches or database switches, as discussed in the next section.

This command starts the named server as a background process, starts the named database if you specify it, and sets all required startup options. Once the server starts, it sends a message to the window or console where you started the server indicating that the server is running. It also displays the version of the Open Client communications library that is in use, and "possible problems" messages on failure to start. This message is saved in the stderr log. After that, all server messages go to the server log. The server log is in $ASLOGDIR/*servername.nnn*.svrlog, where *nnn* is the number of times the server has been started. See Chapter 1, "Environment Variables and Registry Entries" in *Adaptive Server IQ Reference Manual* for a description of $ASLOGDIR and other environment variables you may need to set.

The start_asiq command displays messages as to whether the server started or not, and

The start_asiq utility also adds the appropriate library path to the environment and sets parameters that govern Adaptive Server IQ. Parameter settings vary by platform. See your *Adaptive Server IQ Installation and Configuration Guide* for a list of parameter settings for your platform.

For an explanation of commonly used startup parameters, see “Using command-line switches” on page 28.

Typing the server startup command

You can also start the database server by entering the following command at the UNIX prompt:

```
asiqsrv12 [ server-switches ] [ database-file [
database-switches ]]
```

This command starts the specified database:

- On the specified server, if one is named in the startup command.
- On the server associated with this database, if the startup parameters specify a data source.
- On the local server, if one is running and no other server is specified.

See “Using command-line switches” on page 28 for a description of commonly used startup parameters.

Note To start the server without starting any database, you omit the database file from the asiqsrv12 command and specify a servername. For ease of use, however, it is preferable to start the database and server together, by specifying the database name when you start the server. The server takes its name from the database name by default, or you can specify a different name for the server. See “Naming the server and databases” on page 31 for more information on server and database names.

If you omit the database name, you must name the server explicitly using the -n server switch. This method is appropriate when you are creating or restoring a database. It is also used when you only want to control the starting and stopping of the server, leaving database use to client software.

When you start the server with the asiqsrv12 command, it does not run in the background, and messages do not automatically go to the server log. However, if your include the -o *filename* server switch, messages are sent to the named file in addition to the server window.

Starting the server on Windows NT

This section describes methods for starting the database server that are specific to Windows NT systems. You can also use any of the generic methods described elsewhere in this chapter.

Note the server starting directory

Be sure to make note of what directory you are in when you start the server. The location of any database files you create with relative pathnames depends on the server startup directory. If you start the server in a different directory, Adaptive Server IQ looks for those database files in the new startup directory.

Any server startup scripts should change directory to a known location before issuing the server startup command.

Starting the server from the NT Start menu

The easiest way to start the server on NT is from the Start menu.

Click Start on the Task bar, and select Programs → Sybase → Adaptive Server IQ 12.

From here, you can start the sample database, Sybase Central, Interactive SQL, and the ODBC Administrator.

You can also place databases of your own in the Program group.

Typing the server startup command

You can use a Program Manager icon to hold a command line, or enter the following command at the system command prompt:

```
asiqsrv12 [ server-switches ] [ path\database-file [
database-switches ]]
```

You must either enter the *database-file* or include the *servername* as one of the *server-switches*.

This command starts the specified database:

- On the specified server, if one is named in the startup command
- On the server associated with this database, if the startup parameters specify a data source
- On the local server, if one is running and no other server is specified

See "Using command-line switches" on page 28 for a description of commonly used startup parameters.

Note To start the server without starting any database, you omit the database file from the asiqsrv12 command and specify a servername. See "Naming the server and databases" on page 31 for a discussion of why it is preferable to include both the database and server in the startup command.

If you supply no switches and no database file on Windows NT, a dialog box is displayed, allowing you to use a Browse button to locate your database file.

To start the server in a separate session, use the Windows NT start command:

```
start asiqsrv12 [ server-switches ]  database [
database-switches ]
```

Running the server outside the current session

When you log on to a computer using a user ID and a password, you establish a **session**. When you start a database server, or any other application, it runs within that session. When you log off the computer, all applications associated with the session terminate.

In a production environment, IQ database servers must be available all the time. To make this easier, you can run Adaptive Server IQ in such a way that, when you log off the computer, the database server remains running. The way you do this depends on your operating system.

- **Windows NT service** You can run the Windows NT database server as a **service**. This has many convenient properties for running high availability servers.
- **UNIX daemon** You can run the UNIX database server as a **daemon** by using the -ud command-line option, enabling the database server to run in the background, and to continue running after you log off.

Running the UNIX database server as a daemon

To run the UNIX database server in the background, and enable it to run independently of the current session, you run it as a **daemon**.

Note Do not use '&' to run the database server in the background. It will not work. You must instead run the database server as a daemon.

❖ **To run the UNIX database server as a daemon:**

- Use the `-ud` command-line option when starting the database server. For example:

```
start_asiq -ud asiqdemo.db
```

Running the server as a Windows NT service

You can run the server as a service under Windows NT. This allows it to keep running even when you log off the machine. For details of this and other NT-specific features, see the *Adaptive Server IQ Installation and Configuration Guide*.

Using command-line switches

You use command-line switches to define your Adaptive Server IQ environment.

This section describes *some of the most common* command-line switches, and points out when you may wish to use them. Switches described in this chapter include:

For this switch	See this section
-c	"Catalog Store cache size"
-gb	"Other performance-related switches" (Windows NT only)
-gc	"Checkpoint interval"
-gd	"Controlling permissions from the command line"
-gk	"Controlling permissions from the command line"
-gm	"Concurrent users"
-gn	"Controlling performance from the command line"

For this switch	See this section
-gp	"Setting a maximum Catalog page size"
-gr	"Recovery time"
-gu	"Controlling permissions from the command line"
-iqgovern	"Concurrent queries"
-iqmc	"Buffer caches and physical memory"
-iqtc	"Buffer caches and physical memory"
-iqsmem	"Unwired memory" (AIX, Compaq Tru64 UNIX, and HP UNIX only)
-iqwmem	"Wired memory" (Compaq Tru64 UNIX, HP UNIX, and Sun UNIX only)
-n	"Naming the server and databases"
-p	"Other performance-related switches"
-ti	"Setting the default client timeout"
-tl	"Setting the default network timeout"
-x	"Selecting communications protocols"
-z	"Debugging network communications startup problems"

Some of the values you can set with command-line switches can also be changed with the SET OPTION command. For details of this command and its options, and *for a complete list of command-line switches and full reference information on them, see the Adaptive Server IQ Reference Manual*.

Displaying command-line options

To display all of the available command-line options, enter one of the following commands at the operating system prompt:

- On UNIX systems, enter:

```
asiqsrv12 -h
```

- On Windows NT systems, enter:

```
asiqsrv12 /?
```

Case sensitivity

Command-line parameters are case sensitive.

Using configuration files

If you use an extensive set of command-line options, you can store them in a configuration file, and invoke that file on a server command line. Specify switches in the configuration file as you would on the command line, with these exceptions:

- You can enter switches on multiple lines.
- You must not include either single or double quotes in a configuration file.

For example, the following configuration file starts the database mydb.db, on the database server named Elora, with a Catalog cache size of 16MB, TCP/IP as a network protocol and a specified port number, user connections limited to 10, and a Catalog page size of 4096 bytes.

```
-n Elora
 -c 16M
 -x tcpip(port=2367
 -gm 10
 -gp 4096
 path\mydb.db
```

If you name the file *mydb.cfg*, you could use these command-line options as follows:

```
asiqsrv12 @mydb.cfg
```

In examples throughout this chapter where there are several command-line options, we show them for clarity on separate lines as they could be written in a configuration file. If you enter them directly on a command line, you must enter them all on one line.

Note When you stop the server with the DBSTOP command, you need to specify the same parameters as when you started the server. Using a configuration file to start the server ensures that you will be able to find these parameters when you need them.

Required command-line switches

While most of the command-line switches described in the sections that follow are optional, you must specify the -n, -c, -gp, and -gm switches to run Adaptive Server IQ effectively.

For this release, recommended server startup values are:

```
asiqsrv12 -n servername -c 16M -gc 6000 -gd all -gm 10
-gp 4096 -gr 6000 -ti 4400 -tl 300 database
```

If you use TCP/IP to connect to the server, you should include network connection parameters as well. If you start the server without the parameter -x 'tcpip(port=nnnn)' set, then the server uses the default TCP/IP port number 2638.

On UNIX platforms, if you start the database server with the start_asiq command, these parameters are included automatically with values shown above, along with others specific to your platform. You can override these values and include other parameters by specifying them on the start_asiq command line.

Configuration file for the sample database

The *asiqdemo.cfg* file, which you use to start the sample database, sets startup parameters to the recommended defaults. You can also use this file as a template for your own configuration files. Chapter 3, "Running and Connecting to Servers", *Introduction to Adaptive Server IQ* gives an example of the sample database configuration file. This file is found in *demo/asiqdemo.cfg* in your installation directory.

A note about defaults

In the discussion of individual server options that follows, "default" means the value that applies if you start the server with the asiqsrv12 command, or from the Windows NT Start menu, and do not specify a different value.

If you start the server with the start_asiq UNIX startup utility, or with *asiqdemo.cfg* or your own configuration file, many of these options are set to other values.

Naming restrictions

Do not use hyphenated names or reserved words for database names, user identifiers or server names, even enclosed in quotation marks. For example, the following are *not* allowed:

grant

june-1999-prospects

"foreign"

For a complete list of reserved words (keywords), see the *Adaptive Server IQ Reference Manual*.

Naming the server and databases

You can use the -n command-line option as a database switch (to name the database) or as a server switch (to name the server). The server switch is required if you do not supply a database.

The server and database names are among the connection parameters that client applications can use when connecting to a database. On Windows NT, the server name appears on the desktop icon and on the title bar of the server window.

Default names

If no server name is provided, the default server name is the name of the first database started.

The default database name is the root of the Catalog Store file name (the file name without a directory path or the *.db* extension). For example, in the following command line the first database is named mydb, the second database is sample, and the server is named mydb.

```
asiqsrv12 mydb.db sample.db
```

Naming databases

You can name databases by supplying a -n switch following the database file. For example, the following command line starts a database and names it:

```
asiqsrv12 mydb.db -n MyDB
```

Naming a database lets you use a nickname in place of a file name that may be difficult to remember.

Naming the server

You name the server by supplying a -n switch before the first database file. For example, the following command line starts a server named Cambridge_sample and the sample database on that server:

```
asiqsrv12 -n Cambridge_sample sample.db -gm 10 -gp 4096
```

Putting the host name, in this case Cambridge, at the start of the server name is a useful convention. It is especially important in a multiuser, networked environment where shared memory will be used for local database connections. This convention ensures that all users will be able to connect to the correct database, even when other databases with the same name have been started on other host systems.

To allow Adaptive Server IQ to locate the server no matter what character set is in use, include only seven-bit ASCII (lower page) characters in the server name. For more information on character sets, see Chapter 9, “International Languages and Character Sets”

Specifying a server name lets you start a database server with no database loaded. The following command starts a server named Galt with no database loaded:

```
asiqsrv12 -n Galt -gm 10 -gp 4096
```

Note Although you can start a server by relying on the default server name, it is better to include both the server name and the database name, and to make the two names different. This approach helps users distinguish between the server and the databases running on it. You *must* specify the server name in order to start the server without starting a specific database.

For information about starting databases on a running server, see “Starting and stopping databases”.

Case sensitivity and naming conventions

Server names and database names are case insensitive on Windows NT, and case sensitive on UNIX.

You should adopt a set of naming conventions for your servers and databases, as well as for all other database objects, that includes a case specification. Enforcing naming conventions can prevent problems for users.

Controlling performance from the command line

Several command-line options can affect database server performance. Most of the switches described in this section control resources for operations on the IQ Store, which can have a major impact on performance. Switches that affect only the resources available for operations on the Catalog Store may have a minor impact on overall performance. If you need to specify switches that affect the Catalog Store only, see the *Adaptive Server IQ Reference Manual* for more information.

Performance tuning suggestions are given throughout this guide. See Chapter 12, “Managing System Resources” for a full discussion of how Adaptive Server IQ uses memory, disk, and processors, the effect of user connections on resource use, and options you can set to control resource use.

Some platform-specific tuning suggestions are presented in this guide. See also the *Adaptive Server IQ Installation and Configuration Guide* for your platform.

Setting memory switches

Adaptive Server IQ uses memory for a variety of purposes:

- Buffers for data read from disk to resolve queries
- Buffers for data read from disk when loading from flat files
- Overhead for managing connections, transactions, buffers, and database objects

The switches discussed below, as well as other options you can set once the server is running, determine how much memory is available for these purposes.

IQ buffer cache sizes

Normally, you set the buffer cache size for the IQ main and temporary stores using the SET OPTION command to set the Main_Cache_Memory_MB and Temp_Cache_Memory_MB options. If you set IQ buffer cache sizes higher than your system will accommodate, however, Adaptive Server IQ cannot open the database.

To override these settings for the current server session, specify the server startup options -iqmc (main cache size) and -iqtc (temp cache size) to open the database and reset the defaults. The default sizes are 8MB for the main cache and 4MB for the temporary cache, which are too low for any active database use.

Concurrent users

Your license sets the absolute number of concurrent users. However, you must also set the -gm switch. This required switch lets you limit the number of concurrent user connections on a particular server.

The -gn switch sets the number of execution threads that will be used for the Catalog Store and connectivity while running with multiple users. It applies to all operating systems and servers.

On Windows NT you need to specify this parameter in the asiqsrv12 command. To calculate its value use the following formula:

```
gn_value = gm_value - (( 2 * num_CPUs ) + 10)
```

Specify a minimum of 25.

On UNIX platforms, the start_asiq utility sets this parameter. See the *Adaptive Server IQ Installation and Configuration Guide* for your platform for more information.

There may be times when you want to tune performance for a particular operation by limiting the number of user connections to fewer than your license allows. Alternatively, you may want to use the -iqgovern switch to control query use; see “Concurrent queries.”

Concurrent queries

The -iqgovern switch lets you specify the number of concurrent queries on a particular server. This is not the same as the number of connections, which is controlled by your license. By specifying the -iqgovern switch, you can help IQ optimize paging of buffer data out to disk, and avoid overcommitting memory. The default value of -iqgovern is (2 x the number of CPUs) +10.

Wired memory

The -iqwmem switch creates a pool of “wired” memory on certain UNIX platforms only. This memory is locked down so that it cannot be paged. Wired memory can improve performance on Tru64, HP and Sun platforms. Specify this switch as the number of megabytes of wired memory.

Warning! Use this switch only if you have enough memory to dedicate some of it for this purpose. Otherwise, you can cause serious performance degradation.

Unwired memory

The -iqsmem switch creates a memory pool to increase total available memory. This switch is available on all UNIX platforms, but is required in some cases:

- On HP systems use -iqsmem if you want to use more than 2GB of memory. The value should be between 500 and 1400MB.
- On AIX systems always use -iqsmem. The value for -iqsmem should be between 356 and 2560; otherwise, the server aborts.

Specify this switch as the number of megabytes of memory. The maximum value for -iqsmem is 2000. For example, to add 1GB of unwired memory you specify:

```
-iqsmem 1000
```

Number of processing threads

Use the -iqmt switch to set the number of processing threads that Adaptive Server IQ can use. Adaptive Server IQ assigns varying numbers of kernel threads to each user connection, based on the type of processing being done by that process, the total number of threads available, and the setting of various options. Increasing the number of threads can improve performance.

Catalog Store cache size

Use the -c switch to set the amount of memory in the cache for the Catalog Store. The default initial cache size is computed based on the amount of physical memory, the operating system, and the size of the database files. On Windows NT, the database server takes additional cache for the Catalog when the available cache is exhausted.

For many Adaptive Server IQ and Java applications, you need to raise the size of the Catalog cache above the default value of 2MB. Any cache size less than 10000 is assumed to be in KB (1K =1024 bytes); any cache size 10000 or greater is assumed to be in bytes. You can also specify the cache size as *n*K or *n*M.

Both start_asiq and the *asiqdemo.cfg* configuration file set this parameter to 16MB.

Note The cache size for the IQ Store does not rely on the Catalog cache size. See “IQ buffer cache sizes.”

Setting switches that affect timing

Checkpoint interval

Adaptive Server IQ uses checkpoints to generate reference points and other information that it needs to recover databases. Use the -gc switch to set the maximum desired length of time (in minutes) that the database server will run without doing a checkpoint. The default value is 60 minutes.

When a database server is running with multiple databases, the checkpoint time specified by the first database started will be used unless overridden by this switch. If a value of 0 is entered, the default value of 60 minutes is used.

Recovery time

The -gr parameter lets you set the maximum number of minutes that the database server will take to recover from system failure. When a database server is running with multiple databases, the recovery time specified by the first database started will be used unless overridden by this switch.

Other performance-related switches

Several switches help you tune network performance. They include -gb (database process priority on Windows NT), and -p (maximum packet size).

Controlling permissions from the command line

Some command-line options control the permissions required to carry out certain global operations.

Starting and stopping databases

The -gd option allows you to limit the users who can start a database on a running server to those with a certain level of permission in the database to which they are already connected:

- DBA (the default) —Only the DBA can start an extra database.
- ALL—Any user can start and stop databases.
- NONE—No one can start or stop a database on a running server.

Sybase recommends that only the DBA be allowed to start and stop production databases.

Note If you do not set -gd ALL when you start the server, only the DBA can start additional databases on that server. This means that users cannot connect to databases that are not already started, either at the same time as the server, or since then by the DBA.

Creating and deleting databases

The -gu option allows you to limit the users who can stop the server to users with a certain level of permission in the database to which they are connected.

- DBA—Only the DBA can create and drop databases.
- ALL (default)—Any user can create and drop databases.
- NONE—No user can create or drop a database.

- UTILITY_DB—Only those users who can connect to the utility_db database can create and drop databases. See “The utility database” on page 18 for information.

Stopping the server

The -gk option limits the users who can shut down a server to those with a certain level of permission in the database.

- DBA (default) —Only the DBA can stop the server.
- ALL (default)—Any user can stop the server.
- NONE—No user can shut down the server with the STOP ENGINE command.

Setting a maximum Catalog page size

The database server cache is arranged in pages, which are fixed-size areas of memory. Since the server uses a single cache for the Catalog Store until it is shut down, all Catalog pages must have the same size.

A Catalog file is also arranged in pages, of size 1024, 2048, or 4096 bytes. Every database page must fit into a cache page.

You use the -gp option to set the Catalog page size explicitly. By setting -gp to the maximum size, 4096, you maximize the number of columns per table that Adaptive Server IQ can support.

By default, the server page size is the same as the largest page size of the databases on the command line. The -gp option overrides this default. Once the server starts, you cannot load a database with a larger Catalog page size than the server. Unless you specify -gp , an attempt to load a database file with a Catalog page size larger than the databases started on the command line will fail.

If you use larger page sizes, remember to increase your cache size. A cache of the same size will accommodate only a fraction of the number of the larger pages, leaving less flexibility in arranging the space.

Note The -gp option and the page sizes listed here apply to the Catalog Store only. You set the page size for the IQ Store in the IQ PAGE SIZE parameter of the CREATE DATABASE command. See “Choosing an IQ page size” for more information.

Setting up a client/server environment

Three switches can help you set up your client/server environment.

- -x specifies communication protocol options.
- -tl sets the network connection timeout.
- -ti sets the client connection timeout.

See the sections that follow for details.

Selecting communications protocols

Any communications between a client application and a database server require a communications protocol. Adaptive Server IQ supports a set of communications protocols for communications across networks and for same-machine communications.

The database server supports the following protocols:

- *Shared memory* is used for same-machine communications, and is loaded by default (unless the -hs parameter is specified on startup).
- *TCP/IP* is supported on all platforms.
- *IPX* is supported on Windows NT (client and server) and Windows 95 (client only).
- *NetBIOS* is supported on Windows NT (client and server) and Windows 95 (client only).
- *Named pipes* is supported on Windows NT only. Named Pipes is provided for same machine communications to and from Windows 3.x client applications using ODBC or Embedded SQL.

Specifying protocols

By default, the database server starts up all available protocols. You can limit the protocols available to a database server by using the –x command-line switch. At the client side, many of the same options can be controlled using the CommLinks connection parameter.

The following command starts a server using the TCP/IP protocol:

```
asiqsrv12 -x "tcpip"
```

The quotes are not strictly required in this example, but are needed if there are spaces in any of the arguments to –x. If you omit this switch and you are using TCP/IP, or if you do not specify a port number, the default port 2638 is used.

Additional parameters can be added to tune the behavior of the server for each protocol. For example, the following command line instructs the server to use two network cards, one with a specified port number. This command must be entered all on one line, even though it appears on multiple lines here.

```
asiqsrv12
 -x "tcpip(MyIP=192.75.209.12:2367,192.75.209.32)"
 -gm 10 -gp 4096
  path\asiqdemo.db
```

For detailed descriptions of network communications parameters that can serve as part of the –x switch, see "Network communications parameters" in the *Adaptive Server IQ Reference Manual*.

Limiting inactive connections

Adaptive Server IQ uses two parameters, -tl and -ti, to determine when it should close user connections.

Setting the default network timeout

A liveness packet is sent periodically across a client/server TCP/IP or IPX communications protocol to confirm that a connection is intact. If the server runs for a liveness timeout period (default 2 minutes) without detecting a liveness packet, the communication is severed. The server drops any connections associated with that client. There is no warning. All activity that falls within any open transaction is rolled back.

The –tl switch on the server sets the liveness timeout, in seconds, for all clients that do not specify a –tl switch when they connect. Liveness packets are sent at an interval of the (liveness timeout)/4.

You may want to set a higher value for this switch at the server level. Many users, especially those who have used earlier versions of Adaptive Server IQ, will not expect to be disconnected after only 2 minutes of inactivity.

Try setting the liveness timeout to 300, together with the recommended value for –ti discussed in the next section. Set this switch as follows:

```
-tl 300
```

If this value does not work well, try -tl 1200, which sets the liveness timeout to 20 minutes.

Note Users who are running a client and server on the same machine do not experience a liveness timeout.

Setting the default client timeout

Adaptive Server IQ disconnects client connections that have not submitted a request for the number of minutes you specify with the -ti switch. By disconnecting inactive connections, this option frees any locks those connections hold. The default is 240 (4 hours). Raising this to the recommended value, 4400 (about 73 hours), lets you start long runs at the beginning of a weekend, for example, and ensure that any interim results will not be rolled back.

Starting a server in forced recovery mode

Should you need to restart your server after a failure, you can usually do so using the same startup options as usual.

On rare occasions, you may need to supply startup options to force recovery or to recover leaked storage. To start the server with these options, see the chapter "System Recovery and Database Repair" in the *Adaptive Server IQ Troubleshooting and Error Messages Guide*.

Starting a server from DBISQL

If you are already connected to a running database server, you can start a new server from DBISQL. Use the START ENGINE command to start a named server from DBISQL.

Note This method is not recommended for most situations. If you use it be sure you are starting the server on the system you intend, that you include appropriate server parameters in the STARTLINE, and that environment variables are set appropriately on the system where the server will start.

Example

The following DBISQL command, entered on one line, starts a database server, names it jill_newserv, and specifies the network connection, number of connections, and Catalog page size.

```
START ENGINE AS jill_newserv
STARTLINE 'asiqsrv12 -x tcpip(port=5678) -gm 10 -gp
4096'
```

Starting multiple servers or clients on the same machine

In a production environment, it would be unusual to have more than one server running on the same system. In a development environment, however, this situation can occur.

If you are running more than one server or client on the same UNIX machine, and shared memory is enabled, you must take certain precautions to prevent users from connecting to the wrong server. To avoid conflicts when using shared memory, consider doing one or more of the following:

- Create a temporary directory dedicated to each server. Make sure that each client uses the same temporary directory as its server by setting the ASTMP environment variable explicitly on both systems. For details about setting environment variables, see the *Adaptive Server IQ Reference Manual*.
- Create a data source name in the *.odbc.ini* file (on UNIX) for each server and provide detailed connection information. For details, see the *Adaptive Server IQ Installation and Configuration Guide.*
- Use connection strings that specify explicit parameters instead of relying on defaults.
- Confirm connections by issuing the following command:

```
SELECT "database name is" = db_name(),
"servername_is" = @@servername
```

Monitoring server activity

It may be helpful, especially for new users, to monitor server activity. Using commands appropriate for your platform, you can direct Adaptive Server IQ to capture server activity in a log file.

Unix server log file

When you start a server on a UNIX system with the start_asiq utility, server activity is logged in an ASCII text file placed in the directory defined by $ASLOGDIR. (If $ASLOGDIR is not defined, it defaults to *$ASDIR/logfiles*.)

The log file name has this format:

```
your_server_name.###.srvlog
```

Each time you start the server, the number is incremented. For example, your directory may look like this:

```
demo.001.srvlog   demo.002.srvlog
janedemo.001.srvlog
```

For information about your most recent session, choose the log with the largest number for the desired server. Issue a tail –f command to view the log contents. For example:

```
% tail -f demo.002.srvlog
```

When you run start_asiq, specify the –z option to enhance the log file with additional information about connections. This will help new users or those troubleshooting connection problems.

On UNIX systems, there are two ways to check if a particular server is running:

- Log into the machine where the server was started, and issue the command:

```
% ps -eaf | grep asiqsrv12
maryc 24836 25554   0   Feb 09      - 17:36
asiqsrv12 -c 16m -gc 6000 -gd all
-gr 6000 -gm 10 -gp 4096 -ti 4400
-tl 300 -iqmt 450 -iqsmem 2560
@fnma.cfg asiqdemo.db
janed 28932 38122   0 11:39:24      -  2:10
asiqsrv12 -c 16m -gc 6000 -gr 6000
-gm 10 -gp 4096 -ti 4400
-tl 300 -iqsmem 2560 -n janedemo -gd all
-iqmt 256 -x tcpip(port=1872)
```

- Use the stop_asiq utility, described in the following section, which displays all Adaptive Server IQ processes running.

On Windows systems, look in the system tray for one or more Adaptive Server IQ icons. Place the cursor over each icon and read the server name.

Windows server log file

On Windows systems, use the -o parameter on the asiqserv12 startup command to create a log file of server activity. For example, to save output to a file named *results*, start the server as follows:

```
asiqsrv12 -o results
```

Stopping the database server

The preferred ways to stop the database server are:

- In UNIX, use the stop_asiq utility. For details, see "Example — Stop a server with stop_asiq".

  Note that when stop_asiq is used, the following message appears:

```
"Please note that 'stop_asiq' will shutdown a server
completely without regard for users connections or load
processes status. For a finer level of detail the utility 'dbstop'
has the options to control whether a server is stopped based on
active connections."
```

- In Windows NT, click Shutdown on the database server display or right-click the IQ icon in the system tray and select Exit.

Normally, you should not shut down a server while it is still connected to one or more clients. If you try this, you get a warning that any uncommitted transactions will be lost. Disconnect or close all the clients and try again.

You can also stop the database server in the following ways:

- At the operating system command line, issue the DBSTOP command with appropriate parameters. *Use the same parameters as when you started the server.* Without the proper connection parameters DBSTOP doesn't know how to connect to the server to tell it to shutdown. For details on using DBSTOP, see Chapter 4, "Database Administration Utilities" in the *Adaptive Server IQ Reference Manual*.
- In a DBISQL window or command file, issue the STOP ENGINE command to stop a named database server.
- In UNIX, in the window where the database server was started, type:

  ```
  q
  ```

  This command does not work if you have redirected input to a different device.

Example — Stop a server with stop_asiq

The following example uses the stop_asiq utility on UNIX systems to shut down an Adaptive Server IQ server and close all user connections to it.

When you issue the stop_asiq command, Adaptive Server IQ lists all the servers owned by other users, followed by the server(s) you own. It then asks if you want to stop your server. For example:

```
% stop_asiq
Checking system for ASIQ 12 Servers ...
The following 3 server(s) are owned by other users.

##     Owner    PID   Started  CPU_Time
 -- ---------  -----  --------  --------  ----------------------

        hsin  19895    Mar.21      1:33
asiqsrv12 -c 16m -gd all -gm 10 -gn 25 -gp 4096 -ti 4400 -tl 300
-n hsin -x tcp
qadaily  24754  01:25:07   1286:53
asiqsrv12 -gn 25 @/express1/qa/daily/engine/new.cfg asiqdemo.db
-o /express1/qa
washburn  28350    Apr.11      0:20
asiqsrv12 -gn 25 @asiqdemo.cfg -o
/express1/users/washburn/mysybase12.4.0/asiq1

The following 1 server(s) are owned by 'janed'
##     Owner    PID   Started  CPU_Time
-- ---------  -----  --------  --------  ----------------------
1:     janed   2838  15:11:37      0:07
asiqsrv12 -c 16m -gd all -gm 10 -gn 25 -gp 4096 -ti 4400 -tl 300 @asiqdemo.cfg

--
   Please note that 'stop_asiq' will shutdown a server completely
   without regard for users connections or load processes status.
   For a finer level of detail the utility 'dbstop' has the options
   to control whether a server is stopped based on active connections.

Do you want to stop the server displayed above <Y/N>?
```

To shut down the server, type `Y` (yes). Messages like the following display:

```
Shutting down server (2838) ...
Checkpointing server (2838) ...
Server shutdown.
```

To leave the server running, type `N` (no). You return to the system prompt and IQ does not shut down the server.

If no running servers were started by your user ID, Adaptive Server IQ displays information about servers run by other users, then a message like the following:

```
There are no servers owned by 'janed'
```

Example —Stop a server from DBISQL

The following example stops a server from DBISQL:

```
STOP ENGINE Ottawa UNCONDITIONALLY
```

The optional keyword UNCONDITIONALLY specifies that the database server will be stopped even if there are connections to it.

Note You can stop a server from DBISQL if you are connected as DBA to one of the databases running on that server (including the utility_db database), or if the server was started with the -gk ALL option.

Who can stop the server?

When you start a server, you can use the -gk option to set the level of permissions required for users to stop the server. The default level of permissions required is DBA, but you can also set the value to ALL or NONE. If you set it to NONE, even the DBA cannot execute STOP ENGINE. In a production environment, Sybase strongly recommends that only the DBA be allowed to stop the database server.

Interactively, of course, anyone at the machine where the server was started can click Shutdown (NT only) or type q on the server window.

Shutting down operating system sessions

Always stop the database server explicitly before closing the operating system session.

If you close an operating system session where a database server is running, or if you use an operating system command to stop the database server (other than the UNIX command shown in the previous section), the server shuts down, but not cleanly. Next time the database is loaded, recovery happens automatically. For information on system recovery, see *Adaptive Server IQ Troubleshooting and Error Messages Guide*.

Examples of commands that *do not* stop a server cleanly include:

- Stopping the process in the Windows NT Task Manager Processes window.
- Using a UNIX kill command.

Starting and stopping databases

You can start databases when you start the server, or after the server is running. To start a database when you start the server, see “Starting the database server” on page 21 for details.

A database server can have more than one database in use at a time. However, it is more common to run one database per server, especially in a production environment.

Starting a database on a running server

There are several ways to start a database on a running server.

- To start a database from DBISQL or Embedded SQL, use the START DATABASE statement. For a description, see the chapter “SQL Statements” in the *Adaptive Server IQ Reference Manual*.
- To start and connect to a database from DBISQL or Sybase Central, use a data source that specifies the database file. See “Working with ODBC data sources”.
- To start and connect to a database when you start DBISQL from a system command prompt, include the parameter “DBF=*db-file*” in the connection parameters. See “Connecting to a database from DBISQL”.
- To start a database from Sybase Central, see Chapter 4, “Managing Databases with Sybase Central” in *Introduction to Adaptive Server IQ*
- To start an embedded database, while connected to a server, connect to a database using a DBF parameter. This parameter specifies a database file for a new connection. The database file is loaded onto the current server.

Page size limitations

The server holds database information in memory using pages of a fixed size. Once a server has been started, you cannot load a database that has a larger Catalog page size or IQ page size than the server. For this reason, you should always set the Catalog page size to its maximum value, 4096 bytes, with the -gp switch.

Permission limitations

The -gd server command-line option determines the permission level required to start databases. By default, this option is set to DBA, so that only users with database administrator privileges can start IQ databases. However, you can also set this option to ALL or NONE. ALL means that all users can start a database. NONE means that no users, including the DBA, can start a database.

Stopping a database

You can stop a database in the following ways:

- Disconnect from a database started by a connection string. The database stops automatically when the last user disconnects from it, unless you explicitly set the AUTOSTOP connection parameter to NO.
- From DBISQL or Embedded SQL, use the STOP DATABASE statement.

For information, see the *Adaptive Server IQ Reference Manual*.

Starting the asiqdemo database

You can start the server and the asiqdemo database easily, using the configuration file that Adaptive Server IQ provides. This configuration file, called *asiqdemo.cfg*, contains all the parameters necessary to start the sample database.

❖ **To start the server and asiqdemo database on UNIX operating systems:**

- From a command line, type the following command:

```
%cd $ASDIR/demo
%start_asiq @asiqdemo.cfg asiqdemo
```

These commands use the configuration file *asiqdemo.cfg* that is created automatically at installation. You can edit this file to change the parameters you use to start the sample database. For example, the server name in this file is *hostname*_asiqdemo. You can rename the server to a unique name of your choice, like janed_server.

❖ **To start the server and asiqdemo database on a Windows NT system:**

- Click Start on the Taskbar, and select Programs→Adaptive Server IQ 12.0→ Sample Database.

Behind the scenes

The command that executes when you perform these steps is:

```
path\win32\asiqsrv12 @demo\asiqdemo.cfg
 demo\asiqdemo.db
```

where *path* is your Adaptive Server IQ installation directory, *demo\asiqdemo.cfg* specifies the configuration file, and *demo\asiqdemo.db* is the sample database file. The asiqsrv12 command starts the server in a dedicated window. You can start database servers by entering this command at a system command prompt, as described elsewhere in this chapter.

Starting and stopping Sybase Central

If your system supports a graphical user interface, you will use Sybase Central to perform many administrative tasks. This guide gives summary instructions for using Sybase Central. For more information, see the *Introduction to Adaptive Server IQ*, or use the online help available within Sybase Central.

Starting Sybase Central on UNIX Systems

To start Sybase Central, change directory to *$SYBASE/sybcentral* and type:

```
% scjview
```

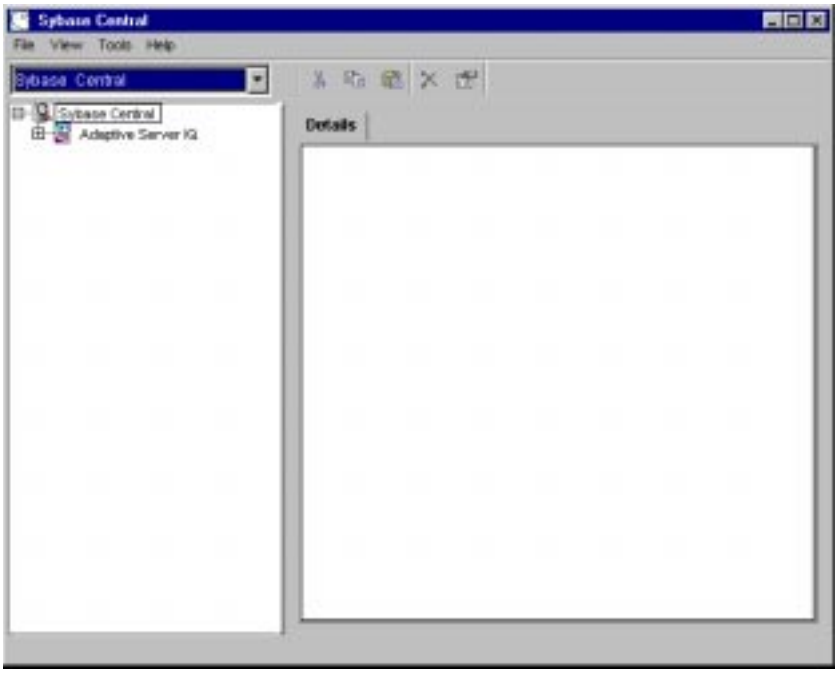
If you have added *$SYBASE/asiq12/bin* or *$SYBASE/bin* to your path, as instructed at the end of the installation, you can issue the scjview command from any directory.

Starting Sybase Central on Windows NT Systems

To start Sybase Central, select Start→Programs→Adaptive Server IQ 12→Sybase Central Java Edition.

The main Sybase Central window appears.

Figure 2-1: The Sybase Central Hierarchy



Plug-ins for Sybase Central, such as the Adaptive Server IQ database management system, occupy the first level in the Sybase Central hierarchy after the root level. A **plug-in** is a graphical tool for managing a particular product. When you install the product, you can also install its Sybase Central plug-in. When you next start Sybase Central, the new product automatically "plugs in" to Sybase Central and appears in the main window.

The right panel displays the contents of the container that has been selected in the left panel.

Connecting a plug-in

If you do not see the plug-in for Adaptive Server IQ in the main Sybase Central window, you can connect to it manually.

❖ **Connecting to a plug-in**

1 Select Tools → Adaptive Server IQ 12.

2 If you do not see Adaptive Server IQ on the Connect Menu, select Tools → Plug-ins.

3 If Adaptive Server IQ (ASIQ) is listed, select Register. If not, select Load.

Use the Browse button to find and select the file *ASIQPlugin.jar*. Click OK.

Stopping Sybase Central

To stop Sybase Central, select File → Exit.

Introduction to connections

The remainder of this chapter describes how client applications connect to databases. It contains information about connecting to databases from ODBC applications and application development systems, as well as from Embedded SQL applications.

Any client application that uses a database must establish a **connection** to that database before any work can be done. The connection forms a channel through which all activity from the client application takes place. For example, your user ID determines permissions to carry out actions on the database—and the database server has your user ID because it is part of the request to establish a connection.

This sounds simple, but some client tools may not clearly indicate connection status, and a failed command is your first indication that the connection does not exist. For a novice user, a quick way to confirm the connection is by a simple `select db_name()`.

The syntax is:

```
select db_name()
```

to display the current database, or

```
select db_name([ database_id ])
```

to display any database you specify.

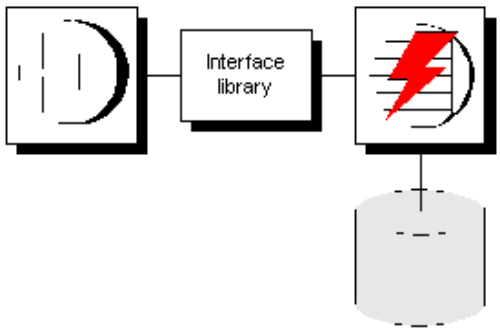
How connections are established

To establish a connection, the client application calls functions in one of the supported interfaces. Adaptive Server IQ supports the following interfaces:

- *ODBC* — ODBC connections are discussed in this chapter.
- *Embedded SQL* — Embedded SQL connections are discussed in this chapter.
- *Sybase Open Client* — Open Client connections are not discussed in this chapter. For information on connecting to IQ from Open Client applications, see Chapter 14, “Adaptive Server IQ as a Data Server”
- *JDBC* — JDBC connections are not discussed in this chapter. For information on connecting via JDBC, see Chapter 4, “Managing Databases with Sybase Central” in *Introduction to Adaptive Server IQ*. To create JDBC data sources, see the chapter entitled “Data Access Using JDBC” in the *Adaptive Server Anywhere User’s Guide*.

Note JDBC provides the link between the execution of Java objects and database operations. For a description of Java support in Adaptive Server IQ, see “Enabling Java in the database” on page 113.

The interface uses connection information included in the call from the client application, perhaps together with information held on disk in a file data source, to locate and connect to a server running the required database. The following figure is a simplified representation of the pieces involved.



Learning about connections

If you want ...	Consider reading ...
Some examples to get started quickly	“Simple connection examples”

If you want ...	Consider reading ...
A conceptual overview	"Connection parameters specify connections"
To create data sources	"Working with ODBC data sources"
To see an in-depth description of how connections are established	"Working with ODBC data sources"
To add users and grant them permissions	"How Adaptive Server IQ makes connections"
To diagnose network-specific connection issues	"Troubleshooting network communications" in the *Adaptive Server IQ Troubleshooting and Error Messages Guide*
To learn about character set issues affecting connections	"Connection strings and character sets" on page 338

Connection parameters specify connections

When an application connects to a database, it uses a set of **connection parameters** to define the connection. Connection parameters include information such as the server name, the database name, and a user ID.

A keyword-value pair, of the form *parameter=value*, specifies each connection parameter. For example, you specify the password connection parameter for the default password as follows:

```
Password=sql
```

Connection parameters are passed as connection strings

Connection parameters are assembled into connection strings. In a connection string, a semicolon separates each connection parameter, as follows:

```
ServerName=host_asiqdemo;DatabaseName=asiqdemo
```

Representing connection strings

This chapter has many examples of connection strings, represented in the following form:

parameter1=value1
parameter2=value2
...

This is equivalent to the following connection string:

parameter1=value1;*parameter2=value2*

You must enter a connection string on a single line, with the parameter settings separated by semicolons.

Connection parameters are passed as connection strings

Connection parameters are passed to the interface library as a **connection string**. This string consists of a set of parameters, separated by semicolons.

In general, the connection string built up by an application and passed to the interface library does not correspond directly to the way a user enters the information. Instead, a user may fill in a dialog box, or the application may read connection information from an initialization file.

Certain Adaptive Server IQ utilities accept a connection string as the -c command-line option and pass the connection string on to the interface library without change. For example, the following is a typical Collation utility (dbcollat) command line for Windows NT systems. It should be entered all on one line.

```
dbcollat -c "uid=DBA;pwd=SQL;dbn=asiqdemo"
c:\temp\asiqdemo.col
```

Note DBISQL processes the connection string internally. It does not simply pass on the connection parameters to the interface library. Do not use Interactive SQL to test command strings from a command prompt.

Simple connection examples

Although the connection model for Adaptive Server IQ is configurable, and can become complex, in many cases connecting to a database is very simple.

This section describes some simple cases of applications connecting to an Adaptive Server IQ database. When you are getting started, this section may be all you need, for example, if you are running the asiqdemo sample database on a local server and are not connected to a network. However, in most IQ environments, in order to ensure that you can connect and disconnect properly, a very complete set of connection parameters is essential.

For steps in connecting to a database using Sybase Central, see the *Introduction to Adaptive Server IQ*. For more detailed information on available connection parameters and their use, see "Connection parameters" on page 73.

Connecting to a database from DBISQL

Many examples and exercises throughout the documentation start by connecting to the sample database from Interactive SQL, also called DBISQL. Here is how to carry out this step.

Note To avoid ambiguity, specify connection parameters for DBISQL instead of relying on defaults. You can specify connection parameters in a command line or an initialization file such as *.odbc.ini* or *odbc.ini*. For a complete list, see Chapter 3, "Connection and Communication Parameters" in *Adaptive Server IQ Reference Manual*.

If more than one database is started on a server, for example, you should specify the database name. In a network with subnets, specify the CommLinks parameter with protocol options including the host number.

In the *.odbc.ini* file, you must use the long form of each parameter. For example, use DatabaseFile instead of DBF.

If your parameters are incomplete or incorrect, you may see an error such as

```
Database name required to start engine
```

❖ **To connect from a UNIX system:**

1. Make sure that your PATH and other environment variables are correctly set, as described in Chapter 1, "File Locations and Installation Settings" in the *Adaptive Server IQ Reference Manual*.
2. To ensure that the sample database is loaded on a running server, at the UNIX prompt enter:

   ```
   ps -eaf | grep asiqdemo
   ```

   If you need to start the sample database, enter:

   ```
   cd $ASDIR/demo
   start_asiq @asiqdemo.cfg asiqdemo
   ```

3. If you have not already done so, change to your home directory ($HOME) and issue the following command to copy the terminfo extension file *default.tix* into it:

```
% cp $SYBASE/asiq12/tix/default.tix
```

This file controls key sequences for DBISQL and improves the command window display. For more information, see Chapter 6, "Getting Started with DBISQL" in *Introduction to Adaptive Server IQ*.

4 Start DBISQL by entering

```
dbisql -c
"uid=DBA;pwd=SQL;eng=servername;links=tcpip"
```

at the command line. Make sure that the value supplied for the *servername* is the same server name that was supplied in the start_asiq command to start the server.

The –c parameter specifies connection parameters. You can also specify these parameters in a data source, as described later in this chapter.

Note `links=tcpip` (or `CommLinks=tcpip`) is only required if you use TCP/IP to connect to the database. If you use the shared memory port to connect to a local database you can omit the `links` parameter; however, it is always safer—and required on some platforms—to include complete network parameters.

To connect to a database on a foreign host, you must add the host. For example:

```
dbisql -c "uid=DBA;pwd=SQL;eng=SERV1_asiqdemo;
links=tcpip(host=SERV2)"
```

If the host was started with a non-default port number (not 2638) then the port number must be added also. For example:

```
dbisql -c "uid=DBA;pwd=SQL;eng=SERV1_asiqdemo;
links=tcpip(host=SERV2;port=1234)"
```

If you prefer, use this alternate form of the links clause, which has the same result:

```
links=tcpip(host=SERV2:1234)"
```

❖ **To connect from a Windows NT system**

1 Select Start → Προγραμσ → Sybase Adaptive Server IQ 12 → Interactive SQL, or at the NT command prompt enter

```
dbisql
```

You can include the -c parameter to specify connection parameters in the dbisql command, as described in the procedure above for connecting to UNIX. If you omit these parameters, the DBISQL logon window appears.

2 Enter the user ID

```
DBA
```

and the password

```
SQL
```

This is the default user ID and password for Adaptive Server IQ databases when they are created.

3 Click the Database tab and type the server name (for example, "*hostname*_asiqdemo" for the asiqdemo database).

4 If you use TCP/IP to connect to databases, on the Network tab, click on TCPIP. (If you use the shared memory port for connecting, skip this step.)

If your database is on a remote machine, you must add host information in the space beside TCPIP by typing "host=*servername*:*nnnn*" where *servername* is the name of your system and *nnnn* is your port number. (The default port number is 2638, but if the host was started with a different number, use that instead.)

5 Click OK to connect to the database.

6 After you connect to the database, the DBISQL window appears. The DBISQL window displays the database name, user ID, and server name for the connection on its title bar. The words "Connected to database" appear in the Statistics window along with a message displaying the collation sequence used by the database.

You can connect to any database server that is already running in the same manner. You can also specify a non-default character set and language.

For more information on using DBISQL, see the chapter "Getting Started with DBISQL" in the *Introduction to Adaptive Server IQ*.

Connecting to other databases from DBISQL

The following procedure shows how to connect to a running database from DBISQL.

❖ **To connect to a database from DBISQL on UNIX:**

1 Start the server and the database by typing at a system command prompt:

```
start_asiq dbname
```

2 Start DBISQL by typing at a system command prompt:

```
dbisql -c
"uid=userID;pwd=password;eng=dbname;links=tcpip"
```

For example, to connect to the sample database you would enter:

```
dbisql -c
"uid=DBA;pwd=SQL;eng=asiqdemo;links=tcpip"
```

The –c parameter specifies connection parameters. See “Connection parameters” for more about connection parameters.

To connect to a system on a foreign host, you must add the host:

```
dbisql -c "uid=DBA;pwd=SQL;eng=dbname;
links=tcpip(host=hostname"
```

If the host was started with a non-default port number (not 2638) then the port number must be added as well:

```
dbisql -c "uid=DBA;pwd=SQL;eng=anotherdb;
links=tcpip(host=hostname;port=nnnn)"
```

Connecting to an embedded database

An **embedded database**, designed for use by a single application, runs on the same machine as the application and is largely hidden from the application user.

When an application uses an embedded database, the database server is generally not running when the application connects. In this case, you can start the database using the connection string, and by specifying the database file in the DatabaseFile (DBF) parameter of the connection string.

Using the DBF parameter

The DBF parameter specifies which database file to use. The database file automatically loads onto the default server, or starts a server if none is running.

The database unloads when there are no more connections to the database (generally when the application that started the connection disconnects). If the connection started the server, it stops once the database unloads.

The following connection parameters show how to load the sample database as an embedded database:

```
dbf=path\asiqdemo.db
uid=dba
pwd=sql
```

where *path* is the name of your Adaptive Server IQ installation directory.

Using the Start parameter

The following connection parameters show how you can customize the startup of the sample database as an embedded database. This is useful if you wish to use command-line options, such as the cache size:

```
Start=asiqsrv12 -gm 10 -gp 4096 -c 8M
dbf=path\asiqdemo.db
uid=dba
pwd=sql
```

Extra cache needed for Java

If you are using Java in an embedded database, you should use the start line to provide more than the default cache size. For development purposes, a cache size of 8 MB is sufficient.

Example: connecting from DBSQL

In this example, the sample database is an embedded database within DBSQL.

❖ **To connect to an embedded database from DBSQL in Windows NT:**

1. Start DBISQL with no databases running. You can use either of the following ways:
   - From the Windows NT Start menu, choose Sybase→Adaptive Server Anywhere →Interactive SQL.
   - Type `dbisql` at a system command prompt.

   When DBISQL starts, it is not connected to any database.
2. Type CONNECT in the command window, and press F9 to execute the command. The connection dialog appears.
3. If you have an ODBC data source for your database, select that data source.
4. Enter `DBA` as the user ID and `SQL` as the password. Then click the Database tab. Enter the full path of the sample database in the Database File field. For example, if your installation directory is *c:\sybase\asiq12* you should enter the following:

   ```
   c:\sybase\asiq12\asiqdemo.db
   ```

5 Leave all other fields blank, and click OK. Adaptive Server IQ starts up and loads the sample database, and DBISQL connects to the database.

Connecting using a data source

You can save sets of connection parameters in a data source. Data sources can be used by ODBC and Embedded SQL applications like DBISQL. You can create data sources from the ODBC Administrator; see "Creating and editing ODBC data sources" for details.

The following procedure shows how to connect to the sample database from DBISQL using a data source.

❖ **To connect using a data source:**

1 Start DBISQL with no databases running.

- On UNIX, type `dbisql` at a system command prompt.
- On Windows NT, from the Start menu choose Programs→Sybase → Adaptive Server IQ 12.0 → Interactive SQL.

2 Enter `DBA` as the user ID and `SQL` as the password.

3 Specify the data source. On Windows NT, you can select from the drop-down list of ODBC data sources; for the sample database, select ASIQ12 Sample. On UNIX you must enter it in the ODBC Data Source field.

4 For the sample database, leave all other fields blank, and click OK. Adaptive Server IQ starts up and loads the sample database, and Interactive SQL connects to the database. For other databases you may need to provide additional information, depending on your data source.

Note You can also specify the data source name by including the `dsn` connection parameter in the `dbisql` command, as follows:

```
dbisql -c "dsn=ASIQ12 Sample"
```

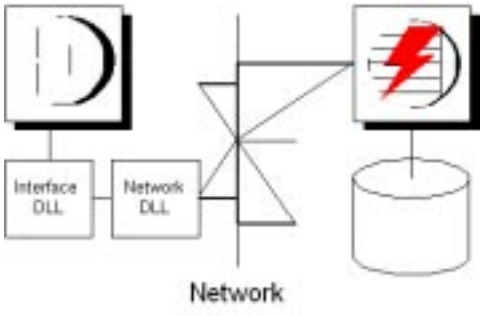
The asiqdemo data source

The asiqdemo data source holds a set of connection parameters, including the database file and a Start parameter to start the sample database. The server name in this data source is "*hostname*_asiqdemo" where hostname represents your system name.

Connecting to a server on a network

To connect to a database running on a network server somewhere on a local or wide area network, the client software must be able to locate the database server. Adaptive Server IQ provides a network library (a DLL or shared library) that handles this task.

Network connections occur over a network protocol. Several protocols are supported, including TCP/IP, IPX, and NetBIOS.



Specifying the server

Adaptive Server IQ server names are unique on a local domain for a given network protocol. The following connection parameters provide a simple example for connecting to a server running elsewhere on a network:

```
eng=svr_name
dbn=db_name
uid=user_id
pwd=password
CommLinks=all
```

The client library first looks for a local server of the given name, and then looks on the network for a server of the specified name.

The above example finds any server started using the default port number. However, you can start servers using other port numbers by providing more information in the CommLinks parameter. For information on this parameter, see Chapter 3, “Connection and Communication Parameters” in *Adaptive Server IQ Reference Manual*.

Specifying the protocol

If several protocols are available, you can tell the network library which ones to use. The following parameters use only the TCP/IP protocol:

```
eng=svr_name
dbn=db_name
uid=user_id
pwd=password
CommLinks=tcpip
```

The network library searches for a server by broadcasting over the network, which can be a time-consuming process. Once the network library locates a server, the client library stores its name and network address in a file. Users should never need to use this file directly. Adaptive Server IQ reuses this entry for subsequent connection attempts, which can be many times faster than a connection that is achieved by broadcast.

Many other connection parameters are available to assist Adaptive Server IQ in locating a server efficiently over a network. For more information see "Network communications parameters" in the *Adaptive Server IQ Reference Manual*.

To see how you can include connection parameters in an ODBC data source, see "Creating and editing ODBC data sources".

Note In a subnetted network environment, it is possible to have multiple servers with the same name and port number running on different nodes in different subnets. This is true because in most situations, routers are not programmed to pass broadcast messages between subnets. If you are running in a subnetted environment, it is always safest to use specific host, port numbers, and server names to guarantee that you are connecting to the proper server and database. This is particularly true when using default connection parameters, and is required on AIX platforms.

Using default connection parameters

You can leave many connection parameters unspecified, and instead use the default behavior to make a connection.

Note Be extremely cautious about relying on default behavior in production environments, especially if you distribute your application to customers who may install other Adaptive Server IQ or Adaptive Server Anywhere applications on their machine.

Default database server

If you are connecting to a database on your local server, and more than one database has been started on that server, you need to specify the database you wish to connect to, but you can leave the server as a default:

```
dbn=db_name
uid=user_id
```

```
pwd=password
```

Note Do not use these parameters if more than one local server is running, or you may connect to the wrong server.

Default database

If more than one server is running, you need to specify which one you wish to connect to. If only one database has been started on that server, you do not need to specify the database name. The following connection string connects to a named server, using the default database:

```
eng=server_name
uid=user_id
pwd=password
```

No defaults

The following connection string connects to a named server, using a named database:

```
eng=server_name
dbn=db_name
uid=user_id
pwd=password
```

For more information about default behavior, see "How Adaptive Server IQ makes connections".

Connecting from Adaptive Server IQ utilities

Adaptive Server IQ database utilities that communicate with the server (rather than acting directly on database files) do so using Embedded SQL. They follow the procedure outlined in "How Adaptive Server IQ makes connections" when connecting to a database.

How database utilities obtain connection parameter values

Many of the administration utilities obtain the connection parameter values by:

1 Using values specified on the command line (if there are any). For example, the following command starts the collation utility on the sample database on the default server, using the user ID `DBA` and the password `SQL` and the *asiqdemo.col* collation file:

```
dbcollat -c "uid=DBA;pwd=SQL;dbn=asiqdemo"
c:\temp\asiqdemo.col
```

2 Using the SQLCONNECT environment variable settings if any command line values are missing. Adaptive Server IQ database utilities do not set this variable automatically. For a description of the SQLCONNECT environment variable, see Chapter 1, "Environment Variables and Registry Entries," in *Adaptive Server IQ Reference Manual*.

3 Prompting you for a user ID and password to connect to the default database on the default server, if parameters are not set in the command line or the SQLCONNECT environment variable.

For a description of command-line switches for each database utility, see Chapter 4, "Database Administration Utilities" in the *Adaptive Server IQ Reference Manual*.

Working with ODBC data sources

You can store a set of Adaptive Server IQ connection parameters as a data source. Data sources are required to use applications that connect using the **Open Database Connectivity** (**ODBC**) interface.

Microsoft Corporation defines the ODBC interface, which is a standard interface for connecting client applications to database management systems in the Windows and Windows NT environments. Many client applications, including application development systems, use the ODBC interface to access a wide range of database systems.

Although data sources are especially designed for Windows and Windows NT, Adaptive Server IQ allows you to create and use them on UNIX servers as well. This allows ODBC–based client applications to connect to databases on UNIX servers.

When you connect to a database using ODBC, you use an ODBC data source. The data source contains a set of connection parameters. You need an ODBC data source on the client computer for each database you will connect to.

If you have a data source, your connection string can simply name the data source to use.

Embedded SQL can use data sources

Embedded SQL applications such as Interactive SQL and the other Adaptive Server IQ database administration utilities can also use ODBC data sources, even though they are not ODBC applications.

DSNs and FILEDSNs

You specify a data source either as a DSN (data source name) or as a FileDSN (file data source name).

You can reference a data source in the Windows NT registry using the DSN connection parameter:

DSN=*my data source*

You can reference a data source held in a file using the FileDSN connection parameter:

FileDSN=*mysource*.dsn

DSNs and FileDSNs differ only in how they are stored, and how you create them. With the exception of encrypted passwords, you can put identical connection information in them. You can use both DSNs and FileDSNs on any platform.

Where DSNs and FileDSNs are stored

A DSN, or Data Source Name, is stored in the file *odbc.ini* and in the registry on Windows NT systems. On UNIX platforms it is stored in the *odbc.ini* file only.

A FileDSN, or File Data Source Name, is always stored on a file on all platforms.

File data sources can be distributed

File data sources can easily be distributed to end users, so that connection information does not have to be reconstructed on each machine. It can be sent via email, for example, but is not stored automatically in any public place. If the file is placed in the default location for file data sources, it is picked up automatically by ODBC. In this way, managing connections for many users can be made simpler.

Note Because DSNs are stored in the NT registry, they are public information. For this reason you should not put a password in a DSN, unless you encrypt it. If you want to store your password in your data source, use a File DSN.

How you create DSNs and FILEDSNs

To create DSNs on NT systems, use the ODBC Administrator; do not edit *odbc.ini* directly. See “Creating and editing ODBC data sources” for details.

To create File DSNs on Windows NT systems, use the ODBC Administrator. See “Creating and editing ODBC data sources”.

To create or edit DSNs or File DSNs on UNIX systems, use a text editor. For DSNs you can edit the *.odbc.ini* file directly. For File DSNs, create a file with the name you choose, using the file extension *.dsn*.

Note Sybase recommends that, to avoid ambiguity, you be as specific as possible in creating ODBC and other data sources, whether you create them using the ODBC Administrator, or by editing *odbc.ini*, *.odbc.ini*, or *.dsn* files directly. If more than one database is started on a server, for example, you should specify the database name, and in a network with subnets, specify the CommLinks parameter including the host number when editing files; include the host number in the network protocol options on the Network tab in the ODBC Administrator.

If connection parameters are incomplete or incorrect, you may see an error such as

```
Database name required to start engine
```

For a complete list of connection parameters, see Chapter 3, "Connection and Communication Parameters" in *Adaptive Server IQ Reference Manual*.

Examples of connection strings using data sources

The following connection string specifies an ODBC Data Source Name and a user ID.

```
DSN=ASIQ sample;uid=DBA
```

The following connection string specifies a File Data Source Name, with a user ID and password.

```
FILEDSN=ASIQ on UNIX;uid=DBA;pwd=SQL
```

Creating and editing ODBC data sources

You need an ODBC data source on the client computer for each database you wish to connect to. You probably already have an *odbc.ini* file on your system.

On Windows NT, the ODBC Administrator provides a central place for managing ODBC data sources. The following procedure uses the ODBC Administrator to add a new data source to your existing *odbc.ini*, or creates a new file if necessary.

To create ODBC data sources on UNIX systems, see also "Using ODBC data sources on UNIX".

❖ **To create an ODBC User Data Source:**

1 Select Settings → Control Panel → ODBC or Select Programs → Sybase → Adaptive Server IQ → ODBC Administrator

2 In the ODBC Data Source Administrator, click Add on the User DSN tab.

3 Select the Adaptive Server IQ 12 from the list of drivers and click Finish.

4 In the Adaptive Server IQ ODBC Configuration box, type the Data Source Name.

5 Now click the Login tab. Type the User ID and Password for your database. For example, use "DBA" and "SQL".

6 Click the Database tab. If the data source is on your local machine, type a Start line and Database file, including the path.

7 If the data source is on a remote system, click the Network tab. Click the box for the appropriate protocol and specify the options beside the box. For example, to connect to a server on system PUSHKIN using TCP/IP protocol and port 1870, you would click TCP/IP and type:

```
host=pushkin:1870
```

You could also use the host network address. For example:

```
host=157.133.66.75:1870
```

8 Click OK when you have finished defining your data source.

The ODBC Data Source Administrator returns you to the User DSN tab.

For details of the ODBC configuration box and its tabs, see "Configuring ODBC data sources" on page 67

Note When specifying network connections, you need a different *systemname*:*port#* combination for each database server. The port number must match the one you started the server with.

❖ **To test an ODBC Data Source**

To test your data source, you must first start the database.

1 Start the database. For example, to start the Sample Database, select Start → Programs → Sybase → Adaptive Server IQ 12 → Start ASIQ Demo Database.

2 In the ODBC Data Source Administrator, select your new data source from the list of User Data Sources.

3 Click Configure.

4 On the ODBC Configuration dialog box, click Test Connection.

If you cannot access the Data Source, check that you have filled out the various tabs with correct file and pathnames.

To edit a data source, select one from the list in the ODBC administrator window and click Configure.

If you need to access Windows NT across a network in order to create an ODBC data source, see the *Adaptive Server IQ Installation and Configuration Guide*.

Configuring ODBC data sources

This section describes the meaning of each of the options on the ODBC configuration dialog box, organized by tab.

ODBC tab

Data source name The Data Source Name is used to identify the ODBC data source. You can use any descriptive name for the data source (spaces are allowed) but it is recommended that you keep the name short, as you may need to enter it in connection strings.

For more information, see the DataSourceName connection parameter in the *Adaptive Server IQ Reference Manual*.

Description You can enter an optional longer description of the Data Source.

Translator Choose Adaptive Server IQ 12.0 Translator if your database uses an OEM code page. If your database uses an ANSI code page, which is the default, leave this unchecked.

Isolation level The isolation level for an IQ data source is always effectively 3. However, the default Catalog Store isolation level is 0.

For more information, see “Isolation levels” on page 302.

Microsoft applications (keys in SQL Statistics) Check this box if you wish foreign keys to be returned by SQL statistics. The ODBC specifications states that primary and foreign keys should not be returned by SQL statistics, however, some Microsoft applications (such as Visual Basic and Access) assume that primary and foreign keys are returned by SQL statistics.

Delphi applications Check this box to improve performance for Borland Delphi applications. When this option is checked, one bookmark value is assigned to each row, instead of the two that are otherwise assigned (one for fetching forwards and a different one for fetching backwards).

Delphi cannot handle multiple bookmark values for a row. If the option is unchecked, scrollable cursor performance can suffer since scrolling must always take place from the beginning of the cursor to the row requested in order to get the correct bookmark value.

Prevent Driver Not Capable errors The Adaptive Server Anywhere ODBC driver returns a
Driver not capable
error code because it does not support qualifiers. Some ODBC applications do not handle this error properly. Check this box to disable this error code, allowing such applications to work.

Delay AutoCommit until statement close Check this box if you wish the Adaptive Server Anywhere ODBC driver to delay the commit operation until a statement has been closed.

Describe cursor behavior Select how often you wish a cursor to be re-described when a procedure is executed or resumed.

Test Connection Tests if the information provided will result in a proper connection. In order for the test to work a user ID and password must have been specified.

Login tab

Use integrated login Connects using an integrated login. The User ID and password do not need to be specified. To use this type of login users must have been granted integrated login permission. The database being connected to must also be set up to accept integrated logins. Only users with DBA access can administer integrated login permissions.

For more information, see "Using integrated logins" on page 87.

User ID Provide a place for you to enter the User ID for the connection.

Password Provides a place for you to enter the password for the connection.

Encrypt password Check this box if you wish the password to be stored in encrypted form in the profile.

For more information, on User ID, Password, and Encrypt password, see the chapter "Connection and Communication Parameters" in the *Adaptive Server IQ Reference Manual*.

Database tab

Server name Provides a place for you to enter the name of the IQ server.

Start line Enter the server that should be started. Only provide a Start Line parameter if a database server is being connected to that is not currently running. For example:

```
C:\Program Files\Sybase\ASIQ12\win32\asiqsrv12.exe
-gm 10 -gp 4096 -c 8M
dbf=path\asiqdemo.db
uid=DBA pwd=SQL
```

Database name Provides a place for you to enter the name of the Adaptive Server IQ database that you wish to connect to.

Database file Provides a place for you to enter the full path and name of the Adaptive Server IQ database file on the server machine. You can also click Browse to locate the file. For example:

```
C:\Program Files\Sybase\ASIQ12\demo\asiqdemo.db
```

Automatically shut down database after last disconnect Selecting this will cause the automatic shutdown of the server after the last user has disconnected.

For more information on the parameters in the Database tab, see the EngineName, StartLine, DatabaseName, DatabaseFile, and AutoStop connection parameters in the chapter "Connection and Communication Parameters" in the *Adaptive Server IQ Reference Manual*.

Network tab

Select the network protocol and specify any protocol specific options where necessary The TCP/IP, IPX, and NetBIOS check boxes specifies what protocol or protocols the ODBC DSN will use to access a network database server. In the adjacent boxes, you may enter communication parameters that establish and tune connections from your client application to a database.

For a TCP/IP example, see "To create an ODBC User Data Source:" on page 66. For more information see the CommLinks connection parameter, and Network communications parameters, in the chapter "Connection and Communication Parameters" in the *Adaptive Server IQ Reference Manual*.

Encrypt all network packets Enables encryption of packets transmitted from the client machine over the network. By default, network encryption packets is set to OFF.

Liveness timeout A liveness packet is sent across a client/server to confirm that a connection is intact. If the client runs for the liveness timeout period without detecting a liveness packet, the communication will be severed. This parameter works only with network server and TCP/IP or IPX communications protocols. The default is 120 seconds.

Buffer size Set the maximum size of communication packets, in bytes.

Buffer space Indicates the amount of space to allocate on startup for network buffers, in kilobytes.

For more information on the Encryption, LivenessTimeout, CommBufferSize and CommBufferSpace connection parameters, see the *Adaptive Server IQ Reference Manual*.

Advanced tab

Connection name The name of the connection that is being created.

Character set The name of the character set.

Allow multiple record fetching Enables multiple records to be retrieved at one time instead of individually. By default, multiple record fetching is allowed.

Display debugging information in a log file The name of the file in which the debugging information is to be saved.

Additional connection parameters Enter any additional switches here. Parameters set throughout the remainder of this dialog take precedence over parameters typed here.

Creating a File Data Source

Data sources are stored in the system registry. File data sources are an alternative, which are stored as files. File data sources typically have the extension *.dsn*. They consist of sections, each section starting with a name enclosed in square brackets. DSN files are very similar in layout to initialization files.

Creating a file data source from the ODBC Administrator

On Windows NT systems, you can create a file data source using the following procedure.

❖ **To create an ODBC file data source:**

1. Select Settings→Control Panel, and then click the ODBC icon to start the ODBC Administrator.
2. From the File DSN tab, click Add.
3. Select Adaptive Server IQ 12 from the list of drivers, and click Next.
4. Follow the instructions to create the data source.

Creating a file data source using a text editor

A file data source is a text file, so it can be edited using any text editor. On UNIX systems you must use a text editor to create file data sources. One limitation to using a text editor is that you cannot store encrypted passwords in the file.

Example of a file data source

```
[Sample File Data Source]
 ENG = asiqdemo
 DBA = DBA
 PWD = SQL
```

Using ODBC data sources on UNIX

On UNIX operating systems, ODBC data sources are held in a file named *.odbc.ini*. When creating a *.odbc.ini* file on any UNIX system, you must use the long form of each identifier, for example:

```
[My Data Source]
EngineName=myserver
CommLinks=tcpip
UserID=DBA
Password=SQL
```

Network communications parameters are added as part of the CommLinks parameter. For a complete list, see “Connection parameters” on page 73.

References to ODBC functions are resolved at run time. The database server looks for the *.odbc.ini* file in:

1 The directory specified by the ODBCHOME environment variable

2 The directory specified by the HOME environment variables

3 The path

The database server ignores the ODBC_HOME, ODBC_INI and ODBCINI environment variables.

Note On UNIX systems, Adaptive Server IQ installation installs only the ODBC driver, and not the driver manager. The name of the driver file includes an operating system-specific extension, for example, *so* for Solaris systems. For example, on a Sun Solaris system, if you are using an ODBC application that uses *libodbc.so* (*libodbc.so.1*) or *libodbcinst.so* (*libodbcinst.so.1*), simply create symbolic links for these that point to *$SYBASE/asiq12/lib/dbodbc6.so.1*. If you are creating a custom ODBC application, you can link directly to *dbodbc6.so*.

If Adaptive Server IQ does not detect the presence of an ODBC driver manager, it will use *~/.odbc.ini* for data source information. Otherwise, it will query the driver manager for data source information.

Connection parameters

Adaptive Server IQ connection parameters are listed in the following table. For a full description of each of these connection parameters, see Chapter 3, "Connection and Communication Parameters" in the *Adaptive Server IQ Reference Manual*.

Parameter	Short form	Argument	Description
AutoPreCommit	AutoPreCommit	Yes/No	Force each statement to commit before execution
AutoStop	Astop	Yes/No	Prevent a database from being unloaded as soon as there are no more open connections. (Embedded databases)
CommAutoStop	CAstop	Yes/No	Unload network communications ports as soon as there are no more open connections from the client machine.
CommBufferSize	CBSize	Integer	Set the maximum size of communication packets, in bytes.
CommBufferSpace	CBSpace	Integer	Specify the amount of space to allocate on startup for network buffers, in kilobytes.
CommLinks	Links	String	Specify network communications links.
ConnectionName *	CON	String	Name a connection to make switching to it easier in multi-connection applications.
DatabaseFile	DBF	String	Identify a database file to load and connect to (for embedded databases).
DatabaseName	DBN	String	Identify a loaded database to which a connection needs to be made.

Parameter	Short form	Argument	Description
DatabaseSwitches	DBS	String	Provide database-specific switches when starting a database.
DataSourceName **	DSN	String	Tell the ODBC driver manager where to look in *odbc.ini* to find ODBC data source information.
Debug	DBG	Boolean	Provide diagnostic information on communications links on startup.
DisableMultiRowFetch	DMRF	Boolean	Turn off multi-record fetches across the network.
EngineName	ENG	String	Identify server to connect to
EncryptedPassword	ENP	Encrypted string	Provide a password, and store it in an encrypted fashion in a data source.
Encryption	ENC	Boolean	Encrypt packets transmitted from the client machine over the network.
EngineName / ServerName	ENG	String	Name of the database server.
FileDataSourceName	FILEDSN	String	Provide a file data source name for the connection.
Integrated	INT	Yes/No	Enable integrated logins. For a client application to use an integrated login, server must be running with LOGIN_MODE database option set to Mixed or Integrated.
LivenessTimeout	LTO	Integer	Control the termination of connections when they are no longer intact.

Parameter	Short form	Argument	Description
Logfile	LOG	String	Send client error messages and debugging messages to a file.
Password **	PWD	String	Provide a password for the connection
ServerName	ENG	String	Specify server to connect to
StartLine	Start	String	Start a database server running from an application (for embedded databases).
Unconditional	UNC	Yes/No	Stop a server even if connections are active
Userid **	UID	String	User ID with which you log on to the database

* Not supported in ODBC connections

** Verbose form of keyword not supported in DSN and FILEDSN connection parameters

Notes

- Boolean (true or false) arguments are either YES, ON, 1, or TRUE if true, or NO, OFF, 0, or FALSE if false.
- Connection parameters and their values are case insensitive.
- The connection parameters used by the interface library can be obtained from the following places (in order of precedence):
  - Connection string
  - SQLCONNECT environment variable
  - Data sources
- The server name must be composed of characters in the range 1 to 127 of the ASCII character set. There is no such limitation on other parameters. For more information on the character set issues, see “Connection strings and character sets”.
- The following rules govern the priority of parameters:

- The entries in a connection string are read left to right. If the same parameter is specified more than once, the last one in the string applies.
- If a string contains a DSN or FILEDSN entry, the profile is read from the configuration file, and the entries from the file are used if they are not already set. For example, if a connection string contains a data source name and sets some of the parameters contained in the data source explicitly, then in case of conflict the explicit parameters are used.

Connection parameter priorities

Connection parameters often provide more than one way of accomplishing a given task. This is particularly the case with embedded databases, where a database server is started by the connection string.

For example, if your connection starts a database, you can specify the database name using the DBN connection parameter or using the DBS parameter.

Here are some recommendations and notes for situations where connection parameters conflict:

- **Specify database files using DBF** You can specify a database file on the Start parameter or using the DBF parameter. DBF is recommended.
- **Specify database names using DBN** You can specify a database name on the Start parameter, the DBS parameter, or using the DBN parameter. DBN is recommended.
- **Use the Start parameter to specify cache size** Even though you use the DBF connection parameter to specify a database file, you may still want to tune the way in which it starts. You can use the Start parameter to do this.

  For example, if you are using the Java features of Adaptive Server IQ, you should provide additional cache memory for the Catalog Store on the Start parameter. The following sample set of embedded database connection parameters describes a connection that may use Java features:

  ```
  DBF=path\asademo.db
  DBN=Sample
  ENG=Sample Server
  UID=DBA
  PWD=SQL
  Start=asiqsrv12 -c 8M
  ```

How Adaptive Server IQ makes connections

This section describes how the interface libraries establish connections.

Who needs to read this section?

In many cases, establishing a connection to a database is straightforward using the information presented in the preceding sections of this chapter. However, if you are having problems establishing connections to a server, you may need to understand how Adaptive Server IQ establishes connections in order to resolve your problems.

Note If you have no problem establishing connections to your database, you do not need to read this section.

The software follows exactly the same procedure for each of the following types of client application:

- Any ODBC application using the SQLDriverConnect function, which is the common method of connection for ODBC applications. Many application development systems, such as Sybase PowerBuilder and Power++, belong to this class of application.
- Any client application using Embedded SQL and using the recommended function for connecting to a database (db_string_connect).

  The SQL CONNECT statement is available for Embedded SQL applications and in Interactive SQL. It has two forms: CONNECT AS... and CONNECT USING... . All the database administration tools, including utilities and Interactive SQL, use db_string_connect.

Steps in establishing a connection

To establish a connection to Adaptive Server IQ, the client application carries out the following steps:

1 *Locate the interface library.* The client application must locate the ODBC driver or Embedded SQL interface library.

2 *Assemble a list of connection parameters.* Connection parameters may be provided in several places, such as data sources, a connection string assembled by the application, and an environment variable. The ODBC driver or Embedded SQL interface library assembles the parameters into a single list.

3 *Locate a server.* Using the connection parameters, the ODBC driver or Embedded SQL interface library must locate a database server on your machine or over a network.

4 *Locate the database.* Once it locates the server, the ODBC driver or Embedded SQL interface library must locate the database you are connecting to.

The following sections describe each of these steps in detail.

Locating the interface library

The client application makes a call to one of the Adaptive Server IQ interface libraries. In general, the location of this DLL or shared library is transparent to the user. Here we describe how the library is located, in case of problems.

ODBC driver location

For ODBC, the interface library is also called an ODBC driver. An ODBC client application calls the ODBC driver manager, and the driver manager locates Adaptive Server IQ's driver.

The ODBC driver manager looks in the supplied data source in the *odbc.ini* file or registry to locate the driver. When you create a data source using the ODBC Administrator, Adaptive Server IQ fills in the current location for your ODBC driver.

Embedded SQL interface library location

Embedded SQL applications call the interface library by name. The name of the Adaptive Server IQ Embedded SQL interface library is as follows:

- *Windows NT: dblib6t.dll*
- *UNIX: dblib6* with an operating system-specific extension.

The locations that are searched depend on the operating system:

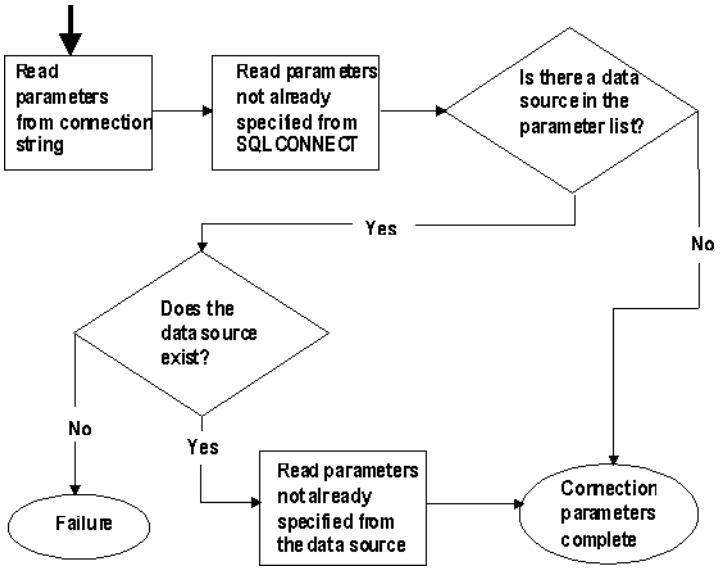
- On Windows NT, the client application looks for files in the current directory, in the system path, and in the *Windows* and *Windows\system* directories.
- On UNIX, the client application looks for files in the system path and the user path.

When the library is located

Once it locates the interface library, the client application passes a connection string to it. The interface library uses the connection string to assemble a list of connection parameters, which it uses to establish a connection to a server.

Assembling a list of connection parameters

The following figure illustrates how the interface libraries assemble the list of connection parameters they will use to establish a connection.



Notes

Key points from the figure are as follows:

- *Precedence* — Parameters held in more than one place are subject to the following order of precedence:

  ```
  Connection string > SQLCONNECT > profile
  ```

  That is, if a parameter is supplied both in a data source and in a connection string, the connection string value overrides the data source value.

- *Failure* — Failure at this stage occurs only if you specify in the connection string or in SQLCONNECT a data source that does not exist in the client connection file.

- *Common parameters* — Depending on other connections already in use, some connection parameters may be ignored. These include the following:

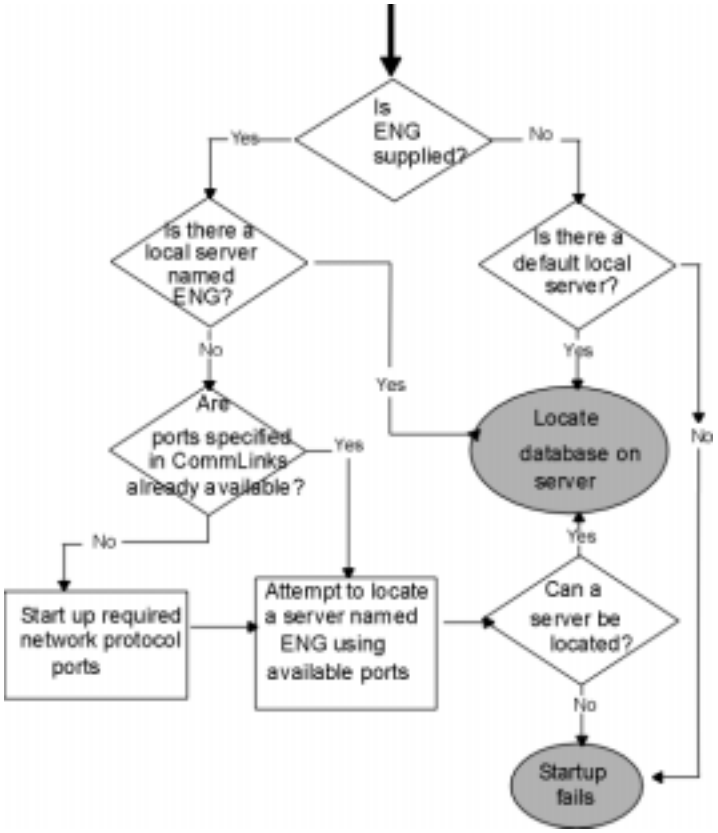
  - AutoStop Ignored if the database is already loaded.
  - CommLinks The specifications for a network protocol are ignored if another connection has already set parameters for that protocol.
  - CommBufferSize Ignored if another connection has already set this parameter.

- CommBufferSpace Ignored if another connection has already set this parameter.
- Unconditional Ignored if the database is already loaded or if the server is already running.

The interface library uses the completed list of connection parameters to attempt to connect.

Locating a server

The next step in establishing a connection is to attempt to locate a server. If the connection parameter list includes a server name (ENG parameter), the interface library carries out a search first for a database server of that name, followed by a search over a network. If no ENG parameter is supplied, the interface library looks for a default server.



If the interfaces library locates a server, it tries to locate or load the required database on that server. For information, see “Locating the database” on page 83.

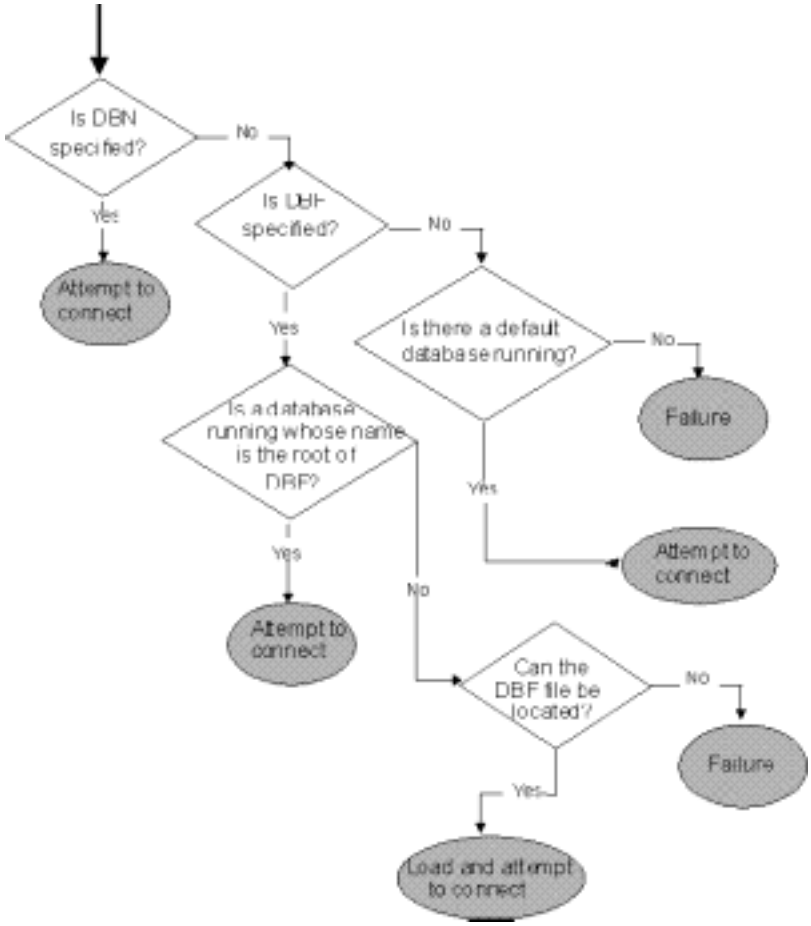
Notes

- For local connections, locating a server is simple. For connections over a network, you can use the CommLinks parameter to tune the search in many ways by supplying network communication parameters.

- The network search involves a search over one or more of the protocols that Adaptive Server IQ supports. For each protocol, the network library starts a single **port**. All connections over that protocol at any one time use a single port.
- You can specify a set of network communication parameters for each network port in the argument to the CommLinks parameter. Since these parameters are used only when the port first starts, the interface library ignores any connection parameters specified in CommLinks for a part already started.
- Each attempt to locate a server (the local attempt and the attempt for each network port) involves two steps. First, the interfaces library looks in the server name cache to see if a server of that name is available. Second, it uses the available connection parameters to attempt a connection.
- The default server is the first one started on a machine. This server gains use of the shared memory port.

Locating the database

If the interfaces library successfully locate a server, it then tries to locate the database. For example:



Notes

- If you rely on the DBF parameter, the DBF path must either be an absolute path, or relative to where the server was started, in order for Adaptive Server IQ to find the database it specifies. For example, if you specify *../foo/asiqdemo*, it looks in the directory above where the server is, and then in *foo*.
- The default database is the one started with the server.

Server name caching for faster connections

The network library looks for a database server on a network by broadcasting over the network using the CommLinks connection parameter.

Tuning the broadcast

The CommLinks parameter takes as argument a string that lists the protocols to use and, optionally for each protocol, a variety of network communication parameters that tune the broadcast.

For a complete listing of network communications parameters, see Chapter 3, "Connection and Communication Parameters" in the *Adaptive Server IQ Reference Manual*.

Caching server information

Broadcasting over large networks to search for a server of a specific name can be time-consuming. To speed up network connections (except for the first connection to a server), when a server is located, the protocol it was found on and its address are saved to a file.

The server information is saved in a file named *asasrv.ini*, in your Adaptive Server IQ executable directory. The file contains a set of sections, each of the following form:

```
[Server name]
Link=protocol_name
Address=address_string
```

How the cache is used

When a connection specifies a server name, and a server with that name is not found, the network library looks first in the server name cache to see if the server is known. If there is an entry for the server name, an attempt is made to connect using the link and address in the cache. If the server is located using this method, the connection is much faster, as no broadcast is involved.

If the server is not located using cached information, the connection string information and CommLinks parameter are used to search for the server using a broadcast. If the broadcast is successful, the server name entry in the named cache is overwritten.

Note If a server name is held in the cache, the cache entry is used before the CommLinks string.

Interactive SQL connections

The Interactive SQL (DBISQL) utility has a different behavior from the default Embedded SQL behavior when a CONNECT statement is issued while already connected to a database. If no database or server is specified in the CONNECT statement, Interactive SQL connects to the current database, rather than to the default database. This behavior is required for database restarting operations.

For an example, see "CONNECT statement" in the *Adaptive Server IQ Reference Manual*.

Connecting from other databases

You can access data in Adaptive Server IQ tables as a foreign data source from Adaptive Server Enterprise. To take advantage of this feature, you use the Component Integration Services (CIS) interface, which makes data from distributed, heterogeneous sources available to clients.

With CIS in place, you define "proxy tables" in Adaptive Server Enterprise that represent your Adaptive Server IQ tables. You can then query the proxy tables from Adaptive Server Enterprise. For details, see *Component Integration Services User's Guide for Adaptive Server Enterprise and OmniConnect*.

CIS and Adaptive Server IQ offer several other ways for you to connect to other databases and share data, so that user applications can access your entire data warehouse through a common interface. Using CIS, you can:

- Access data in an Adaptive Server Enterprise database.
- Access data in Adaptive Server IQ and Adaptive Server Anywhere databases on other database servers.
- Access other foreign data sources, including other vendors' relational databases, Excel spreadsheet data, and text files.
- Join tables in separate Adaptive Server IQ databases.

Note Use of these features is currently supported on Windows NT systems only.

Using an integrated login

The integrated login feature allows you to maintain a single user ID and password for both database connections and operating system and/or network logins. This section describes the integrated login feature.

Operating systems supported

Integrated login capabilities are available for the Windows NT server only. It is possible for Windows 95, Windows 98, and Windows NT clients to use integrated logins to connect to a network server running on Windows NT.

Benefits of an integrated login

An integrated login is a mapping from one or more Windows NT user profiles to an existing user in a database. A user who has successfully navigated the security for that user profile and logged in to their machine can connect to a database without providing an additional user ID or password.

To accomplish this, the database must be enabled to use integrated logins and a mapping must have been granted between the user profile used to log in to the machine and/or network, and a database user.

Using an integrated login is more convenient for the user and permits a single security system for database and network security. Its advantages include:

- When connecting to a database using an integrated login, the user does not need to enter a user ID or password.
- If you use an integrated login, the user authentication is done by the operating system, not the database: a single system is used for database security and machine or network security.
- Multiple user profiles can be mapped to a single database user ID.
- The name and password used to log in to the Windows NT machine do not have to match the database user ID and password.

Warning! Integrated logins offer the convenience of a single security system but there are important security implications which database administrators should be familiar with.

For more information about security and integrated logins, see “Security concerns: unrestricted database access”.

Using integrated logins

Several steps must be implemented in order to connect successfully via an integrated login.

❖ **To use an integrated login:**

1 Enable the integrated login feature in a database by setting the value of the LOGIN_MODE database option to either Mixed or Integrated (the option is case insensitive), in place of the default value of Standard. This step requires DBA authority).

2 Create an integrated login mapping between a user profile and an existing database user. This can be done using a SQL statement.

3 Connect from a client application in such a way that the integrated login facility is triggered.

Each of these steps is described in the sections below.

Enabling the integrated login feature

The LOGIN_MODE database option determines whether the integrated login feature is enabled. As database options apply only to the database in which they are found, different databases can have a different integrated login setting even if they are loaded and running within the same server.

The LOGIN_MODE database option accepts one of following three values (which are case insensitive).

- **Standard** This is the default setting, which does not permit integrated logins. An error occurs if an integrated login connection is attempted.
- **Mixed** With this setting, both integrated logins and standard logins are allowed.
- **Integrated** With this setting, all logins to the database must be made using integrated logins.

Warning! Setting the LOGIN_MODE database option to Integrated restricts connections to only those users who have been granted an integrated login mapping. Attempting to connect using a user ID and password generates an error. The only exception to this are users with DBA authority (full administrative rights).

Example

The following SQL statement sets the value of the LOGIN_MODE database option to Mixed, allowing both standard and integrated login connections:

```
SET OPTION "PUBLIC".LOGIN_MODE = Mixed
```

Creating an integrated login

User profiles can only be mapped to an existing database user ID. When that database user ID is removed from the database, all integrated login mappings based on that database user ID are automatically removed.

A user profile does not have to exist for it to be mapped to a database user ID. More than one user profile can be mapped to the same user ID.

Only users with DBA authority are able to create or remove an integrated login mapping.

An integrated login mapping is made either using a wizard in Sybase Central or a SQL statement.

❖ **To map an integrated login from Sybase Central:**

1 Connect to a database as a user with DBA authority.

2 Open the Integrated Logins folder for the database, and double-click Add Integrated Login. The Integrated Login wizard is displayed.

3 On the first page of the wizard, enter the name of the system (computer) user for whom the integrated login is to be created. You can either select a name from the list or enter a name.

Also, select the database user ID this user maps to. The wizard displays the available database users. You must select one of these. You cannot add a new database user ID.

4 Follow the remaining instructions in the Wizard.

❖ **To map an integrate login using a SQL statement:**

- The following SQL statement allows Window NT users dmelanso and bhay to log in to the database as the user DBA, without having to know or provide the DBA user ID or password.

```
GRANT INTEGRATED LOGIN
TO dmelanso, bhay
AS USER DBA
```

Connecting from a client application

A client application can connect to a database using an integrated login in one of the following ways:

- Set the INTEGRATED parameter in the list of connection parameters to yes.
- Specify neither a user ID nor a password in the connection string or connection dialog. This method is available only for Embedded SQL applications, including the Adaptive Server IQ administration utilities.

If INTEGRATED=yes is specified in the connection string, an integrated login is attempted. If the connection attempt fails and the LOGIN_MODE database option is set to Mixed, the server attempts a standard login.

If an attempt to connect to a database is made without providing a user ID or password, an integrated login is attempted. The attempt succeeds or fails depending on whether the current user profile name matches a integrated login mapping in the database.

Interactive SQL Examples

For example, a connection attempt using the following Interactive SQL statement will succeed, providing the user has logged on with a user profile name that matches a integrated login mapping in a default database of a server:

```
CONNECT USING 'INTEGRATED=yes'
```

The following DBISQL statement.

```
CONNECT
```

can connect to a database if all the following are true:

- A server is currently running.
- The default database on the current server is enabled to accept integrated login connections.
- An integrated login mapping has been created that matches the current user's user profile name.
- If the user is prompted with a dialog box by the server for more connection information (such as occurs when using the DBISQL utility), the user clicks OK *without* providing more information.

Integrated logins via ODBC

A client application connecting to a database via ODBC can use an integrated login by including the Integrated parameter among other attributes in its Data Source configuration.

Setting the attribute 'Integrated=yes' in an ODBC data source causes database connection attempts using that DSN to attempt an integrated login. If the LOGIN_MODE database option is set to Standard, the ODBC driver prompts the user for a database user ID and password.

Security concerns: unrestricted database access

The integrated login features works by using the login control system of Windows NT in place of the system Adaptive Server IQ uses to control access to the database. Essentially, you pass through the database security if you can log in to the machine hosting the database, and if other conditions outlined in this chapter are met.

If you successfully log in to the Windows NT server as “dsmith”, you can connect to the database without any further proof of identification provided there is either an integrated login mapping or a default integrated login user ID.

When using integrated logins, database administrators should give special consideration to the way Windows NT enforces login security in order to prevent unwanted access to the database.

In particular, be aware that by default a "Guest" user profile is created and enabled when Windows NT Workstation or Server is installed.

Warning! Leaving the user profile Guest enabled can permit unrestricted access to a database being hosted by that server.

If the Guest user profile is enabled and has a blank password, any attempt to log in to the server will be successful. It is not required that a user profile exist on the server, or that the login ID provided have domain login permissions. Literally any user can log in to the server using any login ID and any password: they are logged in by default to the Guest user profile.

This has important implications for connecting to a database with the integrated login feature enabled.

Consider the following scenario, which assumes the Windows NT server hosting a database has a "Guest" user profile that is enabled with a blank password.

- An integrated login mapping exists between the user `dsmith` and the database user ID `DBA`. When the user `dsmith` connects to the server with her correct login ID and password, she connects to the database as `DBA`, a user with full administrative rights.
- But anyone else attempting to connect to the server as "dsmith" will successfully log in to the server regardless of the password they provide because Windows NT will default that connection attempt to the "Guest" user profile. Having successfully logged in to the server using the "dsmith" login ID, the unauthorized user successfully connects to the database as `DBA` using the integrated login mapping.

Note *Disable the "Guest" user profile for security.* The safest integrated login policy is to disable "Guest" on any Windows NT machine hosting an Adaptive Server IQ database This can be done using the Windows NT User Manager utility.

Setting temporary public options for added security

Setting the value of the LOGIN_MODE option for a given database to Mixed or Integrated using the following SQL statement permanently enables integrated logins for that database.

```
SET OPTION Public.LOGIN_MODE = Mixed
```

If the database is shut down and restarted, the option value remains the same and integrated logins are still enabled.

Changing the LOGIN_MODE option temporarily will still allow user access via integrated logins. The following statement will change the option value temporarily:

```
SET TEMPORARY OPTION "Public".LOGIN_MODE = Mixed
```

If the permanent option value is Standard, the database will revert to that value when it is shut down.

Setting temporary public options can be considered an additional security measure for database access since enabling integrated logins means that the database is relying on the security of the operating system on which it is running. If the database is shut down and copied to another machine (such as a user's machine) access to the database reverts to the Adaptive Server Anywhere security model and not the security model of the operating system of the machine where the database has been copied.

For more information on using the SET OPTION statement see Chapter 9, "SQL Statements" in *Adaptive Server IQ Reference Manual*.

Network aspects of integrated logins

If the database is located on a network server, then one of two conditions must be met for integrated logins to be used:

- The user profile used for the integrated login connection attempt must exist on both the local machine and the server. As well as having identical user profile names on both machines, the passwords for both user profiles must also be identical.

  For example, when the user jsmith attempts to connect using an integrated login to a database loaded on network server, identical user profile names and passwords must exist on both the local machine and application server hosting the database. jsmith must be permitted to log in to both the local machine and the server hosting the network server.

- If network access is controlled by a Microsoft Domain, the user attempting an integrated login must have domain permissions with the Domain Controller server and be logged in to the network. A user profile on the network server matching the user profile on the local machine is not required.

Creating a default integrated login user

A default integrated login user ID can be created so that connecting via an integrated login will be successful even if no integrated login mapping exists for the user profile currently in use.

For example, if no integrated login mapping exists for the user profile name JSMITH, an integrated login connection attempt will normally fail when JSMITH is the user profile in use.

However, if you create a user ID named Guest in a database, an integrated login will successfully map to the Guest user ID if no integrated login mapping explicitly identifies the user profile JSMITH.

The default integrated login user permits anyone attempting an integrated login to successfully connect to a database if the database contains a user ID named Guest. The permissions and authorities granted to the newly-connected user are determined by the authorities granted to the Guest user ID.

Troubleshooting startup, shutdown, and connections

See the sections that follow for help in resolving problems with your database server, connections, and DBISQL. For other troubleshooting hints, see the *Adaptive Server IQ Troubleshooting and Error Messages Guide*.

What to do if you can't start Adaptive Server IQ

This section describes some common problems when starting the database server.

Ensure that your files are valid

The server will not start if the existing transaction log is invalid. For example, during development, you may replace a database file with a new version, without deleting the transaction log at the same time. This causes the transaction log file to be different from the database, and results in an invalid transaction log file.

The same is true for the IQ Temporary Store file.

Ensure that you have sufficient disk space for your temporary file

Adaptive Server IQ uses a temporary file to store information while running. This file is stored in the directory pointed to by the TMP or TEMP environment variable, or the ASTMP environment variable on UNIX. On Windows NT, this directory is typically *c:\temp*. On UNIX, if more than one database server is running on the same machine, each user needs a separate temporary directory; typically this directory is set to */tmp/.userid*.

If you do not have sufficient disk space available to the temporary directory, you will have problems starting the server.

Ensure that network communication software is running

Appropriate network communication software must be installed and running before you run the database server. If you are running reliable network software with just one network installed, this should be straightforward. If you experience problems, if you are running non-standard software, or if you are running multiple networks, read the discussion of network communication issues in the *Adaptive Server IQ Installation and Configuration Guide*. You should also refer to your network vendor's documentation.

You should confirm that other software that requires network communications is working properly before running the database server.

For example, if you are running under the TCP/IP protocol, you may want to confirm that ping and telnet are working properly. The ping and telnet applications are provided with many TCP/IP protocol stacks.

If you are using NetBIOS under Windows NT you may want to confirm that the *chat* or *winpopup* application is working properly between machines running client and database server software.

Check environment variables

In order to start the server, certain environment variables must be set properly. On Windows NT, the installation procedure sets any environment variables you need automatically. On UNIX, you must set these variables. While it is unlikely for these settings to change, you should check to be sure they are correct if you are unable to start the server. See Chapter 1, "File Locations and Installation Settings" in *Adaptive Server IQ Reference Manual* for information on environment variable settings.

Debugging network communications startup problems

If you are having problems establishing a connection across a network, you can use debugging options at both client and server to diagnose problems. On the server, you use the -z command-line option. The startup information appears on the server window (or the server log, if you start the server with start_asiq). You can use the -o *filename* option to log the results to an output file if you start the server with asiqsrv12.

What to do if you can't connect to a database

If you are unable to connect to an Adaptive Server IQ database, check the items described below.

- Check that you have entered your data source name correctly, or that you have selected the correct server name for a JDBC connection.
- Check that your data source (DSN or FILEDSN) contains the correct server name, database, network parameters, and any other connection information you expect.
  - On Windows NT, select Settings→Control Panel → ODBC Administrator, then select the User DSN tab and select the source name for the server you want.
  - On UNIX, check your *.odbc.ini* file
- Check that the database server you want is running.
  - On Windows NT, select Settings→Control Panel → ODBC to open the ODBC Administrator, then select the User DSN tab, highlight the source name for the server you want, and click Configure→Test Connection. If that server is running, you see a Connection Successful message.
  - On UNIX, enter the following at the system prompt, substituting the name of your database server for *asiqdemo*:

    ```
    ps -eaf | grep asiqdemo
    ```
- Check that any connection parameters you enter on the command line are correct.
- If you are connecting to a database that is not running, check that the server was started with the -gd ALL switch. If not, then only the DBA can start databases on that server, by first connecting to the utility_db database and then issuing a START DATABASE command for the desired database.
- Check that you have permission to use the database for the requested operation. The DBA or database owner must grant you CONNECT permission; see "Managing individual user IDs and permissions".
- If you are having problems establishing a connection across a network, you can use debugging options at both client and server to diagnose problems. On the server, you use the -z command-line option. The startup information appears on the server window: you can use the -o option to log the results to an output file.

- Check that all of the files exist for the database you have requested. At a minimum, there must be an IQ Store (*dbname.iq*), a Catalog Store (*dbname.db*), an IQ Temporary Store (*dbname.iqtmp*), a transaction log (*dbname.log* This may be missing if the database is newly created and has not been modified.), and a message file (*dbname.iqmsg*). The names shown here in parentheses are the default format; yours may be different.
- Check that any restores have completed successfully.

See also “How Adaptive Server IQ makes connections”.

Stopping a database server in an emergency (UNIX)

Always try first to stop the server using the methods described in “Stopping the database server”. If you are unable to stop it using those methods, and if you started the database server as a batch or background process (using start_asiq), try the following:

1 If possible, you should make sure that no users are connected to the database.

2 At the UNIX prompt, enter the following command:

```
kill -hup pid
```

where *pid* is the process id of the database server you are stopping.

See also *Adaptive Server IQ Troubleshooting and Error Messages Guide*.

Resolving problems with your DBISQL window on UNIX

The interactive DBISQL utility on UNIX uses character-based windows. These windows rely on line-drawing characters that are part of the ASCII character set, and some other character sets as well. The ability of DBISQL to display these windows correctly depends on the type of terminal you use, and the character set translation your operating system uses. If your windows appear to be drawn with accented characters rather than line-draw characters, you can still use them to enter commands and receive output as described throughout this book.

DBISQL uses function keys for many operations. Some UNIX windowing environments may not support these function keys, unless you make some adjustments.

For help in improving the appearance of DBISQL windows, or if you are unable to use function keys in DBISQL, see the Chapter 6, “Getting Started with DBISQL” in *Introduction to Adaptive Server IQ*.

CHAPTER 3

Working with Database Objects

About this chapter

This chapter describes the mechanics of creating, altering, and deleting database objects such as tables, views, and indexes. The SQL statements for carrying out these tasks are called the **Data Definition Language** (DDL).

The definitions of the database objects form the database schema. You can think of the schema as an empty database.

Procedures are also database objects, but are discussed in Chapter 6, “Using Procedures and Batches”

Note Remember that Adaptive Server IQ consists of both a Catalog Store and an IQ Store. This chapter explains how you create both stores, and the objects in your IQ Store. Tables created in the Catalog Store have the characteristics of Adaptive Server Anywhere tables. If you want to create tables in the Catalog Store, you need to refer to the Adaptive Server Anywhere documentation.

Building Your Adaptive Server IQ Databases

This section introduces you to the steps involved in creating a database, and the tools you use. It also explains decisions you need to make about where to store the data, how much space it will require, and who will be able to define or modify database objects.

Designing your database

It's important to design your database before you actually create it. The right database design can make a major difference in the usefulness of your data, and the speed with which you can retrieve it.

Sybase WarehouseArchitect helps you design your database. WarehouseArchitect is a component of Sybase Warehouse Studio, an integrated platform for designing and managing a data warehouse.

No matter what design tool you use, it is generally the database administrator (DBA) who designs the database and defines its contents. To create an effective design, the DBA needs to work with individuals throughout your organization to understand how data will be used. The DBA also needs to understand the concepts underlying IQ databases.

An Adaptive Server IQ database is a *relational database* that is optimized for use as a *data warehouse*. As a relational database, it consists of a set of related tables that organize the data; as a data warehouse, it provides efficient access to very large sets of data by means of indexes.

When you create a database, you specify the structure of these tables, the types of data allowed in them, the relationships among tables, the indexes that store the table data, and views that control who has access to the data. Before using the procedures in this chapter to create an IQ database, be sure you understand the relational database and data warehousing concepts described in *Introduction to Adaptive Server IQ*.

Tools for working with database objects

Adaptive Server IQ includes two utilities for working with database objects: Sybase Central and DBISQL. In addition, Warehouse Architect can be used for designing and creating whole data warehouses.

Using Sybase Central to work with database objects

Sybase Central is the primary tool for working with database objects on windowing systems. You can use Sybase Central to create, modify, and delete all kinds of database objects, including tables, procedures, views, indexes, users and groups.

If you use the Adaptive Server IQ multiplex feature, Sybase strongly recommends that you use Sybase Central to create and modify database objects. In a multiplex, Sybase Central is important for creating databases and dbspaces and for starting up and shutting down databases. DML and DDL statements are the same for multiplex and non-multiplex Adaptive Server IQ databases, except that the DDL must be in simplex mode. For more information about the multiplex feature, see *Adaptive Server IQ Multiplex User's Guide*.

This chapter is concerned with the SQL statements for working with database objects. If you are using Sybase Central, these SQL statements are generated for you. The primary source of information about Sybase Central is the Sybase Central online Help. This chapter gives only brief pointers for tasks that you can carry out using Sybase Central.

For an introduction to using Sybase Central, see "Managing Databases with Sybase Central" in *Introduction to Adaptive Server IQ*.

Using DBISQL to work with database objects

Interactive SQL (DBISQL) is a utility for entering SQL statements. If you are using DBISQL to work with your database schema, instead of executing the SQL statements one at a time, build up the set of commands in a DBISQL command file. Then you can execute this file in DBISQL to build the database.

If you use a tool other than DBISQL, all the information in this chapter concerning SQL statements still applies.

DBISQL command file

A DBISQL command file is a text file with semicolons placed at the end of commands as shown below.

```
CREATE TABLE t1 ( .. );
CREATE TABLE t2 ( .. );
CREATE LF INDEX i2 ON t2 ( .. );
..
```

A DBISQL command file usually carries the extension *.sql*. To execute a command file, either paste the contents of the file into the DBISQL command window (if the file has less than 500 lines) or enter a command that reads the file into the command window. For example, the command:

```
read makedb
```

reads the DBISQL commands in the file *makedb.sql*.

For more information about reading a file into the command window, see the READ statement in the *Adaptive Server IQ Reference Manual*.

A step-by-step overview of database setup

Creating an IQ database is part of a larger setup process that begins with installation and ends when your database is available to users. This section summarizes the steps in setting up an IQ database and the objects in it.

Multiplex users: The following steps are for creating a *non-multiplex* database. To create a multiplex database, see the *Adaptive Server IQ Multiplex User's Guide*.

❖ **To set up an IQ database:**

1 Install and configure Adaptive Server IQ.

This step creates the database server and the asiqdemo database, and allows you to create your first database when you have no other database to connect to. See the *Adaptive Server IQ Installation and Configuration Guide* for your platform for details.

2 Create an IQ database.

This step creates both the IQ Store and the Catalog Store. Use the CREATE DATABASE statement or the Sybase Central Create Database Wizard. See "Working with databases" on page 106.

3 Create the tables in your IQ database.

Use the CREATE TABLE statement or the Sybase Central table editor. See "Working with tables" on page 118

4 Create indexes for the tables.

Use the CREATE INDEX statement or the Sybase Central Index Wizard. You can also create certain indexes automatically when you create your tables. See Chapter 4, "Adaptive Server IQ Indexes."

5 Load data into the tables.

Use the LOAD TABLE statement to bulk load data from files, or use the INSERT statement to extract rows of data from an existing database. See Chapter 5, "Moving Data In and Out of Databases.".

6 Create join indexes as needed, to improve performance of queries that join data from multiple tables.

To create a join index, use the CREATE JOIN INDEX statement, or the Sybase Central Add JoinIndex Wizard. See Chapter 4, "Adaptive Server IQ Indexes."

Scheduling data definition tasks

Once the database exists and other users have access to it, follow these guidelines when you need to perform additional data definition operations, such as adding or modifying tables or indexes.

You will probably want to schedule data definition operations for times when database usage is low. All other users are blocked from reading or writing to a table while you are creating or altering that table, although for a brief time only. If the table is part of a join index, users cannot read or write to any of the tables in the join index until the data definition operation is complete. For more information on concurrency rules during data definition, see "Locks for DDL operations".

When you are ready to perform data definition tasks:

1 Make sure that all users disconnect from the database.

2 Back up the database, as described in Chapter 11, "Backup and Data Recovery".

3 Do the data definition task.

Note For a multiplex database, you must perform the data definition task on the write server in simplex mode, and then shut it down and bring it up in multiplex mode before backing up the database. See the *Adaptive Server IQ Multiplex User's Guide* for details before data definition.

4 Back up the database again.

5 Allow users to connect to the database.

Extending data definition privileges

In order to perform data definition tasks, you must have the appropriate authority.

- With *DBA authority*, you can perform all data definition tasks. You also can grant authority to other users to perform specific tasks. This includes the ability to grant DBA authority to other users.
- To create any database object, you need *resource authority* for that type of object.
- When you create an object you become its *owner*. The owner of an object automatically has authority to perform all operations on that object, and to grant other users authority to update the information in a table.

The DBA and object owners can grant authority to individual users and to groups of users. For complete information, see Chapter 10, “Managing User IDs and Permissions” You can also use the -gu command-line option to set the permission level required to create or delete a database.

Selecting a device type

You store databases and database objects on devices. On all platforms, these devices can be operating system files. They can also be portions of a disk, called raw partitions. When you create a database, Adaptive Server IQ determines automatically whether it is a raw partition or a disk file.

In a production environment, raw partition installations may provide increased processing performance and better recovery capabilities. File systems, on the other hand, make it easier to manage your devices, and may be preferable in a development environment.

Note The Catalog Store and the transaction log cannot be on a raw partition.

Allocating space for databases

All Adaptive Server IQ databases are preallocated, whether they reside in a file system or a raw partition.

Each database includes multiple **dbspaces**. A dbspace is a logical name for a database file. The Catalog Store, the IQ Store, and the Temporary Store all consist of dbspaces. The first dbspace for each store is created automatically when you create the database. You can create additional dbspaces as needed.

When you create and load a table, Adaptive Server IQ distributes the data among all existing dbspaces in that store with any room available. You cannot control how data is distributed among the dbspaces within a store. Once an IQ dbspace is full, you cannot extend it, and you cannot redistribute the data it holds to other dbspaces. You also cannot make dbspaces smaller once you create them.

When to create dbspaces

When possible, create all dbspaces when you create the database, rather than adding them gradually as old ones become full. This approach ensures that your dbspaces will be filled more evenly, and thus helps improve disk I/O.

Space requirements for IQ Stores

The amount of data, and the number and types of indexes you create, determine how much space you need in your IQ database. If you run out of space when loading or inserting into a database, Adaptive Server IQ prompts you to create another dbspace, and then continues the operation after you add the dbspace.

Space requirements for Temporary Stores

In addition to any temporary tables you define explicitly, Adaptive Server IQ uses the Temporary Store as a temporary result space for sorts, hashes, and bitmaps during loads and deletions. The types of queries issued, the degree of concurrent use, and the size of your data, all determine how much space you need for your Temporary Store.

Estimating space and dbspaces required

To avoid difficulties when a database or a particular dbspace is full, you should estimate the amount of space and dbspaces you need before you create the database and the objects in it. Adaptive Server IQ provides stored procedures that you can run to estimate how much space and how many dbspaces your databases will require. See the *Adaptive Server IQ Reference Manual* for syntax and usage notes for each procedure.

Running the procedures in the sequence that follows can help you avoid running out of space for your objects.

1 Run the stored procedure sp_iqestspace to estimate the amount of space you will need to create a database, based on the number of rows in the underlying database tables. Run the procedure once for each table that you plan to create, as follows:

```
sp_iqestspace table_name, rows[, iqpagesize]
```

The amount of space needed by each table is returned as “RAW DATA index_size”.

2 Add totals under “RAW DATA index_size” for all tables together.

3 Run the stored procedure sp_iqestjoin to estimate the amount of additional space required to create join indexes on tables that you want to join frequently. Run the procedure once for each pair of tables, as follows:

```
sp_iqestjoin table1, table1rows, table2, table2rows
  [,relation] [,iqpagesize] ...
```

sp_iqestjoin suggests different index sizes depending on your queries.

Each time you run sp_iqestjoin, select one of the suggested index sizes. If you know you will always join the tables with exact one-to-one matches, use the "Min Case index_size". If you anticipate occasional one-to-many joins, use the "Avg Case index_size". If you anticipate using numerous one-to-many joins, use the "Max Case index_size".

4 Total the index_sizes you selected for all table pairs.

5 Add the join space total from step number 4 to the table space total from step number 2, doing a separate calculation for minimum and maximum join space.

6 Run the stored procedure sp_iqestdbspaces to determine how many dbspaces to create from the given space and what size they should be. Use the minimum and maximum total index sizes calculated in step number 5 as the *minsize* and *maxsize* parameters for this procedure, as follows:

```
sp_iqestdbspaces (dbsize [,iqpagesize]
  [,minsize] [,maxsize] ...
```

All these calculations are estimates. Results vary based on the columns and indexes you create for your database. For more information on these stored procedures, see the *Adaptive Server IQ Reference Manual*.

Working with databases

Some application design systems, such as Sybase WarehouseArchitect, contain facilities for creating database objects. These tools construct SQL statements that are submitted to the server, typically through its ODBC interface. If you are using one of these tools, you do not need to construct SQL statements to create tables, assign permissions, and so on.

This chapter describes the SQL statements for defining database objects. You can use these statements directly if you are building your database from an interactive SQL tool, such as DBISQL. Even if you are using an application design tool, you may want to use SQL statements to add features to the database if they are not supported by the design tool.

For more advanced use, database design tools such as Sybase Warehouse Architect provide a more thorough and reliable approach to developing well-designed databases.

Creating a database

When you create a database, the database server creates the following four dbspaces:

dbspace name	*Contents*	*Default operating system file name*
IQ_SYSTEM_MAIN	Main (permanent) IQ Store file	*dbname.iq*
IQ_SYSTEM_TEMP	Temporary IQ Store file	*dbname.iqtmp*
IQ_SYSTEM_MSG	Message log file	*dbname.iqmsg*
SYSTEM	Catalog Store file	*dbname.db*

The SYSTEM dbspace contains the system tables, which hold the schema definition as you build your database. It also holds a separate checkpoint log, rollback log, and optionally a write file, transaction log, and transaction log mirror, for the Catalog Store.

Note In addition to these database files, the database server also uses a temporary file to hold information needed during a session. This temporary file is not the same as the Temporary IQ Store, and is not needed once the database server shuts down. The file has a server-generated name with the extension *.tmp*. Its location is determined by the TEMP environment variable, or the ASTMP environment variable on UNIX.

You create a database using either the CREATE DATABASE statement or Sybase Central. Once the database is created, you can connect to it and build the tables and other objects that you need in the database.

Before you create your database

In order to create a database, you must:

- Start the database server
- Start either Sybase Central or DBISQL

To create a database in DBISQL, you need to connect to an existing database, or else start the **utility database**, a phantom database with no database files and no data. You must start the utility database before creating new databases if no databases are built yet. For information on the utility database and its security, see the *Adaptive Server IQ Installation and Configuration Guide*.

If you are creating an IQ database for the first time, see the *Introduction to Adaptive Server IQ* for assistance.

Locating and moving database files

When you create a database, you specify its location. Before you do so, consider whether you will ever need to move the database.

In order to move a database, it is crucial that you have *all* of the files you need, that they be in a consistent state when you move them, and that *no* users are connected to the database. Because it is difficult to achieve these conditions, you should avoid copying a database unless absolutely necessary. Instead, if you must move a database, use the BACKUP command to make a full backup, and then use the RESTORE command with the RENAME option to restore the backup. See Chapter 11, "Backup and Data Recovery" for more information.

Warning! The database file and the transaction log file must be located on the same physical machine as the database server. Locating database files and transaction log files on a network drive can lead to poor performance and data corruption.

If your IQ requirements are large and complex enough that you need multiple physical systems, consider using the Adaptive Server IQ Multiplex feature. See the *Adaptive Server IQ Multiplex User's Guide* for details.

Database file compatibility

Adaptive Server IQ servers cannot manage databases created with versions prior to Adaptive Server IQ 12.0; likewise, old servers cannot manage new databases.

Using Sybase Central to create an IQ database

To create an IQ database in Sybase Central, click the Utilities folder in the left panel, then double-click Create Database in the right panel to start the Create Database Wizard. The Create Database Wizard leads you through the process. If you need more information, see "Managing Databases with Sybase Central" in the *Introduction to Adaptive Server IQ*, or see the Sybase Central online help.

Using Sybase Central to create a multiplex IQ database

To create a multiplex IQ database in Sybase Central, you use the Create Multiplex Wizard. Be sure that you have set up the multiplex environment correctly before running Create Multiplex. See the *Adaptive Server IQ Multiplex User's Guide* for instructions.

Using the CREATE DATABASE statement

You can use the CREATE DATABASE statement to create IQ databases. You must specify the filename for Catalog Store and the IQ PATH. All other parameters are optional. If you use all of the defaults, your database has these characteristics:

- Case sensitive (CASE RESPECT).'ABC' compares NOT EQUAL to 'abc'. Note that the default login is now user ID DBA and password SQL (uppercase). Passwords are case sensitive for a case-sensitive database, and case-insensitive for a case-insensitive database. Usernames are always case insensitive.
- Catalog page size of 2048 bytes (PAGE SIZE 2048).
- When comparing two character strings of unequal length, IQ treats the shorter one as if it were padded with blanks to the length of the longer one, so that 'abc' compares equal to 'abc' (BLANK PADDING ON).
- Incompatible with Adaptive Server Enterprise.
- IQ page size is 64KB (IQ PAGE SIZE 65536).
- IQ message file and IQ Temporary Store are in the same directory as the Catalog Store. See also "Using relative pathnames".
- For a raw device, IQ SIZE and TEMPORARY SIZE are the maximum size of the raw partition. For operating system files, see the discussion of this parameter below.
- IQ Temporary Store size is half the IQ size.
- jConnect JDBC driver is enabled (JCONNECT ON).
- The collation sequence ISO_BINENG is used. The collation order is the same as the order of characters in the ASCII character set. In a case-sensitive database, all uppercase letters precede all lowercase letters (for example, both 'A' and 'B' precede 'a').
- Java is enabled (JAVA ON).

Note Either CREATE DATABASE commands must include CASE IGNORE, or else connections to newly created databases must be made with case-sensitive userid/password combinations.

For a full description of all parameters, see the CREATE DATABASE statement in the *Adaptive Server IQ Reference Manual*. Following are several examples of creating an IQ database.

Using relative pathnames

You can create a database using a relative or fully qualified pathname for each of the files for the database. Sybase recommends that you create databases with relative pathnames.

If your database is on UNIX, you can define a symbolic link for each pathname, as described in the *Adaptive Server IQ Reference Manual*.

If you omit the directory path, Adaptive Server IQ locates the files as follows:

- The Catalog Store is created relative to the working directory of the server.
- The IQ Store is created relative to the working directory of the server.
- The Temporary Store is created in the same directory as the IQ Store, unless it is on a raw device. (This also occurs if you do not specify any file name.)
- The Message Log is created in the same directory as the IQ Store, unless it is on a raw device. (This also occurs if you do not specify any file name.) The Message Log cannot be on a raw partition.
- The Transaction Log is created in the same directory as the Catalog Store. (This also occurs if you do not specify any file name.) However, you should place it on a different physical device from the Catalog Store and IQ Store, on the same physical machine.

Note You must start the database server from the directory where the database is located, for any database created with a relative pathname.

Specifying an IQ PATH

The required IQ PATH parameter tells Adaptive Server IQ that you are creating an IQ database, not an Anywhere database. You specify the location of your IQ Store in this parameter. It is preferable to use a relative pathname. When you do, the IQ Store is created relative to the directory where the server was started, which can change the next time the server is started.

Choose a location for your database carefully. Although you can move an IQ database or any of its files to another location, to do so you must restore the entire database. A full restore is a time-consuming process, during which users cannot be connected to the database.

You can add space on a different drive, as described in “Adding dbspaces” but you can only use this additional space for new data. You cannot readily move a particular table, index, or rows of data from one location to another. You would need to drop the table or index, recreate it, and reload it; or you would need to delete those rows, and reinsert them.

Example

The following statement creates an IQ database called company.db. This database consists of four NT files:

- The Catalog Store is in *company.db*, in the directory where the server was started (in this case, *c:\company*)
- The IQ Store is in *c:\company\iqdata\company.iq*

- The Temporary Store is in *c:\company\company.iqtmp*
- The IQ message log file is in *c:\company\company.iqmsg*

```
CREATE DATABASE 'company.db'
IQ SIZE 20
IQ PATH 'c:\\company\\iqdata\\company.iq'
```

Example

The following statement creates an IQ database called company.db. This database consists of four UNIX files:

- The Catalog Store is in *company.db*, in the directory where the server was started (in this case, */disk1/company*)
- The IQ Store is in */disk1/company/iqdata/company.iq*
- The Temporary Store is in */disk1/company/iqdata/company.iqtmp*
- The IQ message log file is in */disk1/company/iqdata/company.iqmsg*

```
CREATE DATABASE 'company.db'
IQ SIZE 20
IQ PATH '/disk1/company/iqdata/company.iq'
```

Choosing an IQ page size

You set a page size for the IQ Store with the IQ PAGE SIZE option. This option determines memory and disk use. The IQ PAGE SIZE must be a power of 2, from 65536 to 524288 bytes. The IQ page size is the same for all dbspaces in the IQ Store.

To obtain the best performance, Sybase recommends the following minimum IQ page sizes:

- 64 KB (IQ PAGE SIZE 65536) for databases whose largest table contains up to 1 billion rows. Note that this is the default IQ page size, and the absolute minimum for a new database.
- 128 KB (IQ PAGE SIZE 131072) for databases whose largest table contains more than 1 billion rows and fewer than 4billion rows.
- 256 KB (IQ PAGE SIZE 262144) for databases whose largest table contains more than 4 billion rows.

Multiuser environments, and systems with memory constraints, both benefit from an IQ page size of at least 64KB, as this size minimizes paging.

Adaptive Server IQ stores data on disk in compressed form. It uncompresses the data and moves data pages into memory for processing. The IQ page size determines the amount of disk compression and the default I/O transfer block size for the IQ Store. For most applications, this default value is best. For a complete explanation of how the page size and related options affect resource use and performance, see Chapter 12, “Managing System Resources”

Specifying the size of your database

When you create a database, you set the size in MB of the initial IQ database file (the IQ_SYSTEM_MAIN dbspace). This value is defined in the IQ SIZE parameter.

- For raw partitions, you do not specify IQ SIZE; Adaptive Server IQ determines the size of the raw device and sets IQ SIZE to that value.
- For operating system files you can rely on the defaults listed below; or specify a value based on the size of your data, from the required minimum listed below up to a maximum of 128GB, in 1MB increments.

Table 3-1: Default and minimum sizes of IQ and Temporary Stores

IQ page size	*Default size of IQ Store*	*Default size of Temporary Store*	*Minimum IQ Store size when specified explicitly*	*Minimum Temporary Store size when specified explicitly*
65536	4096000	2048000	4MB	2MB
131072	8192000	4096000	8MB	4MB
262144	16384000	8192000	16MB	8MB
524288	32768000	16384000	32MB	16MB

Choosing a Catalog page size

You can select a page size for the Catalog Store, with the PAGE SIZE option. You should always use 4096 for this option. Each database server can support only one Catalog page size. If you start additional databases on a server, each one acquires the Catalog page size of the first database opened on that server. By always setting this value at 4096 (4KB), you ensure that you will always have an adequate page size for the Catalog.

Choosing a block size for your database

Example

The following statement creates a large database on a UNIX raw partition with a Catalog PAGE SIZE of 4KB, and an IQ PAGE SIZE of 128KB. By default, the IQ Store size is 8MB and the Temporary Store is 4MB.

```
CREATE DATABASE 'company' IQ PATH '/dev/rdsk/c2t6d0s3'
PAGE SIZE 4096
IQ PAGE SIZE 131072
```

Enabling Java in the database

By default, Java support is ON for IQ databases. It can be turned off with the JAVA OFF option. With Java ON:

- You can write a Java procedure that accesses tables in the Catalog Store or the IQ Store. These queries are processed like any other query.
- You cannot use a Java-based user-defined function within a query to an IQ table, but you can use it on Catalog Store tables.
- Windows NT users can also use Java-based user-defined functions in queries on tables in an Adaptive Server Anywhere database, or queries to IQ tables from an Adaptive Server Anywhere database, using the remote access capabilities described in the *Adaptive Server IQ Installation and Configuration Guide*.
- You cannot store Java data in an IQ table. If you attempt to create an IQ column of type Java, you receive an error, and you may cause the database server to fail.

Additional support for Java will be provided in a subsequent release. For information on Java support in Adaptive Server Anywhere, see Part 3, "Java in the Database" in the *Adaptive Server Anywhere User's Guide*. The chapter entitled "Data Access Using JDBC" is particularly relevant for IQ users.

Adding dbspaces

When you create a database, it has only one file for storing permanent IQ data, one file for storing Catalog data, and one file each for the IQ message log and the Temporary Store. Each of these files is a dbspace, as described in "Creating a database". Initially, the definitions of all IQ database objects go into the SYSTEM dbspace (the Catalog Store), and all IQ data is placed in the IQ_SYSTEM_MAIN dbspace (the IQ Store). Each dbspace has a maximum size of 128GB, depending on file size limits of your operating system and version. On some platforms you must enable large file system files to reach this maximum.

You can only specify SIZE for the IQ Store and IQ Temporary Store, not for the Catalog Store.

In the large databases typical of a data warehouse, you will need to add dbspaces to any database. You create a new database file—a dbspace—using the CREATE DBSPACE statement, or the Sybase Central Add Dbspace Wizard. A new dbspace can be on the same or a different disk drive as the existing dbspaces. You must have DBA authority to create new dbspaces.

When you create a new dbspace, it has no contents. When you create tables and indexes and load them, Adaptive Server IQ distributes the data as equally as possible among any existing dbspaces that are not already full. This technique optimizes performance.

Because Adaptive Server IQ fills dbspaces in this way, you cannot specify that a particular IQ table be loaded into a particular dbspace. You can only indicate the IQ Store as the dbspace IQ_SYSTEM_MAIN, and the Temporary Store as the dbspace IQ_SYSTEM_TEMP. The only way to control the location of a table within the IQ Store is to completely fill any existing IQ Store dbspaces, then define a new dbspace, and create and load the tables you want in it.

Note This behavior differs from that of Adaptive Server Anywhere, which allows you to place tables in a particular dbspace.

How the number of dbspaces affects resource use and performance

There is an absolute maximum of 2,048 dbspaces per IQ database, plus a maximum of 12 dbspaces for the Catalog Store. However, you should never allow a situation where you come close to the maximum. Increasing the number of dbspaces has no real impact on memory use or performance.

Note On HP and AIX platforms, your use of overlapped I/O improves when you divide data among more dbspaces.

When data is stored on raw partitions, you can have one dbspace per drive.

When data is stored in a file system, you can take advantage of striping in the storage system. If you use operating system or hardware striping on a multiuser system, your stripe size should be a minimum of 1MB, or the highest size possible. In any case, your stripe size should be several times your IQ page size.

For more information on disk striping and use of multiple dbspaces, see "Balancing I/O".

Before adding any more dbspaces you may want to estimate your space requirements. See "Estimating space and dbspaces required" for details of how to estimate space. For the most efficient resource use, make your dbspaces small enough to fit on your backup media, and large enough to fill up the disk.

Example

The following command creates a new dbspace called library in the file *library.iq* in the same directory as the IQ_SYSTEM_MAIN dbspace:

```
CREATE DBSPACE library
AS 'library.iq'
```

Creating a dbspace in Sybase Central

❖ **To create a dbspace in Sybase Central:**

1. Connect to the database.
2. Click the Dbspaces folder for that database.
3. Double-click Add Dbspace in the right panel.
4. Enter the dbspace name.
5. Click the type of data to be stored in this Dbspace: IQ or IQ temporary.
6. Enter the filename, and optionally the size of the dbspace.
7. Click OK to create the dbspace.

Issuing checkpoints for cleaner recovery

After you add or drop a dbspace, it's a good idea to issue a CHECKPOINT. In the event system recovery is needed, it begins after the most recent checkpoint.

Reserving space for DDL commands

In the event that you run out of space to perform an operation, you will see a message telling you to more space. In addition to space for the new dbspace itself, you also need a small amount of space to issue the ADD DBSPACE command. To ensure that you have the space for this and related DDL commands, set the options MAIN_RESERVED_DBSPACE_MB and TEMP_RESERVED_DBSPACE_MB. Do not wait until you have run out of space to set these options. See the "Database Options" chapter of the *Adaptive Server IQ Reference Manual* for option details.

Dropping dbspaces

You can issue a DROP DBSPACE command to remove a database file. In order to drop a dbspace, the following must be true:

- It must not contain any data. Adaptive Server IQ does not allow you to drop a dbspace unless it is empty.
- It must be the last one added. (After you drop the last dbspace, the next most recently added dbspace becomes the last one, and can be dropped.)
- It must not be one of the four initial dbspaces, SYSTEM, IQ_SYSTEM_MAIN, IQ_SYSTEM_TEMP, and IQ_SYSTEM_MSG. These dbspaces can never be dropped.

Because of the way Adaptive Server IQ fills dbspaces with data, it is unlikely that you will be able to drop the last dbspace, especially if disk striping is in use. You also cannot empty a dbspace by truncating the tables in it, as even an empty table takes some space. The only way to completely remove a table and its data is with a DROP TABLE statement (or by dropping the table in Sybase Central).

If you drop or truncate a table while other users are reading from it, the normal rules of table versioning apply, that is, old table versions remain until readers' transactions complete; see Chapter 8, "Transactions and Versioning" for details.

To find out whether you can drop a particular dbspace, run the stored procedure sp_iqstatus. Look at the DB Blocks value, which tells you the block numbers each dbspace includes. Compare this value to the Main IQ Blocks Used (or Temporary IQ Blocks Used), to see whether the Max Block # is in the dbspace. If it is, you cannot drop this dbspace.

```
Name                                    Value
                    ======================================================

Adaptive Server IQ (TM) Copyright (c) 1992-2000 by Sybase, Inc. All rights
reserved.
Version:                            12.4.2/(32bit mode)/Sun_svr4/OS 5.6/EBF 0000
Time Now:                                 2000-03-14 12:05:54.288
Build Time:                               Sat Mar 11, 2000  21:39:55 EST
File Format:                              23 on 03/18/1999
Catalog Format:                           2
Stored Procedure Revision:                1
Page Size:                                131072/8192blksz/16bpp
Number of DB Spaces:                      8
Number of Temp Spaces:                    2
DB Blocks: 1-12132344                     IQ_SYSTEM_MAIN
DB Blocks: 12545280-24677623              mydb_2
DB Blocks: 25090560-37222903              mydb_3
DB Blocks: 37635840-49768183              mydb_4
DB Blocks: 50181120-62313463              mydb_5
DB Blocks: 62726400-74858743              mydb_6
DB Blocks: 75271680-87404023              mydb_7
DB Blocks: 87816960-99949303              mydb_8
Temp Blocks: 1-8823288                    IQ_SYSTEM_TEMP
Temp Blocks: 9408960-18232247             mydb_tmp2
Create Time:                              1999-12-30 19:10:55.231
Update Time:                              2000-03-14 09:52:13.609
Main IQ Buffers:                          11174, 1400Mb
Temporary IQ Buffers:                     15165, 1900Mb
Main IQ Blocks Used:                      43515029 of 97058752, 44%=331Gb, Max
Block#: 95065709
Temporary IQ Blocks Used:                 610 of 17646576, 0%=4Mb, Max Block#: 0
Main Reserved Blocks Available:           1280 of 1280, 100%=10Mb
Temporary Reserved Blocks Available:      1280 of 1280, 100%=10Mb
Memory:                                   Current: 3351mb, Max: 3384mb
Main IQ Buffers:                          Used: 11172, Locked: 0
Temporary IQ Buffers:                     Used: 38, Locked: 0
Main IQ I/O:                              I: L88043944/P495510 O:
C760342/D761393/P736587 D:24753 C:65.9
Temporary IQ I/O:                         I: L16515025/P1222153 O:
C2609951/D3838862/P1228941
D:2609913 C:46.3
Old Versions:                             1 = 59Gb
Active Txn Versions:                      0 = C:0Mb/D:0Mb
```

Dropping a database

Dropping a database deletes all tables and data from disk, including the transaction log that records alterations to the database. It also drops all of the dbspaces associated with the database.

To drop a database, use the following statement:

```
DROP DATABASE dbname
```

You must specify the database name and its pathname *exactly as they were specified when the database was created*.

For example, on a Windows NT system:

```
DROP DATABASE 'c:\sybase\data\mydb.db'
```

The database must be stopped before you can drop it. If the connection parameter AUTOSTOP=no is used, you may need to issue a STOP DATABASE statement.

Working with tables

When you create a database, the only tables in it are the **system tables**, which hold the database schema.

This section describes how to create, alter, and delete tables from a database. The examples can be executed in DBISQL, but the SQL statements are independent of the administration tool you are using.

You may want to create command files containing the CREATE TABLE and ALTER TABLE statements that define the tables in your database. The command files allow you to re-create the database when necessary. They also let you create tables in a standardized way, which you can copy and revise.

Creating tables

Creating tables in Sybase Central

Sybase Central provides a tool called the table editor. In the table editor, you can create a table definition by filling out a spreadsheet-like form.

❖ **To create a table using Sybase Central:**

1 Connect to the database.

2 Click the Tables folder for that database.

3 Double-click Add Table in the right panel.

4 Enter a Name for the table.

5 To create an IQ table, skip this step. To create a table in the Catalog Store, double-click the Advanced Table Properties icon, and select SYSTEM from the DB space dropdown list.

6 Enter the columns you want and their data types and other attributes in the Table Editor.

7 Click OK to create the table.

SQL statement for creating tables

The SQL statement for creating tables is CREATE TABLE.

This section describes how to use the CREATE TABLE statement. The examples in this section use the sample database. To try the examples, run DBISQL and connect to the sample database with user ID DBA and password SQL.

For information on connecting to the sample database from DBISQL, see "Connecting to a database from DBISQL".

You can create tables with other tools in addition to DBISQL. The SQL statements described here are independent of the tool you are using.

Example

The following statement creates a new, permanent IQ table to describe qualifications of employees within a company. The table has columns to hold an identifying number, a name, and a type (say technical or administrative) for each skill.

```
CREATE TABLE skill (
skill_id INTEGER NOT NULL,
skill_name CHAR( 20 ) NOT NULL,
skill_type CHAR( 20 ) NOT NULL
)
```

You can execute this command by typing it into the DBISQL command window, and pressing the execute key (F9).

- Each column has a **data type**. The skill_id is an integer (like 101), the skill_name is a fixed-width CHARACTER string containing up to 20 characters, and so on.
- The phrase NOT NULL after their data types indicates that all columns in this example must contain a value.
- In general, you would not create a table that has no primary key. To create a primary key, see "Creating primary and foreign keys" on page 125.

By internally executing the COMMIT statement before creating the table, Adaptive Server IQ makes permanent all previous changes to the database. There is also a COMMIT after the table is created.

For a full description of the CREATE TABLE statement, see "CREATE TABLE statement" in the *Adaptive Server IQ Reference Manual*. For information about building constraints into table definitions using CREATE TABLE, see Chapter 7, "Ensuring Data Integrity".

Specifying data types

When you create a table, you specify the type of data that each column holds.

You can also define customized data types for your database. In the *Adaptive Server IQ Reference Manual*, see "SQL Data Types" for a list of supported data types, or see the CREATE DOMAIN statement for details on how to create a customized data type.

Types of tables

Adaptive Server IQ recognizes four types of tables:

- Base tables
- Local temporary tables
- Global temporary tables
- Join virtual tables

Base tables are permanent

Base tables are sometimes called main or permanent tables, because they are stored in the main IQ Store, and are a permanent part of the database, until you drop them explicitly. Base tables and the data in them are accessible to all users who have the appropriate permissions. The CREATE TABLE statement shown in the previous example creates a base table.

Creating temporary tables

There are two types of temporary tables, global and local.

You *create* a global temporary table, using the GLOBAL TEMPORARY option of CREATE TABLE, or by specifying in the Sybase Central table editor that this is a temporary table. When you create a global temporary table, it exists in the database until it is explicitly removed by a DROP TABLE statement.

A database contains only one definition of a global temporary table, just as it does for a base table. However, each user has a separate instance of the data in a global temporary table. Those rows are visible only to the connection that inserts them. They are deleted when the connection ends.

To select into a temporary table, use syntax like the following:

```
SELECT * INTO #TableTemp FROM lineitem
```

```
WHERE l_discount < 0.5
```

You *declare* a local temporary table for your connection only, using the DECLARE LOCAL TEMPORARY TABLE statement. A local temporary table exists until the connection ends, or within a compound statement in which it is declared. The table and its data are completely inaccessible to other users.

See “Versioning of temporary tables” for versioning information on local temporary tables.

Dropping and altering global temporary tables

You drop a global temporary table just as you would a base table, with the DROP TABLE statement, or with the Sybase Central table editor. You cannot drop or alter a global temporary table while other connections are using the table it.

Placement of tables

Adaptive Server IQ creates tables in your current database. If you are connected to an IQ database, tables are placed as follows:

Table 3-2: Table placement

Type of table	Permitted placement	Default placement
Permanent	Main IQ Store or Catalog Store	Main IQ Store
Global temporary	Temporary IQ Store or Catalog Store	Temporary IQ Store
Local temporary	Temporary IQ Store or Catalog Store; only visible to user who creates it	Temporary IQ Store

Join virtual tables

A Join Virtual Table is a denormalized table that looks like a regular table; it has a name, columns, rows, and indexes. Adaptive Server IQ creates Join Virtual Tables as a result of a Create Join Index for internal processing purposes and deletes them when you do a Drop Join Index. You cannot create, modify, or delete Join Virtual Tables, but you may see error messages related to them if you try to use or modify them. Sybase suggests that you ignore all Join Virtual Tables.

Automatic index creation for IQ tables

You can automate indexing for certain columns by creating a table with either PRIMARY KEY or UNIQUE as a single-column constraint. These options cause Adaptive Server IQ to create an HG index for the column that enforces uniqueness.

If you use the ALTER TABLE command to add a UNIQUE column to an existing table, or to designate an existing column as UNIQUE, an HG index is created automatically.

For complete information on IQ indexing, see Chapter 4, "Adaptive Server IQ Indexes"

Optimizing storage and query performance

When you create a permanent table in an IQ database, Adaptive Server IQ automatically stores it in a default index that facilitates a type of query called a projection.

Adaptive Server IQ optimizes this structure for query performance and storage requirements, based on these factors:

- The IQ UNIQUE option of CREATE TABLE.
- The data type of the column and its width
- The IQ PAGE SIZE option of CREATE DATABASE

See the following table for implications of IQ UNIQUE.

Table 3-3: Effect of IQ UNIQUE

IQ UNIQUE 256 or less	IQ UNIQUE 65536 or less	IQ UNIQUE unspecified or greater than 65536
Storage optimized for small number of unique values	Storage optimized for medium number of unique values	Storage optimized for large number of unique values
Faster query performance, less main IQ Store space required	Faster query performance, less main IQ Store space required	Queries may be slower
Need a small amount of extra cache for IQ Temporary Store	Need extra cache for IQ Temporary Store. The amount depends on the number of unique values and the data type.	No extra cache needed
Loads may be slower	Loads may be slower	Loads are faster

Difference between UNIQUE and IQ UNIQUE

IQ UNIQUE (*count*) gives an approximation of the number of distinct values that can be in a given column. Each distinct value can appear many times. For example, in the employee table, a limited set of distinct values could appear in the state column, but each of those values could appear in many rows.

By contrast, when you specify UNIQUE or PRIMARY KEY, each value can occur only once in that column. For example, in the employee table, each value of ss_number, the employee's social security number, can occur just once throughout that column. This uniqueness extends to NULL values. Thus, a column specified as UNIQUE must also have the constraint NOT NULL.

Altering tables

This section describes how to change the structure of a table using the ALTER TABLE statement.

Example 1

The following command adds a column to the skill table to allow space for an optional description of the skill:

```
ALTER TABLE skill
ADD skill_description CHAR( 254 )
```

Example 2

The following statement changes the name of the skill_type column to classification:

```
ALTER TABLE skill
RENAME skill_type TO classification
```

Example 3

The following statement deletes the classification column.

```
ALTER TABLE skill
DELETE classification
```

Example 4

The following statement changes the name of the entire table:

```
ALTER TABLE skill
RENAME qualification
```

These examples show how to change the structure of the database. The ALTER TABLE statement can change many characteristics of a table—foreign keys can be added or deleted, and so on. However, you cannot use MODIFY to change table or column constraints. Instead, you must DELETE the old constraint and ADD the new one. In all these cases, once you make the change, stored procedures, views, and any other item referring to this column will no longer work.

For a complete description of the ALTER TABLE command, see *Adaptive Server IQ Reference Manual*. For information about building constraints into table definitions using ALTER TABLE, see Chapter 7, "Ensuring Data Integrity"

Altering tables in Sybase Central

The property sheets for tables and columns display all the table or column attributes. You can alter a table definition in Sybase Central by displaying the property sheet for the table or column you wish to change, altering the property, and clicking OK to commit the change.

Altering tables in a join index

You cannot ADD, DROP or MODIFY a base table column that participates in a join condition of a join index. To alter joined columns, you must first drop the join index, alter the table, and then recreate the join index. See “Using join indexes” for complete information on join indexes.

Dropping tables

The following DROP TABLE statement deletes all the records in the skill table and then removes the definition of the skill table from the database

```
DROP TABLE skill
```

Like the CREATE statement, the DROP statement automatically executes a COMMIT before and after dropping the table. This makes permanent all changes to the database since the last COMMIT or ROLLBACK.

The DROP statement also drops all indexes on the table, except if any column in the table participates in a join index.

If you only want to remove data rows but not the table itself, use the TRUNCATE TABLE statement. If you truncate a table while other users are reading from it, the normal rules of table versioning apply, that is, old table versions remain until readers' transactions complete; see Chapter 8, “Transactions and Versioning” for details.

DROP TABLE and TRUNCATE TABLE are very fast, taking only seconds to occur. The size of the data does not effect the speed of the operation.

For a full description of the DROP statement, see *Adaptive Server IQ Reference Manual*.

❖ **To drop a table in Sybase Central:**

1 Connect to the database.

2 Click the Tables folder for that database.

3 Right-click the table you wish to delete, and select Delete from the pop-up menu.

Creating primary and foreign keys

The CREATE TABLE and ALTER TABLE statements allow many attributes of tables to be set, including column constraints and checks. This section shows how to set table attributes using the primary and foreign keys as an example.

Creating a primary key

The following statement creates the same skill table as before, except that a primary key is added:

```
CREATE TABLE skill (
  skill_id INTEGER NOT NULL,
  skill_name CHAR( 20 ) NOT NULL,
  skill_type CHAR( 20 ) NOT NULL,
  primary key( skill_id )
)
```

The primary key values must be unique for each row in the table which, in this case, means that you cannot have more than one row with a given skill_id. Each row in a table is uniquely identified by its primary key.

Columns in the primary key are not allowed to contain NULL. You must specify NOT NULL on the column in the primary key.

Note Adaptive Server IQ does not enforce multi-column primary keys. You must specify the keyword UNENFORCED when you define a multi-column primary key.

Creating a primary key in Sybase Central

❖ **To create a primary key in Sybase Central:**

1 Connect to the database.

2 Click the Tables folder for that database.

3 Right-click the table you wish to modify, and select Properties from the pop-up menu to display its property sheet.

4 Click the Columns tab, select the column name, and either click Add to Key or Remove from Key.

For more information, see the Sybase Central online Help.

Note Multi-column primary keys are not enforced, and require the keyword UNENFORCED. Primary key column order is based on the order of the columns during table creation. It is not based on the order of the columns as specified in the primary key declaration.

Creating unenforced foreign keys

You can create a table named emp_skill, which holds a description of each employee's skill level for each skill in which they are qualified, as follows:

```
CREATE TABLE emp_skill(
emp_id INTEGER NOT NULL,
skill_id INTEGER NOT NULL,
"skill level" INTEGER NOT NULL,
PRIMARY KEY( emp_id, skill_id ) UNENFORCED,
FOREIGN KEY REFERENCES employee UNENFORCED,
FOREIGN KEY REFERENCES skill UNENFORCED
)
```

The emp_skill table definition has a primary key that consists of two columns: the emp_id column and the skill_id column. An employee may have more than one skill, and so appear in several rows, and several employees may possess a given skill, so that the skill_id may appear several times.

The emp_skill table also has two foreign keys. The foreign key entries indicate that the emp_id column must contain a valid employee number from the employee table, and that the skill_id must contain a valid entry from the skill table.

A table can only have one primary key defined, but it may have as many foreign keys as necessary.

Note Adaptive Server IQ does not enforce foreign keys or multi-column primary keys. You must specify the keyword UNENFORCED when you add or delete these constraints. They can be useful, nonetheless, because they provide information that Adaptive Server IQ uses to optimize queries, and to define the underlying relationship between joined columns.

For more information about valid strings and identifiers, see the chapter "SQL Language Elements" in the *Adaptive Server IQ Reference Manual*.

Creating an unenforced foreign key in Sybase Central

Each foreign key relationship relates a primary key in one column to a column in another table, which becomes the foreign key.

❖ **To create an unenforced foreign key in Sybase Central:**

1 Connect to the database.

2 Click the Tables folder for that database.

3 Click the table holding the primary key, and drag it to the foreign key table.

4 When the primary key table is dropped on the foreign key table, the Foreign Key Wizard is displayed, which leads you through the process of creating the foreign key.

For more information, see the Sybase Central online Help.

For more information about using primary and foreign keys, see Chapter 7, "Ensuring Data Integrity"

Table information in the system tables

All the information about tables in a database is held in the system tables. The information is distributed among several tables. For more information, see "System Tables" in *Adaptive Server IQ Reference Manual*.

You can use Sybase Central or DBISQL to browse the information in these tables. Type the following command in the DBISQL command window to see all the columns in the SYS.SYSTABLE table:

```
SELECT *
FROM SYS.SYSTABLE
```

❖ **To display the system tables in Sybase Central:**

1 Connect to the database.

2 Right-click the database, and select Filter Objects from the pop-up menu.

3 Select SYS and OK.

4 When you view the database tables or views with Show System Objects checked, the system tables or views are also shown.

Working with views

Views are computed tables. You can use views to show database users exactly the information you want to present, in a format you can control.

Similarities between views and base tables

Views are similar to the permanent tables of the database (a permanent table is also called a **base table**) in many ways:

- You can assign access permissions to views just as to base tables.
- You can perform SELECT queries on views.
- You can perform INSERT and DELETE operations on some views.
- You can create views based on other views.

Differences between views and permanent tables

There are some differences between views and permanent tables:

- You cannot create indexes on views.
- You cannot perform INSERT, DELETE, and UPDATE operations on all views.
- You cannot assign integrity constraints and keys to views.
- Views refer to the information in base tables, but do not hold copies of that information. Views are recomputed each time you invoke them.

Benefits of tailoring access

Views are used to tailor access to data in the database. Tailoring access serves several purposes:

- **Improved security** By not allowing access to information that is not relevant.
- **Improved usability** By presenting users and application developers with data in a more easily understood form than in the base tables.
- **Improved consistency** By centralizing in the database the definition of common queries.

Creating views

A SELECT statement operates on one or more tables and produces a result set that is also a table: just like a base table, a result set from a SELECT query has columns and rows. A view gives a name to a particular query, and holds the definition in the database system tables.

Example

Suppose that you frequently need to list the number of employees in each department. You can get this list with the following statement:

```
SELECT dept_ID, count(*)
FROM employee
GROUP BY dept_ID
```

You can create a view containing the results of this statement as follows:

```
CREATE VIEW DepartmentSize AS
SELECT dept_ID, count(*)
FROM employee
GROUP BY dept_ID
```

The information in a view is not stored separately in the database. Each time you refer to the view, the associated SELECT statement is executed to retrieve the appropriate data.

On one hand, this is good because it means that if someone modifies the employee table, the information in the DepartmentSize view will be automatically up to date. On the other hand, complicated SELECT statements may increase the amount of time SQL requires to find the correct information every time you use the view.

❖ **To create a view in Sybase Central:**

1 Connect to the database.

2 Click the Views folder for that database.

3 Double-click Add View.

4 Enter the tables and columns to be used. For instance, to create the same view as in the SQL example shown above, enter employee and dept_ID.

5 From the File menu select Execute Script and from the File menu select Close.

For more information, see the Sybase Central online Help.

Using views

When you use views, you need to be aware of certain restrictions, both on the SELECT statements you can use to create them, and on your ability to insert into, delete from, or update them.

Restrictions on SELECT statements

There are some restrictions on the SELECT statements that you can use as views. In particular, you cannot use an ORDER BY clause in the SELECT query. A characteristic of relational tables is that there is no significance to the ordering of the rows or columns, and using an ORDER BY clause would impose an order on the rows of the view. You can use the GROUP BY clause, subqueries, and joins in view definitions.

To develop a view, tune the SELECT query by itself until it provides exactly the results you need in the format you want. Once you have the SELECT query just right, you can add a phrase in front of the query to create the view. For example:

```
CREATE VIEW viewname AS
```

Inserting and deleting on views

UPDATE, INSERT, and DELETE statements are allowed on some views, but not on others, depending on their associated SELECT statement.

You *cannot* update, insert into or delete from views in the following cases:

- Views containing aggregate functions, such as COUNT(*)
- Views containing a GROUP BY clause in the SELECT statement
- Views containing a UNION operation

In all these cases, there is no way to translate the UPDATE, INSERT, or DELETE into an action on the underlying tables.

Modifying views

You can modify a view using the ALTER VIEW statement. The ALTER VIEW statement replaces a view definition with a new definition; it does not modify an existing view definition.

The ALTER VIEW statement maintains the permissions on the view.

Example

For example, to replace the column names with more informative names in the DepartmentSize view described above, you could use the following statement:

```
ALTER VIEW DepartmentSize
  (Dept_ID, NumEmployees)
AS
  SELECT dept_ID, count(*)
  FROM Employee
  GROUP BY dept_ID
```

Permissions on views

A user may perform an operation through a view if one or more of the following are true:

- The appropriate permission(s) on the view for the operation has been granted to the user by a DBA.
- The user has the appropriate permission(s) on all the base table(s) for the operation.

- The user was granted appropriate permission(s) for the operation on the view by a non-DBA user. This user must be either the owner of the view or have WITH GRANT OPTION of the appropriate permission(s) on the view. The owner of the view must be either:
  - a DBA, or
  - a non-DBA, but also the owner of all the base table(s) referred to by the view, or
  - a non-DBA, and not the owner of some or all of the base table(s) referred to by the view, but the view owner has SELECT permission WITH GRANT OPTION on the base table(s) not owned and any other required permission(s) WITH GRANT OPTION on the base table(s) not owned for the operation.

    Instead of the owner having permission(s) WITH GRANT OPTION on the base table(s), permission(s) may have been granted to PUBLIC. This includes SELECT permission on system tables.

UPDATE permissions can be granted only on an entire view. Unlike tables, UPDATE permissions cannot be granted on individual columns within a view.

Deleting views

To delete a view from the database, you use the DROP statement. The following statement removes the DepartmentSize view:

```
DROP VIEW DepartmentSize
```

Dropping a view in Sybase Central

To drop a view in Sybase Central, right-click the view you wish to delete and select Delete from the pop-up menu.

For more information, see the Sybase Central online Help.

Views in the system tables

All the information about views in a database is held in the system table SYS.SYSTABLE. The information is presented in a more readable format in the system view SYS.SYSVIEWS. For more information about these, see *Adaptive Server IQ Reference Manual.*

You can use DBISQL to browse the information in these tables. Type the following statement in the DBISQL command window to see all the columns in the SYS.SYSVIEWS view:

```
SELECT *
FROM SYS.SYSVIEWS
```

To extract a text file containing the definition of a specific view, use a statement such as the following:

```
SELECT viewtext FROM SYS.SYSVIEWS
    WHERE viewname = 'DepartmentSize';
OUTPUT TO viewtext.sql
FORMAT ASCII
```

Working with indexes

Performance is a vital consideration when designing and creating your database. Adaptive Server IQ indexes dramatically improve the performance of database searches over searches in traditional relational databases. Even within Adaptive Server IQ, however, it is important to choose the right indexes for your data, to achieve the greatest performance, and to make best use of memory, disk, and CPU cycles.

Introduction to indexes

All IQ database columns with data need an index. When you create a database in an IQ store, a default index is created automatically on every column of every table. You can also choose from several other index types:

- Four column index types optimize specific types of queries on the indexed column.
- Join indexes optimize queries that relate columns from two or more tables.

You will almost certainly want to supplement the default indexing by selecting one or more indexes for many of the columns in your database. You will also want to define join indexes for any table columns that are joined in a consistent way in user queries. Select indexes based on the size of your database, the disk space available, and the type of queries users submit.

Indexes are created on a specified table, or on a set of tables for join indexes. You cannot create an index on a view.

Creating indexes

You can create column indexes in three ways:

- With the CREATE INDEX command
- With the Add Index option in Sybase Central
- With the UNIQUE or PRIMARY KEY column constraint of CREATE TABLE, which creates a unique index automatically.

You can create a join index in two ways:

- With the CREATE JOIN INDEX statement
- With the Join Index Editor in Sybase Central

See Chapter 4, "Adaptive Server IQ Indexes" for details on selecting and creating indexes. See the *Adaptive Server IQ Reference Manual* for command syntax.

Indexes in the system tables

Information on indexes is in the system tables SYSINDEX, SYSIQINDEX, SYSIXCOL, and for join indexes, SYSIQJINDEX. See the *Adaptive Server IQ Reference Manual* for a description of these tables. See *Introduction to Adaptive Server IQ* for an explanation of how to browse system tables in DBISQL and in Sybase Central.

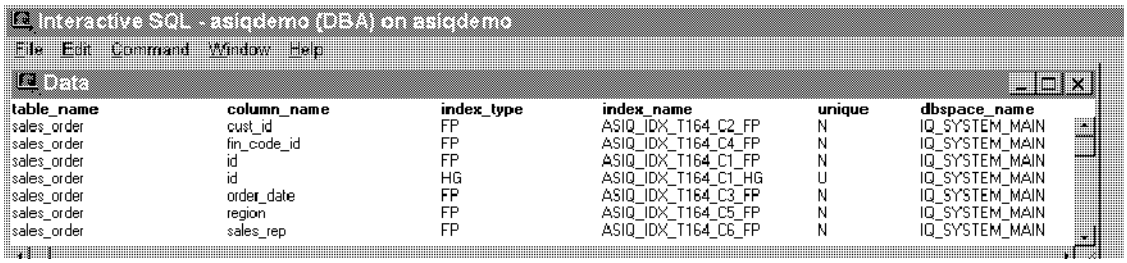
Displaying indexes using stored procedures

You can also use the stored procedure sp_iqindex to display a list of indexes and information about them. For example, to list the indexes in the sales_order table, issue the command:

```
sp_iqindex 'sales_order'
```

The following information displays. (A remarks column also appears, but is not shown here.)

Figure 3-1: sp_iqindex results



table_name	column_name	index_type	index_name	unique	dbspace_name
sales_order	cust_id	FP	ASIQ_IDX_T164_C2_FP	N	IQ_SYSTEM_MAIN
sales_order	fin_code_id	FP	ASIQ_IDX_T164_C4_FP	N	IQ_SYSTEM_MAIN
sales_order	id	FP	ASIQ_IDX_T164_C1_FP	N	IQ_SYSTEM_MAIN
sales_order	id	HG	ASIQ_IDX_T164_C1_HG	U	IQ_SYSTEM_MAIN
sales_order	order_date	FP	ASIQ_IDX_T164_C3_FP	N	IQ_SYSTEM_MAIN
sales_order	region	FP	ASIQ_IDX_T164_C5_FP	N	IQ_SYSTEM_MAIN
sales_order	sales_rep	FP	ASIQ_IDX_T164_C6_FP	N	IQ_SYSTEM_MAIN

If you omit the table name from the command, sp_iqindex displays this information for all tables in the database.

Removing indexes

If a column index or join index is no longer required, you can remove it from the database using the DROP statement. You can also drop indexes in Sybase Central by clicking the table name, right-clicking to display options, and clicking the Delete option. Before you drop a join index, see “Modifying tables included in a join index” for special requirements.

CHAPTER 4

Adaptive Server IQ Indexes

About this chapter

This chapter describes the Adaptive Server IQ index types. It explains how you create an index, and provides information to help you decide what index types are best suited for the way you use the data in your database. It also includes performance and resource issues related to indexing.

Overview of indexes

Indexes are used to improve data retrieval performance. Traditional indexes use a B-tree index strategy to point to the data records. That strategy is valuable only if many unique data values are used to filter down to a very small set of records, as with columns of order numbers or customer names, as you would encounter in a transaction processing system.

Adaptive Server IQ indexes actually represent and store the data so that the data can be used for processing queries. This strategy is designed for the data warehousing environment, in which queries typically examine enormous numbers of records, often with relatively few unique values, and in which aggregate results are commonly required.

Adaptive Server IQ index types

When you load data into a table, Adaptive Server IQ stores data by column rather than by row, for each column in the table. The column orientation gives IQ indexes important advantages over traditional row-based indexing. Column storage structures your data according to the attributes you are interested in tracking. In a data warehousing environment, usually you want to look at specific attributes of thousands or millions of rows of data, rather than complete, single rows of data that typically are the focus in transaction processing. Column storage optimizes your ability to perform selections or calculations on the attributes you care about.

The default column storage structure that Adaptive Server IQ creates for each column is actually an index optimized for storing and projecting data. Depending on the size of your database, the disk space available to you, and the type of queries your users submit, you will almost certainly want to supplement this default index with one or more of the Adaptive Server IQ bitwise index types. You can choose from four column index types. The column indexes you define are created as part of each individual table.

Besides the column indexes, Adaptive Server IQ also allows you to define *join indexes*. Join indexes are optimized for joining related tables. You may want to create a join index for any set of columns that your users commonly join to resolve queries. Column indexes underlie any join indexes involving those columns.

The first half of this chapter discusses column indexes. The second half of this chapter discusses join indexes; see “Using join indexes” for details.

A **default index** that optimizes projections is created by Adaptive Server IQ for all columns.

When a column is designated as either a PRIMARY KEY or UNIQUE, Adaptive Server IQ creates a High_Group index for it automatically.

To achieve maximum query performance, however, you should choose one or more additional index types for most columns that best represent the cardinality and usage of column data:

- Low_Fast or LF A value-based bitmap for processing queries on low-cardinality data (recommended for up to 1,000 distinct values, but can support up to 10,000)
- High_Group or HG An enhanced b-tree index to process equality and group by operations on high-cardinality data (recommended for more than 1,000 distinct values)
- High_Non_Group or HNG A non value-based bitmap index ideal for most high-cardinality DSS operations involving ranges or aggregates

Select column indexes according to the type of data in the column and your intended operations for the column data. In general, you can use any index or combination of indexes on any column. However, there are some exceptions.

To take advantage of the High_Non_Group index types for columns with nonintegral numeric data, use the NUMERIC or DECIMAL data types, which support up to 254 digits to the left or right of the decimal point. Be aware that some index types are incompatible, and that creating indexes you don't need wastes a lot of disk space. Read the sections that follow for details on how to select an index.

How Adaptive Server IQ uses indexes

You may also want to define additional indexes on your columns for best performance. Adaptive Server IQ uses the fastest index available for the current query or join predicate. If you do not create the correct types of indexes for a column, Adaptive Server IQ can still resolve queries involving the column, but response may be slower than it would be with the correct index type(s).

If multiple indexes are defined on a particular column, Adaptive Server IQ builds all the indexes for that column from the same input data.

Adding and dropping indexes

If you discover later that an additional index is needed, you can always add indexes. However, it is much faster to create all the appropriate indexes before you insert any data.

You can drop any optional index if you decide that you do not need it. See the DROP INDEX command in the *Adaptive Server IQ Reference Manual* for more information on dropping indexes. You cannot drop automatically created indexes using DROP INDEX. The only way to remove the default index is to use ALTER TABLE (or the Sybase Central Table Editor) to drop the column, or to drop the table. The only way to remove an automatically created HG index is by using ALTER TABLE (or the Sybase Central Table Editor) to drop the column or the PRIMARY KEY or UNIQUE constraint, or by dropping the table.

Benefits over traditional indexes

Adaptive Server IQ indexes offer these benefits over traditional indexing techniques:

- Index sizes remain small. The entire database can be fully indexed and made available for ad hoc queries in the same space that would be needed to store the raw data. Most traditional databases need three times as much space.
- Queries are resolved by efficiently combining and manipulating indexes on only the relevant columns. This avoids time-consuming table scans.
- I/O is minimized, eliminating potential bottlenecks.

- Because indexes are compact, more data can be kept in memory for subsequent queries, thereby speeding throughput on iterative analysis.
- Tuning is data-dependent, allowing data to be optimized once for any number of ad hoc queries.

Creating Adaptive Server IQ indexes

You can create a column index explicitly using either the CREATE INDEX statement or Sybase Central. These two methods are discussed in the sections that follow.

The CREATE INDEX statement

To create an Adaptive Server IQ column index, use this syntax:

CREATE [**UNIQUE**] [*index-type*] **INDEX** *index-name*
... **ON** [*owner*.]*table-name*
... (*column-name*)
... [{ **IN** | **ON** } *dbspace-name*]
... [**NOTIFY** *integer*]

If you do not specify an *index-type*, Adaptive Server IQ creates an HG index. Several front-end tools create an HG index automatically for this reason.

Examples

The first example creates a High_Non_Group (HNG) index called ship_ix on the ship_date column of the sales_order_items table.

```
CREATE HNG INDEX ship_ix
  ON dbo.sales_order_items (ship_date)
```

The second example creates a Low_Fast index called sales_order_region on the region column of the sales_order table.

```
CREATE LF INDEX sales_order_region
  ON dbo.sales_order (region)
```

By default, after every 100,000 records are inserted and loaded into indexes, you receive a progress message. To change the number of records, specify the NOTIFY option of CREATE INDEX. To prevent these messages, specify NOTIFY 0.

You can use the keywords BEGIN PARALLEL IQ and END PARALLEL IQ to delimit any number of CREATE INDEX statements that you want to execute as a group at the same time. These keywords can only be used when creating indexes on IQ tables, not temporary tables or Adaptive Server Anywhere tables. Note that, if one of these CREATE INDEX statements fails, all of them roll back. For more information, see the *Adaptive Server IQ Reference Manual*.

Note You cannot place an index in a particular dbspace. Adaptive Server IQ always places an index in the same type of dbspace (IQ Store or Temporary Store) as its table. When you load the index, the data is spread across any database files of that type with room available. The *dbspace-name* option of CREATE INDEX is ignored for IQ indexes, and is provided for compatibility with Adaptive Server Anywhere.

Creating an index with Sybase Central

To create a column index using Sybase Central, follow these steps.

❖ **To create an index with Sybase Central:**

1 Connect to the database.

2 Select the table in which the column appears.

3 Open the Indexes folder.

4 Double-click the Add Index icon, enter a name for the index, and click Next.

5 Select an index type. A High Group is created if you do not click another index type.

6 Optionally set the number of records added before each notification message, and click Next.

7 Select the column you want to index, and click Next.

8 Enter attributes for the index as appropriate, and click Finish to create the index.

Creating indexes concurrently

In some cases, you can create more than one column index at the same time:

- Each CREATE INDEX statement can create only one index.
- Each connection can create only one index at a time.
- If two connections issue CREATE INDEX statements on the same table, the first statement works; the other gets an error saying that only 1 writer is allowed.
- If two connections issue CREATE INDEX statements on different tables, both proceed in parallel
- If two connections issue CREATE INDEX statements on different tables but both tables participate in the same join index, then only one CREATE INDEX works; the other gets an error saying that only 1 writer is allowed.

Choosing an index type

The set of indexes you define for any given column can have dramatic impact on the speed of query processing. There are four main criteria for choosing indexes:

- Number of unique values
- Types of queries
- Disk space usage
- Data types

Use the recommendations for all criteria in combination, rather than individually. Remember also that all columns are automatically stored in a way that facilitates fast projections. To decide on additional indexes, look closely at the data in each column. Try to anticipate the number of unique and total values, the query results users will want from it, and whether the data will be used in ad hoc joins or join indexes.

For details of index types, and criteria to use for choosing the correct types, see the sections that follow.

Number of unique values in the index

Adaptive Server IQ indexes are optimized according to the number of unique (distinct) values they include. When this number reaches certain levels, choose indexes according to the recommendations in Table 4-1.

Table 4-1: Consideration order

Number of Unique Values	Recommended Index Type
Below 1,000	LF
1000 and over	HG and/or HNG

Columns for which you specify `IQ UNIQUE 65536` or less are automatically placed in a form of the default index that is optimized for reduced storage, and improved performance for certain types of queries.

Here are some examples of columns with different numbers of unique values:

- Columns that hold marital status will have just a few unique values (single, married, NULL)
- Columns that hold state or province names will have fewer than 100 unique values
- Columns that hold date data probably have more than 100 but fewer than 65536 unique values
- Columns that hold account numbers or social security numbers may have thousands or millions of unique numbers

Types of queries

You should know in advance how data in the columns will generally be queried. For example:

- Will the column be part of a join predicate?
- If the column has a high number of unique values, will the column be used in a GROUP BY clause, be the argument of a COUNT DISTINCT, and/or be in the SELECT DISTINCT projection?

Often, the type of data in a column gives a good indication how the column will be used. For example, a date column will probably be used for range searches in WHERE clauses, and a column that contains prices or sales amounts will probably be used in the projection as an argument for aggregate functions (SUM, AVG, and so on).

Note Adaptive Server IQ can still resolve queries involving a column indexed with the wrong index type, although it may not do so as efficiently.

This table shows recommended index types based on the query. The index that is usually fastest for each query is listed first, the slowest last. These recommendations should not be your only criteria for picking an index type. You should also consider the number of unique values and disk space. See the other tables in this section.

Table 4-2: Query type/index

Type of Query Usage	Recommended Index Type
In a SELECT projection list	Default
In calculation expressions such as SUM(A+B)	Default
As AVG/SUM argument	High_Non_Group, Low_Fast, High_Group, Default
As MIN/MAX argument	LF, HG, HNG
As COUNT argument	LF, HG
As COUNT DISTINCT, SELECT DISTINCT or GROUP BY argument.	LF, Default
If field does not allow duplicates	HG
Columns used in ad hoc join	Default, HG, LF,
Columns used in a join index	HG, LF
As LIKE argument in a WHERE clause	Default
As IN argument	HG, LF
In equality or inequality (=, <>)	HG, LF
In range predicate in WHERE clause (>, <, >=, <=, BETWEEN	LF or HNG

Note While HNG is recommended, in certain cases LF or HG is faster, and is often used in place of HNG. HNG tends to give consistent performance, while the performance of LF or HG with ranges depends on the size of the range selected.

These estimates are generally valid; however, other factors can take precedence:

- For range predicates, the number of unique values is a more important factor.
- With the set functions COUNT, COUNT DISTINCT, SUM, MIN, MAX, and AVG, in order to use any index other than the default, the entire query must be resolvable using a single table or join index.
- BIT data, and VARCHAR data greater than 255 bytes, can only be used in the default index.

Indexing criteria: disk space usage

The following table provides estimates of the amount of space each index uses compared to the amount of column data from the source database or flat file.

Table 4-3: Index disk space usage

Type of index	Estimated space versus raw data	Comments
Default	Smaller than or equal to	If the number of distinct values is less than 255, this index uses significantly less space than the raw data
High_Group	Smaller than up to 2 times larger	As the number of distinct values decreases (that is, the number of entries per group increases), the space used decreases in proportion to the size of the raw data
High_Non_Group	Smaller than or equal to	Smaller than the raw data in most cases
Low_Fast	Smaller than up to 2 times larger	Same as High_Group

For LF and HG indexes, the index size depends on the number of unique values. The more unique values, the more space the index takes.

Data types in the index

Only the default index supports the following data types:

- BIT data

- VARCHAR data with more than 255 bytes

HNG indexes do not allow FLOAT, REAL, or DOUBLE data.

All other data types are supported in all index types.

If you try to create an index on a column that contains VARCHAR data greater than 255 bytes, you get this error message:

```
An index cannot be created on a varchar column greater
than 255 characters.
```

Combining index types

If a column is going to be used in more than one type of query, multiple column index types might be appropriate. The following table shows which index types make good combinations.

Table 4-4: Mix of valid indexes

	Add Index		
Existing Index	*HG*	*HNG*	*LF*
HG	-	1	2
HNG	1	-	1
LF	2	1	-
1 = A reasonable combination 2 = An unlikely combination			

Note The High_Group index in Adaptive Server IQ Version 12.0 differs from earlier versions. For some columns you may want both High_Group and High_Non_Group; previously, it did not make sense to have both.

Adaptive Server IQ index types

This section explores in depth the reasons you might use each of the column index types.

Default column index

For any column that has no index defined, or whenever it is the most effective, query results are produced using the default index. This structure is fastest for projections, but generally is slower than any of the three column index types you define for anything other than a projection. Performance is still faster than most RDBMSs since one column of data is fetched, while other RDBMSs need to fetch all columns which results in more disk I/O operations.

Projections on few rows

If a column is used only in projections, even if some of the queries return a small number of rows, Low_Fast and High_Non_Group indexes are redundant because the default structure is equally as fast for projecting a small number of rows.

The Low_Fast (LF) index type

This index is ideal for columns that have a very low number of unique values (under 1,000) such as sex, Yes/No, True/False, number of dependents, wage class, and so on. LF is the fastest index in Adaptive Server IQ.

When you test for equality, just one lookup quickly gives the result set. To test for inequality, you may need to examine a few more lookups. Calculations such as SUM, AVG, and COUNT are also very fast with this index.

As the number of unique values in a column increases, performance starts to degrade and memory and disk requirements start to increase for insertions and some queries. When doing equality tests, though, it is still the fastest index, even for columns with many unique values.

Recommended use

Use an LF index when:

- A column has fewer than 1,000 unique values.
- A column has fewer than 1,000 unique values and is used in a join predicate.

Never use an LF index for a column with 10,000 or more unique values.

Advantages and disadvantages of Low_Fast

The following table lists advantages and disadvantages of Low_Fast indexes.

Table 4-5: LF advantages/disadvantages

Advantages	*Disadvantages*
This index is fast, especially for single table SUM, AVG, COUNT, COUNT DISTINCT, MIN, and MAX operations.	Can only be used for a maximum of 10,000 unique values. Cannot use this index if data in your columns is BIT, or VARCHAR > 255 bytes.

Comparison with other indexes

HNG/HG The main factor to consider is the number of unique values within a column. Use LF if the number is low.

Additional indexes

The High_Non_Group index type may also be appropriate for a Low_Fast column.

Note It is almost always best to use an LF index if the number of unique values is low (less than 1,000). Consider this index first, if the column appears in the WHERE clause. Only when the number of unique values is high should other indexes (HG and HNG) be considered. For range queries with a high number of unique values, also consider having an HNG index.

The High_Group (HG) index type

The High_Group index is commonly used for join columns with integer data types. It is also more commonly used than High_Non_Group because it handles GROUP BY efficiently.

Recommended use

Use an HG index when:

- The column will be used in a join predicate
- A column has more than 1000 unique values

Advantages and disadvantages of High_Group

The following table lists advantages and disadvantages of High_Group indexes.

Table 4-6: HG advantages/disadvantages

Advantages	*Disadvantages*
Quickly processes queries with GROUP BY.	This index needs additional disk space compared to the HNG index (it can take up as much as three times more space than raw data).
This index facilitates join index processing. It is one of indexes recommended for columns used in join relationships. LF is the other.	This index type takes the longest time to populate with data, and to delete. Cannot use this index if data in your columns is BIT, or VARCHAR > 255 bytes.

Comparison with other indexes

LF The determining factor is the number of unique values. Use High_Group if the number of unique values for the column is high. Use Low_Fast if the number of unique values is low.

HNG The determining factor is whether the column is a join column, and/or whether GROUP BY may be processed on the column. If either of these is true, use High_Group, either alone or in combination with High_Non_Group. Otherwise, use High_Non_Group to save disk space.

Additional indexes

In some cases, a column that meets the criteria for a High_Group index may be used in queries where a different type of index may be faster. If this is the case, create additional indexes for that column.

Automatic creation of High_Group index

Adaptive Server IQ creates a High_Group index by default whenever you issue a CREATE INDEX statement without specifying an index type.

Adaptive Server IQ automatically creates a High_Group index for any column with a UNIQUE or PRIMARY KEY constraint.

However, because multi-column primary keys are always unenforced, the automatically created High_Group index for a multi-column primary key is a phantom index: it includes all of the key columns, but does not contain any data. This structure is used for query optimization, but not for resolving queries. You need to create explicitly an HG (or LF) index on any multi-column primary key columns that will be used in a join predicate.

The High_Non_Group (HNG) index type

Add an HNG index when you need to do range searches.

An HNG index requires approximately three times less disk space than an HG index requires. On that basis alone, if you do not need to do group operations, use an HNG index instead of a HG index.

Conversely, if you know you are going to do queries that a HG index handles more efficiently, or if the column is part of a join and/or you want to enforce uniqueness, use a HG index.

Note Using the HNG index in place of a HG index may seriously degrade performance of complex ad-hoc queries joining four or more tables. If query performance is important for such queries in your application, choose HG instead of HNG.

Recommended use

Use an HNG index when:

- The number of unique values is high (greater than 1000)
- You don't need to do GROUP BY on the column

Advantages and disadvantages of High_Non_Group

See the following table for advantages and disadvantages of using a High_Non_Group index.

Table 4-7: HNG advantages/disadvantages

Advantages	*Disadvantages*
Due to compression algorithms used, disk space requirements can be reduced without sacrificing performance.	This index is not recommended for GROUP BY queries.
If the column has a high number of unique values, this is the fastest index, with few exceptions described below.	Index not possible if uniqueness enforced. Cannot use this index if data in your columns is FLOAT, REAL, DOUBLE, BIT, or VARCHAR > 255 bytes.

Comparison to other indexes

- HNG needs less disk space than HG but can't perform GROUP BY efficiently.
- In choosing between LF and HNG, the determining factor is the number of unique values. Use HNG when the number of unique values is greater than 1000.

Additional indexes

The High_Group index is also appropriate for an HNG column.

Optimizing performance for ad hoc joins

To gain the fastest processing of ad hoc joins, create a Low_Fast or High_Group index on all columns that may be referenced in:

- WHERE clauses of ad hoc join queries
- HAVING clause conditions of ad hoc join queries outside of aggregate functions

For example:

```
SELECT n_name, sum(l_extendedprice*(1-l_discount))
    AS revenue
    FROM customer, orders, lineitem, supplier,
        nation, region
    WHERE c_custkey        = o_custkey
        AND o_orderkey     = l_orderkey
```

```
        AND l_suppkey      = s_suppkey
        AND c_nationkey    = s_nationkey
        AND s_nationkey    = n_nationkey
        AND n_regionkey    = r_regionkey
        AND r_name         = 'ASIA'
        AND o_orderdate   >= '1994-01-01'
        AND o_orderdate    < '1995-01-01'
GROUP BY n_name
HAVING n_name LIKE "I%"
    AND SUM(l_extendedprice*(1-l_discount)) > 0.50
ORDER BY 2 DESC
```

All columns referenced in this query except *l_extendedprice* and *l_discount* should have an LF or HG index.

Selecting an index

Here is a quick chart that summarizes how to select an index type.

Criteria to identify	***Index to select***
Note indexes created automatically on all columns.	*Default index*
Note indexes created automatically on columns with UNIQUE or PRIMARY KEY constraint.	HG with UNIQUE enforced
Identify all columns used in a join predicate and choose the index type depending on the number of unique values.	HG or LF
Identify columns that contain a low number of unique values and do not already use multiple indexes.	LF
Identify columns that have a high number of unique values and that are part of a GROUP BY clause in a select list in a SELECT DISTINCT or DISTINCT COUNT.	HG
Identify columns that may be used in the WHERE clause of ad hoc join queries that do not already have HG or LF indexes.	HG or LF
Identify columns that have a high number of unique values and that will not be used with GROUP BY, SELECT DISTINCT or DISTINCT COUNT.	HNG
Look at any remaining columns and decide on additional indexes based on the number of unique values, type of query, and disk space. Also, for all columns, be sure that the index types you select allow the data type for that column.	

Adding column indexes after inserting data

When you create an additional column index, the CREATE INDEX command creates the new index as part of the individual table and as part of any join indexes that include the column.

If the existing column indexes in the individual table already contain data, the CREATE INDEX statement also inserts data into the new index from an existing index. This ensures data integrity among all the column indexes for columns within an individual table. Data is also inserted and **synchronized** automatically when you add an index to previously loaded tables that are part of a join index. For information on synchronization, see “Synchronizing join indexes”.

This capability is useful if you discover that a column needs an additional index after you have already inserted data. This allows you to add the index without having to start over.

Note Inserting data from an existing index can be slow. It is always faster to create all the appropriate indexes before you insert data, then insert into all of them at once, with either the LOAD TABLE or INSERT statement.

Using join indexes

If you know that certain tables in the same database will typically be joined in a consistent way, you should create a *join index* for those tables. When you create a join index, Adaptive Server IQ produces a new internal structure that relates table columns. It represents two or more tables, including the inner, left outer, and right outer rows.

Join indexes improve query performance

Join indexes provide better query performance than when table joins are first defined at query time (ad hoc joins). However, they require more space and time to load. To load a join index, you must first load the underlying tables, and then load the join index.

How join indexes are used for queries

After you create a join index, its use is determined by the criteria of the SELECT statement. If a join index exists that joins the tables in the FROM clause by the relationship specified in the WHERE clause, or if a join index exists that is based on ANSI join syntax for natural or key joins, the join index is used to speed up queries. Otherwise, ad hoc joins between indexes on the individual tables are performed at query time. If there is a join index for a subset of tables in the SELECT, Adaptive Server IQ uses it to speed up the resulting ad hoc join.

Relationships in join indexes

Adaptive Server IQ join indexes support one-to-many join relationships. A simple example of a one-to-many relationship is a sales representative to a customer. A sales representative can have more than one customer, but a customer has only one sales representative.

There can be multiple levels of such relationships. However, you always specify join relationships between two tables, or between a table and a lower level join. The table that represents the “many” side of the relationship is called the *top table*. See “Join hierarchy overview” below for details.

When a join becomes ad hoc

If there is no join index that handles all of the reference tables involved in a query, the query is resolved with an ad hoc join. Because you cannot create a join index to represent a many-to-many join relationship, you can only issue ad hoc queries against such a relationship. Ad hoc queries provide flexibility at the expense of performance. If you have sufficient space for the join indexes, and you do not require many-to-many relationships, create join indexes whenever performance is critical.

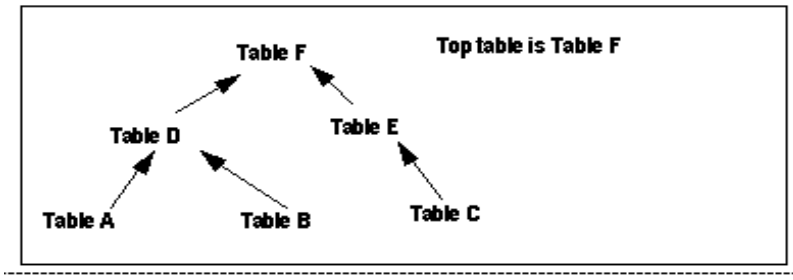
Join hierarchy overview

All join relationships supported by Adaptive Server IQ must have a hierarchy. Think of a join hierarchy as a tree that illustrates how all the tables in the join are connected.

Adaptive Server IQ join hierarchies have one table at the top of the tree where the join ends. This table, known as the *top table*, does not connect to any other tables, although other tables connect to it. The top table always represents the "many" side in a one-to-many relationship.

Depending on the complexity of the join, there could be a straight line of tables down to the bottom of the tree and the beginning of the join, or there could be many branches off to the side as you move down the tree. The following figure shows a join hierarchy with two branches.

Figure 4-1: Hierarchy of a join relationship



In a join hierarchy:

- A table can occur only once
- A table can only connect out once (one arrow leaving it)
- All tables must be connected

Columns in the join index

Suppose that you joined Tables A through E in a join index called ABCDE. If each table has two columns of data, expect the join index to have a total of fourteen columns. Adaptive Server IQ creates an additional column, the ROWID column, for each of the joined tables except the top table. In this case, there are ten columns (two from each of the five tables), plus four ROWID columns.

You can use the NOTIFY option of the LOAD TABLE or INSERT statement to receive notification messages when you insert into a column index. In these messages, the name of each column in a join index, including the ROWID column, is identified.

You can set the frequency of these messages with the NOTIFY_MODULUS option, and override the option value in either the CREATE DATABASE or LOAD TABLE command. For examples of these messages, see “Interpreting notification messages” on page 187.

The join hierarchy in query resolution

Adaptive Server IQ can use the same join index to resolve a query that involves the full join relationship specified in the join index, or a query that involves any contiguous subset of that relationship; you do not have to create separate join indexes for the subset relationships.

For example, assume that join index ABCDEF joins the tables illustrated in Figure 4-1. Adaptive Server IQ can use join index ABCDEF to resolve any queries that involve:

- The entire relationship
- Table A to Table D
- Table A to Table D to Table F
- Table B to Table D
- Table B to Table D to Table F
- Table D to Table F
- Table C to Table E
- Table E to Table F
- Table C to Table E to Table F

However, Adaptive Server IQ cannot use join index ABCDEF to resolve queries against, for example, Table E to Table D.

One-to-many relationship

In a one-to-many join relationship, one row in one table potentially matches with one or more rows in another table, and there is not more than one row in the first table that matches with the same row(s) in the second table. For this to be true, the values in the join column in the first table must be unique.

It is possible that either table has no match on the other table. This constitutes an outer join and is fully supported. For more information, see the *Introduction to Adaptive Server IQ*.

If the join column is made up of more than one column, the combination of the values must be unique on the “one” side. For example, in the asiqdemo database, the id in the customer table and the cust_id in the sales_order table each contain a customer ID. The customer table contains one row for each customer and, therefore, has a unique value in the id column in each row. The sales_order table contains one row for each transaction a customer has made. Presumably, there are many transactions for each customer, so there are multiple rows in the sales_order table with the same value in the cust_id column.

So, if you join customer.id to sales_order.cust_id, the join relationship is one-to-many. As you can see in the following example, for every row in customer, there are potentially many matching rows in sales_order.

```
select sales_order.id, sales_order.cust_id,
 customer.lname
from sales_order, customer
where sales_order.cust_id = customer
```

```
id   cust_id    id             lname
             2583,101,101,'Devlin'
 2001,101,101,'Devlin'
 2005,101,101,'Devlin'
 2125,101,101,'Devlin'
 2206,101,101,'Devlin'
 2279,101,101,'Devlin'
 2295,101,101,'Devlin'
 2002,102,102,'Reiser'
 2142,102,102,'Reiser'
 2318,102,102,'Reiser'
 2338,102,102,'Reiser'
 2449,102,102,'Reiser'
 2562,102,102,'Reiser'
 2585,102,102,'Reiser'
 2340,103,103,'Niedringhaus'
 2451,103,103,'Niedringhaus'
 2564,103,103,'Niedringhaus'
 2587,103,103,'Niedringhaus'
 2003,103,103,'Niedringhaus'
 2178,103,103,'Niedringhaus'
 2207,103,103,'Niedringhaus'
```

```
2307,103,103,'Niedringhaus'
```

Warning! If the one-to-many relationship is incorrect, the join cannot be synchronized until you remove the extra rows from the "one" table. If you try to synchronize, you get a Duplicate Row error, and the transaction rolls back.

When you create a join index, you use ANSI FULL OUTER join syntax. Adaptive Server IQ stores the index as a full outer join. Later, when you issue queries against the columns in a join index, you can specify inner, left outer, and right outer join relationships as well as full outer joins. Adaptive Server IQ uses only the parts of the join index needed for a given query.

Multiple table joins and performance

Here are rules for multiple table joins:

- A table can be on the "one" side of a one-to-many relationship just once. For example, you cannot have a join index or a join query where Table A is joined to Table B in a one-to-many relationship, and Table A is joined to Table C in a one-to-many relationship. You need to create separate join indexes for each of these relationships.
- A table can appear in the relationship hierarchy only once. So, for example, you cannot predefine a join relationship query where Table A is joined to Table B, Table B is joined to Table C, and Table C is joined to Table A. You can use predefined joins to query on the Table A to Table B and the Table C to Table A relationships separately. To do so, create a separate join index for each of these relationships.
- A table can be joined to another table, or to a join definition. For example, you can create a join index that joins Table A to Table B, or a join index that joins Table C to the join of Tables A and B.
- The top table in the hierarchy is the "many" side of a one-to-many relationship with the rest of the hierarchy.

In some circumstances, you may want to create a separate join index for a subset of the join relationship. If the top table in the subset of the join index has a significantly smaller number of rows than the top table in the full join index, a query on the subset may be faster than the same query on the full join index if only tables in the subset are used in the query.

Of course, this approach requires more disk space to build an additional join index and more index building time (not to mention increased maintenance). In the case of a subset join index, the additional join index repeats a subset of the information already in the full join index. You must decide whether the query speed or disk space usage of your application is more important for this particular join relationship.

Steps in creating a join index

In order to create a join index you must perform all of the following steps:

1 Create the tables involved in the join index, using the CREATE TABLE command, or using Sybase Central.

2 Identify the *join condition* that relates specific pairs of columns in the underlying tables involved in any one join. Where the relationship is based on a key join, you must define join conditions as referential integrity constraints—primary and foreign key declarations—in the CREATE TABLE commands in step 1, or in ALTER TABLE commands.

3 Create column indexes for the tables being joined.

When Adaptive Server IQ creates a join index between tables, the IQ column index types and data types already defined on the single tables are used in the join index.

4 Load the data into the tables, using the LOAD TABLE command. You also can add data to existing tables using the INSERT INTO command.

Note You must insert into the column index of each table in the join index as a single-table insert, rather than into the join index itself. This approach conforms to ANSI rules for prejoined data.

---

5 Create the join index by issuing the CREATE JOIN INDEX command, or in Sybase Central with the Add JoinIndex Wizard. You specify the join hierarchy as part of this step, as described in “Join hierarchy overview”.

Note If data exists in the join tables, a synchronize occurs automatically.

---

6 Depending on the order in which you perform these steps, you may need to synchronize the tables in the join index, as described below. If data exists in the join tables, synchronization occurs automatically.

The index remains unavailable until all steps are complete. However, you can adjust the order of some steps, depending on the needs of your site:

- You can combine steps 1 and 2 by defining relationships when you create the table.
- You can load the data either before or after you create the join index. If you load the data into the underlying column indexes after you create the join index, you must perform the synchronization step.

Privileges needed to create a join index

You must be the owner of a table or the DBA to create, alter, or synchronize a join index that includes that table. If you are not the DBA, you need to be the owner of the table *and have RESOURCE authority* in order to create a join index.

For details on inserting and deleting data, see Chapter 5, "Moving Data In and Out of Databases" For complete syntax of the CREATE TABLE, ALTER TABLE, LOAD TABLE, INSERT INTO, and SYNCHRONIZE commands, see the *Adaptive Server IQ Reference Manual*. The sections that follow give details on other steps in creating a join index.

Synchronizing join indexes

The data in join index tables must be synchronized before you can use a join index. Synchronization ensures that the data is loaded in the correct order for the joins.

Synchronization occurs automatically when you create the join index. Synchronizing before completing the transaction that loads or inserts data also makes tables available immediately for all readers. Once data is loaded, however, you must synchronize the join index explicitly, with one exception: the join index is synchronized automatically when changes are made to the top table of the join hierarchy.

To synchronize explicitly, issue the following command:

SYNCHRONIZE JOIN INDEX [*join-index-name* [, *join-index-name*]

If you omit the index names, Adaptive Server IQ synchronizes all join indexes.

Performance hints for synchronization

Synchronization can be time-consuming. To improve performance, try these suggestions:

- Schedule synchronization during off-peak hours.
- Synchronize join indexes individually rather than all at once.
- Synchronize after executing an entire set of insertions and deletions. It is not a good idea to synchronize after every insertion or deletion, as the time it takes to update a join index depends significantly on the order of the updates to the tables. Synchronizing sets of updates allows Adaptive Server IQ to pick the optimal order for applying the table changes to the join index.

Defining join relationships between tables

When you create a join index, you must specify the relationship between each related pair in the join. A related pair is always two tables, however, you can also specify a relationship by relating a table to another join relationship.

Depending on the relationship, you specify it either once or twice:

- **Key joins** relate the primary key of one table to a foreign key in another table. For key joins you must specify a PRIMARY KEY and FOREIGN KEY when you create or alter the underlying tables, using the CREATE TABLE or ALTER TABLE command.
- For all joins, you specify the relationship when you create the join index, using the CREATE JOIN INDEX command. The join is defined by the order in which you list the tables, by the columns you specify, and by the join type: key join, natural join, or ON clause join.

Rules for join relationships are:

- Each pair of tables in a join relationship must have at least one join column.
- The join column must exist in both tables.
- A pair of tables can have more than one join column, as long as they have the same number of columns and the join column holds the same position in each table list when you specify it. The order of the lists for the two tables determines how the columns are matched.

Using foreign references

Adaptive Server IQ uses foreign keys to define the relationships among columns that will be used in join indexes, and to optimize queries. However, Adaptive Server IQ does not enforce foreign key constraints. For this reason, when you specify a primary key-foreign key relationship, you must include the UNENFORCED keyword.

Adaptive Server IQ does not support key join indexes based on multicolumn foreign keys.

Examples of join relationships in table definitions

The following example shows how you specify the join relationship by means of primary and foreign keys. In this case, one customer can have many sales orders, so there is a one-to-many relationship between the id column of the customer table (its primary key) and the cust_id column of the sales_order table. Therefore, you designate cust_id in sales_order as a FOREIGN KEY that references the id column of the customer table.

The first example creates the customer table, with the column id as its primary key. To simplify the example, other columns are represented here by ellipses (...).

```
CREATE TABLE DBA.customer
( id integer NOT NULL,
...
PRIMARY KEY (id),)
```

Then you create the sales_order table with six columns, specifying the column named id as the primary key. You also need to add a foreign key relating the cust_id column of the sales_order table to the id column of the customer table.

You can add the foreign key either when you create the table or later. This example adds the foreign key by including the REFERENCES clause as a column constraint in the CREATE TABLE statement.

```
CREATE TABLE DBA.sales_order
(id integer NOT NULL,
cust_id integer NOT NULL
REFERENCES DBA.customer(id) UNENFORCED,
order_date date NOT NULL,
fin-code-id char(2),
region char(7),
sales_rep integer NOT NULL,
PRIMARY KEY (id),)
```

Alternatively, you could create the table without the REFERENCES clause, and then add the foreign key later, as is done in the following ALTER TABLE statement:

```
ALTER TABLE DBA.sales_order
ADD FOREIGN KEY ky_so_customer (cust_id)
REFERENCES DBA.customer (id) UNENFORCED
```

Specifying the join type when creating a join index

The join type is always FULL OUTER, the keyword OUTER being optional. You also need to do one of the following:

- If you are joining equivalent columns with the same name from two tables, you specify that it is a NATURAL JOIN.
- If you are joining columns based on keys, you must also have specified the relationship in the underlying tables as a FOREIGN KEY that references a PRIMARY KEY.
- If you are joining equivalent values (an *equijoin*) in columns from two tables, you specify an ON clause.

These rules conform to ANSI syntax requirements.

Specifying relationships when creating a join index

For non-key joins, the order in which you specify tables when you create the join index determines the hierarchy of the join relationship between the tables. The CREATE JOIN INDEX statement supports two ways to specify the join hierarchy:

- List each table starting with the lowest one in the hierarchy, and spell out the join relationship between each pair of tables. The last table in the list will be the top table in the hierarchy. For example, in Figure 4-1 on page 153, F is the top table, E is below it, and C is at the bottom of the hierarchy. You could specify the join hierarchy for these three tables as follows:

  ```
  C FULL OUTER JOIN E FULL OUTER JOIN F
  ```

- Use parentheses to control the order in which the join relationships are evaluated. Parentheses control evaluation order just as they do in mathematics, that is, innermost pairs are evaluated first. With this method you start with the top table in the outermost set of parentheses, then any intermediate levels, and include the lowest two levels in the innermost parentheses. Using this method, you would specify the same three tables as follows:

  ```
  (F FULL OUTER JOIN (C FULL OUTER JOIN E))
  ```

  Note that the lowest level table appears first in the innermost parentheses, just as it does in the first method.

Note While you can join these three tables in the way described here, in order to create the complete hierarchy shown in Figure 4-1 you would need to use key joins. See “Types of join hierarchies” for more information.

When you create a join index, a message in the log identifies the top table in the join. For example,

```
[20691]: Join Index 'join_on_tabletable' created from the following join
relations:
 [20694]:      Table Name             Relationship
 [20697]: ------------------------------------------------------------
 [20696]: 1. join_on_table_a joined to 'join_on_table_b' One >> Many
 [20692]: The ultimate/top table is join_on_table_b
 [20697]: ------------------------------------------------------------
```

Issuing the CREATE JOIN INDEX statement

To create a join index, issue the CREATE JOIN INDEX statement. Here is a summary of the syntax for this command:

CREATE JOIN INDEX *join-index-name* **FOR** *join-clause*

The parameters of this command are:

join-clause:
[( ] *join-expression join-type join-expression*
[**ON** *search-condition*] [ )]

join-expression:
{ *table-name* | *join-clause* }

join-type:
[**NATURAL**] **FULL** [**OUTER**] **JOIN**

search-condition:
[( ] *search-expression* [**AND** *search-expression*] [ )]

- The *join-clause* can be expressed either with or without parentheses.
- The ON clause can reference only two tables. One must be the current one, and the other can be any one table in the current join tree.
- All join predicates must be equijoins; that is, the *search_expression* must indicate that the value in *column_1* equals the value in *column_2*. No single-variable predicates, intracolumn comparisons, or non-equality joins are permitted in the ON clause.
- To specify a multicolumn join, you include more than one predicate linking the two tables, and connect them with logical AND.
- You cannot connect join predicates with logical OR.
- The keyword NATURAL can replace the ON clause, when you are pairing columns from a single pair of tables by name.

Example 1: Key join

Here is an example of how you create a join index for the key join between the sales_order table and the customer table. Remember that this is a key join, based on the foreign key ky_so_customer which relates the cust_id column of sales_order to the primary key id of the customer table. You can give the index any name you want. This example names it ky_so_customer_join to identify the foreign key on which the key join relies.

```
CREATE JOIN INDEX ky_so_customer_join
FOR customer FULL OUTER JOIN sales_order
```

Example 2: ON clause join

The next example shows how you could create a join index for the same two tables using an ON clause. You could use this syntax whether or not the foreign key existed.

```
CREATE JOIN INDEX customer_sales_order_join
FOR customer FULL OUTER JOIN sales_order
ON customer_id=sales_order.cust_id
```

Example 3: Natural join

To create a natural join, the joined columns must have the same name. If you created a natural join on the tables in previous examples, you would not get the expected results at all. Instead of joining the id column of customer to the cust_id column of sales_order, the following command would join the dissimilar id columns of the two tables:

```
CREATE JOIN INDEX customer_sales_order_join
FOR customer NATURAL FULL OUTER JOIN sales_order
```

A natural join between the id columns of sales_order and sales_order_items makes more sense. In this case, the columns with the same name should contain matching values. The command to create a join index based on a natural join between these two tables is:

```
CREATE JOIN INDEX sales_order_so_items_join
FOR sales_order NATURAL FULL OUTER JOIN
sales_order_items
```

Creating a join index in Sybase Central

To create a join index in Sybase Central, follow these steps.

❖ **To add a join index in Sybase Central:**

1. Select the Join Indexes folder in the left panel of the Sybase Central window.
2. Double-click the Add Join Index object in the right panel to open the Join Index editor.
3. Highlight <Unnamed> in the Name box and enter a name for the index.
4. From the Left Table Name dropdown, select a table name. Repeat for the Right Table Name.
5. Select a Join Type from the dropdown. If you select a type other than Natural, specify the Join Columns.
6. Click Advanced Properties to add a comment.
7. If you are only joining two tables, click Save and Commit.
8. To join more than two tables, click Add Row. In the new row that appears, enter the next table to join in the Right Table Name column. Then click Save and Commit.

Types of join hierarchies

Adaptive Server IQ supports two different types of join hierarchies:

- Linear joins
- Star joins

You create join indexes or ad hoc joins for both linear and star joins.

Linear joins

You can think of a linear join as a tree with no branches. Each table in the hierarchy is related to the table above it, until you reach the top table. In Figure 4-1 on page 153. Tables A, D, and F constitute a linear join hierarchy. Tables C, E, and F form another linear join hierarchy.

In a linear join, each pair of tables represents a one-to-many relationship, in which the lower table of the pair is the “one” side, and the higher table of the pair is the “many” side. Linear join hierarchies can rely on any of the underlying join conditions: key join, natural join, or ON clause join.

Star joins

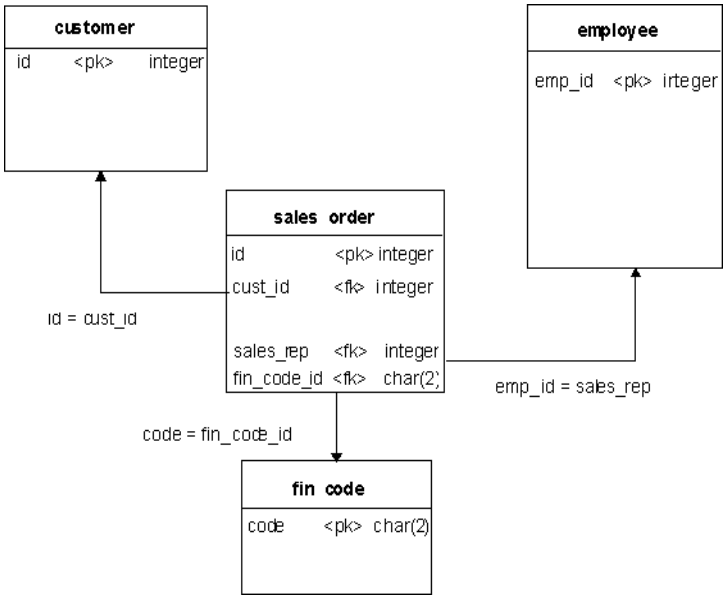
You can picture a star join as a structure with many branches, in which each branch is directly related to one table in the middle. In Figure 4-1, Tables D, F, and E form a very simple star join. More commonly, Table F would be at the center of many tables, each of which is joined to Table F.

In a star join, multiple tables are related to one table at the center of the join, in a one-to-many relationship. The one table at the center of the join represents the “many” side of the relationship, while each of the tables around it represent the “one” side of the relationship. Each table on the “one” side holds a set of values with its own unique primary key. A foreign key in the table on the “many” side of the relationship relates that table to the primary key of the table on the “one” side of the relationship.

The “many” table at the center of the star is sometimes called the **fact** table. The “one” tables related to it are called the **dimension** tables.

Example

In the sample database used throughout this book, the sales_order table contains three foreign keys, each of which is related to the primary key of another table.



You can create this table using the following commands:

```
CREATE TABLE "DBA"."sales_order"(
(
"id"           integer NOT NULL,
"cust_id"      integer NOT NULL
REFERENCES "DBA"."customer" ("id")
UNENFORCED,
"order_date"   datetime NOT NULL,
"fin_code_id"  char(2) NULL
REFERENCES "DBA"."fin_code" ("code")
UNENFORCED,
"region"       char(7) NULL,
"sales_rep"    integer NOT NULL
REFERENCES "DBA"."employee" ("emp_id")
UNENFORCED,
PRIMARY KEY ("id"),
);
```

As shown in the figure, the sales_order table is at the center of the star join. Each of its foreign key columns can contain many instances of the primary key it refers to. For example, if you enter:

```
SELECT sales_rep FROM sales_order
WHERE sales_rep = 299
```

the results show 20 rows with 299 in the sales_rep column.

However, if you enter:

```
SELECT emp_id FROM employee
WHERE emp_id = 299
```

the results show only one row with 299 in the emp_id column.

Note Query optimizations for star joins rely on the underlying primary key-foreign key relationships. Because Adaptive Server IQ does not enforce foreign keys, in order for your query results to be exactly as expected, your application needs to ensure that data inserted into or deleted from the database does not violate the primary key-foreign key relationship.

To declare a foreign key, see "Creating primary and foreign keys" on page 125. For other information on foreign keys, see "Declaring entity and referential integrity" on page 281.

Modifying tables included in a join index

Once you have created a join index, you are restricted in the types of changes you can make to the join index and its underlying tables and indexes.

You cannot drop any table that participates in a join index. Likewise, you cannot use ALTER TABLE to add, drop, or modify a column that participates in a join index. In both cases, you must first drop the join index. Then you can either drop the table, or modify any columns that participate in the join index.

You can add columns to the tables that participate in a join index. However, there are restrictions on inserting data into these columns, as described in the next section.

You can drop indexes on columns not involved in the join relationship, and you can add, drop or modify nonjoined columns of tables in a join index. However, you cannot drop either the indexes on a join column or the join column itself. You need at least one index on a column involved in a predefined join relationship. It is highly desirable to have either an HG or LF index on all columns that are part of a join index.

Adaptive Server IQ automatically applies the changes to the join index at the same time as it changes the base table. You do not need to synchronize the join index after any ALTER TABLE on nonjoined columns.

Other restrictions on ALTER TABLE for join indexes include the following:

- You cannot rename a column into or out of a NATURAL join condition.
- You cannot add a column that would participate in a previously specified NATURAL join.
- You cannot drop a PRIMARY KEY/FOREIGN KEY relationship if it matches a join condition that is in use in a join index.
- You cannot drop a NOT NULL constraint from a column that participates in a join condition.
- You cannot modify the data type of a column that participates in a join condition.

Inserting or deleting from tables in a join index

You always insert or load into, or delete from, the underlying tables, not the join index itself. When you first create the join index, Adaptive Server IQ synchronizes the joined tables automatically, whether or not you have previously loaded data into the tables.

If you insert into or delete from a table that participates in an existing join index, you must synchronize the join index explicitly, unless you are updating the top table in the join hierarchy. If you insert rows and then delete them before the synchronization takes place, Adaptive Server IQ optimizes synchronization to omit the insertions.

You cannot perform partial-width inserts to tables that participate in a join index. If you need to add columns to a table in a join index, you must do one of the following:

- Drop the join index, do the partial-width insert, and then recreate the join index.
- Load or insert into all columns of the table.

Table versioning controls access to join indexes

Any table is only available for write use to a single user at any given time. For join indexes, this means that when one user is updating any table in a join index, no one else can update any of the tables in that index. All the joined tables remain unavailable until the first user's transaction is committed and you have synchronized the tables with the SYNCHRONIZE command.

Other users receive the following error while the join index tables are in use:

```
Cannot write to this table in current transaction.
Another user has write mode access.
```

Their current transactions cannot write to any of the join index tables; they must begin a new transaction to write to those tables.

For more information on versioning, see Chapter 8, "Transactions and Versioning"

Estimating the size of a join index

Adaptive Server IQ provides a stored procedure, sp_iqestjoin, to help you estimate the size of a join index.

You run this procedure for each pair of tables being joined. Each time you run the procedure, you must supply the following parameters:

- Name of the first table to be joined
- Number of rows in the first table
- Name of the second table to be joined
- Number of rows in the second table
- Relationship (default is one-to-many)
- IQ page size (default is 65536 bytes, or 64KB)

Many factors affect the size of a join index, especially the number of outer joins it includes. For this reason, the procedure offers you three types of results. If you know you will always join the tables with exact one-to-one matches, use the "Min Case index_size." If you anticipate occasional one-to-many joins, use the "Avg Case index_size." If you anticipate using numerous one-to-many joins, use the "Max Case index_size."

These calculations should give you an idea of how much disk space you need for the join index. The results include the segment size in bytes, and the number of blocks. The procedure also tells you how long it will take to create the join index.

If you want to know the actual size of an existing join index, you use a different stored procedure, sp_iqjoinindexsize.

See the *Adaptive Server IQ Reference Manual* for syntax details of all stored procedures.

CHAPTER 5

Moving Data In and Out of Databases

About this chapter

This chapter describes several methods of moving data into and out of your database, and explains when you should use each of them. It also discusses conversion issues for data inserted from other types of databases.

Import and export overview

Adaptive Server IQ lets you import data from flat files, or directly from database tables. You can also enter specified values directly into the database. Export of data to other formats, such as spreadsheet program formats, is available from the DBISQL utility.

An Adaptive Server IQ table is a logical table; it does not contain data. All the information needed to resolve queries, including data, is contained in the Adaptive Server IQ indexes. When you insert data into the columns in an IQ table, you are not actually adding data to the columns in the table, but rather to the column indexes. You build indexes by inserting data on a table-by-table basis.

Import and export methods

Adaptive Server IQ offers you a choice of methods for adding, changing, or deleting data.

- For efficient bulk loading of tables from flat files, use the SQL statement LOAD TABLE.
- To insert specified values into a table row by row, use the SQL statement INSERT with the VALUES option.
- To insert rows selected from a database, use the SQL statement INSERT with a SELECT statement clause.

- To remove specific rows from a table, use the DELETE statement.
- To change existing rows in a table, you can also use the UPDATE statement.

From DBISQL you can export data to another database in a variety of formats, or produce a text file as output. See the next section for a list of formats and how to select them. You can also redirect the output of any command.

Input and output data formats

The LOAD TABLE statement imports text files with one row per line. Both ASCII and binary input files are supported, with either fixed-length fields or variable-length fields ended by a delimiter.

The INSERT statement moves data into an Adaptive Server IQ table either from a specified set of values, or directly from tables.

Interactive SQL supports the following output file formats:

File Format	Description
ASCII	A text file, one row per line, with values separated by a delimiter. String values are optionally enclosed in apostrophes (single quotes). This is the same as the format used by LOAD TABLE
DBASEII	DBASE II format
DBASEIII	DBASE III format
DIF	Data Interchange Format
FIXED	Data records are in fixed format with the width of each column either the same as defined by the column's type or specified as a parameter
FOXPRO	FoxPro format
LOTUS	Lotus workspace format
SQL	Interactive SQL INPUT statement required to recreate the information in the table
TEXT	TEXT format file that prints the results in columns with the column names at the top and vertical lines separating the columns. This format is similar to that used to display data in the Interactive SQL data window
WATFILE	WATFILE format.

Specifying an output format for Interactive SQL

You can set the DBISQL output format in three ways:

- Select Command → Options from the DBISQL menu bar, and then choose an Output Format from the dropdown list. To make this the default output format, click Permanent.
- Specify the DBISQL option, OUTPUT_FORMAT, to set the default output format.

For syntax details see the *Adaptive Server IQ Reference Manual.*

Permissions for modifying data

You can only execute data modification statements if you have the proper permissions on the database tables you want to modify. The database administrator and the owners of database objects use the GRANT and REVOKE statements to decide who has access to which data modification functions.

To insert data, you need INSERT permission for that table or view. To delete data, you need DELETE permission for that table or view. To update data, you need UPDATE permission. The DBA can insert into or delete from any table. The owner of a table has INSERT, DELETE, and UPDATE permission on it.

Permissions can be granted to and revoked from individual users, groups, or the public group. For more information on permissions, see Chapter 10, “Managing User IDs and Permissions”.

Scheduling database updates

Multiple users can query a database table while one user inserts data into that table. Multiple users can update the database concurrently, as long as they are inserting into or deleting from different tables.

When you allow concurrent use of the database during updates, you pay a penalty in performance and disk use. For an explanation of how Adaptive Server IQ handles concurrency issues, see Chapter 8, “Transactions and Versioning” For other suggestions on improving load performance, see “Tuning bulk loading of data”

Exporting data from a database

This section tells how to export data from an Adaptive Server IQ database.

Note To export IQ data from your database in this version of Adaptive Server IQ, Sybase recommends that you use the method described in this chapter. You may also export data by using a front end tool, written by you or a third party, that effectively queries the IQ database and formats the data as desired.

If you need to export tables (other than your system tables) from your Catalog Store, use the method in this chapter, or see the *Adaptive Server Anywhere Reference Guide* for other ways to unload data.

Using output redirection

Output redirection can be used to export query results.

You can redirect the output of any command to a file or device by putting the ># redirection symbol anywhere on the command. The redirection symbol must be followed by a file name. (In a command file, the file name is then followed by the semicolon used as statement terminator.) The file is placed relative to the directory where DBISQL was started.

In this example, output is redirected to the file *empfile*:

```
SELECT *
FROM employee
>#  empfile
```

Do not enclose the file name in quotation marks.

Output redirection is most useful on the SELECT statement. Use the OUTPUT_FORMAT option to control the format of the output file and the OUTPUT_LENGTH option to control truncation. For example, the following commands set the format to ASCII text and does not truncate column contents:

```
SET OPTION OUTPUT_FORMAT = ‘text’
SET OPTION OUTPUT_LENGTH = 0
```

Use two > characters in a redirection symbol instead of one (for example, >>#), to append the output to the specified file instead of replacing the contents of the file. Headings are included in the output from the SELECT statement if the output starts at the beginning of the specified file and the output format supports headings.

Redirecting output and messages

The >& redirection symbol redirects all output including error messages and statistics for the command on which it appears. For example:

```
SELECT *
FROM employee
>& empfile
```

Do not enclose the file name in quotation marks.

This example outputs the SELECT statement to the file *empfile*, followed by the output from the SELECT statement and some statistics pertaining to the command.

The >& redirection method is useful for getting a log of what happens during a READ command. The statistics and errors of each command are written following the command in the redirected output file.

NULL value output

The most common reason to extract data is for use in other software products. The other software package may not understand NULL values, however.

The DBISQL option NULLS allows you to choose how NULL values are output. Alternatively, you can use the IFNULL function to output a specific value whenever there is a NULL value.

For information on setting DBISQL options, see “SET OPTION statement” in *Adaptive Server IQ Reference Manual*.

Bulk loading data using the LOAD TABLE statement

The LOAD TABLE statement is used for efficient importing of data from a text or binary file into an existing database table. It loads data into any column indexes you have defined, as well as any created automatically.

In order to use the LOAD TABLE statement, you need INSERT permission on the table.

See the description of the ON FILE ERROR load option for what happens when errors occur during a load.

Using command files to load data

To load large amounts of data, most users create command files. To create a command file, follow the instructions in the chapter entitled "Getting Started with DBISQL" in the *Introduction to Adaptive Server IQ*.

Transaction processing and LOAD TABLE

When you issue the LOAD TABLE statement for an IQ table, a savepoint occurs automatically before the data is loaded. If the load completes successfully, Adaptive Server IQ releases the savepoint. If the load fails, the transaction rolls back to the savepoint. This approach gives you flexibility in committing transactions. For example, if you issue two LOAD TABLE commands, you can ensure that either both commit or neither.

When you issue LOAD TABLE for a Catalog Store table, there is no automatic savepoint. If the load succeeds, it commits automatically. If the load fails, it rolls back. You cannot roll back a successful load of a Catalog Store table.

For more information on transaction processing, see Chapter 8, "Transactions and Versioning".

Summary of LOAD TABLE syntax

The basic form of the LOAD TABLE statement is:

LOAD TABLE [*owner*].*table-name*
[(*load-specification*, ...)]
FROM '*filename-string*', ...
[**FORMAT** { **'ascii'** | **'binary'** }]
... [**DELIMITED BY** *string*]
... [**STRIP** { **ON** | **OFF** }]
... [**QUOTES** { **ON** | **OFF** }]
... [**ESCAPES** { **ON** | **OFF** }]
[**ESCAPE CHARACTER** character]
[**WITH CHECKPOINT ON**|**OFF**]
... [*load-options*]

Load specification

The *load-specification* does the following:

- Lists each column to be loaded and describes the data in it. A column can contain fixed-length data, variable-length characters delimited by a separator, or data that uses a binary prefix to represent the number of bytes being read.
- Specifies FILLER format for any fields you want to skip.

The syntax for *load-specification* is as follows:

load-specification:
{ *column-name* [*column-spec*] |
FILLER (*filler-type*) }

For each column, you can specify a *column-spec*. If you omit this option, the format information in the *load-options* applies to this column. The *column-spec* and *load-options* format information tell Adaptive Server IQ what type of data to expect, and how to convert it into a compatible data format if necessary.

Syntax for the *column-spec* is:

column-spec:
{ **ASCII** (*input-width*) |
BINARY [**WITH NULL BYTE**] |
PREFIX { **1** | **2** | **4** } |
'*delimiter-string*' |
DATE (*input-date-format*) |
TIME (*input-time-format*) |
DATETIME (*input-datetime-format*) }
[**NULL** ({ **BLANKS** | **ZEROS** | '*literal*', ... })]

You can specify the following types of data in the *column-spec*:

- Data with bytes of fixed length. Although specified by the keyword ASCII, any 8-bit characters may be used, and for 16-bit character sets, two 8-bit characters are used for each 16-bit character. No code conversion is performed for char and varchar fields except truncation, blank stripping, or blank padding. ASCII is also used to fill numeric data, time, and date-time fields. In each case, the conversion is the same if the value were first inserted as a character field, then cast to the data type of the column in the table. The *input-width* value is an integer value indicating the fixed width in bytes of the input field in every record.
- Binary fields that use a number of PREFIX bytes (1, 2, or 4) to specify the length of the binary input. The BINARY keyword indicates that data is already converted to the internal form (except for when the byte-order load option is specified.
- Variable-length characters delimited by a separator. You specify the *delimiter-string* as a string of one to four ASCII characters, or any 8–bit hexadecimal ASCII code that represents a single, non-printing character. The delimiter-string must be enclosed in single quotes. For example, you specify:
  - '\x09' to represent a tab as the terminator.
  - '\x00' for a null terminator (no visible terminator as in “C” strings).
  - '\x0a' for a newline character as the terminator. You can also use the special character combination of \n for newline.

- DATE, TIME, DATETIME or TIMESTAMP string as ASCII characters. You must define the *input-date-format* or *input-datetime-format* of the string using one of the corresponding formats for the date and datetime data types supported by Adaptive Server IQ. For information about these, see the *Adaptive Server IQ Reference Manual*.

Note The *column-spec* is for IQ tables only. If you specify a *column-spec* for a Catalog Store table, you get an error.

The NULL portion of the *column-spec* indicates how to treat certain input values as NULL values when loading into the table column. These characters can include BLANKS, ZEROS, or any other list of literals you define. When you specify a NULL value or read a NULL value from the source file, the destination column must be able to contain NULLs.

The FILLER clause indicates you want to skip over a specified field in the source input file. For example, there may be characters at the end of rows or even entire fields in the input files that you do not want to add to the table. As with the *column-spec* definition, FILLER allows you to specify ASCII fixed length of bytes, variable length characters delimited by a separator, and binary fields using PREFIX bytes. FILLER clause syntax is as follows:

FILLER (*filler-type*)
filler-type:
{ *input-width* | **PREFIX** { **1** | **2** | **4** } | '*delimiter-string*' }

For more information on how to use data conversion options, see "Converting data on insertion".

Specifying files to load

You specify one or more files from which to load data. In the FROM clause, you specify each *filename-string*, and separate multiple strings by commas.

The files are read one at a time, and processed in a left-to-right order as specified in the FROM clause. Any SKIP or LIMIT value only applies in the beginning of the load, not for each file.

If a load cannot complete, for example due to insufficient memory, the entire load transaction is rolled back.

filename-string The *filename-string* is passed to the server as a string. The string is therefore subject to the same formatting requirements as other SQL strings. In particular:

- If a backslash (\) precedes the characters n, x, or \ it is considered an escape character. For this reason, to indicate directory paths in Windows NT systems, you must represent the backslash character by two backslashes if the next character is any of those listed. (It is always safe to double the backslashes.) Therefore, the statement to load data from the file *c:\newinput.dat* into the employee table is:

  ```
  LOAD TABLE employee
  FROM 'c:\\newinput.dat' ...
  ```

- The pathname is relative to the database server, not to the client application. If you are running the statement on a database server on some other computer, the directory name refers to directories on the server machine, not on the client machine. The input file for the load must be on the server machine.

Named pipes

The file specification can be a named pipe. When you load from a named pipe (or FIFO) on Windows NT, the program writing to the pipe must close the pipe in a special way. The pipe writer must call FlushFileBuffers( ) and then DisconnectNamedPipe( ). (If you do not, Adaptive Server IQ reports an exception from hos_io::Read( ).) This issues a PIPE_NOT_CONNECTED error, which notifies Adaptive Server IQ that the pipe was shut down in an orderly manner rather than an uncontrolled disconnect. See Microsoft documentation for details on these calls.

Specifying table-wide format options

You can specify several options that describe the format of input data.

FORMAT option You can specify a default format for table columns, which applies if you omit the *column-spec*. The same formats that can appear in the *column-spec* can appear here. If you also omit the FORMAT load option, the file is assumed to be binary.

DELIMITED BY option If you omit a column delimiter in the *column-spec* definition, the default column delimiter character is a comma. You can specify an alternative column delimiter by providing a string consisting of *one to four* ASCII characters, or the hexadecimal representation for a character. The same formatting requirements apply as to other SQL strings. In particular, to specify tab-delimited values use the hexadecimal ASCII code of the tab character (9), as follows:

```
...DELIMITED BY '\x09' ...
```

To use the newline character as a delimiter, you can specify either the special combination '\n' or its ASCII value '\x0a'.

STRIP option With STRIP turned on (the default), trailing blanks are stripped from values before they are inserted. This is effective only for VARCHAR data. To turn the STRIP option off, enter the clause as follows:

```
...STRIP OFF ...
```

Trailing blanks are stripped only for non-quoted strings. Quoted strings retain their trailing blanks. If you don't require blank sensitivity, you may use the FILLER option allows you to be more specific in the number of bytes to strip instead of just all the trailing spaces.

This option does not apply to ASCII fixed-width inserts. For example, the STRIP option in the following statement is ignored:

```
LOAD TABLE dba.foo (col1 ascii(3), col2 ascii(3))
FROM foo_data QUOTES OFF ESCAPES OFF STRIP ON
```

QUOTES option *Currently, you must specify* QUOTES OFF. With quotes off, Adaptive Server IQ does not strip off apostrophes (single quotes) or quotation marks (double quotes). When it encounters these characters in your input file, it treats them as part of the data.

With quotes off, you cannot include column delimiter characters in column values.

ESCAPES option *Currently, you must specify* ESCAPES OFF. The default of ESCAPES ON is provided for compatibility with Adaptive Server Anywhere; this option may be supported in a future version. With ESCAPES turned on, if you omit a *column-spec* definition for an input field, characters following the backslash character are recognized and interpreted as special characters by the database server. Newline characters can be included as the combination \n, and other characters can be included in data as hexadecimal ASCII codes, such as \x09 for the tab character. A sequence of two backslash characters (\\ ) is interpreted as a single backslash.

Example

The following UNIX example specifies a BLOCK FACTOR of 50,000 records along with the PREVIEW option:

```
LOAD TABLE lineitem
    (l_shipmode ASCII(15),
    l_quantity ASCII(8),
    FILLER(30))
FROM '/d1/MILL1/tt.t'
BLOCK FACTOR 50000 PREVIEW ON
```

Specifying load options

You can specify a wide range of load options. These options tell Adaptive Server IQ how to interpret and process the input file, and what to do when errors occur.

You can specify load options in any order. Syntax for *load-options* is as follows:

```
    [ { BLOCK FACTOR number | BLOCK SIZE number } ]
... [ BYTE ORDER { NATIVE | HIGH | LOW } ]
... [ LIMIT number-of-rows ]
... [ NOTIFY number-of-rows ]
... [ ON FILE ERROR { ROLLBACK | FINISH | CONTINUE} ]
... [ PREVIEW { ON | OFF } ]
... [ ROW DELIMITED BY 'delimiter-string' ]
... [ SKIP number-of-rows ]
... [ START ROW ID number ]
... [ UNLOAD FORMAT ]
```

Each of these options is described briefly below. For details of all options of the LOAD TABLE statement, see the Adaptive Server IQ Reference.

BLOCK FACTOR option Specifies blocking factor, or number of records per block, used when a source was created. This option is not valid for insertions from variable length input fields; use the BLOCK SIZE option instead. However, it does affect all file inserts (including from disk) with fixed length input fields, and it can affect performance dramatically.

The default setting for BLOCK FACTOR is 10,000. Higher block factors generally improve the speed of I/O operations. However, consider the following when setting this option:

- If your source is a disk file, memory considerations will determine the best setting for your system.
- If your source is a tape, either use the same blocking factor that was used when creating the tape (for best performance) or a blocking factor that is evenly divisible into it.
- Adaptive Server IQ rejects the insert operation if you specify a BLOCK FACTOR of zero.
- You cannot specify BLOCK FACTOR along with BLOCK SIZE or with any variable-width input fields.

ESCAPE CHARACTER option Specifies an alternative escape character. The default escape character for characters stored as hexadecimal codes and symbols is a backslash (\), so that \x0A is the linefeed character, for example.

This can be changed using the ESCAPE CHARACTER clause. For example, to use the exclamation mark as the escape character, you would enter:

```
... ESCAPE CHARACTER '!'
```

Only one single-byte character can be used as an escape character.

Note Because you must specify ESCAPES OFF in this version of Adaptive Server IQ, the ESCAPE CHARACTER option has no effect. It is provided for compatibility with Adaptive Server Anywhere.

WITH CHECKPOINT ON clause If this option is set to ON, a checkpoint is issued when the LOAD TABLE statement completes and is logged. In the event recovery is required, it is guaranteed even if the data file is then removed from the system.

If WITH CHECKPOINT ON is not specified, the file used for loading must be retained in case recovery is required.

BLOCK SIZE option Specifies the default size in bytes in which input should be read. This option only affects variable-length input data read from files; it is not valid for fixed-length input fields. It is similar to BLOCK FACTOR, but there are no restrictions on the relationship of record size to block size. You cannot specify this option along with the BLOCK FACTOR option.

The default setting for BLOCK SIZE is 500,000, which is high enough for input from disk files. For tape files, you should specify the same block size that was used when creating the tape. You cannot specify BLOCK SIZE along with BLOCK FACTOR or with any fixed width input fields.

Example

The following UNIX example specifies a BLOCK SIZE of 200,000 bytes:

```
LOAD TABLE  mm
    (l_orderkey '\x09',
    l_quantity '\x09',
    l_shipdate DATE('YYYY/MM/DD'))
FROM '/d1/MILL1/tt.t'
BLOCK SIZE 200000
```

BYTE ORDER option Specifies the byte ordering during reads. This option applies to all binary input fields, including those defined as PREFIX 2 or PREFIX 4. If none are defined, this option is ignored. Adaptive Server IQ always reads prefix binary data in the format native to the machine it is running on (default is NATIVE). You can also specify:

- HIGH when multibyte quantities have the high order byte first (for big endian platforms like Sun, IBM AIX, HP, and Silicon Graphics IRIX).
- LOW when multibyte quantities have the low order byte first (for little endian platforms like DEC ALPHA, and Windows NT).

Example

Here is a Windows NT example:

```
LOAD TABLE nn
    (l_orderkey,
    l_quantity ASCII(PREFIX 2),
    FILLER(2),
FROM 'C:\\iq\archive\\mill.txt'
BYTE ORDER LOW
```

LIMIT option Specifies the maximum number of rows to insert into the table. The default is 0 for no limit.

LIMIT works together with the SKIP option. SKIP indicates where to begin reading from the input file, and LIMIT specifies how many of those rows to insert. SKIP takes precedence over LIMIT. If you specify multiple input files, *these options only affect the first file*. The following table shows how these options work together:

Table 5-1: SKIP and LIMIT insert options

If the SKIP value is	And the LIMIT value is	Then IQ does this
0	5	Reads 5 rows and inserts 5 rows.
20	5	Reads 25 rows and inserts 5 rows.
10	5	Reads 10 rows and inserts 5 rows. If the input file has only 8 rows, then zero rows are inserted.

Here is a Windows NT example. In this case, no rows are skipped, and up to 1,000,000 rows are inserted.

```
LOAD TABLE lineitem
    (l_shipmode ASCII(15),
    l_quantity ASCII(8),
    FILLER(30))
FROM 'C:\\iq\archive\\mill.txt'
BLOCK FACTOR 1000
PREVIEW ON
LIMIT 1000000
```

NOTIFY option Specifies that you be notified with a message each time the specified number of rows is inserted successfully into the table. The default is every 100,000 rows. Very frequent notifications can slow down your insert operation. To turn off NOTIFY entirely, set NOTIFY = 0. See "Interpreting notification messages" for an explanation of messages.

ON FILE ERROR option Specifies the action Adaptive Server IQ takes when an input file cannot be opened, either because it does not exist or because you have incorrect permissions to read the file. For all other reasons or errors, it aborts the entire insertion. You can specify one of the following:

- ROLLBACK aborts the entire transaction (the default).
- FINISH finishes the insertions already completed and ends the load operation.
- CONTINUE returns an error but only skips the file to continue the load operation. You cannot use this option with partial-width inserts.

PREVIEW option Displays the layout of input into the destination table including starting position, name, and data type of each column. Adaptive Server IQ displays this information at the start of the load process. If you are writing to a log file, this information is also included in the log.

This option is especially useful with partial-width inserts. It can help you diagnose failed or skewed insertions due to incompatible data types, or destination column alignment that does not match source columns. Look at the expected column data type and starting position information to determine if you need to use an insert conversion option on a column and/or where and how much filler to use.

Note PREVIEW ON helps you determine if a load is correct. It does not stop the load from occurring.

ROW DELIMITED BY option Specifies a string up to 4 bytes in length that indicates the end of an input record. You can use this option only if all fields within the row are any of the following:

- Delimited with column terminators
- Data defined by the DATE or DATETIME *column-spec* options
- ASCII fixed length fields

The row delimiter can be any string of from 1 to 4 8-bit codes, including any combination of printable characters, and/or any 8–bit hexadecimal code that represents a non-printing character. For example, you specify \x09 to represent a tab as the terminator. For a null terminator (no visible terminator as in “C” strings), you specify \x00.

To use the newline character as a row delimiter, you can specify either the special combination '\n' or its ASCII value '\x0a'.

You cannot use this option if any input fields contain binary data. With this option, a row terminator causes any missing fields to be set to NULL. All rows must have the same row delimiters, and it must be distinct from all column delimiters. The row and field delimiter strings cannot be an initial subset of each other. For example, you cannot specify "*" as a field delimiter and "*#" as the row delimiter, but you could specify "#" as the field delimiter with that row delimiter.

If a row is missing its delimiters, Adaptive Server IQ returns an error and rolls back the entire load transaction. The only exception is the final record of a file where it rolls back that row and returns a warning message.

On Windows NT, a row delimiter is usually indicated by the newline character followed by the carriage return character. You may need to specify this as the *delimiter-string* for either this option or FILLER.

Example

The following Windows NT example sets the column delimiter for the l_orderkey column to tab, and the row delimiter to newline (\x0a) followed by carriage return (\x0d):

```
LOAD TABLE mm
    (l_orderkey '\x09',
    l_quantity ASCII(4),
    FILLER(6),
    l_shipdate DATE('YYYY/MM/DD'))
FROM 'C:\\iq\\archive\\mill.txt'
ROW DELIMITED BY '\x0a\x0d'
```

SKIP option Lets you define a number of rows to skip at the beginning of the input file(s) for this load. The default is 0. This option works in conjunction with the LIMIT option, and takes precedence over it.

In this UNIX example, Adaptive Server IQ reads 9,000 rows from the input file, skips the first 5,000, and loads the next 4,000. If there are only 8,000 rows in the input file, then only 3,000 rows are loaded.

```
LOAD TABLE lineitem(
    l_shipmode ASCII(15),
    l_quantity ASCII(8),
FILLER(30))
FROM '/d1/MILL1/tt.t'
BLOCK FACTOR 1000
LIMIT 4000
SKIP 5000
PREVIEW ON
```

START ROW ID option Specifies the id number of a row in the table where insertions should begin. This option is used for *partial-width insertions*, which insert into a subset of the columns in the table. If you are inserting data into an existing row, you must define the format of each input column with a *column-spec*, and use START ROW ID to identify the row where you want to insert it. The default is 0, which causes data to be inserted in a new row wherever there is space in the table. Be sure to read "Partial-width insertions" before using this option and performing partial-width inserts.

UNLOAD FORMAT option Specifies that the data in the input file is in the format produced by the UNLOAD command in Adaptive Server IQ 11.5.1, specifically for upgrading to Adaptive Server IQ 12.x. This format places certain restrictions on other load options you specify:

- The format in the column specifications must be BINARY, the default. Specifying ASCII, PREFIX, FILLER, or *string-delimiter* causes an error.
- You must not use the load options DELIMITED BY and ROW DELIMITED BY.
- To allow NULLs in the data you must specify BINARY WITH NULL BYTE in the column specification. You cannot include NULL in the *column-spec* in any other way.
- For the sake of consistency with the data being loaded, you can specify BINARY WITH NULL BYTE even when loading into a table column that does not allow NULLs (as specified in CREATE TABLE or ALTER TABLE). However, if you try to load any data into a column that does not allow NULLs, you receive an error.

See the *Adaptive Server IQ Installation and Configuration Guide* for more information on upgrading.

LOAD TABLE adds rows

The LOAD TABLE statement appends the contents of the file to the existing rows of the table; it does not replace the existing rows in the table, unless you specify the START ROW ID load option. See "Partial-width insertions" for examples of how you use this option to insert data into existing rows.

If you want to empty out an existing table and reload it, you can use the TRUNCATE TABLE statement to remove all the rows from a table.

Simple LOAD TABLE Example

The following statement loads the data from the file *dept.txt* into all columns of the department table. This example assumes that no explicit data conversion is needed, and that the width of input columns matches the width of columns in the department table.

```
LOAD TABLE department
FROM 'dept.txt'
```

Interpreting notification messages

By default, Adaptive Server IQ displays information about your database during insert and load operations.

The statistics in these messages indicate when you need to perform maintenance and optimization tasks, such as adding more dbspaces. The messages also report on the progress of the load. This section explains each notification message.

At the start of the insert is a description of the operation, such as this one:

```
In table 'partsupp', the full width insert
of 5 columns will begin at record 1.
1998-07-28 13:03:47 0002 Insert Started:
1998-07-28 13:03:47 0002 partsupp
1998-07-28 13:03:48 0002 [20270]:
=n*** File: /remote/rip/tpcd_data/scale_1/partsupp.tbl
```

Each time it inserts the number of records specified in the NOTIFY load option, Adaptive Server IQ sends a message like this:

```
1998-07-28 13:03:49 0002 [20897]: 100000 Records, 2
Seconds
          Mem: 469mb/M470
          Main      Blks: U63137/6%, Buffers: U12578/L7
          Temporary Blks: U273/0%, Buffers: U1987/L1960
          Main      I: L331224/P22 O: D25967/P7805 C:D0
          Temporary I: L25240/P8 O: D4749/P0 C:D0
```

The first line shows how many rows Adaptive Server IQ has read since the last notification message, and the number of seconds taken reading them. Even if Adaptive Server IQ reads the same number of messages each time, the amount of time will vary depending on the data read (for example, how many data conversions are required). Reported time intervals smaller than 1 second are usually reported as “0 Secs”.

Memory message

This message displays memory usage information:

```
Mem: 469mb/M470
```

Table 5-2: Memory messages

Item	Description
Mem: # mb	Current memory being used by this Adaptive Server IQ server, in megabytes.
M# mb	The maximum number of megabytes used by this IQ server since it was started.

Main IQ Store blocks messages

This line describes the permanent (main) IQ Store:

```
Main      Blks: U63137/6%, Buffers: U12578/L7
```

Table 5-3: Main blocks

Item	Description
U#	Number of blocks in use.
#%	Percentage of database filled.
Buffers: U#	Number of buffers in use. *Note:* This value will grow to maximum number of buffers that fit in the main buffer cache. The number increments whenever a buffer is allocated, but only decrements when a buffer is destroyed, not when it is unlocked or flushed. When it decreases, you have hit the current limit of virtual memory available and new memory is coming from buffer cache or you have an error and insert has been rolled back and restarted.
L#	Number of locked buffers. This number increments whenever you request a buffer. If you exceed the maximum while running a script, the command that exceeds it will fail and subsequent commands may complete incorrectly.

IQ Temporary Store blocks message

This message provides similar information to the Main IQ Store Blocks message explained above.

```
Temporary Blks: U273/0%, Buffers: U1987/L1960
```

Main buffer cache activity message

This line displays information about the main buffer cache.

```
Main      I: L331224/P22 O: D25967/P7805 C:D0
```

Table 5-4: Main IQ Store file message

Item	Description
Main: I: L#	Number of logical file reads.
P#	Number of physical file reads.
O: D#	Number of times a buffer was destroyed.
P#	Number of physical writes.
C: D#	Buffer manager data compression ratio. This is the total number of bytes eligible for compression minus number of bytes used after compression divided by total number of bytes eligible for compression times 100. In other words, it tells how much data was compressed (what percentage it is of its uncompressed size). The larger the number, the better. Only certain data blocks are eligible for compression. Eligible blocks include indexes, (90-95% of a database) and Sort sets. This reflects only data compression techniques used by the buffer manager. Other data compression may take place before data reaches the buffer manager, so the total data compression may be higher.

In general, assuming the buffer cache is full, you should have between 10 and 1000 logical reads per physical read. A lower value indicates excessive thrashing in the buffer manager. More than 1000 times larger can indicate that you may be overallocating memory to your buffer cache. If either of these conditions exists, see Chapter 12, “Managing System Resources” for information on setting buffer cache sizes, or Chapter 13, “Monitoring and Tuning Performance” for information on using the IQ performance monitor.

Temporary buffer cache message

These lines display information about the Temp buffer cache.

```
Temporary I: L25240/P8 O: D4749/P0 C:D0
```

See the description for the Main buffer cache message above.

Controlling message logging

The Notify_Modulus database option adjusts the default frequency of notification messages during loads, or omit these message. See the chapter “Database Options” in the *Adaptive Server IQ Reference Manual* for details. The NOTIFY option in the LOAD command overrides the Notify_Modulus setting.

Using the INSERT statement

The INSERT statement allows you to insert data without first putting it into a flat file. Using this command, you can either:

- Insert a specified set of values row by row
- Insert directly from database tables

See the sections that follow for details of these two forms of the command.

Inserting specified values row by row

To add specified values to a table row by row, use the INSERT statement with this syntax:

```
INSERT [ INTO ]
[ owner.] table_name
[ (column_name, ...) ]
... VALUES (expression...)
```

Adaptive Server IQ inserts the first value you specify into the first column you specify, the second value you specify into the second column, and so on. If you omit the list of column names, the values are inserted into the table columns in the order in which the columns were created (the same order as SELECT * would retrieve). Adaptive Server IQ inserts the row into the table wherever room is available.

Values can be NULL, any positive or negative number, or a literal.

- Enclose values for CHAR, VARCHAR, DATE, TIME, and TIMESTAMP or DATETIME columns in single or double quotation marks. To indicate a value with a quotation in it use a different set of quotes for the outer quote, such as “Smith' s”.

- For DATE, TIME, and TIMESTAMP or DATETIME columns, you must use a specific format. See “Converting data on insertion” for information on data type conversions. See the *Adaptive Server IQ Reference Manual* for a complete description of Adaptive Server IQ data types.

Note The TIMESTAMP and DATETIME data types are identical.

Allowing NULL values

When you specify values for only some of the columns in a row, NULL is inserted for columns with no value specified, if the column allows NULL. If you specify a NULL value, the destination column must allow NULLs, or the INSERT is rejected and an error message is produced in the message log. Adaptive Server IQ columns allow NULLs by default, but you can alter this by specifying NOT NULL on the column definition in the CREATE TABLE statement or in other ways, such as using a primary key, for example.

Example

The following example adds 1995-06-09 into the l_shipdate column and 123 into the l_orderkey column in the lineitem table.

```
INSERT INTO lineitem
    (l_shipdate, l_orderkey)
VALUES('1995-06-09', 123)
```

If you are inserting more than a small number of data rows, it is more efficient to insert selected rows directly from a database, as described in the next section, or to load data from a flat file with the LOAD TABLE statement, than to insert values row by row. Consider using a select statement with a few unions instead of inserting values for a few rows, because this requires only a single trip to the server.

Inserting selected rows from the database

To insert data from other tables in the current database, or from a database that is defined as a Specialty Data Store to Adaptive Server IQ, use this syntax:

INSERT [INTO]
[*owner.*]*table_name*
[(*column-name,...*)]
[*insert-load-options*]...
select-statement

insert-load-options:
LIMIT *number-of-rows*

NOTIFY *number-of-rows*

SKIP *number-of-rows*

START ROW ID *number*

This form of the INSERT statement lets you insert any number of rows of data, based on the results of a general SELECT statement.

For maximum efficiency, insert as many rows as possible in one INSERT statement. To insert additional sets of rows after the first insert, use additional INSERT statements.

Like other SQL databases, Adaptive Server IQ inserts data by matching the order in which columns are specified in the destination column list and the select list; that is, data from the first column in the select list is inserted into the first destination column, and so on. For both INSERT SELECT and INSERT VALUES, if you omit destination column names, Adaptive Server IQ inserts data into columns in the order in which they were created.

The tables you are inserting into must exist in the database you are currently connected to. Adaptive Server IQ inserts the data into all indexes for the destination columns. (

The columns in the table in the select-list and in the table must have the same or compatible data types. In other words, the selection's value must be, or must be able to be converted to, the data type of the table's column. See "Converting data on insertion" for more information about data types and conversion options.

With this form of the INSERT statement you can specify any of the following insert-load-options:

The START ROW ID option lets you perform a partial-width insert. Read "Partial-width insertions" before you specify this option.

For an explanation of all of these options, see "Specifying load options".

Example

This example shows an insert from one table, partsupp, to another, lineitem, within the same database. The data from the source column l_quantity is inserted into the destination column ps_availqty.

```
INSERT INTO partsupp(ps_availqty)
SELECT l_quantity FROM lineitem
```

Inserting from a different database

You can insert data from tables in any accessible database:

- Tables in either the IQ Store or the Catalog Store of the database you are currently connected to.
- Tables in an Adaptive Server Enterprise database.
- A **proxy table** in your current database, that corresponds to a table in a database on a remote server. Adaptive Server IQ's remote data access capabilities are currently supported on Windows NT only. For details, see the *Adaptive Server IQ Installation and Configuration Guide for Windows NT*.

Inserting directly from an Adaptive Server Enterprise database

You can insert data easily from an Adaptive Server Enterprise or SQL Server database, using the LOCATION syntax of the INSERT statement. You can also use this method to move selected columns from a pre-Version 12 Adaptive Server IQ database into a Version 12 database.

In order to use this capability, all of the following must be true:

- The Sybase connectivity libraries must be installed on your system, and the load library path environment variable for your platform must point to them.
- The Adaptive Server Enterprise server to which you are connecting must exist in the *interfaces* file on the local machine.
- You must have read permission on the source ASE or pre-Version 12 IQ database, and INSERT permission on the target IQ 12 database

❖ **To insert data directly from Adaptive Server Enterprise**

1. Connect to both the Adaptive Server Enterprise and the Adaptive Server IQ 12 database using the same user ID and password.
2. On the Adaptive Server IQ 12 database, issue a statement using this syntax:

   INSERT INTO *asiq_table*
   LOCATION '*ase_servername.ase_dbname*'
   { SELECT *col1*, *col2*, *col3*,...
   FROM *owner.ase_table* }

3. Issue a COMMIT to commit the insert.

Example

The following command inserts data from the l_shipdate and l_orderkey columns of the lineitem table from the Adaptive Server IQ 11.5 database asiq11db.dba on the server detroit, into the corresponding columns of the lineitem table in the current database.

```
INSERT INTO lineitem
    (l_shipdate, l_orderkey)
```

```
    LOCATION 'detroit.asiq11db'
    { SELECT l_shipdate, l_orderkey
    FROM lineitem }
```

- The destination and source columns may have different names.
- The order in which you specify the columns is important, because data from the first source column named is inserted into the first target column named, and so on.
- You can use the predicates of the SELECT statement within the INSERT command to insert data from only certain rows in the table.

Example

This example inserts the same columns as the previous example, but only for the rows where the value of l_orderkey is 1.

```
INSERT INTO lineitem
    (l_shipdate, l_orderkey)
    LOCATION 'detroit.asiqdb'
    { SELECT l_shipdate, l_orderkey
    FROM lineitem
    WHERE l_orderkey = 1 }
```

Note If you use START ROW ID and you select fewer columns than exist in the destination table, the columns in remaining rows of the destination table will be NULLs, if NULLs are legal values. See "Partial-width insertions" for more information.

Importing data from pre-Version 12 Adaptive Server IQ

To import data from an Adaptive Server IQ database version earlier than 12.0, you must use of the following methods:

- The LOAD TABLE command with the UNLOAD FORMAT option.
- The INSERT...LOCATION syntax

You cannot use other forms of the INSERT command.

For more information on loading from an older version, see the *Adaptive Server IQ Installation and Configuration Guide*.

Importing data interactively

If you are inserting small quantities of data, you may prefer to enter it interactively through DBISQL, using the INSERT statement

For example, you can insert listed values a single row at a time with the following command:

```
INSERT INTO T1
VALUES ( ... )
```

For more information about the INSERT command, see “Using the INSERT statement”.

Inserting into tables of a join index

You load or insert data into the tables underlying a join index, just as you would any other indexes. There are only two differences:

- The data in a join index must be synchronized before you can use the join index to resolve queries.
- You cannot perform a partial-width insert for tables that participate in a join index.

When you first create a join index, Adaptive Server IQ synchronizes the join index for you automatically. It does not matter whether you create the join index before or after loading. The order also does not affect performance of the load or synchronization.

Once you have created a join index, however, if you insert or load data into any of its underlying tables except the top table in the join hierarchy, you must synchronize it explicitly. To do so, use the SYNCHRONIZE command. For the syntax of this command, see “Synchronizing join indexes” or see the Adaptive Server IQ Reference.

Once any user has updated any of the tables in a join index, no other user can update any of the tables underlying that join index until the join index has been synchronized.

Updating from different connections may cause errors

When more than one user inserts into or deletes from different tables that participate in the same join index, the second user's update will fail unless the synchronize commits before the second user’s transaction starts. This failure occurs if either of the following conditions exist:

- The second user's transaction begins before the first user's transaction commits.
- The second user tries to update after the first user's transaction commits, but before the join index is synchronized.

This problem occurs because Adaptive Server IQ makes a new version of the join index when any of its underlying tables is updated. The new version is not visible to other transactions that have already begun. The problem does not occur when one user makes all of the changes, because the newer table version is visible to the user who made the original changes.

For example, assume that tables A, B, and C are all members of the same join index. User 2 begins a transaction, and writes to another table not involved in the join. Now, User 1 inserts into table B. This action creates a new version of table B, and a new version of the join index. User 2 then tries to write to table C. Even though no other user has changed table C, because C is a member of the join index it can't be updated until the join index is synchronized.

For more information on join indexes, see Chapter 4, “Adaptive Server IQ Indexes” For more information on transaction processing, see Chapter 8, “Transactions and Versioning”

Inserting into primary and foreign key columns

You load or insert data into primary key and foreign key columns just as you would into any other column.

When you insert into a single-column primary key, Adaptive Server IQ checks that each value is unique. If it is not, an error occurs.

When you insert into multi-column primary keys, you are responsible for making sure that the values in the primary key columns uniquely identify each row. Adaptive Server IQ does not enforce multi-column primary key uniqueness.

When you insert into foreign key columns, you are responsible for making sure that the values match those in the column they reference. Adaptive Server IQ does not enforce foreign keys. For example, in the sample database, the cust_id column in the sales_order table is a foreign key that references the id column in the customer table. You must insert values directly into both of these columns, and ensure that they match.

An easy way to enforce the integrity is to create and run stored procedures that roll back any transaction that violates a constraint. You can use an EXISTS clause to specify violations.

Partial-width insertions

By default, new rows are inserted wherever there is space in the indexes, and each LOAD TABLE or INSERT statement starts a new row. This approach works as long as the data you are inserting is a new row. Adaptive Server IQ also lets you insert individual columns into an existing row, if you specify its rowid.

A *partial-width insertion*, also called a vertical insertion, is an insertion into a subset of columns in a table. You can use two or more partial-width insertions to insert data into all of the columns of the table.

Partial-width insertions let you:

- Insert data into just a few columns at a time. This approach can be helpful if you have memory limitations.

  For example, you can insert data into a few columns at a time, using separate LOAD TABLE or INSERT statements for each group of indexes and using the START ROW ID option to keep the ROW IDs consistent and the memory requirement lower. You may want to do this if you are inserting into a very wide table and do not have enough free memory to populate all the indexes at one time.
- Use different data sources, such as multiple flat files, to insert into different groups of columns in a table.
- Add a new column and corresponding index to a table after you have already inserted data into the columns for that table. For more information, see the ALTER INDEX command.

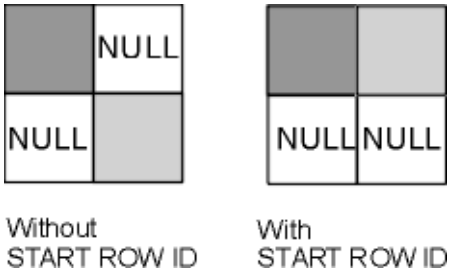
Warning! This is an advanced operation. If you do not perform all the steps correctly in a partial-width insert, you may insert data incorrectly. Never use this type of insert unless you are an experienced Adaptive Server IQ user and are very familiar with your data. Full-width inserts, which insert into all the column indexes on a table at the same time, ensure row-level integrity and are less error-prone.

Use START ROW ID to specify at which row you want to start the insert. This allows you to insert into some of the columns in a row with one partial-width INSERT or LOAD TABLE statement, and insert into the other columns in the same row with additional INSERT or LOAD TABLE statements.

If you try to insert into a column that already contains data, you get an error.

You must be sure to control the row at which each insertion starts. If you do not use START ROW ID, your insertion begins with the next row, and NULLs are inserted in the remaining columns of the current row, as shown in Figure 5-1. (The two shading patterns represent data inserted into columns in two separate insert operations.)

Figure 5-1: Using START ROW ID with partial-width insertions



Note Do not try to perform a partial-width insertion using the INSERT VALUES command format. Because you cannot specify START ROW ID using this format, the problem shown in the figure results.

Partial-width insertion rules

Column indexes that are not included in the initial partial-width insert, and therefore do not already contain data, must allow NULLs. Adaptive Server IQ inserts NULLs into these column indexes. If they do not allow NULLs, the insert fails.

When doing partial-width inserts, follow these steps:

1 For the first partial-width insert for each set of rows, do not specify START ROW ID. Adaptive Server IQ automatically knows what the next available row is for this insert.

2 For the second and any subsequent partial-width inserts for the same set of rows, use the START ROW ID option to specify the row where the insert started. This number is the record number at the beginning of the insert message log, as in this example:

```
In table 'department', the full width insert of 3
columns
will begin at record 1.
```

You can also use the ROWID function to display the row ID, as in the following query:

```
SELECT *, ROWID(table_name) FROM table_name
```

Example 1

The UNIX example below shows an incorrect insertion of four columns from the file *tt.t* into the indexes on the lineitem table. It inserts the first two columns with one LOAD TABLE statement and the second two columns with another LOAD TABLE statement, but does not use the START ROW ID option to align the additional columns.

```
LOAD TABLE lineitem
    (l_partkey ASCII(4),
    l_suppkey ASCII(4),
    FILLER(13))
FROM '/d1/MILL1/tt.t'
PREVIEW ON
NOTIFY 1000



LOAD TABLE lineitem
    (FILLER(8),
    l_quantity ASCII(6),
    l_orderkey ASCII(6),
    FILLER(1))
FROM '/d1/MILL1/tt.t'
PREVIEW ON
NOTIFY 1000
```

The result of the SELECT statement below shows that 10 rows are stored instead of the correct number of 5.

```
SELECT *, rowid(lineitem) FROM lineitem
```

```
l_orderkey   l_partkey   l_suppkey   l_quantity     rowid(lineitem)
----------   ---------   ---------   ------------   ---------------
NULL         1           12          NULL            1
NULL         2           37          NULL            2
```

```
NULL         3           28          NULL           3
NULL         4           13          NULL           4
NULL         5            9          NULL           5
190          NULL        NULL        19             6
215          NULL        NULL        2127           7
 29          NULL        NULL        1376           8
200          NULL        NULL        119            9
 59          NULL        NULL        4             10

(10 rows affected)
```

Example 2

The following example shows the correct way to do this operation. Note the START ROW ID option in the second LOAD TABLE statement.

```
LOAD TABLE lineitem
    (l_partkey ASCII(4),
    l_suppkey ASCII(4),
    FILLER(13))
FROM '/d1/MILL1/tt.t'
PREVIEW ON
NOTIFY 1000

SELECT *, rowid(lineitem) FROM lineitem
l_orderkey   l_partkey   l_suppkey   l_quantity   rowid(lineitem)
----------   ---------   ---------   ----------   ---------------
NULL          1           12          NULL          1
NULL          2           37          NULL          2
NULL          3           28          NULL          3
NULL          4           13          NULL          4
NULL          5            9          NULL          5

(5 rows affected)
LOAD TABLE lineitem
    (FILLER(8),
    l_quantity ASCII(6),
    l_orderkey ASCII(6),
    FILLER(1))
FROM '/d1/MILL1/tt.t'
PREVIEW ON
NOTIFY 1000
START ROW ID 1

SELECT *, rowid(lineitem) FROM lineitem
l_orderkey   l_partkey    l_suppkey     l_quantity   rowid(lineitem)
----------   ----------   ----------    -----------  ---------------
190          1            12              19           1
215          2            37            2127           2
```

```
 29          3           28          1376          3
200          4           13           119          4
 59          5            9             4          5

(5 rows affected)
```

To ensure that the data from the second two columns is inserted into the same rows as the first two columns, you must specify the row number in the START ROW ID option on the INSERT command for the next two columns.

Using the FILLER Option

The FILLER option tells Adaptive Server IQ which columns in the input file to skip. This LOAD TABLE statement inserts NULLs into the second two columns, because those columns are skipped. Note that these columns must allow NULLs in order for this statement to work.

Example 3

For this next Windows NT example, assume the partsupp table has two columns, ps_partkey and ps_availqty, and that partsupp is not part of any join index.

The data for ps_value is calculated from ps_availqty so the ps_availqty column must already contain data. Therefore, to insert data into the partsupp table, do two inserts: one for ps_availqty and ps_partkey and then one for ps_value.

First, insert the data for partsupp directly from an ASCII file named *tt.t*.

```
LOAD TABLE partsupp
    (ps_partkey ASCII(6),
    ps_availqty ASCII(6),
    FILLER(2))
FROM 'C:\\iq\\archive\\mill1.txt'

SELECT *, rowid(partsupp) FROM partsupp
ps_partkey  ps_suppkey    ps_availqty   ps_value   rowid(partsupp)
----------  ----------    -----------   --------   ---------------
213         NULL          190           NULL       1
24          NULL          215           NULL       2

(2 rows affected)
```

Next select the ps_availqty and do an 80% calculation. In this case you must use an INSERT command to insert the results of a SELECT statement.

```
INSERT INTO partsupp(ps_value)
START ROW ID 1
SELECT ps_availqty * 0.80 FROM partsupp

SELECT *, rowid(partsupp) FROM partsupp
ps_partkey  ps_suppkey    ps_availqty   ps_value   rowid(partsupp)
----------  ----------    -----------   --------   ---------------
```

```
213         NULL          190           152.00     1
24          NULL          215           172.00     2

(2 rows affected)
```

If you later load data from another file into ps_partkey and ps_availqty, insertions begin correctly at the next row, as shown below.

```
LOAD TABLE partsupp
    (ps_partkey ASCII(6),
    ps_availqty ASCII(6),
    FILLER(2))
FROM 'C:\\iq\\archive\\mill2.txt'

SELECT *, rowid(partsupp) FROM partsupp
ps_partkey  ps_suppkey    ps_availqty   ps_value   rowid(partsupp)
----------  ----------    -----------   --------   ---------------
213         NULL          190           152.00     1
24          NULL          215           172.00     2
28          NULL          490           NULL       3
211         NULL           15           NULL       4

(4 rows affected)
```

To calculate and insert the values for ps_value, you need to repeat the INSERT statement shown earlier in this example, changing the START ROW ID value to the new row number, 3.

Previewing partial-width inserts

Given the possibility of errors if you do a partial-width insert incorrectly, it is a good idea to preview these inserts. The PREVIEW load option lets you see the layout of input in the destination table. This option is available in LOAD TABLE, but not in the INSERT command.

Converting data on insertion

The data you enter into your Adaptive Server IQ database will likely come from diverse sources. Not all of your data will match the Adaptive Server IQ data types exactly. Some of it will need to be converted. Data is converted in two ways: explicitly and implicitly. For example, to insert CHAR data into an INT column you must convert it explicitly.

Implicit conversions can occur:

- When you insert data selected from another column in the same database

- When you insert data selected from another database
- When you load data from a flat file

When an explicit conversion is needed, the way that you specify the conversion depends on whether you are loading from a flat file or inserting selected rows:

- In the LOAD TABLE statement, you convert data explicitly by specifying a format in the *column-spec*.
- In the INSERT statement, you convert data explicitly using the data conversion functions CAST, CONVERT, and DATEPART in the SELECT statement.

For information on implicit and explicit conversions between Adaptive Server IQ data types, see *Table 5–6*.

For information on conversions that occur if you are inserting from proxy tables, see the *Adaptive Server IQ Installation and Configuration Guide for Windows NT*.

While most Adaptive Server IQ data types are fully compatible with Adaptive Server Anywhere and Adaptive Server Enterprise data types of the same name, there are some differences. For details on compatibility, see *"Matching Adaptive Server Anywhere data types*" and "*"Matching Adaptive Server Enterprise data types*."

For compatibility among versions, a few data types have been defined as synonyms of other data types:

- DECIMAL is a synonym for NUMERIC.
- INTEGER is a synonym for INT.
- DATETIME is a synonym for TIMESTAMP.
- FLOAT (*precision*) is a synonym for REAL or DOUBLE, depending on the value of *precision*. For Adaptive Server Enterprise, REAL is used for *precision* less than or equal to 15, and DOUBLE for *precision* greater than 15. For Adaptive Server IQ and Adaptive Server Anywhere, the cutoff is platform-dependent, but on all platforms the cutoff value is greater than 22.
- MONEY is an Adaptive Server Enterprise-compatible synonym for NUMERIC(19,4), allowing NULL.
- SMALLMONEY is an Adaptive Server Enterprise-compatible synonym for NUMERIC(10,4), allowing NULL.

You can use a synonym interchangeably with its standard data type. Data is stored internally as the standard data type, where synonyms exist. In error messages, the standard name appears in place of the synonym.

Note By default, Adaptive Server IQ assumes that input data is binary (numeric data) and tries to insert it that way. However, this presumes that the input column length in bytes *must* match the destination column length in bytes. If not, the insert will fail or lead to unexpected results. For example, if you attempt to insert an input column with integer data of 4 bytes into a SMALLINT destination column, Adaptive Sever IQ loads only the first 2 bytes of that input column.

Inserting data from pre-Version 12 Adaptive Server IQ

If you are moving data into Adaptive Server IQ Version 12 from an earlier version, you must convert certain data types before inserting or loading them. For details, see "Migrating Data from Previous Versions" in the *Adaptive Server IQ Installation and Configuration Guide*.

Load conversion options

The following table lists the conversion options for the LOAD TABLE statement in alphabetical order and gives a brief description of what each option does. For a detailed description of each option, see the sections that follow. To use these options in the LOAD TABLE statement, see "Specifying load options".

Table 5-5: Conversion options for loading from flat files

Option	Adaptive Server IQ Datatypes	Action
ASCII	TINYINT, SMALLINT, INT (or INTEGER), UNSIGNED INT, BIGINT, UNSIGNED BIGINT, NUMERIC (or DECIMAL), REAL, DOUBLE, BIT, DATE, TIME, TIMESTAMP (or DATETIME)	By default, Adaptive Server IQ assumes input data is binary of appropriate width for the datatype. Using ASCII allows you to tell Adaptive Server IQ that data is in character format and lets you specify how wide it is. This option allows E notation for REAL data, but it can hinder your performance.

Option	Adaptive Server IQ Datatypes	Action
ASCII	CHAR, VARCHAR	By default, Adaptive Server IQ assumes same column width between source and destination columns, which may cause it to read input file incorrectly. This option lets you specify a different width for the input column.
DATE	DATE	Converts ASCII date input of a fixed format to binary.
DATETIME	TIMESTAMP (or DATETIME) or TIME	Converts ASCII time or date/time input of a fixed format to binary. The input specification is based on either a 12-hour or 24-hour clock.
TIME	TIME	Converts ASCII time input of a fixed format to binary.
NULL	all	Lets you specify which input data values to convert to NULL on insert.

Note When loading from a flat file, use binary data if you have a choice of using binary or character data. Using binary input can improve performance by eliminating conversion costs.

Data conversions in IQ

When you use the INSERT statement to insert data directly from a database rather than from a flat file, you cannot use the load conversion options. If the data requires explicit conversion, you must use one of the conversion functions, CAST or CONVERT, in the SELECT statement where you specify the data to be inserted. If the data is converted implicitly, Adaptive Server IQ handles the conversion automatically.

An implicit or explicit conversion is required whenever data types in a SELECT statement need to match, but do not. This occurs when you do an INSERT SELECT from one data type to another, but it also occurs whenever you compare or compute values for differing data types.

The following tables show:

- Which conversions Adaptive Server IQ does implicitly (I)
- Which conversions you must do explicitly (E)
- Which conversions are unsupported (U)

These conversions apply to data within an Adaptive Server IQ database, or coming from an Adaptive Server Anywhere database, or any other database connected as a Specialty Data Store.

The first table shows implicit (I), explicit (E), and unsupported (U) conversions when there is no WHERE clause in the SELECT statement, or when the WHERE clause is based on a comparison operation (=, > or <).

Figure 5-2: IQ conversions for comparison operations

From \ To:	TINYINT	SMALLINT	INT	UNSIGNED INT	BIGINT	UNSIGNED BIGINT	NUMERIC	REAL	DOUBLE	BIT	DATE	TIME	TIMESTAMP	CHAR	VARCHAR
TINYINT	I	I	I	I	I	I	I	I	I	E	E	E	E	E	E
SMALLINT	I	I	I	I	I	I	I	I	I	E	E	E	E	E	E
INT	I	I	I	I	I	I	I	I	I	E	E	E	E	E	E
UNSIGNED INT	I	I	I	I	I	I	I	I	I	E	E	E	E	E	E
BIGINT	I	I	I	I	I	I	I	I	I	E	E	E	E	E	E
UNSIGNED BIGINT	I	I	I	I	I	I	I	I	I	E	E	E	E	E	E
NUMERIC	I	I	I	I	I	I	I	I	I	E	E	E	E	E	E
REAL	I	I	I	I	I	I	I	I	I	E	E	E	E	E	E
DOUBLE	I	I	I	I	I	I	I	I	I	E	E	E	E	E	E
BIT	E	E	E	E	E	E	E	E	E	I	U	U	U	E	E
DATE	E	E	E	E	E	E	E	E	E	E	I	U	I	E	E
TIME	E	E	E	E	E	E	E	E	E	E	E	I	E	E	E
TIME-STAMP	E	E	E	E	E	E	E	E	E	E	E	I	I	E	E
CHAR	E	E	E	E	E	E	E	E	E	E	E	E	E	I	I
VARCHAR	E	E	E	E	E	E	E	E	E	E	E	E	E	I	I

The second table shows implicit (I), explicit (E), and unsupported (U) conversions when the WHERE clause in a SELECT statement is based on an arithmetic operation (+, –, etc.).

Figure 5-3: IQ conversions for arithmetic operations

From: \ To:	TINYINT	SMALLINT	INT	UNSIGNED INT	BIGINT	UNSIGNED BIGINT	NUMERIC	REAL	DOUBLE	BIT	DATE	TIME	TIMESTAMP	CHAR	VARCHAR
TINYINT	I	I	I	I	I	I	I	I	I	U	U	U	U	U	U
SMALLINT	I	I	I	I	I	I	I	I	I	U	U	U	U	U	U
INT	I	I	I	I	I	I	I	I	I	U	U	U	U	U	U
UNSIGNED INT	I	I	I	I	I	I	I	I	I	U	U	U	U	U	U
BIGINT	I	I	I	I	I	I	I	I	I	U	U	U	U	U	U
UNSIGNED BIGINT	I	I	I	I	I	I	I	I	I	U	U	U	U	U	U
NUMERIC	I	I	I	I	I	I	I	I	I	U	U	U	U	U	U
REAL	I	I	I	I	I	I	I	I	I	U	U	U	U	U	U
DOUBLE	I	I	I	I	I	I	I	I	I	U	U	U	U	U	U
BIT	I	I	I	I	I	I	I	I	I	U	U	U	U	U	U
DATE	E	E	E	E	E	E	E	E	E	U	U	U	U	U	U
TIME	E	E	E	E	E	E	E	E	E	U	U	U	U	U	U
TIME-STAMP	E	E	E	E	E	E	E	E	E	U	U	U	U	U	U
CHAR	E	E	E	E	E	E	E	E	E	U	U	U	U	U	U
VARCHAR	E	E	E	E	E	E	E	E	E	U	U	U	U	U	U

Note In arithmetic operations, bit data is implicitly converted to tinyint.

Column width issues

Adaptive Server IQ assumes the width of the input data is the same as the destination column width and reads the input file accordingly. If they are not the same width, Adaptive Server IQ may read too few or too many bytes of the input file for that column. The result is that the read for that column may be incorrect, and the reads for subsequent columns in the input file will be incorrect, because they will not start at the correct position in the input file.

For example, if input_column1 is 15 bytes wide and destination_column1 is 10 bytes wide, and you do not specify the ASCII conversion option, Adaptive Server IQ assumes the input column is only 10 bytes wide. This is fine for destination_column1, because the input data is truncated to 10 bytes in any case. But it also means that Adaptive Server IQ assumes that the next column in the input file starts at byte 11, which is still in the middle of the first column, instead of at byte 16, which is the correct starting position of the next column.

Conversely, if input_column1 is 10 bytes wide and destination_column1 is 15 bytes wide, and you do not specify the ASCII conversion option, Adaptive Server IQ assumes the input column is 15 bytes wide. This means that Adaptive Server IQ reads all of input_column1 plus 5 bytes into the next column in the input file and inserts this value into destination_column1. So, the value inserts into destination_column1 and all subsequent columns are incorrect.

To prevent such problems, use the ASCII conversion option. With this option, Adaptive Server IQ provides several ways to specify the fixed or variable width of an input column. Your input data can contain fixed width input columns with a specific size in bytes, variable width input columns with column delimiters, and variable width input columns defined by binary prefix bytes.

Using the ASCII conversion option

Use the ASCII conversion option to either:

- Convert ASCII input data to binary and specify the width of the input column so data can be read in correctly for that column, or
- Insert ASCII data into an ASCII data type column when the width of the input column is different from the width of the destination column. This option lets you specify how much of the input data it should read for each column.

You can use this option with any of the Adaptive Server IQ data types, with 1, 2, or 4 prefix bytes, and with a column delimiter.

Truncation of data for VARCHAR and CHAR columns

If the width of the input column is greater than the width of the destination column, Adaptive Server IQ truncates the data upon insertion. If the width of the input data is less than the width of the destination column, for CHAR or VARCHAR data types Adaptive Server IQ pads the data with spaces in the table upon insertion.

Variable width inserts to a VARCHAR column will not have trailing blanks trimmed, while fixed width inserts to a VARCHAR column will be trimmed. For example, assume that you are inserting into column varcolumn in a table called vartable. The following would constitute a fixed-width insert, where the value would not be trimmed because you explicitly say to include the two blanks (indicated by __ here):

```
INSERT INTO vartable VALUES ('box__')
```

If instead you inserted the same value from a flat file using delimited input, it would be a variable-width insert, and the trailing blanks would be trimmed.

The following table illustrates how the ASCII conversion option works with the Adaptive Server IQ data types. The example inserts the data from the flat ASCII file *shipinfo.t* into the Adaptive Server IQ table lineitem and summarizes the content and format of the input data and the table.

Table 5-6: Input file conversion example

shipinfo.t			***lineitem***		
column	***format***	***width***	***column***	***datatype***	***width***
l_shipmode	CHAR	15	l_shipmode	VARCHAR	30
l_quantity	ASCII	8	l_quantity	INT	4

For the l_shipmode column, you insert ASCII data into an ASCII column (that has a VARCHAR data type). Notice the width of the two columns is different. In order for the insert on this column and the subsequent l_quantity column to be correct, you specify the width of the l_shipmode column so the correct amount of input data is read at the correct position.

For the l_quantity column, you are inserting ASCII data into a binary column (INT data type). In order for the insert on this column to be correct, you must convert the input data into binary and indicate the width of the input column.

The command for this is shown in the following UNIX example.

```
LOAD TABLE lineitem(
    l_shipmode ASCII(15),
    l_quantity ASCII(8),
FILLER(1))
FROM '/d1/MILL1/shipinfo.t'
PREVIEW ON
```

Substitution of NULL or blank characters

Adaptive Server IQ supports zero-length CHAR and VARCHAR data. If the length of a CHAR or VARCHAR cell is zero and the cell is not NULL, you get a zero-length cell.

For all other data types, if the length of the cell is zero, Adaptive Server IQ inserts a NULL.

This treatment of zero-length character data is ANSI behavior. If you require non-ANSI behavior, see the Non_Ansi_Null_Varchar option in the *Adaptive Server IQ Reference Manual*.

The DATE Option

Use the DATE conversion option to insert ASCII data that is stored in a fixed format into a DATE column. This option converts the ASCII data input to binary and specifies the format of the input data. (The DATE format is used internally to interpret the input; it does not affect the storage or output format of the data.) See the ASCII conversion format for more information.

Example

In this Windows NT example, data for the l_shipdate column is converted from the specified format into binary. The 1–byte FILLER skips over carriage returns in the input file.

```
LOAD TABLE lineitem(
    l_orderkey NULLS(ZEROS) ASCII(4),
    l_partkey ASCII(3),
    l_shipdate DATE('MM/DD/YY'),
    l_suppkey ASCII(5),
FILLER(1))
FROM 'C:\\MILL1\\shipinfo.t'
PREVIEW ON
```

Specifying the DATE Format

Specify the format of the input data using y or Y for years, m or M for months, d or D for days, and j or J for Julian days. The length of the format string is the width of the input column. Table 5-7 describes the formatting options.

Table 5-7: Formatting dates

Option	Meaning
yyyy or YYYY yy or YY	Represents number of year. Default is 1900.

Option	Meaning
mm or MM	Represents number of month. Always use leading zeros for number of the month where appropriate, for example '05' for May. If you omit the month from a DATE value, the day is treated as a Julian date. If you enter only the month, for example, '03', Adaptive Server IQ applies the default year and day and converts it to '1900-03-01'.
dd or DD jjj or JJJ	Represents number of day. Default day is 01. Always use leading zeros for number of day where appropriate, for example '01' for first day. J or j indicates a Julian day (1 to 365) of the year.

On input, the case the format code is ignored.

On output, the case of the format code has the following effect:

- Mixed case (for example, “Dd”) means do not pad with zeroes.
- Same case (for example, “DD” or “dd” means do pad with zeroes.

For example, a time as 17:23:03.774 using the default time format, but as 17:23:3.774 using 'HH:NN:Ss.SSS'.

The next table shows examples of how date input data looks and how to specify the format with the DATE conversion option. Following the table are general rules for specifying dates.

Table 5-8: Sample DATE format options

Input Data	Format Specification
12/31/98	DATE ('MM/DD/YY')
12-31-98	DATE ('MM-DD-YY')
19981231	DATE ('YYYYMMDD')
12/98	DATE ('MM/YY')
1998/123	DATE ('YYYY/JJJ')

- The DATE specification must be in parentheses and enclosed in single or double quotes.
- Adaptive Server IQ stores only the numbers of the year, month, and day; it does not store any other characters that might appear in the input data. However, if the input data contains other characters, for example, slashes (/), dashes (-), or blanks to separate the month, day, and year, the DATE format must show where those characters appear so they can be ignored.

- Use any character other than Y, M, J, or D to indicate the separator character you want Adaptive Server IQ to skip over. You can even use blanks.
- If a DATE format includes only a year and a day number within the year, Adaptive Server IQ treats the date as a Julian date. For example, 1998-33 is the 33rd day in the year 1998, or February 2, 1998.
- If a year is specified with only two digits, for example "5/27/32", then Adaptive Server IQ converts it to 19yy or 20yy, depending on the year and on the setting of the NEAREST_CENTURY option.

NEAREST_CENTURY setting	Year specified as	Years assumed
Default (50)	00-49	2000-2049
	50-99	1950-1999
0	any	1900s
100	any	2000s

For more information, see “Database Options” in the *Adaptive Server IQ Reference Manual*.

The DATETIME conversion option

Use the DATETIME conversion option to insert ASCII data that is stored in a fixed format into a TIME or TIMESTAMP or DATETIME column. This option converts the ASCII data input to binary and specifies the format of the input data. (The DATETIME format is used internally to interpret the input; it does not affect the storage or output format of the data.) See the ASCII conversion format for more information.

Note For compatibility with previous releases, you can specify that a column contains DATETIME data. However, such data is stored internally as the equivalent format, TIMESTAMP.

Here is the syntax:

```
DATETIME ('input_date/time_format')
```

In this UNIX example, slashes are separators in the date portion of the input data, and colons are separators in the time portion:

```
LOAD TABLE lineitem(
```

```
    l_quantity ASCII(4),
    l_shipdate DATETIME('MM/DD/YY hh:mm:ss'),
FILLER(1))
FROM '/d1/MILL1/tt.t'
BLOCK FACTOR 1000
PREVIEW ON
```

In this UNIX example, the FILLER(1) clause prevents Adaptive Server IQ from inserting a NULL in the next column (VWAP) after the DATETIME column:

```
LOAD TABLE snapquote_stats_base
SYMBOL '\x09',
snaptime DATETIME('MM/DD/YY hh:mm:ss'),
FILLER(1))
VWAP '\x09',
RS_DAY '\x09',
FROM '/d1/MILL1/tt.t'
BLOCK FACTOR 1000
PREVIEW ON
```

In this UNIX example, the destination columns contain TIME data, but the input data is DATETIME. You use the TIME conversion option, and use FILLER to skip over the date portion.

```
LOAD TABLE customer(
    open_time TIME('hh:mmaa'),
    close_time TIME('hh:mmaa'),
FILLER(9))
FROM '/d1/MILL1/tt.t'
BLOCK FACTOR 1000
PREVIEW ON
```

Specifying the format for DATETIME conversions

Specify the format of the DATETIME input data using:

- Y or y for years
- M or m for months
- D or d for days
- H or h to indicate hours
- N or n to indicate minutes (mm is also accepted when colons are used as separators
- S or s to indicate seconds and fraction of a second

The length of the format string is the width of the input column. Table 5-7 describes the date formatting options. The following table describes the time formatting options.

Table 5-9: Formatting times

Option	Meaning
hh HH	Represents hour. Hour is based on 24-hour clock. Always use leading zeros for hour where appropriate, for example '01' for 1 am. '00' is also valid value for hour of 12 am.
nn	Represents minute. Always use leading zeros for minute where appropriate, for example '08' for 8 minutes.
ss[.ssssss]	Represents seconds and fraction of a second.
aa	Represents the a.m. or p.m designation.
pp	Represents the p.m designation only if needed. (This is incompatible with Adaptive Server IQ releases prior to 12.0; previously, pp was synonymous with aa.)
hh	Adaptive Server IQ assumes zero for minutes and seconds. For example, if the DATETIME value you enter is '03', Adaptive Server IQ converts it to '03:00:00.0000'.
hh:nn or hh:mm	Adaptive Server IQ assumes zero for seconds. For example, if the time value you enter is '03:25', Adaptive Server IQ converts it to '03:25:00.0000'.

The following table shows examples of how time input data may look and how to specify the format for the DATETIME option. Following this table are the general rules for specifying times.

Table 5-10: DATETIME format options

Input Data	Format Specification
12/31/98 14:01:50	DATETIME ('MM/DD/YY hh:nn:ss')
123198140150	DATETIME ('MMDDYYhhnnss')
14:01:50 12-31-98	DATETIME ('hh:mm:ss MM-DD-YY')
12/31/98 14:01:12.456	DATETIME ('MM/DD/YY hh:nn:sssssss')
12/31/98 14:01:.123456	DATETIME ('MM/DD/YY hh:mm:sssssss')
12/31/98 02:01:50AM	DATETIME ('MM/DD/YY hh:mm:ssaa')
12/31/98 02:01:50pm	DATETIME ('MM/DD/YY hh:mm:sspp')

- Specification letters for time components must be in enclosed in parentheses and single or double quotation marks.

- The input data can include up to nine positions for seconds, including a floating decimal point, to allow for fractional seconds. On input and query, the decimal point floats, so you can specify up to six decimal positions. However, Adaptive Server IQ always stores only six decimal positions with two positions for whole seconds (ss.ssssss). Any more decimal positions are not permitted.
- Separators are used between the time elements. You can use any character as a separator, including blanks. The example uses ':' (colons).
- Adaptive Server IQ stores only the numbers of hours, minutes, and seconds; it does not store any other characters which might appear in the input data. However, if the data contains other characters, for example colons (:) or blanks to separate hours, minutes, and seconds, the time portion of the format specification must show where those characters appear so that Adaptive Server IQ knows to skip over them.
- To indicate whether a particular value is a.m. or p.m., the input data must contain an upper- or lowercase 'a' or 'p' in a consistent place. To indicate where Adaptive Server IQ should look for the a.m. or p.m. designation, put a lowercase only 'aa' or 'pp' in the appropriate place in the format specification. `aa' specifies a.m./p.m. is always indicated, while `pp' specifies that pm is indicated only if needed.
- The format specification must have a character to match every character in the input; you cannot have an 'm' in the format specification to match the 'm' in the input, because 'm' is already used to indicate minutes.
- In the time section, when hours or minutes or seconds are not specified, Adaptive Server IQ assumes 0 for each.

Working With NULLS

Use the NULL conversion option to convert specific values in the input data to NULLS when inserting into Adaptive Server IQ column indexes. This option can be used with any columns, but the column must allow NULLS. You can specify this conversion option with any Adaptive Server IQ data type.

Here is the syntax.

```
NULLS ({BLANKS | ZEROS | literal' ['literal']...})
```

where:

- BLANKS indicates that blanks convert to NULLS.

- ZEROS indicates that binary zeros convert to NULLS.
- literal indicates that all occurrences of the specified literal convert to NULLS. The specified literal must match exactly, including leading and/or trailing blanks, with the value in the input file, for Adaptive Server IQ to recognize it as a match. You can list up to 20 literal values.

You may need to use additional conversion options on the same column. For example, to insert ASCII data into an INT column, which is stored in binary format, and convert blanks in the input data to NULLS when inserted, use the ASCII conversion option to convert the input to binary and the NULL conversion option to convert blanks to NULLS.

Here is a Windows NT example:

```
LOAD TABLE lineitem(
    l_orderkey NULLS(ZEROS) ASCII(4),
    l_partkey ASCII(3),
    l_shipdate date('MM/DD/YY'),
    l_suppkey ascii(5),
FILLER(1))
FROM 'C:\\MILL1\\tt.t'
PREVIEW ON
```

Other factors affecting the display of data

Whenever Adaptive Server IQ requires an explicit or implicit conversion from one data type to another during a query or insert, it always truncates the results. The following describes such situations:

- When you explicitly convert data from a higher scale to a lower scale, Adaptive Server IQ truncates the values in the results. For example, if you CAST a column value in a query to a scale 2 when it is stored with a scale 4, values such as 2.4561 become 2.45. See Chapter 8, "SQL Functions" in the *Adaptive Server IQ Reference Manual* for more information.
- When Adaptive Server IQ implicitly converts from a higher scale to a lower scale during an insertion, it truncates the values before inserting the data into the table. For example, if you insert from one table with a data type ofNUMERIC(7,3) to another table with a data type of DECIMAL(12,2), values such as 2.456 will become 2.45.

- When an arithmetic operation results in a higher scale than the predetermined scale, Adaptive Server IQ truncates the results to fit the scale after it has been determined using the rules defined in the *Adaptive Server IQ Reference Manual*.

If your results require rounding of the values instead of truncation, you should use the ROUND function in your command. However, for inserts, the ROUND function can only be part of its query expression.

The maximum precision for numeric data is 126.

Matching Adaptive Server Enterprise data types

The tables below show which Adaptive Server IQ data types are compatible with Adaptive Server Enterprise data types.

Here are some general rules:

- Adaptive Server IQ character string types accept any Adaptive Server Enterprise character string type.
- Adaptive Server IQ exact numeric types accept any Adaptive Server Enterprise number types. However, if the Adaptive Server IQ data type holds a smaller amount of data than the Adaptive Server Enterprise type, the value converts to a NULL (for example, when inserting data from the underlying database into tables).
- Adaptive Server IQ date/time types accept any Adaptive Server Enterprise date/time types.

Unsupported Adaptive Server Enterprise data types

These Adaptive Server Enterprise data types are not supported by Adaptive Server IQ in this version:

- nchar
- nvarchar
- text
- varbinary
- image

Adaptive Server Enterprise data type equivalents

The table below indicates the Adaptive Server Enterprise exact numeric types and the Adaptive Server IQ equivalents.

Table 5-11: Integer data types

Adaptive Server Enterprise Datatype	Adaptive Server IQ Datatype	Notes
int	INT,BIGINT,UNSIGNED INT, UNSIGNED BIGINT, or NUMERIC	Adaptive Server IQ does not allow scaled integers, such as INT(7,3). Data in the form INT(*precision,scale*) is converted to NUMERIC(*precision,scale*). This differs from Adaptive Server IQ versions prior to 12.0, and from Adaptive Server Enterprise, in which int datatypes can be values between -2,147,483,648 and 2,147,483,647, inclusive. To handle larger integer values, you can use a BIGINT, an unsigned integer (UNSIGNED INT), or an UNSIGNED BIGINT datatype. With UNSIGNED INT, the last bit is used as part of the value. There is no positive or negative indication; all numbers are assumed to be positive, so the value can go up to 4,294,967,295.
numeric	DECIMAL or NUMERIC with appropriate precision	If the precision of the Adaptive Server IQdatatype you define is too small to store the Adaptive Server Enterprise value, the value converts to NULL.
decimal	DECIMAL or NUMERIC with appropriate precision	See above.
smallint	SMALLINT or NUMERIC	Adaptive Server IQ SMALLINTdoes not allow precision and scale. Adaptive Server Enterprise smallint(precision,scale) is converted to NUMERIC(precision,scale)See INT above.
tinyint	TINYINT	Adaptive Server IQ TINYINT columns do not allow precision and scale. Adaptive Server Enterprise tinyint(precision,scale) is converted to NUMERIC(precision,scale). See INT above.
bit	BIT	

The following table indicates the Adaptive Server Enterprise approximate data types and the Adaptive Server IQ equivalents.

Table 5-12: Approximate numeric data types

Adaptive Server Enterprise Datatype	Adaptive Server IQ Datatype	Notes
float (precision)	FLOAT (precision)	IQ supports greater precision for FLOAT HNG indexes do not allow FLOAT, REAL, or DOUBLE data.

Adaptive Server Enterprise Datatype	Adaptive Server IQ Datatype	Notes
double precision	DOUBLE	
real	REAL	

The following table indicates the Adaptive Server Enterprise character data types and the Adaptive Server IQ equivalents.

Table 5-13: Character data types

Adaptive Server Enterprise Datatype	Adaptive Server IQ Datatype	Notes
char	CHAR	Adaptive Server IQ and Adaptive Server Enterprise character (char or CHAR) datatypes are the same except that Adaptive Server IQ can handle NULLs. If you want an Adaptive Server IQ CHAR column to exactly match an Adaptive Server Enterprise char column, specify Adaptive Server IQ column as NOT NULL. Adaptive Server IQ default allows NULLs. Adaptive Server Enterprise char columns that allow NULLs are internally converted to varchar.
varchar	VARCHAR	See above.
nchar	Not supported	
nvarchar	Not supported	See nchar notes above.
text	Not supported	See nchar notes above.

The following table indicates the Adaptive Server Enterprise money data types and the Adaptive Server IQ equivalents.

Table 5-14: Money data types

Adaptive Server Enterprise Datatype	Adaptive Server IQ Datatype	Notes
money	NUMERIC(19,4)	money data is converted implicitly to NUMERIC(19,4).
smallmoney	NUMERIC(10,4)	

The following table indicates the Adaptive Server Enterprise DATE/TIME data types and the Adaptive Server IQ equivalents.

Table 5-15: DATE/TIME data types

Adaptive Server Enterprise Datatype	Adaptive Server IQ Datatype	Notes
datetime	TIMESTAMP or DATE or TIME	Adaptive Server Enterprise datetime columns maintain date and time of day values in 4 bytes for number of days before or after base date of virtual date 0/0/0000 and 8 bytes for time of day, accurate to within one 1,000,000th of a second. Adaptive Server IQ TIMESTAMP (or DATETIME) columns maintain date and time of day values in two 4-byte integers: 4 bytes for number of days since 1/1/0 and 4 bytes for time of day, based on 24-hour clock, accurate to within one 10,000th of a second. Adaptive Server IQ automatically handles the conversion. Adaptive Server IQ also has a separate DATE datatype, a single 4-byte integer. If you want to extract just a date from a SQL Server or Adaptive Server Enterprise datetime column, you can do this with Adaptive Server IQ DATE datatype. To do this, define an Adaptive Server IQ DATE column with same name as the Adaptive Server Enterprise datetime column. Adaptive Server IQ automatically picks up appropriate portion of datetime value.
smalldatetime	TIMESTAMPor DATETIME or DATE or TIME	Define Adaptive Server Enterprise smalldatetime columns as TIMESTAMP (or DATETIME) datatype in Adaptive Server IQ. Adaptive Server IQ properly handles the conversion. As with regular datetime, if you want to extract just a date from an Adaptive Server Enterprise smalldatetime column, do it with the Adaptive Server IQ DATE datatype.

Since the following Adaptive Server Enterprise data types are not supported, you must omit columns with these data types:

- varbinary
- image
- nchar

This also applies to any custom Adaptive Server Enterprise data type.

Handling conversion errors on data import

When you are loading data from external sources, there may be errors in the data. For example, there may be dates that are not valid dates and numbers that are not valid numbers. The CONVERSION_ERROR database option allows you to ignore conversion errors by converting them to NULL values.

For information on setting DBISQL database options, see “SET OPTION statement” in the *Adaptive Server IQ Reference Manual*.

Tuning bulk loading of data

Loading large volumes of data into a database can take a long time and use a lot of disk space. There are a few things you can do to save time.

Improving load performance during database definition

The way you define your database, tables, and indexes can have a dramatic impact on load performance.

Optimizing for the number of distinct values

Adaptive Server IQ optimizes loading of data for a large or small set of distinct values, based on parameters you specify when you create your database and tables. Parameters that affect load optimization include:

- The UNIQUE and IQ UNIQUE options, and the data type and width of the column, all specified in the CREATE TABLE or ALTER TABLE command.
- The IQ PAGE SIZE, specified in the CREATE DATABASE command.

For details of how these parameters affect loading, and information on how to specify them, see “Creating tables” and “Choosing an IQ page size”.

Creating indexes

To make the best use of system resources, create all of the indexes you need before loading data. While you can always add new indexes later, it is much faster to load all indexes at once.

Adding dbspaces

If you run out of space while loading data, Adaptive Server IQ prompts you to create another dbspace, and then continues the operation after you add the dbspace. To avoid this delay, make sure that you have enough room for all of the data you are loading before you start the load operation. Use the sp_estspace or sp_iqestdbspaces stored procedure to help you estimate the space you need for the database and its dbspaces.

To that ensure are you able to add a new dbspace if you do run out of space, see the “RESERVED_TEMP_DBSPACE_MB” and “RESERVED_MAIN_DBSPACE_MB” options in the *Adaptive Server IQ Administration and Performance Guide*.

Setting server startup options

On some platforms you can set command-line options to adjust the amount of memory available. Increasing memory can improve load performance. See *Chapter 2, “Running Adaptive Server IQ”* for command-line options that affect performance.

Adjusting your environment at load time

When you load data, you can adjust several factors to improve load performance:

- Use the LOAD TABLE command whenever you have access to raw data in ASCII or binary format. especially for all loads of over a hundred rows. The LOAD TABLE command is the fastest insertion method.
- When loading from a flat file, use binary data if you have a choice of using binary or character data. This can improve performance by eliminating conversion costs and reducing I/O.
- Set LOAD TABLE command options appropriately, as described in “Bulk loading data using the LOAD TABLE statement”. In particular, if you have sufficient memory to do so, or if no other users are active during the load, increase the BLOCK FACTOR.
- Place data files on a separate physical disk drive from the database file, to avoid excessive disk head movement during the load.

- Increase the size of the database cache. Providing enough memory for the load is a key performance factor. Use the SET OPTION command to adjust MAIN_CACHE_MEMORY_MB and TEMP_CACHE_MEMORY_MB. For these options to take effect, you must ensure that no users are using the database where you set the option, and then disconnect from the database. You can then reconnect and allow other users to connect.
- Adjust the amount of heap memory used by load operations by using the SET OPTION command to change the LOAD_MEMORY_MB option. When LOAD_MEMORY_MB is set to the default (0), Adaptive Server IQ uses the amount of heap memory that gives the best performance. If your system runs out of virtual memory, specify a value less than 500 and decrease the value until the load works. For insertions into wide tables, you may need to set LOAD_MEMORY_MB to a low value (100-200 MB). If you set the value too low, it may be physically impossible to load the data.
- Ensure that only one user at a time updates the database. While users can insert data into different tables at the same time, concurrent updates can slow performance.
- Schedule major updates for low usage times. Although many users can query a table while it is being updated, query users require CPU cycles, disk space, and memory. You will want these resources available to make your inserts go faster.
- If you are using the INSERT statement, run DBISQL or the client application on the same machine as the server if possible. Loading data over the network adds extra communication overhead. This might mean loading new data during off hours.

Reducing Main IQ Store space use in incremental loads

An incremental load may modify a large number of pages within the table being loaded. As a result, the pages are temporarily versioned within the main dbspace, until the transaction commits and a checkpoint can release the old versions. This versioning can be particularly prevalent if the incremental load follows a delete from the same table. The reason for this is that, by default, Adaptive Server IQ (by default) reuses row IDs from deleted records.

Setting this option to OFF reuses ROWIDs from deleted rows. To help reduce space usage from versioned pages, set the APPEND_LOAD option ON so that IQ appends new data to the end of the table. APPEND_LOAD is OFF by default.

The Append_Load option applies to LOAD, INSERT...SELECT, and INSERT...VALUES statements.

For more information on versioning see Chapter 8, “Transactions and Versioning”.

Changing data using UPDATE

You can use the UPDATE statement, followed by the name of the table or view, to change single rows, groups of rows, or all rows in a table. As in all data modification statements, you can change the data in only one table or view at a time.

The UPDATE statement specifies the row or rows you want changed and the new data. The new data can be a constant or an expression that you specify or data pulled from other tables.

If an UPDATE statement violates an integrity constraint, the update does not take place and an error message appears. For example, if one of the values being added is the wrong data type, or if it violates a constraint defined for one of the columns or data types involved, the update does not take place.

UPDATE syntax

See the *Adaptive Server IQ Reference Manual* for complete UPDATE syntax. A simplified version of the syntax is:

UPDATE *table-name*

SET *column_name* = *expression*

WHERE *search-condition*

If the company Newton Ent. (in the customer table of the sample database) is taken over by Einstein, Inc., you can update the name of the company using a statement such as the following:

```
UPDATE customer
SET company_name = 'Einstein, Inc.'
WHERE company_name = 'Newton Ent.'
```

You can use any condition in the WHERE clause. If you are not sure how the company name was entered, you could try updating any company called Newton, with a statement such as the following:

```
UPDATE customer
SET company_name = 'Einstein, Inc.'
WHERE company_name LIKE 'Newton%'
```

The search condition need not refer to the column being updated. The company ID for Newton Entertainments is 109. As the ID value is the primary key for the table, you could be sure of updating the correct row using the following statement:

```
UPDATE customer
SET company_name = 'Einstein, Inc.'
WHERE id = 109
```

The SET clause

The SET clause specifies the columns to be updated, and their new values. The WHERE clause determines the row or rows to be updated. If you do not have a WHERE clause, the specified columns of all rows are updated with the values given in the SET clause.

You can provide any expression of the correct data type in the SET clause.

The WHERE clause

The WHERE clause specifies the rows to be updated. For example, the following statement replaces the One Size Fits All Tee Shirt with an Extra Large Tee Shirt

```
UPDATE product
SET size  = 'Extra Large'
WHERE name = 'Tee Shirt'
   AND size = 'One Size Fits All'
```

The FROM clause

You can use a FROM clause to pull data from one or more tables into the table you are updating.

Deleting data

To remove data from a database, you can do any of the following:

- Use the DELETE statement to remove from a table all rows that meet the criteria you specify.
- Use the DROP TABLE statement to remove an entire table, including all data rows.
- Use the TRUNCATE TABLE statement to delete all rows from a table, without deleting the table definition.

For syntax of these statements, see the *Adaptive Server IQ Reference Manual*.

TRUNCATE TABLE is faster than a DELETE statement with no conditions.

Space for deletions

When you use the DELETE statement, you may need to add space to your database, due to the way Adaptive Server IQ stores versions of data pages. For details, see “Overlapping versions and deletions”.

When you use DROP TABLE or TRUNCATE TABLE, you do not need to add space, as no extra version pages are needed.

Importing data by replication

If you need to update your IQ data frequently from an Adaptive Server Enterprise database, you may want to consider setting up a **replication** environment. In this environment, you can use the Sybase Distribution Director to automate the process of replicating data from an Adaptive Server Enterprise database into an Adaptive Server IQ database.

Distribution Director establishes a two-phase process in which transactions that occur on the source database—the Adaptive Server Enterprise database—are repeated on the Adaptive Server IQ database. To make this process work, you need:

- An operating Replication Server system, which includes a special database called the Replication Server System Database (RSSD). This database contains replication definitions that describe the transactions in the source database, and how they should be replicated to the replicate databases.
- A specially prepared replicate database on an Adaptive Server Enterprise database. This replicate database serves as a staging area for the migration into your IQ database.
- Your IQ database set up with the appropriate tables for the data to be replicated.

Here is a summary of how it works:

1 In Phase 1, the Replication Server replicates transactions from the source database to the RSSD on a continuous basis.

2 In Phase 2, the Adaptive Server IQ staging migration is executed, to transfer the replicated transactions from the RSSD into the IQ database.

This two-phase approach overcomes differences between the way Adaptive Server Enterprise and Adaptive Server IQ store and update data. It also allows you to schedule insertions into your database for lower usage periods, and avoids conflicts with other insertions or loads to the same tables.

For information on using Distribution Director and on setting up an appropriate Replication Server environment, see the *Distribution Director User's Guide*.

CHAPTER 6

Using Procedures and Batches

About this chapter

This chapter explains how you create procedures and batches for use with Adaptive Server IQ.

Procedures store procedural SQL statements in the database for use by all applications. They enhance the security, efficiency, and standardization of databases. User-defined functions are one kind of procedure that return a value to the calling environment for use in queries and other SQL statements. Batches are sets of SQL statements submitted to the database server as a group. Many features available in procedures, such as control statements, are also available in batches.

For many purposes, server-side JDBC provides a more flexible way to build logic into the database than SQL stored procedures. For information on JDBC, see *Data Access Using JDBC* in the *Adaptive Server Anywhere User's Guide*.

Overview of procedures

Procedures store procedural SQL statements in a database for use by all applications.

Procedures can include control statements that allow repetition (LOOP statement) and conditional execution (IF statement and CASE statement) of SQL statements.

Procedures are invoked with a CALL statement, and use parameters to accept values and return values to the calling environment. Procedures can also return result sets to the caller. Procedures can call other procedures.

User-defined functions are one kind of stored procedure that returns a single value to the calling environment. User-defined functions do not modify parameters passed to them. They broaden the scope of functions available to queries and other SQL statements.

Benefits of procedures

Procedures are defined in the database, separate from any one database application. This separation provides a number of advantages.

Standardization

Procedures allow standardization of any actions that are performed by more than one application program. The action is coded once and stored in the database. The applications need only call the procedure to achieve the desired result. If the implementation of the action evolves over time, any changes are made in only one place, and all applications that use the action automatically acquire the new functionality.

Efficiency

When used in a database implemented on a network server, procedures are executed on the database server machine. They can access the data in the database without requiring network communication. This means that they execute faster and with less impact on network performance than if they had been implemented in an application on one of the client machines.

When a procedure is created, it is checked for correct syntax and then stored in the system tables. The first time it is required by any application, it is retrieved from the system tables and compiled into the virtual memory of the server, and executed from there. Subsequent executions of the same procedure will result in immediate execution, since the compiled copy is retained. A procedure can be used concurrently by several applications and recursively by one application. Only one copy is compiled and kept in virtual memory.

Security

Procedures, including user-defined functions, execute with the permissions of the procedure owner but can be called by any user that has been granted permission to do so.

This means that a procedure can (and usually does) have different permissions than the user ID that invoked it. Procedures provide security by allowing users limited access to data in tables that they cannot directly examine or modify.

Introduction to procedures

In order to use procedures, you need to understand how to do the following:

- Call procedures from a database application
- Create procedures
- Drop, or remove, procedures

- Control who has permission to use procedures

This section discusses each of these aspects of using procedures, and also describes some of the different uses of procedures.

Creating procedures

Procedures are created using the CREATE PROCEDURE statement. You must have RESOURCE authority in order to create a procedure.

Where you enter the statement depends on the tool you are using:

- You can create the example procedure new_dept by connecting to the sample database from DBISQL as user ID DBA, using password SQL, and typing the statement in the command window.
- You can create the example procedure by connecting to the sample database from Sybase Central, opening the Procedures folder, and clicking Add Procedure/Function Wizard. The Wizard walks you through the process. Alternatively, click Add Procedure/Function Template, which places you immediately in the last window of the Wizard, the Procedure window, in which you enter the code for the procedure.
- If you are using a tool other than DBISQL or Sybase Central, follow the instructions for your tool. You may need to change the command delimiter away from the semicolon before entering the CREATE PROCEDURE statement.

The following simple example creates a procedure that carries out an INSERT into the department table of the sample database, creating a new department.

```
CREATE PROCEDURE new_dept ( IN id INT,
   IN name CHAR(35),
   IN head_id INT )
BEGIN
  INSERT
    INTO DBA.department ( dept_id,
    dept_name,
    dept_head_id )
    VALUES ( id, name, head_id );
END
```

For a complete description of the CREATE PROCEDURE syntax, see *Adaptive Server IQ Reference Manual*.

The body of a procedure is a **compound statement**. The compound statement starts with a BEGIN statement and concludes with an END statement. In the case of new_dept, the compound statement is a single INSERT bracketed by BEGIN and END statements.

For more information, see “Using compound statements” on page 240

Parameters to procedures are marked as one of IN, OUT, or INOUT. All parameters to the new_dept procedure are IN parameters, as they are not changed by the procedure.

Calling procedures

A procedure is invoked with a CALL statement. Procedures can be called by an application program, or they can be called by other procedures.

For more information, see *Adaptive Server IQ Reference Manual*.

The following statement calls the new_dept procedure to insert an Eastern Sales department:

```
CALL new_dept( 210, 'Eastern Sales', 902 );
```

After this call, you may wish to check the department table to see that the new department has been added.

The new_dept procedure can be called by all users who have been granted EXECUTE permission for the procedure, even if they have no permissions on the department table.

Dropping procedures

Once a procedure is created, it remains in the database until it is explicitly removed. Only the owner of the procedure or a user with DBA authority can drop the procedure from the database.

The following statement removes the procedure new_dept from the database:

```
DROP PROCEDURE new_dept
```

Permissions to execute procedures

A procedure is owned by the user who created it, and that user can execute it without permission. Permission to execute it can be granted to other users using the GRANT EXECUTE command.

For example, the owner of the procedure new_dept could allow another_user to execute new_dept with the statement:

```
GRANT EXECUTE ON new_dept TO another_user
```

The following statement revokes permission to execute the procedure:

```
REVOKE EXECUTE ON new_dept FROM another_user
```

For more information on managing user permissions on procedures, see "Granting permissions on procedures" on page 361.

Returning procedure results in parameters

Procedures can return results to the calling environment in one of the following ways:

- Individual values are returned as OUT or INOUT parameters.
- Result sets can be returned.
- A single result can be returned using a RETURN statement.

This section describes how to return results from procedures as parameters.

The following procedure on the sample database returns the average salary of employees as an OUT parameter.

```
CREATE PROCEDURE AverageSalary( OUT avgsal
    NUMERIC (20,3) )
BEGIN
    SELECT AVG( salary )
    INTO avgsal
    FROM employee;
END
```

To run this procedure and display its output from DBISQL, carry out the following steps:

1 Connect to the sample database from DBISQL as user ID DBA using password SQL.

2 Create the procedure.

3 Create a variable to hold the procedure output. In this case, the output variable is numeric, with three decimal places, so create a variable as follows:

```
CREATE VARIABLE Average NUMERIC(20,3)
```

4 Call the procedure, using the created variable to hold the result:

```
CALL AverageSalary(Average)
```

The DBISQL statistics window displays the message "Procedure completed" if the procedure was created and run properly.

Look at the value of the output variable Average. The DBISQL Data window displays the value 49988.623 for this variable, the average employee salary.

Returning procedure results in result sets

In addition to returning results to the calling environment in individual parameters, procedures can return information in result sets. A result set is typically the result of a query. The following procedure returns a result set containing the salary for each employee in a given department:

```
CREATE PROCEDURE SalaryList (IN department_id INT)
RESULT ( "Employee ID" INT, "Salary" NUMERIC(20,3) )
BEGIN
    SELECT emp_id, salary
    FROM employee
    WHERE employee.dept_id = department_id;
END
```

If this procedure is called from DBISQL, the names in the RESULT clause are matched to the results of the query and used as column headings in the displayed results.

To test this procedure from DBISQL, you can CALL it, specifying one of the departments of the company. The results are displayed in the DBISQL Data window. For example, to list the salaries of employees in the R & D department (department ID 100), type the following:

```
CALL SalaryList (100)
```

Employee ID	Salary
102	45700.000
105	62000.000
160	57490.000

Employee ID	Salary
243	72995.000
247	48023.690

To execute a CALL of a procedure that returns a result set, DBISQL opens a cursor.

The cursor is left open after the CALL in case a second result set is returned. The DBISQL statistics window displays the plan of the SELECT query in the procedure and then displays the line:

Procedure is executing. Use RESUME to continue.

You need to execute the RESUME statement or the DBISQL CLEAR command from the DBISQL Command window before you can alter or drop the procedure.

For more information about using cursors in procedures, see “Using cursors in procedures” on page 251

Introduction to user-defined functions

User-defined functions are a class of procedures that return a single value to the calling environment. This section introduces creating, using, and dropping user-defined functions.

Creating user-defined functions

User-defined functions are created using the CREATE FUNCTION statement. You must have RESOURCE authority in order to create a user-defined function.

The following simple example creates a function that concatenates two strings, together with a space, to form a full name from a first name and a last name.

You can create the example function fullname by connecting to the sample database from DBISQL as user ID DBA, using password SQL, and typing the statement in the command window.

If you are using a tool other than DBISQL or Sybase Central, you may need to change the command delimiter away from the semicolon before entering the CREATE FUNCTION statement.

```
CREATE FUNCTION fullname (firstname CHAR(30),
lastname CHAR(30))
RETURNS CHAR(61)
BEGIN
   DECLARE name CHAR(61);
   SET name = firstname || ' ' || lastname;
   RETURN ( name );
END
```

For a complete description of the CREATE FUNCTION syntax, see *Adaptive Server IQ Reference Manual*.

The CREATE FUNCTION syntax differs slightly from that of the CREATE PROCEDURE statement. The following are distinctive differences:

- No IN, OUT, or INOUT keywords are required, as all parameters are IN parameters.
- The RETURNS clause is required to specify the data type being returned.
- The RETURN statement is required to specify the value being returned.

Calling user-defined functions

A user-defined function can be used, subject to permissions, in any place that a built-in non-aggregate function is used.

The following statement in DBISQL returns a full name from two columns containing a first and last name:

```
SELECT fullname (emp_fname, emp_lname)
FROM employee;
```

fullname (emp_fname, emp_lname)
Fran Whitney
Matthew Cobb
Philip Chin
...

The following statement in DBISQL returns a full name from a supplied first and last name:

```
SELECT fullname ('Jane', 'Smith');
```

fullname ('Jane','Smith')
Jane Smith

The fullname function can be used by any user who has been granted EXECUTE permission for the function.

Dropping user-defined functions

Once a user-defined function is created, it remains in the database until it is explicitly removed. Only the owner of the function or a user with DBA authority can drop a function from the database.

The following statement removes the function fullname from the database:

```
DROP FUNCTION fullname
```

Permissions to execute user-defined functions

A user-defined function is owned by the user who created it, and that user can execute it without permission. Permission to execute it can be granted to other users using the GRANT EXECUTE command.

For example, the creator of the function fullname could allow another_user to use fullname with the statement:

```
GRANT EXECUTE ON fullname TO another_user
```

The following statement revokes permission to use the function:

```
REVOKE EXECUTE ON fullname FROM another_user
```

For more information on managing user permissions on functions, see "Granting permissions on procedures" on page 361

Introduction to batches

A simple batch consists of a set of SQL statements, separated by semicolons. For example, the following set of statements form a batch that adds a new sales representative to the Eastern Sales department, and adds two sales orders for that sales rep.

```
INSERT INTO
employee (emp_id, emp_fname, emp_lname, dept_id,
start_date)
VALUES (2054, Edward, Baer, 220, 1998-08-15);


INSERT INTO
sales_order (id, cust_id, order_date, fin_code_id,
region, sales_rep)
VALUES (41880, 717, 1998-08-24, BU, PA, 2054) ;

INSERT INTO
sales_order (id, cust_id, order_date, fin_code_id,
region, sales_rep)
VALUES (418898, 021, 1998-08-25, BU, PA, 2054) ;
COMMIT ;

INSERT
INTO department ( dept_id, dept_name )
VALUES ( 220, 'Eastern Sales' )
go
UPDATE employee
SET dept_id = 220
WHERE dept_id = 200
AND state = 'MA'
go
COMMIT
go
```

You can include this set of statements in an application and execute them together.

DBISQL and batches

A list of semicolon-separated statements, such as the above, is parsed by DBISQL before it is sent to the server. In this case, DBISQL sends each statement individually to the server, not as a batch. Unless you have such parsing code in your application, the statements would be sent and treated as a batch. Putting a BEGIN and END around a set of statements causes DBISQL to treat them as a batch.

Many statements used in procedures can also be used in batches. You can use control statements (CASE, IF, LOOP, and so on), including compound statements (BEGIN and END), in batches. Compound statements can include declarations of variables, exceptions, temporary tables, or cursors inside the compound statement.

The following batch creates a table only if a table of that name does not already exist:

```
BEGIN
    IF NOT EXISTS (
       SELECT * FROM SYSTABLE
       WHERE table_name = 't1' ) THEN
       CREATE TABLE t1 (
              firstcol INT PRIMARY KEY,
              secondcol CHAR( 30 )
       ) ;
    ELSE
       MESSAGE 'Table t1 already exists' ;
    END IF
END
```

If you run this batch twice from DBISQL, it creates the table the first time you run it. The next time you run it, it prints the message in the server log file on Unix or on the server message window on Windows NT.

Control statements

There are a number of control statements for logical flow and decision making in the body of the procedure or in a batch. The following is a list of control statements available.

Control statement	Syntax

Compound statements	`BEGIN [ ATOMIC ]`
	`  statement-list`
	`END`

Conditional execution: IF	`IF condition THEN`
	`  statement-list`
	`ELSEIF condition THEN`
	`  statement-list`
	`ELSE`
	`  statement-list`
	`END IF`

Conditional execution: CASE	`CASE expression`
	`WHEN value THEN`
	`  statement-list`
	`WHEN value THEN`
	`  statement-list`
	`ELSE`
	`  statement-list`
	`END CASE`

Repetition: WHILE, LOOP	`WHILE condition LOOP`
	`  statement-list`
	`END LOOP`

Repetition: FOR cursor loop	`FOR`
	`  statement-list`
	`END FOR`

Break: LEAVE	`LEAVE label`
CALL	`CALL procname( arg, ... )`

For complete descriptions of each, see the entries in “SQL Statements” in *Adaptive Server IQ Reference Manual*.

Using compound statements

A compound statement starts with the keyword BEGIN and ends with the keyword END. The body of a procedure is a **compound statement**. Compound statements can also be used in batches. Compound statements can be nested, and combined with other control statements to define execution flow in procedures or in batches.

A compound statement allows a set of SQL statements to be grouped together and treated as a unit. SQL statements within a compound statement should be separated with semicolons.

A command delimiter is required after every statement in a statement list except for the last, where it is optional.

Declarations in compound statements

Local declarations in a compound statement immediately follow the BEGIN keyword. These local declarations exist only within the compound statement. The following may be declared within a compound statement:

- Variables
- Cursors
- Temporary tables
- Exceptions (error identifiers)

Local declarations can be referenced by any statement in that compound statement, or in any compound statement nested within it. Local declarations are not visible to other procedures called from the compound statement.

The following user-defined function illustrates local declarations of variables.

The customer table includes some Canadian customers sprinkled among those from the USA, but there is no country column. The user-defined function nationality uses the fact that the US zip code is numeric while the Canadian postal code begins with a letter to distinguish Canadian and US customers.

```
CREATE FUNCTION nationality( cust_id INT )
RETURNS CHAR( 20 )
BEGIN
    DECLARE natl CHAR(20);
    IF cust_id IN ( SELECT id FROM customer
                 WHERE LEFT(zip,1) > '9') THEN
           SET natl = 'CDN';
    ELSE
       SET natl = 'USA';
    END IF;
    RETURN ( natl );
END
```

This example declares a variable natl to hold the nationality string, uses a SET statement to set a value for the variable, and returns the value of the natl string to the calling environment.

The following query lists all Canadian customers in the customer table:

```
SELECT *
```

```
FROM customer
WHERE nationality(id) = 'CDN'
```

Declarations of cursors and exceptions are discussed in later sections.

Atomic compound statements

An **atomic** statement is a statement that is executed completely or not at all. For example, a LOAD statement that inserts thousands of rows might encounter an error after many rows. If the statement does not complete, and the default ON FILE ERROR ROLLBACK option is in effect, all changes are undone. This LOAD statement is atomic.

All noncompound SQL statements are atomic. A compound statement can be made atomic by adding the keyword ATOMIC after the BEGIN keyword.

```
BEGIN ATOMIC
INSERT INTO
sales_order (id, order_date, sales_rep)
VALUES (41880, 1998-08-24, 2054) ;

INSERT INTO
sales_order_items (line_id, prod_id, quantity,
ship_date)
VALUES (01, 43629, 15, 'bad_data') ;
END;
```

In this example, the two INSERT statements are part of an atomic compound statement. They must either succeed or fail as one. The first INSERT statement would succeed. The second one causes a data conversion error since the value being assigned to the ship_date column cannot be converted to a date.

The atomic compound statement fails and the effect of both INSERT statements is undone. Even if the currently executing transaction is eventually committed, neither statement in the atomic compound statement takes effect.

COMMIT and ROLLBACK and some ROLLBACK TO SAVEPOINT statements are not permitted within an atomic compound statement. See "Transactions and savepoints in procedures" on page 265.

There is a case where some, but not all, of the statements within an atomic compound statement are executed. This is when an error occurs, and is handled by an exception handler within the compound statement.

For more information, see "Using exception handlers in procedures" on page 261.

The structure of procedures

The body of a procedure consists of a compound statement as discussed in "Using compound statements" on page 240. A compound statement consists of a BEGIN and an END, enclosing a set of SQL statements. The statements must be separated by semicolons.

The SQL statements that can occur in procedures are described in "SQL statements allowed in procedures" on page 243.

Procedures can contain control statements, which are described in "Control statements" on page 239.

SQL statements allowed in procedures

Almost all SQL statements are allowed within procedures, including the following:

- SELECT, UPDATE, DELETE, INSERT and SET VARIABLE.
- The CALL statement to execute other procedures.
- Control statements (see "SQL statements allowed in procedures" on page 243).
- Cursor statements (see "Using cursors in procedures" on page 251).
- Exception handling statements (see "Using exception handlers in procedures" on page 261).
- The EXECUTE IMMEDIATE statement.

Some SQL statements are not allowed within procedures. These include the following:

- CONNECT statement
- DISCONNECT statement.

COMMIT, ROLLBACK and SAVEPOINT statements are allowed within procedures with certain restrictions (see "Transactions and savepoints in procedures").

For details, see the Usage for each SQL statement in the chapter "SQL Statements" in *Adaptive Server IQ Reference Manual*.

Declaring parameters for procedures

Procedure parameters, or arguments, are specified as a list in the CREATE PROCEDURE statement. Parameter names must conform to the rules for other database identifiers such as column names. They must be a valid data types (see “SQL Data Types” in *Adaptive Server IQ Reference Manual*), and must be prefixed with one of the keywords IN, OUT or INOUT. These keywords have the following meanings:

- **IN** The argument is an expression that provides a value to the procedure.
- **OUT** The argument is a variable that could be given a value by the procedure.
- **INOUT** The argument is a variable that provides a value to the procedure, and could be given a new value by the procedure.

Default values can be assigned to procedure parameters in the CREATE PROCEDURE statement. The default value must be a constant, which may be NULL. For example, the following procedure uses the NULL default for an IN parameter to avoid executing a query that would have no meaning:

```
CREATE PROCEDURE
CustomerProducts( IN customer_id
                    INTEGER DEFAULT NULL )
RESULT ( product_id INTEGER,
          quantity_ordered INTEGER )
BEGIN
    IF customer_id IS NULL THEN
       RETURN;
    ELSE
       SELECT product.id,
                 sum( sales_order_items.quantity )
       FROMproduct,
              sales_order_items,
              sales_order
       WHERE sales_order.cust_id = customer_id
       AND sales_order.id = sales_order_items.id
       AND sales_order_items.prod_id=product.id
       GROUP BY product.id;
    END IF;
END
```

The following statement causes the DEFAULT NULL to be assigned, and the procedure returns instead of executing the query.

```
CALL CustomerProducts();
```

Passing parameters to procedures

You can take advantage of default values of stored procedure parameters with either of two forms of the CALL statement.

If the optional parameters are at the end of the argument list in the CREATE PROCEDURE statement, they may be omitted from the CALL statement. As an example, consider a procedure with three INOUT parameters:

```
CREATE PROCEDURE SampleProc( INOUT var1 INT
                                    DEFAULT 1,
                          INOUT var2 int DEFAULT 2,
                          INOUT var3 int DEFAULT 3 )
...
```

We assume that the calling environment has set up three variables to hold the values passed to the procedure:

```
CREATE VARIABLE V1 INT;
CREATE VARIABLE V2 INT;
CREATE VARIABLE V3 INT;
```

The procedure SampleProc may be called supplying only the first parameter as follows:

```
CALL SampleProc( V1 )
```

in which case the default values are used for *var2* and *var3*.

A more flexible method of calling procedures with optional arguments is to pass the parameters by name. The SampleProc procedure may be called as follows:

```
CALL SampleProc( var1 = V1, var3 = V3 )
```

or as follows:

```
CALL SampleProc( var3 = V3, var1 = V1 )
```

Passing parameters to functions

User-defined functions are not invoked with the CALL statement, but are used in the same manner that built-in functions are. For example, the following statement uses the fullname function defined in “Creating user-defined functions” to retrieve the names of all employees:

```
SELECT fullname(emp_fname, emp_lname) AS Name
FROM employee
```

Name
Fran Whitney
Matthew Cobb
Philip Chin
Julie Jordan
Robert Breault

...

Notes

- Default parameters can be used in calling functions. However, parameters cannot be passed to functions by name.
- Parameters are passed by value, not by reference. Even if the function changes the value of the parameter, this change is not returned to the calling environment.
- Output parameters cannot be used in user-defined functions.
- User-defined functions cannot return result sets.

Returning results from procedures

Procedures can return results that are a single row of data, or multiple rows. In the former case, results can be passed back as arguments to the procedure. In the latter case, results are passed back as result sets. Procedures can also return a single value given in the RETURN statement.

For simple examples of how to return results from procedures, see "Introduction to procedures". For more detailed information, see the following sections.

Returning a value using the RETURN statement

A single value can be returned to the calling environment using the RETURN statement, which causes an immediate exit from the procedure. The RETURN statement takes the form:

```
RETURN expression
```

The value of the supplied expression is returned to the calling environment. To save the return value in a variable, an extension of the CALL statement is used:

```
CREATE VARIABLE returnval INTEGER ;
returnval = CALL myproc() ;
```

Returning results as procedure parameters

Procedures can return results to the calling environment in the parameters to the procedure.

Within a procedure, parameters and variables can be assigned values in one of the following ways:

- The parameter can be assigned a value using the SET statement.
- The parameter can be assigned a value using a SELECT statement with an INTO clause.

Using the SET statement

The following somewhat artificial procedure returns a value in an OUT parameter that is assigned using a SET statement:

```
CREATE PROCEDURE greater (IN a INT,
                          IN b INT,
                          OUT c INT)
BEGIN
    IF a > b THEN
       SET c = a;
    ELSE
       SET c = b;
    END IF ;
END
```

Note The preceding example is artificial: generally a function is easier to use than a procedure when only one result is required.

Using single-row SELECT statements

Single-row queries retrieve at most one row from the database. This type of query is achieved by a SELECT statement with an INTO clause. The INTO clause follows the select list and precedes the FROM clause. It contains a list of variables to receive the value for each select list item. There must be the same number of variables as there are select list items.

When a SELECT statement is executed, the server retrieves the results of the SELECT statement and places the results in the variables. If the query results contain more than one row, the server returns an error. For queries returning more than one row, **cursors** must be used. For information about returning more than one row from a procedure, see "Returning result sets from procedures".

If the query results in no rows being selected, a

```
row not found
```

warning is returned.

The following procedure returns the results of a single-row SELECT statement in the procedure parameters.

To return the number of orders placed by a given customer, type the following:

```
CREATE PROCEDURE OrderCount (IN customer_ID INT,
                                 OUT Orders INT)
BEGIN
    SELECT COUNT(DBA.sales_order.id)
       INTO Orders
    FROM DBA.customer
       KEY LEFT OUTER JOIN DBA.sales_order
    WHERE DBA.customer.id = customer_ID;
END
```

You can test this procedure in DBISQL using the following statements, which show the number of orders placed by the customer with ID 102:

```
CREATE VARIABLE orders INT;
CALL OrderCount ( 102, orders );
SELECT orders;
```

Notes

- The *customer_ID* parameter is declared as an IN parameter. This parameter holds the customer ID that is passed in to the procedure.
- The *Orders* parameter is declared as an OUT parameter. It holds the value of the orders variable that is returned to the calling environment.
- No DECLARE statement is required for the *Orders* variable, as it is declared in the procedure argument list.
- The SELECT statement returns a single row and places it into the variable *Orders.*

Returning result sets from procedures

If a procedure returns more than one row of results to the calling environment, it does so using result sets.

The following procedure returns a list of customers who have placed orders, together with the total value of the orders placed. The procedure does not list customers who have not placed orders.

```
CREATE PROCEDURE ListCustomerValue ()
RESULT ("Company" CHAR(36), "Value" NUMERIC(14,2))
BEGIN
    SELECT company_name,
       CAST( sum(sales_order_items.quantity *
                    product.unit_price)
                    AS NUMERIC(14,2)) AS value
    FROM customer
       INNER JOIN sales_order
       INNER JOIN sales_order_items
       INNER JOIN product
    GROUP BY company_name
    ORDER BY value DESC;
END
```

- Type the following:

```
CALL ListCustomerValue ()
```

Company	Value
Chadwicks	8076
Overland Army Navy	8064
Martins Landing	6888
Sterling & Co.	6804
Carmel Industries	6780
...	...

Notes

- The number of variables in the RESULT list must match the number of the SELECT list items. Automatic data type conversion is carried out where possible if data types do not match.
- The RESULT clause is part of the CREATE PROCEDURE statement, and is not followed by a command delimiter.
- The names of the SELECT list items do not need to match those of the RESULT list.

- When testing this procedure, DBISQL opens a cursor to handle the results. The cursor is left open following the SELECT statement, in case the procedure returns more than one result set. You should type RESUME to complete the procedure and close the cursor.

Returning multiple result sets from procedures

A procedure can return more than one result set to the calling environment. If a RESULT clause is employed, the result sets must be compatible: they must have the same number of items in the SELECT lists, and the data types must all be of types that can be automatically converted to the data types listed in the RESULT list.

The following procedure lists the names of all employees, customers, and contacts listed in the database:

```
CREATE PROCEDURE ListPeople()
RESULT ( lname CHAR(36), fname CHAR(36) )
BEGIN
    SELECT emp_lname, emp_fname
    FROM employee;
    SELECT lname, fname
    FROM customer;
    SELECT last_name, first_name
    FROM contact;
END
```

Notes

To test this procedure in DBISQL, enter the following statement:

```
CALL ListPeople ()
```

You must enter a RESUME statement after each of the three result sets is displayed in the DBISQL Data window to continue, and then complete, the procedure.

Returning variable result sets from procedures

The RESULT clause is optional in procedures. Omitting the result clause allows you to write procedures that return different result sets, with different numbers or types of columns, depending on how they are executed.

If you are not using this feature of variable result sets, it is recommended that you employ a RESULT clause, for performance reasons and to allow front-end tools to discern the columns and data types the procedure will produce without executing it.

For example, the following procedure returns two columns if the input variable is Y, but only one column otherwise:

```
CREATE PROCEDURE names( IN formal char(1))
BEGIN
    IF formal = 'y' THEN
       SELECT emp_lname, emp_fname
       FROM employee
    ELSE
       SELECT emp_fname
       FROM employee
    END IF
END
```

The use of variable result sets in procedures is subject to some limitations, depending on the interface used by the client application.

- **Embedded SQL** You must DESCRIBE the procedure call after the cursor for the result set is opened, but before any rows are returned, in order to get the proper shape of result set.

For information about the DESCRIBE statement, see "DESCRIBE statement" in *Adaptive Server IQ Reference Manual*.

- **ODBC** Variable result set procedures can be used by ODBC applications. The proper description of the variable result sets is carried out by the Adaptive Server IQ ODBC driver.
- **Open Client applications** Variable result set procedures can be used by Open Client applications. The proper description of the variable result sets is carried out by Adaptive Server IQ.
- **DBISQL** DBISQL does not support variable result set procedures, and so cannot be used for testing this feature.

Using cursors in procedures

Cursors are used to retrieve rows one at a time from a query or stored procedure that has multiple rows in its result set. A **cursor** is a handle or an identifier for the query or procedure, and for a current position within the result set.

Cursor management overview

Managing a cursor is similar to managing a file in a programming language. The following steps are used to manage cursors:

1 Declare a cursor for a particular SELECT statement or procedure using the DECLARE statement.

2 Open the cursor using the OPEN statement.

3 Use the FETCH statement to retrieve results one row at a time from the cursor.

4 Records are usually fetched until the warning >Row Not Found> is returned, signaling the end of the result set.

5 Close the cursor using the CLOSE statement.

By default, cursors are automatically closed at the end of a transaction (on explicit or implied COMMIT or ROLLBACK statements). Cursors that are opened using the WITH HOLD clause will be kept open for subsequent transactions until they are explicitly closed.

Cursor positioning

A cursor can be positioned at one of three places:

- On a row
- Before the first row
- After the last row

When a cursor is opened, it is positioned before the first row. The cursor position can be moved using the FETCH command (see “FETCH statement” in *Adaptive Server IQ Reference Manual*). It can be positioned to an absolute position from the start or the end of the query results (using FETCH ABSOLUTE, FETCH FIRST, or FETCH LAST). It can also be moved relative to the current cursor position (using FETCH RELATIVE, FETCH PRIOR, or FETCH NEXT). The NEXT keyword is the default qualifier for the FETCH statement.

Note Adaptive Server IQ treats the FIRST, LAST, and ABSOLUTE options as starting from the beginning of the result set. It treats RELATIVE with a negative row count as starting from the current position.

Using cursors on SELECT statements in procedures

The following procedure uses a cursor on a SELECT statement. It illustrates several features of the stored procedure language. It is based on the same query used in the ListCustomerValue procedure described in "Returning result sets from procedures".

```
CREATE PROCEDURE TopCustomerValue
    (  OUT TopCompany CHAR(36),
       OUT TopValue INT )
BEGIN
    -- 1. Declare the "error not found" exception
    DECLARE err_notfound
       EXCEPTION FOR SQLSTATE '02000';
    -- 2.Declare variables to hold
    --     each company name and its value
    DECLARE ThisName CHAR(36);
    DECLARE ThisValue INT;
    -- 3.Declare the cursor ThisCompany
    --     for the query
    DECLARE ThisCompany CURSOR FOR
    SELECT company_name,
           CAST( sum( sales_order_items.quantity *
                  product.unit_price ) AS INTEGER )
           AS value
    FROM customer
       INNER JOIN sales_order
       INNER JOIN sales_order_items
       INNER JOIN product
    GROUP BY company_name;
    -- 4. Initialize the values of TopValue
    SET TopValue = 0;
    -- 5. Open the cursor
    OPEN ThisCompany;
    -- 6. Loop over the rows of the query
    CompanyLoop:
    LOOP
       FETCH NEXT ThisCompany
           INTO ThisName, ThisValue;
       IF SQLSTATE = err_notfound THEN
           LEAVE CompanyLoop;
       END IF;
       IF ThisValue > TopValue THEN
           SET TopCompany = ThisName;
           SET TopValue = ThisValue;
       END IF;
    END LOOP CompanyLoop;
```

```
    -- 7. Close the cursor
    CLOSE ThisCompany;
END
```

Notes

The TopCustomerValue procedure has the following notable features:

- The "error not found" exception is declared. This exception is used later in the procedure to signal when a loop over the results of a query has completed.

For more information about exceptions, see “Errors and warnings in procedures”.

- Two local variables ThisName and ThisValue are declared to hold the results from each row of the query.
- The cursor ThisCompany is declared. The SELECT statement produces a list of company names and the total value of the orders placed by that company.
- The value of TopValue is set to an initial value of 0, for later use in the loop.
- The ThisCompany cursor is opened.
- The LOOP statement loops over each row of the query, placing each company name in turn into the variables ThisName and ThisValue. If ThisValue is greater than the current top value, TopCompany and TopValue are reset to ThisName and ThisValue.
- The cursor is closed at the end of the procedure.

The LOOP construct in the TopCompanyValue procedure is a standard form, exiting after the last row is processed. You can rewrite this procedure in a more compact form using a FOR loop. The FOR statement combines several aspects of the above procedure into a single statement.

```
CREATE PROCEDURE TopCustomerValue2(
       OUT TopCompany CHAR(36),
       OUT TopValue INT )
BEGIN
    -- Initialize the TopValue variable
    SET TopValue = 0;
    -- Do the For Loop
    CompanyLoop:
    FOR CompanyFor AS ThisCompany
       CURSOR FOR
       SELECT company_name AS ThisName ,
          CAST( sum( sales_order_items.quantity *
                 product.unit_price ) AS INTEGER )
```

```
            AS ThisValue
         FROM customer
            INNER JOIN sales_order
            INNER JOIN sales_order_items
            INNER JOIN product
         GROUP BY ThisName
      DO
         IF ThisValue > TopValue THEN
            SET TopCompany = ThisName;
            SET TopValue = ThisValue;
            END IF;
      END FOR CompanyLoop;
END
```

Errors and warnings in procedures

After an application program executes a SQL statement, it can examine a **return code**. This return code indicates whether the statement executed successfully or failed and gives the reason for the failure. The same mechanism can be used to indicate the success or failure of a CALL statement to a procedure.

Error reporting uses either the SQLCODE or SQLSTATE status descriptions. Whenever a SQL statement is executed, a value is placed in special procedure variables called SQLSTATE and SQLCODE. That value indicates whether or not there were any unusual conditions encountered while the statement was being performed. You can check the value of SQLSTATE or SQLCODE in an IF statement following a SQL statement, and take actions depending on whether the statement succeeded or failed.

For example, the SQLSTATE variable can be used to indicate if a row is successfully fetched. The TopCustomerValue procedure presented in section "Using cursors on SELECT statements in procedures" used the SQLSTATE test to detect that all rows of a SELECT statement had been processed.

For full descriptions of SQLCODE and SQLSTATE error and warning values and their meanings, see "Database Error Messages" in *Adaptive Server IQ Reference Manual*.

Default error handling in procedures

This section describes how Adaptive Server IQ handles errors that occur during a procedure execution, if you have no error handling built in to the procedure.

If you want to have different behavior from that described in this section, you can use exception handlers, described in “Using exception handlers in procedures” on page 261. Warnings are handled in a slightly different manner from errors: for a description, see “Default handling of warnings in procedures” on page 260

There are two ways of handling errors without using explicit error handling:

- **Default error handling** The procedure fails and returns an error code to the calling environment.
- **ON EXCEPTION RESUME** If the ON EXCEPTION RESUME clause is included in the CREATE PROCEDURE statement, the procedure carries on executing after an error, resuming at the statement following the one causing the error.

Default error handling

Generally, if a SQL statement in a procedure fails, the procedure terminates execution and control is returned to the application program with an appropriate setting for the SQLSTATE and SQLCODE values. This is true even if the error occurred in a procedure invoked directly or indirectly from the first one.

The following demonstration procedures show what happens when an application calls the procedure OuterProc, and OuterProc in turn calls the procedure InnerProc, which then encounters an error.

```
CREATE PROCEDURE OuterProc()
BEGIN
    MESSAGE 'Hello from OuterProc.';
    CALL InnerProc();
    MESSAGE 'SQLSTATE set to ',
       SQLSTATE,' in OuterProc.'
END
CREATE PROCEDURE InnerProc()
    BEGIN
       DECLARE column_not_found
          EXCEPTION FOR SQLSTATE '52003';
       MESSAGE 'Hello from InnerProc.';
       SIGNAL column_not_found;
    MESSAGE 'SQLSTATE set to ',
       SQLSTATE, ' in InnerProc.';
END
```

Notes

- The DECLARE statement in InnerProc declares a symbolic name for one of the predefined SQLSTATE values associated with error conditions already known to the server. The DECLARE statement does not take any other action.
- The MESSAGE statement sends a message to the server window and the *dbconsol* message window.
- The SIGNAL statement generates an error condition from within the InnerProc procedure.

The following statement executes the OuterProc procedure:

```
CALL OuterProc();
```

The message window of the server then displays the following:

```
Hello from OuterProc.
Hello from InnerProc.
```

No statements following the SIGNAL statement in InnerProc are executed: InnerProc immediately passes control back to the calling environment, which in this case is the procedure OuterProc. No statements following the CALL statement in OuterProc are executed. The error condition is returned to the calling environment to be handled there. For example, DBISQL handles the error by displaying a message window describing the error.

The TRACEBACK function provides a list of the statements that were executing when the error occurred. You can use the TRACEBACK function from DBISQL by typing the following statement:

```
SELECT TRACEBACK(*)
```

Error handling with ON EXCEPTION RESUME

If the ON EXCEPTION RESUME clause is included in the CREATE PROCEDURE statement, the procedure checks the following statement when an error occurs. If the statement handles the error, then the procedure does not return control to the calling environment when an error occurs. Instead, it continues executing, resuming at the statement after the one causing the error.

Note When a statement has several parts or clauses, such as IF, ELSE IF, END IF, or FOR and END FOR, the "following statement" refers to the next new statement, not a statement part.

The following statements are considered error-handling statements:

- IF
- SELECT @variable =
- CASE
- LOOP
- LEAVE
- CONTINUE
- CALL
- EXECUTE
- SIGNAL
- RESIGNAL
- DECLARE

The following example illustrates how this works.

Drop the procedures

Remember to drop both the InnerProc and OuterProc procedures before continuing with the tutorial. You can do this by entering the following commands in the command window:

```
DROP PROCEDURE OUTERPROC;
DROP PROCEDURE INNERPROC
```

The following demonstration procedures show what happens when an application calls the procedure OuterProc; and OuterProc in turn calls the procedure InnerProc, which then encounters an error. These demonstration procedures are based on those used earlier in this section:

```
CREATE PROCEDURE OuterProc()
ON EXCEPTION RESUME
BEGIN
    DECLARE res CHAR(5);
    MESSAGE 'Hello from OuterProc.';
    CALL InnerProc();
    SELECT @res=SQLSTATE;
    IF @res='52003' THEN
       MESSAGE 'SQLSTATE set to ',
          res, ' in OuterProc.';
    END IF
END;


CREATE PROCEDURE InnerProc()
ON EXCEPTION RESUME
BEGIN
    DECLARE column_not_found
       EXCEPTION FOR SQLSTATE '52003';
    MESSAGE 'Hello from InnerProc.';
    SIGNAL column_not_found;
    MESSAGE 'SQLSTATE set to ',
    SQLSTATE, ' in InnerProc.';
END
```

The following statement executes the OuterProc procedure:

```
CALL OuterProc();
```

The message window of the server then displays the following:

```
Hello from OuterProc.
Hello from InnerProc.
SQLSTATE set to 52003 in OuterProc.
```

The execution path is as follows:

1 OuterProc executes and calls InnerProc.

2 In InnerProc, the SIGNAL statement signals an error.

3 The MESSAGE statement is not an error-handling statement, so control is passed back to OuterProc and the message is not displayed.

4 In OuterProc, the statement following the error assigns the SQLSTATE value to the variable named res. This is an error-handling statement, and so execution continues and the OuterProc message is displayed.

Default handling of warnings in procedures

Warnings are handled differently from errors. While the default action for errors is to set a value for the SQLSTATE and SQLCODE variables, and return control to the calling environment, the default action for warnings is to set the SQLSTATE and SQLCODE values and continue execution of the procedure.

Drop the procedures

Remember to drop both the InnerProc and OuterProc procedures before continuing with the tutorial. You can do this by entering the following commands in the command window:

```
DROP PROCEDURE OUTERPROC;
DROP PROCEDURE INNERPROC
```

The following demonstration procedures illustrate default handling of warnings. These demonstration procedures are based on those used in "Default error handling in procedures" on page 256. In this case, the SIGNAL statement generates a `row not found` condition, which is a warning rather than an error.

```
CREATE PROCEDURE OuterProc()
BEGIN
    MESSAGE 'Hello from OuterProc.';
    CALL InnerProc();
    MESSAGE 'SQLSTATE set to ',
       SQLSTATE,' in OuterProc.';
END
CREATE PROCEDURE InnerProc()
BEGIN
    DECLARE row_not_found
       EXCEPTION FOR SQLSTATE '02000';
    MESSAGE 'Hello from InnerProc.';
    SIGNAL row_not_found;
    MESSAGE 'SQLSTATE set to ',
    SQLSTATE, ' in InnerProc.';
END
```

The following statement executes the OuterProc procedure:

```
CALL OuterProc();
```

The message window of the server then displays the following:

```
Hello from OuterProc.


Hello from InnerProc.
SQLSTATE set to 02000 in InnerProc.
SQLSTATE set to 02000 in OuterProc.
```

The procedures both continued executing after the warning was generated, with SQLSTATE set by the warning (02000).

Using exception handlers in procedures

It is often desirable to intercept certain types of errors and handle them within a procedure, rather than pass the error back to the calling environment. This is done through the use of an **exception handler**.

An exception handler is defined with the EXCEPTION part of a compound statement (see “Using compound statements” on page 240). The exception handler is executed whenever an error occurs in the compound statement. Unlike errors, warnings do not cause exception handling code to be executed. Exception handling code is also executed if an error is encountered in a nested compound statement or in a procedure that has been invoked anywhere within the compound statement.

Drop the procedures

Remember to drop both the InnerProc and OuterProc procedures before continuing with the tutorial. You can do this by entering the following commands in the command window:

```
DROP PROCEDURE OUTERPROC;
DROP PROCEDURE INNERPROC
```

The demonstration procedures used to illustrate exception handling are based on those used in “Default error handling in procedures” on page 256 In this case, additional code is added to handle the `column not found` error in the InnerProc procedure.

```
CREATE PROCEDURE OuterProc()
BEGIN
    MESSAGE 'Hello from OuterProc.';
    CALL InnerProc();
    MESSAGE 'SQLSTATE set to ',
       SQLSTATE,' in OuterProc.'
END
CREATE PROCEDURE InnerProc()
BEGIN
    DECLARE column_not_found
       EXCEPTION FOR SQLSTATE '52003';
    MESSAGE 'Hello from InnerProc.';
    SIGNAL column_not_found;
    MESSAGE 'Line following SIGNAL.';
    EXCEPTION
       WHEN column_not_found THEN
```

```
            MESSAGE 'Column not found handling.';
        WHEN OTHERS THEN
    RESIGNAL ;
END
```

The EXCEPTION statement declares the exception handler itself. The lines following the EXCEPTION statement are not executed unless an error occurs. Each WHEN clause specifies an exception name (declared with a DECLARE statement) and the statement or statements to be executed in the event of that exception. The WHEN OTHERS THEN clause specifies the statement(s) to be executed when the exception that occurred is not in the preceding WHEN clauses.

In this example, the statement RESIGNAL passes the exception on to a higher-level exception handler. RESIGNAL is the default action if WHEN OTHERS THEN is not specified in an exception handler.

The following statement executes the OuterProc procedure:

```
CALL OuterProc();
```

The message window of the server then displays the following:

```
Hello from OuterProc.
Hello from InnerProc.
Column not found handling.
SQLSTATE set to 00000 in OuterProc.
```

Notes

- The lines following the SIGNAL statement in InnerProc are not executed; instead, the EXCEPTION statements are executed.
- As the error encountered was a column not found error, the MESSAGE statement included to handle the error is executed, and SQLSTATE is reset to zero (indicating no errors).
- After the exception handling code is executed, control is passed back to OuterProc, which proceeds as if no error was encountered.
- You should not use ON EXCEPTION RESUME together with explicit exception handlers. The exception handler code is not executed if ON EXCEPTION RESUME is included.
- You should use explicit exception handling code after each statement that may potentially generate an exception whenever you use ON EXCEPTION RESUME. You gain flexibility in handling errors, but the cost is more code and a higher risk of bugs in your code.

- If the error handling code for the `column not found` exception is simply a RESIGNAL statement, control is passed back to the OuterProc procedure with SQLSTATE still set at the value 52003. This is just as if there were no error handling code in InnerProc. As there is no error handling code in OuterProc, the procedure fails.

Exception handling and atomic compound statements

When an exception is handled inside a compound statement, the compound statement completes without an active exception and the changes before the exception are not undone. This is true even for atomic compound statements. If an error occurs within an atomic compound statement and is explicitly handled, some but not all of the statements in the atomic compound statement are executed.

Nested compound statements and exception handlers

The code following a statement that causes an error is not executed unless an ON EXCEPTION RESUME clause is included in a procedure definition.

You can use nested compound statements to give you more control over which statements are and are not executed following an error.

Drop the procedures

Remember to drop both the InnerProc and OuterProc procedures before continuing with the tutorial. You can do this by entering the following commands in the command window:

```
DROP PROCEDURE OUTERPROC;
DROP PROCEDURE INNERPROC
```

The following demonstration procedure illustrates how nested compound statements can be used to control flow. The procedure is based on that used as an example in “Default error handling in procedures” on page 256

```
CREATE PROCEDURE InnerProc()
BEGIN
    DECLARE column_not_found
       EXCEPTION FOR SQLSTATE VALUE '52003';
       MESSAGE 'Hello from InnerProc';
BEGIN
       SIGNAL column_not_found;
          MESSAGE 'Line following SIGNAL'
    EXCEPTION
       WHEN column_not_found THEN
          MESSAGE 'Column not found handling';
       WHEN OTHERS THEN
          RESIGNAL;
```

```
END
       MESSAGE 'Outer compound statement';
END
```

The following statement executes the InnerProc procedure:

```
CALL InnerProc();
```

The message window of the server then displays the following:

```
Hello from InnerProc
Column not found handling
Outer compound statement
```

When the SIGNAL statement that causes the error is encountered, control passes to the exception handler for the compound statement, and the `Column not found handling` message is printed. Control then passes back to the outer compound statement and the `Outer compound statement` message is printed.

If an error other than `column not found` is encountered in the inner compound statement, the exception handler executes the RESIGNAL statement. The RESIGNAL statement passes control directly back to the calling environment, and the remainder of the outer compound statement is not executed.

Using the EXECUTE IMMEDIATE statement in procedures

The EXECUTE IMMEDIATE statement allows statements to be built up inside procedures using a combination of literal strings (in quotes) and variables.

For example, the following procedure includes an EXECUTE IMMEDIATE statement that creates a table.

```
CREATE PROCEDURE CreateTableProc(
       IN tablename char(30) )
BEGIN
   EXECUTE IMMEDIATE 'CREATE TABLE ' || tablename ||'
(column1 INT PRIMARY KEY)'
END
```

In ATOMIC compound statements, you cannot use an EXECUTE IMMEDIATE statement that causes a COMMIT, as COMMITs are not allowed in that context.

Transactions and savepoints in procedures

SQL statements in a procedure are part of the current transaction (see Chapter 8, “Transactions and Versioning”). You can call several procedures within one transaction or have several transactions in one procedure.

COMMIT and ROLLBACK are not allowed within any atomic statement (see “Atomic compound statements” on page 242).

Savepoints (see “Savepoints within transactions” on page 305) can be used within a procedure, but a ROLLBACK TO SAVEPOINT statement can never refer to a savepoint before the atomic operation started. Also, all savepoints within an atomic operation are released when the atomic operation completes.

Some tips for writing procedures

This section provides some pointers for developing procedures.

Check if you need to change the command delimiter

You do not need to change the command delimiter in DBISQL or Sybase Central when you are writing procedures. However, if you are creating and testing procedures from some other browsing tool, you may need to change the command delimiter from the semicolon to another character.

Each statement within the procedure ends with a semicolon. For some browsing applications to parse the CREATE PROCEDURE statement itself, you need the command delimiter to be something other than a semicolon.

If you are using an application that requires changing the command delimiter, a good choice is to use two semicolons as the command delimiter (;;) or a question mark (?) if the system does not permit a multicharacter delimiter.

Remember to delimit statements within your procedure

You should terminate each statement within the procedure with a semicolon. Although you can leave off semicolons for the last statement in a statement list, it is good practice to use semicolons after each statement.

The CREATE PROCEDURE statement itself contains both the RESULT specification and the compound statement that forms its body. No semicolon is needed after the BEGIN or END keywords, or after the RESULT clause.

Use fully-qualified names for tables in procedures

If a procedure has references to tables in it, you should always preface the table name with the name of the owner (creator) of the table.

When a procedure refers to a table, it uses the group memberships of the procedure creator to locate tables with no explicit owner name specified. For example, if a procedure created by user_1 references Table_B and does not specify the owner of Table_B, then either Table_B must have been created by user_1 or user_1 must be a member of a group (directly or indirectly) that is the owner of Table_B. If neither condition is met, a table not found message results when the procedure is called.

You can minimize the inconvenience of long fully qualified names by using a correlation name to provide a convenient name to use for the table within a statement. Correlation names are described in “FROM clause” in *Adaptive Server IQ Reference Manual*.

Specifying dates and times in procedures

When dates and times are sent to the database from procedures, they are sent as strings. The date part of the string is interpreted according to the current setting of the DATE_ORDER database option. As different connections may set this option to different values, some strings may be converted incorrectly to dates, or the database may not be able to convert the string to a date.

You should use the unambiguous date format *yyyy-mm-dd* or *yyyy/mm/dd* when sending dates to the database from procedures. These strings are interpreted unambiguously as dates by the database, regardless of the DATE_ORDER database option setting.

For more information on dates and times, see “Date and time data types” in *Adaptive Server IQ Reference Manual*.

Verifying procedure input arguments

You can verify that input arguments to a procedure are passed correctly in several ways.

You can display the value of the parameter on the message window of the server using the MESSAGE statement. For example, the following procedure simply displays the value of the input parameter *var*:

```
CREATE PROCEDURE message_test (IN var char(40))
BEGIN
    MESSAGE var;
END
```

You can do the following from Interactive SQL:
Create the procedure.
Call the procedure:

```
CALL MESSAGE_TEST ('Test Message');
```

After calling the procedure on a Windows NT system, double click the server icon in the system tray to ensure that the message was passed properly to the server.

```
SELECT GLOBALVAR
```

Statements allowed in batches

The following statements are not allowed in batches:

- CONNECT or DISCONNECT statement
- ALTER PROCEDURE or ALTER FUNCTION statement
- DBISQL commands such as OUTPUT

Otherwise, any SQL statement is allowed, including data definition statements such as CREATE TABLE, ALTER TABLE, and so on.

The CREATE PROCEDURE statement is allowed, but must be the final statement of the batch. Therefore a batch can contain only a single CREATE PROCEDURE statement.

Using SELECT statements in batches

You can include one or more SELECT statements in a batch. Multiple SELECT statements are allowed by Interactive SQL only if they return the same number of columns and each column has the same data type.

The following is a valid batch:

```
IF EXISTS(SELECT *
            FROM systable
            WHERE table_name='employee' )
THEN
   SELECTemp_lname AS LastName,
            emp_fname AS FirstName
   FROM employee;
   SELECT lname, fname
   FROM customer;
   SELECT last_name, first_name
   FROM contact;
END IF
```

The alias for the result set is required only in the first SELECT statement, as the server uses the first SELECT statement in the batch to describe the result set.

A RESUME statement is required following each query to retrieve the next result set.

The following is not a valid batch, as the two queries return different result sets:

```
IF EXISTS( SELECT * FROM systable
       WHERE table_name='employee' )
THEN
   SELECTemp_lname AS LastName,
            emp_fname AS FirstName
   FROM employee;
   SELECT id, lname, fname
   FROM customer;
END IF
```

Calling external libraries from procedures

You can call a function in an external Dynamic Link Library (DLL) from a stored procedure or user-defined functions under an operating system that supports DLLs. You cannot use external functions on UNIX.

This section describes how to use the external library calls in procedures.

Warning! External libraries can corrupt your database.
External libraries called from procedures share the memory of the server. If you call a DLL from a procedure and the DLL contains memory-handling errors, you can crash the server or corrupt your database. Ensure that your libraries are thoroughly tested before deploying them on production databases.

Creating procedures and functions with external calls

This section presents some examples of procedures and functions with external calls.

For a full description of the CREATE PROCEDURE statement syntax, see "CREATE PROCEDURE statement" in *Adaptive Server IQ Reference Manual*.

For a full description of the CREATE FUNCTION statement syntax for external calls, see "CREATE FUNCTION statement" in *Adaptive Server IQ Reference Manual*.

Note You must have DBA permissions in order to create external procedures or functions. This requirement is more strict than the RESOURCE permissions required for creating other procedures or functions.

Syntax

A procedure that calls a function *function_name* in DLL *library.dll* can be created as follows:

```
CREATE PROCEDURE dll_proc ( parameter-list )
EXTERNAL NAME 'function_name@library.dll'
```

Such a procedure is called an **external stored procedure**. If you call an external DLL from a procedure, the procedure cannot carry out any other tasks; it just forms a wrapper around the DLL.

An analogous CREATE FUNCTION statement is as follows:

```
CREATE FUNCTION dll_func ( parameter-list )
RETURNS data-type
EXTERNAL NAME 'function_name@library.dll'
```

In these statements, *function_name* is the name of a function in the dynamic link library, and *library.dll* is the name of the library. The arguments in the procedure argument list must correspond in type and order to the arguments for the library function; they are passed to the external DLL function in the order in which they are listed. Any value returned by the external function is in turn returned by the procedure to the calling environment.

No other statements permitted

A procedure that calls an external function can include no other statements: its sole purposes are to take arguments for a function, call the function, and return any value and returned arguments from the function to the calling environment. You can use IN, INOUT, or OUT parameters in the procedure call in the same way as for other procedures: the input values get passed to the external function, and any parameters modified by the function are returned to the calling environment in OUT or INOUT parameters.

External function declarations

When an external function is called, a stack is fabricated with the arguments (or argument references in the case of INOUT or OUT parameters) and the DLL is called. Only the following data types can be passed to an external library:

- CHARACTER data types, but INOUT and OUT parameters must be no more than 256 bytes in length
- SMALLINT and INT data types
- REAL and DOUBLE data types

This section describes the format of the function declaration.

For information about passing parameters to external functions, see “How parameters are passed to the external function” on page 271

In the external library, function declarations should follow these guidelines:

- **Windows NT** The function declaration should be of the following form for the Watcom C/C++ compiler:

  ```
  return-type * __export __stdcall function-name(
  argument-list )
  ```

  and the following form for Microsoft Visual C++:

  ```
  return-type * __declspec(dllexport) __stdcall
  function-name( argument-list )
  ```

How parameters are passed to the external function

SQL data types are mapped to their C equivalents as follows:

SQL data type	C data type
INTEGER	long (32 bits)
SMALLINT	short
REAL	float
CHAR(n)	char *

These are the only SQL data types you can use: using others produces an error.

Procedure parameters that are INOUT or OUT parameters are passed to the external function by reference. For example, the procedure

```
CREATE PROCEDURE dll_proc( INOUT xvar REAL )
EXTERNAL NAME 'function_name@library.dll'
```

has an associated C function parameter declaration of

```
function_name( float * xvar )
```

Procedure parameters that are IN parameters are passed to the external function by value. For example, the procedure

```
CREATE PROCEDURE dll_proc( IN xvar REAL )
EXTERNAL NAME 'function_name@library.dll'
```

has an associated external function parameter declaration of

```
function_name( float xvar )
```

Character data types are an exception to IN parameters being passed. They are always passed by reference, whether they are IN, OUT, or INOUT parameters. For example, the procedure

```
CREATE PROCEDURE dll_proc ( IN invar CHAR( 128 ) )
EXTERNAL NAME 'function_name@library.dll'
```

has the following external function parameter declaration

```
function_name( char * invar )
```

Special considerations when passing character types

For the character data type (CHAR), Adaptive Server IQ allocates a 255-byte buffer (including one for the null terminator) for each parameter. If the parameter is an INOUT parameter, the existing value is copied into the buffer and null terminated, and a pointer to this buffer is passed to the external function. The external function should therefore not allocate a buffer of its own for OUT or INOUT character parameters: the server has already allocated the space. If the external function writes beyond the 256 bytes (including the ending null character), it is writing over data structures in the server.

When the entry point returns, the parameter buffers are translated back into their server data structure string equivalents based on the strlen() value of the buffer.

The external function should be sure to null-terminate any output string parameters. OUT parameters follow the same procedure except that as there is no initial data, no initial value of the output buffer parameter is guaranteed.

Always be sure to put a null byte into an OUT char parameter, as the lack of one could cause problems if the out buffer happens to be allocated adjacent to an area that is not in the allocate address space of the server.

CHAPTER 7

Ensuring Data Integrity

About this chapter

This chapter describes facilities for ensuring that the data in your database is valid and reliable. These facilities include constraints on tables and columns, and choosing appropriate data types.

The SQL statements in this chapter use the CREATE TABLE statement and ALTER TABLE statement, basic forms of which were introduced in Chapter 3, “Working with Database Objects”

Data integrity overview

For data to have integrity means that the data is valid—that is, correct and accurate—and that the relational structure of the database is intact. The relational structure of the database is described through referential integrity constraints, business rules that maintain the consistency of data between tables.

Adaptive Server IQ supports stored procedures and JDBC, which allow you detailed control over how data gets entered into the database. Procedures are discussed in Chapter 6, “Using Procedures and Batches” See the *Adaptive Server Anywhere User’s Guide* for information on JDBC.

How data can become invalid

Here are a few examples of how the data in a database may become invalid if proper checks are not made. Each of these examples can be prevented by facilities described in this chapter.

Incorrectly formatted information

- An operator enters text where numeric data is required.
- An operator enters numeric data that is too wide for the column.

Duplicated data

- A new department has been created, with dept_id 200, and needs to be added to the department table of the organization's database—but two people enter this information into the table.

Integrity constraints belong in the database

To help ensure that the data in a database are valid, you need to formulate checks that define valid and invalid data and design rules to which data must adhere. The rules to which data must conform are often called business rules. The collective name for checks and rules is constraints.

Build integrity constraints into database whenever possible

Constraints built into the database itself are inherently more reliable than those built into client applications, or spelled out as instructions to database users. Constraints built into the database are part of the definition of the database itself and can be enforced consistently across all applications.

Setting a constraint once, in the database, imposes it for all subsequent interactions with the database, no matter from what source. By contrast, constraints built into client applications are vulnerable every time the software is altered, and may need to be imposed in several applications, or several places in a single client application.

Adaptive Server IQ enforces some constraints but not others. Because IQ data typically is entered by only a few users, and often loaded directly from other databases, IQ databases tend to be less vulnerable than OLTP databases to the kinds of errors that can cause invalid data.

You should declare any constraints that apply, whether Adaptive Server IQ enforces them or not. By declaring constraints, you ensure that you understand your data requirements, and are designing a database that matches the business rules of your organization.

Constraints aid IQ optimization

Adaptive Server IQ performs several types of optimization based on the constraints you specify. This optimization does not depend on enforcement of constraints. For the best performance of queries and load operations, put all constraints in the database.

Here is a list of some of the types of optimization that rely on the constraints and other features you build into the database:

- Join indexes optimize queries that join data from different columns. In many cases, the join relationship for a join index relies on the foreign key constraints you specify for the tables being joined.
- Query optimization relies heavily on the CHECK conditions in the table definition.
- PRIMARY KEY and UNIQUE column constraints and the IQ UNIQUE parameter can improve performance for your loads and queries and facilitate automatic index creation.

See “Creating tables” for more information on how constraints affect optimization. For more on join indexes and foreign keys, see “Using join indexes”.

Constraints and Load Operations

Adaptive Server IQ checks during load operations that certain constraints are obeyed:

- Adaptive Server IQ ensures that data being loaded is the appropriate data type and length.
- If you have a join index that relies on a foreign key-primary key relationship, when synchronizing the join index Adaptive Server IQ checks that data in the underlying tables maintains the expected one-to-many relationship between the joined columns.

How database contents get changed

Information in database tables is changed by submitting SQL statements from client applications. Only a few SQL statements actually modify the information in a database.

- An existing row of a table may be deleted, using the DELETE statement.
- A new row may be inserted into a table, using the INSERT statement.

Data integrity tools

To assist in maintaining data integrity, you can use data constraints, and constraints that specify the referential structure of the database.

Constraints

You can use several types of constraints on the data in individual columns or tables. For example:

- A NOT NULL constraint prevents a column from containing a null entry. Adaptive Server IQ enforces this constraint.
- Columns can have unenforced CHECK conditions assigned to them, to specify that a particular condition should be met by every item in the column. You could specify, for example, that salary column entries should be within a specified range.
- Unenforced CHECK conditions can be made on the relative values in different columns, to specify, for example, in a library database that a date_returned entry is later than a date_borrowed entry.

These and other table and column constraints are discussed in "Using table and column constraints". Column constraints can be inherited from user-defined data types.

Entity and referential integrity

The information in relational database tables is tied together by the relations between tables. These relations are defined by the primary keys and foreign keys built into the database design. The following integrity rules define the structure of the database:

- **Entity integrity** Keeps track of the primary keys. It guarantees that every row of a given table can be uniquely identified by a primary key that guarantees no nulls. Adaptive Server IQ enforces single-column primary keys only; it does not enforce multi-column primary keys.
- **Referential integrity** Keeps track of the foreign keys that define the relationships between tables. All foreign key values either should match a value in the corresponding primary key or contain the NULL value if they are defined to allow NULL. Adaptive Server IQ does not enforce foreign keys, however.

For more information about referential integrity, see "Declaring entity and referential integrity".

SQL statements for implementing integrity constraints

The following SQL statements are used to implement integrity constraints:

- **CREATE TABLE statement** This statement is used to implement integrity constraints as the database is being created.
- **ALTER TABLE statement** This statement is used to add integrity constraints, or to delete constraints, from an existing database.

For full descriptions of the syntax of these statements, see "SQL Statements" in *Adaptive Server IQ Reference Manual*.

Using table and column constraints

The CREATE TABLE statement and ALTER TABLE statement can specify many different attributes for a table. Along with the basic table structure (number, name and data type of columns, name and location of the table), you can specify other features that allow control over data integrity.

Warning! Altering tables can interfere with other users of the database. Although the ALTER TABLE statement can be executed while other connections are active, it is prevented if any other connection is using the table to be altered. For large tables, ALTER TABLE can be a time-consuming operation, and no other requests referencing the table being altered are allowed while the statement is being processed.

This section describes how to use constraints to help ensure that the data entered in the table is correct, and to provide information to Adaptive Server IQ that boosts performance.

Using UNIQUE constraints on columns or tables

The UNIQUE constraint specifies that one or more columns uniquely identify each row in the table. If you apply the UNIQUE constraint to a single column, Adaptive Server IQ enforces this condition. If multiple columns are required to uniquely identify a row, you must specify UNIQUE as an unenforced table constraint.

UNIQUE is essentially the same as a PRIMARY KEY constraint, except that you can specify more than one UNIQUE constraint in a table. With both UNIQUE and PRIMARY KEY, a column must not contain any NULL values.

Example 1

The following example adds the column ss_number to the employee table, and ensures that each value in it is unique throughout the table.

```
ALTER TABLE employee
ADD ss_number char(11) UNIQUE
```

Example 2

In this example, three columns are needed to make a unique entry. Therefore, the UNIQUE constraint is unenforced.

```
ALTER TABLE product
ADD UNIQUE (name, size, color) UNENFORCED
```

Using IQ UNIQUE constraint on columns

The IQ UNIQUE constraint specifies an estimate of the number of distinct values in a column. You can apply the IQ UNIQUE constraint to any column in a table. This constraint helps optimize loading of indexes.

For example, in the state column of the employee table, you would specify IQ UNIQUE(50) to indicate that there are only 50 possible values (assuming U.S. states only). Each of the possible values can occur many times.

Using CHECK conditions on columns

You can use a CHECK condition to specify that the values in a column must satisfy some definite criterion.

You can apply an unenforced CHECK condition to values in a single column, to specify the rules they should follow. These rules may be rules that data must satisfy in order to be reasonable, or they may be more rigid rules that reflect organization policies and procedures.

CHECK conditions on individual column values are useful when only a restricted range of values are valid for that column. Here are some examples:

Example 1

You can specify a particular formatting requirement. If a table has a column for phone numbers you can specify that they all be entered in the same manner. For North American phone numbers, you could use a constraint such as the following:

```
ALTER TABLE customer
MODIFY phone
CHECK ( phone LIKE '(___) ___-____' ) UNENFORCED
```

Note The keyword UNENFORCED must appear after every CHECK condition.

Example 2

You can specify that the entry should match one of a limited number of values. For example, to specify that a city column only contains one of a certain number of allowed cities (say, those cities where the organization has offices), you could use a constraint like the following:

```
ALTER TABLE office
MODIFY city
CHECK ( city IN ( 'city_1', 'city_2', 'city_3' ) )
UNENFORCED
```

By default, string comparisons are case insensitive unless the database is explicitly created as a case-sensitive database, using the CASE RESPECT option.

Example 3

You can specify that a date or number falls in a particular range. For example, you may want to require that the start_date column of an employee table must be between the date the organization was formed and the current date, as in the following:

```
ALTER TABLE employee
MODIFY start_date
CHECK ( start_date BETWEEN '1983/06/27'
                   AND CURRENT DATE ) UNENFORCED
```

You can use several date formats: the YYYY/MM/DD format used in this example has the virtue of always being recognized regardless of the current option settings.

Column CHECK conditions from user-defined data types

You can attach unenforced CHECK conditions to user-defined data types. Columns defined on those data types inherit the CHECK conditions. A CHECK condition explicitly specified for the column overrides that from the user-defined data type.

When defining a CHECK condition on a user-defined data type, any variable prefixed with the @ sign is replaced by the name of the column when the CHECK condition is evaluated. For example, the following user-defined data type accepts only positive integers:

```
CREATE DATATYPE posint INT
CHECK ( @col > 0 ) UNENFORCED
```

Any variable name prefixed with @ could be used instead of @col. Any column defined using the posint data type accepts only positive integers unless it has a CHECK condition explicitly specified.

An ALTER TABLE statement with the DELETE CHECK clause deletes all CHECK conditions from the table definition, including those inherited from user-defined data types.

For information on user-defined data types, see “User-defined data types” in the Adaptive Server IQ Reference.

Working with column constraints in Sybase Central

All adding, altering, and deleting of column constraints in Sybase Central is carried out in the Constraints tab of the column properties sheet.

❖ **To display the property sheet for a column:**

1 Connect to the database.

2 Click the Tables folder for that database, and click the table holding the column you wish to change.

3 Double-click the Columns folder to open it, and double-click the column to display its property sheet.

For more information, see the Sybase Central online Help.

Using CHECK conditions on tables

A CHECK condition can be applied as a constraint on the table, instead of on a single column. Such CHECK conditions typically specify that two values in a row being entered or modified have a proper relation to each other. Column CHECK conditions are held individually in the system tables, and can be replaced or deleted individually. This is more flexible behavior, and CHECK conditions on individual columns are recommended where possible.

For example, in a library database, the date_returned column for a particular entry must be later than (or the same as) the date_borrowed entry:

```
ALTER TABLE loan
ADD CHECK(date_returned >= date_borrowed) UNENFORCED
```

Modifying and deleting CHECK conditions

There are several ways to alter the existing set of CHECK conditions on a table.

- You can add a new CHECK condition to the table or to an individual column, as described above.
- You can delete a CHECK condition on a column by setting it to NULL. The following statement removes the CHECK condition on the phone column in the customer table:

```
 ALTER TABLE customer MODIFY phone
CHECK NULL
```

- You can replace a CHECK condition on a column in the same way as you would add a CHECK condition. The following statement adds or replaces an unenforced CHECK condition on the phone column of the customer table:

```
ALTER TABLE customer
MODIFY phone
CHECK ( phone LIKE '___-___-____' )
UNENFORCED
```

There are two ways of modifying a CHECK condition defined on the table, as opposed to a CHECK condition defined on a column.

- You can add a new CHECK condition using ALTER TABLE with an ADD table-constraint clause.
- You can delete all existing CHECK conditions, including column CHECK conditions, using ALTER TABLE DELETE CHECK, and then add in new CHECK conditions.

All CHECK conditions on a table, including CHECK conditions on all its columns and CHECK conditions inherited from user-defined data types, are removed using the ALTER TABLE statement with the DELETE CHECK clause, as follows:

```
ALTER TABLE table_name
DELETE CHECK
```

Deleting a column from a table does not delete CHECK conditions associated with the column that are held in the table constraint. If the constraints are not removed, any attempt to query data in the table will produce a column not found error message.

Declaring entity and referential integrity

The relational structure of the database enables the database server to identify information within the database. Adaptive Server IQ also ensures that primary key-foreign key relationships between tables are properly upheld by all the rows in any join index relying on these relationships.

Enforcing entity integrity

When a new row in a table is created, or when a row is updated, the database server ensures that the primary key for the table is still valid: that each row in the table is uniquely identified by the primary key.

Note Adaptive Server IQ enforces single-column primary keys only. No action is taken for invalid multi-column primary keys. If you have any multi-column primary keys, you may want to define a procedure to use when you load or insert data, that validates each set of values you insert in the primary key columns.

You cannot create a join index that relies on a foreign key-primary key relationship where the primary key is multi-column.

Example 1

The employee table in the sample database uses an employee ID as the primary key. When a new employee is added to the table, IQ checks that the new employee ID value is unique, and is not NULL.

Example 2

The sales_order_items table in the sample database uses two columns to define a primary key.

This table holds information about items ordered. One column contains an id specifying an order, but there may be several items on each order, so this column by itself cannot be a primary key. An additional line_id columns identifies which line corresponding to the item. The two columns id and line_id, taken together, specify an item uniquely, and form the primary key.

Because it relies on multiple columns, this primary key is unenforced in the current version of Adaptive Server IQ. However, you could create a stored procedure to check insertions in both columns.

If a client application breaches entity integrity

Entity integrity requires that each value of a primary key be unique within the table, and that there are no NULL values. If a client application attempts to insert or update a single-column primary key value, and provides values that are not unique, entity integrity would be breached.

If an attempt to breach entity integrity is detected, Adaptive Server IQ does not add the new information to the database, and instead reports an error to the client application.

It is up to the application programmer to decide how to present this information to the user and enable the user to take appropriate action. The appropriate action in this case is usually just to provide a unique value for the primary key.

Primary keys enforce entity integrity

Once the primary key for each table is specified, no further action is needed by client application developers or by the database administrator to maintain entity integrity, if it is a single-column primary key.

For a multi-column primary key, you can create a stored procedure to check insertions into all primary key columns, so that the combined columns would always produce a unique value.

The primary key for a table is defined by the table owner when the table is created. If the structure of a table is modified at a later date, the primary key may also be redefined using the ALTER TABLE statement clauses DELETE PRIMARY KEY or ADD PRIMARY KEY. For details, see the ALTER TABLE statement in *Adaptive Server IQ Reference Manual*.

Some application development systems and database design tools allow you to create and alter database tables. If you are using such a system, you may not have to enter the CREATE TABLE or ALTER TABLE command explicitly: the application generates the statement itself from the information you provide.

For information on creating primary keys, see “Creating primary and foreign keys”. For the detailed syntax of the CREATE TABLE statement, see “CREATE TABLE statement;” for information about changing table structure, see the “ALTER TABLE statement,” both in the Adaptive Server IQ Reference.

Declaring referential integrity

A foreign key relates the information in one table (the foreign table) to information in another (referenced or primary) table. A particular column, or combination of columns, in a foreign table is designated as a foreign key to the primary table.

For the foreign key relationship to be valid, the entries in the foreign key must correspond to the primary key values of a row in the referenced table. Occasionally, some other unique column combination may be referenced, instead of a primary key.

Example 1

The sample database contains an employee table and a department table. The primary key for the employee table is the employee ID, and the primary key for the department table is the department ID.

One of the items of information about each employee is the department ID of the department to which they belong. In the employee table, the department ID is called a foreign key for the department table; each department ID in the employee table corresponds exactly to a department ID in the department table.

The foreign key relationship is a many-to-one relationship. Several entries in the employee table have the same department ID entry, but the department ID is the primary key for the department table, and so is unique. If a foreign key were able to reference a column in the department table containing duplicate entries, there would be no way of knowing which of the rows in the department table is the appropriate reference.

Example 2

Suppose the database also contained an office table, listing office locations. The employee table might have a foreign key for the office table that indicates where the employee's office is located. The database designer may wish to allow for an office location not being assigned at the time the employee is hired. In this case, the foreign key should allow the NULL value for when the office location is unknown or when the employee does not work out of an office.

How you define foreign keys

Like primary keys, foreign keys are created using the CREATE TABLE statement or ALTER TABLE statement.

For information on creating foreign keys, see "Creating primary and foreign keys".

Referential integrity is unenforced

Adaptive Server IQ does not enforce foreign key relationships. For this reason, you must specify the keyword UNENFORCED when you declare a foreign key. IQ lets you delete a primary key that is referred to by a foreign key; it does not produce an error or carry out any other special action you might specify.

You may wish to create a procedure that is called each time you insert or delete data, to enforce referential integrity independently of IQ.

Integrity rules in the system tables

All the information about integrity checks and rules in a database is held in the following system tables and views:

System table	Description
SYS.SYSTABLE	CHECK constraints are held in the view_def column of SYS.SYSTABLE. For views, the view_def holds the CREATE VIEW command that created the view. You can check whether a particular table is a base table or a view by looking at the table_type column, which is BASE or VIEW.
SYS.SYSFOREIGNKEYS	This view presents the foreign key information from the two tables SYS.SYSFOREIGNKEY and SYS.SYSFKCOL in a more readable format.
SYS.SYSCOLUMNS	This view presents the information from the SYS.SYSCOLUMN table in a more readable format. It includes default settings and primary key information for columns.

For a description of the contents of each system table, see “System Tables” in the *Adaptive Server IQ Reference Manual*. You can use Sybase Central or DBISQL to browse these tables and views.

CHAPTER 8

Transactions and Versioning

About this chapter

This chapter describes Adaptive Server IQ's approach to transaction processing, called snapshot versioning, and its implications for performance and other aspects of database administration.

Overview of transactions and versioning

Adaptive Server IQ uses *transaction processing* to allow many users to read from the database while it is being updated. Transaction processing ensures that logically related commands are executed as a unit. Transactions are fundamental to maintaining the accuracy of your data, and to data recovery in the event of system failure.

A crucial aspect of transaction processing is its ability to isolate users from the effect of other users' transactions. Adaptive Server IQ's approach to transaction processing, called *snapshot versioning*, supports the highest level of isolation recognized by ISO.

Introduction to transactions

Transactions are simply groups of SQL statements. Each transaction performs a task that changes your database from one consistent state to another. These units play an important role in protecting your database from media and system failures, and in maintaining the consistency of your data.

Transactions are logical units of work

A *transaction* is a *logical unit of work*. Each transaction is a sequence of logically related commands that accomplish one task and transform the database from one consistent state into another.

Transactions are *atomic*. In other words, Adaptive Server IQ executes all the statements within a transaction as a unit. At the end of each transaction, changes can be *committed* to make them permanent. If for any reason all the commands in the transaction do not process properly, then some or all of the intermediate changes can be undone, or *rolled back*. The user application controls the conditions under which changes are committed or rolled back. In DBISQL the AUTO_COMMIT option can be used to control commits and rollbacks automatically.

Transactions break the work of each user into small blocks. The completion of each block marks a point at which the information is self-consistent. Transaction processing is fundamental to ensuring that a database contains correct information.

Note Adaptive Server IQ processes transactions quite differently from the way Adaptive Server Anywhere does when it operates without IQ. This chapter describes how Adaptive Server IQ handles transactions. If you are working in an Anywhere-only database, see the *Adaptive Server Anywhere User's Guide* for information on transactions and locking.

Using transactions

Adaptive Server IQ allows commands to be grouped into transactions. In most cases, IQ transactions begin and end automatically, based on the commands being issued, and the options set. You can also issue explicit commands to begin or end a transaction.

Starting transactions

Transactions start automatically with one of the following events:

- The first statement following a connection to a database.
- The first statement following the end of a previous transaction.

Completing transactions

Transactions complete with one of the following events:

- A COMMIT statement makes the changes to the database permanent.

- A ROLLBACK statement undoes all the changes made by the transaction.
- A disconnection from a database causes an implicit rollback (the default) or commit, depending on whether the DBISQL option COMMIT_ON_EXIT is set.
- A statement with a side effect of an automatic commit is executed.

Database definition commands, such as ALTER, CREATE, and DROP all have the side effect of an automatic commit. You can also use two DBISQL options to cause a commit to occur automatically.

Options in DBISQL

DBISQL provides two options that let you control when and how transactions end:

- If you set the option AUTO_COMMIT to ON, DBISQL automatically commits your results following every successful statement, and automatically performs a ROLLBACK after each failed statement.
- The setting of the option COMMIT_ON_EXIT controls what happens to uncommitted changes when you exit DBISQL. If this option is set to ON (the default), DBISQL does a COMMIT; otherwise it undoes your uncommitted changes with a ROLLBACK statement.

Adaptive Server IQ also supports Transact-SQL commands, such as begin transaction, for compatibility with Adaptive Server Enterprise. For further information, see *"Transact-SQL Compatibility"* in the *Adaptive Server Anywhere User's Guide*.

Committing a transaction writes data to disk

When you execute a write operation, Adaptive Server IQ does not immediately write the data to disk. Instead, it writes it into a data *cache*, an area in memory where it stores pages from the database while they are in use. Reading from and writing to the cache reduces the number of number of times Adaptive Server IQ must access the disk. It is an essential part of IQ's high performance.

Eventually, IQ must write dirty pages—that is, pages that have been updated—to the disk. Adaptive Server IQ writes dirty pages to disk each time a transaction commits. This approach is a major benefit to IQ users, because it means that IQ does not need to log data insertions in the transaction log. By not logging the very large insertions that are typical with IQ, users gain tremendous savings in disk and performance cost.

Subdividing transactions

You can identify important states within a transaction and return to them selectively or cause other actions to occur by using savepoints. Savepoints are discussed further in “Savepoints within transactions”.

Introduction to concurrency

Adaptive Server IQ can execute more than one transaction at the same time. The term *concurrency* refers to this ability. Special mechanisms within the database server allow IQ transactions to execute concurrently without interfering with each other.

How concurrency works in IQ

While executing the SQL statements that comprise one transaction, the database server can execute some or all of the statements in other transactions. Transactions processed at the same time are said to be concurrent.

Adaptive Server IQ's approach to concurrency is designed especially for the data warehouse. Typically, in a data warehouse environment, many users need to read from the database, but only the DBA needs to update it. However, there is often a need to be able to make those updates while other users continue to request and receive query results.

Adaptive Server IQ allows many simultaneous connections by many users to one database. It can also process transactions from more than one connected user or application concurrently.

Adaptive Server IQ ensures that all database operations occur within a transaction, and that these operations do not interfere with each other. It does so by setting access restrictions at the table level, and by using a technique called snapshot versioning, described in “Introduction to versioning”. On a given table, IQ allows concurrent processing of multiple read transactions, but only one write transaction. This approach maintains the internal consistency of the database.

Concurrency and IQ Multiplex

IQ Multiplex extends Adaptive Server IQ to allow concurrent processing of read transactions on multiple Adaptive Server IQ servers. IQ Multiplex extends snapshot versioning to maintain the consistency of the database across multiple servers. For more information about using IQ Multiplex, see *Adaptive Server IQ Multiplex User's Guide*.

Concurrency for backups

Adaptive Server IQ also uses transaction processing and snapshot versioning to allow you to back up your database concurrently with read and write operations. Restore operations, however, require exclusive access, because they write to the database. See Chapter 11, "Backup and Data Recovery" for more information on concurrency issues for backup and restore operations.

Why concurrency benefits you

A data warehouse is a common repository of information shared by a large number of people. These people may need frequent access to the information. To avoid impeding their work, the database server must be able to process many transactions at the same time.

Moreover, many sites also require frequent updates to the database. In high availability sites, the DBA cannot postpone insertions and deletions to a time when exclusive access is possible. Similarly, it is important to be able to back up the database on a regular basis, without disrupting the activities of other users.

Adaptive Server IQ's approach to concurrency gives query users immediate access to information, and allows you to ensure the safety and accuracy of the information they receive.

Introduction to versioning

Adaptive Server IQ uses *snapshot versioning* to allow transactions to operate concurrently.

You can think of snapshot versioning as you would a snapshot you take with a camera. When you photograph a snapshot of an object or scene, you get an image of it as it appears at a given moment in time. Likewise, when IQ takes a snapshot of an object in your database, it retains an image of that object at a given instant in time.

Unlike a camera, though, IQ does not need to make a copy of the entire object each time the image changes. Instead, it copies only the parts of the image—the database pages—that have changed. Database pages that have not changed are shared among all active versions in the database.

IQ takes its snapshot when a transaction begins. Throughout the transaction, a user who reads from the object sees the unchanged image, or snapshot version.

Table-level versioning

In Adaptive Server IQ, at the user-visible level, the unit of versioning is the table. Table-level versioning makes sense for Adaptive Server IQ for these reasons:

- IQ data structures aggregate data for columns at the table level.
- Most IQ insertions and deletions write data table-wide.

With table-level versioning, Adaptive Server IQ can control access to the data at the level where write operations occur, and where query results are focused.

Internally, however, data is versioned at the page level. This approach helps conserve system resources.

A given IQ table may consist of millions of pages of data. When you update that table, you may be writing to only a small percentage of those pages. It would require a vast amount of disk space to maintain a complete copy of each version of an entire table. Adaptive Server IQ saves on disk space by allowing table versions to share pages that are not being updated.

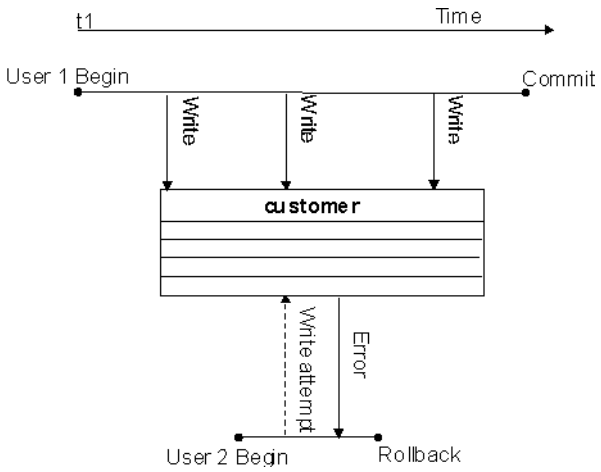
One writer and multiple readers at the table level

On a given table, IQ permits only one user to have write access for doing insertions and deletions, and multiple readers to issue queries concurrently.

Imagine a situation such as the one shown in Figure 8-1. First, User 1 begins a transaction and starts to insert data into the customer table. As long as User 1's transaction remains open, no other user can write to the customer table. Any transaction that attempts to write to the customer table receives an error until User 1's transaction commits.

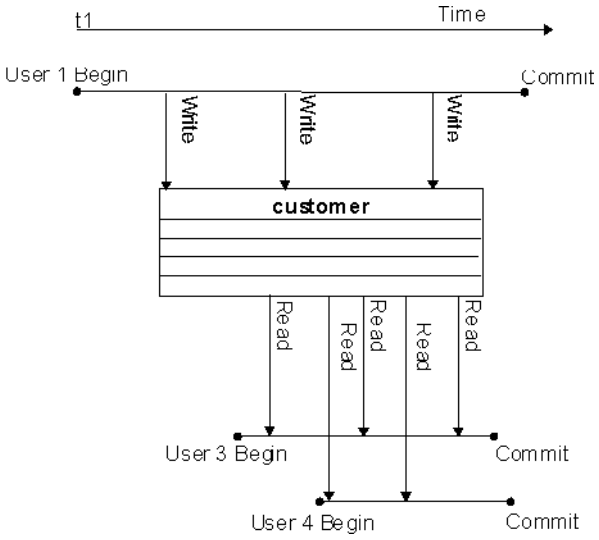
In Figure 8-1, User 2 gets an error for attempting to write before User 1's transaction commits. User 2's application determines whether to roll back the transaction, or to try writing to a different table. However, User 2 cannot write to the customer table again in the same transaction.

Figure 8-1: Only one writer at a time



Meanwhile, other users can read from the customer table at any time. In this way queries can proceed while the database administrator inserts and deletes table data. In Figure 8-2, User 3 and User 4 are able to query the customer table while User 1's write transaction remains open.

Figure 8-2: One writer, multiple readers

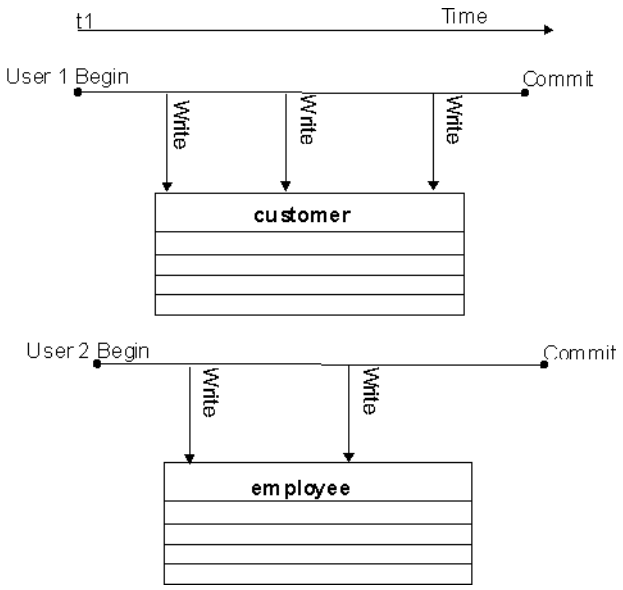


Multiple writers and readers in a database

Within an IQ database that is not multiplex, multiple read-only and read/write users can operate concurrently, as long as the writers are inserting data into (or deleting it from) different tables. So, for example, while User 1's transaction is inserting and deleting in the customer table, User 2 can begin a transaction that loads data into the employee table, as shown in Figure 8-3. At the same time other users can execute transactions that issue queries to both of these tables, or to any other tables in the database.

In an IQ Multiplex database, read/write users must all connect to the write server, whereas read-only users can connect to any query server or the write server. For more information, see *Adaptive Server IQ Multiplex User's Guide.*

Figure 8-3: Concurrent insertions to different tables



Data definition operations on a single table lock out all other readers and writers from that table. See “Locks for DDL operations” for details.

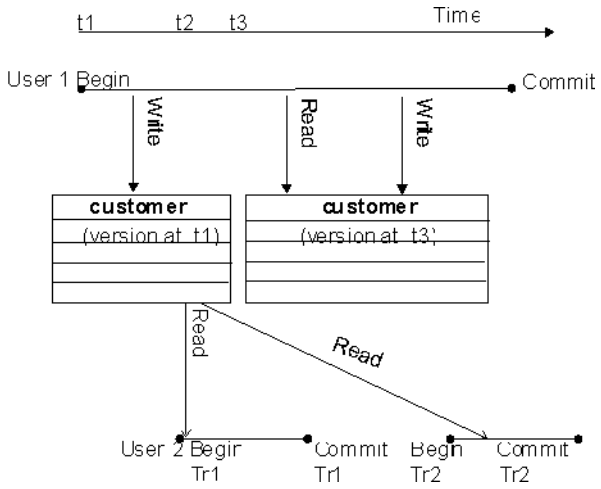
Transactions use committed data

Committed data results when a write transaction commits. Every transaction uses the latest committed version of the database as of the time the transaction begins. It uses that version until the transaction commits.

The time a transaction begins is called its Start Timestamp. The start timestamp can be any time before the transaction's first read. Any insertions and deletions the transaction makes are reflected in the snapshot. Thus, for the user executing a transaction, the image in the snapshot changes whenever that transaction writes data to the table, and then reads it again. For all other users, the image remains static until their transaction commits.

In other words, every transaction begins with a snapshot of the data in a reliable state. The snapshot of the data that you see when you issue a query does not change, even if another user is updating the table you are reading. For example, in Figure 8-4, when User 1's write transaction begins, it uses the customer table version that was committed most recently. User 2's transaction begins after User 1 has begun writing, but before User 1 commits. Therefore, User 2's first transaction (Tr1) does not see any of User 1's updates. User 2's second transaction begins after User 1 commits, so it sees all of User 1's changes.

Figure 8-4: Transactions use committed data



The data that a writer sees changes only according to the changes he or she makes; no other transaction can change what a writer sees until the writer's transaction commits. For example, in Figure 8-4, User 1 inserts some data, then does a query, and then deletes some data. Those query results reflect the insertions that User 1 has just made.

Other transactions that begin after User 1's transaction begins but before it commits see the version of the data from the time User 1's transaction begins. They can't see the latest changes, because those changes were not yet committed. As soon as User 1's transaction commits, new transactions see User 1's changes.

Timing of commits on read transactions affects versions

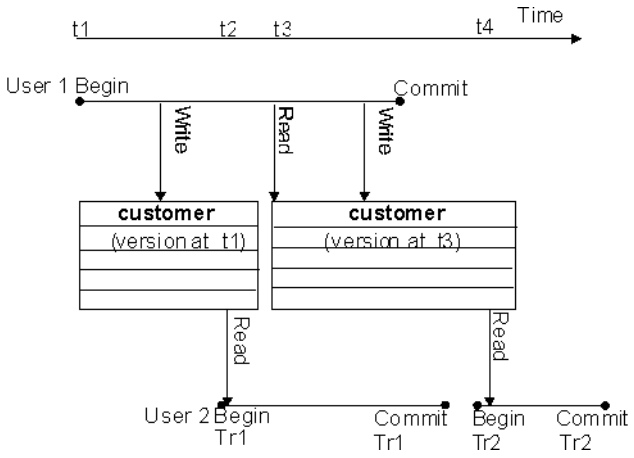
While a read transaction cannot affect what an existing write transaction sees, committing a read transaction does have implications for other transactions.

- If a user's read transaction commits *before* a concurrent write transaction does, and that user begins a new read transaction, the version remains the same.
- If a read transaction commits *after* a concurrent write transaction does, any new transaction, whether read-only or read/write, uses a new version.

Figure 8-4 on page 296 is an example of the first instance. Both of User 2's transactions use the same version as User 1's transaction began with, because that is the latest committed version of the data.

Figure 8-5 shows what happens in the second instance. This time, User 2's first read transaction (Tr1) commits after User 1's write transaction. When User 2's second transaction (Tr2) begins, it uses a new version that reflects the committed data from User 1.

Figure 8-5: Effect of read transaction committing



Hold cursors span transactions

The only exception to the rule that transactions always use the latest committed version is in transactions that use hold cursors. Hold cursors are treated differently because they can span transactions. See “Cursors in transactions” for details.

How Adaptive Server IQ keeps track of versions

Adaptive Server IQ assigns a version identifier to each database object that exists in the metadata, and that has a life span beyond a single command. IQ uses these version identifiers to ensure that writes to any database object are always based on the latest version of the object. It keeps each active version of a database object on disk.

When an older version is no longer needed by active transactions, Adaptive Server IQ drops it from the database. A version is needed until the transactions using it do one of the following:

- Commit
- Roll back
- Issue a RELEASE SAVEPOINT command releasing that version

For information on defining, releasing, and rolling back to savepoints, see "Savepoints within transactions".

Versioning of temporary tables

A temporary table that is created in the database is called a **global temporary table**. A global temporary table is accessible to all users with the appropriate permissions. Each user has his or her own instance of the table, however; only one user ever sees a given set of rows. By default, a global temporary table is deleted at the next COMMIT. You can override this default, by specifying ON COMMIT PRESERVE ROWS when you create the temporary table.

A **local temporary table** is declared rather than created in the database. Only one user sees any of the rows in a local temporary table. The table is dropped when that user disconnects. When you declare a local temporary table, Adaptive Server IQ issues a savepoint instead of committing the transaction automatically, as it would for a data definition operation on any other type of table.

For purposes of versioning, Adaptive Server IQ makes no distinction between base tables (main database tables) and global temporary tables. Because the data in any temporary table is accessible to only one user, there will never be more than one write transaction open for a temporary table.

Versioning prevents inconsistencies

Without versioning, concurrent read and write operations could cause inconsistencies in the database. The table-level versioning provided by Adaptive Server IQ prevents inconsistencies both by *serializing* transactions, and by making the table the version level.

Adaptive Server IQ allows multiple writers to modify a table serially—that is, one after the other, never more than one at a time—while multiple readers continue to work on an original copy of the table. With this method, IQ takes on full responsibility for preventing inconsistencies.

While any transaction processing system is designed to ensure that the database remains consistent, the Adaptive Server IQ approach means that users don't need to worry about placing their queries and updates in appropriate transactions. IQ begins and ends transactions automatically, and ensures that read and write operations do not interfere with each other.

How locking works

All Adaptive Server IQ locks occur automatically, based on the type of operation a user requests. You do not need to request a lock explicitly. The transaction that has access to the table is said to hold the lock.

When a table is locked in Adaptive Server IQ, no other transaction can have write access to it, but any transaction can have read access to it. Data definition operations form an exception to this universal read access; see the discussion below for details. Any other write transaction that attempts to access a table with a write lock on it receives an error.

The locks maintain the reliability of information in the database by preventing concurrent access by other transactions. The database server retains all the locks acquired by a transaction until the transaction completes, due to either a commit or a rollback.

Locks for DML operations

Data Manipulation Language (DML) operations include insertions, deletions, and queries. For all such operations, Adaptive Server IQ permits one writer and multiple readers on any given table. This rule has the following implications:

- Read transactions do not block write transactions.
- Write transactions do not block read transactions.
- A single update user and multiple read-only users can concurrently access a table.
- Only a single user can update the data in a given table at one time.

The first transaction to open a table in write mode gains access to the table. A second transaction that tries to open the table in write mode receives an error. Any additional attempts to write to the table in the current transaction will fail. The transaction can continue, but only with read operations or with writes to other tables.

Locks for DDL operations

Data Definition Language (DDL) operations include CREATE, DROP, and ALTER. DDL operations on a given table or index lock out all other readers and writers from any table being modified. This approach is crucial to the accuracy of query results. It ensures, for example, that a table column does not disappear from the database while you are selecting data from that column.

CREATE, DROP, and ALTER commands have the following special properties:

- They cannot start while any other transaction is using the table or index they are modifying.
- They cannot start while any other DDL command is operating in the database. However, this restriction is in force for only a few seconds during the operation.
- They include an automatic COMMIT on completion.
- Existing transactions that try to use the database object being modified receive an error. In other words, if you are accessing an object, and a DDL command changes that object, your command fails.
- At any given time, only one of the commands CREATE DBSPACE, DROP DBSPACE, and CHECKPOINT can be executing in a database.
- They cannot execute while an IQ Multiplex is in multiplex mode. The query servers must be stopped and the write server placed in simplex mode to execute DDL commands.

If more than one DDL command is attempted at the same time, users may get this error message:

```
Cannot perform DDL command now as a DDL command is already in progress.
```

If a CREATE DBSPACE or DROP DBSPACE command is in progress, and a user explicitly issues a CHECKPOINT command, the checkpoint fails with the message:

```
Run time SQL Error
```

If a CHECKPOINT command is in progress, a user who issues a CREATE DBSPACE or DROP DBSPACE command gets the following message:

```
Cannot perform requested command as there is a
CHECKPOINT command in progress.
```

A user who issues CREATE DBSPACE during a drop gets the message

```
Cannot perform requested command as there is a
DROP DBSPACE command in progress.
```

A user who issues DROP DBSPACE during a create gets the message:

```
Cannot perform requested command as there is a
CREATE DBSPACE command in progress.
```

See “Versioning of temporary tables” for special rules regarding temporary tables.

When one transaction issues a DDL command on a given table or index, any other transaction that began before the DDL transaction commits, and that tries to access that table, receives an error.

When this error occurs, any additional attempts to read or write to the table in the current transaction will fail.

If a transaction modifies the definition of a table that is part of a join index, it locks *every* table with any columns that are joined in that index. This result occurs whether or not the particular columns in the original write transaction are being joined.

Concurrency rules for index creation commands

There is an exception to these rules for index creation commands. CREATE INDEX and CREATE JOIN INDEX can occur concurrently with a SELECT on the table(s) affected by the index creation. Adaptive Server IQ prevents use of the new index or join index until the transaction creating the index commits.

GRANT, REVOKE, and SET OPTION are not restricted

While the commands GRANT, REVOKE, and SET OPTION are also considered DDL operations, they cause no concurrency conflicts, and so are not restricted. GRANT and REVOKE always cause an automatic commit; SET OPTION causes an automatic commit except when it is specified as TEMPORARY. GRANT and REVOKE are not allowed for any user currently connected to the database. SET OPTION affects all subsequent SQL statements sent to the database server, except for certain options that do not take effect until after you restart the database server. See the *Adaptive Server IQ Reference Manual* for details of setting options.

Primary keys and locking

Because only one user can update a table, primary key generation does not cause concurrency conflicts.

Isolation levels

An important aspect of transaction processing is the database server's ability to isolate an operation. ANSI standards define four levels of isolation. Each higher level provides transactions a greater degree of isolation from other transactions, and thus a greater assurance that the database remains internally consistent.

The isolation level controls the degree to which operations and data in one transaction are visible to operations in other, concurrent transactions. IQ snapshot versioning supports the highest level of isolation. At this level, all schedules may be serialized.

Snapshot versioning maintains this high level of isolation between concurrent transactions by following these rules:

- Transaction management maintains a snapshot of committed data at the time each transaction begins.
- A transaction can always read, as long as the snapshot version it uses is maintained.
- A transaction's writes are reflected in the snapshot it sees.
- Once a transaction begins, updates made by other transactions are invisible to it.

The level of isolation that Adaptive Server IQ provides prevents several types of inconsistencies. The ones most commonly encountered are listed here:

- *Dirty Reads* Transaction A modifies an object, but does not commit or roll back the change. Transaction B reads the modified object. Then Transaction A further changes the object before performing a COMMIT. In this situation, Transaction B has seen the object in a state that was never committed.
- *Non-Repeatable Reads* Transaction A reads an object. Transaction B then modifies or deletes the object and performs a COMMIT. If Transaction A attempts to read the same object again, it will have been changed or deleted.
- *Phantom Data Elements* Transaction A reads a set of data that satisfies some condition. Transaction B then executes an INSERT and then a COMMIT. The newly committed data now satisfies the condition, when it did not previously. Transaction A then repeats the initial read and obtains a different set of data.
- *Lost Update* In an application that uses cursors, Transaction A writes a change for a set of data. Transaction B then saves an update that is based on earlier data. Transaction A's changes are completely lost.

Adaptive Server IQ protects you from all of these inconsistencies by ensuring that only one user can modify a table at any given time, by keeping the changes invisible to other users until the changes are complete, and by maintaining time-stamped snapshots of data objects in use at any time.

While IQ allows you to set the isolation level to 0, 1, 2, or 3 (comparable to ANSI levels 1, 2, 3, or 4) using SET OPTION ISOLATION_LEVEL, there is no reason to do so. All users execute at isolation level 4, even if you set a different level. There is no performance advantage to setting a lower isolation level.

Checkpoints, savepoints, and transaction rollback

Besides permitting concurrency, transaction processing plays an important role in data recovery. Database recovery always recovers every committed transaction. Transactions that have not committed at the time of a database crash are not recovered.

Adaptive Server IQ relies on three transaction-related commands that help you recover a stable set of data in the event of system or media failure. These commands set checkpoints, set and release savepoints, and roll back transactions.

Checkpoints

A *checkpoint* marks a significant point in a transaction, when Adaptive Server IQ writes to disk certain information it tracks internally. It uses this information in the event you need to recover your database.

Adaptive Server IQ uses checkpoints differently than OLTP databases such as Adaptive Server Anywhere. OLTP databases tend to have short transactions, that affect only a small number of rows. It would be very expensive for them to write entire pages to disk. Instead, OLTP databases generally write to disk at checkpoints, and write only the changed data rows.

As discussed in Chapter 1, “Overview of Adaptive Server IQ System Administration”, Adaptive Server IQ is an OLAP database. A single OLAP transaction can change thousands or millions of rows of data. For this reason, Adaptive Server IQ does not wait for a checkpoint to occur to perform physical writes. It writes updated data pages to disk after each transaction commits. For an OLAP database, it is much more effective to write full pages of data to disk than to write small amounts of data at arbitrary checkpoints.

Checkpoints aid in recovery

In order to recover from a system or media failure, Adaptive Server IQ must be able to restore the database to a point where it is internally consistent. IQ uses checkpoints to generate reference points and other information that it needs to recover databases. The information that IQ writes to disk at each checkpoint is essential to the recovery process.

When checkpoints occur

Most Adaptive Server IQ checkpoints occur automatically. You can also set explicit checkpoints, although you do not need to do so.

A checkpoint occurs at the following times:

- When a transaction issues a CHECKPOINT command.
- When the CHECKPOINT_TIME is exceeded.

- At the start and end of the backup process.
- When the database server is shut down.

The CHECKPOINT_TIME is the maximum time that can pass between checkpoints. It is set by default at 60 minutes. You can adjust the checkpoint interval with the SET OPTION command; see the *Adaptive Server IQ Reference Manual* for details. You probably do not need to adjust the checkpoint time or issue explicit checkpoints, however. Controlling checkpoints is less important in Adaptive Server IQ than in OLTP database products, because IQ writes the actual data pages after each transaction commits.

For more information on checkpoints in recovery, see “How transaction information aids recovery”.

Savepoints within transactions

Adaptive Server IQ supports savepoints within a transaction.

A SAVEPOINT statement defines an intermediate point during a transaction. Because a single IQ transaction may write millions of rows of data, you may want to limit the amount of data that is committed—and thus written to disk—to less than a full transaction's worth. Setting savepoints allows you to subdivide transactions.

You can undo all changes after a savepoint using a ROLLBACK TO SAVEPOINT statement. For more information on savepoints and rollback, see “Naming and nesting savepoints”.

Releasing savepoints

Once a RELEASE SAVEPOINT statement has been executed or the transaction has ended, you can no longer use the savepoint. Releasing a savepoint frees up the version pages that have been used, up to that savepoint. Remember that data is versioned at the page level internally. Adaptive Server IQ maintains a separate copy of just the updated pages; the remaining pages are shared with the previous version. By releasing savepoints, you free up the pages associated with them, and thus make better use of your disk space.

Releasing savepoint *n* both releases all resources after that savepoint, and gives up your ability to roll back to any intermediate savepoints.

No locks are released by the RELEASE SAVEPOINT command.

Rolling back to a savepoint

You can undo all changes after a savepoint by issuing a ROLLBACK TO SAVEPOINT. This command rolls back to the savepoint you specify, or to the most recent SAVEPOINT if you do not specify a named savepoint. Rolling back to savepoint *n* undoes all actions for all savepoints greater than or equal to *n*.

Normally, locks are released only at the end of a transaction. However, ROLLBACK TO SAVEPOINT does release locks under certain conditions, as in the following scenario.

Example

Assume that you have a series of savepoints in a transaction, and then perform a write operation. You then roll back the transaction to an earlier savepoint. The rollback undoes all actions after that savepoint, including the write operation and any locks it acquires after the savepoint you are rolling back to.

Automatic and user-defined savepoints

IQ sets an implicit savepoint before and after every DML command. The data page versions associated with these savepoints are released when the command completes. If you want to retain data page versions beyond the end of a single DML command, you need to set your own, named savepoints.

Naming and nesting savepoints

Savepoints can be named and they can be nested. By using named, nested savepoints, you can have many active savepoints within a transaction. Changes between a SAVEPOINT and a RELEASE SAVEPOINT can still be canceled by rolling back to a previous savepoint or rolling back the transaction itself. Changes within a transaction are not a permanent part of the database until the transaction is committed. All savepoints are released when a transaction ends.

Savepoints cause Adaptive Server IQ to update information it maintains about the location of available disk space. This information is used during transaction rollback.

There is no additional overhead in using savepoints, although unreleased savepoints may consume extra disk space by keeping older intermediate versions active.

Rolling back transactions

When you roll back a transaction, you undo all of the operations in that transaction. We say that you are rolling back the database, since you are returning the database to an earlier state.

What causes a rollback

Rollbacks can occur either due to an explicit user request, or automatically.

You use a ROLLBACK statement to undo any changes to the database since the last COMMIT or ROLLBACK.

You use a ROLLBACK TO SAVEPOINTstatement to undo any changes to the database since the SAVEPOINT you name, or else to the last SAVEPOINT.

Adaptive Server IQ rolls back the database automatically if a user is in a transaction and then logs out or disconnects without committing. The rollback is to the most recent commit or rollback.

Effect of rollback

Rollback returns both the main and temporary stores to their former state. It also releases locks:

- Transaction rollback releases all locks held by the transaction.
- Rollback to a savepoint releases all locks acquired after that savepoint.

Rollback of open cursors deletes all cursor information and closes both hold and non-hold cursors:

- Transaction rollback closes all cursors. It does not matter whether the cursor was opened in the transaction being rolled back, or in an earlier transaction.
- Rollback to a savepoint closes all cursors opened after that savepoint.

For more information on cursors, see “Cursors in transactions”. For more information on rollback to a savepoint, see “Rolling back to a savepoint”.

System recovery

In the event of a system failure or power outage, or when you restart the database server after it has been stopped, Adaptive Server IQ attempts to recover automatically.

During Adaptive Server IQ database recovery, any uncommitted transactions are rolled back, and any disk space used for old versions is returned to the pool of available space. At this point, the database contains only the most recently committed version of each permanent table.

During recovery from a system failure, Adaptive Server IQ reopens all connections that were active at the time of the failure. If the -gm parameter, which sets the number of user connections, was in effect at the time of the failure, you need to restart the IQ server with at least as many connections as were actually in use when the failure occurred. Temporary table contents are not recoverable.

If a failure occurs, try to restart the database server and database. If you have trouble starting a server or database, or if users are unable to connect to it, see *Adaptive Server IQ Troubleshooting and Error Messages Guide* for information on how to proceed. You will need information from your server log and IQ message log to recover.

Sybase recommends that you run the stored procedure sp_iqcheckdb after a system failure, preferably before allowing users to connect. This procedure checks every block in your database, and produces statistics that allow you to check the consistency and integrity of your database. For details, see *Adaptive Server IQ Troubleshooting and Error Messages Guide*.

How transaction information aids recovery

Adaptive Server IQ's recovery mechanism is designed for the data warehouse. Typically in this environment, few transactions occur, but each transaction can be quite time consuming.

To best suit this model, Adaptive Server IQ performs database updates by making them on a copy of the actual database page, and then writes the data to disk whenever a write transaction commits. It also records the following information:

- The location and quantity of changed data for each transaction. It stores this information in a *transaction log.*
- The location of any version pages and free space on disk. It uses this information to free up space when versions are no longer needed. All versions created throughout the duration of a write transaction become obsolete when the write transaction commits or rolls back. Individual versions can be released at a savepoint.

- Additional information about checkpoints that occurred during a transaction.

When you need to recover your database, instead of repeating all of the lengthy transactions that have occurred, Adaptive Server IQ restores quickly from the information in the transaction log and the checkpoint information. It uses the information about versions and free space to roll back transactions, and to release the disk space occupied by obsolete versions.

The transaction log requires very little space, only about 128 bytes for each committed transaction. The information about checkpoints and disk space availability are also very small.

The transaction log is deleted:

- Always after a full backup.
- Optionally after incremental backup.
- Always after backup files are restored following media failure, and a new log is started.

The checkpoint information is deleted at the next checkpoint. Information related to particular savepoints is deleted when the savepoint is released or rolled back.

For other concurrency issues relating to backing up and restoring databases, see “Concurrency and backups”.

Performance implications

Snapshot versioning should have a minimal impact on performance. The flexibility you gain by being able to update the database while other users read from it far outweigh any negative effects. There are certain resource issues you should be aware of, however:

- Buffer consumption may increase slightly, if multiple users are using different versions of the same database page simultaneously.
- Version management requires some overhead, but the effect on performance is minimal. See also the bullet on disk space.
- The thread control, which determines how many processing resources a user gets, and the sweeper controls, which use a small number of threads to sweep dirty data pages out to disk, have a minor impact on performance.

- Disk space can sometimes become an issue. Storing overlapping versions has the potential to use a lot of disk space, depending on the number and size of versions in use simultaneously. Metadata and database page versions are retained until they are dropped, either at a RELEASE SAVEPOINT or when the last transaction that can see a given version commits or rolls back. The space is then reclaimed.

Delays due to locking are minimal. Individual commits, rollbacks, and checkpoints can block other read or write transactions only very briefly.

Remember that all of these performance and disk use factors only affect your system in the degree to which you take advantage of IQ's concurrent read and write capabilities. Disk space requirements in particular can vary widely, depending on how long write transactions take before they commit, how many read transactions take place during write transactions, the number of rows these transactions affect, and whether you allow the release of data pages at interim savepoints.

For an explanation of how Adaptive Server IQ uses the resources discussed in this section, see Chapter 12, “Managing System Resources”

Overlapping versions and deletions

In order to delete data, you may actually need to increase disk space by adding a dbspace to your IQ Store. The amount of space you need for a deletion depends on the distribution of the data on data pages, more than on the size or number of rows being deleted. IQ needs to retain a version of each page that contains any of the data you are deleting, from the time the deletion begins until the transaction commits. If the rows being deleted happen to be distributed across many data pages, then you need space in your IQ Store to retain all of those extra data pages.

For example, assume that you need to delete ten rows from a database where each page holds 100 rows. If each of those ten rows is on a separate data page, then your IQ Store needs to have space for ten version pages, each big enough to hold 100 rows. While this distribution is unlikely, it is possible.

The space needed to delete data varies by index type. It is proportional to—and in the worst case, equal to—the size of the index from which you are deleting. For information on sizes of index types, see “Indexing criteria: disk space usage”.

If you run out of space while deleting data, Adaptive Server IQ halts the deletion and displays this message in the notification log:

```
Out of disk space
```

After you add space, the deletion resumes. When the delete transaction commits, the space becomes available for other deletions or insertions. If you do not need normally that much space in your database, you can drop the dbspace to regain the extra disk space for other purposes. Be sure you do so before inserting any data, so that you do not lose any data that Adaptive Server IQ might put in the new dbspace.

Running out of space during a deletion should not affect other query users.

If you run out of space, but do not have enough disk space to add another dbspace, you must shut down the database engine and then restart it, allowing the database to roll back. You can then delete the rows in smaller, separate transactions.

Note DROP TABLE and DROP DATABASE delete the table or database and all data in it without creating any version pages, so you do not need to add space to use these commands.

Cursors in transactions

A *cursor* allows you to return the results of a SELECT in the form of a data type called a cursor. A cursor is similar to a table, but has the additional property that one row is identified as the present, or current row. Various commands allow you to navigate through the rows of a cursor. For example, the FETCH command retrieves a row from the cursor and identifies it as the current row. You can step through all the rows in a cursor by calling this command repeatedly.

Cursors are of most use when you program procedures, or when you write applications that access a database using embedded SQL. They are also used by many front-end query tools. They are not available when using DBISQL interactively.

All Adaptive Server IQ cursors are read-only. You can write data, but the cursor does not see the write operation.

The rows in a cursor, like those in a table, have no order associated with them. The FETCH command steps through the rows, but the order may appear random and can even be inconsistent. For this reason, you will want to impose an order by appending an ORDER BY phrase to your SELECT statement.

Cursors and versioning

When you use cursors, Adaptive Server IQ needs to be able to manage multiple versions within a single transaction. For example, assume that you open a cursor called cust_cursor at time x that uses the customer table. You then update that table later on at time y. Adaptive Server IQ needs to retain the version of the customer table from time x until you are done using cust_cursor.

See “Effect of rollback” for what happens to cursors during a rollback of the database.

Adaptive Server IQ's support for cursors is oriented toward their likely use in DSS applications. The following sections discuss specific cursor characteristics with implications for transaction processing.

Cursor sensitivity

A cursor is said to be *sensitive* if its membership—the data rows it returns—can vary from the time it is opened until the time it is closed. An *insensitive* cursor has its membership fixed when it is opened. Adaptive Server IQ supports only insensitive cursors.

Cursor scrolling

Adaptive Server IQ cursors can be either scrolling or non-scrolling. Non-scrolling cursors allow only the command forms FETCH NEXT and FETCH RELATIVE 0 to find and retrieve data. They do not keep track of which rows have been fetched. A cursor declared as DYNAMIC SCROLL is the same as a cursor declared as SCROLL.

You can force all cursors to be non-scrolling by setting the option FORCE_NO_SCROLL_CURSORS to ON. You may want to use this option to save on temporary storage requirements if you are retrieving very large numbers (millions) of rows.

Hold cursors

Specifying the HOLD option when you open a cursor keeps the cursor open past the end of the transaction, if the transaction ends in a COMMIT. A hold cursor does not remain open across a ROLLBACK in which a cursor is opened.

Although the HOLD option is not commonly used in a DSS environment, with long transactions and no positioned updates, it may prove useful in some situations. For example, many existing applications expect to use hold cursors, and some ODBC drivers use hold cursors by default.

Adaptive Server IQ provides the version management needed for hold cursors.

Hold cursors do impact performance. All resources used by the cursor, including memory, disk space, and process threads, are held until the cursor is closed.

Positioned operations

In a positioned operation, the current location of the cursor determines where a read or write operation begins. Adaptive Server IQ supports positioned fetches, which can be helpful in long query transactions. It does *not* support positioned updates, which are intended for shorter insertions and deletions. For the most part, updates to IQ databases are likely to involve large amounts of data; repositioning is a very minor part of such write operations.

Cursor command syntax and examples

For more information on using cursors in procedures, including examples of cursor use, see Chapter 6, “Using Procedures and Batches”. For syntax of cursor-related commands, see the *Adaptive Server IQ Reference Manual*.

Controlling message logging for cursors

By default, cursor operations are not logged in the IQ message file. If you need to track cursor operations in order to determine the cause of a problem, turn on the Log_Cursor_Operations option to produce a message each time a cursor is opened or closed. See the *Adaptive Server IQ Reference Manual* for details.

CHAPTER 9

International Languages and Character Sets

About this chapter

This chapter describes how to configure your Adaptive Server IQ installation to handle international language issues.

Introduction to international languages and character sets

This section provides an introduction to the issues you may face when working in an environment that uses more than one character set, or when using languages other than English.

When you create a database, you specify a collating sequence or **collation** to be used by the database. A collation is a combination of a **character set** and a **sort order** for characters in the database.

Adaptive Server IQ international features

Adaptive Server IQ provides two sets of features that are of particular interest when setting up databases for languages.

- **Collations** You can choose from a wide selection of supplied collations when you create a database. By creating your database with the proper collation, you ensure proper sorting of data.

  Whenever the database compares strings, sorts strings, or carries out other string operations such as case conversion, it does so using the collation sequence. The database carries out sorting and string comparison when statements such as the following are executed:

  - Queries with an ORDER BY clause.
  - Expressions that use string functions, such as LOCATE, SIMILAR, SOUNDEX.

- Conditions using the LIKE keyword.

  IQ indexes that hold character data are created based on the database collation. The database also uses collations to identify valid or unique identifiers (column names and so on).

- **Character set translation** You can set up Adaptive Server IQ to convert data between the character set encoding on your server and client systems, thus maintaining the integrity of your data even in mixed character set environments.

  Character set translation is provided between client and server, and also by the ODBC driver. The Adaptive Server IQ ODBC driver provides OEM to ANSI character set translation and Unicode support.

Using the default collation

If you use the default actions when creating an IQ database, your database has the collation ISO_BINENG. This collation provides optimal performance for IQ databases, but not necessarily the most natural sort order. For more information, see “Performance issues” on page 352.

Note that this differs from Adaptive Server Anywhere, which infers the default collation for new databases from the character set in use by the operating system on which the database is created.

If it is not possible to set up your system in this default manner, you need to decide which collation to use in your database, and whether to use character set translation to ensure that data is exchanged consistently between the pieces of your database system. This chapter provides the information you need to make and implement these decisions.

Character set questions and answers

The following table identifies where you can find answers to questions.

To answer the question...	Consider reading...
How do I set up my computing environment to treat character sets properly?	“Configuring your character set environment” on page 344
How do I decide which collation to use for my database?	“Understanding collations” on page 328

To answer the question...	Consider reading...
How are characters represented in software, and Adaptive Server IQ in particular?	“Understanding character sets in software” on page 317
What collations does Adaptive Server IQ provide?	“Supplied collations” on page 329
How do I ensure that error and informational messages sent from the database server to client applications are sent in the proper language and character set for my application?	“Character translation for database messages” on page 336
I have a different character set on client machines from that in use in the database. How can I get characters to be exchanged properly between client and server?	“Starting a database server using character set translation” on page 348
What character sets can I use for connection strings?	“Connection strings and character sets” on page 338
How do I create a collation that is different from the supplied ones?	“Creating a database with a custom collation” on page 351

Understanding character sets in software

This section provides general information about software issues related to international languages and character sets.

Pieces in the character set puzzle

There are several distinct aspects to character storage and display by computer software:

- Each piece of software works with a **character set**. A character set is a set of symbols, including letters, digits, spaces and other symbols.
- To handle these characters, each piece of software employs a character set **encoding**, in which each character is mapped onto one or more **bytes** of information, typically represented as hexadecimal numbers. This encoding is also called a **code page**.

- Database servers, which sort characters (for example, list names alphabetically), use a **collation**. A collation is a combination of a character encoding (a map between characters and hexadecimal numbers) and a **sort order** for the characters. There may be more than one sort order for each character set; for example, a case-sensitive order and a case-insensitive order, or two languages may sort characters in a different order.
- Characters are printed or displayed on a screen using a **font**, which is a mapping between characters in the character set and their appearance. Fonts are handled by the operating system.
- Operating systems also use a **keyboard mapping** to map keys or key combinations on the keyboard to characters in the character set.

Language issues in client/server computing

Database users working at client applications may see or access strings from the following sources:

- **Data in the database** Strings and other text data are stored in the database. The database server processes these strings when responding to requests.

  For example, the database server may be asked to supply all the last names beginning with a letter ordered less than N in a table. This request requires string comparisons to be carried out, and assumes a character set ordering.

  The database server receives strings from client applications as streams of bytes. It associates these bytes with characters according to the database character set. Data in some IQ indexes is stored based on the sort order of the collation.
- **Database server software messages** Applications can cause database errors to be generated. For example, an application may submit a query that references a column that does not exist. In this case, the database server returns a warning or error message. This message is held in a **language resource library**, which is a DLL or shared library called by Adaptive Server IQ.
- **Client application** The client application interface displays text, and internally the client application may process text.
- **Client software messages** The client library uses the same language library as the database server to provide messages to the client application.

- **Operating system** The client operating system has text displayed on its interface, and may also process text.

For a satisfactory working environment, all these sources of text must work together. Loosely speaking, they must all be working in the user's language and/or character set.

Code pages in Windows and Windows NT

Many languages have few enough characters to be represented in a single-byte character set. In such a character set, each character is represented by a single **byte**: a two-digit hexadecimal number.

At most, 256 characters can be represented in a single byte. No single-byte character set can hold all of the characters used internationally, including accented characters. This problem was addressed by the development of a set of **code pages**, each of which describes a set of characters appropriate for one or more national languages. For example, code page 869 contains the Greek character set, and code page 850 contains an international character set suitable for representing many characters in a variety of languages.

Upper and lower pages

With few exceptions, characters 0 to 127 are the same for all the single-byte code pages. The mapping for this range of characters is called the **ASCII** character set. It includes the English language alphabet in upper and lower case, as well as common punctuation symbols and the digits. This range is often called the **seven-bit** range (because only seven bits are needed to represent the numbers up to 127) or the **lower** page. The characters from 128 to 256 are called **extended characters**, or **upper** code-page characters, and vary from code page to code page.

Problems with code page compatibility are rare if the only characters used are from the English alphabet, as these are represented in the ASCII portion of each code page (0 to 127). However, if other characters are used, as is generally the case in any non-English environment, there can be problems if the database and the application use different code pages.

Example

Suppose a database holding French language strings uses code page 850, and the client operating system uses code page 437. The character À (upper case A grave) is held in the database as character \xB7 (decimal value 183). In code page 437, character \xB7 is a graphical character. The client application receives this byte and the operating system displays it on the screen, the user sees a graphical character instead of an A grave.

Remember that the code page used by the client system determines both the values that are sent to server for each character you enter, and the characters that are displayed when particular values are sent to the client from the server. The code page used by the server system determines how the server interprets values the client sends.

ANSI and OEM code pages in Windows and Windows NT

For Microsoft Windows and Windows NT users, the issue is complicated because there are at least two code pages in use on most PCs. This issue affects both Windows and NT clients and NT servers.

MS-DOS, as well as character-mode applications (those using the console or "DOS box") in Windows 95/98 and Windows NT, use code pages taken from the IBM set. These are called **OEM code pages** (Original Equipment Manufacturer) for historical reasons.

Windows operating systems do not require the line drawing characters that were held in the extended characters of the OEM code pages, so they use a different set of code pages. These pages are based on the ANSI standard and are therefore commonly called **ANSI code pages**.

Adaptive Server IQ supports collations based on both OEM and ANSI code pages.

Example

Consider the following situation:

- A PC is running the Windows 98 operating system with ANSI code page 1252.
- The code page for character-mode applications is OEM code page 437.
- Text is held in a database created using the collation corresponding to OEM code page 850.

An uppercase A grave in the database is stored as character 183. This value is displayed as a graphical character in a character-mode application. The same character is displayed as a dot in a Windows application.

For information about choosing a single-byte collation for your database, see “Understanding collations” on page 328.

Multibyte character sets

Some languages, such as Japanese and Chinese, have many more than 256 characters. These characters cannot all be represented using a single byte, but can be represented in multibyte character sets. In addition, some character sets use the much larger number of characters available in a multibyte representation to represent characters from many languages in a single, more comprehensive, character set.

Multibyte character sets are of two types. Some are **variable width**, in which some characters are single-byte characters, others are double-byte, and so on. Other sets are **fixed width**, in which all characters in the set have the same number of bytes. Adaptive Server IQ supports only variable-width character sets.

Example

As an example, characters in the Shift-JIS character set are of either one or two bytes in length. If the value of the first byte is in the range of hexadecimal values from \x81 to \x9F or from \xE0 to \xEF (decimal values 129-159 or 224-239) the character is a two-byte character and the subsequent byte (called a **follow byte**) completes the character. If the first byte is outside this range, the character is a single-byte character and the next byte is the first byte of the following character.

- The properties of any Shift-JIS character can be read from its first byte also. Characters with a first byte in the range \x09 to \x0D, or \x20, are space characters.
- Characters in the ranges \x41 to \x5A, \x61 to \x7A, \x81 to \x9F or \xA1 to \xEF are considered to be alphabetic (letters).
- Characters in the range \x30 to \x39 are digits.

In building custom collations, you can specify which ranges of values for the first byte signify single- and double-byte (or more) characters, and which specify space, alpha, and digit characters. However, all first bytes of value less than 64 (hex 40) must be single-byte characters, and no follow bytes may have values less than 64. This restriction is satisfied by all known current encodings.

For information on the multibyte character sets, see “Using multibyte collations” on page 336.

Sorting characters using collations

The database collation sequence includes the notion of alphabetic ordering of letters, and extends it to include all characters in the character set, including digits and space characters.

Associating more than one character with each sort position

More than one character can be associated with each sort position. This is useful if you wish, for example, to treat an accented character the same as the character without an accent.

Two characters with the same sort position are considered identical in all ways by the database. Therefore, if a collation assigned the characters *a* and *e* to the same sort position, then a query with the following search condition:

```
WHERE col1 = 'want'
```

is satisfied by a row for which col1 contains the entry went.

At each sort position, lower- and uppercase forms of a character can be indicated. For case-sensitive databases (the default for IQ databases created as of version 12.4.2), the lower- and uppercase characters are not treated as equivalent. For case-insensitive databases, the lower- and uppercase versions of the character are considered equivalent.

First-byte collation orderings for multibyte character sets

A sorting order for characters in a multibyte character set can be specified only for the first byte. Characters that have the same first byte are sorted according to the hexadecimal value of the following bytes.

International aspects of case sensitivity

Adaptive Server IQ is **case preserving** and **case insensitive** for identifiers, such as table names and column names. This means that the names are stored in the case in which they are created, but any access to the identifiers is done in a case-insensitive manner.

For example, the names of the system tables are held in upper case (SYSDOMAIN, SYSTABLE, and so on), but access is case insensitive, so that the two following statements are equivalent:

```
SELECT *
FROM systable
SELECT *
FROM SYSTABLE
```

The equivalence of upper and lower case characters is enforced in the collation. There are some collations where particular care may be needed when assuming case insensitivity of identifiers.

Example

In the Turkish 857TRK collation, the lower case i does not have the character I as its upper case equivalent. Therefore, despite the case insensitivity of identifiers, the following two statements are *not* equivalent in this collation:

```
SELECT *
FROM sysdomain
SELECT *
FROM SYSDOMAIN
```

Understanding locales

Both the database server and the client library recognize their language and character set environment using a **locale definition**.

Introduction to locales

The application locale, or client locale, is used by the client library when making requests to the database server, to determine the character set in which results should be returned. If character-set translation is enabled, the database server compares its own locale with the application locale to determine whether character set translation is needed. Different databases on a server may have different locale definitions.

For information on enabling character-set translation, see “Starting a database server using character set translation” on page 348.

The locale consists of the following components:

- **Language** The language is a two-character string using the ISO-639 standard values: DE for German, FR for French, and so on. Both the database server and the client have language values for their locale.

  The database server uses the locale language to determine which language library to load.

  The client library uses the locale language to determine:

  - Which language library to load.

- Which language to request from the database.

  For more information, see “Understanding the locale language” on page 324.

- **Character set** The character set is the code page in use. The client and server both have character set values, and they may differ. If they differ, character set translation may be required to enable interoperability.

  For machines that use both OEM and ANSI code pages, the ANSI code page is the value used here.

  For more information, see “Understanding the locale character set” on page 325.

- **Collation label** The collation label is the Adaptive Server IQ collation. The client side does not use a collation label. Different databases on a database server may have different collation labels.

  For more information, see “Understanding the locale collation label” on page 328.

Understanding the locale language

The locale language is an indicator of the language being used by the user of the client application, or expected to be used by users of the database server.

For a list of supported locale languages, see “Language label values” on page 325.

For how to find locale settings, see “Determining locale information” on page 345.

The client library or database server determines the language component of the locale as follows:

1 It checks the SQLLOCALE environment variable, if it exists.

  For more information, see “Setting the SQLLOCALE environment variable” on page 328.

2 On Windows and Windows NT, it checks the Adaptive Server IQ language registry entry.

3 On other operating systems, or if the registry setting is not present, it checks the operating system language setting.

Language label values

The following table shows the valid language label values, together with the equivalent ISO 639 labels:

Language label	Alternative label	ISO_639 language code
us_english	english	EN
french	N/A	FR
german	N/A	DE
spanish	N/A	ES
japanese	N/A	JA
korean	N/A	KO
portuguese	portugue	PT
chinese	simpchin	ZH
italian	N/A	IT
tchinese	tradchin	TW
polish	N/A	PL
norwegian	norweg	NO
swedish	N/A	SV
danish	N/A	DA

Understanding the locale character set

Both application and server locale definitions have a character set. The application uses its character set when requesting character strings from the server. If character set translation is enabled, the database server compares its character set with that of the application to determine whether character set translation is needed.

For a list of available character set labels, see “Character set labels” on page 326.

For how to find locale settings, see “Determining locale information” on page 345.

The client library or database server determines the character set as follows:

1 If the connection string specifies a character set, it is used.

   For more information, see the CharSet connection parameter in the *Adaptive Server IQ Reference Manual*.

2 ODBC and Embedded SQL applications check the SQLLOCALE environment variable, if it exists.

For more information, see “Setting the SQLLOCALE environment variable” on page 328.

Open Client applications check the *locales.dat* file in the Sybase *locales* directory is used.

3 Character set information from the operating system is used to determine the locale:

- On Windows operating systems, use the GetACP system call. This returns the ANSI character set, not the OEM character set.
- On UNIX, default to ISO8859-1.
- On other platforms, use code page 850.

Character set labels

The following table shows the valid character set label values, together with the equivalent IANA labels and a description:

Character set label	IANA label	Description
iso_1	iso_8859-1:1987	ISO 8859-1 Latin-1
cp850	<N/A>	IBM CP850 - European code set
cp437	<N/A>	IBM CP437 - U.S. code set
roman8	hp-rpman8	HP Roman-8
mac	macintosh	Standard Mac coding
sjis	shift_jis	Shift JIS (no extensions)
eucjis	euc-jp	Sun EUC JIS encoding
deckanji	<N/A>	DEC Unix JIS encoding
euccns	<N/A>	EUC CNS encoding: Traditional Chinese with extensions
eucgb	<N/A>	EUC GB encoding = Simplified Chinese
cp932	windows-31j	Microsoft CP932 = Win31J-DBCS
iso88592	iso_8859-2:1987	ISO 8859-2 Latin-2 Eastern Europe
iso88595	iso_8859-5:1988	ISO 8859-5 Latin/Cyrillic
iso88596	iso_8859-6:1987	ISO 8859-6 Latin/Arabic
iso88597	iso_8859-7:1987	ISO 8859-7 Latin/Greek
iso88598	iso_8859-8:1988	ISO 8859-8 Latin/Hebrew
iso88599	iso_8859-9:1989	ISO 8859-9 Latin-5 Turkish
iso15	<N/A>	ISO 8859-15 Latin1 with Euro, etc.
mac_cyr	<N/A>	Macintosh Cyrillic
mac_ee	<N/A>	Macintosh Eastern European

Character set label	IANA label	Description
macgrk2	<N/A>	Macintosh Greek
macturk	<N/A>	Macintosh Turkish
greek8	<N/A>	HP Greek-8
turkish8	<N/A>	HP Turkish-8
koi8	<N/A>	KOI-8 Cyrillic
tis620	<N/A>	TIS-620 Thai standard
big5	<N/A>	Traditional Chinese (cf. CP950)
eucksc	<N/A>	EUC KSC Korean encoding (cf. CP949)
cp852	<N/A>	PC Eastern Europe
cp855	<N/A>	IBM PC Cyrillic
cp856	<N/A>	Alternate Hebrew
cp857	<N/A>	IBM PC Turkish
cp860	<N/A>	PC Portuguese
cp861	<N/A>	PC Icelandic
cp862	<N/A>	PC Hebrew
cp863	<N/A>	IBM PC Canadian French code page
cp864	<N/A>	PC Arabic
cp865	<N/A>	PC Nordic
cp866	<N/A>	PC Russian
cp869	<N/A>	IBM PC Greek
cp874	<N/A>	Microsoft Thai SB code page
cp936	</N/A>	Simplified Chinese
cp949	<N/A>	Korean
cp950	<N/A>	PC (MS) Traditional Chinese
cp1250	<N/A>	MS Windows 3.1 Eastern European
cp1251	<N/A>	MS Windows 3.1 Cyrillic
cp1252	<N/A>	MS Windows 3.1 US (ANSI)
cp1253	<N/A>	MS Windows 3.1 Greek
cp1254	<N/A>	MS Windows 3.1 Turkish
cp1255	<N/A>	MS Windows Hebrew
cp1256	<N/A>	MS Windows Arabic
cp1257	<N/A>	MS Windows Baltic
cp1258	<N/A>	MS Windows Vietnamese
utf8	utf-8	UTF-8 treated as a character set

Understanding the locale collation label

Each database has its own collation.

The database server determines the collation label as follows:

1 It checks the SQLLOCALE environment variable, if it exists.

For more information, see “Setting the SQLLOCALE environment variable” on page 328.

2 It uses an internal table to find a collation label corresponding to the language and character set.

Collation label values

The collation label is a label for one of the supplied Adaptive Server IQ collations, as listed in “Understanding collations” on page 328.

Setting the SQLLOCALE environment variable

The SQLLOCALE environment variable is a single string that consists of three semicolon-separated assignments. It has the following form:

`Charset=`*cslabel*`;Language=`*langlabel*`;CollationLabel=`*colabel*

where *cslabel*, *langlabel*, and *colabel* are labels as defined in the previous sections.

For information on how to set environment variables, see the *Adaptive Server IQ Reference Manual*.

Understanding collations

This section describes the supplied collations, and provides suggestions as to which collations to use under certain circumstances.

For information on how to create a database with a specific collation, see “Creating a database with a named collation” on page 346.

Displaying collations

Each time the database server opens an IQ database, it displays the following collation information:

- The collation (ASA_Label)
- Case sensitivity (Case)
- Blank padding (Blank Padding) if it was specified when the database was created.

You can also see the collation of your current database by using the dbcollat utility to write the collation into a file:

```
dbcollat -c "connection-string" filename
```

For example, you might extract the collation from the asiqdemo database as follows:

```
dbcollat -c "uid=DBA;pwd=SQL;eng=myhost_asiqdemo"
demo_col
```

You can display the contents of *filename* from the File menu in dbisql.

To see details of any collation that exists on your system, use the -z option of dbcollat. For example, to extract collation 850, you could enter:

```
dbcollat -c "uid=DBA;pwd=SQL;eng=myhost_asiqdemo" -z
850 demo_col
```

Supplied collations

The following collations are supplied with Adaptive Server IQ.

Collation label	Type	Description
437LATIN1	OEM	Code Page 437, Latin 1, Western
437ESP	OEM	Code Page 437, Spanish
437SVE	OEM	Code Page 437, Swedish/Finnish
819CYR	ANSI	Code Page 819, Cyrillic
819DAN	ANSI	Code Page 819, Danish
819ELL	ANSI	Code Page 819, Greek
819ESP	ANSI	Code Page 819, Spanish
819ISL	ANSI	Code Page 819, Icelandic
819LATIN1	ANSI	Code Page 819, Latin 1, Western
819LATIN2	ANSI	Code Page 819, Latin 2, Central/Eastern European
819NOR	ANSI	Code Page 819, Norwegian
819RUS	ANSI	Code Page 819, Russian

Collation label	Type	Description
819SVE	ANSI	Code Page 819, Swedish/Finnish
819TRK	ANSI	Code Page 819, Turkish
850CYR	OEM	Code Page 850, Cyrillic, Western
850DAN	OEM	Code Page 850, Danish
850ELL	OEM	Code Page 850, Greek
850ESP	OEM	Code Page 850, Spanish
850ISL	OEM	Code Page 850, Icelandic
850LATIN1	OEM	Code Page 850, Latin 1
850LATIN2	OEM	Code Page 850, Latin 2, Central/Eastern European
850NOR	OEM	Code Page 850, Norwegian
850RUS	OEM	Code Page 850, Russian
850SVE	OEM	Code Page 850, Swedish/Finnish
850TRK	OEM	Code Page 850, Turkish
852LATIN2	OEM	Code Page 852, Latin 2, Central/Eastern European
852CYR	OEM	Code Page 852, Cyrillic
852POL	OEM	Code Page 852, Polish
855CYR	OEM	Code Page 855, Cyrillic
856HEB	OEM	Code Page 856, Hebrew
857TRK	OEM	Code Page 857, Turkish
860LATIN1	OEM	Code Page 860, Latin 1, Western
861ISL	OEM	Code Page 861, Icelandic
862HEB	OEM	Code Page 862, Hebrew
863LATIN1	OEM	Code Page 863, Latin 1, Western
865NOR	OEM	Code Page 865, Norwegian
866RUS	OEM	Code Page 866, Russian
869ELL	OEM	Code Page 869, Greek
920TRK	ANSI	Code Page 920, Turkish, ISO-8859-9
932JPN	Multibyte	Code Page 932, Japanese Shift-JIS encoding
936ZHO	Multibyte	Code Page 936, Simplified Chinese, GB 2312-80 8-bit encoding
949KOR	Multibyte	Code Page 949, Korean KS C 5601-1987 encoding, Wansung
950TWN	Multibyte	Code Page 950, Traditional Chinese, Big 5 Encoding

Collation label	Type	Description
1250LATIN2	ANSI	Code Page 1250, Windows Latin 2, Central/Eastern European
1250POL	ANSI	Code Page 1250, Windows Latin 2, Polish
1252LATIN1	ANSI	Code Page 1252, Windows Latin 1, Western
SJIS	Multibyte	Japanese Shift-JIS Encoding
SJIS2	Multibyte	Japanese Shift-JIS Encoding, Sybase Adaptive Server Enterprise-compatible
EUC_JAPAN	Multibyte	Japanese EUC JIS X 0208-1990 and JIS X 0212-1990 Encoding
EUC_CHINA	Multibyte	Simplified Chinese GB 2312-80 Encoding
EUC_TAIWAN	Multibyte	Taiwanese Big 5 Encoding
EUC_KOREA	Multibyte	Korean KS C 5601-1992 Encoding, Johad, Code Page 1361
ISO_1	ANSI	ISO8859-1, Latin 1, Western
ISO_BINENG	ANSI	Binary ordering, English ISO/ASCII 7-bit letter case mappings (IQ default)
ISO1LATIN1	ANSI	ISO8859-1, ISO Latin 1, Western, Latin 1 Ordering
ISO9LATIN1	ANSI	ISO8859-15, ISO Latin 9, Western, Latin 1 Ordering
WIN_LATIN1	ANSI	Code Page 1252 Windows Latin 1, Western, ISO8859-1 with extensions
WIN_LATIN5	ANSI	Code Page 1254 Windows Latin 5, Turkish, ISO8859-9 with extensions
UTF8	Multibyte	UCS-4 Transformation Format

ANSI or OEM?

Adaptive Server IQ collations are based on code pages that are designated as either ANSI or OEM. In most cases, use of an ANSI code page is recommended.

If you choose to use an ANSI code page, you must *not* use the ODBC translation driver in the ODBC data source configuration window.

If you choose to use an OEM code page, you must do the following:

- Choose a code page that matches the OEM code pages on your users' client machines.

- When setting up data sources for Windows-based ODBC applications, *do* choose the Adaptive Server Anywhere or Adaptive Server IQ translation driver in the ODBC data source configuration.

  The translation driver converts between the OEM code page on your machine and the ANSI code page used by Windows. If the database collation is a different OEM code page than the one on your machine, an incorrect translation will be applied.

Both DBISQL and Sybase Central detect whether the database collation is ANSI or OEM by checking the first few characters, and either enable or disable translation as needed.

For more information about code page translation in DBISQL, see the CHAR_OEM_TRANSLATION option in the *Adaptive Server IQ Reference Manual*.

Notes on ANSI collations

The ISO_1 collation

ISO_1 is provided for compatibility with the Adaptive Server Enterprise default ISO_1 collation. The differences are as follows:

- The lower case letter sharp s (\xDF) sorts with the lower case s in Adaptive Server IQ and Adaptive Server Anywhere, but after ss in Adaptive Server Enterprise.
- The ligatures corresponding to AE and ae (\xC6 and \xE6) sort after A and a respectively in Adaptive Server IQ and Adaptive Server Anywhere, but after AE and ae in Adaptive Server Enterprise.

The 1252LATIN1 collation

This collation is the same as WIN_LATIN1 (see below), but includes the euro currency symbol and several other characters (Z-with-caron and z-with-caron). If you do not wish to use the default collation ISO_BINENG, the recommended collation in most cases is 1252LATIN1 on Windows NT, and ISO1LATIN1 on UNIX.

Windows NT service patch 4 changes the default character set in many locales to a new 1252 character set on which 1252 LATIN1 is based. If you have this service patch, you should use this collation instead of WIN_LATIN1.

The euro symbol sorts with the other currency symbols.

The WIN_LATIN1 collation

WIN_LATIN1 is similar to ISO_1, except that Windows has defined characters in places where ISO_1 says "undefined", specifically the range \x80-\xBF. The differences from Adaptive Server Enterprise's ISO_1 are as follows:

- The upper case and lower case Icelandic Eth (\xD0 and \xF0) is sorted with D in Adaptive Server IQ and Adaptive Server Anywhere, but after all other letters in Adaptive Server Enterprise.
- The upper case and lower case Icelandic Thorn (\xD0 and \xF0) is sorted with T in Adaptive Server IQ and Adaptive Server Anywhere, but after all other letters in Adaptive Server Enterprise.
- The upper-case Y-diaresis (\x9F) is sorted with Y in Adaptive Server IQ and Adaptive Server Anywhere, and case converts with lower-case Y-diaresis (\xFF). In Adaptive Server Enterprise it is undefined and sorts after \x9E.
- The lower case letter sharp s (\xDF) sorts with the lower case s in Adaptive Server IQ and Adaptive Server Anywhere, but after ss in Adaptive Server Enterprise.
- Ligatures are two characters combined into a single character. The ligatures corresponding to AE and ae (\xC6 and \xE6) sort after A and a respectively in Adaptive Server IQ and Adaptive Server Anywhere, but after AE and ae in Adaptive Server Enterprise.
- The ligatures corresponding to OE and oe (\x8C and \x9C) sort with O in Adaptive Server IQ and Adaptive Server Anywhere, but after OE and oe in Adaptive Server Enterprise.
- The upper case and lower case letter S with caron (\x8A and \x9A) sorts with S in Adaptive Server IQ and Adaptive Server Anywhere, but is undefined in Adaptive Server Enterprise, sorting after \x89 and \x99.

The ISO1LATIN1 collation

This collation is the same as ISO_1, but with sorting for values in the range A0-BF. For compatibility with Adaptive Server Enterprise, the ISO_1 collation has no characters for 0xA0-0xBF. However the ISO Latin 1 character set on which it is based does have characters in these positions. The ISO1LATIN1 collation reflects the characters in these positions.

If you are not concerned with Adaptive Server Enterprise compatibility, ISO1LATIN1 is generally recommended instead of ISO_1.

The ISO9LATIN1 collation

This collation is the same as ISO1LATIN1, but includes the euro currency symbol and the other new characters included in the 1252 LATIN1 collation.

If your machine uses the ISO Latin 9 character set, and you are willing to sacrifice some of the optimal performance of ISO_BINENG, then you should use this collation.

Notes on OEM collations

The following table shows the built-in collations that correspond to OEM code pages. The table and the corresponding collations were derived from several manuals from IBM concerning National Language Support, subject to the restrictions mentioned above. (This table represents the best information available at the time of writing. Due to continuing rapid geopolitical changes, the table may contain names for countries that no longer exist.)

Country	Language	Primary Code Page	Primary Collation	Second-ary Code Page	Secondary Collation
Argentina	Spanish	850	850ESP	437	437ESP
Australia	English	437	437LATIN1	850	850LATIN1
Austria	German	850	850LATIN1	437	437LATIN1
Belgium	Belgian Dutch	850	850LATIN1	437	437LATIN1
Belgium	Belgian French	850	850LATIN1	437	437LATIN1
Belarus	Belarussian	855	855CYR		
Brazil	Portuguese	850	850LATIN1	437	437LATIN1
Bulgaria	Bulgarian	855	855CYR	850	850CYR
Canada	Cdn French	850	850LATIN1	863	863LATIN1
Canada	English	437	437LATIN1	850	850LATIN1
Croatia	Croatian	852	852LATIN2	850	850LATIN2
Czech Republic	Czech	852	852LATIN2	850	850LATIN2
Denmark	Danish	850	850DAN		
Finland	Finnish	850	850SVE	437	437SVE
France	French	850	850LATIN1	437	437LATIN1
Germany	German	850	850LATIN1	437	437LATIN1
Greece	Greek	869	869ELL	850	850ELL
Hungary	Hungarian	852	852LATIN2	850	850LATIN2
Iceland	Icelandic	850	850ISL	861	861ISL
Ireland	English	850	850LATIN1	437	437LATIN1
Israel	Hebrew	862	862HEB	856	856HEB
Italy	Italian	850	850LATIN1	437	437LATIN1
Mexico	Spanish	850	850ESP	437	437ESP
Nether-lands	Dutch	850	850LATIN1	437	437LATIN1

Country	Language	Primary Code Page	Primary Collation	Second-ary Code Page	Secondary Collation
New Zealand	English	437	437LATIN1	850	850LATIN1
Norway	Norwegian	865	865NOR	850	850NOR
Peru	Spanish	850	850ESP	437	437ESP
Poland	Polish	852	852LATIN2	850	850LATIN2
Portugal	Portuguese	850	850LATIN1	860	860LATIN1
Romania	Romanian	852	852LATIN2	850	850LATIN2
Russia	Russian	866	866RUS	850	850RUS
S. Africa	Afrikaans	437	437LATIN1	850	850LATIN1
S. Africa	English	437	437LATIN1	850	850LATIN1
Slovak Republic	Slovakian	852	852LATIN2	850	850LATIN2
Slovenia	Slovenian	852	852LATIN2	850	850LATIN2
Spain	Spanish	850	850ESP	437	437ESP
Sweden	Swedish	850	850SVE	437	437SVE
Switzer-land	French	850	850LATIN1	437	437LATIN1
Switzer-land	German	850	850LATIN1	437	437LATIN1
Switzer-land	Italian	850	850LATIN1	437	437LATIN1
Turkey	Turkish	857	857TRK	850	850TRK
UK	English	850	850LATIN1	437	437LATIN1
USA	English	437	437LATIN1	850	850LATIN1
Venezuela	Spanish	850	850ESP	437	437ESP
Yugoslavia	Maced-onian	852	852LATIN2	850	850LATIN2
Yugoslavia	Serbian Cyrillic	855	855CYR	852	852CYR
Yugoslavia	Serbian Latin	852	852LATIN2	850	850LATIN2

Using multibyte collations

This section describes how multibyte character sets are handled. The description applies to the supported collations and to any multibyte custom collations you may create.

Adaptive Server IQ provides collations using several multibyte character sets.

For a complete listing, see “Understanding collations” on page 328 Understanding collations.

Adaptive Server IQ supports variable-width character sets. In these sets, some characters are represented by one byte, and some by more than one, to a maximum of four bytes. The value of the first byte in any character indicates the number of bytes used for that character, and also indicates whether the character is a space character, a digit, or an alphabetic (alpha) character.

Adaptive Server IQ does not support fixed-length multibyte character sets such as 2-byte Unicode (UCS-2) or 4-byte Unicode (UCS-4).

Understanding character set translation

Adaptive Server IQ can carry out character set translation among character sets that represent the same characters, but at different positions in the character set or code page. There needs to be a degree of compatibility between the character sets for this to be possible. For example, character set translation is possible between EUC-JIS and Shift-JIS character sets, but not between EUC-JIS and OEM code page 850.

This section describes how Adaptive Server IQ carries out character set translation. This information is provided for advanced users, such as those who may be deploying applications or databases in a multi-character-set environment.

Character translation for database messages

Error and other messages from the database software are held in a **language resource library**. Localized versions of this library are provided with localized versions of Adaptive Server IQ.

Client application users may see messages from the database as well as data from the database. Some database messages, which are strings from the language library, may include placeholders that are filled by characters from the database. For example, if you execute a query with a column that does not exist, the returned error messages is:

Column *column-name* not found

where *column-name* is filled in from the database.

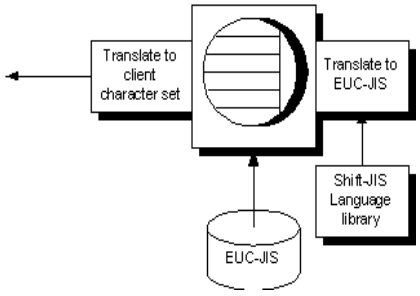
To present these kinds of information to the client application in a consistent manner, even if the database is in a different character set from the language library, the database server automatically translates the characters of the messages so that they match the character set used in the database collation.

❖ **To use character translation for database messages:**

- Ensure that the collation for your database is compatible with the character set used on your computer, and with the character set used in the Adaptive Server IQ language resource library. The language resource library differs among different localized versions of Adaptive Server IQ.

  You must check that the characters of interest to you exist in each character set.

Messages are always translated into the database collation character set, regardless of whether the `-ct` command-line option is used.



A further character set translation is carried out if the database server `-ct` command-line option is used, and if the client character set is different from that used in the database collation.

Connection strings and character sets

Connection strings present a special case for character set translation. The connection string is parsed by the client library, in order to locate or start a database server. This parsing is done with no knowledge of the server character set or language.

The interface library parses the connection string as follows:

1 It is broken down into its *keyword = value* components. This can be done independently of character set, as long as you do not use the curly braces {} around CommLinks parameters. Instead, use the recommended parentheses (). Curly braces are valid follow bytes in some multi-byte character sets.

2 The server is located. The server name is interpreted according to the character set of the client machine. In the case of Windows operating systems, the ANSI character set is used. Extended chars can be used unless they cause character set conversion issues between client and server machine.

   For maximum compatibility among different machines, you should use server names built from ASCII characters 1 to 128 , using no punctuation characters. Server names are truncated at 40 characters.

3 The DatabaseName or DatabaseFile parameter is interpreted in the database server character set.

4 Once the database is located, the remaining connection parameters are interpreted according to its character set.

Avoiding character-set translation

There is a performance cost associated with character set translation. If you can set up an environment such that no character set translation is required, then you do not have to pay this cost, and your setup is simpler to maintain.

If you work with a single-byte character set and are concerned only with seven-bit ASCII characters (values 1 through 127), then you do not need character set translation. Even if the code pages are different in the database and on the client operating system, they are compatible over this range of characters. Many English-language installations will meet these requirements.

If you do require use of extended characters, there are other steps you may be able to take:

- If the code page on your client machine operating system matches that used in the database, no character set translation is needed for data in the database.

  For example, in many environments it is appropriate to use the 1252LATIN1 collation in your database, which corresponds to the Windows NT code page in many single-byte environments.

- If you are able to use a version of Adaptive Server IQ built for your language, and if you use the code page on your operating system, no character set translation is needed for database messages. The character set used in the Adaptive Server IQ message strings is as follows:

Language	Character set
English	1252LATIN1
French	1252LATIN1
German	1252LATIN1
Japanese	SJIS2

Also, recall that client/server character set translation takes place only if the database server is started using the `-ct` command-line switch.

Collation internals

This section describes internal technical details of collations, including the file format of collation files.

This section is of particular use if you want to create a database using a custom collation. For information on the steps involved, see “Creating a custom collation” on page 349 and “Creating a database with a custom collation” on page 351.

You can create a database using a collation different from the supplied collations. This section describes how to build databases using such a **custom collation**.

In building multibyte custom collations, you can specify which ranges of values for the first byte signify single- and double-byte (or more) characters, and which specify space, alpha, and digit characters. However, all first bytes of value less than \x40 must be single-byte characters, and no follow bytes may have values less than \x40. This restriction is satisfied by all supported encodings.

Collation files may include the following elements:

- Comment lines, which are ignored by the database.
- A title line.
- A collation sequence section.
- An Encodings section.
- A Properties section.

Comment lines

In the collation file, spaces are generally ignored. Comment lines start with either the percent sign (%) or two dashes (--).

The title line

The first non-comment line must be of the form:

```
Collation label (name)
```

In this statement:

Item	Description
Collation	A required keyword.
label	The collation label, which appears in the system tables as SYS.SYSCOLLATION.collation_label and SYS.SYSINFO.default_collation. The label must contain no more than 10 characters, and must not be the same as one of the built-in collations. (In particular, do not leave the collation label unchanged.)
name	A descriptive term, used for documentation purposes. The name should contain no more than 128 characters.

For example, the Shift-JIS collation file contains the following collation line, with label SJIS and name (Japanese Shift-JIS Encoding):

```
Collation SJIS (Japanese Shift-JIS Encoding)
```

The collation sequence section

After the title line, each non-comment line describes one position in the collation. The ordering of the lines determines the sort ordering used by the database, and determines the result of comparisons. Characters on lines appearing higher in the file (closer to the beginning) sort before characters that appear later.

The form of each line in the sequence is:

[*sort-position*] : *character* [[, *character*] ...]

or

[*sort-position*] : *character* [*lowercase uppercase*]

Descriptions of arguments

Argument	Description
sort-position	Optional. Specifies the position at which the characters on that line will sort. Smaller numbers represent a lesser value, so will sort closer to the beginning of the sorted set. Typically, the sort-position is omitted, and the characters sort immediately following the characters from the previous sort position.
character	The character whose sort-position is being specified.
lowercase	Optional. Specifies the lowercase equivalent of the character. If not specified, the character has no lowercase equivalent.
uppercase	Optional. Specifies the uppercase equivalent of the character. If not specified, the character has no uppercase equivalent.

Multiple characters may appear on one line, separated by commas (,). In this case, these characters are sorted and compared as if they were the same character.

Specifying character and sort-position

Each character and sort position is specified in one of the following ways:

Specification	Description
\dnnn	Decimal number, using digits 0-9 (such as \d001)
\xhh	Hexadecimal number, using digits 0-9 and letters a-f or A-F (such as \xB4)
'c'	Any character in place of c (such as ',')
c	Any character other than quote ('), backslash (\), colon (:) or comma (,). These characters must use one of the previous forms.

The following are some sample lines for a collation:

```
% Sort some special characters at the beginning:
```

```
: ' '
: _
: \xF2
: \xEE
: \xF0
: -
: ',
: ;
: ':'
: !
% Sort some letters in alphabetical order
: A a A
: a a A
: B b B
: b b B
% Sort some E's from code page 850,
% including some accented extended characters:
: e e E, \x82 \x82 \x90, \x8A \x8A \xD4
: E e E, \x90 \x82 \x90, \xD4 \x8A \xD4
```

Other syntax notes

For databases using case-insensitive sorting and comparison (that is, CASE IGNORE was specified when the database was created), the lowercase and uppercase mappings are used to find the lowercase and uppercase characters that will be sorted together.

For multibyte character sets, the first byte of a character is listed in the collation sequence, and all characters with the same first byte are sorted together, and ordered according to the value of the following bytes. For example, the following is part of the Shift-JIS collation file:

```
:   \xfb
:   \xfc
:   \xfd
```

In this collation, all characters with first byte \xfc come after all characters with first byte \xfb and before all characters with first byte \xfd. The two-byte character \xfc \x01 would be ordered before the two-byte character \xfc \x02.

Any characters omitted from the collation are added to the end of the collation. The tool that processes the collation file issues a warning.

The Encodings section

The Encodings section is optional, and follows the collation sequence. It is not useful for single-byte character sets.

The Encodings section lists which characters are lead-bytes, for multi-byte character sets, and what are valid follow-bytes.

For example, the Shift-JIS Encodings section is as follows:

```
Encodings:
[\x00-\x80,\xa0-\xdf,\xf0-\xff]
[\x81-\x9f,\xe0-\xef][\x40-\x7e,\x80-\xfc]
```

The first line following the section title lists valid single-byte characters. The square brackets enclose a comma-separated list of ranges. Each range is listed as a hyphen-separated pair of values. In the Shift-JIS collation, values \x00 to \x80 are valid single-byte characters, but \x81 is not a valid single-byte character.

The second line following the section title lists valid multibyte characters. Any combination of one byte from the second line followed by one byte from the first is a valid character. Therefore \x81\x40 is a valid double-byte character, but \x81 \x00 is not.

The Properties section

The Properties section is optional, and follows the Encodings section.

If a Properties section is supplied, an Encodings section must be supplied also.

The Properties section lists values for the first-byte of each character that represent alphabetic characters, digits, or spaces.

The Shift-JIS Properties section is as follows:

```
Properties:
space: [\x09-\x0d,\x20]
digit: [\x30-\x39]
alpha: [\x41-\x5a,\x61-\x7a,\x81-\x9f,\xe0-\xef]
```

This indicates that characters with first bytes \x09 to \x0d, as well as \x20, are to be treated as space characters, digits are found in the range \x30 to \x39 inclusive, and alphabetic characters in the four ranges \x41-\x5a, \x61-\x7a, \x81-\x9f, and \xe0-\xef.

International language and character set tasks

This section groups together the tasks associated with international language and character set issues.

Finding the default collation

If you do not explicitly specify a collation when creating a database, a default collation is used. For IQ databases, the default collation is always ISO_BINENG.

Configuring your character set environment

This section describes how to set up your computing environment so that character set issues are handled properly. If you set your locale environments properly, then you do not need to turn on character set translation between client and server.

❖ **To configure your character set environment:**

1. Determine the default locale of each computing platform in your environment. The default locale is the character set and language of each computer. On Windows operating systems, the character set is the ANSI code page.

   For how to find locale information, see “Determining locale information” on page 345.

2. Decide whether the locale settings are appropriate for your environment.

   For more information, see “Understanding collations” on page 328.

3. If the default settings are inappropriate, decide on a character set, language, and database collation that matches your data and avoids character set translation.

   For more information, see “Avoiding character-set translation” on page 338.

4. Set locales on each of the machines in the environment to these values.

   For more information, see “Setting locales” on page 346.

5. Create your database using the default collation. If the default collation does not match your needs, create a database using a named collation.

For more information, see “Creating a database with a named collation” on page 346.

When choosing the collation for your database,

- Choose a collation that uses a character set and sort order appropriate for the data in the database. It is often the case that there are several alternative collations that meet this requirement, including some that are OEM collations and some that are ANSI collations.
- There is a performance cost, as well as extra complexity in system configuration, when you use character set translation. Choose a collation that avoids the need for character set translation.

  You can avoid character set translation by using a collation sequence in the database that matches the character set in use on your client machine operating system. In the case of Windows operating systems on the client machine, choose the ANSI character set.

  For information, see “Avoiding character-set translation” on page 338.

Determining locale information

You can determine locale information using system functions.

For a complete list, see the *Adaptive Server IQ Reference Manual*.

❖ **To determine the locale of a database server:**

1. Start DBISQL, and connect to a database server.
2. Execute the following statement to determine the database server character set:

   ```
   SELECT PROPERTY( 'CharSet' )
   ```

   The query returns one of the supported character sets listed in “Character set labels” on page 326.
3. Execute the following statement to determine the database server language:

   ```
   SELECT PROPERTY( 'Language' )
   ```

   The query returns one of the supported languages listed in “Language label values” on page 325.
4. Execute the following statement if you need to determine a good alternative to the default collation, ISO_BINENG:

```
SELECT PROPERTY( 'DefaultCollation' )
```

The query returns one of the collations listed in "Supplied collations" on page 329.

Notes

To obtain client locale information, connect to a database server running on your current machine.

To obtain the character set for an individual database, execute the following statement:

```
SELECT DB_PROPERTY ( 'CharSet' )
```

Setting locales

You can use the default locale on your operating system, or explicitly set a locale for use by the Adaptive Server IQ components on your machine.

❖ **To set the Adaptive Server IQ locale on a computer:**

1 If the default locale is appropriate for your needs, you do not need to take any action.

To find out the default locale of your operating system, see "Determining locale information" on page 345.

2 If you need to change the locale, create a SQLLOCALE environment variable with the following value:

`Charset=`*cslabel*`;Language=`*langlabel*`;CollationLabel=`*colabel*

where *cslabel* is a character set label from the list in "Character set labels" on page 326, *langlabel* is a language label from the list in "Language label values" on page 325, and *colabel* is from the list in "Understanding collations" on page 328 Understanding collations, or is a custom collation label.

For information on how to set environment variables on different operating systems, see the *Adaptive Server IQ Reference Manual*.

Creating a database with a named collation

The default collation for an IQ database is always ISO_BINENG. You can specify a different collation for each database when you create it.

❖ **To specify a database collation when creating a database (Sybase Central):**

- You can use the Create Database wizard in Sybase Central to create a database. The wizard has a Collation Sequence page where you choose a collation from a list.

You can also see the name of your current collation in Sybase Central. Right-click on the database whose collation you need. In the dropdown menu select Properties, and then click the Extended Information tab.

❖ **To specify a database collation when creating a database (SQL)**

1 List the supplied collation sequences:

```
SELECT * FROM SYS.SYSCOLLATIONMAPPINGS
```

The first column of the list is the collation label, which you supply when creating the database.

```
437LATIN1  Code Page 437, Latin 1, Western
437ESP     Code Page 437, Spanish
437SVE     Code Page 437, Swedish/Finnish
819CYR     Code Page 819, Cyrillic
819DAN     Code Page 819, Danish
819ELL     Code Page 819, Greek
...
```

2 Use the CREATE DATABASE statement to create a database. The following statement creates a database with a Greek collation:

```
CREATE DATABASE 'mydb.db'
COLLATION '819ELL'
IQ SIZE 100
IQ PATH 'myiq.iq'
```

Starting a database server using character set translation

Character set translation takes place if the client and server locales are different, but only if you specifically turn on character set conversion on the database server command line.

❖ **To enable character-set translation on a database server:**

- Start the database server using the `-ct` command-line option. For example:

  ```
  asiqsrv12 -ct asiqdemo.db
  ```

  or on UNIX:

  ```
  start_asiq -ct asiqdemo.db
  ```

Using ODBC code page translation

Adaptive Server IQ provides an **ODBC translation driver**. This driver converts characters between OEM and ANSI code pages. It allows Windows applications using ANSI code pages to be compatible with databases that use OEM code pages in their collations.

Note If you use an ANSI character set in your database, and are using ANSI character set applications, you do not need to use this translation driver.

The translation driver carries out a mapping between the OEM code page in use in the "DOS box" and the ANSI code page used in the Windows operating system. If your database uses the same code page as the OEM code page, the characters are translated properly. If your database does not use the same code page as your machine's OEM code page, you will still have compatibility problems.

Embedded SQL does not provide any such code page translation mechanism.

❖ **To use the ODBC translation driver:**

1. In the ODBC Administrator, choose Add to create a new Adaptive Server IQ data source or Configure to edit an existing Adaptive Server IQ data source.
2. On the ODBC tab of the ODBC Configuration for Adaptive Server IQ window, click Select and choose Adaptive Server Anywhere 6.0 Translator from the list of translation drivers.

Character set translation for Sybase Central and DBISQL

DBISQL and Sybase Central both employ internal OEM to ANSI code page translation if the database uses an OEM character set. As with the ODBC translation driver, there is an assumption that the OEM code page on the local machine matches the data in the database.

❖ **To turn off character set translation in DBISQL:**

- Set the DBISQL option CHAR_OEM_Translation to a value of OFF.

```
SET OPTION CHAR_OEM_TRANSLATION = 'OFF'
```

For more information on OEM to ANSI character set translation in Interactive SQL, see CHAR_OEM_TRANSLATION option in the *Adaptive Server IQ Reference Manual*.

Creating a custom collation

If none of the supplied collations meet your needs, you can modify a supplied collation to create a **custom collation**. You can then use this custom collation when creating a database.

For a list of supplied collations, see “Supplied collations” on page 329.

❖ **To create a custom collation:**

1. Decide on a starting collation.

   You should choose a collation as close as possible to the one you want to create as a starting point for your custom collation.

   For a listing of supplied collations, see “Understanding collations” on page 328.
2. Create a custom collation file.

You do this using the Collation utility. The output is a collation file.

For example, the following statement extracts the 1252LATIN1 collation into a file named *mycol.col*:

```
dbcollat -z 1252LATIN1 mycol.col
```

3 Edit the custom collation file.

Open the collation file (in this case *mycol.col*) in a text editor.

4 Change the name of the collation.

The name of the collation is specified on a line near the top of the file, starting with `Collation`. You should edit this line to provide a new name, The name you need to change is the second word on the line: in this case 1252LATIN1.

The other entries on this line are descriptive only, and do not need to be changed.

5 Change the collation definition.

Make the changes you wish in the custom collation file to define your new collation.

For information on the collation file contents and format, see “Collation internals” on page 339.

6 Convert the file to SQL scripts.

You do this using the *dbcollat* command-line utility using the `-d` switch.

For example, the following command line creates the *mycustmap.sql* file and *mycustom.sql* files from the *mycol.col* collation file:

```
dbcollat -d mycol.col mycustmap.sql mycustom.sql
```

7 Add the SQL scripts to the scripts in your installation.

The scripts used when creating databases are held in the scripts subdirectory of your Adaptive Server IQ installation directory. Append the contents of *mycustmap.sql* to *custmap.sql*, and the contents of *mycustom.sql* to end of *custom.sql*.

The new collation is now in place, and can be used when creating databases.

8 Restart the database.

Stop and restart the database server in order for it to recognize the new collations and insert them into system tables SYSCOLLATION and SYSCOLLATIONMAPPINGS.

Creating a database with a custom collation

If none of the supplied collations meet your needs, you can create a database using a custom collation. The custom collation is used in indexes and any string comparisons.

❖ **To create a database with a custom collation:**

1 Create a custom collation.

You must have a custom collation in place to use when creating a database.

For instructions on how to create custom collations, see "Creating a custom collation" on page 349.

2 Create the new database.

Use the CREATE DATABASE statement or Sybase Central, specifying the name of your custom collation.

For example, the following statement creates a database named *newcol.db* using the custom collation sequence newcol.

```
CREATE DATABASE 'newcol.db'
COLLATION 'newcol'
IQ PATH 'newcol.iq'
```

Compatibility issues

Prior to version 12.0, Adaptive Server IQ always used the ASCII sort order, which sorts uppercase characters before lowercase. As of version 12.4.2, by default IQ databases sort data in the same way as pre-version 12 Adaptive Server IQ. The default applies these CREATE DATABASE options:

```
CREATE DATABASE dbname
COLLATION 'ISO_BINENG'
BLANK PADDING ON
CASE RESPECT
```

With these options, uppercase characters precede all lowercase characters in the collation sequence. For example, 'XYZ' sorts before 'abc' with these options, just as it did in older versions of Adaptive Server IQ.

Performance issues

Performance for character data is better with a binary character set and collation sequence than with a non-binary one.

To maximize performance, create a database with these default option settings:

```
CREATE DATABASE dbname
COLLATION 'ISO_BINENG'
CASE RESPECT
```

These options result in a binary character set and collation sequence. All other settings for these two options form a non-binary character set and collation sequence.

The disadvantage of these settings is that uppercase characters are always sorted before lowercase ones. For example, BANANA sorts before apple. If you prefer a more natural sort order, but still need a case sensitive database, and you are willing to sacrifice some degree of performance, use the collation ISO_1 instead of the default, ISO_BINENG.

Note When your database uses the CASE RESPECT option, your user ID and password become case sensitive. This means that you must enter them as they have been defined, and the DBA's user ID and default password must be entered in uppercase. For example, you could enter the CONNECT statement as follows:

```
connect database dbasiq user DBA identified by SQL
```

You would not be able to connect if you entered this statement as:

```
connect database dbasiq user dba identified by sql
```

CHAPTER 10

Managing User IDs and Permissions

About this chapter

Each user of a database must be assigned a unique user ID: the name they type when connecting to the database. This chapter describes how to manage user IDs.

An overview of database permissions

Proper management of user IDs and permissions is essential in a data warehouse. It allows users to carry out their jobs effectively, while maintaining the security and privacy of appropriate information within the database.

You use SQL statements for assigning user IDs to new users of a database, granting and revoking permissions for database users, and finding out the current permissions of users.

Database permissions are assigned to user IDs. Throughout this chapter, the term **user** is used as a synonym for user ID. You should remember, however, that permissions are granted and revoked for each user ID.

Setting up individual user IDs

Even if there are no security concerns regarding a multiuser database, there are good reasons for setting up an individual user ID for each user. The administrative overhead for individual user IDs is very low if a group with the appropriate permissions is set up. Groups of users are discussed later in this chapter.

Among the reasons for using individual user IDs are the following:

- The network server screen and the listing of connections in Sybase Central are both much more useful with individual user IDs, as you can tell which connections are which users.
- The backup log identifies the user ID that created the backup.

DBA authority overview

When a database is created, a single usable user ID is created. This first user ID is DBA and the password is initially set to SQL. The DBA user ID is automatically given DBA permissions, also called DBA authority, within the database. This level of permission enables the DBA user ID to carry out any activity in the database: create tables, change table structures, create new user IDs, revoke permissions from users, and so on.

Note To ensure database security, the DBA needs to change the password from the default of SQL to a new value.

Users with DBA authority

A user with DBA authority is referred to as the **database administrator** or **database owner**. In this chapter, frequent reference is made to the database administrator, or *the DBA*. This is shorthand for any user or users with DBA authority.

Although DBA authority may be granted or transferred to other user IDs, in this chapter it is assumed that the DBA user ID is the database administrator, and the abbreviation *DBA* is used interchangeably to mean both the DBA user ID and any user ID with DBA authority.

Adding new users

The DBA has the authority to add new users to the database. As users are added, they are also granted permissions to carry out tasks on the database. Some users may need to simply look at the database information using SQL queries, others may need to add information to the database, and others may need to modify the structure of the database itself. Although some of the responsibilities of the DBA may be handed over to other user IDs, the DBA is responsible for the overall management of the database by virtue of the DBA authority.

The DBA has authority to create database objects and assign ownership of these objects to other user IDs

See the syntax of the commands for creating database objects, in “SQL Language Elements” in *Adaptive Server IQ Reference Manual*.

DBA user ID in case sensitive databases

User IDs and passwords are actually objects in the database. For this reason, if your database was created with the CASE RESPECT parameter, you must enter the user ID DBA and its default password SQL in uppercase. For case insensitive databases (the default), you can enter this user ID and password in either uppercase or lowercase.

RESOURCE authority overview

RESOURCE authority is the permission to create database objects, such as tables, views, and stored procedures. Resource authority may be granted only by the DBA to other users.

Ownership permissions overview

The creator of a database object becomes the owner of that object. Ownership of a database object carries with it permissions to carry out actions on that object. These are not assigned to users in the same way that other permissions in this chapter are assigned.

Owners

A user who creates a new object within the database is called the **owner** of that object, and automatically has permission to carry out any operation on that object. The owner of a table may modify the structure of that table, for instance, or may grant permissions to other database users to update the information within the table.

The DBA has permission to modify any component within the database, and so could delete a table created by another user, for instance. The DBA has all the permissions regarding database objects that the owner of each object has.

The DBA is also able to create database objects for other users, and in this case the owner of an object is not the user ID that executed the CREATE statement. A use for this ability is discussed in “Groups without passwords”. Despite this possibility, this chapter refers interchangeably to the owner and creator of database objects.

Table and views permissions overview

There are several distinct permissions that may be granted to user IDs concerning tables and views:

Permission	Description
ALTER	Permission to alter the structure of a table
DELETE	Permission to delete rows from a table or view
INSERT	Permission to insert rows into a table or view
REFERENCES	Permission to create indexes on a table, and to create unenforced foreign keys that reference a table
SELECT	Permission to look at information in a table or view

Permission	Description
UPDATE	Permission to update rows in a table or view. This may be granted on a set of columns in a table only
ALL	All the above permissions

Group permissions overview

Setting permissions individually for each user of a database can be a time-consuming and error-prone process. For most databases, permission management based on groups, rather than on individual user IDs, is a much more efficient approach.

You can assign permissions to a group in exactly the same way as to an individual user. You can then assign membership in appropriate groups to each new user of the database, and they gain a set of permissions by virtue of their group membership.

Example

For example, you may create groups for different departments in a company database (sales, marketing, and so on) and assign these groups permissions. Each salesperson is made a member of the sales group, and automatically gains access to the appropriate areas of the database.

Any user ID can be a member of several groups, and inherits all permissions from each of the groups.

Managing individual user IDs and permissions

This section describes how to create new users and grant permissions to them. For most databases, the bulk of permission management should be carried out using groups, rather than by assigning permissions to individual users one at a time. However, as groups are simply a user ID with special properties attached, you should read and understand this section before moving on to the discussion of managing groups.

Using ASE stored procedures to manage users

The procedures in this chapter let you manage users and groups using DBISQL and Sybase Central. You can perform many of the same tasks using Adaptive Server Enterprise-compatible stored procedures. If you have previously used Adaptive Server Enterprise or pre-Version 12.0 Adaptive Server IQ, you may prefer to use these stored procedures. For details, see “Adaptive Server Enterprise system and catalog procedures”.

Creating new users

A new user is added to a database by the DBA using the GRANT CONNECT statement. For example:

❖ **To add a new user to a database, with user ID M_Haneef and password welcome:**

1 From DBISQL, connect to the database as a user with DBA authority.

2 Issue the SQL statement:

```
GRANT CONNECT TO M_Haneef
IDENTIFIED BY welcome
```

Only the DBA has the authority to add new users to a database.

Initial permissions for new users

By default, new users are not assigned any permissions beyond connecting to the database and viewing the system tables. In order to access tables in the database they need to be assigned permissions.

The DBA can set the permissions granted automatically to new users by assigning permissions to the special PUBLIC user group, as discussed in "Special groups".

Using a DBISQL command file to set up new users

You may want to put commands for setting up new users into a DBISQL command file. Command files help you standardize the way you perform processes you repeat over time. For details on using command files, see the chapter "Getting Started with DBISQL" in the *Introduction to Adaptive Server IQ*.

Creating users in Sybase Central

❖ **To create a user in Sybase Central:**

1 Connect to the database.

2 Click the Users and Groups folder for that database.

3 Double-click Add User. A Wizard is displayed, which leads you through the process.

For more information, see the Sybase Central online Help.

Changing a password

Changing a user's password

If you have DBA authority, you can change the password of any existing user with the following command:

```
GRANT CONNECT TO userid IDENTIFIED BY password
```

The same command can also be used to add a new user. For this reason, if you inadvertently enter the user ID of an existing user when you mean to add a new user, you are actually changing the password of the existing user. You do not receive a warning because this behavior is considered normal. This behavior differs from pre-Version 12 Adaptive Server IQ.

To avoid this situation, use the system procedures sp_addlogin and sp_adduser to add users. These procedures give you an error if you try to add an existing user ID, as in Adaptive Server Enterprise and pre-Version 12 Adaptive Server IQ.

Changing the DBA password

The default password for the DBA user ID for all databases is SQL. You should change this password to prevent unauthorized access to your database. The following command changes the password for user ID DBA to new_password:

```
GRANT CONNECT TO DBA
IDENTIFIED BY new_password
```

If you are using DBISQL, it is a good idea to put your permission grants into a command file for reference and so that it can be modified and run again if it is necessary to recreate the permissions.

Granting DBA and resource authority

DBA and RESOURCE authority are granted in exactly the same manner as each other.

❖ **To grant resource permissions to a user ID:**

1. Connect to the database as a user with DBA authority.
2. Type and execute the SQL statement:

   ```
   GRANT RESOURCE TO userid
   ```

   For DBA authority, the appropriate SQL statement is:

   ```
   GRANT DBA TO userid
   ```

Notes

- Only the DBA can grant DBA or RESOURCE authority to database users.
- DBA authority is very powerful, granting the ability to carry out any action on the database and access to all the information in the database. It is generally inadvisable to grant DBA authority to more than a very few people.

- You should give users with DBA authority two user IDs, one with DBA authority and one without, so that they connect as DBA only when necessary.
- RESOURCE authority allows the user to create new database objects, such as tables, views, indexes, or procedures.

Granting permissions on tables and views

You can assign a set of permissions on individual tables and views. Users can be granted combinations of these permissions to define their access to a table or view.

Combinations of permissions

- The ALTER (permission to alter the structure of a table) and REFERENCES (permission to create indexes and to create unenforced foreign keys) permissions grant the authority to modify the database schema, and so will not be assigned to most users. These permissions do not apply to views.
- The DELETE, INSERT, and UPDATE permissions grant the authority to modify the data in a table or view. The DELETE, INSERT, and UPDATE permissions grant the authority to modify the data in a table or view. Of these, the UPDATE permission may be restricted to a set of columns in the table or view.
- The SELECT permission grants authority to look at data in a table or view, but does not give permission to alter it.
- ALL permission grants all the above permissions.

Example

All table and view permissions are granted in a very similar fashion. You can grant permission to M_Haneef to delete rows from the table named sample_table as follows:

1 Connect to the database as a user with DBA authority, or as the owner of sample_table.

2 Type and execute the SQL statement:

```
GRANT DELETE
ON sample_table
TO M_Haneef
```

You can grant permission to M_Haneef to update the column_1 and column_2 columns only in the table named sample_table as follows:

1 Connect to the database as a user with DBA authority, or as the owner of sample_table.

2 Type and execute the SQL statement:

```
GRANT UPDATE (column_1, column_2)
ON sample_table
TO M_Haneef
```

Table and view permissions are limited in that they apply to all the data in a table or view (except for the UPDATE permission which may be restricted). Finer tuning of user permissions can be accomplished by creating procedures that carry out actions on tables, and then granting users the permission to execute the procedure.

Granting user permissions on tables in Sybase Central

One way to grant a user permissions on a table in Sybase Central is as follows:

❖ **To grant user permission on tables in Sybase Central**

1 Connect to the database.

2 Double-click the Tables folder for that database, to display the tables in the left panel.

3 Click the Users and Groups folder, and locate the user you want to grant permissions to.

4 Drag the user to the table for which you want to grant permissions.

For more information, see the Sybase Central online Help.

Granting users the right to grant permissions

Each of the table and view permissions described in “Granting permissions on tables and views” can be assigned WITH GRANT OPTION. This option gives the right to pass on the permission to other users. This feature is discussed in the context of groups in “Permissions of groups”.

Example

You can grant permission to M_Haneef to delete rows from the table named sample_table, and the right to pass on this permission to other users, as follows:

1 Connect to the database as a user with DBA authority, or as the owner of sample_table:

2 Type and execute the SQL statement:

```
GRANT DELETE ON sample_table
```

```
TO M_Haneef
WITH GRANT OPTION
```

Granting permissions on procedures

There is only one permission that may be granted on a procedure, and that is the EXECUTE permission to execute (or CALL) the procedure.

Permission to execute stored procedures may be granted by the DBA or by the owner of the procedure (the user ID that created the procedure).

The method for granting permissions to execute a procedure is similar to that for granting permissions on tables and views, discussed in "Granting permissions on tables and views".

Example

You can grant M_Haneef permission to execute a procedure named my_procedure, as follows:

1 Connect to the database as a user with DBA authority or as owner of my_procedure procedure.

2 Execute the SQL statement:

```
GRANT EXECUTE
ON my_procedure
TO M_Haneef
```

Execution permissions of procedures

Procedures execute with the permissions of their owner. Any procedure that updates information on a table will execute successfully only if the owner of the procedure has UPDATE permissions on the table.

As long as the procedure owner does have the proper permissions, the procedure will execute successfully when called by any user assigned permission to execute it, whether or not they have permissions on the underlying table. You can use procedures to allow users to carry out well-defined activities on a table, without having any general permissions on the table.

Granting user permissions on procedures in Sybase Central

One way to grant a user permissions on a table in Sybase Central is as follows:

❖ **To grant user permissions on procedures in Sybase Central:**

1 Connect to the database.

2 Click the Users and Groups folder, and locate the user you want to grant permissions to.

3 Right-click the user, and select Copy from the popup menu.

4 Locate the procedure you want to allow the user to execute, in the Stored Procedures folder.

5 Click the procedure, and choose Edit→Paste from the main menu to grant permissions.

For more information, see the Sybase Central online Help.

Revoking user permissions

Any user's permissions are a combination of those that have been granted and those that have been revoked. By revoking and granting permissions, you can manage the pattern of user permissions on a database.

The REVOKE statement is the exact converse of the GRANT statement. To disallow M_Haneef from executing my_procedure, the command is:

```
REVOKE EXECUTE ON my_procedure FROM M_Haneef
```

This command must be issued by the DBA or by the owner of the procedure.

Permission to delete rows from sample_table can be revoked by issuing the command:

```
REVOKE DELETE ON sample_table FROM M_Haneef
```

Warning! If you revoke a user's connect privileges, any database objects owned by that user are deleted without warning. Likewise, if you use the stored procedure sp_dropuser to drop a user, database objects owned by that user are dropped without warning. To avoid this problem, remove objects owned by a user or assign them to another user before issuing REVOKE CONNECT or sp_dropuser.

Note Procedures like sp_dropuser provide minimal compatibility with Adaptive Server Enterprise stored procedures. If you are accustomed to Adaptive Server Enterprise (or Adaptive Server IQ 11.x) stored procedures, you should compare their text with Adaptive Server IQ 12 procedures before using the procedure in dbisql. To compare, use the command

```
sp_helptext sp_name_in_question
```

Managing groups

Once you understand how to manage permissions for individual users (as described in the previous section) working with groups is straightforward. A group is identified by a user ID, just like a single user, but this user ID is granted the permission to have **members**.

DBA, RESOURCE, and GROUP permissions

When permissions on tables, views, and procedures are granted to or revoked from a group, all members of the group inherit those changes. The DBA, RESOURCE, and GROUP permissions are not inherited: they must be assigned individually to each individual user ID requiring them.

A group is simply a user ID with special permissions. Granting permissions to a group and revoking permissions from a group are done in exactly the same manner as any other user, using the commands described in “Managing individual user IDs and permissions”.

A group can also be a member of a group. A hierarchy of groups can be constructed, each inheriting permissions from its parent group.

A user ID may be granted membership in more than one group, so the user-to-group relationship is many-to-many.

The ability to create a group without a password enables you to prevent anybody from signing on using the group user ID. This security feature is discussed in “Groups without passwords”.

Creating groups

❖ **To create a group with a name and password:**

1 Connect to the database as a user with DBA authority.

2 Create the group's user ID just as you would any other user ID, using the following SQL statement:

```
GRANT CONNECT
TO personnel
IDENTIFIED BY group_password
```

3 Give the personnel user ID the permission to have members, with the following SQL statement:

```
GRANT GROUP TO personnel
```

The GROUP permission, which gives the user ID the ability to have members, is not inherited by members of a group. If this were not the case, then every user ID would automatically be a group as a consequence of membership in the special PUBLIC group.

Creating groups in Sybase Central

❖ **To create a group in Sybase Central:**

1 Connect to the database.

2 Click the Users and Groups folder for that database.

3 Double-click Add Group. A Wizard leads you through the process.

For more information, see the Sybase Central online Help.

Granting group membership to users

Making a user a member of a group is done with the GRANT statement. Membership in a group can be granted either by the DBA or by the group user ID. You can grant user M_Haneef membership in a group personnel as follows:

1 Connect to the database as a user with DBA authority, or as the group user ID personnel.

2 Grant membership in the group to M_Haneef with the following SQL statement:

```
GRANT MEMBERSHIP
IN GROUP personnel
TO M_Haneef
```

When users are assigned membership in a group, they inherit all the permissions on tables, views, and procedures associated with that group.

Adding users to groups in Sybase Central

❖ **To add a user to a group in Sybase Central:**

1 Connect to the database.

2 Double-click the Users and Groups folder for that database, to open it. Groups are displayed in the left panel, and both users and groups are displayed in the right panel.

3 In the right panel, select the users you want to add to a group, and drag them to the group.

For more information, see the Sybase Central online Help.

Permissions of groups

Permissions may be granted to groups in exactly the same way as to any other user ID. Permissions on tables, views, and procedures are inherited by members of the group, including other groups and their members. There are some complexities to group permissions that database administrators need to keep in mind.

Notes

The DBA, RESOURCE, and GROUP permissions are not inherited by the members of a group. Even if the personnel user ID is granted RESOURCE permissions, the members of personnel do not have RESOURCE permissions.

Ownership of database objects is associated with a single user ID and is not inherited by group members. If the user ID personnel creates a table, then the personnel user ID is the owner of that table and has the authority to make any changes to the table, as well as to grant privileges concerning the table to other users. Other user IDs who are members of personnel are not the owners of this table, and do not have these rights. If, however, SELECT authority is explicitly granted to the personnel user ID by the DBA or by the personnel user ID itself, all group members do have select access to the table. In other words, only granted permissions are inherited.

Referring to tables owned by groups

Groups are used for finding tables and procedures in the database. For example, the query

```
SELECT * FROM SYSGROUPS
```

will always find the table SYSGROUPS, because all users belong to the PUBLIC group and PUBLIC belongs to the SYS group which owns the SYSGROUPS table. (The SYSGROUPS table contains a list of *group_name*, *member_name* pairs representing the group memberships in your database.)

If a table employees is owned by the personnel user ID, and if M_Haneef is a member of the personnel group, then M_Haneef can refer to the employees table simply as employees in SQL statements. Users who are not members of the personnel group need to use the qualified name personnel.employees.

Creating a group to own the tables

It is advisable that you create a group whose only purpose is to own the tables. Do not grant any permissions to this group, but make all users members of the group. This allows everyone to access the tables without qualifying names. You can then create permission groups and grant users membership in these permission groups as warranted. For an example of this, see the section “Database object names and prefixes”.

Groups without passwords

Users connected to a group's user ID have certain permissions. This user ID can grant and revoke membership in the group. Also, this user would have ownership permissions over any tables in the database created in the name of the group's user ID.

It is possible to set up a database so that all handling of groups and their database objects is done by the DBA, rather than permitting other user IDs to make changes to group membership.

This is done by disallowing connection as the group's user ID when creating the group. To do this, the GRANT CONNECT statement is typed without a password. Thus:

```
GRANT CONNECT
TO personnel
```

creates a user ID personnel. This user ID can be granted group permissions, and other user IDs can be granted membership in the group, inheriting any permissions that have been given to personnel, but nobody can connect to the database using the personnel user ID, because it has no valid password.

The user ID personnel can be an owner of database objects, even though no user can connect to the database using this user ID. The CREATE TABLE statement, CREATE PROCEDURE statement, and CREATE VIEW statement all allow the owner of the object to be specified as a user other than that executing the statement. This assignment of ownership can be carried out only by the DBA.

Special groups

When a database is created, two groups are also automatically created. These are SYS and PUBLIC. Neither of these groups has passwords, so it is not possible to connect to the database as either SYS or as PUBLIC. The two groups serve important functions in the database.

The SYS group

The SYS group is owner of the system tables and views for the database, which contain the full description of database structure, including all database objects and all user IDs.

For a description of the system tables and views, together with a description of access to the tables, see Chapter 15, “System Tables” and Chapter 16, “System Views” in *Adaptive Server IQ Reference Manual*.

The PUBLIC group

When a database is created, the PUBLIC group is automatically created, with CONNECT permissions to the database and SELECT permission on the system tables.

The PUBLIC group is a member of the SYS group, and has read access for some of the system tables and views, so that any user of the database can find out information about the database schema. If you wish to restrict this access, you can REVOKE PUBLIC's membership in the SYS group.

Any new user ID is automatically a member of the PUBLIC group and inherits any permissions specifically granted to that group by the DBA. You can also REVOKE membership in PUBLIC for users if you wish.

Database object names and prefixes

The name of every database object is an identifier. The rules for valid identifiers are described in Chapter 6, “SQL Language Elements” in *Adaptive Server IQ Reference Manual*.

In queries and sample SQL statements throughout this guide, database objects from the sample database are generally referred to using their simple name. For example:

```
SELECT *
FROM employee
```

Tables, procedures, and views all have an owner. The owner of the tables in the sample database is the user ID DBA. In some circumstances, you must prefix the object name with the owner user ID, as in the following statement.

```
SELECT *
FROM "DBA".employee
```

The employee table reference is said to be qualified. (In this case the owner name is enclosed in double quotes, as DBA is a SQL keyword.) In other circumstances it is sufficient to give the object name. This section describes when you need to use the owner prefix to identify tables, view and procedures, and when you do not.

When referring to a database object, a prefix is required unless:

- You are the owner of the database object.
- The database object is owned by a group ID of which you are a member.

Example

Consider the following example of a corporate database. All the tables are created by the user ID company. This user ID is used by the database administrator and is therefore given DBA authority.

```
GRANT CONNECT TO company
IDENTIFIED BY secret;
GRANT DBA TO company;
```

The tables in the database are created by the company user ID.

```
CONNECT USER company IDENTIFIED BY secret;
CREATE TABLE company.Customers ( ... );
CREATE TABLE company.Products ( ... );
CREATE TABLE company.Orders ( ... );
CREATE TABLE company.Invoices ( ... );
CREATE TABLE company.Employees ( ... );
CREATE TABLE company.Salaries ( ... );
```

Not everybody in the company should have access to all information. Consider two user IDs in the sales department, Joe and Sally, who should have access to the Customers, Products and Orders tables. To do this, you create a Sales group.

```
GRANT CONNECT TO Sally IDENTIFIED BY xxxxx;
GRANT CONNECT TO Joe IDENTIFIED BY xxxxx;
GRANT CONNECT TO Sales IDENTIFIED BY xxxxx;
GRANT GROUP TO Sales;
GRANT ALL ON Customers TO Sales;
GRANT ALL ON Orders TO Sales;
GRANT SELECT ON Products TO Sales;
GRANT MEMBERSHIP IN GROUP Sales TO Sally;
GRANT MEMBERSHIP IN GROUP Sales TO Joe;
```

Now Joe and Sally have permission to use these tables, but they still have to qualify their table references because the table owner is company, and Sally and Joe are not members of the company group:

```
SELECT *
FROM company.customers
```

To rectify the situation, make the Sales group a member of the company group.

```
GRANT GROUP TO company;
GRANT MEMBERSHIP IN GROUP company TO Sales;
```

Now Joe and Sally, being members of the Sales group, are indirectly members of the company group, and can reference their tables without qualifiers. The following command will now work:

```
SELECT *
FROM Customers
```

Note

Joe and Sally do not have any extra permissions because of their membership in the company group. The company group has not been explicitly granted any table permissions. (The company user ID has implicit permission to look at tables like Salaries because it created the tables and has DBA authority.) Thus, Joe and Sally still get an error executing either of these commands:

```
SELECT *
FROM Salaries;
SELECT *
FROM company.Salaries
```

In either case, Joe and Sally do not have permission to look at the Salaries table.

Using views and procedures for extra security

For databases that require a high level of security, defining permissions directly on tables has limitations. Any permission granted to a user on a table applies to the whole table. There are many cases when users' permissions need to be shaped more precisely than on a table-by-table basis. For example:

- It is not desirable to give access to personal or sensitive information stored in an employee table to users who need access to other parts of the table.
- You may wish to give sales representatives update permissions on a table containing descriptions of their sales calls, but limit such permissions to their own calls.

In these cases, you can use views and stored procedures to tailor permissions to suit the needs of your organization. This section describes some of the uses of views and procedures for permission management.

For information on how to create views, see “Working with views”.

Using views for tailored security

Views are computed tables that contain a selection of rows and columns from base tables. Views are useful for security when it is appropriate to give a user access to just one portion of a table. The portion can be defined in terms of rows or in terms of columns. For example, you may wish to disallow a group of users from seeing the salary column of an employee table, or you may wish to limit a user to see only the rows of a table that they have created.

Example

The Sales manager needs access to information in the database concerning employees in the department. However, there is no reason for the manager to have access to information about employees in other departments.

This example describes how to create a user ID for the sales manager, create views that provide the information she needs, and grants the appropriate permissions to the sales manager user ID.

1 Create the new user ID using the GRANT statement, from a user ID with DBA authority. Enter the following:

```
CONNECT "DBA"
IDENTIFIED by SQL;
GRANT CONNECT
TO SalesManager
IDENTIFIED BY sales
```

(You must enclose DBA in quotation marks because it is a SQL keyword, just like SELECT and FROM.)

2 Define a view which only looks at sales employees as follows:

```
CREATE VIEW emp_sales AS
SELECT emp_id, emp_fname, emp_lname
FROM "DBA".employee
WHERE dept_id = 200
```

The table should be identified as "DBA".employee, with the owner of the table explicitly identified, for the SalesManager user ID to be able to use the view. Otherwise, when SalesManager uses the view, the SELECT statement refers to a table that user ID does not recognize.

3 Give SalesManager permission to look at the view:

```
GRANT SELECT
ON emp_sales
```

```
TO SalesManager
```

Exactly the same command is used to grant permission on a view as to grant permission on a table.

Example 2

The next example creates a view which allows the Sales Manager to look at a summary of sales orders. This view requires information from more than one table for its definition:

1 Create the view.

```
CREATE VIEW order_summary AS
SELECT order_date, region, sales_rep, company_name
FROM "DBA".sales_order
KEY JOIN "DBA".customer
```

2 Grant permission for the Sales Manager to examine this view.

```
GRANT SELECT
ON order_summary
TO SalesManager
```

3 To check that the process has worked properly, connect to the SalesManager user ID and look at the views you have created:

```
CONNECT SalesManager IDENTIFIED BY sales ;
SELECT * FROM "DBA".emp_sales ;
SELECT * FROM "DBA".order_summary ;
```

No permissions have been granted to the Sales Manager to look at the underlying tables. The following commands produce permission errors.

```
SELECT * FROM "DBA".employee ;
SELECT * FROM "DBA".sales_order;
```

Other permissions on views

The previous example shows how to use views to tailor SELECT permissions. INSERT, DELETE, and UPDATE permissions can be granted on views in the same way.

For information on allowing data modification on views, see “Using views” on page 129.

Using procedures for tailored security

While views restrict access on the basis of data, procedures restrict the actions a user may take. As described in “Granting permissions on procedures” a user may have EXECUTE permission on a procedure without having any permissions on the table or tables on which the procedure acts.

Strict security

For strict security, you can disallow all access to the underlying tables, and grant permissions to users or groups of users to execute certain stored procedures. With this approach, the manner in which data in the database can be modified is strictly defined.

How user permissions are assessed

Groups do introduce complexities in the permissions of individual users. Suppose user M_Haneef has been granted SELECT and UPDATE permissions on a specific table individually, but is also a member of two groups, one of which has no access to the table at all, and one of which has only SELECT access. What are the permissions in effect for this user?

Adaptive Server IQ decides whether a user ID has permission to carry out a specific action in the following manner:

1 If the user ID has DBA permissions, the user ID can carry out any action in the database.

2 Otherwise, permission depends on the permissions assigned to the individual user. If the user ID has been granted permission to carry out the action, then the action is allowed to proceed.

3 If no individual settings have been made for that user, permission depends on the permissions of each of the groups of which the user is a member. If any of these groups has permission to carry out the action, the user ID has permission by virtue of membership in that group, and the action is allowed to proceed.

This approach minimizes problems associated with the order in which permissions are set.

Managing the resources connections use

Building a set of users and groups allows you to manage permissions on a database. Another aspect of database security and management is to limit the resources an individual user can use.

For example, you may wish to prevent a single connection from taking too much of the available memory or CPU resources, so that one connection does not slow down other users of the database.

Adaptive Server IQ provides a set of database options that the DBA can use to control resources. These options are called **resource governors**.

Setting options

You can set database options using the SET OPTION statement, which has the following syntax:

SET [**TEMPORARY**] **OPTION**
... [*userid.* | **PUBLIC**.]*option-name* = [*option-value*]

For reference information about options, see "Database Options" in *Adaptive Server IQ Reference Manual*. For information on the SET OPTION statement, see *Adaptive Server IQ Reference Manual*.

Resources that can be managed

The following options can be used to manage resources. See Chapter 12, "Managing System Resources" or see the *Adaptive Server IQ Reference Manual* for more information on these options.

- **AGGREGATION_CUTOFF** Sets the precision level at which Adaptive Server IQ uses a more efficient internal storage type to do calculations on SUM or AVG numeric expressions.
- **CURSOR_WINDOW_ROWS** Defines the number of cursor rows to buffer.
- **LOAD_MEMORY_MB** Sets an upper bound for the amount of heap memory that subsequent load operations can use.
- **MAIN_CACHE_MEMORY_MB** Sets the size of the cache for the main IQ Store.
- **MAX_CARTESIAN_RESULT** Limits the number of result rows from a query containing a cartesian join.
- **MAX_IQ_THREADS_PER_CONNECTION** Sets the number of processing threads available to a connection for use in IQ operations.
- **TEMP_CACHE_MEMORY_MB** Sets the size of the cache for the IQ Temporary Store.
- **JOIN_OPTIMIZATION** Enables optimization of join order. When this option is on (default), Adaptive Server IQ optimizes the join order to reduce the size of intermediate results and sorts, and to balance the system load.

The following options affect the database engine, but have limited impact on Adaptive Server IQ:

- **JAVA_HEAP_SIZE** Sets the maximum size (in bytes) of that part of the memory that is allocated to Java applications on a per connection basis.
- **MAX_CURSOR_COUNT** Limits the number of cursors for a connection.
- **MAX_STATEMENT_COUNT** Limits the number of prepared statements for a connection.
- **BACKGROUND_PRIORITY** Limits the impact requests on the current connection have on the performance of other connections

Database option settings are not inherited through the group structure.

Users and permissions in the system tables

Information about the current users of a database and about their permissions is stored in the database system tables and system views.

For a description of each of these tables, see “System Tables” in *Adaptive Server IQ Reference Manual*.

The system tables are owned by the special user ID SYS. It is not possible to connect to the SYS user ID.

The DBA has SELECT access to all system tables, just as to any other tables in the database. The access of other users to some of the tables is limited. For example, only the DBA has access to the SYS.SYSUSERPERM table, which contains all information about the permissions of users of the database, as well as the passwords of each user ID. However, SYS.SYSUSERPERMS is a view containing all information in SYS.SYSUSERPERM except for the password, and by default all users have SELECT access to this view. All permissions and group memberships set up in a new database for SYS, PUBLIC, and DBA can be fully modified.

The following table summarizes the system tables containing information about user IDs, groups, and permissions. All tables and views are owned by user ID SYS, and so their qualified names are SYS.SYSUSERPERM and so on.

Appropriate SELECT queries on these tables generates all the user ID and permission information stored in the database.

Table	Default	Contents
SYSUSERPERM	DBA only	Database-level permissions and password for each user ID
SYSGROUP	PUBLIC	One row for each member of each group
SYSTABLEPERM	PUBLIC	All permissions on table given by the GRANT commands
SYSCOLPERM	PUBLIC	All columns with UPDATE permission given by the GRANT command
SYSDUMMY	PUBLIC	Dummy table, can be used to find the current user ID
SYSPROCPERM	PUBLIC	Each row holds one user granted permission to use one procedure

The following table summarizes the system views containing information about user IDs, groups, and permissions.

Views	Default	Contents
SYSUSERAUTH	DBA only	All information in SYSUSERPERM except for user numbers
SYSUSERPERMS	PUBLIC	All information in SYSUSERPERM except for passwords
SYSUSERLIST	PUBLIC	All information in SYSUSERAUTH except for passwords
SYSGROUPS	PUBLIC	Information from SYSGROUP in a more readable format
SYSTABAUTH	PUBLIC	Information from SYSTABLEPERM in a more readable format
SYSCOLAUTH	PUBLIC	Information from SYSCOLPERM in a more readable format
SYSPROCAUTH	PUBLIC	Information from SYSPROCPERM in a more readable format

In addition to these, there are tables and views containing information about each object in the database.

CHAPTER 11

Backup and Data Recovery

About this chapter

This chapter explains how to back up your database, and how to recover data when necessary. It tells you why it is important to perform backups on regular basis, and gives recommendations for scheduling backups.

Backup protects your data

Adaptive Server IQ provides a full set of features that protect you from two types of computer failure, and from database corruption.

- A *system failure* occurs when the computer or operating system goes down while there are partially completed transactions. This could occur when the computer is inappropriately turned off or rebooted, when another application causes the operating system to crash, or because of a power failure.
- A *media failure* occurs when the database file, the file system, or the device storing the database file, becomes unusable.

After a system failure, Adaptive Server IQ can usually recover automatically, so that you may not need to restore your database. Recovery from system failures is discussed in *Adaptive Server IQ Troubleshooting and Error Messages Guide*.

After media failure, or if for any reason the data in your database is corrupted, you must restore your database. To protect your data in all of these situations, make regular backups of your databases. In particular, you should back up your database each time you finish inserting any large quantities of new data into the database.

When failures occur, the recovery mechanism treats transactions properly, as atomic units of work: any incomplete transaction is rolled back and any committed transaction is preserved. This ensures that even in the event of failure, the data in your database remains in a consistent state.

Backing up your database

You use the BACKUP command to back up your IQ database. Backup includes both the Adaptive Server IQ data (the IQ Store) and the underlying Adaptive Server Anywhere database (the Catalog Store)

Backup runs concurrently with read and write operations in the database. By contrast, during a restore no other operations are allowed on that database.

You must be connected to a database in order to back it up. The BACKUP command has no way to specify another database.

For an IQ multiplex database, you must run backups on the write server, but you may execute backups while the servers are all running in multiplex mode. For more information about multiplex backups, see *Adaptive Server IQ Multiplex User's Guide*.

Types of backups

Adaptive Server IQ provides three types of backups:

- *Full backup* makes a complete copy of the database.
- *Incremental backup* copies all transactions since the last backup of any type.
- *Incremental-since-full backup* copies all transactions since the last full backup.

All three backup types fully back up the Catalog Store. In most cases, the Catalog Store is much smaller than the IQ Store. If the Catalog Store is larger than (or nearly as large as) the IQ store, however, incremental backups of IQ will be bigger than you may want or expect.

Temporary Store data is not backed up. However, the meta data and any other information needed to recreate the Temporary Store structure is backed up.

Data in backups

BACKUP *backs up committed data only.* Backups begin with an automatic checkpoint. At this point, the backup program determines what data will be backed up. It backs up the current snapshot version of your database as of the time of this checkpoint. *Any data that is not yet committed when this checkpoint occurs is not included in the backup.*

A second automatic checkpoint occurs at the end of backup. Any data that is committed while the backup is in progress is included in any subsequent backups. However, if a failure occurs between the first and second checkpoints, any work that occurred after the first checkpoint cannot be restored.

Adaptive Server IQ backs up only those database blocks actually in use at the time of backup. Free blocks are not backed up.

Adaptive Server IQ backs up the database files and the Catalog information that pertains to the IQ database to which you are connected. *It does not back up the transaction log file.* It does not use the transaction log to restore the database.

If your database needs a rollback or is missing files, the backup fails.

The transaction log in backup, restore, and recovery

Adaptive Server IQ uses the transaction log file during recovery from a system failure. It does not use the transaction log to restore an IQ database, to recover committed IQ transactions, or to restore the Catalog Store for an Adaptive Server IQ database. However, the restore program does check for the existence of the transaction log:

- For a full restore, the transaction log *must not* exist. You must delete this file before starting a full restore.
- For an incremental restore, the transaction log *must* exist. You must not delete this file or you will not be able to do an incremental restore.

Note Adaptive Server Anywhere databases use the transaction log and other logs differently. If you are recovering such a database, you need its transaction log file, and BACKUP retains it for you. See the *Adaptive Server Anywhere User's Guide* for details. Also, if you have data (other than the system tables) in your Catalog store, transactions for that data can only be recovered if they were written to disk before a failure.

Distribution of backup data

BACKUP always makes a full backup of the Catalog Store on the first archive device, and then backs up the data from the IQ Store in parallel across all of the devices you specify. Blocks are not distributed evenly across archive media. You may have more on one device than others, depending on the processing speed of individual threads.

Note The distribution of backup data is important because sets of files must be restored in the order in which they were backed up. See "Restoring in the correct order" on page 403 for more information.

Ensuring that your database is consistent

Although Backup does check that all necessary files are present before backing up your database, it does not check internal consistency. For a more thorough check, you can run the stored procedure sp_iqcheckdb before making a backup. See "Validating your database" on page 393 for details.

Selecting archive devices

You can back up any IQ database onto either disk or magnetic tape. Adaptive Server IQ supports backup and restore using multiple tape drives at near device speeds, or to multiple disks if disk striping is in use. You specify the backup device name in the *archive_device* parameter of the BACKUP command.

Disk backup requirements

Disk backups must go to a file system; raw disk is not supported as a backup medium. All disks on a RAID device are treated as a single device.

Tape backup requirements

If you regularly back up large databases, you should use DLT drives, if they are supported for your platform. In any case, Sybase recommends that you use multiple tape drives.

Adaptive Server IQ BACKUP can support the following tape drives:

- Digital Linear Tape (DLT) on UNIX systems

- 4 mm DDS
- 8 mm

Adaptive Server IQ also allows Stacker drives with multiple tapes.

Adaptive Server IQ BACKUP does *not* support jukeboxes or robotic loaders. If you need them, use a third party media manager.

Adaptive Server IQ BACKUP does *not* support fixed-length tape devices on UNIX systems, like Quarter Inch Cartridge (QIC) drives.

Note Tape devices on AIX systems can be configured for either fixed- or variable-length block mode. See the *Adaptive Server IQ Installation and Configuration Guide* for information on how to show and change the block mode. Adaptive Server IQ BACKUP does not support fixed-length block mode.

Preparing for backup

In order to run BACKUP, you must first install and run Adaptive Server IQ. You must also make sure that you meet the other requirements described in the sections that follow.

Obtaining DBA privileges

You need DBA privileges on a database to run BACKUP or RESTORE. You must either log on as the DBA user, or be granted DBA authority by the DBA as described in “Granting DBA and resource authority”.

Rewinding tapes

Adaptive Server IQ does not rewind tapes before using them. You must ensure the tapes used for backup or restore operations are at the correct starting point before putting them in the tape device.

Tapes are rewound after the backup if you are using a rewinding device. If your tape device automatically rewinds tapes, take care that you do not overwrite any information on the tape.

Retaining old disk backups

BACKUP overwrites existing disk files of the same name. If you need to retain a backup, when you create a new backup either use different file or path names for the archive devices, or move the old backup to another location before starting the backup.

Two ways to run BACKUP

You can run BACKUP in two ways:

- *Attended*. In attended mode, BACKUP assumes that an operator is present, and prompts you to mount the archive media when necessary. With this method, you must run BACKUP interactively from the command line.
- *Unattended*. In unattended mode, BACKUP assumes that no operator is present, and does not issue prompts. Instead, you must make appropriate estimates of the space required, and set up your devices accordingly. Any error is considered fatal.

In some cases, you can use third party software to create backups. Such products can be particularly useful for unattended backups. See “Unattended backup” for details if you want to run backups when no operator is present.

Note You can run BACKUP from a batch script or procedure, as well as from Interactive SQL.

Estimating Media Capacity

Before you do a backup, be sure that your archive media has sufficient space. When you estimate available space on disk or tape, keep in mind these rules:

- You need enough room for a full backup of the Catalog Store, as well as the full or incremental backup of the IQ Store. If your Catalog Store holds Adaptive Server Anywhere data in addition to the Adaptive Server IQ system tables, you need room to back up this data as well.
- You do not need to include space for the transaction log, as this log is not backed up.
- For tape backups, the first tape set you specify must be able to hold the full backup of the Catalog Store, including any non-IQ data in the Catalog Store. (A tape set consists of one or more backup tapes produced on a given archive device.)

- For stacker devices that hold multiple tape drives, all tapes for a given device must be the same size.

Sybase recommends that you always start a new tape for every backup.

Before starting a backup to disk, Adaptive Server IQ first tests whether there is enough disk file space for the backup. For an operator-attended backup to disk, if there is not enough space, BACKUP prompts you to move some files from the disk before it writes any data. The backup does not start until you provide more disk space.

Likewise, if you run out of space during an attended disk backup, BACKUP closes all open backup files and waits until it detects that you have cleared some space. Then it restarts with new backup files. You can also stop the backup if you prefer.

By default, you must provide at least 8KB of free disk space before the backup resumes.

Unattended backup cannot prompt you to provide more space. If enough space is not available, unattended backup fails. BACKUP treats size estimates differently for unattended backups. See "Unattended backup" for details.

For an operator-attended backup to tape, BACKUP simply begins the backup. If it runs out of room, you must mount additional tapes.

Concurrency and backups

Backups can be run concurrently with all other database operations with one exception: no metadata changes can occur while the Catalog Store is backed up. Be aware, however, that transactions that have not committed when you start a backup are not backed up. If a system or media failure occurs during backup, you cannot restore uncommitted transactions.

Once a backup is started, you cannot execute a CHECKPOINT command.

The BACKUP statement

To back up an IQ database, use the following syntax:

```
BACKUP DATABASE
...[ CRC ON | OFF ]
...[ ATTENDED ON | OFF ]
...[ BLOCK FACTOR integer ]
...[ { FULL | INCREMENTAL | INCREMENTAL SINCE FULL } ]
```

...TO '*archive_device*' [SIZE *#_of_KB*][STACKER *#_of_drives_in_stack*] ...
[WITH COMMENT '*string*']

Note If you need to back up an Adaptive Server Anywhere database, see the *Adaptive Server IQ Reference Manual* for additional options.

Specifying operator presence

ATTENDED ON or OFF controls whether or not human intervention is expected when new tapes or disk files are needed. The default is ON.

For unattended backups to disk, BACKUP does not prompt you to add more disk space. If you run out of space, an error occurs and BACKUP halts.

For unattended backups to tape, BACKUP does not prompt for a new tape to be loaded. The SIZE and STACKER options determine what happens if you run out of space. See the information on these options under "Specifying archive devices".

Specifying the type of backup

FULL | INCREMENTAL | INCREMENTAL SINCE FULL specifies the type of backup. Choose one:

- FULL causes a full backup of both the Catalog Store and the IQ Store. FULL is the default action.
- INCREMENTAL makes a full backup of the Catalog Store, and then backs up all changes to the IQ Store since the last IQ backup of any type.
- INCREMENTAL SINCE FULL makes a full backup of the Catalog Store, and then backs up all changes to the IQ store since the last full IQ backup.

For guidance in selecting a backup type, see "Scheduling routine backups".

Specifying archive devices

The TO *archive_device* clause indicates the destination disk file(s) or system tape drive(s) for the backup. You specify one TO *archive_device* clause for each destination file or device. At least one is required. BACKUP distributes output *in parallel*—that is, concurrently—across all of the devices you specify. For faster backups you should specify more devices, up to the number your hardware platform supports.

Backup file names for backup to disk

BACKUP always assigns file names to disk backup files by appending a suffix to the *archive_device* name you specify. The suffix consists of "." followed by a number that increases by one for each new file. For example, if you specify */iqback/mondayinc* as the *archive_device*, the backup files are */iqback/mondayinc.1*, */iqback/mondayinc.2*, and so on. This convention allows you to store as large a backup as you need, while allowing you control over the file size; see the SIZE option for details. Your file system must support long file names to accommodate this convention.

You must make sure that the directory names you specify for the *archive_device* exist. BACKUP does not create missing directories. If you try to start a backup in a directory that does not exist, the backup fails.

You should avoid using relative pathnames to specify the location of disk files. BACKUP interprets the pathname as relative to the location where the server was started, which you may not be able to identify with certainty when you do a backup. Also, if there is data in other directories along the path, you may not have enough room for the backup.

Positioning tape devices

BACKUP does not position tapes for you. You must position the tape appropriately before starting your backup, and be sure that you do not overwrite any of the backup if you use a rewinding tape device. For these reasons, Sybase recommends you use a non-rewinding tape device. See the operating system documentation for your platform for appropriate naming conventions.

Specifying tape devices on UNIX

Here are examples of how you specify non-rewinding tape devices on UNIX platforms:

- On Sun Solaris platforms, insert the letter n for "no rewind" after the device name, for example, '*/dev/rmt/0n*'.
- On IBM AIX platforms, use a decimal point followed by a number that specifies the appropriate compression setting with rewind setting, for example, '*/dev/rmt0.1*'.
- On HP-UX platforms, use '0m' to specify the default tape mechanism and 'n' for "no rewind," for example, '*/dev/rmt/0mn*'.
- On DEC UNIX platforms, put an n in front of the device name, for example, '*/dev/nrmt0h*'.

Warning! If you misspell a tape device name and write a name that is not a valid tape device on your system, BACKUP assumes it is a disk file.

Specifying tape devices on Windows NT

Windows NT systems do not specify rewind or no rewind devices and only support fixed-length I/O operations to tape devices. Adaptive Server IQ requires variable-length devices. It does additional processing to accommodate NT's fixed-length tape I/O.

While Windows NT supports tape partitioning, Adaptive Server IQ does not use it, so do *not* use another application to format tapes for Adaptive Server IQ backup or restore. Windows NT has a simpler naming strategy for its tape devices, where the first tape device is *'\\.\tape0'*, the second is *'\\.\tape1'*, and so on.

Warning! For backup (and for most other situations) Adaptive Server IQ treats the leading backslash in a string as an escape character, when the backslash precedes an n, an x, or another backslash. For this reason, when you specify backup tape devices you must double each backslash required by the NT naming convention. For example, indicate the first NT tape device you are backing up to as *'\\\\.\\tape0'*, the second as *'\\\\.\\tape1'*, and so on. If you omit the extra backslashes, or otherwise misspell a tape device name, and write a name that is not a valid tape device on your system, Adaptive Server IQ interprets this name as a disk file name.

For more information about fixed-length I/O on NT, see "Tuning backup operations" in the *Adaptive Server IQ Installation and Configuration Guide*.

Specifying the size of tape backups

The SIZE option of the TO clause identifies the maximum size of the backed up data on that stripe, in KB.

If you use the Sybase–provided backup (as opposed to a third party backup product), you should specify SIZE for *unattended* tape backups on platforms that do not reliably detect the end-of-tape marker. No volume used on the corresponding device can be shorter than this value. Although IQ does not require you to specify SIZE for an *attended* tape backup, it is always best to supply an accurate size estimate.

If tapes run out of space and you have not specified SIZE, you get an error. If tapes run out of space before the specified size, you do not get an error immediately; instead, here is what happens:

- For attended backups with SIZE and STACKER specified, Backup tries to open the next tape.
- For attended backups with SIZE specified but not STACKER, Backup asks you to put in a new tape.

- For unattended backups with SIZE and STACKER specified, Backup tries to open the next tape. If there are no volumes available, or if you did not specify STACKER, you get an error.

Any additional tapes do not contain the header information needed for a restore, so you must be careful to mount tapes in order during the restore or your database could become corrupt.

On Windows NT, there are special requirements for the SIZE option on tape devices:

- The value of SIZE must be a multiple of 64.
- If you specify a SIZE that is not a multiple of 64, it is automatically rounded down to a multiple of 64.
- If you do not specify SIZE explicitly, it is automatically set to 1.5GB.

If you specify SIZE explicitly on any platform, and on NT even if you do not specify it explicitly, then if you run of space on a tape backup, you get an error and the backup fails.

Specifying the size of disk backups

The SIZE option of the TO clause identifies the maximum size of the backed up data on that stripe, in KB.

If you use the Sybase–provided backup, either attended or unattended, specify SIZE if you need a maximum size other than the default of 2GB. When you omit SIZE for a backup to disk, BACKUP assumes that each disk file you name as an *archive_device* can be up to 2GB.

For example, if you specify one *archive_device*, a disk file called *janfull*, and you specify SIZE 200000 for a maximum 200MB file, but your backup requires 2GB, then BACKUP creates ten 200MB files: *janfull.1*, *janfull.2*,...*janfull.10*.

Specifying stacker devices

The STACKER option of the TO clause indicates that you are backing up to an automatically loaded multitape stacker device, and specifies the number of tapes in that device. When ATTENDED is ON and STACKER is specified, BACKUP waits indefinitely for the next tape to be loaded. All tapes in a given stacker device must be the same size.

Specifying devices for third party backups

Note Do not specify SIZE or STACKER if you are using a third party backup product, as size information is conveyed in the *vendor_specific_information* string. To specify this string, see “Performing backups with non-Sybase products”.

Other backup options

Specifying the block factor

BLOCK FACTOR specifies the number of IQ blocks to write to the archive device at one time. It must be greater than 0, or BACKUP returns an error message. BLOCK FACTOR defaults to 25 on UNIX platforms. On Windows NT, the default BLOCK FACTOR is based on the block size of your database. For example, if the block size is 512 bytes, BLOCK FACTOR is 120 blocks. If the block size is 32KB, BLOCK FACTOR is 1 block.

This parameter also controls the amount of memory used for buffers during the backup, and has a direct impact on backup performance. The effects of the block factor are a function of disk subsystem speed, tape speed, and processor speed. Some systems have better backup performance with a smaller block factor, while others may have better backup performance with a larger one.

Error checking

CRC ON or OFF activates or deactivates 32-bit cyclical redundancy checking on a per block basis. (BACKUP also uses whatever error detection is available in the hardware.) With CRC ON, the numbers computed on backup are verified during any subsequent RESTORE operation. The default is CRC ON.

Adding comments

WITH COMMENT specifies a string up to 32KB long as part of the header information for the backup archive. If you omit this option, BACKUP enters a NULL. You can view the comment string by executing a RESTORE DATABASE FROM CATALOG ONLY, or by displaying the backup log,*backup.syb*, that Adaptive Server IQ provides.

If you need to back up an Adaptive Server Anywhere-only database, see the *Adaptive Server Anywhere Reference Guide* for additional BACKUP options.

Waiting for Tape Devices

During backup and restore operations, if Adaptive Server IQ cannot open the archive device (for example, when it needs the media loaded), it waits for ten seconds and tries again. It continues these attempts indefinitely until either it is successful or the operation is terminated with a CTRL-C.

Backup Examples

Example 1 — Full backup

This example makes a full, attended backup of the database asiquser to two tape devices on UNIX. Before running this backup you must position the tapes to the start of where the backup files will be written, and connect to asiquser. Then issue the following command:

```
BACKUP DATABASE
```

```
TO '/dev/rmt/0n'
TO '/dev/rmt/1n'
WITH COMMENT 'Jan 18 full backup of asiquser'
```

The Catalog Store is backed up first, to */dev/rmt/0n*. The IQ Store is backed up next, to both tapes.

Example 2 — Incremental backup

To make an incremental backup of the same database, this time using only one tape device, issue the command as follows:

```
BACKUP DATABASE
INCREMENTAL
TO '/dev/rmt/0n' SIZE 150
WITH COMMENT 'Jan 30 incremental backup of asiquser'
```

An example of how to restore this database from these two backups is provided later in this chapter.

Recovery from errors during backup

There are two likely reasons for a failed backup: insufficient space, or hardware failure. Problems with third party software could also cause a failure.

Checking for backup space

BACKUP uses the STACKER and SIZE parameters to determine whether there is enough space for the backup.

- For disk backups, if it decides that you have not provided enough space, it fails the backup before actually writing any of the data.
- If it decides that there is enough space to start the backup, but then runs out before it finishes (for example, if your estimate is incorrect, or if a user in another application fills up a lot of disk space while your backup is in progress), an attended backup prompts you to load a new tape, or to free up disk space. An unattended backup fails if it runs out of space.
- If neither STACKER nor SIZE is specified, backup proceeds until it completes or until the tape or disk is full. If you run out of space, an attended backup prompts you to load a new tape, or to free up disk space; an unattended backup fails.

Recovery attempts

If a backup fails, the backup program attempts to recover as follows:

- If backup fails during either the checkpoint at the start of backup or the checkpoint when backup is complete, it performs normal checkpoint recovery.
- If backup fails between checkpoints, it rolls back the backup.
- If the system fails at any time between the initial and final checkpoint and you must restore the database, you must do so using an older set of backup tapes or disk files.
- If the system fails during the final checkpoint after a FULL backup, you can restore from the backup tapes or files you have just created.

After you complete a backup

In the event that you ever need to move a database or one of its dbspaces, you need to know the name of every dbspace in the database when the backup was made. See “Recording dbspace names” for details on how to record this information after you complete a backup.

Performing backups with non-Sybase products

Adaptive Server IQ supports backup and restore using a number of third-party products. The package you use must conform to the Adaptive Server Enterprise Backup Interface. Check the documentation for your product to be sure that it supports Sybase databases.

To perform such a backup or restore, you issue the BACKUP or RESTORE statement as if you were using Adaptive Server IQ to perform the operation, with the following exceptions:

- For each *archive_device*, instead of specifying the actual device name, specify a string in the following format:

  dll_name::*vendor_specific_information*

- Do not specify the STACKER or SIZE parameters.

The *dll_name* corresponds to a Dynamic Link Library loaded at run time. It can be from 1 to 30 bytes long, and can contain only alphanumeric and underscore characters. The *dll_name* must be the same for each *archive_device*.

The content of *vendor_specific_information* varies by product, and can differ for each *archive_device*. The total string (including *dll_name*:: and vendor information) can be up to 255 bytes long.

The backup program passes vendor information to the third-party program automatically. When you request a third-party backup, it places this information in the backup header file, and writes the header file on the first tape or disk file actually created for each *archive_device* you specify.

Performing system-level backups

The BACKUP command is the most reliable method you can use to back up IQ data. If you are careful to follow the procedures in this section, however, you can use system-level backups for an IQ database.

Warning! Do not use system-level backups for backing up your IQ database unless you follow these procedures. If you attempt to restore your IQ database files from a system-level backup without these safeguards in place, you are likely to cause data loss or corruption, either from activity in the database while the system-level backup occurred, or from missing files.

Shutting down the database

Your IQ database must not be running during a system-level backup.

You must shut down your IQ database before starting the system-level backup. You must also ensure that no one starts the IQ database until the system-level backup is complete.

Ensuring that the database is shut down

The file protection of the *.db* file is read-only when the database is shut down cleanly, and set to read/write when the database is in use. If you are writing a script to perform backups, it is a good idea for the script to check the access mode of the file, to be sure that the database is shut down.

To ensure that a database remains shut down, the script can check the size of the *.iqmsg* file at the start and end of the script to make sure it has not changed. If the database was started while the script was running, the *.iqmsg* file will be bigger.

Backing up the right files

Required files

You must back up the following files:

- SYSTEM dbspace file, typically named *dbname*.db.
- The transaction log file, which is required for system recovery, typically named *dbname*.log
- The IQ_SYSTEM_MAIN dbspace file, typically named *dbname*.iq
- The IQ_SYSTEM_TEMP dbspace file, typically named *dbname*.iqtmp
- Files for any additional dbspaces that have been added to IQ_SYSTEM_MAIN or IQ_SYSTEM_TEMP

Optional files

It is a good idea to back up the ASCII message files such as *dbname*.iqmsg and the *$ASLOGDIR/*.svrlog* and *$ASLOGDIR/*.stderr* files. These files are not required. However, if problems occur during a restore, the *.iqmsg* file will prove that the database was shut down before the backup started.

These files may be useful in diagnosing the cause of the database failure you are recovering from. Be sure to make a copy before restoring, for use in later analysis.

Keeping your backup list updated

It is critically important to add to your system backup specification any dbspaces that are added to the database, whether they are in SYSTEM, IQ_SYSTEM_MAIN, or IQ_SYSTEM_TEMP. If a dbspace is added several months down the road, or after some turnover in your organization, you may miss this step.

To ensure that you are backing up all the files you need, use a script for system-level backups. In the script, before starting the backup, compare a select from SYSFILES (for the system dbspaces) and from IQSYSFILES (for the IQ dbspaces) to a list of dbspaces known to be in the system backup specification.

Raw devices and symbolic links

If your database files are on raw devices, be sure your system backup is backing up the raw device contents, not just the NAME of the device in */dev/**.

If symbolic links are used for raw device names, as recommended, be sure the system backup utility follows the symbolic link and backs up the device.

Restoring from a system-level backup

If you must restore from a system-level backup, you must ensure that database server is shut down, just as it was during the backup. See “Shutting down the database” on page 391 for details.

Ensuring that all files exist

Before restoring, review the table of contents of the backup to ensure that all files required for IQ are present. The list of files depends on your application. See the discussion of required and optional files in “Backing up the right files” on page 392.

Checking ownership and permissions

Ensure that ownership and permission levels do not change during the system-level restore.

Validating your database

Backing up a database is useful only if the database is internally consistent. Backup always makes sure that a database is in a usable state before it proceeds. However, it's a good idea to validate any database before you back it up, to ensure that any database you restore is stable. The restore program does not check for corruption in the data it is restoring, since the database may not even exist.

To validate your database, issue the following command:

```
sp_iqcheckdb
```

You should run sp_iqcheckdb periodically, and whenever you suspect a problem with the database. The sections that follow provide basic information on using sp_iqcheckdb. For full details see the *Adaptive Server IQ Troubleshooting and Error Messages Guide*.

This stored procedure works in conjunction with the set option DBCC_OPTION. This option should be set to its default value, 0, when you run sp_iqcheckdb for a routine validation before backup.

sp_iqcheckdb reads every database page from disk into memory and does various consistency checks. For this reason, running this procedure on a large database can take a long time. Reading the data consumes most of the execution time, so you can estimate how long it will take to run the procedure by the size of your database:

For this size database	It takes about this long
10GB	30 minutes
100GB	400 minutes (6 1/2 hours)

Interpreting results

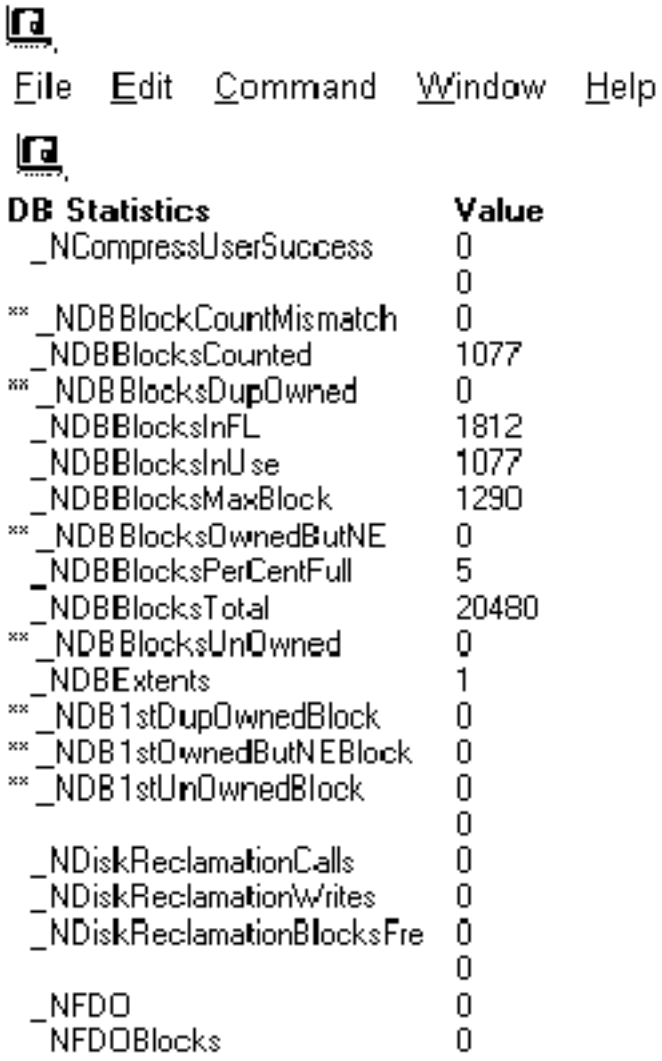
The procedure produces a very long list of statistics about your database. Statistics are listed first for the Main IQ Store, then for Temporary Store. For each store, you see three types of statistics:

- Dynamic statistics. These are cumulative counts from the time the database server was started, and vary each time you run the procedure. Examples include buffer manager statistics. You can also obtain these statistics by running the stored procedure sp_iqcommandstats.
- Size statistics. These report on space used by various database objects.
- Orphaned blocks. These are the key statistics to look for. They always have an asterisk next to them so you can find them easily. Orphaned block statistics are described in the table below. If you see a non-zero value for any of these statistics, your database likely has a serious consistency problem. (You also see a non-zero value if other users are active while sp_iqcheckdb is run; see "Concurrency issues for sp_iqcheckdb" below.)

Orphaned block statistic	*Meaning*
NDBBlocksDupOwned	More than one table claims ownership of the same page
NDBBlocksUnOwned	No table owns the pages, but the free list says these pages are free
NDBBlocksOwnedButNE	A table claims to own these pages, but the free list says they are available (you will never see a non-zero value for this statistic)
NDB1stDupOwnedBlock	First orphaned block of this type
NDB1stUnOwnedBlock	First orphaned block of this type
NDB1stOwnedButNEBlock	First orphaned block of this type
NDBBlockCountMismatch	Sum of NDBBlocksDupOwned, NDBBlocksUnOwned, NDBBlocksOwnedButNE

The following figure shows an excerpt from sp_iqcheckdb output for the sample database. You can see the key statistics designated by asterisks.

Figure 11-1: sp_iqcheckdb results



Concurrency issues for sp_iqcheckdb

When you run sp_iqcheckdb, it reads every database page in use. This procedure consumes most of the database server's time, so that the I/O is as efficient as possible. Any other concurrent activities on the system will run

more slowly than usual.

If other users are active when you run sp_iqcheckdb, the results you see reflect only what your transaction sees.

If another user is doing inserts and deletes, those blocks appear as unowned in the Main IQ Store. To avoid confusion, you should not allow inserts and deletes while sp_iqcheckdb executes.

If another user is running queries, Temporary Store blocks used for the queries appear as unowned, and also affect CountMismatch. This is not really a problem, as consistency in the temporary store is not important.

Restoring your databases

Once you have created a database and made a full backup of it, you can restore it when necessary. Adaptive Server IQ restores the database to its state as of the automatic CHECKPOINT at the start of the backup.

Before you restore

Before you can restore a database, make sure that the following conditions are met:

- You must have DBA privileges.
- You must be connected to the utility_db database. For information on utility_db and how to set privileges for using it, see the *Adaptive Server IQ Installation and Configuration Guide* for your platform.
- No user can be connected to the database being restored. RESTORE exits with an error if there are any active Read Only or Read/Write users of the specified database.
- You must restore the database to the appropriate server, and that server must have the archive devices you need. When you use the Sybase-provided restore, you need the same number of archive devices (that is, the disk files or tape drives) as when the backup was created.

- For a full restore, the Catalog Store (by default the *.db* file) and the transaction log (by default the *.log* file) *must not* exist in the location you are restoring to. If either of these files exists, you must delete it or move it to a different directory before doing the full restore.

  When a full restore begins, it destroys all old database files and then recreates them. The requirement that you manually delete the Catalog Store and transaction log files protects you from doing a full restore accidentally.

- For any incremental restore, the Catalog Store (*.db*) and transaction log (*.log*) files *must* exist. If they exist, but in a different location than the one you are restoring to, you must follow the procedure described in "Moving database files". If either of these files does not exist, you can only do a full restore.

- For any incremental restore, the database must not have changed since the last restore.

Restore requires exclusive access to the database. The default database server startup option -gd DBA guarantees that only the DBA can start a database. To ensure exclusive access, start the database server with the -gd DBA option set, but do not start the database you are restoring. RESTORE automatically starts the database in such a way that no other users can connect to it.

You must restore an entire backup or set of backups. Restoring individual files is not supported. However, you can move database files to a new location, using the RENAME clause of the RESTORE command.

Restore accommodates dbspace changes

During a set of incremental restores, RESTORE creates and drops dbspaces as needed to match what was done during the period of operation encompassed by the restores. For example, assume that you make a full backup of a database, then add a dbspace to that database, and then do an incremental backup after adding the dbspace. When you restore from these backups, RESTORE creates a file for the new dbspace, at the start of the incremental restore. Similarly, if you drop a dbspace, it is dropped during the restore, although the actual file is not removed.

Restoring disk backup files

If you back up to disk and then move those files to tape, you must move them back to disk files with the same names as when you created the backup. Adaptive Server IQ cannot restore disk files that are moved to tape directly from tape.

When you restore using the Sybase-provided backup and restore, you must specify the same number of archive devices (disk files) for the restore as were used to create the backup.

Restoring tape backup files

When restoring from tape, you must position the tape to the start of the IQ data. RESTORE does not reposition the tape for you.

When you restore using the Sybase-provided backup and restore, you must use the same number of tape drives for the restore as were used to create the backup(s) you are restoring.

Specifying files for an incremental restore

For an incremental restore, files you restore must match in number and size the files they replace, for both the IQ and Catalog Stores.

Keeping the database unchanged between restores

If you are doing a set of incremental restores, and any user changes the database before you finish restoring the complete set, the Restore program does not let you restore the remaining incrementals. For example, if you have a set consisting of a full restore and two incrementals, and a user's write transaction commits after the full restore but before you issue the second or third RESTORE command, you cannot proceed with the incremental restores. Instead, you must restore the full backup and apply the incrementals again.

If the database has changed since the last restore and you try to do an incremental restore, the following error occurs:

```
Database has changed since the last restore
```

Note Adaptive Server IQ does not let you do an incremental restore if the database has changed since the previous restore. However, it does not prevent users from making changes. It is the responsibility of the DBA or system operator to ensure that no changes are made to the database until all restores are complete.

Restoring from a compatible backup

RESTORE lets you restore database files for Adaptive Server IQ 12.0 and up. Due to changes in the format of the database, Adaptive Server IQ 12.0 does not let you restore from a backup created on an older version. Likewise, you cannot restore a pre-Version 12.0 IQ database from a Version 12.0 backup.

To move your data from an Adaptive Server IQ 11.5.1 database to Adaptive Server IQ 12.0, you must follow the migration procedure described in the *Adaptive Server IQ Installation and Configuration Guide*.

RESTORE does not let you restore an Adaptive Server IQ backup to an Adaptive Server Anywhere database.

The RESTORE statement

To restore a database, use the following syntax:

```
RESTORE DATABASE 'db_file'
FROM 'archive_device' [ FROM 'archive_device' ]...
... [ RENAME dbspace_name TO 'new_dbspace_path' ]...
... [ CATALOG ONLY ]
```

Remember that you must be connected to the utility_db database as DBA to issue this statement.

You must specify the *db_file* and at least one *archive_device*.

For *db_file* you specify the location of the Catalog Store file for the database (created with the suffix *.db* by default). You can specify the full pathname or a pathname relative to the server where the database was created. If you specify a new pathname, the Catalog Store and any files created relative to it will be moved to that location, except for any files you include in a RENAME clause.

Just as for backup, each *archive_device* specifies the API (Sybase or third party) and, for the Sybase API, the physical tape device or disk file name from which you are restoring. For third-party APIs, the content of the *archive_device* string depends on your vendor. The archive device must not be a raw disk device. When you restore from disk files using the Sybase API, you must supply the same number of archive devices as were specified when this backup was created.

Warning! If you misspell a tape device name and give a name that is not a valid tape device on your system, RESTORE assumes it is a disk file and tries to read from it.

See “Specifying archive devices” for details on specifying devices.

Note If you are restoring from tape devices on Windows NT, note that you do not need to redouble the backslashes when you specify tape devices for restore, as you did for backup.

Example 1 — Restoring to the same location

This Windows NT example restores a database to *asiquser.db*. The database is restored from two disk files. All database files will be restored to their original locations.

```
RESTORE DATABASE 'asiquser.db'
FROM 'c:\\asiq\\backup1'
FROM 'c:\\asiq\\backup2'
```

Moving database files

If you need to move database files to a new location—for example, if one of your disk drives fails—you use one of the following methods:

- To move the database file that holds the Catalog Store (by default, the *.db* file), you simply specify the new name as *db_file*.
- To move or rename the transaction log file, you use the Transaction Log utility (DBLOG). For syntax and details, see “The DBLOG command-line utility” on page 405.

- To move any other database file, you use the RENAME option.

Note The DBTRAN utility is not supported by Adaptive Server IQ because it regenerates only those parts of the transaction log that are specific to Adaptive Server Anywhere.

Example 2 — Moving the Catalog Store

This example restores the same database as Example 1. In Example 2, however, you move the Catalog Store file and any database files that were created relative it. To do so, you replace the original file name with its new location, *c:\newdir*, as follows:

```
RESTORE DATABASE 'c:\\newdir\\asiqnew.db'
FROM 'c:\\asiq\\backup1'
FROM 'c:\\asiq\\backup2'
```

Adaptive Server IQ moves database files other than the Catalog Store as follows:

- If you specify a RENAME clause, the file is moved to that location.
- If you do not specify a RENAME clause, and the file was created using a relative pathname, it is restored relative to the new location of that database file. In other words, files originally created relative to the SYSTEM dbspace, which holds the Catalog Store file, are restored relative to the Catalog Store file. Files originally created relative to the IQ_SYSTEM_MAIN dbspace, which holds the main IQ Store file, are restored relative to the main IQ Store file.
- If you do not specify a RENAME clause, and the file was created using an absolute pathname, the file is restored to its original location.

In other words, if you want to move an entire database, you should specify in a RENAME clause the new location for *every* IQ dbspace in the database—required, temporary, and user-defined. The SYSTEM dbspace is the only one you do not include in a RENAME clause.

If you only want to move some of the files, and overwriting the original files is not a problem, then you only need to rename the files you actually want to move.

You specify each *dbspace_name* as it appears in the SYSFILE table. You specify *new_dbspace_path* as the new raw partition, or the new full or relative pathname, for that dbspace.

You cannot use the RENAME option to specify a partial restore.

Relative pathnames in the RENAME clause work as they do when you create a database or dbspace: the main IQ Store dbspace, Temporary Store dbspaces, and Message Log are restored relative to the location of *db_file* (the Catalog Store); user-created IQ Store dbspaces are restored relative to the directory that holds the main IQ dbspace.

If you are renaming files while restoring both full and incremental backups, be sure you use the dbspace names and paths consistently throughout the set of restores. It is the safest way to ensure that files are renamed correctly.

If a dbspace was added between the full backup and an incremental backup, and you are renaming database files, you need one more RENAME clause for the incremental restore than for the full restore. Similarly, if a dbspace was deleted between backups, you need one fewer RENAME clause for the restores from any backups that occurred after the dbspace was deleted.

See “Recording dbspace names” for information on how to obtain a list of the dbspace names in your database, so that you will know the correct names to include in RENAME clauses.

Example 3 — Moving a user dbspace

This example shows how you restore the full and incremental backups in example shown earlier in this chapter. In this case, media failure has made a UNIX raw partition unusable. The user-defined dbspace on that raw partition, IQ_USER, must be moved to a new raw partition, /dev/rdsk/c1t5d2s1. No other database files are affected.

First, you connect to the utility_db database. Then you restore the full backup from two tape devices. In this case they are the same two tape devices used to make the backup, but the devices could differ as long as you use the same number of archive devices, the same media type (tape or disk), and the same tape sets in the correct order, as described in “Restoring in the correct order”.

The first RESTORE command is:

```
RESTORE DATABASE 'asiquser'
FROM '/dev/rmt/0n'
FROM '/dev/rmt/1n'
RENAME IQ_SYSTEM_MAIN TO '/dev/rdsk/c2t0d1s1'
RENAME IQ_SYSTEM_TEMP TO '/dev/rdsk/c2t1d1s1'
RENAME IQ_SYSTEM_MSG TO 'asiquser.iqmsg'
RENAME IQ_USER TO '/dev/rdsk/c1t5d2s1'
```

The second RESTORE command, to restore the incremental backup, is:

```
RESTORE DATABASE 'asiquser'
FROM '/dev/rmt/0n'
RENAME IQ_SYSTEM_MAIN TO '/dev/rdsk/c2t0d1s1'
RENAME IQ_SYSTEM_TEMP TO '/dev/rdsk/c2t1d1s1'
```

```
RENAME IQ_SYSTEM_MSG TO 'asiquser.iqmsg'
RENAME IQ_USER TO '/dev/rdsk/c1t5d2s1'
```

Note You could also issue these commands with only the last RENAME clause, since only one dbspace is being restored to a new location. Listing all of the files or raw partitions, as shown here, ensures that you know exactly where each will be restored.

Displaying header information

The CATALOG ONLY option displays the header information for the database. It does not restore any data, either from the Catalog Store or the IQ Store. See "Displaying header information" for a list of the information displayed.

When you specify CATALOG ONLY you include the FROM *archive_device* clause, but omit the RENAME clause.

Adjusting data sources and configuration files

When you move a database, you may need to modify your data sources, configuration files, and integrated logins to reflect the new location of the database.

Restoring in the correct order

When you restore from a full backup, every block in use at the time the backup was made is written to disk. When you restore from an incremental backup, only the blocks that changed between the previous backup (or the previous full backup) and this backup are written to disk.

You must restore full and incremental backups in the correct order, with a separate RESTORE command for each backup you are restoring. RESTORE ensures that backups are restored in order, and gives the following error if it determines that the order is incorrect:

```
SQL Code:  -1012009
SQL State: QUA09
This restore cannot immediately follow the previous
restore.
```

To determine the correct order, you need the information about backup files that is stored in the backup log. See “Getting information about backups and restores” for the content and location of this file.

Restore backups as follows:

- If your database is corrupt, or if you are moving any files to a new location, you must restore a FULL backup.
- If your most recent backup is a FULL backup, or if you need to restore a database to the state that existed before any existing incremental(s) were made, restore the full backup only.
- If you have an INCREMENTAL_SINCE_FULL backup that precedes the database failure, first restore from the last FULL backup, and then restore the INCREMENTAL_SINCE_FULL backup.
- If you do not have an INCREMENTAL_SINCE_FULL backup, but you have performed one or more INCREMENTAL backups since your last FULL backup, first restore the FULL backup, and then restore the INCREMENTAL backups in the order in which they were made.

Within a given backup, the order in which you restore tapes is also important. In particular, you need to keep track of the order of tapes in each backup tape set, that is, the set of tapes produced in a given backup on a given archive device:

- You must restore the tape set that contains the backup of the Catalog Store first, and it must be on the first archive device.
- Within each set, you must restore tapes in the order in which they were created.
- You cannot interleave sets; each set must be restored before you can restore another set.
- After the first set, the order in which sets are restored does not matter, as long as it is correct within each set.

Use the same number of drives to restore as were used to produce the backup, so that you do not accidentally interleave tapes from different sets.

Example

Assume that you are restoring a full backup, in which you used three archive devices, and thus produced three tape sets, A, B, and C. The contents of each set, and the restore order, are as follows:

Set A Tapes A_1, A_2, and A_3. Tapes A_1 and A_2 contain the Catalog Store. This set must be restored first, and must be in the first device.

Set B Tapes B_1 and B_2. These must be restored as a set, after Set A, and either before or after Set C. They can be in either the second or third device.

Set C Tapes C_1, C_2, and C_3. These must be restored as a set, after Set A, and either before or after Set B. They can be in either the second or third device.

The Restore program checks that tapes within each set are in the correct order on a single device. If not, you get an error, and the restore does not proceed until you supply the correct tape. Except for the set with the Catalog Store, it does not matter which set you put on a given device.

Note You must ensure that the Catalog Store tape set is restored first. The Restore program does not check this.

Although these rules also apply to disk files, you are not likely to back up to multiple files on a given disk device.

Renaming the transaction log after you restore

When you rename or move all other files in the database, you should also do the same for the log file. To move or rename the log file, use the Transaction Log utility (DBLOG). You should run this utility:

- After using RESTORE with a new database name
- After using RESTORE with the RENAME option

Note The database server must not be running on that database when the transaction log filename is changed. If you try to use this utility on a running database, you get an error message.

You can access the Transaction Log utility from the system command line, using the DBLOG command-line utility.

The DBLOG command-line utility

Syntax **dblog** *[switches] database-file*

Switches

Switch	Description
-m *mirror-name*	Set transaction log mirror name.
-t *log-name*	Set the transaction log name

Description

The DBLOG command line utility allows you to display or change the name of the transaction log or transaction log mirror associated with a database. You can also stop a database from maintaining a transaction log or mirror, or start maintaining a transaction log or mirror.

Transaction log utility options

Set the name of the transaction log mirror file (-m) This option sets a filename for a new transaction log mirror. If the database is not currently using a transaction log mirror, it starts using one. If the database is already using a transaction log mirror, it changes to using the new file as its transaction log mirror. Most Adaptive Server IQ databases do not use a transaction log mirror, so this switch is rarely used.

Set the name of the transaction log file (-t) This option sets a filename, including an optional directory path, for a new transaction log. If the database is not currently using a transaction log, it starts using one. If the database is already using a transaction log, it changes to using the new file as its transaction log.

Validating the database after you restore

To ensure that tapes have been restored in the correct order, you should run the stored procedure sp_iqcheckdb after you finish restoring your database. If you are restoring a set of incremental backups, it is safest to run sp_iqcheckdb after restoring each backup. Because this procedure can take many hours, however, you may prefer to run it after the full backup only, not after each incremental. For more information, see “Validating your database”.

Restore requires exclusive write access

Once RESTORE starts, no other users are allowed to access the specified database. If you restore from a full backup and then from one or more incremental backups, you should ensure that no users are modifying the database between the restores. The modifications are permitted, but you cannot perform any more incremental restores. Instead, you must start the entire restore again.

In an IQ Multiplex, you must restore on the write server in simplex mode, and synchronize the query server following the completion of the restore. For more information on multiplex restores, see *Adaptive Server IQ Multiplex User's Guide*.

This restriction extends to any incremental restores you may need if your system crashes during recovery. If you need to recover from a system or media failure that occurs during a restore, you must do one of the following:

- Continue the original sequence of full and incremental restore operations, or
- Perform a full restore, followed by any incremental restores needed to fully recover your database.

The default database server startup setting -gd DBA makes DBA privileges a requirement for starting up a database. When the DBA runs RESTORE, the command automatically starts the database, gets the information it needs for the restore, and then stops the database. At the end of the restore, the command starts the database, issues a checkpoint, and stops it again. This procedure ensures that the DBA has exclusive write access throughout a restore.

When all incremental restores are complete, the DBA issues the START DATABASE command again to allow other users access to the database.

Displaying header information

You can display the contents of the header file by using the RESTORE statement with the CATALOG ONLY option and no FILE clauses. The header file includes the following information:

- Database name
- Database type (Adaptive Server IQ or Adaptive Server Anywhere)
- Backup creation date
- Approximate number of tapes or disk files in the backup
- User who did the backup
- Backup type (full, incremental, or incremental-since-full)
- Medium (always Othr)
- Number, type, and size of dbspaces

For an example of the information you see in a header file, see any RESTORE line in the sample backup log in "Content of the backup log". A RESTORE with CATALOG ONLY produces the information in the same format as the backup log entry for an actual RESTORE.

Recovery from errors during restore

If an incremental restore fails early in the operation, the database is still usable (assuming it existed and was not corrupt before the restore). If a full restore fails, you will not have a usable database.

If a failure occurs after a certain point in the operation, the restore program marks the database as corrupted. In this case recovery is only possible by means of a FULL RESTORE. If you were performing a FULL RESTORE when the failure occurred, you may need to go back to the previous FULL BACKUP.

Using Symbolic Links (UNIX Only)

If you use symbolic links, you may unknowingly cause dbspaces to be created in a different directory from where you may want them to be. For example, suppose you have created dbspaces in the following files:

```
-rw-r--r--   1 dkusner  sybase   122880000 Feb 26 18:27 asiqdemo.db
-rw-r--r--   1 dkusner  sybase   122880000 Feb 26 18:27 asiqdemo.iq1
-rw-r--r--   1 dkusner  sybase   122880000 Feb 26 18:27 asiqdemo.iq2
-rw-r--r--   1 dkusner  sybase   122880000 Feb 26 18:27 asiqdemo.iq3
-rw-r--r--   1 dkusner  sybase   122880000 Feb 26 18:27 asiqdemo.iqtmp
-rw-r--r--   1 dkusner  sybase   122880000 Feb 26 18:27 asiqdemo.iqmsg
```

If you create the following links beforehand, then the dbspaces, when they are created, are actually created in the directories (or on the raw partitions) pointed to by the links:

```
lrwxrwxrwx   1 dkusner  sybase        14 Feb 26 17:48 asiqdemo.iq1 ->
 LINKS/asiqdemo.iq1
lrwxrwxrwx   1 dkusner  sybase        14 Feb 26 17:48 asiqdemo.iq2 ->
 LINKS/asiqdemo.iq2
lrwxrwxrwx   1 dkusner  sybase        18 Feb 26 17:48 asiqdemo.iq3 ->
 /dev/rdsk/c2t6d0s0
```

When you back up the files and restore them with the CATALOG ONLY option, you don't see anything telling you that these files were links; in fact, this information is not saved.

Adaptive Server IQ saves these files as though they were actually present in the directory where the symbolic links reside. When you do the restore, the files are recreated in the directories or on the raw partitions named by the database name. Whether or not the links exist at restore time, they will never be used again. The database is restored to its original location.

Unattended backup

With the ATTENDED OFF option, you can specify that no operator will be present during a backup. Adaptive Server IQ currently supports two unattended backup features:

- The operator does not need to respond to prompts during the backup.
- The archive devices can be stacker drives, which automatically load a set of tapes into a single drive. You can use stacker drives for both attended and unattended backups.

Unattended backup tries to detect all possible reasons for a backup failing except tape media failure, and report any potential errors before attempting the backup, such as available space on disk or tape, and consistent size and block factor.

For unattended backup to disk, Adaptive Server IQ first tests whether there is enough free disk space for the backup, However, it does not preallocate the backup files to reserve the space. If another user writes to that disk and as a result there is not enough room for the backup, the backup fails when disk space runs out.

For backup to tape, you must estimate how much data each tape will hold, and specify that number of kilobytes in the TO *archive_device* parameter of the BACKUP command. The backup program checks information stored internally to see how much room it needs to back up your database. If it determines that there is enough room on the tape, the backup proceeds. However, if you overestimate the amount of space available on the tape(s) and the backup runs out of space, the backup fails at that point.

If you omit the SIZE parameter for an unattended backup, the entire backup must fit on one tape.

If you are using a third-party backup product, the vendor information string needs to convey any information needed for the backup, such as the specification of devices, size of files, and stacker drives. See your vendor's documentation for details.

Note Adaptive Server IQ does not permit unattended restore.

Getting information about backups and restores

Adaptive Server IQ provides a backup log, *.backup.syb*, to help you manage your backup media. This log is not used to create the backup or to restore the database; however, information describing the backup or restore is recorded in this file during both Backup and Restore.

Note To display only the information about a particular backup, you can run RESTORE with the CATALOG ONLY option. This option displays the header file for a backup from the media rather than from the file, so that the DBA can identify what is on the tape or file. See "Displaying header information".

Locating the backup log

The*.backup.syb* file is in ASCII text format. Its location depends on the setting of environment variables at the time the server is started:

- On UNIX, the server tries to place it in the following locations, in this order:
  - The directory specified by the ASLOGDIR environment variable.
  - The directory specified by the HOME environment variable.
  - The home directory as obtained from account information.
  - The current directory (where the server was started).

  If the file is placed in the "home" directory, it is prefixed with a "." in order to make it a hidden file.

- On Windows NT, the server tries to place it in the following locations, in this order:
  - The directory specified by the ASLOGDIR environment variable.
  - The directory that holds the server executable files.

Content of the backup log

For every backup or restore you perform, the backup log contains the following fields, separated by commas:

- Operation (Backup or Restore)
- Version
- Database name
- Database type (Adaptive Server IQ or Adaptive Server Anywhere)
- Date and time of backup or restore
- Creator user ID
- Type of backup/restore: Full, Incremental, or Incremental_since_full, or Database File Only (for Adaptive Server Anywhere databases only)
- Method: Archive or Image
- Location
- Comment (if entered on the BACKUP command), enclosed in single quotes. If the comment includes quotes, they appear as two consecutive single quotes.

Here is a sample backup log, with ellipses added to show continuation lines.

```
BACKUP, 1.0, all_types.db, ASIQ, '1998-12-22 16:25:00.000',.....
DBA, Full, Arch, TED_FULL00, '' BACKUP, 1.0, all_types.db, ASIQ, '1998-12-22
16:53:00.000',...
 DBA, Incr, Arch, TED_X_bkup_inc, '' RESTORE, 1.0, all_types.db, ASIQ, '1998-
12-22
16:25:00.000',...
DBA, Full, Arch, TED_FULL00, '' RESTORE, 1.0, all_types.db, ASIQ, '1998-12-22
16:53:00.000',...
DBA, Incr, Arch, TED_X_bkup_inc, '' BACKUP, 1.0, all_types.db, ASIQ, '1998-12-22
20:07:00.000',...
DBA, InSF, Arch, A_partial2_yes_sf, '' BACKUP, 1.0, all_types.db, ASIQ, '1998-
12-22
```

```
20:07:00.000', ...
DBA, InSF, Arch, A_partial2_yes_sf, ''
```

Maintaining the backup log

It's a good idea to clean up the backup log after you purge backup media. Use a text editor to do so. Be careful with your edits: once BACKUP or RESTORE records information in this file, it does not check its accuracy.

There is only one backup log on a server. The server must be able to read and write this file. The system administrator may want to limit access to this file by other users. If you are running more than one database server on a system, you should set the ASLOGDIR environment variable differently for each server, to produce separate backup logs.

Warning! Do not edit the backup log while a backup or restore is taking place. If you are modifying the file while BACKUP or RESTORE is writing to it, you may invalidate the information in the file.

Viewing the backup log in Sybase Central

The backup log contains information in raw, unsorted form. To see the information in a form that is easier to understand, you can view it in Sybase Central.

Note This feature is not yet supported.

Recording dbspace names

In the event that you ever need to use the RENAME option of RESTORE to move a database or one of its dbspaces, you need to know the name of every dbspace in the database. The dbspace names are in the SYSFILE table of every database, but you will not have this table available when you are restoring. For this reason, you should issue the following statement any time you back up your database:

```
select * from SYSFILE
```

Keep the results of this query some place other than the disk where the database resides, so that you will have a complete list of dbspace names if you need them.

You can also run the following script in DBISQL. This script produces an output file that contains the set of rename clauses you would use if you did not actually change the location of any files. You can substitute any new file locations, and use the resulting file in your RESTORE statement.

Note Because the database may not exist when you need to restore, you may want to run this script after you back up your database.

```
 -- This select statement will get names of IQ dbspaces
and file names
 -- and add rename syntax including quotes

select 'rename' , dbspace_name , 'to' ,'''' +  file_name
+ ''''
from SYSFILE where store_type ='IQ';

 -- output to file in proper format
 -- no delimiters and no additional quotes

output to restore.tst delimited by ' ' quote '';

 --this produces a file  restore.tst looking like this:
 --rename IQ_SYSTEM_MAIN to '/dev/rdsk/c2t0d1s7'
 --rename IQ_SYSTEM_TEMP to '/dev/rdsk/c2t1d1s7'
 --rename IQ_SYSTEM_MSG to 'all_types.iqmsg'
```

Determining your data backup and recovery strategy

To develop an effective strategy for backing up your system, you need to determine the best combination of full, incremental, and incremental-since-full backups for your site, and then set up a schedule for performing backups. Consider the performance implications of various backup options, and how they affect your ability to restore quickly in the event of a database failure.

Scheduling routine backups

Make a full backup of each database just after you create it, to provide a base point, and perform full and incremental backups on a fixed schedule thereafter. It is especially important to back up your database after any large number of changes.

Your backup plan depends on:

- The load on your system
- The size of your database
- The number of changes made to the data
- The relative importance of faster backups and faster recovery

Determining the type of backup

When you decide whether to do a full, incremental, or incremental_since_full backup, you need to balance the time it takes to create the backup with the time it would take to restore. You also should consider media requirements. A given incremental backup is relatively quick and takes a relatively small amount of space on tape or disk. Full backups are relatively slow and require a lot of space.

Incremental_since_full is somewhere in between. It starts out as equivalent to incremental, but as the database changes and the number of backups since a full backup increases, incremental_since_full can become as time-consuming and media-consuming as a full backup, or worse.

In general, the opposite is true for restore operations. For example, if you need to restore from a very old full backup and a dozen or more incrementals, the restore may take longer and the backup may use up more space than a new full backup.

The obvious advantage of incremental backups is that it is much faster and takes less space to back up only the data that has changed since the last backup, or even since the last full backup, than to back up your entire database. The disadvantage of relying too heavily on incremental backups is that any eventual restore takes longer.

For example, once you have a full backup of your database, in theory you could perform only incremental backups thereafter. You would not want to do this, however, because any future recovery would be intolerably slow, and would require more tape or disk space than doing a full backup periodically. Remember that other users can have read and write access while you do backups, but no one else can use the database while you are restoring it. You might find yourself needing to restore dozens of incremental backups, with your system unavailable to users throughout the process.

A much better approach is a mix of incremental and full backups.

The greater the volume of your database changes, the more important it is do a backup, and the smaller the advantage of incremental backups. For example, if you update your database nightly with changes that affect 10 percent or more of the data, you may want to do an incremental_since_full backup each night, and a full backup once a week. On the other hand, if your changes tend to be few, a full backup once a month with incrementals in between might be fine.

Designating Backup and Restore Responsibilities

Many organizations have an operator whose job is to perform all backup and recovery operations. Anyone who is responsible for backing up or restoring an Adaptive Server IQ database must have DBA privileges for the database.

Improving performance for backup and restore

The overall time it takes to complete a backup or recover a database depends largely on the strategy you choose for mixing full and incremental restores. Several other factors also affect the speed of backup and restore operations: the number of archive devices, data verification, the memory available for the backup, and size of the IQ and Catalog Stores.

Increasing the number of archive devices

BACKUP and RESTORE write your IQ data in parallel to or from all of the archive devices you specify. The Catalog Store is written serially to the first device. Faster backups and restores result from greater parallelism. To achieve greater performance when backing up or restoring a large database, specify more archive devices.

Eliminating data verification

You can also improve the speed of backup and restore operations by setting CRC OFF in the BACKUP command. This setting deactivates cyclical redundancy checking. With CRC ON, numbers computed on backup are verified during any subsequent restore operation, affecting performance of both commands. The default is CRC ON. If you turn off this checking, remember that you are giving up a greater assurance of accurate data in exchange for faster performance.

Spooling backup data

You may find that it is faster and more efficient to create backups on disk, and then spool them onto tape for archival storage. If you choose this approach, you need to unspool the data onto disk before restoring it.

Increasing memory used during backup

The amount of memory used for buffers during backup directly affects backup speed, primarily for tape backups. The BLOCK FACTOR parameter of the BACKUP command controls the amount of memory used. If your backups are slow, you may want to increase the value of BLOCK FACTOR for faster backups.

The effect of BLOCK FACTOR depends on your operating system, and on the block size specified when the database was created. By default, the database block size is 4096.

On UNIX, the default BLOCK FACTOR is 25. With this combination, BACKUP is able to buffer data ideally for most UNIX tape drives, with enough data in memory that drives are kept busy constantly throughout the backup.

On Windows NT, the default BLOCK FACTOR is computed based on the database block size. This value usually achieves maximum throughput on NT. Because of the way NT handles tape devices, you may not be able to achieve faster backups by increasing the BLOCK FACTOR.

Balancing system load

Adaptive Server IQ allows you to perform backups concurrently with all other read/write operations, except those that affect the structure of the database. It is still a good idea to schedule backups during times of low system use, however, to make the best possible use of system resources—disk, memory, and CPU cycles.

Controlling the size of the Catalog Store

An IQ database consists of an IQ Store and an underlying Catalog Store.

BACKUP makes a full backup of the Catalog Store at the start of every backup, both full and incremental. Ordinarily the Catalog Store is quite small, containing only the system tables, metadata, and other information Adaptive Server IQ needs to manage your database. However, it is possible to create non-IQ tables in the Catalog Store. You can improve IQ backup performance by keeping any non-IQ data in a separate Adaptive Server Anywhere-only database, rather than in the Catalog Store.

Backup copies only the latest committed version of the database. Other version pages used by open transactions are not backed up.

CHAPTER 12

Managing System Resources

About this chapter

This chapter describes the way Adaptive Server IQ uses memory, disk I/O, and CPUs, and the relationships among these factors. It also explains how the DBA can tune performance by adjusting resource usage.

The suggestions in this chapter are generic. You need to adjust them to suit your hardware and software configuration.

Introduction to performance terms

Performance is the measure of efficiency of a computerized business application, or of multiple applications running in the same environment. It is usually measured in *response time* and *throughput*.

Response time is the time it takes for a single task to complete. It is affected by:

- Reducing contention and wait times, particularly disk I/O wait times
- Using faster components
- Reducing the amount of time the resources are needed (this is the same as increasing concurrency)

Throughput refers to the volume of work completed in a fixed time period. Throughput is commonly measured in transactions per second (tps), but can be measured per minute, per hour, per day, and so on.

Designing for performance

Most gains in performance derive from good database design, thorough query analysis, and appropriate indexing. The largest performance gains can be realized by establishing a good design and by choosing the correct indexing strategy.

Other considerations, such as hardware and network analysis, can locate bottlenecks in your installation.

Overview of memory use

Adaptive Server IQ uses memory for several purposes:

- Buffers for data read from disk to resolve queries
- Buffers for data read from disk when loading from flat files
- Overhead for managing connections, transactions, buffers, and database objects

The sections that follow explain how the operating system supports IQ's use of memory, how IQ allocates memory for various purposes, how you can adjust the memory allocations for better performance, and what you may need to do to configure the operating system so that enough memory is available for IQ.

Paging increases available memory

When there is not enough memory on your system, performance can degrade severely. If this is the case, you need to find a way to make more memory available. Like any RDBMS software, Adaptive Server IQ requires a lot of memory. The more memory you can allocate to Adaptive Server IQ, the better.

However, there is always a fixed limit to the amount of memory in a system, so sometimes operating systems can have only part of the data in memory and the rest on disk. When the operating system must go out to disk and retrieve any data before a memory request can be satisfied, it is called *paging* or *swapping*. The primary objective of good memory management is to avoid or minimize paging or swapping.

The most frequently used operating system files are *swap files*. When memory is exhausted, the operating system swaps pages of memory to disk to make room for new data. When the pages that were swapped are called again, other pages are swapped, and the required memory pages are brought back. This is very time-consuming for users with high disk usage rates. In general, try to organize memory to avoid swapping and, thus, to minimize use of operating system files.

To make the maximum use of your physical memory, Adaptive Server IQ uses buffer caches for *all* reads and writes to your databases.

Utilities to monitor swapping

You can use the UNIX vmstat command, the UNIX sar command, or the Windows NT Task Manager, to get statistics on the number of running processes and the number of page-outs and swaps. Use this information to find out if the system is paging excessively. Then make any necessary adjustments. You may want to put your swap files on special fast disks.

For examples of vmstat output, see "Monitoring paging on UNIX systems".

Server memory

Adaptive Server IQ allocates memory for various purposes from a single memory pool, called *server memory*. Server memory includes all of the memory allocated for managing buffers, transactions, databases and servers.

This concept differs markedly from the way memory was used in versions prior to 12, which relied heavily on the use of shared memory for buffer caches. Buffer caches are still a crucial aspect of IQ memory management. However, they now receive a memory allocation from the server memory pool.

At the operating system level, IQ server memory consists of both heap memory and shared memory. For the most part, you do not need to be concerned with whether memory used by Adaptive Server IQ is heap memory or shared memory. All memory allocation is handled automatically. However, you may need to make sure that your operating system kernel is correctly configured to use shared memory before you run Adaptive Server IQ. See the *Adaptive Server IQ Installation and Configuration Guide* for your platform for details.

Memory for loads, synchronizations, and deletions

To avoid overallocating the physical memory on the machine, you can set the LOAD_MEMORY_MB database option for operations where loads occur. In addition to LOAD operations, this option affects SYNCHRONIZE and DELETE operations. The LOAD_MEMORY_MB option sets an upper bound (in MB) on the amount of heap memory subsequent loads can use. For information on loads and buffer cache use, see "Memory requirements for loads" on page 424. For details of the LOAD_MEMORY_MB option, see the *Adaptive Server IQ Reference Manual*.

Killing processes affects shared memory

Warning! Killing processes on UNIX systems may result in semaphores or shared memory being left behind instead of being cleaned up automatically.

The correct way to shut down an IQ server on UNIX is the stop_asiq utility, described in "Stopping the database server" on page 43. For information on cleaning up after an abnormal exit, see the chapter "Troubleshooting Hints" in *Adaptive Server IQ Troubleshooting and Error Messages Guide*.

Managing buffer caches

Adaptive Server IQ needs more memory for buffer caches than for any other purpose. Adaptive Server IQ has two buffer caches, one for the IQ Store and one for the Temporary Store. It uses these two buffer caches for all database I/O operations—for paging, for insertions into the database, and for backup and restore. Data is stored in one of the two caches whenever it is in memory. All user connections share these buffer caches. Adaptive Server IQ keeps track of which data is associated with each connection.

Read the sections that follow for in-depth information on managing buffer caches:

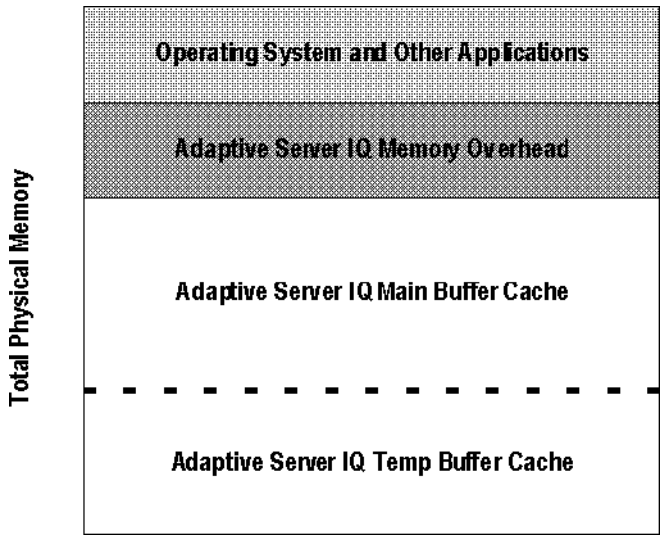
- For information on how to calculate your memory requirements, see "Determining the sizes of the buffer caches"
- For information on how to set buffer cache sizes once you know what they should be, see "Setting buffer cache sizes"

Determining the sizes of the buffer caches

The buffer cache sizes you specify for the Main IQ Store and Temporary Store will vary based on several factors. The default values (8MB and 4MB) are too low for most large databases. The actual values required for your application depend on the total amount of physical memory on your system and how much of this memory Adaptive Server IQ, the operating system, and other applications need to do their tasks.

The following diagram shows the relationship between the buffer caches and other memory consumption.

Figure 12-1: Buffer caches in relation to physical memory



The following sections describe each part in more detail and provide guidelines to help you determine how much memory each part requires.

Operating system and other applications

This amount will vary for different platforms and how the system is used. For example, UNIX “cooked” file systems do more file buffering than UNIX raw partitions, so the operating system has a higher memory requirement. As a minimum, you can assume that UNIX systems use 60MB or more, while Windows NT systems use 30MB or more.

In addition, other applications that run in conjunction with Adaptive Server IQ (such as query tools) have their own memory needs. See your application and operating system documentation for information on their memory requirements.

Adaptive Server IQ memory overhead

After determining how much physical memory the operating system, and other applications use, you can calculate how much of the remaining memory Adaptive Server IQ requires to do its tasks. The factors that affect this overhead are described in the following sections.

Raw partitions versus file systems

For UNIX systems, databases using “cooked” file systems rather than raw partitions may require another 30% of the remaining memory to handle file buffering by the operating system. Windows NT file systems do not have the same overhead as UNIX file systems. However, Windows NT and some UNIX systems may benefit from reserving a significant portion of memory for the file system to better handle I/O operations. For more information, see the *Adaptive Server IQ Installation and Configuration Guide* for your platform.

Multi-user database access

For multi-user queries of a database, Adaptive Server IQ needs about 10MB per “active” user. An active user is defined as one that simultaneously accesses or queries the database. For example, 30 users may be connected to Adaptive Server IQ, but only 10 or so may be actively using a database at any one time.

Memory requirements for loads

Adaptive Server IQ also requires a portion of memory separate from the buffer caches to perform loads operations, synchronization, and deletions. This memory is used for buffering I/O for flat files. Adaptive Server IQ uses memory to buffer a read from disk. The size of this read equals the BLOCK FACTOR multiplied by the size of the input record. BLOCK FACTOR is an option of the LOAD TABLE command. With the default value of 10,000, an input row of data of 200 bytes results in 2MB total that Adaptive Server IQ uses for buffering I/O. This memory is required only when loading from flat files, *not* for inserts from a database.

Memory for thread stacks

Processing threads require a small amount of memory. The more IQ processing threads you use, the more memory needed. The -iqmt server switch controls the number of threads for IQ.

If you have a large number of users, the memory needed for Catalog Store processing threads also increases, although it is still relatively small. The -gn switch controls Catalog Store processing threads.

Adaptive Server IQ main and temp buffer caches

After determining how much overhead memory Adaptive Server IQ needs, you must decide how to split what's left between your main IQ and temp buffer caches. The dashed line dividing the two areas in Figure 12-1 indicates that this split may change from one database to another based on several factors.

The general rule of thumb for IQ, unlike most other databases, is a split of about 40% for the main buffer cache and 60% for temp buffer cache. However, this rule of thumb is only a beginning. While some operations, such as queries with large sort-merge joins or inserts involving HG indexes, may require a larger temp buffer cache than main, other applications can have entirely different needs. IQ supports memory allocation ratios from 30/70 to 70/30, main to temp.

Note These guidelines assume you have one active database on your system at a time (that is, any Adaptive Server IQ users are accessing only one database). If you have more than one, you need to further split the remaining memory among the databases you expect to use.

It is highly recommended that you start with the general guidelines presented here and watch the performance of Adaptive Server IQ by using its monitor tool (described in "Monitoring the buffer caches" on page 467) and any specific tools described in the *Adaptive Server IQ Installation and Configuration Guide* for your platform.

Buffer caches and physical memory

The total memory used for IQ main and temporary buffer caches, plus IQ memory overhead, and memory used for the operating system and other applications, must not exceed the physical memory on your system.

If you set buffer cache sizes higher than your system will accommodate, Adaptive Server IQ cannot open the database. Specify the server startup options -iqmc (main cache size) and -iqtc (temp cache size) to open the database and reset the defaults. The default sizes are 8MB for the main cache and 4MB for the temporary cache.

Note On some UNIX platforms, you may need to set other server switches to make more memory available for buffer caches. See "Platform-specific memory options" on page 434 for more information.

Other considerations

Adaptive Server IQ buffer cache sizes may differ from one database to the next based on how you use it. For maximum performance, you need to change the settings between inserting, querying the database, and mixed use. In a mixed-use environment, however, it is not always feasible to require all users to exit the database so that you can reset buffer cache options. In those cases, you may need to favor either load or query performance. When possible, define the cache sizes before doing any work in the database.

The buffer cache and memory overhead guidelines also may differ between platforms. See your *Adaptive Server IQ Installation and Configuration Guide* for any other issues.

Example of setting buffer cache sizes

The following table provides a list of the factors that may consume memory for your system and how much remains for your main and temp buffer caches. It assumes that the system has 1GB of physical memory, no other significant applications on the hardware other than running Adaptive Server IQ, and only one active database at a time. The table makes a distinction in the storage type (raw versus “cooked”) and the way the database is accessed (queries or inserts).

Table 12-1: Memory available for buffer caches (Example)

Memory Use	Amount Used	Memory available using raw partitions		Memory available using "cooked" file systems	
		Queries	Inserts	Queries	Inserts
Total amount of physical memory available (approximate in MB)		1000	1000	1000	1000
Operating system use assuming a minimum amount for a UNIX system	60[a]	940	940	940	940
Overhead from using "cooked" file system: 30% of remaining memory from step 3 above	278			647	647
Overhead for number of active users: approximately 30 connected users but only about 10 active at 10MB each	100	825		547	
Overhead for inserts from flat files assuming a 200-byte record size and default settings	97		828		550

Memory Use	Amount Used	Memory available using raw partitions		Memory available using "cooked" file systems	
		Queries	Inserts	Queries	Inserts
Memory remaining for the main and temp buffer caches		675	828	397	550
Main_Cache_Memory_Mb setting: 60% of memory remaining for buffer caches		405	497	238	330
Temp_Cache_Memory_Mb setting: 40% of memory remaining for buffer caches		270	331	159	220

[a]Minimum operating system use for Windows NT is 30MB

As shown in the table, you should have one set of values for your buffer caches when primarily inserting into the database, another set when primarily querying the database, each differing from a typical mixed load of inserting and querying. To change the cache sizes, see “Setting buffer cache sizes”. Remember that the cache size options do not take effect until you stop and restart the database.

Setting buffer cache sizes

By default, Adaptive Server IQ sets the size of the main and temporary buffer caches to 8MB and 4MB respectively. Most applications will require much higher values (limited by the total amount of physical memory).

Several options and server switches can affect buffer cache sizes:

Table 12-2: Methods of adjusting buffer cache sizes

Method	When to use it	How long the setting is effective	For more information, see
MAIN_CACHE_MEMORY_MB and TEMP_CACHE_MEMORY_MB database options	Normal way to set buffer cache sizes. Database must be open to set these values.	From the next time the database is restarted, until you reset these options, or temporarily override them with server switches	“Setting buffer cache size database options” on page 428

Method	When to use it	How long the setting is effective	For more information, see
-iqmc and -iqtc server switches	Reset cache sizes when the database is not running. Especially useful if cache sizes are larger than your system can accommodate.	From the time the server is started until it is stopped	"Setting buffer cache size server switches" on page 429
-iqsmem and -iqwmem server switches	Use on some UNIX platforms to provide additional memory for use as buffer caches.	From the time the server is started until it is stopped	"Platform-specific memory options" on page 434
LOAD_MEMORY_MB database option	Indirectly affects buffer cache size, by controlling the memory that can be used for loads. On some platforms, allowing unlimited memory for loads means less memory is available for buffer caches.	Immediately until you reset the option	"Memory for loads, synchronizations, and deletions" on page 421

Setting buffer cache size database options

To set buffer cache sizes permanently (that is, until you explicitly reset them) use the SET OPTION statement. Follow the procedure below.

❖ **To change the buffer cache sizes permanently:**

1. If the database whose cache sizes you are changing is not already started, start it now:

   ```
   START DATABASE dbfile [AS dbname] [ON engine_name]
   ```

2. Set one or both cache sizes.

   - To set the buffer cache size for the IQ Store (the main buffer cache) use the following syntax:

     ```
     SET OPTION "PUBLIC".MAIN_CACHE_MEMORY_MB =
     #_of_MB
     ```

   - To set the buffer cache size for the Temporary Store (the temp buffer cache) use the following syntax:

     ```
     SET OPTION "PUBLIC".TEMP_CACHE_MEMORY_MB =
     #_of_MB
     ```

3 Make sure all users are disconnected from the database, and stop the database.

- If the -ga command-line switch is set, the database shuts down automatically after the last user disconnects.
- If -ga is not set, stop the database, by using the stop_asiq utility on UNIX, or by clicking Shutdown on the database server display on Windows NT.

4 Restart the database. The new cache sizes are now in effect.

Note It is important to have an appropriate PUBLIC setting of the cache size options. Otherwise, when the database server is restarted they will revert to the default settings, which are far too low for most applications.

Setting buffer cache size server switches

Normally you change the buffer cache sizes by setting the MAIN_CACHE_MEMORY_MB and TEMP_CACHE_MEMORY_MB database options. However, if you set these parameters to a value that is higher than your system will accommodate, you will not be able to open the database. If this occurs, use the server startup options -iqmc and -iqtc to change the current buffer cache sizes. These parameters only remain in effect while the server is running, so you still need to set the buffer cache size database options.

Specifying page size

When you create a database, you set its page size. This parameter, in conjunction with the size of the buffer cache, determines memory use and disk I/O throughput for that database.

Setting the page size

Adaptive Server IQ swaps data in and out of memory in units of **pages**. When you create a database, you specify a separate page size for the Catalog Store and the IQ Store. The Temporary Store has the same page size as the IQ Store.

For IQ page size recommendations for the best performance, see “Choosing an IQ page size” on page 111.

Because the Catalog Store accounts for only a tiny fraction of I/O, the page size for the Catalog Store has no real impact on performance. The default value of 4096 bytes should be adequate.

The IQ page size determines two other performance factors, the default I/O transfer block size, and the maximum data compression for your database. These factors are discussed in the sections that follow.

Block size

All I/O occurs in units of **blocks**. The size of these blocks is set when you create an IQ database; you cannot change it without recreating the database. By default, the IQ page size determines the I/O transfer block size. For example, the default IQ page size of 64KB results in a default block size of 4096 bytes. In general, IQ uses this ratio of default block size to page size, but it considers other factors also.

The default block size should result in an optimal balance of I/O transfer rate and disk space usage for most systems. It does favor saving space over performance, however. If the default block size does not work well for you, you can set it to any power of two between 4096 and 32,768, subject to the constraints that there can be no fewer than two and no more than 16 blocks in a page. You may want to set the block size explicitly in certain cases:

- For a raw disk installation that uses a disk array, larger blocks may give better performance at the expense of disk space.
- For a file system installation, to optimize performance over disk space, the IQ block size should be greater than or equal to the operating system's native block size, if there is one. You may get better I/O rates if your IQ block size matches your file system’s block size.

Table 12-3 shows the default block size for each IQ page size.

Table 12-3: Default block sizes

Page Size (KB)	*Block Size (bytes)*
64	4096
128	8192
256	16384
512	32768

Data compression

Adaptive Server IQ compresses all data when storing it on disk. Data compression both reduces disk space requirements and contributes to performance. The amount of compression is determined automatically, based on the IQ page size.

Saving memory

If your machine does not have enough memory, to save memory you can try the following adjustments.

Decrease buffer cache settings

You may be able to save memory by decreasing buffer cache sizes. Keep in mind that if you decrease the buffer caches too much, you could make your data loads or queries inefficient or incomplete due to insufficient buffers.

Decrease memory used for loads

You can set the LOAD_MEMORY_MB option to limit the amount of heap memory used for loads and other similar operations. See “Memory for loads, synchronizations, and deletions” on page 421.

Adjust blocking factor for loads

Use BLOCK FACTOR to reduce I/O when loading from a flat file. The BLOCK FACTOR option of the LOAD command specifies the blocking factor, or number of records per block, that were used when the input file was created. The default BLOCK FACTOR is 10,000.

The syntax for this load option is as follows:

BLOCK FACTOR = *integer*

Use the following guideline to determine BLOCK FACTOR:

```
record size * BLOCK FACTOR = memory required
```

You need extra memory for this option, in addition to the memory for the buffers. If you have a lot of memory available, or if no other users are active concurrently, increasing the value of BLOCK FACTOR can improve load performance.

Optimizing for large numbers of users

Adaptive Server IQ, running on Tru64-UNIX, Solaris/32, and Solaris/64, handles up to 500 user connections. In order to support this greater number of users you must adjust both operating system parameters and start_asiq server parameters.

IQ command line option changes:

-gm *#_connections_to_support*

-iqgovern *#_ ACTIVE_ queries_to_support*

-gn *#_Catalog_Store_front_end_threads*

-c

-gm

This is the total number of connections the server will support. Statistically, some of these are expected to be connected and idle while others are connected and actively using the database.

-iqgovern

Although 500 users can be connected to IQ, for best throughput it is recommended that far fewer users are allowed to query at once in order to allow each of them sufficient resources to be productive. The -iqgovern value places a ceiling on the maximum number of queries to execute at once. If more users than the -iqgovern limit have submitted queries, new queries will be queued until one of the active queries is finished.

The optimal value for -iqgovern depends on the nature of your queries, number of CPUs, and size of the IQ buffer cache. The default value is 2**numcpus* + 10.

-gn

The correct value for -gn depends on the value of -gm. Setting -gn too low can result in a hung server. Setting -gn above 480 is not recommended. For this reason, for 500 users an -iqgovern value of 40 is required.

-c

The Catalog Store buffer cache is also the general memory pool for the Catalog Store (the front end of Adaptive Server IQ). Sybase recommends a 64MB minimum for 500 users.

Use of the -iqmt option is not required. If -iqmt is set too low for the number of specified connections, the number of threads will be increased to handle the number of requested connections. That is, -gm overrides -iqmt. However, if the number of IQ threads is elevated by means of the -iqmt option then that factor needs to be used in setting limits, as described in "Setting Operating System Parameters" below.

IQ Temp space

You may need to increase your temp dbspace to accommodate more users.

Relative priorities of new and existing connections

If Adaptive Server IQ is very busy handling already connected users, it maybe slow to respond to new connection requests. In extreme cases (such as test scripts that fire off hundreds of connections in a loop while the server is busy with inserts) new connections may have to wait up to a minute to before becoming active or may even time out their connection request. In this situation, the server may appear to be down when it is merely very busy. A user getting this behavior should try to connect again. This issue will be addressed in a future version.

Setting operating system parameters

To run Adaptive Server IQ with many connections you need to change certain system parameters.

Solaris

Although the Solaris thread limit is not a problem, developers and Sybase field personnel should be aware that using the Solaris debugger on IQ requires a file descriptor for each thread in addition to the file descriptors for each dbspace. You need to adjust the number of file descriptors by means of the C shell limit command and "set rlim_fd_max=4096" in */etc/system.*

Tru64-UNIX / Digital UNIX

Adaptive Server IQ needs three threads to support each connection plus some overhead threads the operating system needs to have its maximum number of threads adjusted upwards. To accomplish this, you must raise the Digital UNIX default number of threads, using the formula 60*NUMCPUS +10 +3*. You can change this value either by editing Digital UNIX's */etc/sysconfigtab* directly or updating it using a Compaq GUI (see *Adaptive Server IQ Installation and Configuration Guide* or your Compaq documentation).

Within the "proc:" section of this file you must update max-threads-per-user. For example:

```
proc:
:
.
max-threads-per-user = 9000
```

Since this count is on a per user basis (not a per process basis) this number must be high enough to allow for all threads of all processes running under the Sybase user ID.

Platform-specific memory options

On all platforms, Adaptive Server IQ uses memory for four primary purposes:

- Main buffer cache
- Temporary buffer cache
- Thread stacks
- Load buffers

See *Figure 12-1: Buffer caches in relation to physical memory* earlier in this chapter for a diagram of IQ memory use.

The HP UNIX and AIX platforms limit the total amount of memory available to IQ or any other single application. You must set IQ server options on these platforms in order to gain the maximum usable memory.

The total amount of usable memory varies by platform. See the following table for details.

Table 12-4: Total available memory by platform

Platform	*Total memory available*
CompaqTru64 (Digital UNIX)	Effectively unlimited
HP UNIX	3GB[a]
IBM RS6000 AIX	2GB[a]
SGI IRIX	Effectively unlimited
Sun Solaris 32-bit	3.3GB
Sun Solaris 64-bit	Effectively unlimited
Windows NT[b]	2.5GB

[a]You must specify the -iqsmem option to get this much memory on HP UNIX and AIX.

[b]You need Windows NT Enterprise to get this much memory.

On 64-bit platforms (Tru64, SGI IRIX, and Solaris 64-bit), the only limit is the physical size of memory on the system.

For Windows NT systems, see the *Adaptive Server IQ Installation and Configuration Guide* for more performance tuning hints, including recommendations for small memory configurations.

For UNIX systems only, Adaptive Server IQ provides two command-line options that can provide more memory.

Wired memory pool

On Digital UNIX, HP and Sun platforms, you can designate a specified amount of memory as "wired" memory. This memory is locked down so that it cannot be paged. Wired memory can improve performance. To create a pool of "wired" memory on these UNIX platforms only, specify the -iqwmem command-line switch, indicating the number of MB of wired memory. The maximum value for -iqwmem varies by platform:

- 3800 on Sun
- 2000 on HP UNIX
- no real maximum for DEC

For example, to add 1GB of wired memory, you specify:

```
-iqwmem 1000
```

Warning! Use this switch only if you have enough memory to dedicate some of it for this purpose. Otherwise, you can cause serious performance degradation.

Unwired memory pool

On AIX, Tru64 (Digital UNIX), and HP UNIX systems, you can create an unwired (swappable) memory pool to increase total available memory. Unwired memory can be paged. To create the unwired memory pool, use the -iqsmem command-line switch. Specify this switch as the number of MB of unwired memory. The maximum value for -iqsmem is platform-specific. For example, to add 1GB of unwired memory you specify:

```
-iqsmem 1000
```

Note For this version, on some platforms there is no difference between wired and unwired memory:

- On Sun Solaris, -iqwmem always provides wired memory. You cannot specify -iqsmem on this platform.
- On HP, AIX, and Tru64, -iqsmem and -iqwmem provide wired memory if you start the server as root. They provide unwired memory if you are not root when you start the server. This behavior may change in a future version.

Settings in start_asiq

The start_asiq startup utility sets -iqsmem to a platform-specific value automatically. On Tru64 (Digital UNIX) systems, start_asiq does not set -iqsmem automatically, but the range of permissible values is up to 28,000MB. See the *Adaptive Server IQ Installation and Configuration Guide* for your platform for the range of permissible values.

Impact of other applications and databases

Remember, the memory used for buffer caches comes out of a pool of memory used by all applications and databases. If you try to run multiple servers or multiple databases on the same machine at the same time, or if you have other applications running that use shared memory, you may need to make your buffer caches smaller.

You may also be unable to get all of memory you request in -iqsmem. The server log reports how much memory you actually get:

```
Created 1073741824 byte segement id 51205 Attached at
80000000

Created 184549376 byte segement id 6151 Attached at
C3576000
```

You can also issue the UNIX command `ipcs -mb` to see the actual number of segments.

Managing large buffer caches on HP

On HP UNIX, start_asiq sets -iqsmem to 500 by default. This setting allows a total buffer cache size (i.e., main and temp caches combined) of 2GB.

If you need more than 2GB for buffer caches, and your system can accommodate a larger value, you must add unwired memory, by specifying -iqsmem. The value you specify on the command line overrides the start_asiq setting.

To get this much memory for buffer caches	Set -iqsmem to this value
Up to 2000MB	provided by default by start_asiq
2200MB	600
2400MB	800
2600	1000
2800	1200
3000	1400

For example, the following settings are needed to allow buffer caches of 1600MB main and 800MB temp on HP UNIX:

```
SET OPTION "PUBLIC".MAIN_CACHE_MEMORY_MB = 1600
SET OPTION "PUBLIC".TEMP_CACHE_MEMORY_MB = 800
```

You must then restart the server with the following command:

```
start_asiq my_iqserver -iqsmem 800 my_iqdb
```

Controlling file system buffering

On Solaris UFS file systems and Windows NT file systems only, you can control whether file system buffering is turned on or off. Turning off file system buffering saves a data copy from the file system buffer cache to the main IQ buffer cache. Usually, doing so reduces paging, and therefore improves performance. However, you need to be aware of certain exceptions:

- If the IQ page size for the database is less than the file system's block size (typically only in the case in testing situations) turning off file system buffering may *decrease* performance, especially during multiuser operation.
- During loads, file system buffering may be helpful.

- On Solaris systems with more than 4GB of memory, the file system buffer cache competes with IQ's buffer cache less, so you *may decrease* performance by turning off file system buffering.
- On NT systems, under certain loads and configurations, disabling the file system buffer cache can likely improve performance.

As of Version 12.4.2, file system buffering is turned off by default for newly created IQ databases.

To disable file system buffering for existing databases, issue the following statement:

```
SET OPTION "PUBLIC".OS_FILE_CACHE_BUFFERING = OFF
```

You can only set this option for the PUBLIC group. You must shut down the database and restart it for the change to take effect.

Note Solaris does not have a kernel parameter to constrain the size of its file system buffer cache. Over time, the file system buffer cache grows and displaces the IQ buffer cache pages, leading to excess operating system paging activity and reduced IQ performance.

NT can bias the paging algorithms to favor applications at the expense of the file system. This bias is recommended for IQ performance. See Chapter 5, “Performance and Tuning Tasks” in the *Adaptive Server IQ Installation and Configuration Guide for Windows NT* for details.

Other ways to get more memory

In certain environments, you may be able to adjust other options to make more memory available to Adaptive Server IQ.

Options for Java-enabled databases

The JAVA_HEAP_SIZE option of the SET OPTION command sets the maximum size (in bytes) of that part of the memory that is allocated to Java applications on a per connection basis. Per connection memory allocations typically consist of the user's working set of allocated Java variables and Java application stack space. While a Java application is executing on a connection, the per connection allocations come out of the fixed cache of the database server, so it is important that a run-away Java application is prevented from using up too much memory.

The JAVA_NAMESPACE_SIZE option of the SET OPTION command sets the maximum size (in bytes) of that part of the memory that is allocated to Java applications on a per database basis. Per database memory allocations include Java class definitions. As class definitions are effectively read-only, they are shared among connections. Consequently, their allocations come right out of the fixed cache, and this option sets a limit on the size of these allocations.

The process threading model

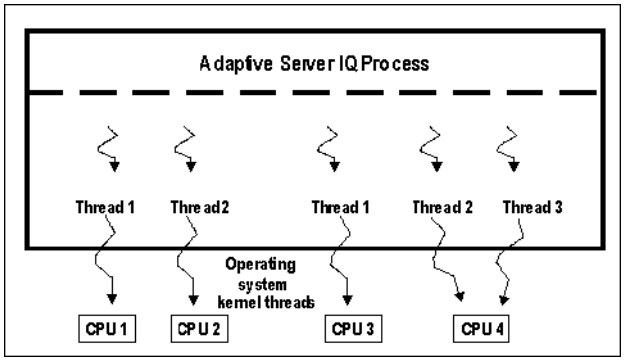
Adaptive Server IQ uses operating system kernel threads to improve performance. Threads can be found at the user level and at the kernel level. Lightweight processes are underlying threads of control that are supported by the kernel. The operating system decides which lightweight processes (LWPs) should run on which processor and when. It has no knowledge about what the user threads are or how many are active in each process.

The operating system kernel schedules LWPs onto CPU resources. It uses their scheduling classes and priorities. Each LWP is independently dispatched by the kernel, performs independent system calls, incurs independent page faults, and runs in parallel on a multiprocessor system.

Adaptive Server IQ Version 12 uses a simpler process threading model than previous versions. Instead of multiple processes for each CPU shuttling among users, there is now a single, highly threaded process that serves all Adaptive Server IQ users. Adaptive Server IQ assigns varying numbers of kernel threads to each user connection, based on the type of processing being done by that process, the total number of threads available, and the setting of various options.

The following figure shows kernel threads for various users as they are distributed across multiple CPUs.

Figure 12-2: Multithreaded architecture



Multiple threads improve performance. Even a single-CPU machine gets better performance by using threads.

Insufficient threads error

When you do not have enough server threads to initiate the query you have issued, you get the error:

```
Not enough server threads available for this query
```

This condition may well be temporary. When some other query finishes, threads are made available and the query may succeed the next time you issue it. If the condition persists, you may need to restart the server and specify more IQ threads, as described in the next section.

IQ options for managing thread usage

Adaptive Server IQ offers the following options to help you manage thread usage.

- To set the maximum number of threads available for Adaptive Server IQ use, set the server startup option -iqmt. This option is set automatically by the start_asiq startup utility on the IBM UNIX platform only. The default value is calculated from the number of connections and the number of CPUs and is usually adequate. See the *Adaptive Server IQ Installation and Configuration Guide* for the default value of -iqmt on your platform.

- To set the maximum number of threads a single user will use, issue the command SET OPTION MAX_IQ_THREADS_PER_CONNECTION. This can be used to control the amount of memory a particular operation consumes. For example, the DBA can set this option before issuing an INSERT or LOAD command.

Balancing I/O

This section explains the importance of balancing I/O on your system. It explains how to use disk striping and how to locate files on separate disks to gain better performance.

Raw I/O (on UNIX operating systems)

Most UNIX files systems divide disks into fixed size partitions. *Partitions* are physical subsets of the disk that are accessed separately by the operating system. Disk partitions are typically accessed in two modes: cooked mode (through the UFS file system) or raw mode. Raw mode (sometimes called character mode) does unbuffered I/O, generally making a data transfer to or from the device with every read or write system call. The UFS (cooked) mode is a UNIX file system and a buffered I/O system which collects data in a buffer until it can transfer an entire buffer at a time.

When you create a database or a dbspace, you can place it on either a raw device or a file system file. Adaptive Server IQ determines automatically from the pathname you specify whether it is a raw partition or a file system file. Raw partitions can be up to 128GB.

For more information, see “Working with databases”.

Using disk striping

Traditional file management systems allow you to locate individual files on specific disks. Consequently, all file operations occur against a single disk drive. Some operating systems allow you to create logical devices or volumes that span multiple disk drives. Once a file fills the first disk drive, it is automatically continued onto the next drive in the logical volume. This feature increases the maximum file size and concentrates activity on a single disk until it is full.

However, there is another way. *Disk striping* is a generic method of spreading data from a single file across multiple disk drives. This method allows successive disk blocks to be located on striped disk drives. Striping combines one or more physical disks (or disk partitions) into a single logical disk. Striped disks split I/O transfers across the component physical devices, performing them in parallel. They achieve significant performance gains over single disks.

Disk striping lets you locate blocks on different disks. The first block is located on the first drive. The second block is located on the second drive, and so on. When all the drives have been used, the process cycles back and uses additional blocks on the drives. The net effect of disk striping is the random distribution of data across multiple disk drives. Random operations against files stored on striped disks tend to keep all of the drives in the striped set equally busy, thereby maximizing the total number of disk operations per second. This is a very effective technique in a database environment.

You can use disk striping either as provided by your operating system and hardware, or IQ's internal disk striping.

Setting up disk striping on UNIX

UNIX systems offering striped disks provide utilities for configuring physical disks into striped devices. See your UNIX system documentation for details.

Setting up disk striping on Windows NT

On Windows NT systems, use hardware disk striping via an appropriate SCSI-2 disk controller. If your machine does not support hardware disk striping, but you have multiple disks available for your databases, you can use Windows NT striping to spread disk I/O across multiple disks. Set up Windows NT striping using the NT Disk Administrator.

Recommendations for disk striping

Here are some general rules on disk striping:

- For maximum performance, the individual disks in a striped file system should be spread out across several disk controllers. But be careful not to saturate a disk controller with too many disks. Typically, most SCSI machines can handle 2–3 disks per controller. See your hardware documentation for more information.
- Do not put disks on the same controller as slower devices, such as tape drives or CD-ROMs. This slows down the disk controller.
- Allocate 4 disks per server CPU in the strip.
- The individual disks must be identical devices. This means they must be the same size, have the same format, and often be the same brand. If the layouts are different, then the size of the smallest one is often used and other disk space is wasted. Also, the speed of the slowest disk is often used.
- In general, disks used for file striping should not be used for any other purpose. For example, do not use a file striped disk as a swap partition.
- Never use the disk containing the root file system as part of a striped device.

In general, you should use disk striping whenever possible.

Note For the best results when loading data, dump the data to a flat file located on a striped disk and then read the data into Adaptive Server IQ with the LOAD TABLE command.

Internal striping

Adaptive Server IQ stores its information in a series of dbspaces—files or raw partitions of a device—in blocks. Assuming that disk striping is in use, Adaptive Server IQ spreads data across data across all dbspaces that have space available. This approach lets you take advantage of multiple disk spindles at once, and provides the speed of parallel disk writes.

Disk striping option

This section explains how you can use the option Adaptive Server IQ provides to do disk striping, without using third party software. If you already have a disk striping solution through third party software and hardware, you should use it instead.

Turning disk striping on or off

The syntax you use to turn disk striping on or off is:

SET OPTION "PUBLIC".DISK_STRIPING = { ON | OFF }

The default is ON for UNIX systems, and OFF for Windows NT systems. When disk striping is ON, incoming data is spread across all dbspaces with space available. When disk striping is OFF, dbspaces (disk segments) are filled up from the front on the logical file, filling one disk segment at a time.

As with all PUBLIC options, you must disconnect and then reconnect in order for the change to take effect.

When disk striping is on, you cannot drop dbspaces with the DROP DBSPACE command. Since dbspaces are dropped as they are empty from last to first, and with this strategy dbspaces are filled partially in a more distributed manner, it is unlikely the dbspaces will be empty. If you want to be able to drop dbspaces, you should set DISK_STRIPING to OFF.

Disk striping hints

Here are several different ways to think about distributing space on a large disk drive, for example 9GB:

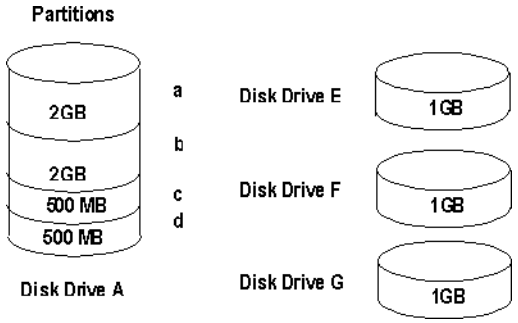
1 Use different segments in different databases.

2 Mix them into the usage list with segments from different disk drives in between.

3 For the best multiuser performance, set your operating system or disk array to the maximum stripe size it supports.

Here is a good example:

Figure 12-3: Internal disk striping



The example above shows disk drive A has two 2GB partitions (a and b) and two 500MB (or .5GB) partitions (c and d). There are three other 1GB disk drives (E, F, and G). You should create your database on partition a, then add dbspaces for E, c, F, b, G and d.

Using multiple dbspaces

Using multiple dbspaces allows your IQ and temporary data to be broken down into multiple operating system files or partitions. These files can then be spread across multiple disks.

Like disk striping, randomness can be created by placing successive database files across multiple drives. You can create additional segments for your IQ and temporary data with the CREATE DBSPACE command.

When to create dbspaces

When possible, allocate all dbspaces when you create a database.

If you add dbspaces later, IQ stripes new data across both old and new dbspaces. Striping may even out, or it may remain unbalanced, depending on the type of updates you have. The number of pages that are “turned over” due to versioning has a major impact on whether striping is rebalanced.

The transaction log file

The transaction log file contains information that allows Adaptive Server IQ to recover from a system failure. Adaptive Server IQ does not use the transaction log to restore an IQ database, to recover committed IQ transactions, or to restore the Catalog Store for an IQ database. All databases require a transaction log.

To move or rename the transaction log file, use the Transaction Log utility (DBLOG). For syntax and details, see “The DBLOG command-line utility” on page 405.

Warning! The Adaptive Server IQ transaction log file is different than most relational database transaction log files. If for some reason you lose your database files, then you lose your database (unless it's the log file that is lost). However, if you have an appropriate backup, then you can reload the database.

The message log

A message log file exists for each database. The default name of this file is *dbname.iqmsg*, although you can specify a different name when you create the database. The message log file is actually created when the first user connects to a database.

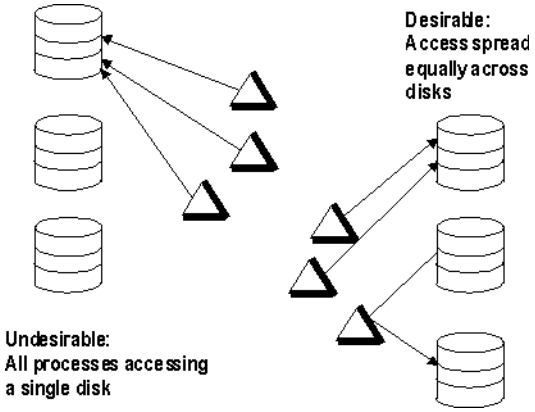
By default, Adaptive Server IQ logs all messages in the message log file, including error, status, and insert notification messages. You can turn off notification messages in the LOAD and INSERT statements.

Strategic file locations

Performance related to randomly accessed files can be improved by increasing the number of disk drives devoted to those files, and therefore, the number of operations per second performed against those files. Random files include those for the IQ Store, the Temporary Store, the Catalog Store, programs (including the IQ executables, user and stored procedures, and applications), and operating system files.

Conversely, performance related to sequentially accessed files can be improved by locating these files on dedicated disk drives, thereby eliminating contention from other processes. Sequential files include the transaction log and message log files.

Figure 12-4: Avoid I/O contention



The figure above illustrates how you want to spread access across separate disks to avoid I/O contention.

To avoid disk bottlenecks, follow these suggestions:

- Keep random disk I/O away from sequential disk I/O.
- Isolate IQ database I/O from I/O for proxy tables in other databases, such as Adaptive Server Enterprise.
- Place the transaction log and message log on separate disks from the IQ Store, Catalog Store, and Temporary Store, and from any proxy databases such Adaptive Server Enterprise.

Working space for inserting, deleting, and synchronizing

When you insert or delete data, and when you synchronize join indexes, Adaptive Server IQ needs some working space in the IQ Store. This space is reclaimed for other purposes when the transaction that needs it commits.

Ordinarily, as long as you maintain a reasonable percentage of free space in your IQ Store, you will have enough free space. However, for certain deletions, depending on the size of the data and its distribution among database pages, you may need a large amount of working space. In the case where you are deleting a major portion of your database, and the data is distributed sparsely across many pages, you could temporarily double the size of your database.

Note In other databases, including Adaptive Server IQ Version 11.x, this working space is in a pre-image file. If you are migrating from Version 11.x, you need working space in your IQ Store comparable to the space in your Version 11.x transaction image (TI) file.

Options for tuning resource use

The number of concurrent users of an IQ database, the queries they run, and the processing threads and memory available to them, can have a dramatic impact on performance, memory use, and disk I/O. Adaptive Server IQ provides several options for adjusting resource use to accommodate varying numbers of users and types of queries. Most of these are SET OPTION command options that affect only the current database. A few are command-line options that affect an entire database server.

For more information on all of these options, including parameters, when the options take effect, and whether you can set them for both a single connection and the PUBLIC group, see the *Adaptive Server IQ Reference Manual*.

Restricting concurrent queries

The -iqgovern command-line option takes the opposite approach from the OPTIMIZE_FOR_THIS_MANY_USERS option. Instead of letting the number of users determine resource use, the -iqgovern switch lets you control the number of concurrent queries on a server. This is not the same as the number of connections, which is controlled by your license.

The -iqgovern switch optimizes paging of buffer data out to disk, so that memory is used most effectively. The default value of -iqgovern is (2 x the number of CPUs) +10.

Limiting a query's memory use

The QUERY_TEMP_SPACE_LIMIT option of the SET command lets you restrict the amount of memory available to any one query. By default, a query can use 1000MB of memory.

When you issue a query, Adaptive Server IQ estimates the temporary space needed to resolve the query. If the total estimated temporary result space for sorts, hashes, and row stores exceeds the current QUERY_TEMP_SPACE_LIMIT setting, the query is rejected, and you receive a message such as:

```
Query rejected because it exceeds total space resource
limit
```

If this option is set to 0 there is no limit, and no queries are rejected based on their temporary space requirements.

Limiting queries by rows returned

The QUERY_ROWS_RETURNED_LIMIT option of the SET command tells the query optimizer to reject queries that might otherwise consume too many resources. If the query optimizer estimates that the result set from a query will exceed the value of this option, it rejects the query with the message:

```
Query rejected because it exceed resource:
Query_Rows_Returned_Limit
```

If you use this option, set it so that it only rejects queries that consume vast resources.

Forcing cursors to be non-scrolling

When you use scrolling cursors with no host variable declared, Adaptive Server IQ creates a temporary store node where query results are buffered. This storage is separate from the Temporary Store buffer cache. If you are retrieving very large numbers (millions) of rows, this store node can require a lot of memory.

You can eliminate this temporary store node by forcing all cursors to be non-scrolling. To do so, set the FORCE_NO_SCROLL_CURSORS option to ON. You may want to use this option to save on temporary storage requirements if you are retrieving very large numbers (millions) of rows. The option takes effect immediately for all new queries submitted.

If scrolling cursors are never used in your application, you should make this a permanent PUBLIC option. It will use less memory and make a big improvement in query performance.

Limiting the number of cursors

The MAX_CURSOR_COUNT option specifies a resource governor to limit the maximum number of cursors that a connection can use at once. The default is 50. Setting this option to 0 allows an unlimited number of cursors.

Limiting the number of statements

The MAX_STATEMENT_COUNT option specifies a resource governor to limit the maximum number of prepared statements that a connection can use at once.

Lowering a connection's priority

When you set the BACKGROUND_PRIORITY option to ON, requests on the current connection have minimal impact on the performance of other connections. This option allows tasks for which responsiveness is critical to coexist with other tasks for which performance is not as important.

Prefetching cache pages

The SET option PREFETCH_BUFFER_LIMIT defines the number of cache pages available to Adaptive Server IQ for use in prefetching (the read ahead of database pages). This option has a default value of 20, which can degrade multi-user performance. Sybase recommends that you set this option to 0 for multi-user applications. For more information, see the *Adaptive Server IQ Reference Manual*.

Optimizing for typical usage

Adaptive Server IQ tracks the number of open cursors and allocates memory accordingly. In certain circumstances, USER_RESOURCE_RESERVATION option can be set to adjust the minimum number of current cursors that IQ thinks is currently using the product and hence allocate memory from the temporary cache more sparingly.

This option should only be set after careful analysis shows it is actually required. Contact Sybase Technical Support with details if you need to set this option.

Other ways to improve resource use

This section describes several ways to adjust your system for maximum performance or better use of disk space.

Restricting database access

For better query performance, set the database to read-only, if possible, or schedule significant updates for low usage hours. Adaptive Server IQ allows multiple query users to read from a table while you are inserting or deleting from that table. However, performance can degrade during concurrent updates.

Disk caching

Disk cache is memory used by the operating system to store copies of disk blocks temporarily. All file-system based disk reads and writes usually pass through a disk cache. From an application's standpoint, all reads and writes involving disk caches are equivalent to actual disk operations.

Operating systems use two different methods to allocate memory to disk cache: fixed and dynamic. A preset amount of memory is used in a fixed allocation; usually a 10–15 percent memory allocation is set aside. The operating system usually manages this workspace using a LRU (least recently used) algorithm. For a dynamic allocation, the operating system determines the disk cache allocation as it is running. The goal is to keep as much memory in active use as possible, balancing the demand for real memory against the need for data from disk.

Using RAM disk

When RAM disk is implemented, the operating system views a portion of memory as a disk drive. Disk operations involving RAM disk are very fast. When files are placed on RAM disk, the performance of processes using those files can improve dramatically. Primary candidates for RAM disks are programs and temporary files.

Warning! This is not recommended for database files or transaction log files. Database integrity may be compromised if these files are placed on RAM disk.

Indexing tips

The following sections give some tips for selecting and managing indexes. See Chapter 4, “Adaptive Server IQ Indexes” for more information on these topics.

Picking the right index type

It is important to pick the correct index type for your column data. Adaptive Server IQ provides some indexes automatically—a default index on all columns that optimizes projections, and an HG index for UNIQUE and single-column PRIMARY KEY columns. While these indexes are useful for some purposes, you need other indexes to process certain queries as quickly as possible. Adaptive Server IQ chooses the best index type for you when there are multiple index types for a column.

You should create either an LF or HG index in addition to the default index on each column referenced by the WHERE clause in a join query. Adaptive Server IQ cannot guarantee that its query optimizer will produce the best execution plan if some columns referenced in the WHERE clause lack either an LF or HG index. Non-aggregated columns referenced in the HAVING clause must also have the LF or HG index in addition to the default index. For example:

```
SELECT c.name, SUM(l.price * (1 - l.discount))
FROM customer c, orders o, lineitem l
WHERE c.custkey = o.custkey
    AND o.orderkey = l.orderkey
    AND o.orderdate >= "1994-01-01"
    AND o.orderdate < "1995-01-01"
GROUP by c.name
HAVING c.name NOT LIKE "I%"
    AND SUM(l.price * (1 - l.discount)) > 0.50
ORDER BY 2 desc
```

In addition to the default index, all columns in this example beside l.price and l.discount should have an LF or HG index.

Using join indexes

Users frequently need to see the data from more than one table at once. This data can be joined at query time, or in advance by creating a join index. You can usually improve query performance by creating a join index for columns that must be joined in a consistent way.

Because join indexes require substantial time and space to load, you should create them only for joins needed on a regular basis. Adaptive Server IQ join indexes support one-to-many and one-to-one join relationships.

Allowing enough disk space for deletions

When you delete data rows, Adaptive Server IQ creates a version page for each database page that contains any of the data being deleted. The versions are retained until the delete transaction commits. For this reason, you may need to add disk space when you delete data. See “Overlapping versions and deletions” for details.

Managing database size and structure

This section offers ideas on improving your database design and managing your data.

Managing the size of your database

The size of your database depends largely on the indexes you create, and the quantity of data you maintain. You achieve faster query processing by creating all of the indexes you need for the types of queries your users issue. However, if you find that some tables or indexes are not needed, you can drop them. By doing so, you free up disk space, increase the speed of backups, and reduce the amount of archive storage you need for backups.

To control the quantity of data stored in a given table, consider how best to eliminate data rows you no longer need. If your IQ database contains data that originated in an Adaptive Server Anywhere database, you may be able to eradicate unneeded data by simply replaying Anywhere deletions; command syntax is compatible. You can do the same with data from an Adaptive Server Enterprise database, because Adaptive Server IQ provides Transact-SQL compatibility.

Denormalizing for performance

Once you have created your database in normalized form, you may perform benchmarks and decide to intentionally back away from normalization to improve performance. Denormalizing:

- Can be done with tables or columns
- Assumes prior normalization
- Requires a knowledge of how the data is being used

Good reasons to denormalize are:

- All queries require access to the “full” set of joined data
- Computational complexity of derived columns require storage for selects

Denormalization has risks

Denormalization can be successfully performed only with thorough knowledge of the application and should be performed only if performance issues indicate that it is needed. One of the things to consider when you denormalize is the amount of effort it will then take to keep your data up-to-date with changes.

This is a good example of the differences between decision support applications, which frequently need summaries of large amounts of data, and transaction processing needs, which perform discrete data modifications. Denormalization usually favors some processing, at a cost to others.

Whatever form of denormalization you choose, it has the potential for data integrity problems which must be carefully documented and addressed in application design.

Disadvantages of denormalization

Denormalization has these disadvantages:

- Denormalization usually speeds retrieval but can slow updates. This is not a real concern in a DSS environment.
- Denormalization is always application-specific and needs to be re-evaluated if the application changes.
- Denormalization can increase the size of tables, which is not a problem in Adaptive Server IQ.
- In some instances, denormalization simplifies coding; in others, it makes it more complex.

Performance benefits of denormalization

Denormalization can improve performance by:

- Minimizing the need for joins
- Precomputing aggregate values, that is, computing them at data modification time, rather than at select time
- Reducing the number of tables, in some cases

Deciding to denormalize

When deciding whether to denormalize, you need to analyze the data access requirements of the applications in your environment and their actual performance characteristics. Some of the issues to examine when considering denormalization include:

- What are the critical queries, and what is the expected response time?
- What tables or columns do they use? How many rows per access?
- What is the usual sort order?
- What are concurrency expectations?
- How big are the most frequently accessed tables?
- Do any processes compute summaries?
- Should you create join indexes to gain performance?

Improving your queries

This section discusses several ways to improve queries for better performance, including:

- Tips on how to structure your queries to avoid operations that may be time consuming
- Suggestions for using the query plans Adaptive Server IQ provides
- Options you can set to modify query processing

Tips for structuring queries

Here are some hints for better query structure:

- In some cases, command statements that include subqueries can also be formulated as joins and may run faster.
- If you group on multiple columns in a GROUP BY clause, list the columns by descending order by number of unique values. This will give you the best query performance.

- Join indexes typically cause join queries to execute faster than ad hoc joins, at the expense of using more disk space. However, when a join query does not reference the largest table in a multi-table join index, an ad hoc join usually outperforms the join index.
- You can improve performance by using an additional column to store frequently calculated results.

Planning queries

If you have created the right indexes, the Adaptive Server IQ query optimizer can usually execute queries in the most efficient way—sometimes even if you have not used the most effective syntax. Proper query design is still important, however. When you plan your queries carefully, you can have a major impact on the speed and appropriateness of results.

Before it executes any query, the Adaptive Server IQ query optimizer creates a query plan. Adaptive Server IQ helps you evaluate queries by letting you examine and influence the query plan, using the options described in the sections that follow. For details of how to specify these options, see the *Adaptive Server IQ Reference Manual*.

Query evaluation options

The following options can help you evaluate the query plan. All of these options are OFF by default.

- IQ_QUERY_PLAN_ONLY When you set this option ON, the query optimizer dumps the query plan into the log transaction file rather than submitting it to the query engine.
- QUERY_INFORMATION When you set this option ON, Adaptive Server IQ produces messages about queries. These include messages about using join indexes, about the join order, and about join algorithms for the queries.
- QUERY_DETAIL When you set this option ON, Adaptive Server IQ displays additional information (as part of the QUERY_INFORMATION option) about the query when producing its query plan. When QUERY_INFORMATION is OFF (the default), this option is ignored.

- QUERY_TIMING This option controls the collection of timing statistics on subqueries and some other repetitive functions in the query engine. Normally it should be OFF because for very short correlated subqueries the cost of timing every subquery execution can be very expensive in terms of performance.

Setting query optimization options

By adjusting the following options you can influence the speed at which queries are processed.

- AGGREGATION_ALGORITHM_PREFERENCE Controls the choice of algorithms for processing an aggregate (GROUP BY, DISTINCT, SET functions). This option is designed primarily for internal use; do not use it unless you are an experienced database administrator. See the *Adaptive Server IQ Reference Manual* for details.
- AGGREGATION_CUTOFF Specifies at which precision level to use a more efficient internal storage type for SUM or AVG calculations. The default is 10. The internal storage type is slower, but avoids risking overflows.
- INDEX_PREFERENCE Sets the index to use for query processing. The Adaptive Server IQ optimizer normally chooses the best index available to process local WHERE clause predicates and other operations which can be done within an IQ index. This option is used to override the optimizer choice for testing purposes; under most circumstances it should not be changed.
- JOIN_ALGORITHM_PREFERENCE Controls the choice of algorithms when processing joins. This option is designed primarily for internal use; do not use it unless you are an experienced database administrator. See the *Adaptive Server IQ Reference Manual* for details.
- JOIN_OPTIMIZATION When this option is ON (the default), Adaptive Server IQ optimizes the join order to reduce the size of intermediate results and sorts and to balance the system load. When it is OFF, the join order is determined by the order of the tables in the FROM clause of the SELECT statement. (The left-most table becomes the outer table of the topmost join.) This option should be ON whenever queries are ad hoc and untried, when you don't know optimum join order for a multi-table join query, or when you cannot alter queries.

- JOIN_MAX_HASH_ROWS Sets the maximum estimated number of rows the query optimizer will consider for a hash algorithm. The default is 125,000 rows. For example, if there is a join between two tables, and the estimated number of rows entering the join from both tables exceeds this option value, the optimizer will not consider a hash join. On systems with more than 50MB per user of TEMP_CACHE_MEMORY_MB, you may want to consider a higher value for this option.
- MAX_CARTESIAN_RESULT Limits the number of result rows from a query containing a cartesian join (usually the result of missing one or more join conditions when creating the query). If Adaptive Server IQ cannot find a query plan for the cartesian join with an estimated result under this limit, it rejects the query and returns an error. The default is 100,000,000 rows.
- ROW_COUNTS Specifies whether the database will always count the number of rows in a query when it is opened. Default is OFF. Turning on this option guarantees an accurate count, but can slow the start of query processing.

Network performance

The following sections offer suggestions for solving some network performance issues.

Improving large data transfers

Large data transfers simultaneously decrease overall throughput and increase the average response time. Here are some suggestions to improve performance during these transfers:

- Perform large transfers during off-hour periods, if possible.
- Limit the number of concurrent queries during large transfers.
- Do not run queries and insertions concurrently during large transfers.
- Use stored procedures to reduce total traffic.
- Use row buffering to move large batches through the network.

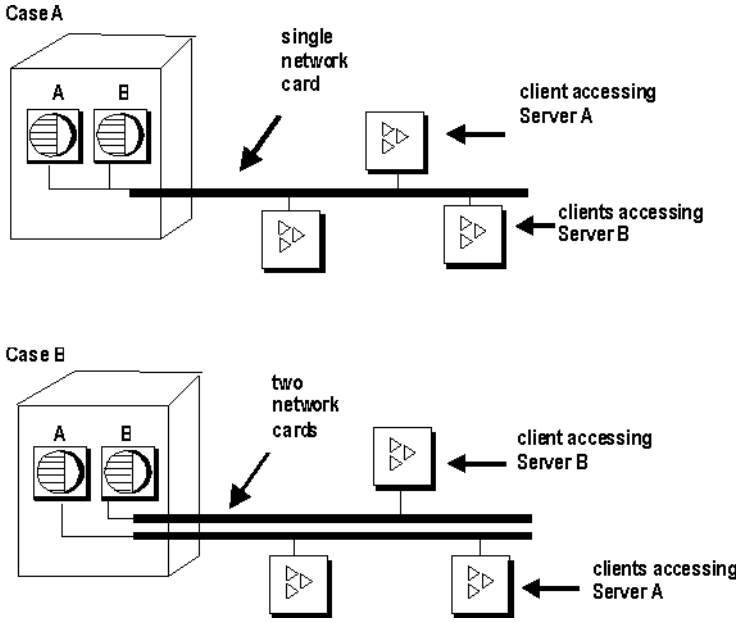
- If large transfers are common, consider installing better network hardware that is suitable for such transfers. For example:
  - Token ring–responds better during heavy utilization periods than ethernet hardware.
  - Fiber optic–provides very high bandwidth, but is usually too expensive to use throughout the entire network.
  - Separate network–can be used to handle network traffic between the highest volume workstations and the server.

Isolate heavy network users

In case A, clients accessing two different database servers use one network card. That means that clients accessing Servers A and B have to compete over the network and past the network card. In the case B, clients accessing Server A use a different network card than clients accessing Server B.

It would be even better to put your database servers on different machines. You may also want to put heavy users of different databases on different machines.

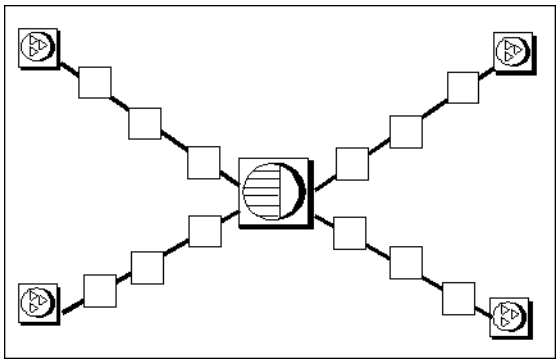
Figure 12-5: Isolating heavy network users



Put small amounts of data in small packets

If you send small amounts of data over the network, keep the default network packet size small (default is 512 bytes). The -p server startup option lets you specify a maximum packet size. Your client application may also let you set the packet size.

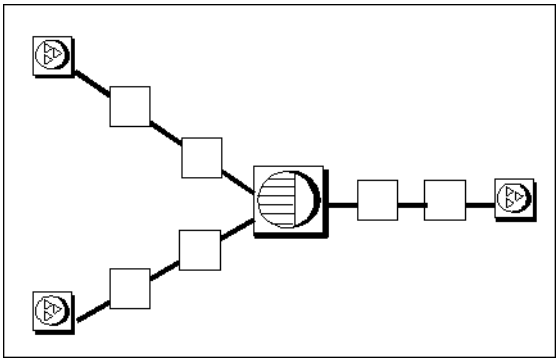
Figure 12-6: Small data transfers and small packet sizes



Put large amounts of data in large packets

If most of your applications send and receive large amounts of data, increase default network packet size. This will result in fewer (but larger) transfers.

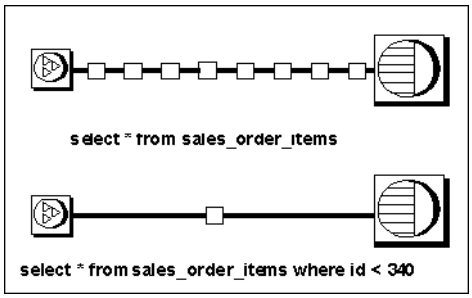
Figure 12-7: Large data transfers and larger packet sizes



Process at the server level

Filter as much data as possible at the server level.

Figure 12-8: Work at the server level



CHAPTER 13

Monitoring and Tuning Performance

About this chapter

This chapter describes tools you use to monitor Adaptive Server IQ performance. Use these tools to determine whether your system is making optimal use of available resources. To understand how Adaptive Server IQ uses memory, process threads, and disk, and to learn about options you can set to control resource use, see Chapter 12, “Managing System Resources” See also the sections on performance implications and tuning in other chapters of this guide for more tuning hints.

Viewing the Adaptive Server IQ environment

The first step in tuning Adaptive Server IQ performance is to look at your environment. You have various options:

- Use system monitoring tools (each system and site has different tools in place).
- Use one of the stored procedures that displays information about Adaptive Server IQ. See the next section for more information.
- Determine appropriateness of index types. See Chapter 4, “Adaptive Server IQ Indexes” for more information about choosing index types.
- For on-screen information, look at your insert and delete notification messages. “Interpreting notification messages” gives more information about these messages.
- Look at the IQ message file, called *dbname.iqmsg* by default.

Getting information using stored procedures

Adaptive Server IQ offers several stored procedures that display information about your database:

- sp_iqcheckdb checks the validity of your current database
- sp_iqdbstatistics reports results of the most recent sp_iqcheckdb
- sp_iqdbsize gives the size of the current database
- sp_iqstatus displays miscellaneous status information about the database. See the example below.
- sp_iqtablesize gives the size of the table you specify.
- sp_iqgroupsize lists the members of the specified group.

See *Adaptive Server IQ Reference Manual* for details of all Adaptive Server IQ stored procedures.

Example

The output from sp_iqstatus looks like the following:

```
Name                                    Value
=======================================================
==================
Adaptive Server IQ (TM) Copyright (c) 1992-2000 by Sybase, Inc. All rights
reserved.
Version:                                12.4.2/(32bit mode)/Sun_svr4/OS
5.6/EBF 0000
Time Now:                               2000-03-14 12:05:54.288
Build Time:                             Sat Mar 11, 2000  21:39:55 EST
File Format:                            23 on 03/18/1999
Catalog Format:                         2
Stored Procedure Revision:              1
Page Size:                              131072/8192blksz/16bpp
Number of DB Spaces:                    8
Number of Temp Spaces:                  2
DB Blocks: 1-12132344                   IQ_SYSTEM_MAIN
DB Blocks: 12545280-24677623            mydb_2
DB Blocks: 25090560-37222903            mydb_3
DB Blocks: 37635840-49768183            mydb_4
DB Blocks: 50181120-62313463            mydb_5
DB Blocks: 62726400-74858743            mydb_6
DB Blocks: 75271680-87404023            mydb_7
DB Blocks: 87816960-99949303            mydb_8
Temp Blocks: 1-8823288                  IQ_SYSTEM_TEMP
Temp Blocks: 9408960-18232247           mydb_tmp2
Create Time:                            1999-12-30 19:10:55.231
Update Time:                            2000-03-14 09:52:13.609
Main IQ Buffers:                        11174, 1400Mb
Temporary IQ Buffers:                   15165, 1900Mb
Main IQ Blocks Used:                   43515029 of 97058752, 44%=331Gb, Max
```

```
Block#: 95065709
Temporary IQ Blocks Used:             610 of 17646576, 0%=4Mb, Max Block#: 0
Main Reserved Blocks Available:         1280 of 1280, 100%=10Mb
Temporary Reserved Blocks Available:    1280 of 1280, 100%=10Mb
Memory:                                 Current: 3351mb, Max: 3384mb
Main IQ Buffers:                        Used: 11172, Locked: 0
Temporary IQ Buffers:                   Used: 38, Locked: 0
Main IQ I/O:                            I: L88043944/P495510 O:
C760342/D761393/P736587 D:24753 C:65.9
Temporary IQ I/O:                       I: L16515025/P1222153 O:
C2609951/D3838862/P1228941
D:2609913 C:46.3
Old Versions:                           1 = 59Gb
Active Txn Versions:                    0 = C:0Mb/D:0Mb
```

Monitoring the buffer caches

Adaptive Server IQ provides a tool to monitor the performance of the buffer caches. This monitor collects statistics on the buffer cache, memory, and I/O functions taking place within Adaptive Server IQ, and stores them in a log file.

Buffer cache performance is a key factor in overall performance of Adaptive Server IQ. Using the information the monitor provides, you can fine tune the amount of memory you allocate to the main and temp buffer caches. If one cache is performing significantly more I/O than the other, reallocate some of the memory appropriately. Reallocate in small amounts such as 10 to 50MB and on an iterative basis. After reallocating, rerun the workload and monitor the changes in performance.

Starting the buffer cache monitor

You run the Adaptive Server IQ buffer cache monitor from DBISQL. Each time you start the monitor it runs as a separate kernel thread within DBISQL. Use this syntax to start the monitor:

IQ UTILITIES { MAIN | PRIVATE }
INTO *dummy_table_name*
START MONITOR '*monitor_options* [...]'

MAIN starts monitoring of the main buffer cache, for the IQ Store of the database you are connected to.

PRIVATE starts monitoring of the temp buffer cache, for the Temporary Store of the database you are connected to. You need to issue a separate command to monitor each buffer cache.

dummy_table_name can be any IQ table. However, it's a good idea to create a table that you use only for monitoring. The table name is required for syntactic compatibility with other IQ UTILITIES commands. No matter what table name you specify, you are monitoring buffer caching for all tables in a database.

'monitor_options' can include one or more of the following values:

- -summary displays summary information for both the main and temp buffer caches. If you do not specify any monitor options, you receive a summary report. The fields displayed are as described for the other options, plus the following:
  - *Users*: Number of users connected to the buffer cache
  - *IO*: Combined physical reads and writes by the buffer cache
- -cache displays activity in detail for the main or temp buffer cache. The fields displayed are:
  - *Finds*: Find requests to the buffer cache
  - *Creats*: Requests to create a page within the database
  - *Dests*: Requests to destroy a page within the database
  - *Dirty*: Number of times the buffer was dirtied (modified)
  - *HR%*: Percentage of above satisfied by the buffer cache without requesting any I/O
  - *BWaits*: Find requests forced to wait for a busy page (page frame contention)
  - *ReReads*: Number of times the same portion of the store needed to be reread into the cache within the same transaction
  - *FMiss*: False misses, number of times the buffer cache needed multiple lookups to find a page in memory. This number should be 0 or very small. If the value is high, it is likely that a rollback occurred, and certain operations needed to be repeated
  - *Cloned*: Number of buffers that Adaptive Server IQ needed to make a new version for a writer, while it had to retain the previous version for concurrent readers

  - *Reads/Writes*: Physical reads and writes performed by the buffer cache
  - *PF/PFRead*: Prefetch requests and reads done for prefetch
  - *GDirty*: Number of times the LRU buffer was grabbed dirty and Adaptive Server IQ had to write it out before using it
  - *Pin%*: Percentage of pages in the buffer cache in use and locked
  - *Dirty%*: Percentage of buffer blocks that were modified
- -cache_by_type produces the same results as -cache, but broken down by IQ page type. (An exception is the Bwaits column, which shows a total only.) This format is most useful when you need to supply information to Sybase Technical Support.
- -file_suffix *suffix* creates a monitor output file named `<dbname>.<connid>-<main_or_temp>-<suffix>`. If you do not specify a suffix, it defaults to *iqmon*.
- -io displays main or temp (private) buffer cache I/O rates and compression ratios. The fields displayed are:
  - *Reads*: Physical reads performed by the buffer cache
  - *Lrd(KB)*: Logical kilobytes read in
  - *Prd(KB)*: Physical kilobytes read in
  - *Rratio*: Compression ratio of logical to physical data read in
  - *Writes*: Physical writes performed by the buffer cache
  - *Lwrt(KB)*: Logical kilobytes written
  - *Pwrt(KB)*: Physical kilobytes written
  - *Wratio*: Compression ratio of logical to physical data written
- -bufalloc displays information on the main or temp buffer allocator, which reserves space in the buffer cache for objects like sorts, hashes, and bitmaps.
  - *OU*: OptimizeForThisManyUsers option setting
  - *AU*: Current number of active users
  - *MaxBuf*: Number buffers under control of the buffer allocator
  - *Avail*: Number of currently available buffers for pin quota allocation

- *AvPF*: Number of currently available buffers for prefetch quota allocation
- *Slots*: Number of currently registered objects using buffer cache quota
- *PinUser*: Number of objects using pin quota
- *PFUsr*: Number of objects using prefetch quota
- *Posted*: Number of objects that are pre-planned users of quota
- *UnPost*: Number of objects that are ad hoc quota users
- *Locks*: Number of mutex locks taken on the buffer allocator
- *Waits*: Number of times a thread had to wait for the lock

- -contention displays many key buffer cache and memory manager locks
  - *AU*: Current number of active users
  - *LRULks*: Number times the LRU was locked (repeated for the temp cache)
  - *woTO*: Number times lock was granted without timeout (repeated for the temp cache)
  - *Loops*: Number times IQ retried before lock was granted (repeated for the temp cache)
  - *TOs*: Number of times IQ timed out and had to wait for the lock (repeated for the temp cache)
  - *BWaits*: Number of "Busy Waits" for a buffer in the cache (repeated for the temp cache)
  - *IOLock*: Number of times IQ locked the compressed I/O pool (repeated for the temp cache)
  - *IOWait*: Number of times IQ had to wait for the lock on the compressed I/O pool (repeated for the temp cache)
  - *HTLock*: Number of times IQ locked the blockmaps hash table (repeated for the temp cache)
  - *HTWait*: Number of times IQ had to wait for the blockmaps hash table (repeated for the temp cache)
  - *FLLock*: Number of times IQ had to lock the free list (repeated for the temp cache)

    - *FLWait*: Number of times IQ had to wait for the lock on the free list (repeated for the temp cache)
    - *MemLks*: Number of times IQ took the memory manager (heap) lock
    - *MemWts*: Number of times IQ had to wait for the memory manager lock
- -threads displays information about processing threads
    - *cpus*: Number of CPUs on system
    - *Limit*: size of thread manager pool
    - *NTeams*: Number of thread teams currently in use
    - *MaxTms*: Largest number of teams that has ever been in use
    - *NThrds*: Current number of existing threads
    - *Resrvd*: Number of threads reserved for system (connection) use
    - *Free*: Number of threads available for assignment
    - *Locks*: Number of locks taken on the thread manager
    - *Waits*: Number of times IQ had to wait for the lock on the thread manager
- -interval specifies the reporting interval in seconds. The default is every 60 seconds. The minimum is every 2 seconds. You can usually get useful results by running the monitor at the default interval during a query or time of day with performance problems.
- -append | - truncate Append to existing output file or truncate existing output file, respectively. Truncate is the default.

- -debug is used mainly to supply information to Sybase Technical Support. It displays all the information available to the performance monitor, whether or not there is a standard display mode that covers the same information. The top of the page is an array of statistics broken down by disk block type. This is followed by other buffer cache statistics, memory manager statistics, thread manager statistics, free list statistics, CPU utilization, and finally buffer allocator statistics. The buffer allocator statistics are then broken down by client type (hash, sort, and so on) and a histogram of the most recent buffer allocations is displayed.

Note The interval, with two exceptions, applies to each line of output, not to each page. The exceptions are -cache_by_type and -debug, where a new page begins for each display.

Stopping the buffer cache monitor

The command you use to stop a monitor run is similar to the one you use to start it, except that you do not need to specify any options. Use this syntax to stop the IQ buffer cache monitor:

IQ UTILITIES { MAIN | PRIVATE }
INTO *dummy_table_name* **STOP MONITOR**

Examining and saving monitor results

The monitor stores results in an ordinary text file. This file defaults to:

- *dbname.connection#-main-iqmon* for main buffer cache results
- *dbname.connection#-temp-iqmon* for temp buffer cache results

The prefix *dbname.connection#* represents your database name and connection number. If you see more than one connection number and are uncertain which is yours, you can run the Catalog stored procedure sa_conn_info. This procedure displays the connection number, user ID, and other information for each active connection to the database.

You can use the -file_suffix parameter on the IQ UTILITIES command to change the suffix *iqmon* to a suffix of your choice.

To see the results of a monitor run, use a text editor or any other method you would normally use to display or print a file.

When you run the monitor again from the same database and connection number, by default it overwrites the previous results. If you need to save the results of a monitor run, copy the file to another location before starting the monitor again from the same database or use the -append option.

Examples of monitor results

This section shows sample results using different monitor options.

Example of -summary option

The -summary option produces results like the following. Note that it shows both main and temp buffer cache statistics, no matter which you request in the IQ UTILITIES command:

```
 Options string for private cache: "-summary -interval 5"
                                    Summary
                                1998-08-18 14:07:51
 Users          Main Cache                                    Temp Cache
C/A  Finds   HR%  Reads/     GDirty  Pin%  Finds   HR% Reads/ GDirty Pin%
                  Writes                                    Writes
0/0    347 100.0     0/0          0   0.1   1219 100.0    0/0          0  8.8
0/0    163  98.8     2/0          0   0.1    357 100.0    0/0          0  0.0
0/0   4662  99.8    10/0          0   3.7   1740 100.0    0/0          0  7.8
0/0   1386  99.8     3/0          0   0.2   1716 100.0    0/0          0  0.3
0/0   1472  91.2   129/0          0   6.1   1327 100.0    0/0          0  3.2
0/0   1152  99.7     3/0          0   0.8   4137 100.0    0/0          0  2.8
0/0    262  97.7     6/0          0   1.7   1149 100.0    0/0          0  0.4
0/0   1358  98.0    27/0          0   0.1    853 100.0    0/0          0  5.4
0/0    321  80.1    64/0          0   1.9    458 100.0    0/0          0  4.3
0/0    102  82.4    18/0          0   1.9     14 100.0    0/0          0  5.8
0/0    104  82.7    18/0          0   1.9     64 100.0    0/0          0  4.7
0/0     85  81.2    16/0          0   1.3     14 100.0    0/0          0  6.2
0/0      1 100.0     0/0          0   0.1   1974 100.0    0/0          0  0.1
0/0    736  86.1   102/0          0   2.2   1070 100.0    0/0          0  6.8
0/0     79 100.0     0/0          0   0.1   4109 100.0    0/0          0  0.4
0/0    518  96.1    20/0          0   0.1   1576 100.0    0/0          0  0.0
0/0   1083  86.2   149/0          0   0.1   1578 100.0    0/0          0  0.2
0/0    704  99.3     5/0          0   0.1   1240 100.0    0/0          0  0.4
0/0    872 100.0     0/0          0   4.0   1764 100.0    0/0          0  0.8
0/0    346  87.0    45/2          2   0.1    597 100.0    0/0          0  7.8
```

Example of -cache option

The -cache option produces results like the following, which are for the temp buffer cache.

```
Options string for Temp cache: "-cache -interval 10"
                          Temp Shared Buffer Cache
                            1999-01-17 17:43:55
```

```
   Finds Creats Dests Dirty   HR% BWaits ReReads FMiss Cloned Reads/    PF/
GDirty Pin% Dirty%
                                                              Writes PFRead
Tm:   640    82    57    84  99.4      0      4     0      0    4/0    0/0
0  0.0   2.8
Tm:  1139   109    83   109 100.0      0      0     0      0    0/0    0/0
0  0.0   5.5
Tm:  6794   754   749   754 100.0      0      0     0      0    0/0    0/0
0  0.0   6.1
Tm: 10759  1646  1646  1646 100.0      0      0     0      0    0/0    0/0
0  0.0   6.1
```

Example of -io option

The -io option produces results like the following, which are for the main buffer cache:

```
Options string for main cache: "-IO -interval 5"
                          Main Buffer Cache
                         1998-08-18 13:58:48
                Input                              Output
      Reads Lrd(KB) Prd(KB)    Rratio  Writes  Lwrt(KB)  Pwrt(KB)  Wratio
Mn:      10      40      34      1.18      14        56        23    2.43
Mn:       0       0       0      0.00      21        84        34    2.43
Mn:       0       0       0      0.00       7        28        11    2.43
Mn:       0       0       0      0.00      22        88        35    2.48
Mn:       0       0       0      0.00      63       252       100    2.51
Mn:       0       0       0      0.00      54       216        93    2.32
Mn:       0       0       0      0.00      64       256       101    2.52
Mn:       0       0       0      0.00      62       248        94    2.62
Mn:       0       0       0      0.00      73       292       110    2.65
Mn:       0       0       0      0.00     105       420       121    3.47
```

Example of -bufalloc option

The -buffalloc option produces results like the following.

```
 Options string for Main cache: "-bufalloc -file_suffix bufalloc-iqmon -
append -interval 10"

                              Buffer Allocation
2000-01-24 10:58:39

OU/AU MaxBuf  Avail   AvPF  Slots PinUsr  PFUsr Posted UnPost  Quota  Locks
Waits
1/0    1592   1592     20      0      0      0      0      0      0      1      0

 1/1    1592   1592     20      0      0      0      0      0      0      1      0

 1/1    1592   1592     20      0      0      0      0      0      0      1      0
```

Example of -contention option

Note The actual -contention output shows Main Cache, Temp Cache, and Memory Manager on the same line. Because this format is very wide, each of these sets of columns is shown separately here.

The -contention results for the main cache are:

```
Options string for Main cache:
"-contention -file_suffix contention-iqmon -append -interval 10"
                    Contention
                    2000-01-24 10:57:03


AU|                 Main Cache                                          |
|LRULks   woTO  Loops    TOs BWaits IOLock IOWait HTLock HTWait FLLock FLWait

 0     66      0      0      0      0      1      0      5      0      4      0

 1   2958      0      0      0      0    160      0   1117      0      6      0

 1   1513      0      0      0      1    378      0      2      0      8      0

 1    370      0      0      0      0   94      0      2      0     10   0
1    156      0      0      0      0     46      0      2      0     12 0
1    885      0      0      0      0    248      0      2      0     14 0
1    1223      0      0      0      0    332      1      2      0     16 0

 1    346      0      0      0      0     66      0      2      0     18      0
```

The -contention results for the temp cache are:

```
                    Temp Cache
|LRULks   woTO  Loops    TOs BWaits IOLock IOWait HTLock HTWait FLLock FLWait
70      0      0      0      0      1      0      4      0      5      0
466      0      0      0      0      2      0     15      0     12      0
963      0      0      0      0      2      0      8      0     20      1
1186      0      0      0      0      2      0      2      0     23      1
357      0      0      0      0      2      0      2      0     25      1
444      0      0      0      0      2      0      3      0     29      0
884      0      0      0      0      2      0      2      0     31      1
1573      0      0      0      0      2      0      5      0     37      1
```

The results for the memory manager are:

```
| Memory Mgr
MemLks MemWts
55483     13
5705      0
2048      0
186      4
```

```
2      0
137      0
22      0
203      3
```

Example of -threads option

The results of the -threads option look like the following:

```
 Options string for Main cache: "-threads -file_suffix threads-iqmon -append
-interval 10"


                                    Threads

                                2000-01-24 10:59:24


 CPUs  Limit NTeams MaxTms NThrds  Resrvd Free  Locks Waits
 10    100      4     12    100     13     68    106    590
 10    100      6     12    100     12     63      4      6
 10    100      6     12    100     12     63      0      0
 10    100      7     12    100     12     62      1      1
 10    100      7     12    100     12     62      0      0
 10    100      7     12    100     12     58      1      5
 10    100      7     12    100     12     58      0      0
```

Avoiding buffer manager thrashing

Operating system paging affects queries that need buffers which exceed the free memory available. Some of this paging is necessary, especially as you allocate more and more physical memory to your buffer caches. However, if you overallocate the physical memory to your buffer caches, the operating system paging occurs much more frequently, and it can cause your entire system to thrash. The reverse is true as well: IQ thrashes if you do not allocate enough memory to your buffer caches.

Buffer manager thrashing occurs when the operating system chooses less optimum buffers to page out to disk, which forces the buffer manager to make extra reads from disk to bring those buffers back to memory. Since Adaptive Server IQ knows which buffers are the best candidates to flush out to disk, you want to avoid this operating system interference by reducing the overall number of page outs.

When you set buffer sizes, keep in mind the following trade-off:

- If the IQ buffer cache is too large, the operating system is forced to page as Adaptive Server IQ tries to use all of that memory.
- If the IQ buffer cache is too small, then Adaptive Server IQ thrashes because it cannot fit enough of the query data into the cache.

If you are experiencing dramatic performance problems, you should monitor paging to determine if thrashing is a problem. If so, then reset your buffer sizes as described in “Managing buffer caches”.

Monitoring paging on Windows NT systems

Windows NT provides the NT Performance Monitor to help you monitor paging. To access it, select the object Logical Disk, the instance of the disk containing the file *PAGEFILE.SYS*, and the counter Disk Transfers/Sec. This should be on a separate disk from your database files. You can also monitor the Object Memory and the counter Pages/Sec. However, this value is the sum of all memory faults which includes both soft and hard faults.

Monitoring paging on UNIX systems

UNIX provides a system command, vmstat, to help you monitor system activity such as paging. The abbreviated command syntax is:

vmstat

interval count

The *interval* is the time between rows of output, and *count* is the number times a row of output is displayed. For more information about vmstat (including its options and field descriptions), see your operating system's documentation. Here is an example:

```
> vmstat 2 3
procs    memory            page            disk     faults     cpu
r b w swap    free  re mf pi po fr de sr s0 s1 sd  in   sy  cs us sy id
```

```
0 0 0 3312376 31840 0  8  0  0  0  0  0   0  0  0 297  201 472 82  4 14
0 0 0 3312376 31484 2  3  0  0  0  0  0   0  0  0 260  169 597 80  3 17
0 0 0 3312368 31116 0  8  0  0  0  0  0   0  0  0 205 1202 396 67  4 29
```

The above output shows a steady Adaptive Server IQ querying state where the physical memory of the machine has not been overallocated. Little to no system page faulting is occurring. These next set of examples show vmstat output that indicates a problem. (The output shown omits some of the above fields to fit better on the page.)

```
procs     memory            page               faults       cpu
r b w swap    free   re   mf  pi po fr de sr  in   sy   cs us sy  id

0 0 0 217348  272784  0  148  11  3  9  0  2 251 1835  601  6  3  91
0 0 0 3487124 205572  0    5   0  0  0  0  0  86  131  133  0  1  99
0 0 0 3487124 205572  0    5   0  0  0  0  0  71  162  121  0  0 100
0 0 0 3483912 204500  0  425  36  0  0  0  0 169  642  355  2  2  96
0 0 0 3482740 203372  0   17   6  0  0  0  0 158  370  210  1  3  97
0 0 0 3482676 203300  0    4  10  0  0  0  0 160 1344  225  1  2  97
0 0 0 3343272 199964  1 2123  36  0  0  0  0 213  131  399  7  8  85
0 0 0 3343264 185096  0  194  84  0  0  0  0 283  796  732  1  6  93
0 0 0 3342988 183972  0   17  58  0  0  0  0 276 1051  746  2  4  94
0 0 0 3342860 183632  0  119 314  0  0  0  0 203 1660  529  3  4  94
0 0 0 3342748 182316  2  109 184  0  0  0  0 187  620  488  4  2  95
0 0 0 3342312 181104  2  147  96  0  0  0  0 115  256  260  9  2  89
0 0 0 3340748 179180  0  899  26  0  0  0  0 163  836  531  4  4  92
0 0 0 3328704 167224  0 2993   6  0  0  0  0  82 2195  222  4  7  89
```

The first line of the above output provides a summary of the system activity since the machine was started. The first three lines show that there is approximately 200MB of free physical memory and that the machine is idle. The fourth line corresponds to Adaptive Server IQ starting up for the first time. Beginning at the eighth line, the amount of free memory starts to reduce rapidly. This corresponds to the Adaptive Server IQ buffer caches being allocated and database pages being read in from disk (note that CPU usage has increased). At this time there is little user CPU time as no queries have begun.

```
procs     memory               page            faults      cpu
r  b w swap    free   re mf  pi   po fr de sr in    sy  cs   us sy id

 7 0 0 3247636 58920  0 1880 1664 0  0  0  0  1131  442 1668 80 18  3
18 0 0 3246568 43732  0  709 1696 0  0  0  0  1084  223 1308 90 10  1
12 0 0 3246604 37004  0  358  656 0  0  0  0   600  236  722 95  5  0
15 0 0 3246628 32156  0  356 1606 0  0  0  0  1141  226 1317 91  9  0
```

```
19 0 0 3246612 26748  0  273 1248 0  0  0  0   950  394 1180 92  7  0
```

The above output is from slightly later when the query is underway. This is evident from the user mode CPU level (*us* field). The buffer cache is not yet full as page-in faults (*pi* field or KB paged in) are still occurring and the amount of free memory is still going down.

```
procs     memory            page                    faults        cpu
r  b w swap    free  re mf pi   po  fr   de sr  in   sy   cs   us sy id

21 0 0 3246608 22100 0 201 1600   0    0 0    0 1208 1257 1413 88 12  0
18 0 0 3246608 17196 0 370 1520   0  464 0  139  988  209 1155 91  8  0
11 0 0 3251116 16664 0 483 2064 138 2408 0  760 1315  218 1488 88 12  0
30 0 0 3251112 15764 0 475 2480 310 4450 0 1432 1498  199 1717 87 13  0
```

The above output is from even later. On the third line of the output it shows that the system has reached its threshold for the amount of free memory it can maintain. At this point, page-outs (*po* field or KB paged out) occur and the level of system mode CPU (*sy* field) increases accordingly. This situation results because physical memory is overallocated: the Adaptive Server IQ buffer caches are too big for the machine. To resolve this problem, reduce the size of one or both of the buffer caches.

System utilities to monitor CPU use

Use these operating system utilities to monitor CPU usage while using Adaptive Server IQ. On UNIX systems use:

- ps command
- vmstat command (see example in the previous section)
- sar command (UNIX SystemV)

On Windows NT systems use:

- Performance Monitor
- Task Manager

CHAPTER 14

Adaptive Server IQ as a Data Server

About this chapter

Adaptive Server IQ supports client application connections through either ODBC or JDBC. This chapter describes how to use Adaptive Server IQ as a data server for client applications.

With certain limitations, Adaptive Server IQ may also appear to certain client applications as an Open Server.This chapter also briefly describes the restrictions for creating and running these applications.

For information on developing Open Client applications for use with Adaptive Server IQ, see “The Open Client Interface” in *Adaptive Server Anywhere Programming Interfaces Guide*.

You do not use the facilities described in this chapter to use the remote data access capabilities available to IQ users on Windows NT systems. For information on remote data access, see the *Adaptive Server IQ Installation and Configuration Guide for Windows NT*.

Client/server interfaces to Adaptive Server IQ

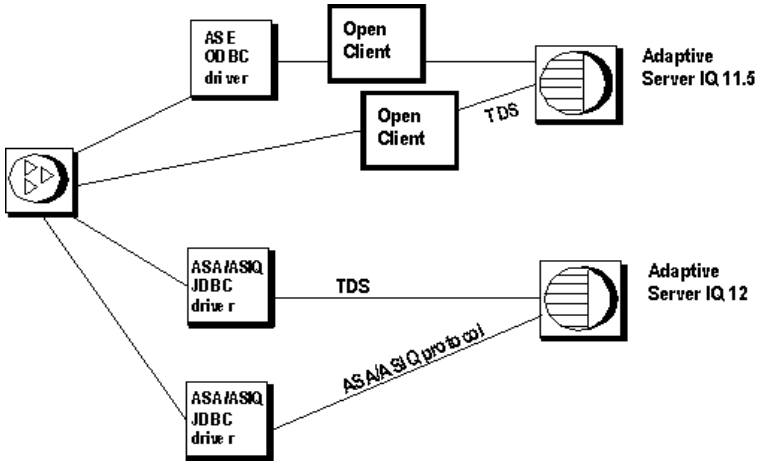
This section describes the key concepts of the Adaptive Server IQ client/server architecture, and provides the conceptual background for the rest of the chapter.

If you simply wish to use a Sybase application or a third-party client application with Adaptive Server IQ, you do not need to know any details of connectivity interfaces or network protocols. However, an understanding of how these pieces fit together may be helpful for configuring your database and setting up applications. This section explains how the pieces fit together, and avoids any discussion of the internal features of the pieces. For more details about third party client applications, see the *Adaptive Server IQ Installation and Configuration Guide*.

Open Clients and Open Servers

Members of the Adaptive Server family act as **Open Servers**. Client applications communicate with Open Servers using the **Open Client** libraries available from Sybase. Open Client includes both the Client Library (CT-Library) and the older DB-Library interfaces. Adaptive Server IQ can also act as an Open Server, but *in order to use the Open Client libraries, the client application must use only the supported system tables, views and stored procedures.* See Appendix A, "Transact-SQL Compatibility," in *Adaptive Server IQ Reference Manual* for a list of compatible syntax.

The following figure shows how client applications communicate with an Adaptive Server IQ. In Adaptive Server IQ 12, you do not need to install Open Client libraries, and you can connect through either ODBC or JDBC. This contrasts with Adaptive Server IQ 11.5 and earlier, which required separate Open Client libraries, and did not support JDBC.



Programming Interfaces and application protocols

Adaptive Server IQ supports two application protocols:

- An application protocol specific to Adaptive Server IQ and Adaptive Server Anywhere is used for ODBC, JDBC, and Embedded SQL applications.
- TDS (**tabular data stream**) is used for JDBC connections, Open Client applications and for other Sybase applications such as OmniConnect.

Tabular Data Stream

Open Clients and Open Servers exchange information using the TDS application protocol. All applications built using the Sybase Open Client libraries are also TDS applications, because the Open Client libraries handle the TDS interface. However, some applications (such as Sybase jConnect) are TDS applications even though they do not use the Sybase Open Client libraries (they communicate directly to the TDS layer).

At the other end of the client/server connection, while many Open Servers use the Sybase Open Server libraries to handle the interface to TDS, some applications have a direct interface to TDS of their own. Sybase Adaptive Server Enterprise and Adaptive Server IQ both have internal TDS interfaces. They appear to client applications as an Open Server, but do not use the Sybase Open Server libraries.

TDS uses TCP/IP

Application protocols such as TDS sit on top of lower level communications protocols that handle network traffic. Adaptive Server IQ supports TDS only over the TCP/IP network protocol. In contrast, the Adaptive Server IQ-specific application protocol supports several network protocols as well as a shared memory protocol designed for same-machine communication.

Configuring IQ Servers with DSEDIT

Adaptive Server IQ can communicate with other Adaptive Servers, Open Server applications, and client software on the network. Clients can talk to one or more servers, and servers can communicate with other servers via remote procedure calls. In order for products to interact with one another, each needs to know where the others reside on the network. This network service information is stored in the interfaces file.

The interfaces file

The interfaces file is usually named *sql.ini* on PC operating systems, and *interfaces* or *interfac* on UNIX operating systems.

The interfaces file is like an address book. It lists the name and address of every database server known to Open Client applications on your machine. When you use an Open Client program to connect to a database server, the program looks up the server name in the interfaces file and then connects to the server using the address.

The name, location, and contents of the interfaces file differ between operating systems. Also, the format of the addresses in the interfaces file differs between network protocols.

When you install Adaptive Server IQ, the setup program creates a simple interfaces file that you can use for local connections to Adaptive Server IQ over TCP/IP. It is the System Administrator's responsibility to modify the interfaces file and distribute it to users so that they can connect to Adaptive Server IQ over the network.

Using the DSEDIT utility

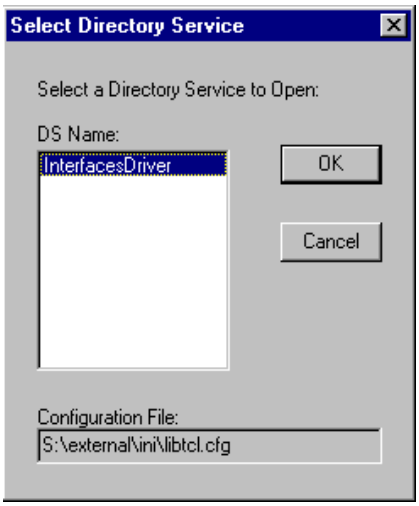
The DSEDIT utility is an Open Client utility that allows you to configure the interfaces file (*sql.ini* or *interfaces*). The following sections explain how to use the DSEDIT utility to configure the interfaces file. You must be the owner of the Sybase home directory ($SYBASE on UNIX or %SYBASE% on Windows NT) in order to run DSEDIT.

These sections describe how to use DSEDIT for those tasks required for Adaptive Server IQ. It is not complete documentation for the DSEDIT utility. For more information on DSEDIT, see the *Utility Programs* book for your platform, included with other Sybase products.

Starting DSEDIT

The *dsedit* executable is held in the *SYBASE\bin* directory, which is added to your path on installation. You can start DSEDIT either from the command line or (Windows NT only) by double-clicking *dsedit.exe* from the Windows Explorer

When you start DSEDIT, the Select Directory Service window appears.



Opening a Directory Services session

The Select Directory Service window allows you to open a session with a directory service. You can open a session to edit one of the following:

- Any directory service that has a driver listed in the *libtcl.cfg* file

- The interfaces file (*sql.ini*).

❖ **To open a session:**

- Select Interfaces Driver from the DS Name box and click OK.

Note The DSEDIT utility uses the SYBASE environment variable to locate the *libtcl.cfg* file. If the SYBASE environment variable is not set correctly, DSEDIT cannot locate the *libtcl.cfg* file.

You can add, modify, or delete entries for servers, including Adaptive Server IQ servers, in this window.

Adding a server entry

❖ **To add a server entry:**

1. Choose Add from the Server Object menu. The Input Server Name window appears.
2. Type a server name in the Server Name box, and click OK to enter the server name.

The server entry appears in the Server box. To specify the attributes of the server, you must modify the entry.

Server entry name need not match server command-line name

The server name entered here does not need to match the name provided on the Adaptive Server IQ command line. The server *address*, not the server name, is used to identify and locate the server.

It server name field is purely an identifier for Open Client. For Adaptive Server IQ, if the server has more than one database loaded, the DSEDIT server name entry identifies which database to use.

Adding or changing the server address

Once you have entered a Server Name, you need to modify the Server Address to complete the interfaces file entry.

❖ **To enter a Server Address:**

1. Select a server entry in the Server box.

2 Select the Server Address in the Attributes box.

3 Double-click on the Server Address or right click and choose Modify Attribute from the popup menu. The Network Address Attribute window appears, showing the current value of the address. If you have no address entered, the box will be empty.

4 Click Add. The Network Address for Protocol window appears. Select TCP from the Protocol list box and enter a value in the Network Address text box.

For TCP/IP, addresses take one of the following two forms:

- computer name,port number
- IP-address,portnumber

The address or computer name is separated from the port number by a comma.

Machine name

The machine on which the server is running is identified by a name or an IP address. On Windows and Windows NT you can find the machine name in Network Settings, in the Control Panel.

If your client and server are on the same machine, you must still enter the machine name. In this case, you can use

```
localhost
```

to identify the current machine.

Port Number

The port number you enter must match the port specified on the Adaptive Server IQ database server command line, as described in "Starting the database server as an Open Server". The default port number for Adaptive Server IQ servers is 2638.

The following are valid server address entries:

```
elora,2638
123.85.234.029,2638
```

Verifying the server address

You can verify your network connection by using the Ping command from the Server Object menu.

Note Verifying a network connection confirms that a server is receiving requests on the machine name and port number specified. It does not verify anything about database connections.

❖ **To ping a server:**

1 Ensure that the database server is running.

2 Click the server entry in the Server box of the *dsedit* session window.

3 Select Ping Server from the Server Object menu. The Ping window appears.

4 Click the address that you want to ping. Click Ping.

A message box appears, to notify you if the connection is successful or not. A message box for a successful connection states that both Open Connection and Close Connection succeeded.

Renaming a server entry

You can rename server entries from the *dsedit* session window.

❖ **To rename a server entry:**

1 Select a server entry in the Server box.

2 Choose Rename from the Server Object menu. The Input Server Name window appears.

3 Type a new name for the server entry in the Server Name box. Click OK to make the change.

Deleting server entries

You can delete server entries from the *dsedit* session window.

❖ **To delete a server entry:**

1 Click a server entry in the Server box.

2 Choose Delete from the Server Object menu.

Sybase applications and Adaptive Server IQ

The ability of Adaptive Server IQ to act as an Open Server enables Sybase applications such as OmniConnect to work with Adaptive Server IQ. Note that, *in order to use the Open Client libraries, the client application must use only the supported system tables, views and stored procedures.*

OmniConnect support

Sybase OmniConnect provides a unified view of disparate data within an organization, allowing users to access multiple data sources without having to know what the data looks like or where it is located. In addition, OmniConnect performs heterogeneous joins of data across the enterprise, enabling cross-platform table joins of targets such as DB2, Sybase Adaptive Server Enterprise, Adaptive Server Anywhere, Oracle, and VSAM.

Using the Open Server interface, Adaptive Server IQ can act as a data source for OmniConnect.

Open Client applications and Adaptive Server IQ

You can build Open Client applications using the Open Client libraries directly from a C or C++ programming environment such as Powersoft Power++, as long as the applications use *only* catalog tables, views and system stored procedures that are supported by *both* Adaptive Server Enterprise (Transact-SQL syntax) and Adaptive Server IQ. Appendix A, “Transact-SQL Compatibility,” in the *Adaptive Server IQ Reference Manual* describes how to create compatible applications.

Setting up Adaptive Server IQ as an Open Server

This section describes how to set up an Adaptive Server IQ server to receive connections from Open Client applications.

System requirements

There are separate requirements at the client and server for using Adaptive Server IQ as an Open Server.

Server-side requirements

At the server side, in order to use Adaptive Server IQ as an Open Server, you must have a TCP/IP protocol stack in order to use Adaptive Server IQ as an Open Server, even if you are not connecting over a network.

Note When connecting to a remote Adaptive Server IQ from a local Adaptive Server Enterprise server using OmniConnect, use these server classes:

- To connect to Adaptive Server IQ 12.x, use server classes asaodbc and asajdbc.
- To connect to Adaptive Server IQ 11.x, use server class asiq.

Client-side requirements

In order to use Sybase client applications to connect to an Open Server, including Adaptive Server IQ, you need the following:

- *Open Client components*—The Open Client libraries provide the network libraries that your application needs to communicate via TDS.
- *DSEDIT* —The Directory Services Editor makes server names available to your Open Client application.

Starting the database server as an Open Server

If you wish to use Adaptive Server IQ as an Open Server, you must ensure that it is started using the TCP/IP protocol. By default, all available communications protocols are started by the server, but you can limit the protocols started by listing them explicitly on the command line. For example, the following command lines are both valid:

```
asiqsrv12 -x tcpip,ipx other_server_switches
asiqdemo.db
asiqsrv12 -x tcpip -n myserver other_server_switches
```

```
asiqdemo.db
```

On UNIX, you can use the start_asiq utility in place of asiqsrv12.

The first command line uses both TCP/IP and IPX protocols, of which TCP/IP is available for use by Open Client applications. The second line uses only TCP/IP.

The server can serve other applications through the TCP/IP protocol or other protocols using the Adaptive Server IQ-specific application protocol at the same time as serving Open Client applications over TDS.

Port numbers

Every application using TCP/IP on a machine uses a distinct TCP/IP **port**, so that network packets end up at the right application. The default port for Adaptive Server IQ is port 2638, which is used for shared memory communications. You can specify a different port number with the Port network option:

```
asiqsrv12 -x tcpip(Port=2629) -n myserver asiqdemo.db
```

On UNIX you can include this parameter in the start_asiq command.

Open Client settings

To connect to this server, the *interfaces* file at the client machine must contain an entry specifying the machine name on which the database server is running, and the TCP/IP port it uses.

For details on setting up the client machine, see “Configuring IQ Servers with DSEDIT”.

Configuring your database for use with Open Client

Your database must be Adaptive Server IQ 12.0 or higher.

Ensure your database is compatible

If you are using Adaptive Server IQ together with Adaptive Server Enterprise, you should ensure that your database is created for maximum compatibility with Adaptive Server Enterprise.

When connecting to Adaptive Server IQ as an Open Server, applications frequently assume services they expect under Adaptive Server Enterprise (or SQL Server) are provided. These services are not always present.

For information on creating Adaptive Server Enterprise-compatible databases, see the appendix “Transact-SQL Compatibility” in the *Adaptive Server IQ Reference Manual*.

Characteristics of Open Client and jConnect connections

When Adaptive Server IQ is serving applications over TDS, it automatically sets relevant database options to values that are compatible with Adaptive Server Enterprise default behavior. These options are set temporarily, for the duration of the connection only. They can be overridden by the client application at any time.

Default settings

The database options that are set on connection using TDS are as follows:

Option	Set to
ALLOW_NULLS_BY_DEFAULT	OFF
ANSINULL	OFF
AUTOMATIC_TIMESTAMP	ON
CHAINED	OFF
CONTINUE_AFTER_RAISERROR	ON
DATE_FORMAT	YYYY-MM-DD
DATE_ORDER	MDY
ESCAPE_CHARACTER	OFF
ISOLATION_LEVEL	1
FLOAT_AS_DOUBLE	ON
QUOTED_IDENTIFIER	OFF
TIME_FORMAT	HH:NN:SS.SSS
TIMESTAMP_FORMAT	YYYY-MM-DD HH:NN:SS.SSS
TSQL_HEX_CONSTANT	ON
TSQL_VARIABLES	ON

How the startup options are set

The default database options are set for TDS connections using a system procedure named sp_tsql_environment. This procedure sets the following options:

```
SET TEMPORARY OPTION TSQL_VARIABLES='ON';
SET TEMPORARY OPTION ANSI_BLANKS='ON';
SET TEMPORARY OPTION TSQL_HEX_CONSTANT='ON';
SET TEMPORARY OPTION CHAINED='OFF';
SET TEMPORARY OPTION QUOTED_IDENTIFIER='OFF';
SET TEMPORARY OPTION ALLOW_NULLS_BY_DEFAULT='OFF';
SET TEMPORARY OPTION AUTOMATIC_TIMESTAMP='ON';
SET TEMPORARY OPTION ANSINULL='OFF';
SET TEMPORARY OPTION CONTINUE_AFTER_RAISERROR='ON';
SET TEMPORARY OPTION FLOAT_AS_DOUBLE='ON';
SET TEMPORARY OPTION ISOLATION_LEVEL='1';
```

```
SET TEMPORARY OPTION DATE_FORMAT='YYYY-MM-DD';
SET TEMPORARY OPTION TIMESTAMP_FORMAT='YYYY-MM-DD
HH:NN:SS.SSS';
SET TEMPORARY OPTION TIME_FORMAT='HH:NN:SS.SSS';
SET TEMPORARY OPTION DATE_ORDER='MDY';
SET TEMPORARY OPTION ESCAPE_CHARACTER='OFF'
```

Note Do not edit the sp_tsql_environment procedure yourself. It is for system use only. Options that are not supported by Adaptive Server IQ are ignored.

The procedure only sets options for connections that use the TDS communications protocol. This includes Open Client and JDBC connections using jConnect. Other connections (ODBC and Embedded SQL) have the default settings for the database.

You can change the options for TDS connections as follows:

❖ **To change the option settings for TDS connections:**

1 Create a procedure that sets the database options you want. For example, you could use a procedure such as the following:

```
CREATE PROCEDURE my_startup_procedure()
BEGIN
  IF connection_property('CommProtocol')='TDS' THEN
    SET TEMPORARY OPTION QUOTED_IDENTIFIER='OFF';
  END IF
END
```

This procedure changes only the QUOTED_IDENTIFIER option from the default settings.

2 Set the LOGIN_PROCEDURE option to the name of a new procedure:

```
SET OPTION LOGIN_PROCEDURE=
'dba.my_startup_procedure'
```

3 Future connections will use the procedure.

For more information about database options, see Chapter 5, "Database Options" in the *Adaptive Server IQ Reference.*

Data type mappings

If you are developing Open Client applications, you should be aware of mappings between the data types supported by Adaptive Server IQ and those expected by Open Client. For more information about these data type mappings, see the chapter entitled "The Open Client Interface" in *Adaptive Server Anywhere Programming Interfaces Guide.*

Servers with multiple databases

Using Open Client Library, you can now connect to a specific database on a server with multiple databases.

- Set up entries in the *interfaces* file for each server.
- Use the -n parameter on the start_asiq command to set up a shortcut for the database name.
- Specify the -S *database_name* parameter with the database name on the isql command. *This parameter is now required whenever you connect.*

You can run the same program against multiple databases without changing the program itself by putting the shortcut name into the program and merely changing the shortcut definition.

For example, the following *interfaces* file excerpt defines two servers, live_credit and test_credit:

```
live_credit
     query tcp ether host8832 5555
    master tcp ether host 8832 5555
test_credit
     query tcp ether host8832 7777
    master tcp ether host 8832 7777
```

Start the server(s) and set up an alias for a particular database. The following command sets live_credit equivalent to creditcard.db:

```
start_asiq -n amxcredit_live <other parameters> \ -x
‘tcpip{port=5555}’ creditcard.db -n live_credit
```

To connect to the live_credit server, use this syntax:

```
isql -Udba -Psql -Slive_credit
```

A server name may only appear once in the *interfaces* file. Because the connection to Adaptive Server IQ is now based on the database name, the database name must be unique. If all your scripts are set up to work on *creditcard* database, you will not have to modify them to work with live_credit or test_credit.

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