Adaptive Server® Anywhere Programming Guide

Last modified: October 2002
Part Number: 38130-01-0802-01

Last modified October 2002. Part number 38130-01-0802-01.

Contents

About This Manual

Subject	This book describes how to build and deploy database applications using the C, C++, and Java programming languages. Users of tools such as Visual Basic and PowerBuilder can use the programming interfaces provided by those tools.
Audience	This manual is intended for application developers writing programs that work *directly* with one of the Adaptive Server Anywhere interfaces. You do not need to read this manual if you are using a development tool such as PowerBuilder or Visual Basic, each of which has its own database interface on top of ODBC.

SQL Anywhere Studio documentation

This book is part of the SQL Anywhere documentation set. This section describes the books in the documentation set and how you can use them.

The SQL Anywhere Studio documentation set

The SQL Anywhere Studio documentation set consists of the following books:

- **Introducing SQL Anywhere Studio** This book provides an overview of the SQL Anywhere Studio database management and synchronization technologies. It includes tutorials to introduce you to each of the pieces that make up SQL Anywhere Studio.
- **What's New in SQL Anywhere Studio** This book is for users of previous versions of the software. It lists new features in this and previous releases of the product and describes upgrade procedures.
- **Adaptive Server Anywhere Getting Started** This book is for people new to relational databases or new to Adaptive Server Anywhere. It provides a quick start to using the Adaptive Server Anywhere database-management system and introductory material on designing, building, and working with databases.
- **Adaptive Server Anywhere Database Administration Guide** This book covers material related to running, managing, and configuring databases.
- **Adaptive Server Anywhere SQL User's Guide** This book describes how to design and create databases; how to import, export, and modify data; how to retrieve data; and how to build stored procedures and triggers.
- **Adaptive Server Anywhere SQL Reference Manual** This book provides a complete reference for the SQL language used by Adaptive Server Anywhere. It also describes the Adaptive Server Anywhere system tables and procedures.
- **Adaptive Server Anywhere Programming Guide** This book describes how to build and deploy database applications using the C, C++, and Java programming languages. Users of tools such as Visual Basic and PowerBuilder can use the programming interfaces provided by those tools.

- **Adaptive Server Anywhere Error Messages** This book provides a complete listing of Adaptive Server Anywhere error messages together with diagnostic information.
- **Adaptive Server Anywhere C2 Security Supplement** Adaptive Server Anywhere 7.0 was awarded a TCSEC (Trusted Computer System Evaluation Criteria) C2 security rating from the U.S. Government. This book may be of interest to those who wish to run the current version of Adaptive Server Anywhere in a manner equivalent to the C2-certified environment. The book does *not* include the security features added to the product since certification.
- **MobiLink Synchronization User's Guide** This book describes all aspects of the MobiLink data synchronization system for mobile computing, which enables sharing of data between a single Oracle, Sybase, Microsoft or IBM database and many Adaptive Server Anywhere or UltraLite databases.
- **SQL Remote User's Guide** This book describes all aspects of the SQL Remote data replication system for mobile computing, which enables sharing of data between a single Adaptive Server Anywhere or Adaptive Server Enterprise database and many Adaptive Server Anywhere databases using an indirect link such as e-mail or file transfer.
- **UltraLite User's Guide** This book describes how to build database applications for small devices such as handheld organizers using the UltraLite deployment technology for Adaptive Server Anywhere databases.
- **UltraLite User's Guide for PenRight! MobileBuilder** This book is for users of the PenRight! MobileBuilder development tool. It describes how to use UltraLite technology in the MobileBuilder programming environment.
- **SQL Anywhere Studio Help** This book is provided online only. It includes the context-sensitive help for Sybase Central, Interactive SQL, and other graphical tools.

In addition to this documentation set, SQL Modeler and InfoMaker include their own online documentation.

Documentation formats

SQL Anywhere Studio provides documentation in the following formats:

- **Online books** The online books include the complete SQL Anywhere Studio documentation, including both the printed books and the context-sensitive help for SQL Anywhere tools. The online books are updated with each maintenance release of the product, and are the most complete and up-to-date source of documentation.

  To access the online books on Windows operating systems, choose Start➤Programs➤Sybase SQL Anywhere 8➤Online Books. You can navigate the online books using the HTML Help table of contents, index, and search facility in the left pane, and using the links and menus in the right pane.

  To access the online books on UNIX operating systems, run the following command at a command prompt:

  ```
  dbbooks
  ```

- **Printable books** The SQL Anywhere books are provided as a set of PDF files, viewable with Adobe Acrobat Reader.

  The PDF files are available on the CD ROM in the *pdf_docs* directory. You can choose to install them when running the setup program.

- **Printed books** The following books are included in the SQL Anywhere Studio box:

  - *Introducing SQL Anywhere Studio*.
  - *Adaptive Server Anywhere Getting Started*.
  - *SQL Anywhere Studio Quick Reference*. This book is available only in printed form.

  The complete set of books is available as the SQL Anywhere Documentation set from Sybase sales or from e-Shop, the Sybase online store, at http://e-shop.sybase.com/cgi-bin/eshop.storefront/.

Documentation conventions

This section lists the typographic and graphical conventions used in this documentation.

Syntax conventions

The following conventions are used in the SQL syntax descriptions:

- **Keywords** All SQL keywords are shown like the words ALTER TABLE in the following example:

  ALTER TABLE [*owner.*]*table-name*

- **Placeholders** Items that must be replaced with appropriate identifiers or expressions are shown like the words *owner* and *table-name* in the following example.

  ALTER TABLE [*owner.*]*table-name*

- **Repeating items** Lists of repeating items are shown with an element of the list followed by an ellipsis (three dots), like *column-constraint* in the following example:

  ADD *column-definition* [*column-constraint, …*]

  One or more list elements are allowed. If more than one is specified, they must be separated by commas.

- **Optional portions** Optional portions of a statement are enclosed by square brackets.

  RELEASE SAVEPOINT [*savepoint-name*]

  These square brackets indicate that the *savepoint-name* is optional. The square brackets should not be typed.

- **Options** When none or only one of a list of items can be chosen, vertical bars separate the items and the list is enclosed in square brackets.

  [**ASC** | **DESC**]

  For example, you can choose one of ASC, DESC, or neither. The square brackets should not be typed.

- **Alternatives** When precisely one of the options must be chosen, the alternatives are enclosed in curly braces.

  [**QUOTES** { **ON** | **OFF** }]

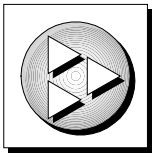
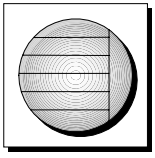
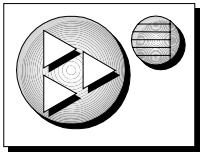
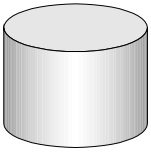
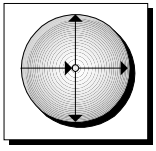
If the QUOTES option is chosen, one of ON or OFF must be provided. The brackets and braces should not be typed.

- **One or more options** If you choose more than one, separate your choices with commas.

  { **CONNECT**, **DBA**, **RESOURCE** }

Graphic icons

The following icons are used in this documentation:

Icon	Meaning
	A client application.
	A database server, such as Sybase Adaptive Server Anywhere or Adaptive Server Enterprise.
	An UltraLite application and database server. In UltraLite, the database server and the application are part of the same process.
	A database. In some high-level diagrams, the icon may be used to represent both the database and the database server that manages it.
	Replication or synchronization middleware. These assist in sharing data among databases. Examples are the MobiLink Synchronization Server, SQL Remote Message Agent, and the Replication Agent (Log Transfer Manager) for use with Replication Server.
	A Sybase Replication Server.
	A programming interface.

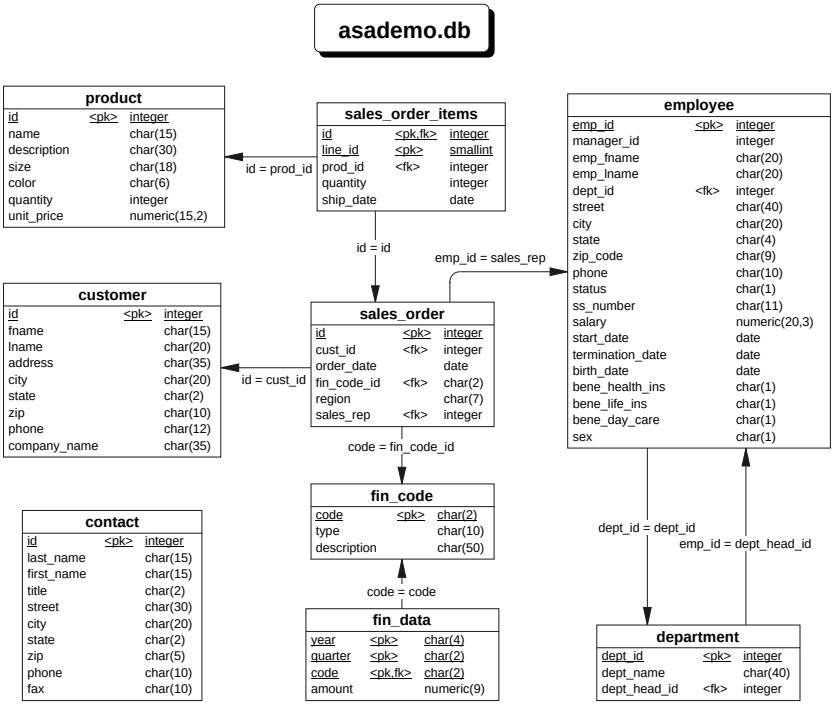
The Adaptive Server Anywhere sample database

Many of the examples throughout the documentation use the Adaptive Server Anywhere sample database.

The sample database is held in a file named *asademo.db*, and is located in your SQL Anywhere directory.

The sample database represents a small company. It contains internal information about the company (employees, departments, and finances) as well as product information and sales information (sales orders, customers, and contacts). All information in the database is fictional.

The following figure shows the tables in the sample database and how they relate to each other.



Finding out more and providing feedback

We would like to receive your opinions, suggestions, and feedback on this documentation.

You can provide feedback on this documentation and on the software through newsgroups set up to discuss SQL Anywhere technologies. These newsgroups can be found on the *forums.sybase.com* news server.

The newsgroups include the following:

- sybase.public.sqlanywhere.general.
- sybase.public.sqlanywhere.linux.
- sybase.public.sqlanywhere.mobilink.
- sybase.public.sqlanywhere.product_futures_discussion.
- sybase.public.sqlanywhere.replication.
- sybase.public.sqlanywhere.ultralite.

Newsgroup disclaimer

iAnywhere Solutions has no obligation to provide solutions, information or ideas on its newsgroups, nor is iAnywhere Solutions obliged to provide anything other than a systems operator to monitor the service and insure its operation and availability.

iAnywhere Solutions Technical Advisors as well as other staff assist on the newsgroup service when they have time available. They offer their help on a volunteer basis and may not be available on a regular basis to provide solutions and information. Their ability to help is based on their workload.

CHAPTER 1

Programming Interface Overview

About this chapter

This chapter introduces each of the programming interfaces for Adaptive Server Anywhere. Any client application uses one of these interfaces to communicate with the database.

Contents

The ODBC programming interface

ODBC (Open Database Connectivity) is a standard call level interface (CLI) developed by Microsoft. It is based on the SQL Access Group CLI specification. ODBC applications can run against any data source that provides an ODBC driver. You should use ODBC if you would like your application to be portable to other data sources that have ODBC drivers. Also, if you prefer working with an API, use ODBC.

ODBC is a low-level interface—about the same as Embedded SQL. Almost all the Adaptive Server Anywhere functionality is available with this interface. ODBC is available as a DLL under Windows operating systems with the exception of Windows CE. It is provided as a library for UNIX.

The primary documentation for ODBC is the Microsoft ODBC Software Development Kit. The current book provides some additional notes specific to Adaptive Server Anywhere for ODBC developers.

ODBC is described in "ODBC Programming" on page 251

The OLE DB programming interface

OLE DB is a set of Component Object Model (COM) interfaces developed by Microsoft, which provide applications with uniform access to data stored in diverse information sources and which also provide the ability to implement additional database services. These interfaces support the amount of DBMS functionality appropriate to the data store, enabling it to share its data.

ADO is an object model for programmatically accessing, editing, and updating a wide variety of data sources through OLE DB system interfaces. ADO is also developed by Microsoft. Most developers using the OLE DB programming interface do so by writing to the ADO API rather than directly to the OLE DB API.

Adaptive Server Anywhere includes an OLE DB provider for OLE DB and ADO programmers.

The primary documentation for OLE DB and ADO programming is the Microsoft Developer Network. The current book provides some additional notes specific to Adaptive Server Anywhere for OLE DB and ADO developers.

For more information, see "The OLE DB and ADO Programming Interfaces" on page 337

The Embedded SQL programming interface

Embedded SQL is a system in which SQL commands are embedded right in a C or C++ source file. A preprocessor translates these statements into calls to a runtime library. Embedded SQL is an ISO/ANSI and IBM standard.

Embedded SQL is portable to other databases and other environments, and is functionally equivalent in all operating environments. It provides all of the functionality available in the product. Embedded SQL is quite easy to work with, although it takes a little getting used to the idea of Embedded SQL statements (rather than function calls) in C code.

Embedded SQL is described in "Embedded SQL Programming" on page 163.

The JDBC programming interface

JDBC is a call-level interface for Java applications. Developed by Sun Microsystems, JDBC provides Java programmers with a uniform interface to a wide range of relational databases, and provides a common base on which higher level tools and interfaces can be built. JDBC is now a standard part of Java and is included in the JDK.

SQL Anywhere Studio includes a pure Java JDBC driver, named Sybase jConnect. It also includes a JDBC-ODBC bridge. Both are described in "Data Access Using JDBC" on page 129. For information on choosing a driver, see "Choosing a JDBC driver" on page 131.

In addition to using JDBC as a client side application programming interface, you can also use JDBC inside the database server to access data from Java in the database. For that reason JDBC is documented as part of the Java in the database documentation.

 JDBC is not described in this book. For a description of JDBC, see "Data Access Using JDBC" on page 129.

The Open Client programming interface

Sybase Open Client provides customer applications, third-party products, and other Sybase products with the interfaces needed to communicate with Adaptive Server Anywhere and other Open Servers.

When to use Open Client

You should consider using the Open Client interface if you are concerned with Adaptive Server Enterprise compatibility or if you are using other Sybase products that support the Open Client interface, such as Replication Server.

☞ The Open Client interface is described in "The Open Client Interface" on page 353. ☞ For more information about the Open Client interface, see "Adaptive Server Anywhere as an Open Server" on page 105 of the book *ASA Database Administration Guide*.

Open Client architecture

Open Client can be thought of as comprising two components: programming interfaces and network services.

Client Library and DB-Library

Open Client provides two core programming interfaces for writing client applications: DB-Library and Client-Library.

Open Client DB-Library provides support for older Open Client applications, and is a completely separate programming interface from Client-Library. DB-Library is documented in the *Open Client DB-Library/C Reference Manual*, provided with the Sybase Open Client product.

Client-Library programs also depend on CS-Library, which provides routines that are used in both Client-Library and Server-Library applications. Client-Library applications can also use routines from Bulk-Library to facilitate high-speed data transfer.

Both CS-Library and Bulk-Library are included in the Sybase Open Client, available separately.

Network services

Open Client network services include Sybase Net-Library, which provides support for specific network protocols such as TCP/IP and DECnet. The Net-Library interface is invisible to application programmers. However, on some platforms, an application may need a different Net-Library driver for different system network configurations. Depending on your host platform, the Net-Library driver is specified either by the system's Sybase configuration or when you compile and link your programs.

☞ Instructions for driver configuration can be found in the *Open Client/Server Configuration Guide*.

☞ Instructions for building Client-Library programs can be found in the *Open Client/Server Programmer's Supplement*.

CHAPTER 2

Using SQL in Applications

About this chapter

Many aspects of database application development depend on your application development tool, database interface, and programming language, but there are some common problems and principles that affect multiple aspects of database application development.

This chapter describes some principles and techniques common to most or all interfaces and provides pointers for more information. It does not provide a detailed guide for programming using any one interface.

Contents

Executing SQL statements in applications

The way you include SQL statements in your application depends on the application development tool and programming interface you use.

- **ODBC** If you are writing directly to the ODBC programming interface, your SQL statements appear in function calls. For example, the following C function call executes a DELETE statement:

```
SQLExecDirect( stmt,
    "DELETE FROM employee
     WHERE emp_id = 105",
    SQL_NTS );
```

- **JDBC** If you are using the JDBC programming interface, you can execute SQL statements by invoking methods of the **statement** object. For example,

```
stmt.executeUpdate(
    "DELETE FROM employee
     WHERE emp_id = 105" );
```

- **Embedded SQL** If you are using embedded SQL, you prefix your C language SQL statements with the keyword EXEC SQL. The code is then run through a preprocessor before compiling. For example,

```
EXEC SQL EXECUTE IMMEDIATE
 'DELETE FROM employee
  WHERE emp_id = 105';
```

- **Sybase Open Client** If you use the Sybase Open Client interface, your SQL statements appear in function calls. For example, the following pair of calls executes a DELETE statement:

```
ret = ct_command(cmd, CS_LANG_CMD,
                   "DELETE FROM employee
                    WHERE emp_id=105"
                  CS_NULLTERM,
                  CS_UNUSED);
ret = ct_send(cmd);
```

- **Application Development Tools** Application development tools such as the members of the Sybase Enterprise Application Studio family provide their own SQL objects, which use either ODBC (PowerBuilder) or JDBC (Power J) under the covers.

For more detailed information on how to include SQL in your application, see your development tool documentation. If you are using ODBC or JDBC, consult the software development kit for those interfaces.

☞ For a detailed description of embedded SQL programming, see "Embedded SQL Programming" on page 163.

Applications inside the server

In many ways, stored procedures and triggers act as applications or parts of applications running inside the server. You can use many of the techniques here in stored procedures also. Stored procedures use statements very similar to embedded SQL statements.

☞ For more information about stored procedures and triggers, see "Using Procedures, Triggers, and Batches" on page 507 of the book *ASA SQL User's Guide*.

Java classes in the database can use the JDBC interface in the same way as Java applications outside the server. This chapter discusses some aspects of JDBC. For other information on using JDBC, see "Data Access Using JDBC" on page 129.

Preparing statements

Each time a statement is sent to a database, the server must first **prepare** the statement. Preparing the statement can include:

- Parsing the statement and transforming it into an internal form.
- Verifying the correctness of all references to database objects by checking, for example, that columns named in a query actually exist.
- Causing the query optimizer to generate an access plan if the statement involves joins or subqueries.
- Executing the statement after all these steps have been carried out.

Reusing prepared statements can improve performance

If you find yourself using the same statement repeatedly, for example, inserting many rows into a table, repeatedly preparing the statement causes a significant and unnecessary overhead. To remove this overhead, some database programming interfaces provide ways of using prepared statements. A **prepared statement** is a statement containing a series of placeholders. When you want to execute the statement, all you have to do is assign values to the placeholders, rather than prepare the entire statement over again.

Using prepared statements is particularly useful when carrying out many similar actions, such as inserting many rows.

Generally, using prepared statements requires the following steps:

1 **Prepare the statement** In this step you generally provide the statement with some placeholder character instead of the values.

2 **Repeatedly execute the prepared statement** In this step you supply values to be used each time the statement is executed. The statement does not have to be prepared each time.

3 **Drop the statement** In this step you free the resources associated with the prepared statement. Some programming interfaces handle this step automatically.

Do not prepare statements that are used only once

In general, you should not prepare statements if you'll only execute them once. There is a slight performance penalty for separate preparation and execution, and it introduces unnecessary complexity into your application.

In some interfaces, however, you do need to prepare a statement to associate it with a cursor.

For information about cursors, see "Introduction to cursors" on page 15.

The calls for preparing and executing statements are not a part of SQL, and they differ from interface to interface. Each of the Adaptive Server Anywhere programming interfaces provides a method for using prepared statements.

How to use prepared statements

This section provides a brief overview of how to use prepared statements. The general procedure is the same, but the details vary from interface to interface. Comparing how to use prepared statements in different interfaces illustrates this point.

❖ **To use a prepared statement (generic):**

1. Prepare the statement.
2. Set up **bound parameters**, which will hold values in the statement.
3. Assign values to the bound parameters in the statement.
4. Execute the statement.
5. Repeat steps 3 and 4 as needed.
6. Drop the statement when finished. This step is not required in JDBC, as Java's garbage collection mechanisms handle this for you.

❖ **To use a prepared statement (embedded SQL):**

1. Prepare the statement using the EXEC SQL PREPARE command.
2. Assign values to the parameters in the statement.
3. Execute the statement using the EXE SQL EXECUTE command.
4. Free the resources associated with the statement using the EXEC SQL DROP command.

❖ **To use a prepared statement (ODBC):**

1. Prepare the statement using **SQLPrepare**.
2. Bind the statement parameters using **SQLBindParameter**.
3. Execute the statement using **SQLExecute**.
4. Drop the statement using **SQLFreeStmt**.

For more information, see "Executing prepared statements" on page 269 and the ODBC SDK documentation.

❖ **To use a prepared statement (JDBC):**

1 Prepare the statement using the **prepareStatement** method of the connection object. This returns a prepared statement object.

2 Set the statement parameters using the appropriate **set***Type* methods of the prepared statement object. Here, *Type* is the data type assigned.

3 Execute the statement using the appropriate method of the prepared statement object. For inserts, updates, and deletes this is the **executeUpdate** method.

For more information on using prepared statements in JDBC, see "Using prepared statements for more efficient access" on page 155.

❖ **To use a prepared statement (Open Client):**

1 Prepare the statement using the **ct_dynamic** function, with a CS_PREPARE type parameter.

2 Set statement parameters using **ct_param**.

3 Execute the statement using **ct_dynamic** with a CS_EXECUTE type parameter.

4 Free the resources associated with the statement using **ct_dynamic** with a CS_DEALLOC type parameter.

For more information on using prepared statements in Open Client, see "Using SQL in Open Client applications" on page 357.

Introduction to cursors

When you execute a query in an application, the result set consists of a number of rows. In general, you do not know how many rows the application is going to receive before you execute the query. Cursors provide a way of handling query result sets in applications.

The way you use cursors, and the kinds of cursors available to you, depend on the programming interface you use. JDBC 1.0 provides rudimentary handling of result sets, while ODBC and embedded SQL have many different kinds of cursors. Open Client cursors can only move forward through a result set.

With cursors, you can carry out the following tasks within any programming interface:

- Loop over the results of a query.
- Carry out inserts, updates, and deletes on the underlying data at any point within a result set.

In addition, some programming interfaces allow you to use special features to tune the way result sets return to your application, providing substantial performance benefits for your application.

For more information on the kinds of cursors available through different programming interfaces, see "Availability of cursors" on page 24.

What are cursors?

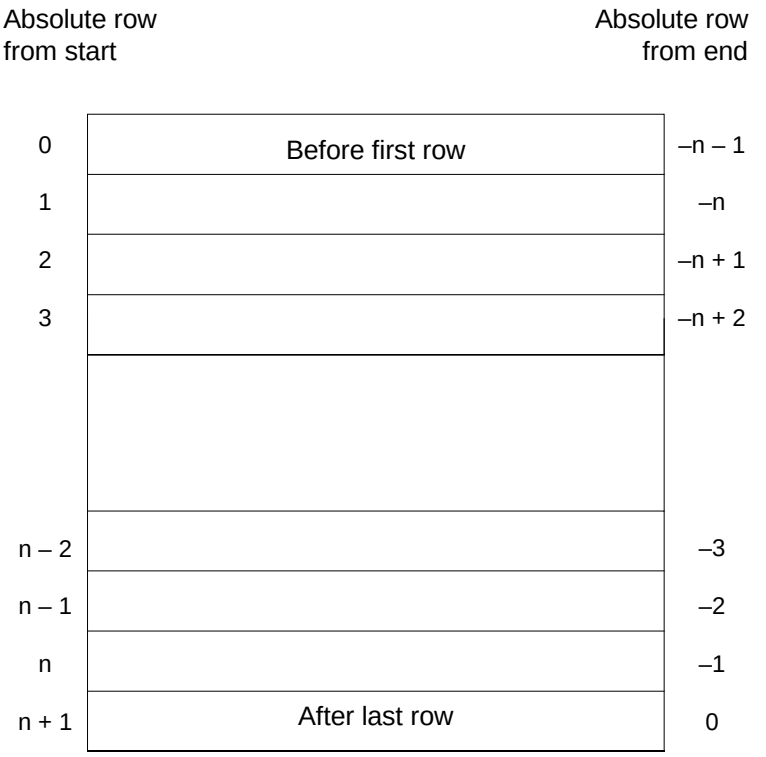
A **cursor** is a name associated with a result set. The result set is obtained from a SELECT statement or stored procedure call.

A cursor is a handle on the result set. At any time, the cursor has a well-defined position within the result set. With a cursor you can examine and possibly manipulate the data one row at a time. Adaptive Server Anywhere cursors support forward and backward movement through the query results.

Cursor positions

Cursors can be positioned in the following places:

- Before the first row of the result set.
- On a row in the result set.
- After the last row of the result set.



Cursor position and result set are maintained in the database server. Rows are **fetched** by the client for display and processing either one at a time or a few at a time. The entire result set does not need to be delivered to the client.

Benefits of using cursors

You do not need to use cursors in database applications, but they do provide a number of benefits. These benefits follow from the fact that if you do not use a cursor, the entire result set must be transferred to the client for processing and display:

- **Client-side memory** For large results, holding the entire result set on the client can lead to demanding memory requirements.
- **Response time** Cursors can provide the first few rows before the whole result set is assembled. If you do not use cursors, the entire result set must be delivered before any rows are displayed by your application.

- **Concurrency control** If you make updates to your data and do not use cursors in your application, you must send separate SQL statements to the database server to apply the changes. This raises the possibility of concurrency problems if the result set has changed since it was queried by the client. In turn, this raises the possibility of lost updates.

  Cursors act as pointers to the underlying data, and so impose proper concurrency constraints on any changes you make.

Steps in using cursors

Using a cursor in embedded SQL is different than using a cursor in other interfaces.

❖ **To use a cursor (embedded SQL):**

1. Prepare a statement.

   Cursors generally use a statement handle rather than a string. You need to prepare a statement to have a handle available.

   For information on preparing a statement, see "Preparing statements" on page 12.

2. Declare the cursor.

   Each cursor refers to a single SELECT or CALL statement. When you declare a cursor, you state the name of the cursor and the statement it refers to.

   For more information, see "DECLARE CURSOR statement [ESQL] [SP]" on page 379 of the book *ASA SQL Reference Manual*.

3. Open the cursor.

   For more information, see "OPEN statement [ESQL] [SP]" on page 485 of the book *ASA SQL Reference Manual*.

   In the case of a CALL statement, opening the cursor executes the query up to the point where the first row is about to be obtained.

4. Fetch results.

   Although simple fetch operations move the cursor to the next row in the result set, Adaptive Server Anywhere permits more complicated movement around the result set. How you declare the cursor determines which fetch operations are available to you.

For more information, see "FETCH statement [ESQL] [SP]" on page 424 of the book *ASA SQL Reference Manual*, and "Fetching data" on page 193.

5 Close the cursor.

When you have finished with the cursor, close it. This frees any locks held on the underlying data.

For more information, see "CLOSE statement [ESQL] [SP]" on page 261 of the book *ASA SQL Reference Manual*.

6 Drop the statement.

To free the memory associated with the cursor and its associated statement, you must free the statement.

For more information, see "DROP STATEMENT statement [ESQL]" on page 405 of the book *ASA SQL Reference Manual*.

❖ **To use a cursor (ODBC, JDBC, Open Client):**

1 Prepare and execute a statement.

Execute a statement using the usual method for the interface. You can prepare and then execute the statement, or you can execute the statement directly.

2 Test to see if the statement returns a result set.

A cursor is implicitly opened when a statement that creates a result set is executed. When the cursor is opened, it is positioned before the first row of the result set.

3 Fetch results.

Although simple fetch operations move the cursor to the next row in the result set, Adaptive Server Anywhere permits more complicated movement around the result set.

4 Close the cursor.

When you have finished with the cursor, close it to free associated resources.

5 Free the statement.

If you used a prepared statement, free it to reclaim memory.

Prefetching rows

In some cases the interface library may carry out performance optimizations under the covers (such as prefetching results), so these steps in the client application may not correspond exactly to software operations.

Working with cursors

This section describes how to carry out different kinds of operations using cursors.

Cursor positioning

When a cursor is opened, it is positioned before the first row. You can move the cursor position to an absolute position from the start or the end of the query results, or to a position relative to the current cursor position. The specifics of how you change cursor position, and what operations are possible, is governed by the programming interface.

The number of row positions you can fetch in a cursor is governed by the size of an integer. You can fetch rows numbered up to number 2147483646, which is one less than the value that can be held in an integer. When using negative numbers (rows from the end) you can fetch down to one more than the largest negative value that can be held in an integer.

You can use special positioned update and delete operations to update or delete the row at the current position of the cursor. If the cursor is positioned before the first row or after the last row, a No current row of cursor error is returned.

Cursor positioning problems
Inserts and some updates to asensitive cursors can cause problems with cursor positioning. Adaptive Server Anywhere does not put inserted rows at a predictable position within a cursor unless there is an ORDER BY clause on the SELECT statement. In some cases, the inserted row does not appear at all until the cursor is closed and opened again.

With Adaptive Server Anywhere, this occurs if a work table had to be created to open the cursor (see "Use of work tables in query processing" on page 160 of the book *ASA SQL User's Guide* for a description).

The UPDATE statement may cause a row to move in the cursor. This happens if the cursor has an ORDER BY clause that uses an existing index (a work table is not created). Using STATIC SCROLL cursors alleviates these problems but requires more memory and processing.

Configuring cursors on opening

You can configure the following aspects of cursor behavior when you open the cursor:

- **Isolation level** You can explicitly set the isolation level of operations on a cursor to be different from the current isolation level of the transaction. To do this, set the ISOLATION_LEVEL option.

  For more information, see "ISOLATION_LEVEL option" on page 571 of the book *ASA Database Administration Guide*.

- **Holding** By default, cursors in embedded SQL close at the end of a transaction. Opening a cursor **WITH HOLD** allows you to keep it open until the end of a connection, or until you explicitly close it. ODBC, JDBC and Open Client leave cursors open at the end of transactions by default.

Fetching rows through a cursor

The simplest way of processing the result set of a query using a cursor is to loop through all the rows of the result set until there are no more rows.

❖ **To loop through the rows of a result set:**

1. Declare and open the cursor (embedded SQL), or execute a statement that returns a result set (ODBC, JDBC, Open Client).
2. Continue to fetch the next row until you get a Row Not Found error.
3. Close the cursor.

How step 2 of this operation is carried out depends on the interface you use. For example,

- **ODBC** **SQLFetch, SQLExtendedFetch**, or **SQLFetchScroll** advances the cursor to the next row and returns the data.

  For more information on using cursors in ODBC, see "Working with result sets" on page 272.

- **Embedded SQL** The FETCH statement carries out the same operation.

  For more information on using cursors in embedded SQL, see "Using cursors in embedded SQL" on page 194.

- **JDBC** The **next** method of the **ResultSet** object advances the cursor and returns the data.

For more information on using the **ResultSet** object in JDBC, see "Queries using JDBC" on page 153.

- **Open Client** The **ct_fetch** function advances the cursor to the next row and returns the data.

  For more information on using cursors in Open Client applications, see "Using cursors" on page 358.

Fetching multiple rows

This section discusses how fetching multiple rows at a time can improve performance.

Multiple-row fetching should not be confused with prefetching rows, which is described in the next section. Multiple row fetching is performed by the application, while prefetching is transparent to the application, and provides a similar performance gain.

Multiple-row fetches

Some interfaces provide methods for fetching more than one row at a time into the next several fields in an array. Generally, the fewer separate fetch operations you execute, the fewer individual requests the server must respond to, and the better the performance. A modified FETCH statement that retrieves multiple-rows is also sometimes called a **wide fetch**. Cursors that use multiple-row fetches are sometimes called **block cursors** or **fat cursors**.

Using multiple-row fetching

- In ODBC, you can set the number of rows that will be returned on each call to **SQLFetchScroll** or **SQLExtendedFetch** by setting the SQL_ROWSET_SIZE attribute.
- In embedded SQL, the FETCH statement uses an ARRAY clause to control the number of rows fetched at a time.
- Open Client and JDBC do not support multi-row fetches. They do use prefetching.

Fetching with scrollable cursors

ODBC and embedded SQL provide methods for using scrollable cursors and dynamic scrollable cursors. These methods allow you to move several rows forward at a time, or to move backwards through the result set.

The JDBC and Open Client interfaces do not support scrollable cursors.

Prefetching does not apply to scrollable operations. For example, fetching a row in the reverse direction does not prefetch several previous rows.

Modifying rows through a cursor

Cursors can do more than just read result sets from a query. You can also modify data in the database while processing a cursor. These operations are commonly called **positioned** update and delete operations, or **PUT** operations if the action is an insert.

Not all query result sets allow positioned updates and deletes. If you carry out a query on a non-updatable view, then no changes occur to the underlying tables. Also, if the query involves a join, then you must specify which table you wish to delete from, or which columns you wish to update, when you carry out the operations.

Inserts through a cursor can only be executed if any non-inserted columns in the table allow NULL or have defaults.

ODBC, embedded SQL, and Open Client permit data modification using cursors, but JDBC 1.1 does not. With Open Client, you can delete and update rows, but you can only insert rows on a single-table query.

Which table are rows deleted from?

If you attempt a positioned delete through a cursor, the table from which rows are deleted is determined as follows:

1. If no FROM clause is included in the delete statement, the cursor must be on a single table only.
2. If the cursor is for a joined query (including using a view containing a join), then the FROM clause must be used. Only the current row of the specified table is deleted. The other tables involved in the join are not affected.
3. If a FROM clause is included, and no table owner is specified, the table-spec value is first matched against any correlation names.

   For more information, see the "FROM clause" on page 433 of the book *ASA SQL Reference Manual*.
4. If a correlation name exists, the table-spec value is identified with the correlation name.
5. If a correlation name does not exist, the table-spec value must be unambiguously identifiable as a table name in the cursor.
6. If a FROM clause is included, and a table owner is specified, the table-spec value must be unambiguously identifiable as a table name in the cursor.
7. The positioned DELETE statement can be used on a cursor open on a view as long as the view is updatable.

Canceling cursor operations

You can cancel a request through an interface function. From Interactive SQL, you can cancel a request by pressing the Interrupt SQL Statement button on the toolbar (or by choosing Stop from the SQL menu).

If you cancel a request that is carrying out a cursor operation, the position of the cursor is indeterminate. After canceling the request, you must locate the cursor by its absolute position, or close it.

Choosing cursor types

This section describes mappings between Adaptive Server Anywhere cursors and the options available to you from the programming interfaces supported by Adaptive Server Anywhere.

For information on Adaptive Server Anywhere cursors, see "Adaptive Server Anywhere cursors" on page 28.

Availability of cursors

Not all interfaces provide support for all types of cursors.

- ODBC and OLE DB (ADO) support all types of cursors.

  For more information, see "Working with result sets" on page 272.

- Embedded SQL supports all the types of cursors.
- For JDBC:
  - jConnect 4.x provides only asensitive cursors.
  - jConnect 5.x supports all types of cursors, but there is a severe performance penalty for scrollable cursors.
  - The JDBC-ODBC bridge supports all types of cursors.
- Sybase Open Client supports only asensitive cursors. Also, a severe performance penalty results when using updatable, non-unique cursors.

Cursor properties

You request a cursor type, either explicitly or implicitly, from the programming interface. Different interface libraries offer different choices of cursor types. For example, JDBC and ODBC specify different cursor types.

Each cursor type is defined by a number of characteristics:

- **Uniqueness** Declaring a cursor to be unique forces the query to return all the columns required to uniquely identify each row. Often this means returning all the columns in the primary key. Any columns required but not specified are added to the result set. The default cursor type is non-unique.
- **Updatability** A cursor declared as read only may not be used in a positioned update or delete operation. The default cursor type us updatable.

- **Scrollability** You can declare cursors to behave different ways as you move through the result set. Some cursors can fetch only the current row or the following row. Others can move backwards and forwards through the result set.
- **Sensitivity** Changes to the database may or may not be visible through a cursor.

These characteristics may have significant side effects on performance and on database server memory usage.

Adaptive Server Anywhere makes available cursors with a variety of mixes of these characteristics. When you request a cursor of a given type, Adaptive Server Anywhere matches those characteristics as well as it can. The details of how Adaptive Server Anywhere cursors match the cursor types specified in the programming interfaces are the subject of the following sections.

There are some occasions when not all characteristics can be supplied. For example, insensitive cursors in Adaptive Server Anywhere must be read-only, for reasons described below. If your application requests an updatable insensitive cursor, a different cursor type (value-sensitive) is supplied instead.

Requesting Adaptive Server Anywhere cursors

When you request a cursor type from your client application, Adaptive Server Anywhere provides a cursor. Adaptive Server Anywhere cursors are defined, not by the type as specified in the programming interface, but by the sensitivity of the result set to changes in the underlying data. Depending on the cursor type you ask for, Adaptive Server Anywhere provides a cursor with behavior to match the type.

Adaptive Server Anywhere cursor sensitivity is set in response to the client cursor type request.

ODBC and OLE DB

The following table illustrates the cursor sensitivity that is set in response to different ODBC scrollable cursor types.

ODBC scrollable cursor type	Adaptive Server Anywhere cursor
STATIC	Insensitive
KEYSET	Value-sensitive
DYNAMIC	Sensitive
MIXED	Value-sensitive

☞ For information on Adaptive Server Anywhere cursors and their behavior, see "Adaptive Server Anywhere cursors" on page 28. For information on how to request a cursor type in ODBC, see "Choosing a cursor characteristics" on page 272.

Exceptions

If a STATIC cursor is requested as updatable, a value-sensitive cursor is supplied instead and a warning is issued.

If a DYNAMIC or MIXED cursor is requested and the query cannot be executed without using work tables, a warning is issued and an asensitive cursor is supplied instead.

Embedded SQL

To request a cursor from an embedded SQL application, you specify the cursor type on the DECLARE statement. The following table illustrates the cursor sensitivity that is set in response to different requests:

Cursor type	Adaptive Server Anywhere cursor
NO SCROLL	Asensitive
DYNAMIC SCROLL	Asensitive
SCROLL	Value-sensitive
INSENSITIVE	Insensitive
SENSITIVE	Sensitive

Exceptions

If an DYNAMIC SCROLL or NO SCROLL cursor is requested as UPDATABLE, then a sensitive or value-sensitive cursor is supplied. It is not guaranteed which of the two is supplied. This uncertainty fits the definition of asensitive behavior.

If an INSENSITIVE cursor is requested as UPDATABLE, then a value-sensitive cursor is supplied.

If a DYNAMIC SCROLL cursor is requested, if the PREFETCH database option is set to OFF, and if the query execution plan involves no work tables, then a sensitive cursor may be supplied. Again, this uncertainty fits the definition of asensitive behavior.

JDBC

Only one kind of cursor is available to JDBC applications. This is an asensitive cursor. In JDBC you execute an **ExecuteQuery** statement to open a cursor.

Open Client

Only one kind of cursor is available to JDBC applications. This is an asensitive cursor.

Bookmarks and cursors

ODBC provides **bookmarks**, or values, used to identify rows in a cursor. Adaptive Server Anywhere supports bookmarks for all kinds of cursors except DYNAMIC cursors.

Block cursors

ODBC provides a cursor type called a block cursor. When you use a BLOCK cursor, you can use **SQLFetchScroll** or **SQLExtendedFetch** to fetch a block of rows, rather than a single row. Block cursors behave identically to embedded SQL ARRAY fetches.

Adaptive Server Anywhere cursors

Any cursor, once opened, has an associated result set. The cursor is kept open for a length of time. During that time, the result set associated with the cursor may be changed, either through the cursor itself or, subject to isolation level requirements, by other transactions. Some cursors permit changes to the underlying data to be visible, while others do not reflect these changes. The different behavior of cursors with respect to changes to the underlying data is the **sensitivity** of the cursor.

Adaptive Server Anywhere provides cursors with a variety of sensitivity characteristics. This section describes what sensitivity is, and describes the sensitivity characteristics of cursors.

This section assumes that you have read "What are cursors?" on page 15.

Membership, order, and value changes

Changes to the underlying data can affect the result set of a cursor in the following ways:

- **Membership** The set of rows in the result set, as identified by their primary key values.
- **Order** The order of the rows in the result set.
- **Value** The values of the rows in the result set.

For example, consider the following simple table with employee information (*emp_id* is the primary key column):

emp_id	emp_lname
1	Whitney
2	Cobb
3	Chin

A cursor on the following query returns all results from the table in primary key order:

```
SELECT emp_id, emp_lname
FROM employee
ORDER BY emp_id
```

The membership of the result set could be changed by adding a new row or deleting a row. The values could be changed by changing one of the names in the table. The order could be changed by changing the primary key value of one of the employees.

Visible and invisible changes

Subject to isolation level requirements, the membership, order, and values of the result set of a cursor can be changed after the cursor is opened. Depending on the type of cursor in use, the result set as seen by the application may change to reflect these changes or may not.

Changes to the underlying data may be **visible** or **invisible** through the cursor. A visible change is a change that is reflected in the result set of the cursor. Changes to the underlying data that are not reflected in the result set seen by the cursor are invisible.

Cursor sensitivity overview

Adaptive Server Anywhere cursors are classified by their sensitivity with respect to changes of the underlying data. In particular, cursor sensitivity is defined in terms of which changes are visible.

- **Insensitive cursors** The result set is fixed when the cursor is opened. No changes to the underlying data are visible.

  For more information, see "Insensitive cursors" on page 33.

- **Sensitive cursors** The result set can change after the cursor is opened. All changes to the underlying data are visible.

  For more information, see "Sensitive cursors" on page 34.

- **Asensitive cursors** Changes may be reflected in the membership, order, or values of the result set seen through the cursor, or may not be reflected at all.

  For more information, see "Asensitive cursors" on page 36.

- **Value-sensitive cursors** Changes to the order or values of the underlying data. The membership of the result set is fixed when the cursor is opened.

  For more information, see "Value-sensitive cursors" on page 37.

The differing requirements on cursors place different constraints on execution, and so performance. For more information, see "Cursor sensitivity and performance" on page 39.

Cursor sensitivity example: a deleted row

This example uses a simple query to illustrate how different cursors respond to a row in the result set being deleted.

Consider the following sequence of events:

1 An application opens a cursor on the following query against the sample database.

```
SELECT emp_id, emp_lname
FROM employee
ORDER BY emp_id
```

emp_id	emp_lname
102	Whitney
105	Cobb
160	Breault
…	…

2 The application fetches the first row through the cursor (102).

3 The application fetches the next row through the cursor (105).

4 A separate transaction deletes employee 102 (Whitney) and commits the change.

The results of cursor actions in this situation depend on the cursor sensitivity:

- **Insensitive cursors** The DELETE is not reflected in either the membership or values of the results as seen through the cursor:

Action	Result
Fetch previous row	Returns the original copy of the row (102).
Fetch the first row (absolute fetch)	Returns the original copy of the row (102).
Fetch the second row (absolute fetch)	Returns the unchanged row (105).

- **Sensitive cursors** The membership of the result set has changed so that row 105 is now the first row in the result set:

Action	Result
Fetch previous row	Returns Row Not Found error. There is no previous row.
Fetch the first row (absolute fetch)	Returns row 105.
Fetch the second row (absolute fetch)	Returns row 160.

- **Value-sensitive cursors** The membership of the result set is fixed, and so row 105 is still the second row of the result set. The DELETE is reflected in the values of the cursor, and creates an effective "hole" in the result set.

Action	Result
Fetch previous row	Returns No current row of cursor. There is a hole in the cursor where the first row used to be.
Fetch the first row (absolute fetch)	Returns No current row of cursor. There is a hole in the cursor where the first row used to be.
Fetch the second row (absolute fetch)	Returns row 105.

- **Asensitive cursors** The membership and values of the result set are indeterminate with respect to the changes. The response to a fetch of the previous row, the first row, or the second row depends on the particular optimization method for the query, whether that method involved the formation of a work table, and whether the row being fetched was prefetched from the client.

  The benefit of asensitive cursors is that for many applications, sensitivity is unimportant. In particular, if you are using a forward-only, read-only cursor, no underlying changes are seen. Also, if you are running at a high isolation level, underlying changes are disallowed.

Cursor sensitivity example: an updated row

This example uses a simple query to illustrate how different cursor types respond to a row in the result set being updated in such a way as to change the order of the result set.

Consider the following sequence of events:

1 An application opens a cursor on the following query against the sample database.

```
SELECT emp_id, emp_lname
FROM employee
```

emp_id	emp_lname
102	Whitney
105	Cobb
160	Breault
…	…

2 The application fetches the first row through the cursor (102).

3 The application fetches the next row through the cursor (105).

4 A separate transaction updates the employee ID of employee 102 (Whitney) to 165 and commits the change.

The results of the cursor actions in this situation depend on the cursor sensitivity:

- **Insensitive cursors** The UPDATE is not reflected in either the membership or values of the results as seen through the cursor:

Action	Result
Fetch previous row	Returns the original copy of the row (102).
Fetch the first row (absolute fetch)	Returns the original copy of the row (102).
Fetch the second row (absolute fetch)	Returns the unchanged row (105).

- **Sensitive cursors** The membership of the result set has changed so that row 105 is now the first row in the result set:

Action	Result
Fetch previous row	Returns Row Not Found. The membership of the result set has changed so that 105 is now the first row. The cursor is moved to the position before the first row.
Fetch the first row (absolute fetch)	Returns row 105.
Fetch the second row (absolute fetch)	Returns row 160.

In addition, a fetch on a sensitive cursor returns the warning SQLE_ROW_UPDATED_WARNING if the row has changed since the last reading. The warning is given only once. Subsequent fetches of the same row do not produce the warning.

Similarly, a positioned update or delete through the cursor on a row since it was last fetched returns the SQLE_ROW_UPDATED_SINCE_READ error. An application must fetch the row again for an update or delete on a sensitive cursor to work.

An update to any column causes the warning/error, even if the column is not referenced by the cursor. For example, a cursor on a query returning *emp_lname* would report the update even if only the *salary* column was modified.

- **Value-sensitive cursors** The membership of the result set is fixed, and so row 105 is still the second row of the result set. The DELETE is reflected in the values of the cursor, and creates an effective "hole" in the result set.

Action	Result
Fetch previous row	Returns Row Not Found. The membership of the result set has changed so that 105 is now the first row: The cursor is positioned on the hole: it is before row 105.
Fetch the first row (absolute fetch)	Returns Row Not Found. The membership of the result set has changed so that 105 is now the first row: The cursor is positioned on the hole: it is before row 105.
Fetch the second row (absolute fetch)	Returns row 105.

- **Asensitive cursors** The membership and values of the result set are indeterminate with respect to the changes. The response to a fetch of the previous row, the first row, or the second row depends on the particular optimization method for the query, whether that method involved the formation of a work table, and whether the row being fetched was prefetched from the client.

No warnings or errors in bulk operations mode
Update warning and error conditions do not occur in bulk operations mode (`-b` database server option).

Insensitive cursors

These cursors have insensitive membership, order, and values. No changes made after cursor open time are visible.

Insensitive cursors are used only for read-only cursor types.

Standards

Insensitive cursors correspond to the ISO/ANSI standard definition of insensitive cursors, and to ODBC static cursors.

Programming interfaces

Interface	Cursor type	Comment
ODBC, OLE DB, and ADO	Static	If an updatable static cursor is requested, a value-sensitive cursor is used instead.
Embedded SQL	INSENSITIVE or NO SCROLL	
JDBC	Unsupported	
Open Client	Unsupported	

Description

Insensitive cursors always return rows that match the query's selection criteria, in the order specified by any ORDER BY clause.

The result set of an insensitive cursor is fully materialized as a work table when the cursor is opened. This has the following consequences:

- If the result set is very large, the disk space and memory requirements for managing the result set may be significant.
- No row is returned to the application before the entire result set is assembled as a work table. For complex queries, this may lead to a delay before the first row is returned to the application.
- Subsequent rows can be fetched directly from the work table, and so are returned quickly. The client library may prefetch several rows at a time, further improving performance.
- Insensitive cursors are not affected by ROLLBACK or ROLLBACK TO SAVEPOINT.

Sensitive cursors

These cursors have sensitive membership, order, and values.

Sensitive cursors can be used for read-only or updatable cursor types.

Standards

Sensitive cursors correspond to the ISO/ANSI standard definition of sensitive cursors, and to ODBC dynamic cursors.

Programming interfaces

Interface	Cursor type	Comment
ODBC, OLE DB, and ADO	Dynamic	
Embedded SQL	SENSITIVE	Also supplied in response to a request for a DYNAMIC SCROLL cursor when no work table is required and PREFETCH is off.

Description

All changes are visible through the cursor, including changes through the cursor and from other transactions. Higher isolation levels may hide some changes made in other transactions because of locking.

Changes to cursor membership, order, and all column values are all visible. For example, if a sensitive cursor contains a join, and one of the values of one of the underlying tables is modified, then all result rows composed from that base row show the new value. Result set membership and order may change at each fetch.

Sensitive cursors always return rows that match the query's selection criteria, and are in the order specified by any ORDER BY clause. Updates may affect the membership, order, and values of the result set.

The requirements of sensitive cursors place restrictions on the implementation of sensitive cursors:

- Rows cannot be prefetched, as changes to the prefetched rows would not be visible through the cursor. This may impact performance.
- Sensitive cursors must be implemented without any work tables being constructed, as changes to those rows stored as work tables would not be visible through the cursor.
- The no work table limitation restricts the choice of join method by the optimizer and therefore may impact performance.
- For some queries, the optimizer is unable to construct a plan that does not include a work table that would make a cursor sensitive.

  Work tables are commonly used for sorting and grouping intermediate results. A work table is not needed for sorting if the rows can be accessed through an index. It is not possible to state exactly which queries employ work tables, but the following queries do employ them:

  - UNION queries, although UNION ALL do not necessarily use work tables.
  - Statements with an ORDER BY clause, if there is no index on the ORDER BY column.
  - Any query that is optimized using a hash join.
  - Many queries involving DISTINCT or GROUP BY clauses.

  In these cases, Adaptive Server Anywhere either returns an error to the application, or changes the cursor type to an asensitive cursor and returns a warning.

☞ For more information on query optimization and the use of work tables, see "Query Optimization and Execution" on page 313 of the book *ASA SQL User's Guide*.

Asensitive cursors

These cursors do not have well-defined sensitivity in their membership, order, or values. The flexibility that is allowed in the sensitivity permits asensitive cursors to be optimized for performance.

Asensitive cursors are used only for read-only cursor types.

Standards

Insensitive cursors correspond to the ISO/ANSI standard definition of asensitive cursors, and to ODBC cursors with unspecific sensitivity.

Programming interfaces

Interface	Cursor type
ODBC, OLE DB, and ADO	Unspecified sensitivity
Embedded SQL	DYNAMIC SCROLL

Description

A request for an asensitive cursor places few restrictions on the methods Adaptive Server Anywhere can use to optimize the query and return rows to the application. For these reasons, asensitive cursors provide the best performance. In particular, the optimizer is free to employ any measure of materialization of intermediate results as work tables, and rows can be prefetched by the client.

Adaptive Server Anywhere makes no guarantees about the visibility of changes to base underlying rows. Some changes may be visible, others not. Membership and order may change at each fetch. In particular, updates to base rows may result in only some of the updated columns being reflected in the cursor's result.

Asensitive cursors do not guarantee to return rows that match the query's selection and order. The row membership is fixed at cursor open time, but subsequent changes to the underlying values are reflected in the results.

Asensitive cursors always return rows that matched the customer's WHERE and ORDER BY clauses at the time the cursor membership is established. If column values change after the cursor is opened, rows may be returned that no longer match WHERE and ORDER BY clauses.

Value-sensitive cursors

These cursors are insensitive with respect to their membership, and sensitive with respect to the order and values of the result set.

Value-sensitive cursors can be used for read-only or updatable cursor types.

Standards

Value-sensitive cursors do not correspond to an ISO/ANSI standard definition. They correspond to ODBC keyset-driven cursors.

Programming interfaces

Interface	Cursor type
ODBC, OLE DB, and ADO	Keyset-driven
Embedded SQL	SCROLL
JDBC	Keyset-driven
Open Client	Keyset-driven

Description

If the application fetches a row composed of a base underlying row that has changed, then the application must be presented with the updated value, and the SQL_ROW_UPDATED status must be issued to the application. If the application attempts to fetch a row that was composed of a base underlying row that was deleted, a SQL_ROW_DELETED status must be issued to the application.

Changes to primary key values remove the row from the result set (treated as a delete, followed by an insert). A special case occurs when a row in the result set is deleted (either from cursor or outside) and a new row with the same key value is inserted. This will result in the new row replacing the old row where it appeared.

There is no guarantee that rows in the result set match the query's selection or order specification. Since row membership is fixed at open time, subsequent changes that make a row not match the WHERE clause or ORDER BY do not change a row's membership nor position.

All values are sensitive to changes made through the cursor. The sensitivity of membership to changes made through the cursor is controlled by the ODBC option SQL_STATIC_SENSITIVITY. If this option is on, then inserts through the cursor add the row to the cursor. Otherwise, they are not part of the result set. Deletes through the cursor remove the row from the result set, preventing a hole returning the SQL_ROW_DELETED status.

Value-sensitive cursors use a **key set table**. When the cursor is opened, Adaptive Server Anywhere populates a work table with identifying information for each row contributing to the result set. When scrolling through the result set, the key set table is used to identify the membership of the result set, but values are obtained, if necessary, from the underlying tables.

The fixed membership property of value-sensitive cursors allows your application to remember row positions within a cursor and be assured that these positions will not change. For more information, see "Cursor sensitivity example: a deleted row" on page 29.

- If a row was updated or may have been updated since the cursor was opened, Adaptive Server Anywhere returns a SQLE_ROW_UPDATED_WARNING when the row is fetched. The warning is generated only once: fetching the same row again does not produce the warning.

  An update to any column of the row causes the warning, even if the updated column is not referenced by the cursor. For example, a cursor on *emp_lname* and *emp_fname* would report the update even if only the *birthdate* column was modified. These update warning and error conditions do not occur in bulk operations mode (-b database server option) when row locking is disabled. See "Performance considerations of moving data" on page 422 of the book *ASA SQL User's Guide*.

   For more information, see "Row has been updated since last time read" on page 243 of the book *ASA Errors Manual*

- An attempt to execute a positioned update or delete on a row that has been modified since it was last fetched returns a SQLE_ROW_UPDATED_SINCE_READ error and cancels the statement. An application must FETCH the row again before the UPDATE or DELETE is permitted.

  An update to any column of the row causes the error, even if the updated column is not referenced by the cursor. The error does not occur in bulk operations mode.

   For more information, see "Row has changed since last read -- operation cancelled" on page 244 of the book *ASA Errors Manual*.

- If a row has been deleting after the cursor is opened, either through the cursor or from another transaction, a **hole** is created in the cursor. The membership of the cursor is fixed, so a row position is reserved, but the DELETE operation is reflected in the changed value of the row. If you fetch the row at this hole, you receive a No Current Row of Cursor error (SQL state 24503), indicating that there is no current row, and the cursor is left positioned on the hole. You can avoid holes by using sensitive cursors, as their membership changes along with the values.

For more information, see "No current row of cursor" on page 215 of the book *ASA Errors Manual*.

Rows cannot be prefetched for value-sensitive cursors. This requirement may impact performance in some cases.

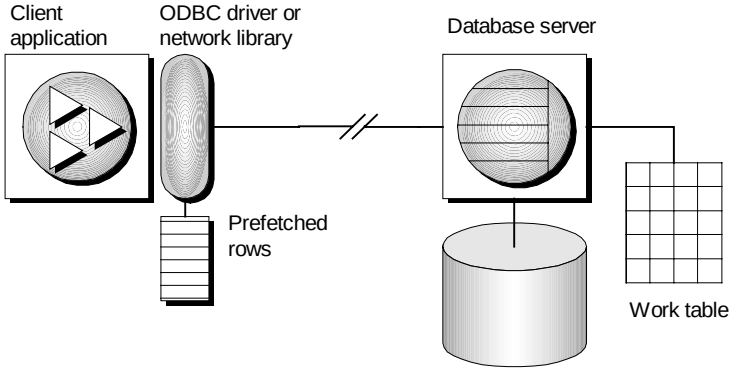
Cursor sensitivity and performance

There is a trade-off between performance and other cursor properties. In particular, making a cursor updatable places restrictions on the cursor query processing and delivery that constrain performance. Also, putting requirements on cursor sensitivity may constrain cursor performance.

To understand how the updatability and sensitivity of cursors affects performance, you need to understand how the results that are visible through a cursor are transmitted from the database to the client application.

In particular, results may be stored at two intermediate locations for performance reasons:

- **Work tables** Either intermediate or final results may be stored as work tables. Value-sensitive cursors employ a work table of primary key values. Query characteristics may also lead the optimizer to use work tables in its chosen execution plan.
- **Prefetching** The client side of the communication may retrieve rows into a buffer on the client side to avoid separate requests to the database server for each row.



Sensitivity and updatability limit the use of intermediate locations.

Any updatable cursor is prevented from using work tables and from prefetching results. If either of these were used, the cursor would be vulnerable to lost updates. The following example illustrates this problem:

1 An application opens a cursor on the following query against the sample database.

```
SELECT id, quantity
FROM product
```

id	quantity
300	28
301	54
302	75
…	…

2 The application fetches the row with *id* = 300 through the cursor.

3 A separate transaction updates the row is updated using the following statement:

```
UPDATE product
SET quantity = quantity - 10
WHERE id = 300
```

4 The application updates the row through the cursor to a value of `(quantity - 5 )`.

5 The correct final value for the row would be 13. If the cursor had prefetched the row, the new value of the row would be 23. The update from the separate transaction is lost.

Similar restrictions govern sensitivity. For more information, see the descriptions of distinct cursor types.

Prefetching rows

Prefetches and multiple-row fetches are different. Prefetches can be carried out without explicit instructions from the client application. Prefetching retrieves rows from the server into a buffer on the client side, but does not make those rows available to the client application until the application fetches the appropriate row.

By default, the Adaptive Server Anywhere client library prefetches multiple rows whenever an application fetches a single row. The Adaptive Server Anywhere client library stores the additional rows in a buffer.

Prefetching assists performance by cutting down on client/server traffic, and increases throughput by making many rows available without a separate request to the server for each row or block of rows.

☞ For more information on controlling prefetches, see "PREFETCH option" on page 592 of the book *ASA Database Administration Guide*.

Controlling prefetching from an application

- The PREFETCH option controls whether or not prefetching occurs. You can set the PREFETCH option to ON or OFF for a single connection. By default, it is set to ON.
- In embedded SQL, you can control prefetching on a per-cursor basis when you open a cursor on an individual FETCH operation using the BLOCK clause.

  The application can specify a maximum number of rows contained in a single fetch from the server by specifying the BLOCK clause.
  For example, if you are fetching and displaying 5 rows at a time, you could use BLOCK 5. Specifying BLOCK 0 fetches 1 record at a time and also causes a FETCH RELATIVE 0 to always fetch the row from the server again.

  Although you can also turn off prefetch by setting a connection parameter on the application, it is more efficient to set BLOCK=0 than to set the PREFETCH option to OFF.

  ☞ For more information, see "PREFETCH option" on page 592 of the book *ASA Database Administration Guide*
- In Open Client, you can control prefetching behavior using **ct_cursor** with CS_CURSOR_ROWS after the cursor is declared, but before it is opened.

Cursor sensitivity and isolation levels

Both cursor sensitivity and transaction isolation levels address the problem of concurrency, but in different ways.

By choosing an isolation level for a transaction (often at the connection level), you determine when locks are placed on rows in the database. Locks prevent other transactions from accessing or modifying values in the database.

By choosing a cursor sensitivity, you determine which changes are visible to the application using the cursor. By setting cursor sensitivity you are not determining when locks are placed on rows in the database, and you do not limit the changes that can be made to the database itself.

Describing result sets

Some applications build SQL statements which cannot be completely specified in the application. In some cases, for example, statements depend on a response from the user before the application knows exactly what information to retrieve, such as when a reporting application allows a user to select which columns to display.

In such a case, the application needs a method for retrieving information about both the nature of the **result set** and the contents of the result set. The information about the nature of the result set, called a **descriptor**, identifies the data structure, including the number and type of columns expected to be returned. Once the application has determined the nature of the result set, retrieving the contents is straightforward.

This **result set metadata** (information about the nature and content of the data) is manipulated using descriptors. Obtaining and managing the result set metadata is called **describing**.

Since cursors generally produce result sets, descriptors and cursors are closely linked, although some interfaces hide the use of descriptors from the user. Typically, statements needing descriptors are either SELECT statements or stored procedures that return result sets.

A sequence for using a descriptor with a cursor-based operation is as follows:

1 Allocate the descriptor. This may be done implicitly, although some interfaces allow explicit allocation as well.

2 Prepare the statement.

3 Describe the statement. If the statement is a stored procedure call or batch, and the result set is not defined by a result clause in the procedure definition, then the describe should occur after opening the cursor.

4 Declare and open a cursor for the statement (embedded SQL) or execute the statement.

5 Get the descriptor and modify the allocated area if necessary. This is often done implicitly.

6 Fetch and process the statement results.

7 Deallocate the descriptor.

8 Close the cursor.

9 Drop the statement. Some interfaces do this automatically.

Implementation notes

- In embedded SQL, a SQLDA (SQL Descriptor Area) structure holds the descriptor information.

  For more information, see "The SQL descriptor area (SQLDA)" on page 206.

- In ODBC, a descriptor handle allocated using **SQLAllocHandle** provides access to the fields of a descriptor. You can manipulate these fields using **SQLSetDescRec**, **SQLSetDescField**, **SQLGetDescRec**, and **SQLGetDescField**.

  Alternatively, you can use **SQLDescribeCol** and **SQLColAttributes** to obtain column information.

- In Open Client, you can use **ct_dynamic** to prepare a statement and **ct_describe** to describe the result set of the statement. However, you can also use **ct_command** to send a SQL statement without preparing it first and use **ct_results** to handle the returned rows one by one. This is the more common way of operating in Open Client application development.

- In JDBC, the **java.SQL.ResultSetMetaData** class provides information about result sets.

- You can also use descriptors for sending data to the engine (for example, with the INSERT statement); however, this is a different kind of descriptor than for result sets.

  For more information about input and output parameters of the DESCRIBE statement, see the "DESCRIBE statement [ESQL]" on page 392 of the book *ASA SQL Reference Manual*.

Controlling transactions in applications

Transactions are sets of atomic SQL statements. Either all statements in the transaction are executed, or none. This section describes a few aspects of transactions in applications.

For more information about transactions, see "Using Transactions and Isolation Levels" on page 89 of the book *ASA SQL User's Guide*.

Setting autocommit or manual commit mode

Database programming interfaces can operate in either **manual commit** mode or **autocommit** mode.

- **Manual commit mode** Operations are committed only when your application carries out an explicit commit operation or when the database server carries out an automatic commit, for example when executing an ALTER TABLE statement or other data definition statement. Manual commit mode is also sometimes called **chained mode**.

  To use transactions in your application, including nested transactions and savepoints, you must operate in manual commit mode.

- **Autocommit mode** Each statement is treated as a separate transaction. Autocommit mode is equivalent to appending a COMMIT statement to the end of each of your commands. Autocommit mode is also sometimes called **unchained mode**.

Autocommit mode can affect the performance and behavior of your application. Do not use autocommit if your application requires transactional integrity.

For information on autocommit impact on performance, see "Turn off autocommit mode" on page 149 of the book *ASA SQL User's Guide*.

Controlling autocommit behavior

The way to control the commit behavior of your application depends on the programming interface you are using. The implementation of autocommit may be client-side or server-side, depending on the interface.

For more information, see "Autocommit implementation details" on page 45.

❖ **To control autocommit mode (ODBC):**

♦ By default, ODBC operates in autocommit mode. The way you turn off autocommit depends on whether you are using ODBC directly, or using an application development tool. If you are programming directly to the ODBC interface, set the SQL_ATTR_AUTOCOMMIT connection attribute.

❖ **To control autocommit mode (JDBC):**

♦ By default, JDBC operates in autocommit mode. To turn off autocommit, use the **setAutoCommit** method of the connection object:

```
conn.setAutoCommit( false );
```

❖ **To control autocommit mode (Open Client):**

♦ By default, a connection made through Open Client operates in autocommit mode. You can change this behavior by setting the CHAINED database option to ON in your application using a statement such as the following:

```
SET OPTION CHAINED='ON'
```

❖ **To control autocommit mode (embedded SQL):**

♦ By default, embedded SQL applications operate in manual commit mode. To turn on autocommit, set the CHAINED database option to OFF using a statement such as the following:

```
SET OPTION CHAINED='OFF'
```

Autocommit implementation details

The previous section, "Controlling autocommit behavior" on page 44, describes how autocommit behavior can be controlled from each of the Adaptive Server Anywhere programming interfaces. Autocommit mode has slightly different behavior depending on the interface you are using and how you control the autocommit behavior.

Autocommit mode can be implemented in one of two ways:

♦ **Client-side autocommit** When an application uses autocommit, the client-library sends a COMMIT statement after each SQL statement executed.

Adaptive Server Anywhere uses client-side autocommit for ODBC and OLE DB applications.

- **Server-side autocommit** When an application uses autocommit, the database server issues a commit after each SQL statement. This behavior is controlled, implicitly in the case of JDBC, by the CHAINED database option.

  Adaptive Server Anywhere uses server-side autocommit for embedded SQL, JDBC, and Open Client applications.

There is a difference between client-side and server-side autocommit in the case of compound statements such as stored procedures or triggers. From the client side, a stored procedure is a single statement, and so autocommit sends a single commit statement after the whole procedure is executed. From the database server perspective, the stored procedure may be composed of many SQL statements, and so server-side autocommit issues a COMMIT after each SQL statement within the procedure.

Do not mix client-side and server-side implementations
Do not combine use of the CHAINED option with autocommit in your ODBC or OLE DB application.

Controlling the isolation level

You can set the isolation level of a current connection using the ISOLATION_LEVEL database option.

Some interfaces, such as ODBC, allow you to set the isolation level for a connection at connection time. You can reset this level later using the ISOLATION_LEVEL database option.

Cursors and transactions

In general, a cursor closes when a COMMIT is performed. There are two exceptions to this behavior:

- The CLOSE_ON_ENDTRANS database option is set to OFF.
- A cursor is opened WITH HOLD, which is the default with Open Client and JDBC.

If either of these two cases is true, the cursor remains open on a COMMIT.

ROLLBACK and cursors

If a transaction rolls back, then cursors close except for those cursors opened WITH HOLD. However, don't rely on the contents of any cursor after a rollback.

The draft ISO SQL3 standard states that on a rollback, all cursors (even those cursors opened WITH HOLD) should close. You can obtain this behavior by setting the ANSI_CLOSE_CURSORS_AT_ROLLBACK option to ON.

Savepoints

If a transaction rolls back to a savepoint, and if the ANSI_CLOSE_CURSORS_AT_ROLLBACK option is ON, then all cursors (even those cursors opened WITH HOLD) opened after the SAVEPOINT close.

Cursors and isolation levels

You can change the isolation level of a connection during a transaction using the SET OPTION statement to alter the ISOLATION_LEVEL option. However, this change affects only closed cursors.

CHAPTER 3

Introduction to Java in the Database

About this chapter

This chapter provides motivation and concepts for using Java in the database.

Adaptive Server Anywhere is a runtime environment for Java. Java provides a natural extension to SQL, turning Adaptive Server Anywhere into a platform for the next generation of enterprise applications.

Contents

Introduction

Adaptive Server Anywhere is a **runtime environment for Java**. This means that Java classes can be executed in the database server. Building a runtime environment for Java classes into the database server provides powerful new ways of managing and storing data and logic.

Java in the database offers the following:

- You can reuse Java components in the different layers of your application—client, middle-tier, or server—and use them wherever makes the most sense to you. Adaptive Server Anywhere becomes a platform for distributed computing.
- Java is a more powerful language than stored procedures for building logic into the database.
- Java classes become rich user-defined data types.
- Methods of Java classes provide new functions accessible from SQL.
- Java can be used in the database without jeopardizing the integrity, security, and robustness of the database.

Separately-licensable component

Java in the database is a separately licensable component and must be ordered before you can install it. To order this component, see the card in your SQL Anywhere Studio package or see http://www.sybase.com/detail?id=1015780.

The SQLJ standard

Java in the database is based on the SQLJ Part 1 and SQLJ Part 2 proposed standards. SQLJ Part 1 provides specifications for calling Java static methods as SQL stored procedures and user-defined functions. SQLJ Part 2 provides specifications for using Java classes as SQL domains.

Learning about Java in the database

Java is a relatively new programming language with a growing, but still limited, knowledge base. Intended for a variety of Java developers, this documentation will be useful for everyone from the experienced Java developer to the many readers who are unfamiliar with the language, its possibilities, syntax, and use.

For those readers familiar with Java, there is much to learn about using Java in a database. Adaptive Server Anywhere not only extends the capabilities of the database with Java, but also extends the capabilities of Java with the database.

Java documentation

The following table outlines the documentation regarding the use of Java in the database.

Title	Purpose
"Introduction to Java in the Database" on page 49 (this chapter)	Java concepts and how to apply them in Adaptive Server Anywhere.
"Using Java in the Database" on page 85	Practical steps to using Java in the database.
"Data Access Using JDBC" on page 129	Accessing data from Java classes, including distributed computing.
"Debugging Logic in the Database" on page 571 of the book *ASA SQL User's Guide*	Testing and debugging Java code running in the database.
Adaptive Server Anywhere Reference.	The *Reference Manual* includes material on the SQL extensions that support Java in the database.
Reference guide to Sun's Java API	Online guide to Java API classes, fields and methods. Available as Windows Help only.
Thinking in Java by Bruce Eckel.	Online book that teaches how to program in Java. Supplied in Adobe PDF format in the *Samples\ASA\Java* subdirectory of your SQL Anywhere directory.

Using the Java documentation

The following table is a guide to which parts of the Java documentation apply to you, depending on your interests and background. It is a guide only and should not limit your efforts to learn more about Java in the database.

If you ...	Consider reading ...
Are new to object-oriented programming.	"A Java seminar" on page 59
	Thinking in Java by Bruce Eckel.
Want an explanation of terms such as instantiated, field, and class method.	"A Java seminar" on page 59
Are a Java developer who wants to just get started.	"The runtime environment for Java in the database" on page 69
	"Tutorial: A Java in the database exercise" on page 77
Want to know the key features of Java in the database.	"Java in the database Q & A" on page 53
Want to find out how to access data from Java.	"Data Access Using JDBC" on page 129
Want to prepare a database for Java.	"Java-enabling a database" on page 89
Want a complete list of supported Java APIs.	"Java class data types" on page 77 of the book *ASA SQL Reference Manual*
Are trying to use a Java API class and need Java reference information.	The online guide to Java API classes (Windows Help only)
Want to see an example of distributed computing.	"Creating distributed applications" on page 158

Java in the database Q & A

This section describes the key features of Java in the database.

What are the key features of Java in the database?

Detailed explanations of all the following points appear in later sections.

- **You can run Java in the database server** An internal Java Virtual Machine (VM) runs Java code in the database server.
- **You can call Java from SQL** You can call Java functions (methods) from SQL statements. Java methods provide a more powerful language than SQL stored procedures for adding logic to the database.
- **You can access data from Java** An internal JDBC driver lets you access data from Java.
- **You can debug Java in the database** You can use the Sybase debugger to test and debug your Java classes in the database.
- **You can use Java classes as data types** Every Java class installed in a database becomes available as a data type that can be used as the data type of a column in a table or a variable.
- **You can save Java objects in tables** An instance of a Java class (a Java object) can be saved as a value in a table. You can insert Java objects into a table, execute SELECT statements against the fields and methods of objects stored in a table, and retrieve Java objects from a table.

  With this ability, Adaptive Server Anywhere becomes an object-relational database, supporting objects while not degrading existing relational functionality.
- **SQL is preserved** The use of Java does not alter the behavior of existing SQL statements or other aspects of non-Java relational database behavior.

How do I store Java instructions in the database?

Java is an object-oriented language, so its instructions (source code) come in the form of classes. To execute Java in a database, you write the Java instructions outside the database and compile them outside the database into compiled classes (**byte code**) which are binary files holding Java instructions.

You then install these compiled classes into a database. Once installed, you can execute these classes in the database server.

Adaptive Server Anywhere is a runtime environment for Java classes, not a Java development environment. You need a Java development environment, such as Sybase PowerJ or the Sun Microsystems Java Development Kit, to write and compile Java.

For more information, see "Installing Java classes into a database" on page 94.

How does Java get executed in a database?

Adaptive Server Anywhere includes a **Java Virtual Machine** (**VM**) which runs in the database environment. The Sybase Java VM interprets compiled Java instructions and runs them in the database server.

In addition to the VM, the SQL request processor in the database server has been extended so it can call into the VM to execute Java instructions. It can also process requests from the VM to enable data access from Java.

Differences from a standalone VM

There is a difference between executing Java code using a standard VM such as the Sun Java VM *java.exe* and executing Java code in the database. The Sun VM runs from a command line, while the Adaptive Server Anywhere Java VM is available at all times to perform a Java operation whenever it is required as part of the execution of a SQL statement.

You cannot access the Sybase Java interpreter externally. It is only used when the execution of a SQL statement requires a Java operation to take place. The database server starts the VM automatically when needed: you do not have to take any explicit action to start or stop the VM.

Why Java?

Java provides a number of features that make it ideal for use in the database:

- Thorough error checking at compile time.
- Built-in error handing with a well-defined error handling methodology.
- Built-in garbage collection (memory recovery).
- Elimination of many bug-prone programming techniques.
- Strong security features.
- Java code is interpreted, so no operations get executed without being acceptable to the VM.

On what platforms is Java in the database supported?

Java in the database is not supported on Windows CE. It is supported on other Windows operating systems, UNIX, and NetWare.

How do I use Java and SQL together?

A guiding principle for the design of Java in the database is that it provides a natural, open extension to existing SQL functionality.

- **Java operations are invoked from SQL** Sybase has extended the range of SQL expressions to include properties and methods of Java objects, so you can include Java operations in a SQL statement.
- **Java classes become domains** You store Java classes using the same SQL statements as those used for traditional SQL data types.

You can use many of the classes that are part of the Java API as included in the Sun Microsystems Java Development Kit. You can also use classes created and compiled by Java developers.

What is the Java API?

The Java Application Programmer's Interface (API) is a set of classes created by Sun Microsystems. It provides a range of base functionality that can be used and extended by Java developers. It is at the core of what you can do with Java.

The Java API offers a tremendous amount of functionality in its own right. A large portion of the Java API is available to any database able to use Java code. This exposes the majority of non-visual classes from the Java API that should be familiar to developers currently using the Sun Microsystems Java Development Kit (JDK).

For more information about supported Java APIs, see "Supported Java packages" on page 77 of the book *ASA SQL Reference Manual*.

How do I access Java from SQL?

In addition to using the Java API in classes, you can use it in stored procedures and SQL statements. You can treat the Java API classes as extensions to the available built-in functions provided by SQL.

For example, the SQL function PI(*) returns the value for pi. The Java API class **java.lang.Math** has a parallel field named PI returning the same value. But **java.lang.Math** also has a field named E that returns the base of the natural logarithms, as well as a method that computes the remainder operation on two arguments as prescribed by the IEEE 754 standard.

Other members of the Java API offer even more specialized functionality. For example, **java.util.Stack** generates a last-in, first-out queue that can store ordered lists; **java.util.HashTable** maps values to keys; **java.util.StringTokenizer** breaks a string of characters into individual word units.

For more information, see "Inserting, updating, and deleting Java objects" on page 101.

Which Java classes are supported?

The database does not support all Java API classes. Some classes, for example the *java.awt* package containing user interface components for applications, are inappropriate inside a database server. Other classes, including parts of *java.io*, deal with writing information to disk, and this also is unsupported in the database server environment.

For more information about supported and unsupported classes, see "Supported Java packages" on page 77 of the book *ASA SQL Reference Manual* and "Unsupported Java packages and classes" on page 78 of the book *ASA SQL Reference Manual*.

How can I use my own Java classes in databases?

You can install your own Java classes into a database. For example, a developer could design, write in Java, and compile with a Java compiler a user-created Employee class or Package class.

User-created Java classes can contain both information about the subject and some computational logic. Once installed in a database, Adaptive Server Anywhere lets you use these classes in all parts and operations of the database and execute their functionality (in the form of class or instance methods) as easily as calling a stored procedure.

Java classes and stored procedures are different
Java classes are different from stored procedures. Whereas stored procedures are written in SQL, Java classes provide a more powerful language, and can be called from client applications as easily and in the same way as stored procedures.

When a Java class gets installed in a database, it becomes available as a new domain. You can use a Java class in any situation where you would use built-in SQL data types: as a column type in a table or as a variable type.

For example, if a class called **Address** has been installed into a database, a column in a table called **Addr** can be of type **Address**, which means only objects based on the **Address** class can be saved as row values for that column.

For more information, see "Installing Java classes into a database" on page 94.

Can I access data using Java?

The JDBC interface is an industry standard, designed specifically to access database systems. The JDBC classes are designed to connect to a database, request data using SQL statements, and return result sets that can be processed in the client application.

Normally, client applications use JDBC classes, and the database system vendor supplies a JDBC driver that allows the JDBC classes to establish a connection.

You can connect from a client application to Adaptive Server Anywhere via JDBC, using jConnect or a JDBC/ODBC bridge. Adaptive Server Anywhere also provides an internal JDBC driver which permits Java classes installed in a database to use JDBC classes that execute SQL statements.

For more information, see "Data Access Using JDBC" on page 129.

Can I move classes from client to server?

You can create Java classes that can be moved between levels of an enterprise application. The same Java class can be integrated into either the client application, a middle tier, or the database—wherever is most appropriate.

You can move a class containing business logic, data, or a combination of both to any level of the enterprise system, including the server, allowing you complete flexibility to make the most appropriate use of resources. It also enables enterprise customers to develop their applications using a single programming language in a multi-tier architecture with unparalleled flexibility.

Can I create distributed applications?

You can create an application that has some pieces operating in the database and some on the client machine. You can pass Java objects from the server to the client just as you pass SQL data such as character strings and numeric values.

For more information, see "Creating distributed applications" on page 158.

What can I not do with Java in the database?

Adaptive Server Anywhere is a runtime environment for Java classes, not a Java development environment.

You cannot carry out the following tasks in the database:

- Edit class source files (**.java* files).
- Compile Java class source files (**.java* files).
- Execute unsupported Java APIs, such as applet and visual classes.
- Execute Java methods that require the execution of native methods. All user classes installed into the database must be 100% Java.

The Java classes used in Adaptive Server Anywhere must be written and compiled using a Java application development tool, and then installed into a database for use, testing, and debugging.

A Java seminar

This section introduces key Java concepts. After reading this section you should be able to examine Java code, such as a simple class definition or the invocation of a method, and understand what is taking place.

Java samples directory
Some of the classes used as examples in this manual are located in the Java samples directory, which is the *Samples\ASA\Java* subdirectory of your SQL Anywhere directory.

Two files represent each Java class example: the Java source and the compiled class. You can immediately install to a database (without modification) the compiled version of the Java class examples.

Understanding Java classes

A Java class combines data and functionality—the ability to hold information and perform computational operations. One way of understanding the concept of a class is to view it as an entity, an abstract representation of a thing.

You could design an Invoice class, for example, to mimic paper invoices, such as those used every day in business operations. Just as a paper invoice contains certain information (line-item details, who is being invoiced, the date, payment amount, payment due-date), so also does an instance of an Invoice class. Classes hold information in fields.

In addition to describing data, a class can make calculations and perform logical operations. For example, the Invoice class could calculate the tax on a list of line items for every Invoice object, and add it to the sub total to produce a final total, without any user intervention. Such a class could also ensure all essential pieces of information are present in the Invoice and even indicate when payment is over due or partially paid. Calculations and other logical operations are carried out by the *methods* of the class.

Example

The following Java code declares a class called Invoice. This class declaration would be stored in a file named *Invoice.java*, and then compiled into a Java class using a Java compiler.

Compiling Java classes
Compiling the source for a Java class creates a new file with the same name as the source file, but with a different extension. Compiling *Invoice.java* creates a file called *Invoice.class* which could be used in a Java application and executed by a Java VM.

The Sun JDK tool for compiling class declarations is *javac.exe*.

```
public class Invoice {
  // So far, this class does nothing and knows nothing
}
```

The **class** keyword is used, followed by the name of the class. There is an opening and closing brace: everything declared between the braces, such as fields and methods, becomes part of the class.

In fact, no Java code exists outside class declarations. Even the Java procedure that a Java interpreter runs automatically to create and manage other objects—the **main** method that is often the start of your application—is itself located within a class declaration.

Subclasses in Java

You can define classes as **subclasses** of other classes. A class that is a subclass of another class can use the fields and method of its parent: this is called **inheritance**. You can define additional methods and fields that apply only to the subclass, and redefine the meaning of inherited fields and methods.

Java is a single-hierarchy language, meaning that all classes you create or use eventually inherit from one class. This means the low-level classes (classes further up in the hierarchy) must be present before higher-level classes can be used. The base set of classes required to run Java applications is called the **runtime Java classes**, or the **Java API**.

Understanding Java objects

A **class** is a template that defines what an object is capable of doing, just as an invoice form is a template that defines what information the invoice should contain.

Classes contain no specific information about objects. Rather, your application creates, or **instantiates**, objects based on the class (template), and the objects hold the data or perform calculations. The instantiated object is an **instance** of the class. For example, an Invoice object is an instance of the Invoice class. The class defines what the object is capable of but the object is the incarnation of the class that gives the class meaning and usefulness.

In the invoice example, the invoice form defines what all invoices based on that form can accomplish. There is one form and zero or many invoices based on the form. The form contains the definition but the invoice encapsulates the usefulness.

The Invoice object is created, stores information, is stored, retrieved, edited, updated, and so on.

Just as one invoice template can create many invoices, with each invoice separate and distinct from the other in its details, you can generate many objects from one class.

Methods and fields

A **method** is a part of a class that does something—a function that performs a calculation or interacts with other objects—on behalf of the class. Methods can accept arguments, and return a value to the calling function. If no return value is necessary, a method can return **void**. Classes can have any number of methods.

A **field** is a part of a class that holds information. When you create an object of type *JavaClass*, the fields in *JavaClass* hold the state unique to that object.

Class constructors

You create an object by invoking a class constructor. A **constructor** is a method that has the following properties:

- A constructor method has the same name as the class, and has no declared data type. For example, a simple constructor for the Product class would be declared as follows:

```
Product () {
...constructor code here...
}
```

- If you include no constructor method in your class definition, a default method is used that is provided by the Java base object.
- You can supply more than one constructor for each class, with different numbers and types of arguments. When a constructor is invoked, the one with the proper number and type of arguments is used.

Understanding fields

There are two categories of Java fields:

- **Instance fields** Each object has its own set of instance fields, created when the object was created. They hold information specific to that instance. For example, a **lineItem1Description** field in the Invoice class holds the description for a line item on a particular invoice. You can access instance fields only through an object reference.
- **Class fields** A class field holds information that is independent of any particular instance. A class field is created when the class is first loaded, and no further instances are created no matter how many objects are created. Class fields can be accessed either through the class name or the object reference.

To declare a field in a class, state its type, then its name, followed by a semicolon. To declare a class field, use the **static** Java keyword in the declaration. You declare fields in the body of the class and not within a method; declaring a variable within a method makes it a part of the method, not of the class.

Examples

The following declaration of the class Invoice has four fields, corresponding to information that might be contained on two line items on an invoice.

```
public class Invoice {

    // Fields of an invoice contain the invoice data
    public String lineItem1Description;
    public int lineItem1Cost;

    public String lineItem2Description;
    public int lineItem2Cost;

}
```

Understanding methods

There are two categories of Java methods:

- **Instance methods** A **totalSum** method in the Invoice class could calculate and add the tax, and return the sum of all costs, but would only be useful if it is called in conjunction with an **Invoice** object, one that had values for its line item costs. The calculation can only be performed for an object, since the object (not the class) contains the line items of the invoice.

- **Class methods** Class methods (also called **static methods**) can be invoked without first creating an object. Only the name of the class and method is necessary to invoke a class method.

  Similar to instance methods, class methods accept arguments and return values. Typically, class methods perform some sort of utility or information function related to the overall functionality of the class.

  Class methods cannot access instance fields.

To declare a method, you state its return type, its name and any parameters it takes. Like a class declaration, the method uses an opening and closing brace to identify the body of the method where the code goes.

```
public class Invoice {

    // Fields
    public String lineItem1Description;
    public double lineItem1Cost;

    public String lineItem2Description;
    public double lineItem2Cost;

    // A method
    public double totalSum() {
        double runningsum;

        runningsum = lineItem1Cost + lineItem2Cost;
        runningsum = runningsum * 1.15;

        return runningsum;
    }
}
```

Within the body of the **totalSum** method, a variable named **runningsum** is declared. First, this holds the sub total of the first and second line item cost. This sub total is then multiplied by 15 per cent (the rate of taxation) to determine the total sum.

The local variable (as it is known within the method body) is then returned to the calling function. When you invoke the **totalSum** method, it returns the sum of the two line item cost fields plus the cost of tax on those two items.

Example

The **parseInt** method of the **java.lang.Integer** class, which is supplied with Adaptive Server Anywhere, is one example of a class method. When given a string argument, the **parseInt** method returns the integer version of the string.

For example given the string value "1", the **parseInt** method returns 1, the integer value, without requiring an instance of the **java.lang.Integer** class to first be created, as illustrated by this Java code fragment:

```
String num = "1";
int i = java.lang.Integer.parseInt( num );
```

Example

The following version of the Invoice class now includes both an instance method and a class method. The class method named **rateOfTaxation** returns the rate of taxation used by the class to calculate the total sum of the invoice.

The advantage of making the **rateOfTaxation** method a class method (as opposed to an instance method or field) is that other classes and procedures can use the value returned by this method without having to create an instance of the class first. Only the name of the class and method is required to return the rate of taxation used by this class.

Making **rateofTaxation** a method, as opposed to a field, allows the application developer to change how the rate is calculated without adversely affecting any objects, applications, or procedures that use its return value. Future versions of Invoice could make the return value of the **rateOfTaxation** class method based on a more complicated calculation without affecting other methods that use its return value.

```
public class Invoice {
    // Fields
    public String lineItem1Description;
    public double lineItem1Cost;
    public String lineItem2Description;
    public double lineItem2Cost;
    // An instance method
    public double totalSum() {
        double runningsum;
        double taxfactor = 1 + Invoice.rateOfTaxation();

        runningsum = lineItem1Cost + lineItem2Cost;
        runningsum = runningsum * taxfactor;

        return runningsum;
    }
    // A class method
    public static double rateOfTaxation() {
        double rate;
        rate = .15;

        return rate;
    }
}
```

Object oriented and procedural languages

If you are more familiar with procedural languages such as C, or the SQL stored procedure language, than object-oriented languages, this section explains some of the key similarities and differences between procedural and object-oriented languages.

Java is based on classes

The main structural unit of code in Java is a **class**.

A Java class could be looked at as just a collection of procedures and variables that have been grouped together because they all relate to a specific, identifiable category.

However the manner in which a class gets used sets object-oriented languages apart from procedural languages. When an application written in a procedural language is executed, it is typically loaded into memory once and takes the user down a pre-defined course of execution.

In object-oriented languages such as Java, a class is used like a template: a definition of potential program execution. Multiple copies of the class can be created and loaded dynamically, as needed, with each instance of the class capable of containing its own data, values, and course of execution. Each loaded class could be acted on or executed independently of any other class loaded into memory.

A class that is loaded into memory for execution is said to have been instantiated. An instantiated class is called an object: it is an application derived from the class that is prepared to hold unique values or have its methods executed in a manner independent of other class instances.

A Java glossary

The following items outline some of the details regarding Java classes. It is by no means an exhaustive source of knowledge about the Java language, but may aid in the use of Java classes in Adaptive Server Anywhere.

For more information about the Java language, see the online book *Thinking in Java*, by Bruce Eckel, included with Adaptive Server Anywhere in the file *Samples\ASA\Java\Tjava.pdf*.

Packages

A **package** is a grouping of classes that share a common purpose or category. One member of a package has special privileges to access data and methods in other members of the package, hence the **protected** access modifier.

A package is the Java equivalent of a library. It is a collection of classes which can be made available using the **import** statement. The following Java statement imports the utility library from the Java API:

```
import java.util.*
```

Packages are typically held in JAR files, which have the extension *.jar* or *.zip*.

Public versus private

An access modifier determines the visibility (essentially the **public**, **private**, or **protected** keyword used in front of any declaration) of a field, method or class to other Java objects.

- A **public** class, method, or field is visible everywhere.
- A **private** class, method, or field is visible only in methods defined within that class.
- A **protected** method or field is visible to methods defined within that class, within sublclasses of the class, or within other classes in the same package.
- The default visibility, known as package, means that the method or field is visible within the class and to other classes in the same package.

Constructors

A constructor is a special method of a Java class that is called when an instance of the class is created.

Classes can define their own constructors, including multiple, overriding constructors. Which arguments were used in the attempt to create the object determine which constructor is used. When the type, number, and order of arguments used to create an instance of the class match one of the class's constructors, that constructor is used when creating the object.

Garbage collection

Garbage collection automatically removes any object with no references to it, with the exception of objects stored as values in a table.

There is no such thing as a destructor method in Java (as there is in C++). Java classes can define their own **finalize** method for clean up operations when an object is discarded during garbage collection.

Interfaces

Java classes can inherit only from one class. Java uses interfaces instead of multiple-inheritance. A class can implement multiple interfaces. Each **interface** defines a set of methods and method profiles that must be implemented by the class for the class to be compiled.

An interface defines what methods and static fields the class must declare. The implementation of the methods and fields declared in an interface is located within the class that uses the interface: the interface defines what the class must declare; it is up to the class to determine how it is implemented.

Java error handling

Java error handling code is separate from the code for normal processing.

Errors generate an exception object representing the error. This is called **throwing an exception**. A thrown exception terminates a Java program unless it is caught and handled properly at some level of the application.

Both Java API classes and custom-created classes can throw exceptions. In fact, users can create their own exception classes which throw their own custom-created classes.

If there is no exception handler in the body of the method where the exception occurred, then the search for an exception handler continues up the call stack. If the top of the call stack is reached and no exception handler has been found, the default exception handler of the Java interpreter running the application is called and the program terminates.

In Adaptive Server Anywhere, if a SQL statement calls a Java method, and an unhandled exception is thrown, a SQL error is generated.

Error types in Java

All errors in Java come from two types of error classes: **Exception** and **Error**. Usually, Exception-based errors are handled by error handling code in your method body. Error type errors are specifically for internal errors and resource exhaustion errors inside the Java run-time system.

Exception class errors are thrown and caught. Exception handling code is characterized by **try**, **catch**, and **finally** code blocks.

A **try** block executes code that may generate an error. A **catch** block is code that executes if the execution of a **try** block generates (or throws) an error.

A **finally** block defines a block of code that executes regardless of whether an error was generated and caught and is typically used for cleanup operations. It is used for code that, under no circumstances, can be omitted.

There are two types of exception class errors: those that are runtime exceptions and those that are not runtime exceptions.

Errors generated by the runtime system are known as implicit exceptions, in that they do not have to be explicitly handled as part of every class or method declaration.

For example, an array out of bounds exception can occur whenever an array is used, but the error does not have to be part of the declaration of the class or method that uses the array.

All other exceptions are explicit. If the method being invoked can throw an error, it must be explicitly caught by the class using the exception-throwing method, or this class must explicitly throw the error itself by identifying the exception it may generate in its class declaration. Essentially, explicit exceptions must be dealt with explicitly. A method must declare all the explicit errors it throws, or catch all the explicit errors that may potentially be thrown.

Non-runtime exceptions are checked at compile time. Runtime exceptions are usually caused by errors in programming. Java catches many such errors during compilation, before running the code.

Every Java method is given an alternative path of execution so that all Java methods complete, even if they are unable to complete normally. If the type of error thrown is not caught, it's passed to the next code block or method in the stack.

The runtime environment for Java in the database

This section describes the Sybase runtime environment for Java, and how it differs from a standard Java runtime environment.

Supported versions of Java and JDBC

The Sybase Java VM provides you with the choice of using the JDK 1.1, JDK 1.2, or JDK 1.3 programming interfaces. The specific versions provided are JDK versions 1.1.8 and 1.3.

Between release 1.0 of the JDK and release 1.1, several new APIs were introduced. As well, a number were deprecated—the use of certain APIs became no longer recommended and support for them may be dropped in future releases.

A Java class file using deprecated APIs generates a warning when compiled, but does still execute on a Java virtual machine built to release 1.1 standards, such as the Sybase VM.

The internal JDBC driver supports JDBC version 2.

For more information on the JDK APIs that are supported, please see "Supported Java packages" on page 77 of the book *ASA SQL Reference Manual*.

For information on how to create a database that supports Java, see "Java-enabling a database" on page 89.

The runtime Java classes

The runtime Java classes are the low-level classes that are made available to a database when it is created or Java-enabled. These classes include a subset of the Java API. These classes are part of the Sun Java Development Kit.

The runtime classes provide basic functionality on which to build applications. The runtime classes are always available to classes in the database.

You can incorporate the runtime Java classes in your own user-created classes: either inheriting their functionality or using it within a calculation or operation in a method.

Examples

Some Java API classes included in the runtime Java classes include:

- **Primitive Java data types** All primitive (native) data types in Java have a corresponding class. In addition to being able to create objects of these types, the classes have additional, often useful, functionality.

  The Java **int** data type has a corresponding class in **java.lang.Integer**.

- **The utility package** The package **java.util.*** contains a number of very helpful classes whose functionality has no parallel in the SQL functions available in Adaptive Server Anywhere.

  Some of the classes include:

  - **Hashtable** which maps keys to values.
  - **StringTokenizer** which breaks a String down into individual words.
  - **Vector** which holds an array of objects whose size can change dynamically
  - **Stack** which holds a last-in, first-out stack of objects.

- **JDBC for SQL operations** The package **java.SQL.*** contains the classes needed by Java objects to extract data from the database using SQL statements.

Unlike user-defined classes, the runtime classes are not stored in the database. Instead, they are stored in files in the *java* subdirectory of the Adaptive Server Anywhere installation directory.

User-defined classes

User-defined classes are installed into a database using the INSTALL statement. Once installed, they become available to other classes in the database. If they are public classes, they are available from SQL as domains.

For more information about installing classes, see "Installing Java classes into a database" on page 94.

Identifying Java methods and fields

The dot in SQL

In SQL statements, the dot identifies columns of tables, as in the following query:

```
SELECT employee.emp_id
FROM employee
```

The dot also indicates object ownership in qualified object names:

```
SELECT emp_id
FROM DBA.employee
```

The dot in Java

In Java, the dot is an **operator** that invokes the methods or access for the fields of a Java class or object. It is also part of an identifier, used to identify class names, as in the fully qualified class name **java.util.Hashtable**.

In the following Java code fragment, the dot is part of an identifier on the first line of code. On the second line of code, it is an operator.

```
java.util.Random rnd = new java.util.Random();
int i = rnd.nextInt();
```

Invoking Java methods from SQL

In SQL, the dot operator can be replaced with the double right angle bracket (>>). The dot operator is more Java-like, but can lead to ambiguity with respect to existing SQL names. The use of >> removes this ambiguity.

>> in SQL is not the same as >> in Java
You can only use the double right angle bracket operator in SQL statements where a Java dot operator is otherwise expected. Within a Java class, the double right angle bracket is not a replacement for the dot operator and has a completely different meaning in its role as the right bit shift operator.

For example, the following batch of SQL statements is valid:

```
CREATE VARIABLE rnd java.util.Random;
SET rnd = NEW java.util.Random();
SELECT rnd>>nextInt();
```

The result of the SELECT statement is a randomly generated integer.

Using the variable created in the previous SQL code example, the following SQL statement illustrates the correct use of a class method:

```
SELECT java.lang.Math>>abs( rnd>>nextInt() );
```

Java is case sensitive

Java syntax works as you would expect it to, and SQL syntax is unaltered by the presence of Java classes. This is true even if the same SQL statement contains both Java and SQL syntax. It's a simple statement, but with far-reaching implications.

Java is case sensitive. The Java class **FindOut** is a completely different class from the class **Findout**. SQL is case insensitive with respect to keywords and identifiers.

Java case sensitivity is preserved even when embedded in a SQL statement that is case insensitive. The Java parts of the statement must be case sensitive, even though the parts previous to and following the Java syntax can be in either upper or lower case.

For example, the following SQL statements successfully execute because the case of Java objects, classes, and operators is respected even though there is variation in the case of the remaining SQL parts of the statement.

```
SeLeCt java.lang.Math.random();
```

Data types

When you use a Java class as a data type for a column, it is a user-defined SQL data type. However, it is still case sensitive. This convention prevents ambiguities with Java classes that differ only in case.

Strings in Java and SQL

A set of double quotes identifies string literals in Java, as in the following Java code fragment:

```
String str = "This is a string";
```

In SQL, however, single quotes mark strings, and double quotes indicate an identifier, as illustrated by the following SQL statement:

```
INSERT INTO TABLE DBA.t1
VALUES( 'Hello' )
```

You should always use the double quote in Java source code, and single quotes in SQL statements.

For example, the following SQL statements are valid.

```
CREATE VARIABLE str char(20);
SET str = NEW java.lang.String( 'Brand new object' )
```

The following Java code fragment is also valid, if used within a Java class.

```
String str = new java.lang.String(
            "Brand new object" );
```

Printing to the command line

Printing to the standard output is a quick way of checking variable values and execution results at various points of code execution. When the method in the second line of the following Java code fragment is encountered, the string argument it accepts prints out to standard output.

```
String str = "Hello world";
System.out.println( str );
```

In Adaptive Server Anywhere, standard output is the server window, so the string appears there. Executing the above Java code within the database is the equivalent of the following SQL statement.

```
MESSAGE 'Hello world'
```

Using the main method

When a class contains a **main** method matching the following declaration, most Java run time environments, such as the Sun Java interpreter, execute it automatically. Normally, this static method executes only if it is the class being invoked by the Java interpreter

```
public static void main( String args[ ] ) { }
```

Useful for testing the functionality of Java objects, you are always guaranteed this method will be called first, when the Sun Java runtime system starts.

In Adaptive Server Anywhere, the Java runtime system is always available. The functionality of objects and methods can be tested in an ad hoc, dynamic manner using SQL statements. In many ways this is far more flexible for testing Java class functionality.

Scope and persistence

SQL variables are persistent only for the duration of the connection. This is unchanged from previous versions of Adaptive Server Anywhere, and is unaffected by whether the variable is a Java class or a native SQL data type.

The persistence of Java classes is analogous to tables in a database: tables exist in the database until you drop them, regardless of whether they hold data or even whether they are ever used. Java classes installed to a database are similar: they are available for use until you explicitly remove them with a REMOVE statement.

For more information on removing classes, see "REMOVE statement" on page 507 of the book *ASA SQL Reference Manual*.

A class method in an installed Java class can be called at any time from a SQL statement. You can execute the following statement anywhere you can execute SQL statements.

```
SELECT java.lang.Math.abs(-342)
```

A Java object is only available in two forms: as the value of a variable, or as a value in a table.

Java escape characters in SQL statements

In Java code, you can use escape characters to insert certain special characters into strings. Consider the following code, which inserts a new line and tab in front of a sentence containing an apostrophe.

```
String str = "\n\t\This is an object\'s string literal";
```

Adaptive Server Anywhere permits the use of Java escape characters only when being used by Java classes. From within SQL, however, you must follow the rules that apply to strings in SQL.

For example, to pass a string value to a field using a SQL statement, you could use the following statement, but the Java escape characters could not.

```
SET obj.str = '\nThis is the object''s string field';
```

For more information on SQL string handling rules, see "Strings" on page 9 of the book *ASA SQL Reference Manual*.

Keyword conflicts

SQL keywords can conflict with the names of Java classes, including API classes. This occurs when the name of a class, such as the Date class, which is a member of the **java.util.*** package, is referenced. SQL reserves the word **Date** for use as a keyword, even though it also the name of a Java class.

When such ambiguities appear, you can use double quotes to identify that you are not using the word in question as the SQL reserved word. For example, the following SQL statement causes an error because Date is a keyword and SQL reserves its use.

```
-- This statement is incorrect
CREATE VARIABLE dt java.util.Date
```

However the following two statements work correctly because the word Date is within quotation marks.

```
CREATE VARIABLE dt java.util."Date";
SET dt = NEW java.util."Date"(1997, 11, 22, 16, 11, 01)
```

The variable **dt** now contains the date: November 22, 1997, 4:11 p.m.

Use of import statements

It is common in a Java class declaration to include an import statement to access classes in another package. You can reference imported classes using unqualified class names.

For example, you can reference the Stack class of the **java.util** package in two ways:

- explicitly using the name **java.util.Stack**, or
- using the name **Stack**, and including the following import statement:

```
import java.util.*;
```

Classes further up in the hierarchy must also be installed.

A class referenced by another class, either explicitly with a fully qualified name or implicitly using an import statement, must also be installed in the database.

The import statement works as intended within compiled classes. However, within the Adaptive Server Anywhere runtime environment, no equivalent to the import statement exists. All class names used in SQL statements or stored procedures must be fully qualified. For example, to create a variable of type String, you would reference the class using the fully qualified name: **java.lang.String**.

Using the CLASSPATH variable

Sun's Java runtime environment and the Sun JDK Java compiler use the CLASSPATH environment variable to locate classes referenced within Java code. A CLASSPATH variable provides the link between Java code and the actual file path or URL location of the classes being referenced. For example, `import java.io.*` allows all the classes in the **java.io** package to be referenced without a fully qualified name. Only the class name is required in the following Java code to use classes from the **java.io** package. The CLASSPATH environment variable on the system where the Java class declaration is to be compiled must include the location of the Java directory, the root of the **java.io** package.

CLASSPATH ignored at runtime

The CLASSPATH environment variable does not affect the Adaptive Server Anywhere runtime environment for Java during the execution of Java operations because the classes are stored in the database, instead of in external files or archives.

CLASSPATH used to install classes

The CLASSPATH variable can, however, be used to locate a file during the installation of classes. For example, the following statement installs a user-created Java class to a database, but only specifies the name of the file, not its full path and name. (Note that this statement involves no Java operations.)

```
INSTALL JAVA NEW
FROM FILE 'Invoice.class'
```

If the file specified is in a directory or zip file specified by the CLASSPATH environmental variable, Adaptive Server Anywhere will successfully locate the file and install the class.

Public fields

It is a common practice in object-oriented programming to define class fields as private and make their values available only through public methods.

Many of the examples used in this documentation render fields public to make examples more compact and easier to read. Using public fields in Adaptive Server Anywhere also offers a performance advantage over accessing public methods.

The general convention followed in this documentation is that a user-created Java class designed for use in Adaptive Server Anywhere exposes its main values in its fields. Methods contain computational automation and logic that may act on these fields.

Tutorial: A Java in the database exercise

This tutorial is a primer for invoking Java operations on Java classes and objects using SQL statements. It describes how to install a Java class into the database. It also describes how to access the class and its members and methods from SQL statements. The tutorial uses the Invoice class created in "A Java seminar" on page 59.

Requirements

The tutorial assumes that you have installed Java in the database software. It also assumes that you have a Java Development Kit (JDK) installed, including the Java compiler (*javac*).

Resources

Source code and batch files for this sample are provided in the directory *Samples\ASA\InvoiceJava* under your SQL Anywhere directory.

Create and compile the sample Java class

The first step is to write the Java code and compile it. This is done outside the database

❖ **To create and compile the class:**

1 Create a file called *Invoice.java* holding the following code.

```
public class Invoice {

  // Fields
  public String lineItem1Description;
  public double lineItem1Cost;

  public String lineItem2Description;
  public double lineItem2Cost;

  // An instance method
  public double totalSum() {
    double runningsum;
    double taxfactor = 1 + Invoice.rateOfTaxation();

    runningsum = lineItem1Cost + lineItem2Cost;
    runningsum = runningsum * taxfactor;

    return runningsum;
  }

  // A class method
  public static double rateOfTaxation() {
    double rate;
    rate = .15;

    return rate;
  }
}
```

You can find source code for this class as the file *Samples\ASA\JavaInvoice\Invoice.java* under your SQL Anywhere directory.

2 Compile the file to create the file *Invoice.class*.

From a command prompt in the same directory as *Invoice.java*, execute the following command.

```
javac *.java
```

The class is now compiled and ready to be installed into the database.

Install the sample Java class

Java classes must be installed into a database before they can be used. You can install classes from Sybase Central or Interactive SQL. This section provides instructions for both. Choose whichever you prefer.

❖ **To install the class to the sample database (Sybase Central):**

1 Start Sybase Central and connect to the sample database.

2 Open the Java Objects folder and double-click Add Java Class. The Java Class Creation wizard appears.

3 Use the Browse button to locate *Invoice.class* in the *Samples\ASA\JavaInvoice* subdirectory of your SQL Anywhere installation directory.

4 Click Finish to exit the wizard.

❖ **To install the class to the sample database (Interactive SQL):**

1 Start Interactive SQL and connect to the sample database.

2 In the SQL Statements pane of Interactive SQL, type the following command:

```
INSTALL JAVA NEW
FROM FILE
'path\\samples\\ASA\\JavaInvoice\\Invoice.class'
```

where *path* is your SQL Anywhere directory.

The class is now installed into the sample database.

Notes

- At this point no Java in the database operations have taken place. The class has been installed into the database and is ready for use as the data type of a variable or column in a table.
- Changes made to the class file from now on are *not* automatically reflected in the copy of the class in the database. You must re-install the classes if you want the changes reflected.

☞ For more information on installing classes, and for information on updating an installed class, see "Installing Java classes into a database" on page 94.

Creating a SQL variable of type Invoice

This section creates a SQL variable that references a Java object of type **Invoice**.

Case sensitivity
Java is case sensitive, so the portions of the following examples in this section pertaining to Java syntax are written using the correct case. SQL syntax is rendered in upper case.

1 From Interactive SQL, execute the following statement to create a SQL variable named **Inv** of type **Invoice**, where **Invoice** is the Java class you installed to a database:

```
CREATE VARIABLE Inv Invoice
```

Once you create a variable, it can only be assigned a value if its data type and declared data type are identical or if the value is a subclass of the declared data type. In this case, the variable **Inv** can only contain a reference to an object of type **Invoice** or a subclass of Invoice.

Initially, the variable **Inv** is NULL because no value has been passed to it.

2 Execute the following statement to identify the current value of the variable **Inv**.

```
SELECT IFNULL(Inv,
    'No object referenced',
    'Variable not null: contains object reference')
```

The variable currently has no object referenced.

3 Assign a value to **Inv**.

You must instatiate an instance of the **Invoice** class using the **NEW** keyword.

```
SET Inv = NEW Invoice()
```

The **Inv** variable now has a reference to a Java object. To verify this, you can execute the statement from step 2.

The **Inv** variable contains a reference to a Java object of type **Invoice**. Using this reference, you can access any of the object's fields or invoke any of its methods.

Access fields and methods of the Java object

If a variable (or column value in a table) contains a reference to a Java object, then the fields of the object can be passed values and its methods can be invoked.

For example, the variable of type Invoice that you created in the previous section contains a reference to an **Invoice** object and has four fields, the value of which can be set using SQL statements.

❖ To access fields of the Invoice object:

1 From Interactive SQL, execute the following SQL statements to set field values for the variable **Inv**.

```
SET Inv.lineItem1Description = 'Work boots';
SET Inv.lineItem1Cost = '79.99';
SET Inv.lineItem2Description = 'Hay fork';
```

```
SET Inv.lineItem2Cost = '37.49';
```

Each SQL statement passes a value to a field in the Java object referenced by **Inv**.

2 Execute SELECT statements against the variable. Any of the following SQL statements return the current value of a field in the Java object referenced by **Inv**.

```
SELECT Inv.lineItem1Description;
SELECT Inv.lineItem1Cost;
SELECT Inv.lineItem2Description;
SELECT Inv.lineItem2Cost;
```

3 Use a field of the **Inv** variable in a SQL expression.

Execute the following SQL statement and have executed the above SQL statements.

```
SELECT * FROM PRODUCT
WHERE unit_price < Inv.lineItem2Cost;
```

In addition to having public fields, the **Invoice** class has one instance method, which you can invoke

❖ **To invoking methods of the Invoice object:**

- From Interactive SQL, execute the following SQL statement, which invokes the **totalSum()** method of the object referenced by the variable **Inv**. It returns the sum of the two cost fields plus the tax charged on this sum.

```
SELECT Inv.totalSum();
```

Calling methods versus referencing fields

Method names are always followed by parentheses, even when they take no arguments. Field names are not followed by parentheses.

The **totalSum()** method takes no arguments, but returns a value. The brackets are used because a Java operation is being invoked even though the method takes no arguments.

For Java in the database, direct field access is faster than method invokation. Accessing a field does not require the Java VM to be invoked, while invoking a method requires the VM to execute the method.

As indicated by the Invoice class definition outlined at the beginning of this section, the **totalSum** instance method makes use of the class method **rateOfTaxation**.

You can access this class method directly from a SQL statement.

```
SELECT Invoice.rateOfTaxation();
```

Notice the name of the class is used, not the name of a variable containing a reference to an **Invoice** object. This is consistent with the way Java handles class methods, even though it is being used in a SQL statement. A class method can be invoked even if no object based on that class has been instantiated.

Class methods do not require an instance of the class to work properly, but they can still be invoked on an object. The following SQL statement yields the same results as the previously executed SQL statement.

```
SELECT Inv.rateOfTaxation();
```

Saving Java objects in tables

When you install a class in a database, it is available as a new data type. Columns in a table can be of type *Javaclass* where *Javaclass* is the name of an installed public Java class. You can then create a Java object and add it to a table as the value of a column.

❖ **To use the Invoice class in a table:**

1 Create a table with a column of type **Invoice**.

From Interactive SQL, execute the following SQL statement.

```
CREATE TABLE T1 (
    ID int,
    JCol Invoice
);
```

The column named **JCol** only accepts objects of type **Invoice** or one of its subclasses.

2 Using the variable **Inv**, which contains a reference to a Java object of type **Invoice**, execute the following SQL statement to add a row to the table *T1*.

```
INSERT INTO T1
VALUES( 1, Inv );
```

Once an object has been added to the table **T1**, you can issue select statements involving the fields and methods of the objects in the table.

3 Execute the following SQL statement to return the value of the field **lineItem1Description** for all the objects in the table T1 (right now, there should only be one object in the table).

```
SELECT ID, JCol.lineItem1Description
FROM T1;
```

You can execute similar select statements involving other fields and methods of the object.

4 A second method for creating a Java object and adding it to a table involves the following expression, which always creates a Java object and returns a reference to it.

```
NEW Javaclassname()
```

5 You can use this expression in a number of ways. For example, execute the following SQL statement to create a Java object and inserts it into the table **T1**.

```
INSERT INTO T1
VALUES ( 2, NEW Invoice() );
```

6 Execute the following SQL statement to verify that these two objects have been saved as values of column **JCol** in the table **T1**.

```
SELECT ID, JCol.totalSum()
FROM t1
```

The results of the **JCol** column (the second row returned by the above statement) should be 0, because the fields in that object have no values and the **totalSum** method is a calculation of those fields.

Returning an object using a query

In addition to accessing fields and methods, you can also retrieve an entire object from a table using a query.

❖ **To access Invoice objects stored in a table:**

♦ From Interactive SQL, execute the following series of statements to create a new variable and pass a value (it can only contain an object reference where the object is of type Invoice). The object reference passed to the variable was generated using the table *T1*.

```
CREATE VARIABLE Inv2 Invoice;
SET Inv2 = (select JCol from T1 where ID = 2);
SET Inv2.lineItem1Description = 'Sweet feed';
SET Inv2.lineItem2Description = 'Drive belt';
```

The value for the **lineItem1Description** field and **lineItem2Description** have been changed in the variable **Inv2**, but not in the table that was the source for the value of this variable.

This is consistent with the way SQL variables are currently handled: the variable **Inv** contains a reference to a Java object. The value in the table that was the source of the variable's reference is not altered until an UPDATE statement is executed.

CHAPTER 4

Using Java in the Database

About this chapter

This chapter describes how to add Java classes and objects to your database, and how to use these objects in a relational database.

Contents

Before you begin

To run the examples in this chapter, first run the file *Samples\ASA\Java\jdemo.sql* under your SQL Anywhere directory.

☞ For more information, and full instructions, see "Setting up the Java samples" on page 86.

Introduction

This chapter describes how to accomplish tasks using Java in the database, including the following:

- **How to Java-enable a database** You need to follow certain steps to enable your database to use Java.
- **Installing Java classes** You need to install Java classes in a database to make them available for use in the server.
- **Properties of Java columns** This section describes how columns with Java class data types fit into the relational model.
- **Java database design** This section provides tips for designing databases that use Java classes.

Setting up the Java samples

Many of the examples in this chapter require you to use a set of classes and tables added to the sample database. The tables hold the same information as tables of the same name in the sample database, but the user ID named *jdba* owns them. They use Java class data types instead of simple relational types to hold the information. You can find the sample in the *Samples\ASA\Java* subdirectory of your SQL Anywhere directory.

Sample tables designed for tutorial use only
The sample tables illustrate different Java features. They are not a recommendation for how to redesign your database. You should consider your own situation in evaluating where to incorporate Java data types and other features.

Setting up the Java examples involves two steps:

1 Java-enable the sample database.

2 Add the Java sample classes and tables.

❖ **To Java-enable the sample database:**

1 Start Interactive SQL and connect to the sample database.

2 In the SQL Statements pane of Interactive SQL, type the following statement:

```
ALTER DATABASE UPGRADE JAVA JDK '1.3'
```

3 Shut down Interactive SQL and the sample database.

> The asademo.db database must be shut down before you can use Java features.

❖ **To add Java classes and tables to the sample database:**

1 Start Interactive SQL and connect to the sample database.

2 In the SQL Statements pane of Interactive SQL, type the following statement:

```
READ "path\\Samples\\ASA\\Java\\jdemo.sql"
```

where *path* is your SQL Anywhere directory. This runs the instructions in the *jdemo.sql* command file. The instructions may take some time to complete.

You can view the script *Samples\ASA\Java\jdemo.sql* using a text editor. It executes the following steps:

1 Installs the *JDBCExamples* class.

2 Creates a user ID named **JDBA** with password **SQL** and DBA authority, and sets the current user to be *JDBA*.

3 Installs a JAR file named *asademo.jar*. This file contains the class definitions used in the tables.

4 Creates the following tables under the *JDBA* user ID:

- product
- contact
- customer
- employee
- sales_order
- sales_order_items

This is a subset of the tables in the sample database.

5 Adds the data from the standard tables of the same names into the Java tables. This step uses INSERT from SELECT statements. This step may take some time.

6 Creates some indexes and foreign keys to add integrity constraints to the schema.

Managing the runtime environment for Java

The runtime environment for Java consists of:

- **The Sybase Java Virtual Machine** Running within the database server, the Sybase Java Virtual Machine interprets and executes the compiled Java class files.
- **The runtime Java classes** When you create a database, a set of Java classes becomes available to the database. Java applications in the database require these runtime classes to work properly.

Management tasks for Java

To provide a runtime environment for Java, you need to carry out the following tasks:

- **Java-enable your database** This task involves ensuring the availability of built-in classes and the upgrading of the database to Version 8 standards.

  For more information, see "Java-enabling a database" on page 89.

- **Install other classes your users need** This task involves ensuring that classes other than the runtime classes are installed and up to date.

  For more information, see "Installing Java classes into a database" on page 94.

- **Configuring your server** You must configure your server to make the necessary memory available to run Java tasks.

  For more information, see "Configuring memory for Java" on page 127.

Tools for managing Java

You can carry out all these tasks from Sybase Central or from Interactive SQL.

Java-enabling a database

The Adaptive Server Anywhere Runtime environment for Java requires a Java VM and the **Sybase runtime Java classes**. You need to Java-enable a database for it to be able to use the runtime Java classes.

Java in the database is a separately-licensed component of SQL Anywhere Studio.

> **New databases are not Java-enabled by default**
> By default, databases created with Adaptive Server Anywhere are not Java-enabled.

Java is a single-hierarchy language, meaning that all classes you create or use eventually inherit from one class. This means the low-level classes (classes further up in the hierarchy) must be present before you can use higher-level classes. The base set of classes required to run Java applications are the runtime Java classes, or the Java API.

When not to Java-enable a database

Java-enabling a database adds many entries into the system tables. This adds to the size of the database and, more significantly, adds about 200K to the memory requirements for running the database, even if you do not use any Java functionality.

If you are not going to use Java, and if you are running in a limited-memory environment, you may wish to not Java-enable your database.

The Sybase runtime Java classes

The Sybase runtime Java classes are held on disk rather than stored in a database like other classes. The following files contain the Sybase runtime Java classes. The files are in the *Java* subdirectory of your SQL Anywhere directory:

- **1.1\classes.zip** This file, licensed from Sun Microsystems, contains a subset of the Sun Microsystems Java runtime classes for JDK 1.1.8.
- **1.3\rt.jar** This file, licensed from Sun Microsystems, contains a subset of the Sun Microsystems Java runtime classes for JDK 1.3.
- **asajdbc.zip** This file contains Sybase internal JDBC driver classes for JDK 1.1.
- **asajrt12.zip** This file contains Sybase internal JDBC driver classes for JDK 1.2 and JDK 1.3.

When you Java-enable a database, you also update the system tables with a list of available classes from the system JAR files. You can then browse the class hierarchy from Sybase Central, but the classes themselves are not present in the database.

JAR files

The database stores runtime class names the under the following JAR files:

- **ASAJRT** Class names from *asajdbc.zip* are held here.
- **ASAJDBCDRV** Class names from *jdbcdrv.zip* are held here.
- **ASASystem** Class names from *classes.zip* are held here.

Installed packages

These runtime classes include the following packages:

- **java** Packages stored here include the supported Java runtime classes from Sun Microsystems.

  For a list of the supported Java runtime classes, see "Supported Java packages" on page 77 of the book *ASA SQL Reference Manual*.
- **com.sybase** Packages stored here provide server-side JDBC support.
- **sun** Sun Microsystems provides the packages stored here.
- **sybase.sql** Packages stored here are part of the Sybase server-side JDBC support.

> ***Caution: do not install classes from another version of Sun's JDK***
> *Classes in Sun's JDK share names with the Sybase runtime Java classes that must be installed in any database intended to execute Java operations.*
>
> *You must not replace the* classes.zip *file included with Adaptive Server Anywhere. Using another version of these classes could cause compatibility problems with the Sybase Java Virtual Machine.*
>
> *You must* only *Java-enable a database using the methods outlined in this section.*

Ways of Java-enabling a database

You can Java-enable databases when you create them, when you upgrade them, or in a separate operation at a later time.

Creating databases

You can create a Java-enabled database using:

- the CREATE DATABASE statement.

☞ For details of the syntax, see "CREATE DATABASE statement" on page 273 of the book *ASA SQL Reference Manual*.

- the *dbinit* utility.

  ☞ For details, see "Creating a database using the dbinit command-line utility" on page 466 of the book *ASA Database Administration Guide*.

- Sybase Central.

  ☞ For details, see "Creating a database" on page 29 of the book *ASA SQL User's Guide*.

Upgrading databases

You can upgrade a database to a Java-enabled Version 8 database using:

- the ALTER DATABASE statement.

  ☞ For details of the syntax, see "ALTER DATABASE statement" on page 205 of the book *ASA SQL Reference Manual*.

- the *dbupgrad.exe* upgrade utility.

  ☞ For details, see "Upgrading a database using the dbupgrad command-line utility" on page 522 of the book *ASA Database Administration Guide*.

- Sybase Central.

  ☞ For details, see "Java-enabling a database" on page 92.

If you choose not to install Java in the database, all database operations not involving Java operations remain fully functional and work as expected.

New databases and Java

By default, Adaptive Server Anywhere does not install Sybase runtime Java classes each time you create a database. The installation of this separately-licensable component is optional, and controlled by the method you use to create the database.

CREATE DATABASE options

The CREATE DATABASE SQL statement has an option called JAVA. To Java-enable a database, you can set the option to ON. To disable Java, set the option to OFF. This option is set to OFF by default.

For example, the following statement creates a Java-enabled database file named *temp.db*:

```
CREATE DATABASE 'c:\\sybase\\asa8\\temp' JAVA ON
```

The following statement creates a database file named *temp2.db*, which does not support Java.

```
CREATE DATABASE 'c:\\sybase\\asa8\\temp2'
```

Database initialization utility

You can create databases using the *dbinit.exe* database initialization utility. This utility has options that control whether or not to install the runtime Java classes in the newly-created database. By default, the classes are not installed.

The same options are available when creating databases using Sybase Central.

Upgrading databases and Java

You can upgrade existing databases created with earlier versions of the software using the Upgrade utility or the ALTER DATABASE statement.

Database upgrade utility

You can upgrade databases to Adaptive Server Anywhere Version 8 standards using the *dbupgrad.exe* utility. Using the `-jr` Upgrade utility option prevents the installation of Sybase runtime Java classes.

☞ For information on the conditions under which Java in the database is included in the upgraded database, see "Upgrading a database using the dbupgrad command-line utility" on page 522 of the book *ASA Database Administration Guide*.

Java-enabling a database

If you have created a database, or upgraded a database to standards, but have chosen not to Java-enable the database, you can add the necessary Java classes at a later date, using either Sybase Central or Interactive SQL.

❖ **To add the Java runtime classes to a database (Sybase Central):**

1. Connect to the database from Sybase Central as a user with DBA authority.
2. Right-click the database and choose Upgrade Database.
3. Click Next on the introductory page of the wizard.
4. Select the database you want to upgrade from the list.
5. You can choose to create a backup of the database if you wish. Click Next.
6. You can choose to install jConnect meta-information support if you wish. Click Next.

7 Select the Install Java Support option. You must also choose which version of the JDK you want to install. The default classes are the JDK 1.3 classes. For version 7.x databases, the default classes are the JDK 1.1.8 classes.

8 Follow the remaining instructions in the wizard.

❖ **To add the Java runtime classes to a database (SQL):**

1 Connect to the database from Interactive SQL as a user with DBA authority.

2 Execute the following statement:

```
ALTER DATABASE UPGRADE JAVA ON
```

For more information, see "ALTER DATABASE statement" on page 205 of the book *ASA SQL Reference Manual*.

3 Restart the database for the Java support to take effect.

Using Sybase Central to Java-enable a database

You can use Sybase Central to create databases using wizards. During the creation or upgrade of a database, the wizard prompts you to choose whether or not you have the Sybase runtime Java classes installed. By default, this option Java-enables the database.

Using Sybase Central, you can create or upgrade a database by choosing:

- Create Database from the Utilities folder, or
- Upgrade Database from the Utilities folder to upgrade a database from a previous version of the software to a database with Java capabilities.

Installing Java classes into a database

Before you install a Java class into a database, you must compile it. You can install Java classes into a database as:

- **A single class** You can install a single class into a database from a compiled class file. Class files typically have extension *.class*.
- **A JAR** You can install a set of classes all at once if they are in either a compressed or uncompressed JAR file. JAR files typically have the extension *.jar* or *.zip*. Adaptive Server Anywhere supports all compressed JAR files created with the Sun JAR utility, and some other JAR compression schemes as well.

This section describes how to install Java classes once you have compiled them. You must have DBA authority to install a class or JAR.

Creating a class

Although the details of each step may differ depending on whether you are using a Java development tool such as Sybase PowerJ, the steps involved in creating your own class generally include the following:

❖ **To create a class:**

1 **Define your class** Write the Java code that defines your class. If you are using the Sun Java SDK then you can use a text editor. If you are using a development tool such as Sybase PowerJ, the development tool provides instructions.

> **Use only supported classes**
> If your class uses any runtime Java classes, make certain they are among the list of supported classes as listed in "Supported Java packages" on page 77 of the book *ASA SQL Reference Manual*.
>
> User classes must be 100% Java. Native methods are not allowed.

2 **Name and save your class** Save your class declaration (Java code) in a file with the extension *.java*. Make certain the name of the file is the same as the name of the class and that the case of both names is identical.

For example, a class called Utility should be saved in a file called *Utility.java*.

3 **Compile your class** This step turns your class declaration containing Java code into a new, separate file containing byte code. The name of the new file is the same as the Java code file but has an extension of *.class*. You can run a compiled Java class in a Java runtime environment, regardless of the platform you compiled it on or the operating system of the runtime environment.

The Sun JDK contains a Java compiler, *Javac.exe*.

Java-enabled databases only
You can install any compiled Java class file in a database. However, Java operations using an installed class can only take place if the database has been Java-enabled as described in "Java-enabling a database" on page 89.

Installing a class

To make your Java class available within the database, you **install** the class into the database either from Sybase Central, or using the INSTALL statement from Interactive SQL or other application. You must know the path and file name of the class you wish to install.

You require DBA authority to install a class.

❖ **To install a class (Sybase Central):**

1 Connect to a database with DBA authority.

2 Open the Java Objects folder for the database.

3 Double-click Add Java Class.

4 Follow the instructions in the wizard.

❖ **To install a class (SQL):**

1 Connect to a database with DBA authority.

2 Execute the following statement:

```
INSTALL JAVA NEW
FROM FILE 'path\\ClassName.class'
```

where *path* is the directory where the class file is, and *ClassName.class* is the name of the class file.

The double backslash ensures that the backslash is not treated as an escape character.

For example, to install a class in a file named *Utility.class*, held in the directory *c:\source*, you would enter the following statement:

```
INSTALL JAVA NEW
    FROM FILE 'c:\\source\\Utility.class'
```

If you use a relative path, it must be relative to the current working directory of the database server.

☞ For more information, see "INSTALL statement" on page 467 of the book *ASA SQL Reference Manual*, and "Deleting Java objects, classes, and JAR files" on page 105.

Installing a JAR

It is useful and common practice to collect sets of related classes together in packages, and to store one or more packages in a **JAR file**. For information on JAR files and packages, see the accompanying online book, *Thinking in Java*, or another book on programming in Java.

You install a JAR file the same way as you install a class file. A JAR file can have the extension JAR or ZIP. Each JAR file must have a name in the database. Usually, you use the same name as the JAR file, without the extension. For example, if you install a JAR file named *myjar.zip*, you would generally give it a JAR name of *myjar*.

☞ For more information, see "INSTALL statement" on page 467 of the book *ASA SQL Reference Manual*, and "Deleting Java objects, classes, and JAR files" on page 105.

❖ To install a JAR (Sybase Central):

1. Connect to a database with DBA authority.
2. Open the Java Objects folder for the database.
3. Double-click Add JAR File.
4. Follow the instructions in the wizard.

❖ To install a JAR (SQL):

1. Connect to a database with DBA authority.
2. Enter the following statement:

```
INSTALL JAVA NEW
JAR 'jarname'
FROM FILE 'path\\JarName.jar'
```

Updating classes and Jars

You can update classes and JAR files using Sybase Central or by entering an INSTALL statement in Interactive SQL or some other client application.

To update a class or JAR, you must have DBA authority and a newer version of the compiled class file or JAR file available in a file on disk.

Existing Java objects and updated classes

You may have instances of a Java class stored as Java objects in your database, or as values in a column that uses the class as its data type.

Despite updating the class, these old values will still be available, even if the fields and methods stored in the tables are incompatible with the new class definition.

Any new rows you insert, however, need to be compatible with the new definition.

When updated classes take effect

Only new connections established after installing the class, or which use the class for the first time after installing the class, use the new definition. Once the Virtual Machine loads a class definition, it stays in memory until the connection closes.

If you have been using a Java class or objects based on a class in the current connection, you need to disconnect and reconnect to use the new class definition.

☞ To understand why the updated classes take effect in this manner, you need to know a little about how the VM works. For information, see "Configuring memory for Java" on page 127.

Objects stored in serialized form

Java objects can use the updated class definition because they are stored in serialized form. The serialization format, designed specifically for the database, is not the Sun Microsystems serialization format. The internal Sybase VM carries out all serialization and deserialization, so there are no compatibility issues.

❖ **To update a class or JAR (Sybase Central):**

1. Connect to a database with DBA authority.
2. Open the Java Objects folder.
3. Locate the class or JAR file you wish to update.
4. Right-click the class or JAR file and choose Update from the popup menu.
5. In the resulting dialog, specify the name and location of the class or JAR file to be updated. You can click Browse to search for it.

Tip
You can also update a Java class or JAR file by clicking Update Now on the General tab of its property sheet.

❖ **To update a class or JAR (SQL):**

1 Connect to a database with DBA authority.

2 Execute the following statement:

```
INSTALL JAVA UPDATE
[ JAR 'jarname' ]
FROM FILE 'filename'
```

If you are updating a JAR, you must enter the name by which the JAR is known in the database.

For more information, see "INSTALL statement" on page 467 of the book *ASA SQL Reference Manual*.

Creating columns to hold Java objects

This section describes how columns of Java class data types fit into the standard SQL framework.

Creating columns with Java data types

You can use any installed Java class as a data type. You must use the fully qualified name for the data type.

For example, the following CREATE TABLE statement includes a column that has columns of Java data types **asademo.Name** and **asademo.ContactInfo**. Here, **Name** and **ContactInfo** are classes within the **asademo** package.

```
CREATE TABLE jdba.customer
(
   id    integer NOT NULL,
   company_name CHAR(35) NOT NULL,
   JName asademo.Name NOT NULL,
   JContactInfo asademo.ContactInfo NOT NULL,
   PRIMARY KEY (id)
)
```

Case sensitivity

Unlike other SQL data types, Java data types are case sensitive. You must supply the proper case of all parts of the data type.

Using defaults and NULL on Java columns

You can use defaults on Java columns, and Java columns can hold NULL entries.

Java columns and defaults Columns can have as default values any function of the proper data type, or any preset default. You can use any function of the proper data type (for example, of the same class as the column) as a default value for Java columns.

Java columns and NULL Java columns can allow NULL. If a nullable column with Java data type has no default value, the column contains NULL.

If a Java value is not set, it has a Java null value. This Java null maps onto the SQL NULL, and you can use the IS NULL and IS NOT NULL search conditions against the values. For example, suppose the description of a Product Java object in a column named *JProd* was not set, you can query all products with non-null values for the description as follows:

```
SELECT *
FROM product
WHERE JProd>>description IS NULL
```

Inserting, updating, and deleting Java objects

This section describes how the standard SQL data manipulation statements apply to Java columns.

Throughout the section, concrete examples based on the *Product* table of the sample database and a class named **Product** illustrate points. You should first look at the file *Samples\ASA\Java\\asademo\Product.java* under your SQL Anywhere directory.

Create the Java sample tables

The examples in this section assume that you have added the Java tables to the sample database, and that you are connected as user ID **jDBA** with password **SQL**.

For more information, see "Setting up the Java samples" on page 86.

A sample class

This section describes a class that is used in examples throughout the following sections.

The **Product** class definition, included in the file *Samples\ASA\Java\asademo\Product.jave* under your SQL Anywhere directory, is reproduced in part below:

```
package asademo;

public class Product implements java.io.Serializable {

  // public fields
  public String name ;
  public String description ;
  public String size ;
  public String color;
  public int quantity ;
  public java.math.BigDecimal unit_price ;

  // Default constructor
  Product () {
       unit_price = new java.math.BigDecimal( 10.00 );
       name = "Unknown";
       size = "One size fits all";
  }

  // Constructor using all available arguments
  Product ( String inColor,
        String inDescription,
        String inName,
```

```
        int inQuantity,
        String inSize,
        java.math.BigDecimal inUnit_price
        ) {
    color = inColor;
    description = inDescription;
    name = inName;
    quantity = inQuantity;
    size = inSize;
    unit_price=inUnit_price;
}

public String toString() {
   return size + " " + name + ": " +
   unit_price.toString();
}
```

Notes

- The **Product** class has several public fields that correspond to some of the columns of the *DBA.Product* table that will be collected together in this class.
- The **toString** method is provided for convenience. When you include an object name in a select-list, the **toString** method is executed and its return string displayed.
- Some methods are provided to set and get the fields. It is common to use such methods in object-oriented programming rather than to address the fields directly. Here, the fields are public for convenience in tutorials.

Inserting Java objects

When you INSERT a row in a table that has a Java column, you need to insert a Java object into the Java column.

You can insert a Java object in two ways: from SQL or from other Java classes running inside the database, using JDBC.

Inserting a Java object from SQL

You can insert a Java object using a constructor, or you can use SQL variables to build up a Java object before inserting it.

Inserting an object using a constructor

When you insert a value into a column that has a Java class data type, you are inserting a Java object. To insert an object with the proper set of properties, the new object must have proper values for any public fields, and you will want to call any methods that set private fields.

❖ **To insert a Java object:**

♦ INSERT a new instance of the Product class into the table *product* as follows:

```
INSERT
INTO product ( ID, JProd )
VALUES ( 702, NEW asademo.Product() )
```

You can run this example against the sample database from the user ID *jdba* once the *jdemo.sql* script has been run.

The NEW keyword invokes the default constructor for the **Product** class in the **asademo** package.

Inserting an object from a SQL variable

You can also set the values of the fields of the object individually, as opposed to through the constructor, in a SQL variable of the proper class.

❖ **To insert a Java object using SQL variables:**

1 Create a SQL variable of the Java class type:

```
CREATE VARIABLE ProductVar asademo.Product
```

2 Assign a new object to the variable, using the class constructor:

```
SET ProductVar = NEW asademo.Product()
```

3 Assign values to the fields of the object, where required:

```
SET ProductVar>>color = 'Black';
SET ProductVar>>description = 'Steel tipped boots';
SET ProductVar>>name = 'Work boots';
SET ProductVar>>quantity = 40;
SET ProductVar>>size = 'Extra Large';
SET ProductVar>>unit_price = 79.99;
```

4 Insert the variable into the table:

```
INSERT
INTO Product ( id, JProd )
VALUES ( 800, ProductVar )
```

5 Check that the value is inserted:

```
SELECT *
FROM product
WHERE id=800
```

6 Undo the changes you have made in this exercise:

```
ROLLBACK
```

The use of SQL variables is typical of stored procedures and other uses of SQL to build programming logic into the database. Java provides a more powerful way of accomplishing this task. You can use server-side Java classes together with JDBC to insert objects into tables.

Inserting an object from Java

You can insert an object into a table using a JDBC prepared statement.

A prepared statement uses placeholders for variables. You can then use the **setObject** method of the **PreparedStatement** object.

You can use prepared statements to insert objects from either client-side or server-side JDBC.

For more information on using prepared statements to work with objects, see "Inserting and retrieving objects" on page 156.

Updating Java objects

You may wish to update a Java column value in either of the following ways:

- Update the entire object.
- Update some of the fields of the object.

Updating the entire object

You can update the object in much the same way as you insert objects:

- From SQL, you can use a constructor to update the object to a new object as the constructor creates it. You can then update individual fields if you need to.
- From SQL, you can use a SQL variable to hold the object you need, and then update the row to hold the variable.
- From JDBC, you can use a prepared statement and the **PreparedStatement.setObject** method.

Updating fields of the object

Individual fields of an object have data types that correspond to SQL data types, using the SQL to Java data type mapping described in "Java / SQL data type conversion" on page 84 of the book *ASA SQL Reference Manual*.

You can update individual fields using a standard UPDATE statement:

```
UPDATE Product
SET JProd.unit_price = 16.00
WHERE ID = 302
```

In the initial release of Java in the database, it was necessary to use a special function (EVALUATE) to carry out updates. This is no longer necessary.

To update a Java field, the Java data type of the field must map to a SQL type: the expression on the right hand side of the SET clause must match this type. You may need to use the CAST function to cast the data types appropriate.

For more information about data type mappings between Java and SQL, see "Java / SQL data type conversion" on page 84 of the book *ASA SQL Reference Manual*.

Using set methods

It is common practice in Java programming not to address fields directly, but to use methods to get and set the value. It is also common practice for these methods to return **void**. You can use set methods in SQL to update a column:

```
UPDATE jdba.Product
SET JProd.setName( 'Tank Top')
WHERE id=302
```

Using methods is slower than addressing the field directly, because the Java VM must run.

For more information, see "Return value of methods returning void" on page 112.

Deleting Java objects, classes, and JAR files

Deleting rows containing Java objects is no different than deleting other rows. The WHERE clause in the DELETE statement can include Java objects or Java fields and methods.

For more information, see "DELETE statement" on page 388 of the book *ASA SQL Reference Manual*.

Using Sybase Central, you can also delete an entire Java class or JAR file.

❖ **To delete a Java class or JAR file (Sybase Central):**

1. Open the Java Objects folder.
2. Locate the class or JAR you would like to delete.
3. Right-click the class or JAR file and choose Delete from the popup menu.

See also

- "Installing a class" on page 95
- "Installing a JAR" on page 96

Querying Java objects

You may wish to retrieve a Java column value in either of the following ways:

- Retrieve the entire object.
- Retrieve some of the fields of the object.

Retrieving the entire object

From SQL, you can create a variable of the appropriate type, and select the value from the object into that variable. However, the obvious place in which you may wish to make use of the entire object is in a Java application.

You can retrieve an object into a server-side Java class using the **getObject** method of the **ResultSet** of a query. You can also retrieve an object to a client-side Java application.

For more information about retrieving objects using JDBC, see "Queries using JDBC" on page 153.

Retrieving fields of the object

Individual fields of an object have data types that correspond to SQL data types, using the SQL to Java data type mapping described in "Java / SQL data type conversion" on page 84 of the book *ASA SQL Reference Manual*.

- You can retrieve individual fields by including them in the select-list of a query, as in the following simple example:

```
SELECT JProd>>unit_price
FROM product
WHERE ID = 400
```

- If you use methods to set and get the values of your fields, as is common in object oriented programming, you can include a **getField** method in your query:

```
SELECT JProd>>getName()
FROM Product
WHERE ID = 401
```

For more information about using objects in the WHERE clause and other issues in comparing objects, see "Comparing Java fields and objects" on page 108.

Performance tip
Getting a field directly is faster than invoking a method that gets the field because method invocations require starting the Java VM.

The results of SELECT column-name

You can list the column name in a query select list, as in the following query:

```
SELECT JProd
FROM jdba.product
```

This query returns the Sun serialization of the object to the client application.

When you execute a query that retrieves an object in Interactive SQL, it displays the return value of the object's **toString** method. For the Product class, the **toString** method lists, in one string, the size, name, and unit price of the object. The results of the query are as follows:

JProd
Small Tee Shirt: 9.00
Medium Tee Shirt: 14.00
One size fits all Tee Shirt: 14.00
One size fits all Baseball Cap: 9.00
One size fits all Baseball Cap: 10.00
One size fits all Visor: 7.00
One size fits all Visor: 7.00
Large Sweatshirt: 24.00
Large Sweatshirt: 24.00
Medium Shorts: 15.00

Comparing Java fields and objects

Public Java classes are domains with much more richness than traditional SQL domains. This raises issues about how Java columns behave in a relational database, compared to columns based on traditional SQL data types.

In particular, the issue of how objects are compared has implications for the following:

- Queries with an ORDER BY clause, a GROUP BY clause, a DISTINCT keyword, or using an aggregate function.
- Statements that use equality or inequality comparison conditions.
- Indexes and unique columns.
- Primary and foreign key columns.

Ways of comparing Java objects

Sorting and ordering rows, whether in a query or in an index, implies a comparison between values on each row. If you have a Java column, you can carry out comparisons in the following ways:

- **Compare on a public field** You can compare on a public field in the same way you compare on a regular row. For example, you could execute the following query:

  ```
  SELECT name, JProd.unit_price
  FROM Product
  ORDER BY JProd.unit_price
  ```

  You can use this kind of comparison in queries, but not for indexes and key columns.

- **Compare using a compareTo method** You can compare Java objects that have implemented a **compareTo** method. The Product class on which the **JProd** column is based has a **compareTo** method that compares objects based on the **unit_price** field. This permits the following query:

  ```
  SELECT name, JProd.unit_price
  FROM Product
  ORDER BY JProd
  ```

  The comparison needed for the ORDER BY clause is automatically carried out based on the **compareTo** method.

Comparing Java objects

To compare two objects of the same type, you must implement a **compareTo** method:

- For columns of Java data types to be used as primary keys, indexes, or as unique columns, the column class must implement a **compareTo** method.
- To use ORDER BY, GROUP BY, or DISTINCT clauses in a query, you must be comparing the values of the column. The column class must have a **compareTo** method for any of these clauses to be valid.
- Functions that employ comparisons, such as MAX and MIN, can only be used on Java classes with a **compareTo** method.

Requirements of the compareTo method

The **compareTo** method must have the following properties:

- **Scope** The method must be visible externally, and so should be a **public** method.
- **Arguments** The method takes a single argument, which is an object of the current type. The current object is compared to the supplied object. For example, **Product.compareTo** has the following argument:

  ```
  compareTo( Product anotherProduct )
  ```

  The method compares the **anotherProduct** object, of type Product, to the current object.
- **Return values** The compareTo method must return an **int** data type, with the following meanings:
  - **Negative integer** The current object is less than the supplied object. It is recommended that you return -1 for this case for compatibility with compareTo methods in base Java classes.
  - **Zero** The current object has the same value as the supplied object.
  - **Positive integer** The current object is greater than the supplied object. It is recommended that you return 1 for this case for compatibility with compareTo methods in base Java classes.

Example

The **Product** class installed into the sample database with the example classes has a **compareTo** method as follows:

```
public int compareTo( Product anotherProduct ) {
    // Compare first on the basis of price
    // and then on the basis of toString()
    int lVal = unit_price.intValue();
    int rVal = anotherProduct.unit_price.intValue();
    if ( lVal > rVal ) {
      return 1;
```

```
        }
        else if (lVal < rVal ) {
          return -1;
        }
        else {
          return toString().compareTo(
    anotherProduct.toString() );{
          }
        }
      }
```

This method compares the unit price of each object. If the unit prices are the same, then the names are compared (using Java string comparison, not the database string comparison). Only if both the unit price and the name are the same are the two objects considered the same when comparing.

Make toString and compareTo compatible

When you include a Java column in the select list of a query, and execute it in Interactive SQL, the value of the **toString** method appears. When comparing columns, the **compareTo** method is used. If the **toString** and **compareTo** methods are not implemented consistently with each other, you can get inappropriate results such as DISTINCT queries that appear to return duplicate rows.

For example, suppose the Product class in the sample database had a **toString** method that returned the product name, and a **compareTo** method based on the price. Then the following query, executed in Interactive SQL, would display duplicate values:

```
SELECT DISTINCT JProd
FROM product
```

JProd
Tee Shirt
Tee Shirt
Baseball Cap
Visor
Sweatshirt
Shorts

Here, the returned value being displayed is determined by **toString**. The DISTINCT keyword eliminates duplicates as determined by **compareTo**. As these have been implemented in ways that are not related to each other, duplicate rows appear to have been returned.

Special features of Java classes in the database

This section describes features of Java classes when used in the database.

Supported classes

You cannot use all classes from the JDK. The runtime Java classes available for use in the database server belong to a subset of the Java API.

☞ For more information about supported packages, see "Supported Java packages" on page 77 of the book *ASA SQL Reference Manual*.

Calling the main method

You typically start Java applications (outside the database) by running the Java VM on a class that has a **main** method.

For example, the **JDBCExamples** class in the file *Samples\ASA\Java\JDBCExamples.java* under your SQL Anywhere directory has a main method. When you execute the class from the command line using a command such as the following, it is the main method that executes:

```
java JDBCExamples
```

☞ For more information about how to run the **JDBCExamples** class, see "Establishing JDBC connections" on page 143.

❖ **To call the main method of a class from SQL:**

1. Declare the method with an array of strings as an argument:

   ```
   public static void main( java.lang.String[] args ){
   ...
   }
   ```

2. Invoke the `main` method using the CALL statement.

   Each member of the array of strings must be of CHAR or VARCHAR data type, or a literal string.

Example

The following class contains a `main` method which writes out the arguments in reverse order:

```
public class ReverseWrite {
  public static void main( String[] args ){
    int i:
    for( i = args.length; i > 0 ; i-- ){
        System.out.print( args[ i-1 ] );
    }
  }
}
```

You can execute this method from SQL as follows:

```
call ReverseWrite.main( ' one', ' two', 'three' )
```

The database server window displays the output:

```
three two one
```

Using threads in Java applications

With features of the **java.lang.Thread** package, you can use multiple threads in a Java application. Each Java thread is an engine thread, and comes from the number of threads permitted by the `-gn` database server option.

You can synchronize, suspend, resume, interrupt, or stop threads in Java applications.

For more information about database server threads, see "–gn server option" on page 141 of the book *ASA Database Administration Guide*.

Serialization of JDBC calls

All calls to the server-side JDBC driver are serialized, such that only one thread is actively executing JDBC at any one time.

Procedure Not Found error

If you supply an incorrect number of arguments when calling a Java method, or if you use an incorrect data type, the server responds with a Procedure Not Found error. You should check the number and type of arguments.

For more information about type conversions between SQL and Java, see "Java / SQL data type conversion" on page 84 of the book *ASA SQL Reference Manual*.

Return value of methods returning void

You can use Java methods in SQL statements wherever you can use an expression. You must ensure that the Java method return data type maps to the appropriate SQL data type.

☞ For more information about Java/SQL data type mappings, see "Java / SQL data type conversion" on page 84 of the book *ASA SQL Reference Manual*.

When a method returns void, however, the value **this** is returned to SQL; that is, the object itself. The feature only affects calls made from SQL, not from Java.

This feature is particularly useful in UPDATE statements, where **set** methods commonly return void. You can use the following UPDATE statement in the sample database:

```
update jdba.product
set JProd = JProd.setName('Tank Top')
where id=302
```

The **setName** method returns void, and so implicitly returns the product object to SQL.

Returning result sets from Java methods

This section describes how to make result sets available from Java methods. You must write a Java method that returns a result set to the calling environment, and wrap this method in a SQL stored procedure declared to be EXTERNAL NAME of LANGUAGE JAVA.

❖ **To return result sets from a Java method:**

1. Ensure that the Java method is declared as public and static in a public class.
2. For each result set you expect the method to return, ensure that the method has a parameter of type **java.sql.ResultSet[]**. These result set parameters must all occur at the end of the parameter list.
3. In the method, first create an instance of **java.sql.ResultSet** and then assign it to one of the **ResultSet[]** parameters.
4. Create a SQL stored procedure of type EXTERNAL NAME LANGUAGE JAVA. This type of procedure is a wrapper around a Java method. You can use a cursor on the SQL procedure result set in the same way as any other procedure that returns result sets.

   ☞ For more information about the syntax for stored procedures that are wrappers for Java methods, see "CREATE PROCEDURE statement" on page 305 of the book *ASA SQL Reference Manual*.

Example

The following simple class has a single method which executes a query and passes the result set back to the calling environment.

```
import java.sql.*;

public class MyResultSet {
  public static void return_rset( ResultSet[] rset1 )
       throws SQLException {
    Connection conn = DriverManager.getConnection(
                      "jdbc:default:connection" );
    Statement stmt = conn.createStatement();
    ResultSet rset =
      stmt.executeQuery (
                      "SELECT CAST( JName.lastName " +
                      "AS CHAR( 50 ) )" +
                      "FROM jdba.contact " );
    rset1[0] = rset;
  }
}
```

You can expose the result set using a CREATE PROCEDURE statement that indicates the number of result sets returned from the procedure and the **signature** of the Java method.

A CREATE PROCEDURE statement indicating a result set could be defined as follows:

```
CREATE PROCEDURE result_set()
  DYNAMIC RESULT SETS 1
  EXTERNAL NAME
     'MyResultSet.return_rset ([Ljava/sql/ResultSet;)V'
  LANGUAGE JAVA
```

You can open a cursor on this procedure, just as you can with any ASA procedure returning result sets.

The string **(Ljava/sql/ResultSet;)V** is a Java method signature which is a compact character representation of the number and type of the parameters and return value.

For more information about Java method signatures, see "CREATE PROCEDURE statement" on page 305 of the book *ASA SQL Reference Manual*.

Returning values from Java via stored procedures

You can use stored procedures created using the EXTERNAL NAME LANGUAGE JAVA as wrappers around Java methods. This section describes how to write your Java method to exploit OUT or INOUT parameters in the stored procedure.

Java does not have explicit support for INOUT or OUT parameters. Instead, you can use an array of the parameter. For example, to use an integer OUT parameter, create an array of exactly one integer:

```
public class TestClass {
  public static boolean testOut( int[] param ){
    param[0] = 123;
    return true;
  }
}
```

The following procedure uses the **testOut** method:

```
CREATE PROCEDURE sp_testOut ( OUT p INTEGER )
EXTERNAL NAME 'TestClass/testOut ([I)Z'
LANGUAGE JAVA
```

The string **([I)Z** is a Java method signature, indicating that the method has a single parameter, which is an array of integers, and returns a Boolean value. You must define the method so that the method parameter you wish to use as an OUT or INOUT parameter is an array of a Java data type that corresponds to the SQL data type of the OUT or INOUT parameter.

For more information about the syntax, including the method signature, see "CREATE PROCEDURE statement" on page 305 of the book *ASA SQL Reference Manual*.

For more information, see "Java / SQL data type conversion" on page 84 of the book *ASA SQL Reference Manual*.

Security management for Java

Java provides security managers than you can use to control user access to security-sensitive features of your applications, such as file access and network access. Adaptive Server Anywhere provides the following support for Java security managers in the database:

- Adaptive Server Anywhere provides a default security manager.
- You can provide your own security manager.

  For information, see "Implementing your own security manager" on page 116.

The default security manager

The default security manager is the class **com.sybase.asa.jrt.SAGenericSecurityManager**. It carries out the following tasks:

1 It checks the value of the database option JAVA_INPUT_OUTPUT.

2 It checks whether the database server was started in C2 security mode using the `-sc` database server option.

3 If the connection property is OFF, it disallows access to Java file I/O features.

4 If the database server is running in C2 security mode, it disallows access to **java.net** packages.

5 When the security manager prevents a user from accessing a feature, it returns a **java.lang.SecurityException**.

☞ For more information, see "JAVA_INPUT_OUTPUT option" on page 577 of the book *ASA Database Administration Guide*, and "–sc server option" on page 150 of the book *ASA Database Administration Guide*.

Controlling Java file I/O using the default security manager

Java file I/O is controlled through the JAVA_INPUT_OUTPUT database option. By default this option is set to OFF, disallowing file I/O.

❖ **To permit file access using the default security manager:**

♦ Set the JAVA_INPUT_OUTPUT option to ON:

```
SET OPTION JAVA_INPUT_OUTOUT='ON'
```

Implementing your own security manager

There are several steps to implementing your own security manager.

❖ **To provide your own security manager:**

1 Implement a class that extends **java.lang.SecurityManager**.

The SecurityManager class has a number of methods to check whether a particular action is allowed. If the action is permitted, the method returns silently. If the method returns a value a **SecurityException** is thrown.

You must override methods that govern actions you wish to permit with methods that return silently. You can do this by implementing a `public void` method.

2 Assign appropriate users to your security manager.

You use the *add_user_security_manager*, *update_user_security_manager*, and *delete_user_security_manager* system stored procedures to assign security managers to a user. For example, to assign the MySecurityManager class as the security manager for a user, you would execute the following command:

```
call dbo.add_user_security_manager(
  user_name, 'MySecurityManager', NULL )
```

Example

The following class allows reading from files but disallows writing:

```
public class MySecurityManager extends SecurityManager
{ public void checkRead(FileDescriptor) {}
  public void checkRead(String) {}
  public void checkRead(String, Object) {}
}
```

The **SecurityManager.checkWrite** methods are not overridden, and prevent write operations on files. The **checkRead** methods return silently, permitting the action.

How Java objects are stored

Java values are stored in serialized form. This means that each row contains the following information:

- A version identifier.
- An identifier for the class (or subclass) that is stored.
- The values of non-static, non-transient fields in the class.
- Other overhead information.

The class definition is *not* stored for each row. Instead, the identifier provides a reference to the class definition, which is held only once.

You can use Java objects without knowing the details of how these pieces work, but storage methods for these objects do have some implications for performance and so information follows.

Notes

- **Disk space** The overhead per row is 10 to 15 bytes. If the class has a single variable, then the storage required for the overhead can be similar to the amount needed for the variable itself. If the class has many variables, the overhead is negligible.
- **Performance** Any time you insert or update a Java value, the Java VM needs to serialize it. Any time a Java value is retrieved in a query, it needs to be deserialized by the VM. This can amount to a significant performance penalty.

  You can avoid the performance penalty for queries by using computed columns.
- **Indexing** Indexes on Java columns will not be very selective, and will not provide the performance benefits associated with indexes on simple SQL data types.
- **Serialization** If a class has a **readObject** or **writeObject** method, these are called when deserializing or serializing the instance. Using a **readObject** or **writeObject** method can impact performance because the Java VM is being invoked.

Java objects and class versions

Java objects stored in the database are **persistent**; that is, they exist even when no code is running. This means that you could carry out the following sequence of actions:

1 Install a class.

2 Create a table using that class as the data type for a column.

3 Insert rows into the table.

4 Install a new version of the class.

How will the existing rows work with the new version of the class?

Accessing rows when a class is updated

Adaptive Server Anywhere provides a form of class versioning to allow the new class to work with the old rows. The rules for accessing these older values are as follows:

- If a serializable field is in the old version of the class, but is either missing or not serializable in the new version, the field is ignored.
- If a serializable field is in the new version of the class, but was either missing or not serializable in the old version, the field is initialized to a default value. The default value is 0 for primitive types, false for Boolean values, and NULL for object references.
- If there was a superclass of the old version that is not a superclass of the new version, the data for that superclass is ignored.
- If there is a superclass of the new version that was not a superclass of the old version, the data for that superclass is initialized to default values.
- If a serializable field changes type between the older version and the newer version, the field is initialized to a default values. Type conversions are not supported; this is consistent with Sun Microsystems serialization.

When objects are inaccessible

A serialized object is inaccessible if the class of the object or any of its superclasses has been removed from the database at any time. This behavior is consistent with Sun Microsystems serialization.

Moving objects across databases

These changes make cross database transfer of objects possible even when the versions of classes differ. Cross database transfer can occur as follows:

- Objects are replicated to a remote database.
- A table of objects is unloaded and reloaded into another database.
- A log file containing objects is translated and applied against another database.

When the new class is used

Each connection's VM loads the class definition for each class the first time that class is used.

When you INSTALL a class, the VM on your connection is implicitly restarted. Therefore, you have immediate access to the new class.

For connections other than the one that carries out the INSTALL, the new class loads the next time a VM accesses the class for the first time. If the class is already loaded by a VM, that connection does not see the new class until the VM is restarted for that connection (for example, with a STOP JAVA and START JAVA).

Java database design

There is a large body of theory and practical experience available to help you design a relational database. You can find descriptions of Entity-Relationship design and other approaches not only in introductory form (see "Designing Your Database" on page 3 of the book *ASA SQL User's Guide*) but also in more advanced books.

No comparable body of theory and practice to develop object-relational databases exists, and this certainly applies to Java-relational databases. Here, we offer some suggestions for how to use Java to enhance the practical usefulness of relational databases.

Entities and attributes in relational and object-oriented data

In relational database design, each table describes an **entity**. For example, in the sample database there are tables named *Employee*, *Customer*, *Sales_order*, and *Department*. The attributes of these entities become the columns of the tables: employee addresses, customer identification numbers, sales order dates, and so on. Each row of the table may be considered as a separate instance of the entity—a specific employee, sales order, or department.

In object-oriented programming, each class describes an entity, and the methods and fields of that class describe the attributes of the entity. Each instance of the class (each **object**) holds a separate instance of the entity.

It may seem unnatural, therefore, for relational columns to be based on Java classes. A more natural correspondence may seem to be between table and class.

Entities and attributes in the real world

The distinction between entity and attribute may sound clear, but a little reflection shows that it is commonly not at all clear in practice:

- An address may be seen as an attribute of a customer, but an address is also an entity, with its own attributes of street, city, and so on.
- A price may be seen as an attribute of a product, but may also be seen as an entity, with attributes of amount and currency.

The utility of the object-relational database lies in exactly the fact that there are two ways of expressing entities. You can express some entities as tables and some entities as classes in a table. The next section describes an example.

Relational database limitations

Consider an insurance company wishing to keep track of its customers. A customer may be considered as an entity, so it is natural to construct a single table to hold all customers of the company.

However, insurance companies handle several kinds of customer. They handle policy holders, policy beneficiaries, and people who are responsible for paying policy premiums. For each of these customer types, the insurance company needs different information. For a beneficiary, little is needed beyond an address. For a policy holder, health information is required. For the customer paying the premiums, information may be needed for tax purposes.

Is it best to handle the separate kinds of customers as separate entities, or to handle the customer type as an attribute of the customer? There are limitations to both approaches:

- Building separate tables for each type of customer can lead to a very complex database design, and to multi-table queries when information relating to all customers is required.
- It is difficult, if using a single customer table, to ensure that the information for each customer is correct. Making columns required for some customers but not for others, nullable, permits the entry of correct data, but does not enforce it. There is no simple way in relational databases to tie default behavior to an attribute of the new entry.

Using classes to overcome relational database limitations

You can use a single customer table, with Java class columns for some of the information, to overcome the limitations of relational databases.

For example, suppose different contact information is necessary for policy holders than for beneficiaries. You could approach this by defining a column based on a **ContactInformation** class. Then define classes named **HolderContactInformation** and **BeneficiaryContactInformation** which are subclasses of the **ContactInformation** class. By entering new customers according to their type, you can be sure that the information is correct.

Levels of abstraction for relational data

Data in a relational database can be categorized by its purpose. Which of this data belongs in a Java class, and which is best kept in simple data type columns?

- **Referential integrity columns** Primary key columns and foreign key columns commonly hold identification numbers. These identification numbers may be called **referential** data since they primarily define the structure of the database and the relationships between tables.

  Referential data does not generally belong in Java classes. Although you can make a Java class column a primary key column, integers and other simple data types are more efficient for this purpose.

- **Indexed data** Columns that are commonly indexed may also belong outside a Java class. However, the dividing line between data that needs to be indexed and data that is not to be indexed is vaguely defined.

  With computed columns, you can selectively index on a Java field or method (or, in fact, some other expression). If you define a Java class column and then find that it would be useful to index on a field or method of that column, you can use computed columns to make a separate column from that field or method.

  For more information, see "Using computed columns with Java classes" on page 124.

- **Descriptive data** It is common for some of the data in each row to be descriptive. It is not used for referential integrity purposes, and is possibly not frequently indexed, but it is data commonly used in queries. For an employee table, this may include information such as start date, address, benefit information, salary, and so on. This data can often benefit from being combined into fewer columns of Java class data types.

Java classes are useful for abstracting at a level between that of the single relational column and the relational table.

Using computed columns with Java classes

Computed columns are a feature designed to make Java database design easier, to make it easier to take advantage of Java features for existing databases, and to improve performance of Java data types.

A computed column is a column whose values are obtained from other columns. You cannot INSERT or UPDATE values in computed columns. However, any update that attempts to modify the computed column does fire triggers associated with the column.

Uses of computed columns

There are two main uses of computed columns with Java classes:

- **Exploding a Java column** If you create a column using a Java class data type, computed columns enable you to index one of the fields of the class. You can add a computed column that holds the value of the field, and create an index on that field.
- **Adding a Java column to a relational table** If you wish to use some of the features of Java classes while disturbing an existing database as little as possible, you can add a Java column as a computed column, collecting its values from other columns in the table.

Defining computed columns

Computed columns are declared in the CREATE TABLE or ALTER TABLE statement.

Creating tables with computed columns

The following CREATE TABLE statement is used to create the *product* table in the Java sample tables:

```
CREATE TABLE product
(
  id    INTEGER NOT NULL,
  JProd asademo.Product NOT NULL,
  name CHAR(15) COMPUTE ( JProd>>name ),
  PRIMARY KEY ("id")
)
```

Adding computed columns to tables

The following statement alters the *product* table by adding another computed column:

```
ALTER TABLE product
ADD inventory_Value INTEGER
  COMPUTE ( JProd.quantity * JProd.unit_price )
```

Modifying the expression for computed columns

You can change the expression used in a computed column using the ALTER TABLE statement. The following statement changes the expression that a computed column is based on.

```
ALTER TABLE table_name
ALTER column-name SET COMPUTE ( expression )
```

The column is recalculated when this statement is executed. If the new expression is invalid, the ALTER TABLE statement fails.

The following statement stops a column from being a computed column.

```
ALTER TABLE table_name
ALTER column-name DROP COMPUTE
```

The values in the column are not changed when this statement is executed.

Inserting and updating computed columns

Computed columns have some impact on valid INSERT and UPDATE statements. The *jdba.product* table in the Java sample tables has a computed column (*name*) which we use to illustrate the issues. The table definition is as follows:

```
CREATE TABLE "jdba"."product"
(
   "id"    INTEGER NOT NULL,
   "JProd" asademo.Product NOT NULL,
   "name"  CHAR(15) COMPUTE( JProd.name ),
   PRIMARY KEY ("id")
)
```

- **No direct inserts or updates** You cannot insert a value directly into a computed column. The following statement fails with a Duplicate Insert Column error:

  ```
  -- Incorrect statement
  INSERT INTO PRODUCT (id, name)
  VALUES( 3006, 'bad insert statement' )
  ```

  Similarly, no UPDATE statement can directly update a computed column.

- **Listing column names** You must always specify column names in INSERT statements on tables with computed columns. The following statement fails with a Wrong Number of Values for Insert error:

  ```
  -- Incorrect statement
  INSERT INTO PRODUCT
  VALUES( 3007,new asademo.Product() )
  ```

  Instead, you must list the columns, as follows:

```
INSERT INTO PRODUCT( id, JProd )
VALUES( 3007,new asademo.Product() )
```

- **Triggers** You can define triggers on a computed column, and any INSERT or UPDATE statement that affects the column fires the trigger.

When computed columns are recalculated

Recalculating computed columns occurs when:

- Any column is deleted, added, or renamed.
- The table is renamed.
- Any column's data type or COMPUTE clause is modified.
- A row is inserted.
- A row is updated.

Computed columns are *not* recalculated when queried. If you use a time-dependent expression, or one that depends on the state of the database in some other way, then the computed column may not give a proper result.

Configuring memory for Java

This section describes the memory requirements for running Java in the database and how to set up your server to meet those requirements.

The Java VM requires a significant amount of cache memory.

☞ For information on tuning the cache, see "Using the cache to improve performance" on page 152 of the book *ASA SQL User's Guide*.

Database and connection-level requirements

The Java VM uses memory on both a per-database and on a per-connection basis.

- The per-database requirements are not **relocatable**: they cannot be paged out to disk. They must fit into the server cache. This type of memory is not for the server; it is for each database. When estimating cache requirements, you must sum the requirements for each database you run on the server.
- The per-connection requirements are relocatable, but only as a unit. The requirements for one connection are either all in cache, or all in the temporary file.

How memory is used

Java in the database requires memory for several purposes:

- When Java is first used when a server is running, the VM is loaded into memory, requiring over 1.5 Mb of memory. This is part of the database-wide requirements. An additional VM is loaded for each database that uses Java.
- For each connection that uses Java, a new instance of the VM loads for that connection. The new instance requires about 200K per connection.
- Each class definition that is used in a Java application is loaded into memory. This is held in database-wide memory: separate copies are not required for individual connections.
- Each connection requires a working set of Java variables and application stack space (used for method arguments and so on).

Managing memory

You can control memory use in the following ways:

- **Set the overall cache size** You must use a cache size sufficient to meet all the requirements for non-relocatable memory.

  The cache size is set when the server is started using the `-c` option.

In many cases, a cache size of 8 Mb is sufficient.

- **Set the namespace size** The Java namespace size is the maximum size, in bytes, of the per database memory allocation.

  You can set this using the JAVA_NAMESPACE_SIZE option. The option is global, and can only be set by a user with DBA authority.

- **Set the heap size** This JAVA_HEAP_SIZE option sets the maximum size, in bytes, of per-connection memory.

  This option can be set for individual connections, but as it affects the memory available for other users it can be set only by a user with DBA authority.

Starting and stopping the VM

In addition to setting memory parameters for Java, you can unload the VM when Java is not in use using the STOP JAVA statement. Only a user with DBA authority can execute this statement. The syntax is simply:

```
STOP JAVA
```

The VM loads whenever a Java operation is carried out. If you wish to explicitly load it in readiness for carrying out Java operations, you can do so by executing the following statement:

```
START JAVA
```

CHAPTER 5

Data Access Using JDBC

About this chapter

This chapter describes how to use JDBC to access data.

JDBC can be used both from client applications and inside the database. Java classes using JDBC provide a more powerful alternative to SQL stored procedures for incorporating programming logic in the database.

Contents

JDBC overview

JDBC provides a SQL interface for Java applications: if you want to access relational data from Java, you do so using JDBC calls.

Rather than a thorough guide to the JDBC database interface, this chapter provides some simple examples to introduce JDBC and illustrates how you can use it on the client and in the database.

The examples illustrate the distinctive features of using JDBC in Adaptive Server Anywhere. For more information about JDBC programming, see any JDBC programming book.

JDBC and Adaptive Server Anywhere

You can use JDBC with Adaptive Server Anywhere in the following ways:

- **JDBC on the client** Java client applications can make JDBC calls to Adaptive Server Anywhere. The connection takes place through a JDBC driver. SQL Anywhere Studio includes two JDBC drivers: the jConnect driver for pure Java applications and a JDBC-ODBC bridge.

  In this chapter, the phrase **client application** applies both to applications running on a user's machine and to logic running on a middle-tier application server.

- **JDBC in the database** Java classes installed into a database can make JDBC calls to access and modify data in the database using an internal JDBC driver.

JDBC resources

- **Required software** You need TCP/IP to use the Sybase jConnect driver.

  The Sybase jConnect driver may already be available, depending on your installation of Adaptive Server Anywhere.

  For more information about the jConnect driver and its location, see "The jConnect driver files" on page 136.

- **Example source code** You can find source code for the examples in this chapter in the file *Samples\ASA\Java\JDBCExamples.java* in your SQL Anywhere directory.

  For more information about how to set up the Java examples, including the **JDBCExamples** class, see "Setting up the Java samples" on page 86.

Choosing a JDBC driver

Two JDBC drivers are provided for Adaptive Server Anywhere:

- **jConnect** This driver is a 100% pure Java driver. It communicates with Adaptive Server Anywhere using the TDS client/server protocol.
- **JDBC-ODBC bridge** This driver communicates with Adaptive Server Anywhere using the Command Sequence client/server protocol. Its behavior is consistent with ODBC, embedded SQL, and OLE DB applications.

When choosing which driver to use, you may want to consider the following factors:

- **Features** Both drivers are JDK 2 compliant. The JDBC-ODBC bridge provides fully-scrollable cursors, which are not available in jConnect.
- **Pure Java** The jConnect driver is a pure Java solution. The JDBC-ODBC bridge requires the Adaptive Server Anywhere ODBC driver and is not a pure Java solution.
- **Performance** The JDBC-ODBC bridge provides better performance for most purposes than the jConnect driver.
- **Compatibility** The TDS protocol used by the jConnect driver is shared with Adaptive Server Enterprise. Some aspects of the driver's behavior are governed by this protocol, and are configured to be compatible with Adaptive Server Enterprise.

Both drivers are available on Windows 95/98/Me and Windows NT/2000/XP, as well as supported UNIX and Linux operating systems. They are not available on NetWare or Windows CE.

JDBC program structure

The following sequence of events typically occur in JDBC applications:

1. **Create a Connection object** Calling a **getConnection** class method of the **DriverManager** class creates a **Connection** object, and establishes a connection with a database.
2. **Generate a Statement object** The **Connection** object generates a **Statement** object.
3. **Pass a SQL statement** A SQL statement that executed within the database environment passes to the **Statement** object. If the statement is a query, this action returns a **ResultSet** object.

The **ResultSet** object contains the data returned from the SQL statement, but exposes it one row at a time (similar to the way a cursor works).

4 **Loop over the rows of the result set** The **next** method of the **ResultSet** object performs two actions:

- The current row (the row in the result set exposed through the **ResultSet** object) advances one row.
- A Boolean value (true/false) returns to indicate whether there is, in fact, a row to advance to.

5 **For each row, retrieve the values** Values are retrieved for each column in the **ResultSet** object by identifying either the name or position of the column. You can use the **getDate** method to get the value from a column on the current row.

Java objects can use JDBC objects to interact with a database and get data for their own use, for example to manipulate or for use in other queries.

JDBC in the database features

The version of JDBC that you can use from Java in the database is determined by the JDK version that the database is set up to use.

- If your database is initialized with JDK 1.2 or JDK 1.3, you can use the JDBC 2.0 API.

  For information on upgrading databases to JDK 1.2 or JDK 1.3, see "ALTER DATABASE statement" on page 205 of the book *ASA SQL Reference Manual* or "Upgrading a database using the dbupgrad command-line utility" on page 522 of the book *ASA Database Administration Guide*.

- If your database is initialized with JDK 1.1, you can use JDBC 1.2 features. The internal JDBC driver for JDK 1.1 (*asajdbc*) makes some features of JDBC 2.0 available from server-side Java applications, but does not provide full JDBC 2.0 support.

  For more information, see "Using JDBC 2.0 features from JDK 1.1 databases" on page 132.

Using JDBC 2.0 features from JDK 1.1 databases

This section describes how to access JDBC 2.0 features from databases initialized with JDK 1.1 support. For many purposes, a better solution is to upgrade your version of Java in the database to 1.3.

For databases initialized with JDK 1.1 support, the **sybase.sql.ASA** package contains features that are part of JDBC 2.0. To use these JDBC 2.0 features you must cast your JDBC objects into the corresponding classes in the **sybase.sql.ASA** package, rather than the **java.sql** package. Classes that are declared as **java.sql** are restricted to JDBC 1.2 functionality only.

The classes in **sybase.sql.ASA** are as follows:

JDBC class	Sybase internal driver class
java.sql.Connection	sybase.sql.ASA.SAConnection
java.sql.Statement	sybase.sql.ASA.SAStatement
java.sql.PreparedStatement	sybase.sql.ASA.SAPreparedStatement
java.sql.CallableStatement	sybase.sql.ASA.SACallableStatement
java.sql.ResultSetMetaData	sybase.sql.ASA.SAResultSetMetaData
java.sql.ResultSet	sybase.sql.SAResultSet
java.sql.DatabaseMetaData	sybase.sql.SADatabaseMetaData

The following function provides a **ResultSetMetaData** object for a prepared statement without requiring a **ResultSet** or executing the statement. This function is not part of the JDBC 1.2 standard.

```
ResultSetMetaData
sybase.sql.ASA.SAPreparedStatement.describe()
```

The following code fetches the previous row in a result set, a feature not supported in JDBC 1.2:

```
import java.sql.*;
import sybase.sql.asa.*;
ResultSet rs;
// more code here
( ( sybase.sql.asa.SAResultSet)rs ).previous();
```

JDBC 2.0 restrictions

The following classes are part of the JDBC 2.0 core interface, but are not available in the **sybase.sql.ASA** package:

- java.sql.Blob
- java.sql.Clob
- java.sql.Ref
- java.sql.Struct
- java.sql.Array
- java.sql.Map

The following JDBC 2.0 core functions are not available in the **sybase.sql.ASA** package:

Class in sybase.sql.ASA	Missing functions
SAConnection	java.util.Map getTypeMap()
	void setTypeMap(java.util.Map map)
SAPreparedStatement	void setRef(int pidx, java.sql.Ref r)
	void setBlob(int pidx, java.sql.Blob b)
	void setClob(int pidx, java.sql.Clob c)
	void setArray(int pidx, java.sql.Array a)
SACallableStatement	Object getObject(pidx, java.util.Map map)
	java.sql.Ref getRef(int pidx)
	java.sql.Blob getBlob(int pidx)
	java.sql.Clob getClob(int pidx)
	java.sql.Array getArray(int pidx)
SAResultSet	Object getObject(int cidx, java.util.Map map)
	java.sql.Ref getRef(int cidx)
	java.sql.Blob getBlob(int cidx)
	java.sql.Clob getClob(int cidx)
	java.sql.Array getArray(int cidx)
	Object getObject(String cName, java.util.Map map)
	java.sql.Ref getRef(String cName)
	java.sql.Blob getBlob(String cName)
	java.sql.Clob getClob(String cName)
	java.sql.Array getArray(String cName)

Differences between client- and server-side JDBC connections

A difference between JDBC on the client and in the database server lies in establishing a connection with the database environment.

- **Client side** In client-side JDBC, establishing a connection requires the Sybase jConnect JDBC driver or the Adaptive Server Anywhere JDBC-ODBC bridge. Passing arguments to the **DriverManager.getConnection** establishes the connection. The database environment is an external application from the perspective of the client application.
- **Server-side** When using JDBC within the database server, a connection already exists. A value of **jdbc:default:connection** passes to **DriverManager.getConnection**, which provides the JDBC application with the ability to work within the current user connection. This is a quick, efficient, and safe operation because the client application has already passed the database security to establish the connection. The user ID and password, having been provided once, do not need to be provided again. The internal JDBC driver can only connect to the database of the current connection.

You can write JDBC classes in such a way that they can run both at the client and at the server by employing a single conditional statement for constructing the URL. An external connection requires the machine name and port number, while the internal connection requires **jdbc:default:connection**.

Using the jConnect JDBC driver

If you wish to use JDBC from a client application or applet, you must have the jConnect JDBC driver to connect to Adaptive Server Anywhere databases.

jConnect is included with SQL Anywhere Studio. If you received Adaptive Server Anywhere as part of another package, jConnect may or may not be included. You must have jConnect in order to use JDBC from client applications. You can use JDBC in the database without jConnect.

The jConnect driver files

The jConnect JDBC driver is installed into a set of directories under the *Sybase\Shared* directory. Two versions of jConnect are supplied:

- **jConnect 4.5** This version of jConnect is for use when developing JDK 1.1 applications. jConnect 4.5 is installed into the *Sybase\Shared\jConnect-4_5* directory.

  jConnect 4.5 is supplied as a set of classes.

- **jConnect 5.5** This version of jConnect is for use when developing JDK 1.2 or later applications. jConnect 5.5 is installed into the *Sybase\Shared\jConnect-5_5* directory.

  jConnect 5.5 is supplied as a jar file named *jconn2.jar*.

Examples in this chapter use jConnect 5.5. Users of jConnect 4.5 must make appropriate substitutions.

Setting the CLASSPATH for jConnect

For your application to use jConnect, the jConnect classes must be in your classpath at compile time and run time, so the Java compiler and Java runtime can locate the necessary files.

The following command adds the jConnect 5.5 driver to an existing CLASSPATH environment variable where *path* is your *Sybase\Shared* directory.

```
set classpath=%classpath%;path\jConnect-5_5\classes\jconn2.jar
```

The following command adds the jConnect 4.5 driver to an existing CLASSPATH environment variable:

```
set classpath=%classpath%;path\jConnect-4_5\classes
```

Importing the jConnect classes

The classes in jConnect are all in the **com.sybase** package.

If you are using jConnect 5.5, your application must access classes in **com.sybase.jdbc2.jdbc**. You must import these classes at the beginning of each source file:

```
import com.sybase.jdbc2.jdbc.*
```

If you are using jConnect 4.5, the classes are in **com.sybase.jdbc**. You must import these classes at the beginning of each source file:

```
import com.sybase. jdbc.*
```

Installing jConnect system objects into a database

If you wish to use jConnect to access system table information (database metadata), you must add the jConnect system objects to your database.

By default, the jConnect system objects are added to any new database. You can choose to add the jConnect objects to the database when creating, when upgrading, or at a later time.

You can install the jConnect system objects from Sybase Central or from Interactive SQL.

❖ **To add jConnect system objects to a database (Sybase Central):**

1. Connect to the database from Sybase Central as a user with DBA authority.
2. In the left pane of Sybase Central, right-click the database icon and choose Re-Install jConnect Meta-data Support from the popup menu.

❖ **To add jConnect system objects to a database (Interactive SQL):**

- Connect to the database from Interactive SQL as a user with DBA authority, and enter the following command in the SQL Statements pane:

  ```
  read path\scripts\jcatalog.sql
  ```

  where *path* is your SQL Anywhere directory.

Tip
You can also use a command prompt to add the jConnect system objects to a database. At the command prompt, type:

```
dbisql -c "uid=user;pwd=pwd" path\scripts\jcatalog.sql
```

where *user* and *pwd* identify a user with DBA authority, and *path* is your SQL Anywhere directory.

Loading the jConnect driver

Before you can use jConnect in your application, load the driver by entering the following statement:

```
Class.forName("com.sybase.jdbc2.jdbc.SybDriver").newInstance();
```

Using the **newInstance** method works around issues in some browsers.

Supplying a URL for the server

To connect to a database via jConnect, you need to supply a Uniform Resource Locator (URL) for the database. An example given in the section "Connecting from a JDBC client application using jConnect" on page 143 is as follows:

```
StringBuffer temp = new StringBuffer();
// Use the jConnect driver...
temp.append("jdbc:sybase:Tds:");
// to connect to the supplied machine name...
temp.append(_coninfo);
// on the default port number for ASA...
temp.append(":2638");
// and connect.
System.out.println(temp.toString());
conn = DriverManager.getConnection(temp.toString() ,
_props );
```

The URL is put together in the following way:

```
jdbc:sybase:Tds:machine-name:port-number
```

The individual components are:

- **jdbc:sybase:Tds** The Sybase jConnect JDBC driver, using the TDS application protocol.
- **machine-name** The IP address or name of the machine on which the server is running. If you are establishing a same-machine connection, you can use **localhost**, which means the current machine
- **port number** The port number on which the database server listens. The port number assigned to Adaptive Server Anywhere is 2638. Use that number unless there are specific reasons not to do so.

The connection string must be less than 253 characters in length.

Specifying a database on a server

Each Adaptive Server Anywhere server may have one or more databases loaded at a time. The URL as described above specifies a server, but does not specify a database. The connection attempt is made to the default database on the server.

You can specify a particular database by providing an extended form of the URL in one of the following ways.

Using the ServiceName parameter

```
jdbc:sybase:Tds:machine-name:port-number?ServiceName=DBN
```

The question mark followed by a series of assignments is a standard way of providing arguments to a URL. The case of **servicename** is not significant, and there must be no spaces around the = sign. The *DBN* parameter is the database name.

Using the RemotePWD parameter

A more general method allows you to provide additional connection parameters such as the database name, or a database file, using the **RemotePWD** field. You set **RemotePWD** as a Properties field using the **setRemotePassword()** method.

Here is sample code that illustrates how to use the field.

```
sybDrvr = (SybDriver)Class.forName(
    "com.sybase.jdbc2.jdbc.SybDriver" ).newInstance();
props = new Properties();
props.put( "User", "DBA" );
props.put( "Password", "SQL" );
sybDrvr.setRemotePassword(
   null, "dbf=asademo.db", props );
Connection con = DriverManager.getConnection(
   "jdbc:sybase:Tds:localhost", props );
```

Using the database file parameter **DBF**, you can start a database on a server using jConnect. By default, the database is started with autostop=YES. If you specify a DBF or DBN of **utility_db**, then the utility database will automatically be started.

For more information on the utility database, see "Using the utility database" on page 226 of the book *ASA Database Administration Guide*.

Database options set for jConnect connections

When an application connects to the database using the jConnect driver, two stored procedures are called:

1 *sp_tsql_environment* sets some database options for compatibility with Adaptive Server Enterprise behavior.

2 The *spt_mda* procedure is then called, and sets some other options. In particular, the *spt_mda* procedure determines the QUOTED_IDENTIFIER setting. To change the default behavior, you should modify the *spt_mda* procedure.

Using the JDBC-ODBC bridge

The JDBC-ODBC bridge provides a JDBC driver that has some performance benefits and feature benefits compared to the pure Java jConnect JDBC driver, but which is not a pure-Java solution.

For information on choosing which JDBC driver to use, see "Choosing a JDBC driver" on page 131.

Required files

The Java component of the JDBC-ODBC bridge is included in the *jodbc.jar* file installed into the *Java* subdirectory of your SQL Anywhere installation. For Windows, the native component is *dbjodbc8.dll* in the *win32* subdirectory of your SQL Anywhere installation; for UNIX and Linux, the native component is *dbjodbc8.so*. This component must be in the system path. When deploying applications using this driver, you must also deploy the ODBC driver files.

Establishing a connection

The following code illustrates how to establish a connection using the JDBC-ODBC bridge:

```
String     driver, url;
Connection  conn;

driver="ianywhere.ml.jdbcodbc.IDriver";
url = "jdbc:odbc:dsn=ASA 8.0 Sample";
Class.forName( driver );
conn = DriverManager.getConnection( url );
```

There are several things to note about this code:

- As the classes are loaded using `Class.forName`, the package containing the JDBC-ODBC bridge does not have to be imported using `import` statements.
- *jodbc.jar* must be in your classpath when you run the application.
- The URL contains **jdbc:odbc:** followed by a standard ODBC connection string. The connection string is commonly an ODBC data source, but you can also use explicit semicolon separated individual connection parameters in addition to or instead of the data source. For more information on the parameters that you can use in a connection string, see "Connection parameters" on page 70 of the book *ASA Database Administration Guide*.

  If you do not use a data source, you should specify the ODBC driver to use by including the driver parameter in your connection string:

  ```
  url = "jdbc:odbc:";
  url += "driver=Adaptive Server Anywhere 8.0;...";
  ```

Character sets

On UNIX the JDBC-ODBC bridge does *not* use ODBC Unicode bindings or calls and does not carry out character translations. Sending non-ASCII data through the bridge leads to data corruption.

On Windows the JDBC-ODBC bridge *does* use ODBC Unicode bindings and calls to translate among character sets.

Establishing JDBC connections

This section presents classes that establish a JDBC database connection from a Java application. The examples in this section use jConnect (client side) or Java in the database (server side). For information on establishing connections using the JDBC-ODBC bridge, see "Using the JDBC-ODBC bridge" on page 141.

Connecting from a JDBC client application using jConnect

If you wish to access database system tables (database metadata) from a JDBC application, you must add a set of jConnect system objects to your database. The internal JDBC driver classes and jConnect share stored procedures for database metadata support. These procedures are installed to all databases by default. The *dbinit* `-i` option prevents this installation.

For more information about adding the jConnect system objects to a database, see "Using the jConnect JDBC driver" on page 136.

The following complete Java application is a command-line application that connects to a running database, prints a set of information to your command-line, and terminates.

Establishing a connection is the first step any JDBC application must take when working with database data.

This example illustrates an external connection, which is a regular client/server connection. For information on how to create an internal connection from Java classes running inside the database server, see "Establishing a connection from a server-side JDBC class" on page 146.

External connection example code

The following is the source code for the methods used to make a connection. The source code can be found in the **main** method and the **ASAConnect** method of the file *JDBCExamples.java* in the *Samples\ASA\Java* directory under your SQL Anywhere directory:

```
import java.sql.*;              // JDBC
import com.sybase.jdbc2.jdbc.*;      // Sybase jConnect
import java.util.Properties;    // Properties
import sybase.sql.*;            // Sybase utilities
import asademo.*;               // Example classes
```

```
public class JDBCExamples{
  private static Connection conn;

  public static void main( String args[] ){
    // Establish a connection
    conn = null;
    String machineName = ( args.length == 1 ? args[0] :
"localhost" );
    ASAConnect( "DBA", "SQL", machineName );
    if( conn!=null ) {
        System.out.println( "Connection successful" );
    }else{
        System.out.println( "Connection failed" );
    }

    try{
       getObjectColumn();
       getObjectColumnCastClass();
       insertObject();
    }
    catch( Exception e ){
      System.out.println( "Error: " + e.getMessage() );
      e.printStackTrace();
    }
  }

private static void ASAConnect( String userID,
              String password,
              String machineName ) {
  // Connect to an Adaptive Server Anywhere
    String coninfo = new String( machineName );

    Properties props = new Properties();
    props.put( "user", userID );
    props.put( "password", password );
    props.put("DYNAMIC_PREPARE", "true");

    // Load jConnect
    try {
      Class.forName( "com.sybase.jdbc2.jdbc.SybDriver"
).newInstance();
      String dbURL = "jdbc:sybase:Tds:" + machineName  +
                     ":2638/?JCONNECT_VERSION=5";
      System.out.println( dbURL );
      conn = DriverManager.getConnection( dbURL , props
);
    }
    catch ( Exception e ) {
      System.out.println( "Error: " + e.getMessage() );
      e.printStackTrace();
    }
  }
```

How the external connection example works

The external connection example is a Java command-line application.

Importing packages

The application requires several libraries, which are imported in the first lines of *JDBCExamples.java*:

- The **java.sql** package contains the Sun Microsystems JDBC classes, which are required for all JDBC applications. You'll find it in the *classes.zip* file in your Java subdirectory.
- Imported from **com.sybase.jdbc2.jdbc**, the Sybase jConnect JDBC driver is required for all applications that connect using jConnect.
- The application uses a **property list**. The **java.util.Properties** class is required to handle property lists. You'll find it in the *classes.zip* file in your *Java* subdirectory.
- The **asademo** package contains classes used in some samples. You'll find it in the *Samples\ASA\Java\asademo.jar* file.

The main method

Each Java application requires a class with a method named **main**, which is the method invoked when the program starts. In this simple example, **JDBCExamples.main** is the only method in the application.

The **JDBCExamples.main** method carries out the following tasks:

1. Processes the command-line argument, using the machine name if supplied. By default, the machine name is *localhost*, which is appropriate for the personal database server.
2. Calls the **ASAConnect** method to establish a connection.
3. Executes several methods that scroll data to your command-line.

The ASAConnect method

The **JDBCExamples.ASAConnect** method carries out the following tasks:

1. Connects to the default running database using Sybase jConnect.
   - **Class.forName** loads jConnect. Using the **newInstance** method, it works around issues in some browsers.
   - The **StringBuffer** statements build up a connection string from the literal strings and the supplied machine name provided on the command-line.
   - **DriverManager.getConnection** establishes a connection using the connection string.
2. Returns control to the calling method.

Running the external connection example

This section describes how to run the external connection example.

❖ **To create and execute the external connection example application:**

1. Open the command prompt.
2. Change to your SQL Anywhere directory.
3. Change to the *Samples\ASA\Java* subdirectory.
4. Ensure the database is loaded onto a database server running TCP/IP. You can start such a server on your local machine using the following command (from the *Samples\ASA\Java* subdirectory):

   ```
   start dbeng8 ..\..\..\asademo
   ```

5. Enter the following at the command prompt to run the example:

   ```
   java JDBCExamples
   ```

   If you wish to try this against a server running on another machine, you must enter the correct name of that machine. The default is **localhost**, which is an alias for the current machine name.

6. Confirm that a list of people and products appears at the command prompt.

   If the attempt to connect fails, an error message appears instead. Confirm that you have executed all the steps as required. Check that your CLASSPATH is correct. An incorrect CLASSPATH results in a failure to locate a class.

For more information about using jConnect, see "Using the jConnect JDBC driver" on page 136, and see the online documentation for jConnect.

Establishing a connection from a server-side JDBC class

SQL statements in JDBC are built using the **createStatement** method of a **Connection** object. Even classes running inside the server need to establish a connection to create a **Connection** object.

Establishing a connection from a server-side JDBC class is more straightforward than establishing an external connection. Because a user already connected executes the server-side class, the class simply uses the current connection.

Server-side connection example code

The following is the source code for the example. You can find the source code in the **InternalConnect** method of *Samples\ASA\Java\JDBCExamples.java* under your SQL Anywhere directory:

```
public static void InternalConnect() {
  try {
      conn =
DriverManager.getConnection("jdbc:default:connection");
      System.out.println("Hello World");
    }
    catch ( Exception e ) {
      System.out.println("Error: " + e.getMessage());
      e.printStackTrace();
    }
  }
}
```

How the server-side connection example works

In this simple example, **InternalConnect()** is the only method used in the application.

The application requires only one of the libraries (JDBC) imported in the first line of the *JDBCExamples.java* class. The others are for external connections. The package named **java.sql** contains the JDBC classes.

The **InternalConnect()** method carries out the following tasks:

1 Connects to the default running database using the current connection:

- **DriverManager.getConnection** establishes a connection using a connection string of **jdbc:default:connection**.

2 Prints **Hello World** to the current standard output, which is the server window. **System.out.println** carries out the printing.

3 If there is an error in the attempt to connect, an error message appears in the server window, together with the place where the error occurred.

The **try** and **catch** instructions provide the framework for the error handling.

4 Terminates the class.

Running the server-side connection example

This section describes how to run the server-side connection example.

❖ **To create and execute the internal connection example application:**

1. If you have not already done so, compile the *JDBCExamples.java* file. If you are using the JDK, you can do the following in the *Samples\ASA\Java* directory from a command prompt:

   ```
   javac JDBCExamples.java
   ```

2. Start a database server using the sample database. You can start such a server on your local machine using the following command (from the *Samples\ASA\Java* subdirectory):

   ```
   start dbeng8 ..\..\..\asademo
   ```

   The TCP/IP network protocol is not necessary in this case since you are not using jConnect.

3. Install the class into the sample database. Once connected to the sample database, you can do this from Interactive SQL using the following command:

   ```
   INSTALL JAVA NEW
   FROM FILE 'path\Samples\ASA\Java\JDBCExamples.class'
   ```

   where *path* is the path to your installation directory.

   You can also install the class using Sybase Central. While connected to the sample database, open the Java Objects folder and double-click Add Java Class. Then follow the instructions in the wizard.

4. You can now call the **InternalConnect** method of this class just as you would a stored procedure:

   ```
   CALL JDBCExamples>>InternalConnect()
   ```

   The first time a Java class is called in a session, the internal Java virtual machine must be loaded. This can take a few seconds.

5. Confirm that the message **Hello World** prints on the server screen.

Notes on JDBC connections

♦ **Autocommit behavior** The JDBC specification requires that, by default, a COMMIT is performed after each data modification statement. Currently, the server-side JDBC behavior is to commit. You can control this behavior using a statement such as the following:

```
conn.setAutoCommit( false ) ;
```

where **conn** is the current connection object.

- **Connection defaults** From server-side JDBC, only the first call to **getConnection("jdbc:default:connection")** creates a new connection with the default values. Subsequent calls return a wrapper of the current connection with all connection properties unchanged. If you set AutoCommit to OFF in your initial connection, any subsequent **getConnection** calls within the same Java code return a connection with AutoCommit set to OFF.

  You may wish to ensure that closing a connection resets the connection properties to their default values, so that subsequent connections are obtained with standard JDBC values. The following type of code achieves this:

```
Connection conn = DriverManager.getConnection("");
boolean oldAutoCommit = conn.getAutoCommit();
try {
     // do code here
}
finally {
    conn.setAutoCommit( oldAutoCommit );
}
```

  This discussion applies not only to AutoCommit, but also to other connection properties such as TransactionIsolation and isReadOnly.

Using JDBC to access data

Java applications that hold some or all classes in the database have significant advantages over traditional SQL stored procedures. At an introductory level, however, it may be helpful to use the parallels with SQL stored procedures to demonstrate the capabilities of JDBC. In the following examples, we write Java classes that insert a row into the *Department* table.

As with other interfaces, SQL statements in JDBC can be either **static** or **dynamic**. Static SQL statements are constructed in the Java application and sent to the database. The database server parses the statement, selects an execution plan, and executes the statement. Together, parsing and selecting an execution plan are referred to as **preparing** the statement.

If a similar statement has to be executed many times (many inserts into one table, for example), there can be significant overhead in static SQL because the preparation step has to be executed each time.

In contrast, a dynamic SQL statement contains placeholders. The statement, prepared once using these placeholders, can be executed many times without the additional expense of preparing.

In this section, we use static SQL. Dynamic SQL is discussed in a later section.

Preparing for the examples

This section describes how to prepare for the examples in the remainder of the chapter.

Sample code

The code fragments in this section are taken from the complete class *Samples\ASA\Java\JDBCExamples.java*.

❖ **To install the JDBCExamples class:**

1. If you have not already done so, install the *JDBCExamples.class* file into the sample database. Once connected to the sample database from Interactive SQL, enter the following command in the SQL Statements pane:

   ```
   INSTALL JAVA NEW
   FROM FILE 'path\Samples\ASA\Java\JDBCExamples.class'
   ```

   where *path* is the path to your installation directory.

   You can also install the class using Sybase Central. While connected to the sample database, open the Java Objects folder and double-click Add Java Class. Then follow the instructions in the wizard.

Inserts, updates, and deletes using JDBC

The **Statement** object executes static SQL statements. You execute SQL statements such as INSERT, UPDATE, and DELETE, which do not return result sets, using the **executeUpdate** method of the **Statement** object. Statements, such as CREATE TABLE and other data definition statements, can also be executed using **executeUpdate**.

The following code fragment illustrates how JDBC carries out INSERT statements. It uses an internal connection held in the Connection object named **conn**. The code for inserting values from an external application using JDBC would need to use a different connection, but otherwise would be unchanged.

```
public static void InsertFixed()  {
    // returns current connection
    conn =
DriverManager.getConnection("jdbc:default:connection");
    // Disable autocommit
    conn.setAutoCommit( false );

    Statement stmt = conn.createStatement();

    Integer IRows = new Integer( stmt.executeUpdate
      ("INSERT INTO Department (dept_id, dept_name )"
       + "VALUES (201, 'Eastern Sales')"
        ) );
    // Print the number of rows updated
    System.out.println(IRows.toString() + " row
inserted" );
  }
```

Source code available
This code fragment is part of the **InsertFixed** method of the **JDBCExamples** class included in the *Samples\ASA\Java* subdirectory of your installation directory.

Notes

- The **setAutoCommit** method turns off the AutoCommit behavior so changes are only committed if you execute an explicit COMMIT instruction.
- The **executeUpdate** method returns an integer which reflects the number of rows affected by the operation. In this case, a successful INSERT would return a value of one (1).

- The integer return type converts to an **Integer** object. The Integer class is a wrapper around the basic **int** data type, providing some useful methods such as **toString()**.
- The Integer **IRows** converts to a string to be printed. The output goes to the server window.

❖ **To run the JDBC Insert example:**

1. Using Interactive SQL, connect to the sample database as user ID **DBA**.
2. Ensure the JDBCExamples class has been installed. It is installed together with the other Java examples classes.

   For more information about installing the Java examples classes, see "Setting up the Java samples" on page 86.
3. Call the method as follows:

   ```
   CALL JDBCExamples>>InsertFixed()
   ```
4. Confirm that a row has been added to the *department* table.

   ```
   SELECT *
   FROM department
   ```

   The row with ID 201 is not committed. You can execute a ROLLBACK statement to remove the row.

In this example, you have seen how to create a very simple JDBC class. Subsequent examples expand on this.

Passing arguments to Java methods

We can expand the **InsertFixed** method to illustrate how arguments are passed to Java methods.

The following method uses arguments passed in the call to the method as the values to insert:

```
public static void InsertArguments(
                String id, String name)  {
try {
      conn = DriverManager.getConnection(
                   "jdbc:default:connection" );

String sqlStr =  "INSERT INTO Department "
   + " ( dept_id, dept_name )"
   + " VALUES (" +  id +  ", '"  + name + "')";

      // Execute the statement
      Statement stmt = conn.createStatement();
```

```
      Integer IRows = new Integer( stmt.executeUpdate(
sqlStr.toString() ) );

      // Print the number of rows updated
      System.out.println(IRows.toString() + " row
inserted" );
    }
    catch ( Exception e ) {
      System.out.println("Error: " + e.getMessage());
      e.printStackTrace();
    }
  }
```

Notes

- The two arguments are the department ID (an integer) and the department name (a string). Here, both arguments pass to the method as strings because they are part of the SQL statement string.
- The INSERT is a static statement and takes no parameters other than the SQL itself.
- If you supply the wrong number or type of arguments, you receive the Procedure Not Found error.

❖ **To use a Java method with arguments:**

1. If you have not already installed the *JDBCExamples.class* file into the sample database, do so.
2. Connect to the sample database from Interactive SQL and enter the following command:

   ```
   call JDBCExamples>>InsertArguments( '203', 'Northern
   Sales' )
   ```

3. Verify that an additional row has been added to the Department table:

   ```
   SELECT *
   FROM Department
   ```

4. Roll back the changes to leave the database unchanged:

   ```
   ROLLBACK
   ```

Queries using JDBC

The **Statement** object executes static queries, as well as statements that do not return result sets. For queries, you use the **executeQuery** method of the **Statement** object. This returns the result set in a **ResultSet** object.

The following code fragment illustrates how queries can be handled within JDBC. The code fragment places the total inventory value for a product into a variable named **inventory**. The product name is held in the **String** variable **prodname**. This example is available as the **Query** method of the **JDBCExamples** class.

The example assumes an internal or external connection has been obtained and is held in the Connection object named **conn**.

```
public static int Query () {
int max_price = 0;
    try{
      conn = DriverManager.getConnection(
                  "jdbc:default:connection" );

      // Build the query
      String sqlStr =  "SELECT id, unit_price "
   + "FROM product" ;

      // Execute the statement
      Statement stmt = conn.createStatement();
      ResultSet result = stmt.executeQuery( sqlStr );

      while( result.next() ) {
   int price = result.getInt(2);
   System.out.println( "Price is "  + price );
   if( price > max_price ) {
     max_price = price ;
   }
      }
    }
    catch( Exception e ) {
      System.out.println("Error: " + e.getMessage());
      e.printStackTrace();
    }
      return max_price;
  }
```

Running the example

Once you have installed the **JDBCExamples** class into the sample database, you can execute this method using the following statement in Interactive SQL:

```
select JDBCExamples>>Query()
```

Notes

- The query selects the quantity and unit price for all products named **prodname**. These results are returned into the **ResultSet** object named **result**.
- There is a loop over each of the rows of the result set. The loop uses the **next** method.

- For each row, the value of each column is retrieved into an integer variable using the **getInt** method. **ResultSet** also has methods for other data types, such as **getString**, **getDate**, and **getBinaryString**.

  The argument for the **getInt** method is an index number for the column, starting from 1.

  Data type conversion from SQL to Java is carried out according to the information in "SQL to Java data type conversion" on page 85 of the book *ASA SQL Reference Manual*.
- Adaptive Server Anywhere supports bidirectional scrolling cursors. However, JDBC provides only the **next** method, which corresponds to scrolling forward through the result set.
- The method returns the value of **max_price** to the calling environment, and Interactive SQL displays it on the Results tab in the Results pane.

Using prepared statements for more efficient access

If you use the **Statement** interface, you parse each statement you send to the database, generate an access plan, and execute the statement. The steps prior to actual execution are called **preparing** the statement.

You can achieve performance benefits if you use the **PreparedStatement** interface. This allows you to prepare a statement using placeholders, and then assign values to the placeholders when executing the statement.

Using prepared statements is particularly useful when carrying out many similar actions, such as inserting many rows.

For more information about prepared statements, see "Preparing statements" on page 12.

Example

The following example illustrates how to use the **PreparedStatement** interface, although inserting a single row is not a good use of prepared statements.

The following method of the **JDBCExamples** class carries out a prepared statement:

```
public static void JInsertPrepared(int id, String name)
try {
      conn = DriverManager.getConnection(
                  "jdbc:default:connection");

      // Build the INSERT statement
      // ? is a placeholder character
      String sqlStr = "INSERT INTO Department "
   + "( dept_id, dept_name ) "
```

```
      + "VALUES ( ? , ? )" ;

         // Prepare the statement
         PreparedStatement stmt = conn.prepareStatement(
sqlStr );

         stmt.setInt(1, id);
         stmt.setString(2, name );
         Integer IRows = new Integer(
                              stmt.executeUpdate() );

         // Print the number of rows updated
         System.out.println(IRows.toString() + " row
inserted" );
       }
       catch ( Exception e ) {
         System.out.println("Error: " + e.getMessage());
         e.printStackTrace();
       }
     }
```

Running the example

Once you have installed the **JDBCExamples** class into the sample database, you can execute this example by entering the following statement:

```
call JDBCExamples>>InsertPrepared(
                               202, 'Eastern Sales' )
```

The string argument is enclosed in single quotes, which is appropriate for SQL. If you invoke this method from a Java application, use double quotes to delimit the string.

Inserting and retrieving objects

As an interface to relational databases, JDBC is designed to retrieve and manipulate traditional SQL data types. Adaptive Server Anywhere also provides abstract data types in the form of Java classes. The way you access these Java classes using JDBC depends on whether you want to insert or retrieve the objects.

For more information on getting and setting entire objects, see "Creating distributed applications" on page 158.

Retrieving objects

You can retrieve objects, their fields, and their methods by:

- **Accessing methods and fields** Java methods and fields can be included in the select-list of a query. A method or field then appears as a column in the result set, and can be accessed using one of the standard **ResultSet** methods, such as **getInt** or **getString**.
- **Retrieving an object** If you include a column with a Java class data type in a query select list, you can use the **ResultSet getObject** method to retrieve the object into a Java class. You can then access the methods and fields of that object within the Java class.

Inserting objects

From a server-side Java class, you can use the JDBC **setObject** method to insert an object into a column with Java class data type.

You can insert objects using a prepared statement. For example, the following code fragment inserts an object of type MyJavaClass into a column of table T:

```
java.sql.PreparedStatement ps =
    conn.prepareStatement("insert T values( ? )" );
ps.setObject( 1, new MyJavaClass() );
ps.executeUpdate();
```

An alternative is to set up a SQL variable that holds the object and then to insert the SQL variable into the table.

Miscellaneous JDBC notes

- **Access permissions** Like all Java classes in the database, classes containing JDBC statements can be accessed by any user. There is no equivalent to the GRANT EXECUTE statement that grants permission to execute procedures, and there is no need to qualify the name of a class with the name of its owner.
- **Execution permissions** Java classes are executed with the permissions of the connection executing them. This behavior is different to that of stored procedures, which execute with the permissions of the owner.

Creating distributed applications

In a **distributed application**, parts of the application logic run on one machine, and parts run on another machine. With Adaptive Server Anywhere, you can create distributed Java applications, where part of the logic runs in the database server, and part on the client machine.

Adaptive Server Anywhere is capable of exchanging Java objects with an external Java client.

Having the client application retrieve a Java object from a database is the key task in a distributed application This section describes how to accomplish that task.

Related tasks

In other parts of this chapter, we described how to retrieve several tasks related to retrieving objects, but which should not be confused with retrieving the object itself. For example:

- "Querying Java objects" on page 106 describes how to retrieve an object into a SQL variable. This does not solve the problem of getting the object into your Java application.
- "Querying Java objects" on page 106 also describes how to retrieve the public fields and the return value of Java methods. Again, this is distinct from retrieving an object into a Java application.
- "Inserting and retrieving objects" on page 156 describes how to retrieve objects into server-side Java classes. Again, this is not the same as retrieving them into a client application.

Requirements for distributed applications

There are several tasks in building a distributed application.

❖ **To build a distributed application:**

1. Any class running in the server must implement the Serializable interface. This is very simple.
2. The client-side application must import the class so the object can be reconstructed on the client side.
3. Use the **sybase.sql.ASAUtils.toByteArray** method on the server side to serialize the object. This is only necessary for Adaptive Server Anywhere version 6.0.1 and earlier.
4. Use the **sybase.sql.ASAUtils.fromByteArray** method on the client side to reconstruct the object. This is only necessary for Adaptive Server Anywhere version 6.0.1 and earlier.

These tasks are described in the following sections.

Implementing the Serializable interface

Objects pass from the server to a client application in **serialized** form. This means that each row contains the following information:

- A version identifier.
- An identifier for the class (or subclass) that is stored.
- The values of non-static, non-transient fields in the class.
- Other overhead information.

For an object to be sent to a client application, it must implement the Serializable interface. Fortunately, this is a very simple task.

❖ **To implement the Serializable interface:**

- Add the words **implements java.io.Serializable** to your class definition.

  For example, *Samples\ASA\Java\asademo\Product.java* implements the Serializable interface by virtue of the following declaration:

  ```
  public class Product implements java.io.Serializable
  ```

  Implementing the Serializable interface amounts to simply declaring that your class can be serialized.

The Serializable interface contains no methods and no variables. Serializing an object converts it into a byte stream, which allows it to be saved to disk or sent to another Java application where it can be reconstituted or **deserialized**.

A serialized Java object in a database server, sent to a client application and deserialized, is identical in every way to its original state. Some variables in an object, however, either don't need to be or, for security reasons, should not be serialized. Those variables are declared using the keyword **transient**, as in the following variable declaration.

```
transient String password;
```

When an object with this variable is deserialized, the variable always contains its default value, null.

Custom serialization can be accomplished by adding **writeObject()** and **readObject()** methods to your class.

☞ For more information about serialization, see Sun Microsystems' *Java Development Kit (JDK)*.

Importing the class on the client side

On the client side, any class that retrieves an object has to have access to the proper class definition to use the object. To use the **Product** class, which is part of the **asademo** package, you must include the following line in your application:

```
import asademo.*
```

The *asademo.jar* file must be included in your CLASSPATH for this package to be located.

A sample distributed application

The *JDBCExamples.java* class contains three methods that illustrate distributed Java computing. These are all called from the **main** method. This method is called in the connection example described in "Connecting from a JDBC client application using jConnect" on page 143, and is an example of a distributed application.

Here is the **getObjectColumn** method from the JDBCExamples class.

```
private static void getObjectColumn() throws Exception {
// Return a result set from a column containing
// Java objects
    asademo.ContactInfo ci;
    String name;
    String sComment ;

    if ( conn != null ) {
      Statement stmt = conn.createStatement();
      ResultSet rs = stmt.executeQuery(
           "SELECT JContactInfo FROM jdba.contact"
    );
    while ( rs.next() ) {
    ci = ( asademo.ContactInfo )rs.getObject(1);
  System.out.println( "\n\tStreet: " + ci.street +
      "City: " + ci.city +
      "\n\tState: " + ci.state +
      "Phone: " + ci.phone +
      "\n" );
      }
    }
  }
```

The getObject method is used in the same way as in the internal Java case.

Older method

getObject and setObject recommended
The **getObject** and **setObject** methods remove the need for explicit serialization and deserialization that was needed in earlier versions of the software. The current section describes that older method for users who are maintaining code that uses these techniques.

In this section we describe how one of these examples works. You can study the code for the other examples.

Serializing and deserializing query results

Here is the **serializeColumn** method of an old version of the **JDBCExamples** class.

```
private static void serializeColumn() throws Exception {
  Statement stmt;
  ResultSet rs;
  byte arrayb[];
  asademo.ContactInfo ci;
  String name;

  if ( conn != null ) {
    stmt = conn.createStatement();
    rs = stmt.executeQuery( "SELECT
      sybase.sql.ASAUtils.toByteArray( JName.getName() )
AS Name,
      sybase.sql.ASAUtils.toByteArray(
jdba.contact.JContactInfo )
      FROM jdba.contact" );

    while ( rs.next() ) {
      arrayb = rs.getBytes("Name");
      name = ( String
)sybase.sql.ASAUtils.fromByteArray( arrayb );
      arrayb = rs.getBytes(2);
      ci =
(asademo.ContactInfo)sybase.sql.ASAUtils.fromByteArray(
arrayb );
      System.out.println( "Name: " + name +
                          "\n\tStreet: " + ci.street +
                          "\n\tCity: " + ci.city +
                          "\n\tState: " + ci.state +
                          "\n\tPhone: " + ci.phone +
                          "\n" );
      }
      System.out.println( "\n\n" );
    }
  }
```

Here is how the method works:

1 A connection already exists when the method is called. The connection object is checked, and as long as it exists, the code executes.

2 A SQL query is constructed and executed. The query is as follows:

```
SELECT
sybase.sql.ASAUtils.toByteArray( JName.getName() )
AS Name,
sybase.sql.ASAUtils.toByteArray(
jdba.contact.JContactInfo )
      FROM jdba.contact
```

This statement queries the *jdba.contact* table. It gets information from the **JName** and the **JContactInfo** columns. Instead of just retrieving the column itself, or a method of the column, the **sybase.sql.ASAUtils.toByteArray** function converts the values to a byte stream so it can be serialized.

3 The client loops over the rows of the result set. For each row, the value of each column is deserialized into an object.

4 The output (**System.out.println**) shows that the fields and methods of the object can be used as they could in their original state.

Other features of distributed applications

There are two other methods in *JDBCExamples.java* that use distributed computing:

- **serializeVariable** This method creates a native Java object referenced by a SQL variable on the database server and passes it back to the client application.
- **serializeColumnCastClass** This method is like the **serializeColumn** method, but demonstrates how to reconstruct subclasses. The column that is queried (**JProd** from the **product** table) is of data type **asademo.Product**. Some of the rows are **asademo.Hat**, which is a subclass of the Product class. The proper class is reconstructed on the client side.

CHAPTER 6

Embedded SQL Programming

About this chapter

This chapter describes how to use the embedded SQL programming interface to Adaptive Server Anywhere.

Contents

Introduction

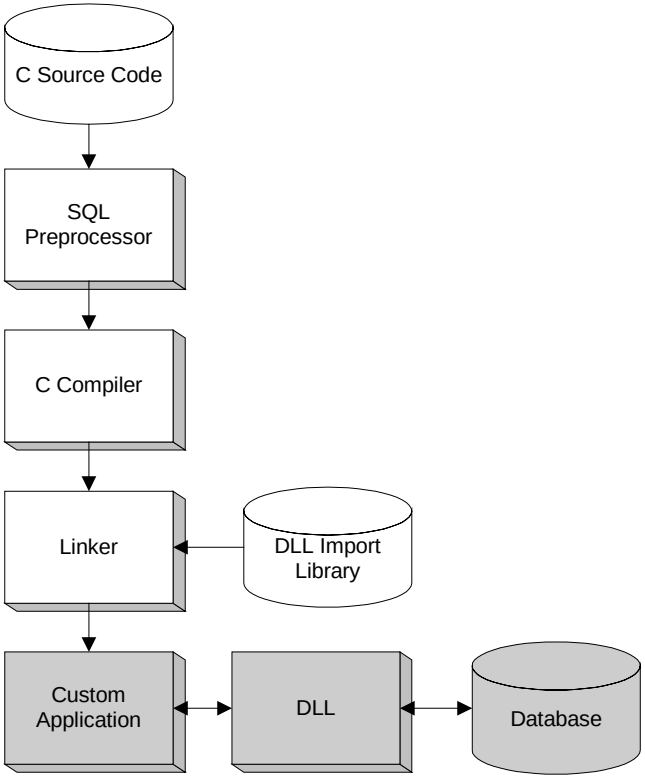
Embedded SQL is a database-programming interface for the C and C++ programming languages. It consists of SQL statements intermixed with (embedded in) C or C++ source code. These SQL statements are translated by a **SQL preprocessor** into C or C++ source code, which you then compile.

At runtime, embedded SQL applications use an Adaptive Server Anywhere **interface library** to communicate with database server. The interface library is a dynamic link library (**DLL**) or shared library on most platforms.

- On Windows operating systems, the interface library is *dblib8.dll*.
- On UNIX operating systems, the interface library is *libdblib8.so*, *libdblib8.sl*, or *libdblib8.a*, depending on the operating system.

Adaptive Server Anywhere provides two flavors of embedded SQL. Static embedded SQL is simpler to use but less flexible than dynamic embedded SQL. Both flavors are discussed in this chapter.

Development process overview



Once the program has been successfully preprocessed and compiled, it is linked with the **import library** for the Adaptive Server Anywhere interface library to form an executable file. When the database is running, this executable file uses the Adaptive Server Anywhere DLL to interact with the database. The database does not have to be running when the program is preprocessed.

For Windows, there are separate import libraries for Watcom C/C++, for Microsoft Visual C++, and for Borland C++.

Using import libraries is the standard development method for applications that call functions in DLLs. Adaptive Server Anywhere also provides an alternative, and recommended method which avoids the use of import libraries. For more information, see "Loading the interface library dynamically" on page 169.

Running the SQL preprocessor

The SQL preprocessor is an executable named *sqlpp.exe*.

Command line

The SQLPP command line is as follows:

sqlpp [*options*] *SQL-filename* [*output-filename*]

The SQL preprocessor processes a C program with embedded SQL before the C or C++ compiler is run. The preprocessor translates the SQL statements into C/C++ language source that is put into the output file. The normal extension for source programs with embedded SQL is *.sqc*. The default output filename is the *SQL-filename* with an extension of *.c*. If the *SQL-filename* already has a *.c* extension, then the output filename extension is *.cc* by default.

For a full listing of the command-line options, see "The SQL preprocessor" on page 226.

Supported compilers

The C language SQL preprocessor has been used in conjunction with the following compilers:

Operating system	Compiler	Version
Windows	Watcom C/C++	9.5 and above
Windows	Microsoft Visual C/C++	1.0 and above
Windows	Borland C++	4.5
Windows CE	Microsoft Visual C/C++	5.0
UNIX	GNU or native compiler	
NetWare	Watcom C/C++	10.6, 11

For instructions on building NetWare NLMs, see "Building NetWare Loadable Modules" on page 170.

Embedded SQL header files

All header files are installed in the *h* subdirectory of your Adaptive Server Anywhere installation directory.

Filename	Description
sqlca.h	Main header file included in all embedded SQL programs. This file includes the structure definition for the SQL Communication Area (SQLCA) and prototypes for all embedded SQL database interface functions.
sqlda.h	SQL Descriptor Area structure definition included in embedded SQL programs that use dynamic SQL.
sqldef.h	Definition of embedded SQL interface data types. This file also contains structure definitions and return codes needed for starting the database server from a C program.
sqlerr.h	Definitions for error codes returned in the **sqlcode** field of the SQLCA.
sqlstate.h	Definitions for ANSI/ISO SQL standard error states returned in the **sqlstate** field of the SQLCA.
pshpk1.h, pshpk2.h, poppk.h	These headers ensure that structure packing is handled correctly. They support Watcom C/C++, Microsoft Visual C++, IBM Visual Age, and Borland C/C++ compilers.

Import libraries

All import libraries are installed in the *lib* subdirectory, under the operating system subdirectory of the Adaptive Server Anywhere installation directory. For example, Windows import libraries are stored in the *win32\lib* subdirectory.

Operating system	Compiler	Import library
Windows	Watcom C/C++	*dblibtw.lib*
Windows	Microsoft Visual C++	*dblibtm.lib*
Windows CE	Microsoft Visual C++	*dblib8.lib*
NetWare	Watcom C/C++	*dblib8.lib*
Solaris (unthreaded applications)	All compilers	*libdblib8.so, libdbtasks8.so*
Solaris (threaded applications)	All compilers	*libdblib8_r.so, libdbtasks8_r.so*

The *libdbtasks8* libraries are called by the *libdblib8* library. Some compilers locate *libdbtasks8* automatically, while for others you need to specify it explicitly.

A simple example

The following is a very simple example of an embedded SQL program.

```
#include <stdio.h>
EXEC SQL INCLUDE SQLCA;
main()
{
   db_init( &sqlca );
   EXEC SQL WHENEVER SQLERROR GOTO error;
   EXEC SQL CONNECT "DBA" IDENTIFIED BY "SQL";
   EXEC SQL UPDATE employee
      SET emp_lname =    'Plankton'
      WHERE emp_id = 195;
   EXEC SQL COMMIT WORK;
   EXEC SQL DISCONNECT;
   db_fini( &sqlca );
   return( 0 );

   error:
   printf( "update unsuccessful -- sqlcode = %ld.n",
      sqlca.sqlcode );
   db_fini( &sqlca );
   return( -1 );
}
```

This example connects to the database, updates the last name of employee number 195, commits the change, and exits. There is virtually no interaction between the SQL and C code. The only thing the C code is used for in this example is control flow. The WHENEVER statement is used for error checking. The error action (GOTO in this example) is executed after any SQL statement that causes an error.

For a description of fetching data, see "Fetching data" on page 193.

Structure of embedded SQL programs

SQL statements are placed (embedded) within regular C or C++ code. All embedded SQL statements start with the words EXEC SQL and end with a semicolon (;). Normal C language comments are allowed in the middle of embedded SQL statements.

Every C program using embedded SQL must contain the following statement before any other embedded SQL statements in the source file.

```
EXEC SQL INCLUDE SQLCA;
```

The first embedded SQL statement executed by the C program must be a CONNECT statement. The CONNECT statement is used to establish a connection with the database server and to specify the user ID that is used for authorizing all statements executed during the connection.

The CONNECT statement must be the first embedded SQL statement executed. Some embedded SQL commands do not generate any C code, or do not involve communication with the database. These commands are thus allowed before the CONNECT statement. Most notable are the INCLUDE statement and the WHENEVER statement for specifying error processing.

Loading the interface library dynamically

The usual practice for developing applications that use functions from DLLs is to link the application against an **import library**, which contains the required function definitions.

This section describes an alternative to using an import library for developing Adaptive Server Anywhere applications. The Adaptive Server Anywhere interface library can be loaded dynamically, without having to link against the import library, using the *esqldll.c* module in the *src* subdirectory of your installation directory. Using *esqldll.c* is recommended because it is easier to use and more robust in its ability to locate the interface DLL.

❖ **To load the interface DLL dynamically:**

1. Your program must call **db_init_dll** to load the DLL, and must call **db_fini_dll** to free the DLL. The **db_init_dll** call must be before any function in the database interface, and no function in the interface can be called after **db_fini_dll**.

   You must still call the **db_init** and **db_fini** library functions.

2. You must **#include** the *esqldll.h* header file before the EXEC SQL INCLUDE SQLCA statement or **#include** <*sqlca.h*> line in your embedded SQL program.

3. A SQL OS macro must be defined. The header file *sqlca.h*, which is included by *esqdll.c*, attempts to determine the appropriate macro and define it. However, certain combinations of platforms and compilers may cause this to fail. In this case, you must add a **#define** to the top of this file, or make the definition using a compiler option.

Macro	Platforms
_SQL_OS_WINNT	All Windows operating systems
_SQL_OS_UNIX	UNIX
_SQL_OS_NETWARE	NetWare

4 Compile *esqldll.c*.

5 Instead of linking against the imports library, link the object module *esqldll.obj* with your embedded SQL application objects.

Sample

You can find a sample program illustrating how to load the interface library dynamically in the *Samples\ASA\ESQLDynamicLoad* subdirectory of your SQL Anywhere directory. The source code is in *Samples\ASA\ESQLDynamicLoad\sample.sqc*.

Building NetWare Loadable Modules

You must use the Watcom C/C++ compiler, version 10.6 or 11.0, to compile embedded SQL programs as NetWare Loadable Modules (NLM).

❖ **To create an embedded SQL NLM:**

1 On Windows, preprocess the embedded SQL file using the following command:

```
sqlpp -o NETWARE srcfile.sqc
```

This instruction creates a file with *.c* extension.

2 Compile *file.c* using the Watcom compiler (10.6 or 11.0), using the `/bt=netware` option.

3 Link the resulting object file using the Watcom linker with the following options:

```
FORMAT NOVELL
MODULE dblib8
OPTION CASEEXACT
IMPORT @dblib8.imp
LIBRARY dblib8.lib
```

The files *dblib8.imp* and *dblib8.lib* are shipped with Adaptive Server Anywhere, in the *nlm\lib* directory. The IMPORT and LIBRARY lines may require a full path.

Sample embedded SQL programs

Sample embedded SQL programs are included with the Adaptive Server Anywhere installation. They are placed in the *Samples\ASA\C* subdirectory of your SQL Anywhere directory.

- The static cursor embedded SQL example, *Samples\ASA\C\cur.sqc*, demonstrates the use of static SQL statements.
- The dynamic cursor embedded SQL example, *Samples\ASA\C\dcur.sqc*, demonstrates the use of dynamic SQL statements.

To reduce the amount of code that is duplicated by the sample programs, the mainlines and the data printing functions have been placed into a separate file. This is *mainch.c* for character mode systems and *mainwin.c* for windowing environments.

The sample programs each supply the following three routines, which are called from the mainlines.

- **WSQLEX_Init** Connects to the database and opens the cursor.
- **WSQLEX_Process_Command** Processes commands from the user, manipulating the cursor as necessary.
- **WSQLEX_Finish** Closes the cursor and disconnect from the database.

The function of the mainline is to:

1. Call the **WSQLEX_Init** routine
2. Loop, getting commands from the user and calling **WSQL_Process_Command** until the user quits
3. Call the **WSQLEX_Finish** routine

Connecting to the database is accomplished with the embedded SQL CONNECT command supplying the appropriate user ID and password.

In addition to these samples, you may find other programs and source files as part of SQL Anywhere Studio which demonstrate features available for particular platforms.

Building the sample programs

Files to build the sample programs are supplied with the sample code.

- For Windows and NetWare operating systems, hosted on Windows operating systems, use *makeall.bat* to compile the sample programs.

- For UNIX, use the shell script makeall.
- For Windows CE, use the *dcur.dsp* project file for Microsoft Visual C++.

The format of the command is as follows:

```
makeall {Example} {Platform} {Compiler}
```

The first parameter is the name of the example program that you want to compile. It is one of the following:

- **CUR** static cursor example
- **DCUR** dynamic cursor example
- **ODBC** ODBC example

The second parameter is the target platform. It is one of the following:

- **WINNT** compile for Windows.
- **NETWARE** compile for NetWare NLM

The third parameter is the compiler to use to compile the program. The compiler can be one of:

- **WC** use Watcom C/C++
- **MC** use Microsoft C
- **BC** use Borland C

Running the sample programs

The executable files are held in the *Samples\ASA\C* directory, together with the source code.

❖ **To run the static cursor sample program:**

1. Start the program:
   - Start the Adaptive Server Anywhere Personal Server Sample database.
   - Run the file *Samples\ASA\C\curwnt.exe*.
2. Follow the on-screen instructions.

   The various commands manipulate a database cursor and print the query results on the screen. Type the letter of the command you wish to perform. Some systems may require you to press ENTER after the letter.

❖ **To run the dynamic cursor sample program:**

1 Start the program:

- Run the file *Samples\ASA\C\dcurwnt.exe*.

2 Connect to a database:

- Each sample program presents a console-type user interface and prompts you for a command. Enter the following connection string to connect to the sample database:

  ```
  DSN=ASA 8.0 Sample
  ```

3 Choose a table:

- Each sample program prompts you for a table. Choose one of the tables in the sample database. For example, you may enter **Customer** or **Employee**.

4 Follow the on-screen instructions.

The various commands manipulate a database cursor and print the query results on the screen. Type the letter of the command you wish to perform. Some systems may require you to press ENTER after the letter.

Windows samples

The Windows versions of the example programs are real Windows programs. However, to keep the user interface code relatively simple, some simplifications have been made. In particular, these applications do not repaint their Windows on WM_PAINT messages except to reprint the prompt.

Static cursor sample

This example demonstrates the use of cursors. The particular cursor used here retrieves certain information from the **employee** table in the sample database. The cursor is declared statically, meaning that the actual SQL statement to retrieve the information is "hard coded" into the source program. This is a good starting point for learning how cursors work. The next example ("Dynamic cursor sample" on page 174) takes this first example and converts it to use dynamic SQL statements.

For information on where the source code can be found and how to build this example program, see "Sample embedded SQL programs" on page 171.

The **open_cursor** routine both declares a cursor for the specific SQL command and also opens the cursor.

Printing a page of information is accomplished by the **print** routine. It loops *pagesize* times, fetching a single row from the cursor and printing it out. Note that the fetch routine checks for warning conditions (such as Row not found) and prints appropriate messages when they arise. In addition, the cursor is repositioned by this program to the row before the one that appears at the top of the current page of data.

The **move**, **top**, and **bottom** routines use the appropriate form of the FETCH statement to position the cursor. Note that this form of the FETCH statement doesn't actually get the data—it only positions the cursor. Also, a general relative positioning routine, **move**, has been implemented to move in either direction depending on the sign of the parameter.

When the user quits, the cursor is closed and the database connection is also released. The cursor is closed by a ROLLBACK WORK statement, and the connection is release by a DISCONNECT.

Dynamic cursor sample

This sample demonstrates the use of cursors for a dynamic SQL SELECT statement. It is a slight modification of the static cursor example. If you have not yet looked at "Static cursor sample" on page 173, it would be helpful to do so before looking at this sample.

For information on where the source code can be found and how to build this sample program, see "Sample embedded SQL programs" on page 171.

The **dcur** program allows the user to select a table to look at with the **n** command. The program then presents as much information from that table as fits on the screen.

When this program is run, it prompts for a connection string of the form:

```
uid=DBA;pwd=SQL;dbf=c:\asa\asademo.db
```

The C program with the embedded SQL is held in the *Samples\ASA\C* subdirectory of your SQL Anywhere directory. The program looks much like the static cursor sample with the exception of the **connect**, **open_cursor**, and **print** functions.

The **connect** function uses the embedded SQL interface function **db_string_connect** to connect to the database. This function provides the extra functionality to support the connection string that is used to connect to the database.

The **open_cursor** routine first builds the SELECT statement

```
SELECT * FROM tablename
```

where *tablename* is a parameter passed to the routine. It then prepares a dynamic SQL statement using this string.

The embedded SQL DESCRIBE command is used to fill in the SQLDA structure the results of the SELECT statement.

Size of the SQLDA
An initial guess is taken for the size of the SQLDA (3). If this is not big enough, the actual size of the select list returned by the database server is used to allocate a SQLDA of the correct size.

The SQLDA structure is then filled with buffers to hold strings that represent the results of the query. The **fill_s_sqlda** routine converts all data types in the SQLDA to DT_STRING and allocates buffers of the appropriate size.

A cursor is then declared and opened for this statement. The rest of the routines for moving and closing the cursor remain the same.

The **fetch** routine is slightly different: it puts the results into the SQLDA structure instead of into a list of host variables. The **print** routine has changed significantly to print results from the SQLDA structure up to the width of the screen. The **print** routine also uses the name fields of the SQLDA to print headings for each column.

Service examples

The example programs *cur.sqc* and *dcur.sqc*, when compiled for a version of Windows that supports services, run optionally as services.

The two files containing the example code for Windows services are the source file *ntsvc.c* and the header file *ntsvc.h*. The code allows a linked executable to be run either as a regular executable or as a Windows service.

❖ **To run one of the compiled examples as a Windows service:**

1. Start Sybase Central and open the Services folder.
2. Select a service type of Sample Application, and click OK.
3. Enter a service name in the appropriate field.
4. Select the sample program (*curwnt.exe* or *dcurwnt.exe*) from the *Samples\ASA\C* subdirectory of your SQL Anywhere directory.
5. Click OK to install the service.
6. Click Start on the main window to start the service.

When run as a service, the programs display the normal user interface if possible. They also write the output to the Application Event Log. If it is not possible to start the user interface, the programs print one page of data to the Application Event Log and stop.

These examples have been tested with the Watcom C/C++ 10.5 compiler and the Microsoft Visual C++ compiler.

Embedded SQL data types

To transfer information between a program and the database server, every piece of data must have a data type. The embedded SQL data type constants are prefixed with DT_, and can be found in the *sqldef.h* header file. You can create a host variable of any one of the supported types. You can also use these types in a SQLDA structure for passing data to and from the database.

You can define variables of these data types using the DECL_ macros listed in *sqlca.h*. For example, a variable holding a BIGINT value could be declared with DECL_BIGINT.

The following data types are supported by the embedded SQL programming interface:

- **DT_BIT** 8-bit signed integer
- **DT_SMALLINT** 16-bit signed integer.
- **DT_UNSSMALLINT** 16-bit unsigned integer
- **DT_TINYINT** 8-bit signed integer
- **DT_BIGINT** 64-bit signed integer
- **DT_INT** 32-bit signed integer.
- **DT_UNSINT** 16-bit unsigned integer
- **DT_FLOAT** 4-byte floating point number.
- **DT_DOUBLE** 8-byte floating point number.
- **DT_DECIMAL** Packed decimal number.

```
typedef struct DECIMAL {
  char array[1];
} DECIMAL;
```

- **DT_STRING** NULL-terminated character string. The string is blank-padded if the database is initialized with blank-padded strings.
- **DT_DATE** NULL-terminated character string that is a valid date.
- **DT_TIME** NULL-terminated character string that is a valid time.
- **DT_TIMESTAMP** NULL-terminated character string that is a valid timestamp.
- **DT_FIXCHAR** Fixed-length blank padded character string.

- **DT_VARCHAR** Varying length character string with a two-byte length field. When supplying information to the database server, you must set the length field. When fetching information from the database server, the server sets the length field (not padded).

```
typedef struct VARCHAR {
   unsigned short int len;
   char array[1];
} VARCHAR;
```

- **DT_LONGVARCHAR** Long varying length character data. The macro defines a structure, as follows:

```
#define DECL_LONGVARCHAR( size )         \
  struct { a_sql_uint32    array_len;    \
           a_sql_uint32    stored_len;   \
           a_sql_uint32    untrunc_len;  \
           char            array[size+1];\
         }
```

  The DECL_LONGVARCHAR struct may be used with more than 32K of data. Large data may be fetched all at once, or in pieces using the GET DATA statement. Large data may be supplied to the server all at once, or in pieces by appending to a database variable using the SET statement. The data is not null terminated.

  For more information, see "Sending and retrieving long values" on page 214.

- **DT_BINARY** Varying length binary data with a two-byte length field. When supplying information to the database server, you must set the length field. When fetching information from the database server, the server sets the length field.

```
typedef struct BINARY {
  unsigned short int len;
  char array[1];
} BINARY;
```

- **DT_LONGBINARY** Long binary data. The macro defines a structure, as follows:

```
#define DECL_LONGBINARY( size )          \
  struct { a_sql_uint32    array_len;    \
           a_sql_uint32    stored_len;   \
           a_sql_uint32    untrunc_len;  \
           char            array[size];  \
         }
```

The DECL_LONGBINARY struct may be used with more than 32K of data. Large data may be fetched all at once, or in pieces using the GET DATA statement. Large data may be supplied to the server all at once, or in pieces by appending to a database variable using the SET statement.

For more information, see "Sending and retrieving long values" on page 214.

- **DT_TIMESTAMP_STRUCT** SQLDATETIME structure with fields for each part of a timestamp.

```
typedef struct sqldatetime {
   unsigned short year; /* e.g. 1999 */
   unsigned char month; /* 0-11 */
   unsigned char day_of_week; /* 0-6 0=Sunday */
   unsigned short day_of_year; /* 0-365 */
   unsigned char day; /* 1-31 */
   unsigned char hour; /* 0-23 */
   unsigned char minute; /* 0-59 */
   unsigned char second; /* 0-59 */
   unsigned long microsecond; /* 0-999999 */
} SQLDATETIME;
```

  The SQLDATETIME structure can be used to retrieve fields of DATE, TIME, and TIMESTAMP type (or anything that can be converted to one of these). Often, applications have their own formats and date manipulation code. Fetching data in this structure makes it easier for a programmer to manipulate this data. Note that DATE, TIME, and TIMESTAMP fields can also be fetched and updated with any character type.

  If you use a SQLDATETIME structure to enter a date, time, or timestamp into the database, the `day_of_year` and `day_of_week` members are ignored.

  For more information, see the DATE_FORMAT, TIME_FORMAT, TIMESTAMP_FORMAT, and DATE_ORDER database options in "Database Options" on page 535 of the book *ASA Database Administration Guide*.

- **DT_VARIABLE** NULL-terminated character string. The character string must be the name of a SQL variable whose value is used by the database server. This data type is used only for supplying data to the database server. It cannot be used when fetching data from the database server.

The structures are defined in the *sqlca.h* file. The VARCHAR, BINARY, and DECIMAL types contain a one-character array and are thus not useful for declaring host variables but they are useful for allocating variables dynamically or typecasting other variables.

DATE and TIME database types

There are no corresponding embedded SQL interface data types for the various DATE and TIME database types. These database types are all fetched and updated using either the SQLDATETIME structure or character strings.

☞ For more information see "GET DATA statement [ESQL]" on page 437 of the book *ASA SQL Reference Manual* and "SET statement" on page 531 of the book *ASA SQL Reference Manual*.

Using host variables

Host variables are C variables that are identified to the SQL preprocessor. Host variables can be used to send values to the database server or receive values from the database server.

Host variables are quite easy to use, but they have some restrictions. Dynamic SQL is a more general way of passing information to and from the database server using a structure known as the SQL Descriptor Area (SQLDA). The SQL preprocessor automatically generates a SQLDA for each statement in which host variables are used.

For information on dynamic SQL, see "Static and dynamic SQL" on page 202.

Declaring host variables

Host variables are defined by putting them into a **declaration section**. According to the IBM SAA and ANSI embedded SQL standards, host variables are defined by surrounding the normal C variable declarations with the following:

```
EXEC SQL BEGIN DECLARE SECTION;
/* C variable declarations */
EXEC SQL END DECLARE SECTION;
```

These host variables can then be used in place of value constants in any SQL statement. When the database server executes the command, the value of the host variable is used. Note that host variables cannot be used in place of table or column names: dynamic SQL is required for this. The variable name is prefixed with a colon (:) in a SQL statement to distinguish it from other identifiers allowed in the statement.

A standard SQL preprocessor does not scan C language code except inside a DECLARE SECTION. Thus, TYPEDEF types and structures are not allowed. Initializers on the variables are allowed inside a DECLARE SECTION.

Example

- The following sample code illustrates the use of host variables on an INSERT command. The variables are filled in by the program and then inserted into the database:

```
EXEC SQL BEGIN DECLARE SECTION;
long employee_number;
char employee_name[50];
char employee_initials[8];
char employee_phone[15];
```

```
EXEC SQL END DECLARE SECTION;
/* program fills in variables with appropriate
values
*/
EXEC SQL INSERT INTO Employee
VALUES (:employee_number, :employee_name,
:employee_initials, :employee_phone );
```

For a more extensive example, see "Static cursor sample" on page 173.

C host variable types

Only a limited number of C data types are supported as host variables. Also, certain host variable types do not have a corresponding C type.

Macros defined in the *sqlca.h* header file can be used to declare host variables of the following types: VARCHAR, FIXCHAR, BINARY, PACKED DECIMAL, LONG VARCHAR, LONG BINARY, or SQLDATETIME structure. They are used as follows:

```
EXEC SQL BEGIN DECLARE SECTION;
DECL_VARCHAR( 10 ) v_varchar;
DECL_FIXCHAR( 10 ) v_fixchar;
DECL_LONGVARCHAR( 32678 ) v_longvarchar;
DECL_BINARY( 4000 ) v_binary;
DECL_LONGBINARY( 128000 ) v_longbinary;
DECL_DECIMAL( 10, 2 ) v_packed_decimal;
DECL_DATETIME v_datetime;
EXEC SQL END DECLARE SECTION;
```

The preprocessor recognizes these macros within a declaration section and treats the variable as the appropriate type.

The following table lists the C variable types that are allowed for host variables and their corresponding embedded SQL interface data types.

C Data Type	Embedded SQL Interface Type	Description
short i; short int i; unsigned short int i;	DT_SMALLINT	16-bit signed integer
long l; long int l; unsigned long int l;	DT_INT	32-bit signed integer
float f;	DT_FLOAT	4-byte floating point
double d;	DT_DOUBLE	8-byte floating point

C Data Type	Embedded SQL Interface Type	Description
DECL_DECIMAL(p,s)	DT_DECIMAL(p,s)	Packed decimal
char a; /*n=1*/ DECL_FIXCHAR(n) a; DECL_FIXCHAR a[n];	DT_FIXCHAR(n)	Fixed length character string blank padded.
char a[n]; /*n>=1*/	DT_STRING(n)	NULL-terminated string. The string is blank-padded if the database is initialized with blank-padded strings.
char *a;	DT_STRING(32767)	NULL-terminated string
DECL_VARCHAR(n) a;	DT_VARCHAR(n)	Varying length character string with 2-byte length field. Not blank padded
DECL_BINARY(n) a;	DT_BINARY(n)	Varying length binary data with 2-byte length field
DECL_DATETIME a;	DT_TIMESTAMP_STRUCT	SQLDATETIME structure
DECL_LONGVARCHAR(n) a;	DT_LONGVARCHAR	Varying length long character string with three 4-byte length fields. Not blank padded or NULL terminated.
DECL_LONGBINARY(n) a;	DT_LONGBINARY	Varying length long binary data with three 4-byte length fields. Not blank padded.

Pointers to char

A host variable declared as a **pointer to char** (*char *a*) is considered by the database interface to be 32 767 bytes long. Any host variable of type **pointer to char** used to retrieve information from the database must point to a buffer large enough to hold any value that could possibly come back from the database.

This is potentially quite dangerous because somebody could change the definition of the column in the database to be larger than it was when the program was written. This could cause random memory corruption problems. If you are using a 16-bit compiler, requiring 32 767 bytes could make the program stack overflow. It is better to use a declared array, even as a parameter to a function, where it is passed as a **pointer to char**. This lets the PREPARE statements know the size of the array.

Scope of host variables

A standard host-variable declaration section can appear anywhere that C variables can normally be declared. This includes the parameter declaration section of a C function. The C variables have their normal scope (available within the block in which they are defined). However, since the SQL preprocessor does not scan C code, it does not respect C blocks.

As far as the SQL preprocessor is concerned, host variables are global; two host variables cannot have the same name.

Host variable usage

Host variables can be used in the following circumstances:

- SELECT, INSERT, UPDATE and DELETE statements in any place where a number or string constant is allowed.
- The INTO clause of SELECT and FETCH statements.
- Host variables can also be used in place of a statement name, a cursor name, or an option name in commands specific to embedded SQL.
- For CONNECT, DISCONNECT, and SET CONNECT, a host variable can be used in place of a user ID, password, connection name, connection string, or database environment name.
- For SET OPTION and GET OPTION, a host variable can be used in place of a user ID, option name, or option value.
- Host variables cannot be used in place of a table name or a column name in any statement.

Examples

- The following is valid embedded SQL:

```
INCLUDE SQLCA;
long SQLCODE;
sub1() {
   char SQLSTATE[6];
   exec SQL CREATE TABLE ...
}
```

- The following is not valid embedded SQL:

```
INCLUDE SQLCA;
sub1() {
   char SQLSTATE[6];
   exec SQL CREATE TABLE...
}
sub2() {
   exec SQL DROP TABLE...
   // No SQLSTATE in scope of this statement
}
```

- The case of SQLSTATE and SQLCODE is important and the ISO/ANSI standard requires that their definitions be exactly as follows:

```
long SQLCODE;
char SQLSTATE[6];
```

Indicator variables

Indicator variables are C variables that hold supplementary information when you are fetching or putting data. There are several distinct uses for indicator variables:

- **NULL values** To enable applications to handle NULL values.
- **String truncation** To enable applications to handle cases when fetched values must be truncated to fit into host variables.
- **Conversion errors** To hold error information.

An indicator variable is a host variable of type **short int** that is placed immediately following a regular host variable in a SQL statement. For example, in the following INSERT statement, **:ind_phone** is an indicator variable:

```
EXEC SQL INSERT INTO Employee
   VALUES (:employee_number, :employee_name,
   :employee_initials, :employee_phone:ind_phone );
```

Using indicator variables to handle NULL

In SQL data, NULL represents either an unknown attribute or inapplicable information. The SQL concept of NULL is not to be confused with the C language constant by the same name (**NULL**). The C constant is used to represent a non-initialized or invalid pointer.

When NULL is used in the Adaptive Server Anywhere documentation, it refers to the SQL database meaning given above. The C language constant is referred to as the **null** pointer (lower case).

NULL is not the same as any value of the column's defined type. Thus, in order to pass NULL values to the database or receive NULL results back, something extra is required beyond regular host variables. **Indicator variables** are used for this purpose.

Using indicator variables when inserting NULL

An INSERT statement could include an indicator variable as follows:

```
EXEC SQL BEGIN DECLARE SECTION;
short int employee_number;
char employee_name[50];
char employee_initials[6];
char employee_phone[15];
short int ind_phone;
EXEC SQL END DECLARE SECTION;

/*
program fills in empnum, empname,
initials and homephone
*/
if( /* phone number is unknown */ ) {
   ind_phone = -1;
} else {
   ind_phone = 0;
}
EXEC SQL INSERT INTO Employee
   VALUES (:employee_number, :employee_name,
   :employee_initials, :employee_phone:ind_phone );
```

If the indicator variable has a value of –1, a NULL is written. If it has a value of 0, the actual value of **employee_phone** is written.

Using indicator variables when fetching NULL

Indicator variables are also used when receiving data from the database. They are used to indicate that a NULL value was fetched (indicator is negative). If a NULL value is fetched from the database and an indicator variable is not supplied, an error is generated (SQLE_NO_INDICATOR). Errors are explained in the next section.

Using indicator variables for truncated values

Indicator variables indicate whether any fetched values were truncated to fit into a host variable. This enables applications to handle truncation appropriately.

If a value is truncated on fetching, the indicator variable is set to a positive value, containing the actual length of the database value before truncation. If the length of the value is greater than 32 767, then the indicator variable contains 32 767.

Using indicator values for conversion errors

By default, the CONVERSION_ERROR database option is set to ON, and any data type conversion failure leads to an error, with no row returned.

You can use indicator variables to tell which column produced a data type conversion failure. If you set the database option CONVERSION_ERROR to OFF, any data type conversion failure gives a CANNOT_CONVERT warning, rather than an error. If the column that suffered the conversion error has an indicator variable, that variable is set to a value of –2.

If you set the CONVERSION_ERROR option to OFF when inserting data into the database, a value of NULL is inserted when a conversion failure occurs.

Summary of indicator variable values

The following table provides a summary of indicator variable usage.

Indicator Value	Supplying Value to database	Receiving value from database
> 0	Host variable value	Retrieved value was truncated — actual length in indicator variable
0	Host variable value	Fetch successful, or CONVERSION_ERROR set to ON
–1	NULL value	NULL result
–2	NULL value	Conversion error (when CONVERSION_ERROR is set to OFF only). SQLCODE indicates a CANNOT_CONVERT warning
< –2	NULL value	NULL result

For more information on retrieving long values, see "GET DATA statement [ESQL]" on page 437 of the book *ASA SQL Reference Manual*.

The SQL Communication Area (SQLCA)

The **SQL Communication Area** (**SQLCA**) is an area of memory that is used on every database request for communicating statistics and errors from the application to the database server and back to the application. The SQLCA is used as a handle for the application-to-database communication link. It is passed in to all database library functions that need to communicate with the database server. It is implicitly passed on all embedded SQL statements.

A global SQLCA variable is defined in the interface library. The preprocessor generates an external reference for the global SQLCA variable and an external reference for a pointer to it. The external reference is named **sqlca** and is of type SQLCA. The pointer is named **sqlcaptr**. The actual global variable is declared in the imports library.

The SQLCA is defined by the *sqlca.h* header file, included in the *h* subdirectory of your installation directory.

SQLCA provides error codes

You reference the SQLCA to test for a particular error code. The **sqlcode** and **sqlstate** fields contain error codes when a database request has an error (see below). Some C macros are defined for referencing the **sqlcode** field, the **sqlstate** field, and some other fields.

SQLCA fields

The fields in the SQLCA have the following meanings:

- **sqlcaid** An 8-byte character field that contains the string **SQLCA** as an identification of the SQLCA structure. This field helps in debugging when you are looking at memory contents.
- **sqlcabc** A long integer that contains the length of the SQLCA structure (136 bytes).
- **sqlcode** A long integer that specifies the error code when the database detects an error on a request. Definitions for the error codes can be found in the header file *sqlerr.h*. The error code is 0 (zero) for a successful operation, positive for a warning and negative for an error.

  For a full listing of error codes, see "Database Error Messages" on page 1 of the book *ASA Errors Manual*.
- **sqlerrml** The length of the information in the **sqlerrmc** field.
- **sqlerrmc** Zero or more character strings to be inserted into an error message. Some error messages contain one or more placeholder strings (*%1*, *%2*, …) which are replaced with the strings in this field.

For example, if a Table Not Found error is generated, **sqlerrmc** contains the table name, which is inserted into the error message at the appropriate place.

For a full listing of error messages, see "Database Error Messages" on page 1 of the book *ASA Errors Manual*.

- **sqlerrp** Reserved.
- **sqlerrd** A utility array of long integers.
- **sqlwarn** Reserved.
- **sqlstate** The SQLSTATE status value. The ANSI SQL standard (SQL-92) defines a new type of return value from a SQL statement in addition to the SQLCODE value in previous standards. The SQLSTATE value is always a five-character null-terminated string, divided into a two-character class (the first two characters) and a three-character subclass. Each character can be a digit from 0 through 9 or an upper case alphabetic character A through Z.

  Any class or subclass that begins with 0 through 4 or A through H is defined by the SQL standard; other classes and subclasses are implementation defined. The SQLSTATE value '00000' means that there has been no error or warning.

  For more SQLSTATE values, see "Database Error Messages" on page 1 of the book *ASA Errors Manual*.

sqlerror array

The **sqlerror** field array has the following elements.

- **sqlerrd[1] (SQLIOCOUNT)** The actual number of input/output operations that were required to complete a command.

  The database does not start this number at zero for each command. Your program can set this variable to zero before executing a sequence of commands. After the last command, this number is the total number of input/output operations for the entire command sequence.

- **sqlerrd[2] (SQLCOUNT)** The value of this field depends on which statement is being executed.

  - **INSERT, UPDATE, PUT, and DELETE statements** The number of rows that were affected by the statement.

    On a cursor OPEN, this field is filled in with either the actual number of rows in the cursor (a value greater than *or equal to* 0) or an estimate thereof (a negative number whose absolute value is the estimate). It is the actual number of rows if the database server can compute it without counting the rows. The database can also be configured to always return the actual number of rows using the ROW_COUNT option.

- **FETCH cursor statement** The SQLCOUNT field is filled if a SQLE_NOTFOUND warning is returned. It contains the number of rows by which a FETCH RELATIVE or FETCH ABSOLUTE statement goes outside the range of possible cursor positions (a cursor can be on a row, before the first row, or after the last row). In the case of a wide fetch, SQLCOUNT is the number of rows actually fetched, and is less than or equal to the number of rows requested. During a wide fetch, SQLE_NOTFOUND is *not* set.

  For more information on wide fetches, see "Fetching more than one row at a time" on page 197.

  The value is 0 if the row was not found but the position is valid, for example, executing FETCH RELATIVE 1 when positioned on the last row of a cursor. The value is positive if the attempted fetch was beyond the end of the cursor, and negative if the attempted fetch was before the beginning of the cursor.

- **GET DATA statement** The SQLCOUNT field holds the actual length of the value.

- **DESCRIBE statement** In the WITH VARIABLE RESULT clause used to describe procedures that may have more than one result set, SQLCOUNT is set to one of the following values:

  - **0** The result set may change: the procedure call should be described again following each OPEN statement.
  - **1** The result set is fixed. No re-describing is required.

  In the case of a syntax error, SQLE_SYNTAX_ERROR, this field contains the approximate character position within the command string where the error was detected.

- **sqlerrd[3] (SQLIOESTIMATE)** The estimated number of input/output operations that are to complete the command. This field is given a value on an OPEN or EXPLAIN command.

SQLCA management for multi-threaded or reentrant code

You can use embedded SQL statements in multi-threaded or reentrant code. However, if you use a single connection, you are restricted to one active request per connection. In a multi-threaded application, you should not use the same connection to the database on each thread unless you use a semaphore to control access.

There are no restrictions on using separate connections on each thread that wishes to use the database. The SQLCA is used by the runtime library to distinguish between the different thread contexts. Thus, each thread wishing to use the database must have its own SQLCA.

Any given database connection is accessible only from one SQLCA, with the exception of the cancel instruction, which must be issued from a separate thread.

For information on canceling requests, see "Implementing request management" on page 224.

Using multiple SQLCAs

❖ **To manage multiple SQLCAs in your application:**

1. You must use the option on the SQL preprocessor that generates reentrant code (`-r`). The reentrant code is a little larger and a little slower because statically initialized global variables cannot be used. However, these effects are minimal.
2. Each SQLCA used in your program must be initialized with a call to **db_init** and cleaned up at the end with a call to **db_fini**.

   Caution
   Failure to call db_fini for each db_init on NetWare can cause the database server to fail and the NetWare file server to fail.

3. The embedded SQL statement SET SQLCA ("SET SQLCA statement [ESQL]" on page 545 of the book *ASA SQL Reference Manual*) is used to tell the SQL preprocessor to use a different SQLCA for database requests. Usually, a statement such as: EXEC SQL SET SQLCA 'task_data->sqlca'; is used at the top of your program or in a header file to set the SQLCA reference to point at task specific data. This statement does not generate any code and thus has no performance impact. It changes the state within the preprocessor so that any reference to the SQLCA uses the given string.

For information about creating SQLCAs, see "SET SQLCA statement [ESQL]" on page 545 of the book *ASA SQL Reference Manual*.

When to use multiple SQLCAs

You can use the multiple SQLCA support in any of the supported embedded SQL environments, but it is only required in reentrant code.

The following list details the environments where multiple SQLCAs must be used:

- **Multi-threaded applications** If more than one thread uses the same SQLCA, a context option can cause more than one thread to be using the SQLCA at the same time. Each thread must have its own SQLCA. This can also happen when you have a DLL that uses embedded SQL and is called by more than one thread in your application.
- **Dynamic link libraries and shared libraries** A DLL has only one data segment. While the database server is processing a request from one application, it may yield to another application that makes a request to the database server. If your DLL uses the global SQLCA, both applications are using it at the same time. Each Windows application must have its own SQLCA.
- **A DLL with one data segment** A DLL can be created with only one data segment or one data segment for each application. If your DLL has only one data segment, you cannot use the global SQLCA for the same reason that a DLL cannot use the global SQLCA. Each application must have its own SQLCA.

Connection management with multiple SQLCAs

You do not need to use multiple SQLCAs to connect to more than one database or have more than one connection to a single database.

Each SQLCA can have one unnamed connection. Each SQLCA has an active or current connection (see "SET CONNECTION statement [Interactive SQL] [ESQL]" on page 536 of the book *ASA SQL Reference Manual*). All operations on a given database connection must use the same SQLCA that was used when the connection was established.

Record locking
Operations on different connections are subject to the normal record locking mechanisms and may cause each other to block and possibly to deadlock. For information on locking, see the chapter "Using Transactions and Isolation Levels" on page 89 of the book *ASA SQL User's Guide*.

Fetching data

Fetching data in embedded SQL is done using the SELECT statement. There are two cases:

- **The SELECT statement returns at most one row** Use an INTO clause to assign the returned values directly to host variables.

  For information, see "SELECT statements that return at most one row" on page 193.

- **The SELECT statement may return multiple rows** Use cursors to manage the rows of the result set.

  For more information, see "Using cursors in embedded SQL" on page 194.

LONG VARCHAR and LONG BINARY data types are handled differently to other data types. For more information, see "Retrieving LONG data" on page 215.

SELECT statements that return at most one row

A single row query retrieves at most one row from the database. A single-row query SELECT statement has an INTO clause following the select list and before the FROM clause. The INTO clause contains a list of host variables to receive the value for each select list item. There must be the same number of host variables as there are select list items. The host variables may be accompanied by indicator variables to indicate NULL results.

When the SELECT statement is executed, the database server retrieves the results and places them in the host variables. If the query results contain more than one row, the database server returns an error.

If the query results in no rows being selected, a Row Not Found warning is returned. Errors and warnings are returned in the SQLCA structure, as described in "The SQL Communication Area (SQLCA)" on page 188.

Example

For example, the following code fragment returns 1 if a row from the employee table is fetched successfully, 0 if the row doesn't exist, and –1 if an error occurs.

```
EXEC SQL BEGIN DECLARE SECTION;
   long         emp_id;
   char         name[41];
   char         sex;
   char         birthdate[15];
```

```
    short int ind_birthdate;
EXEC SQL END DECLARE SECTION;
. . .
int find_employee( long employee )
{
    emp_id = employee;
    EXEC SQL  SELECT emp_fname ||
              ' ' || emp_lname, sex, birth_date
              INTO :name, :sex,
                   :birthdate:ind_birthdate
              FROM "DBA".employee
              WHERE emp_id = :emp_id;
    if( SQLCODE == SQLE_NOTFOUND ) {
       return( 0 ); /* employee not found */
    } else if( SQLCODE < 0 ) {
       return( -1 ); /* error */
    } else {
       return( 1 ); /* found */
    }
}
```

Using cursors in embedded SQL

A cursor is used to retrieve rows from a query that has multiple rows in its result set. A **cursor** is a handle or an identifier for the SQL query and a position within the result set.

For an introduction to cursors, see "Working with cursors" on page 19.

❖ **To manage a cursor in embedded SQL:**

1. Declare a cursor for a particular SELECT statement, using the DECLARE statement.
2. Open the cursor using the OPEN statement.
3. Retrieve results one row at a time from the cursor using the FETCH statement.
4. Fetch rows until the Row Not Found warning is returned.

   Errors and warnings are returned in the SQLCA structure, described in "The SQL Communication Area (SQLCA)" on page 188.
5. Close the cursor, using the CLOSE statement.

By default, cursors are automatically closed at the end of a transaction (on COMMIT or ROLLBACK). Cursors that are opened with a WITH HOLD clause are kept open for subsequent transactions until they are explicitly closed.

The following is a simple example of cursor usage:

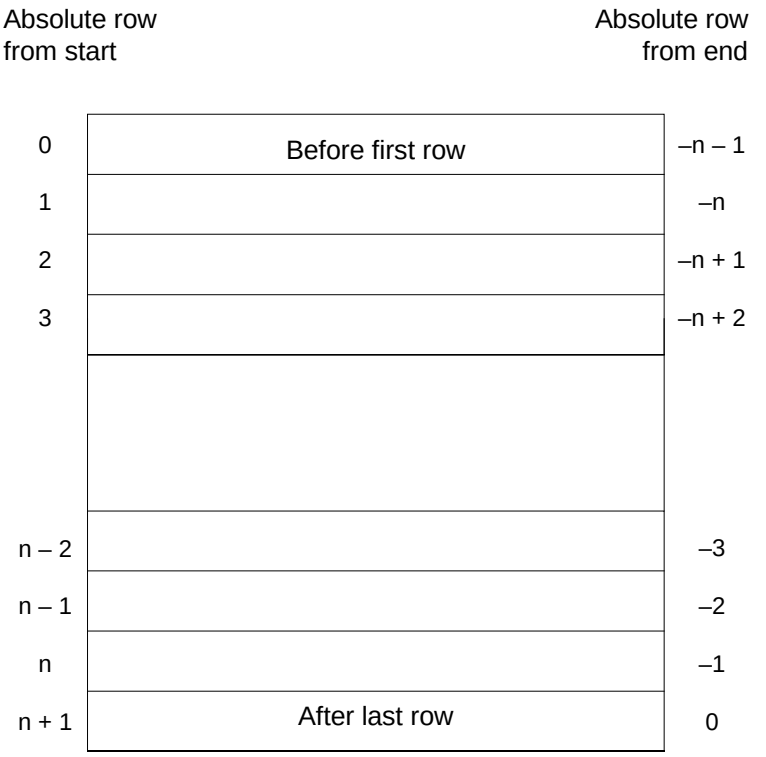
```
void print_employees( void )
{
   EXEC SQL BEGIN DECLARE SECTION;
   char name[50];
   char sex;
   char birthdate[15];
   short int ind_birthdate;
   EXEC SQL END DECLARE SECTION;
   EXEC SQL DECLARE C1 CURSOR FOR
      SELECTemp_fname || ' ' || emp_lname,
                sex, birth_date
      FROM "DBA".employee;
   EXEC SQL OPEN C1;
   for( ;; ) {
      EXEC SQL FETCH C1 INTO :name, :sex,
:birthdate:ind_birthdate;
      if( SQLCODE == SQLE_NOTFOUND ) {
         break;
      } else if( SQLCODE < 0 ) {
         break;
      }
      if( ind_birthdate < 0 ) {
         strcpy( birthdate, "UNKNOWN" );
      }
      printf( "Name: %s Sex: %c Birthdate:
                %s.n",name, sex, birthdate );
   }
EXEC SQL CLOSE C1;
}
```

For complete examples using cursors, see "Static cursor sample" on page 173 and "Dynamic cursor sample" on page 174.

Cursor positioning

A cursor is positioned in 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 [ESQL] [SP]" on page 424 of the book *ASA SQL Reference Manual*). It can be positioned to an absolute position either from the start or from the end of the query results. It can also be moved relative to the current cursor position.

There are special *positioned* versions of the UPDATE and DELETE statements that can be used to update or delete the row at the current position of the cursor. If the cursor is positioned before the first row or after the last row, a No Current Row of Cursor error is returned.

The PUT statement can be used to insert a row into a cursor.

Cursor positioning problems

Inserts and some updates to DYNAMIC SCROLL cursors can cause problems with cursor positioning. The database server does not put inserted rows at a predictable position within a cursor unless there is an ORDER BY clause on the SELECT statement. In some cases, the inserted row does not appear at all until the cursor is closed and opened again.

With Adaptive Server Anywhere, this occurs if a temporary table had to be created to open the cursor.

☞ For a description, see "Use of work tables in query processing" on page 160 of the book *ASA SQL User's Guide*.

The UPDATE statement may cause a row to move in the cursor. This happens if the cursor has an ORDER BY clause that uses an existing index (a temporary table is not created).

Fetching more than one row at a time

The FETCH statement can be modified to fetch more than one row at a time, which may improve performance. This is called a **wide fetch** or an **array fetch**.

☞ Adaptive Server Anywhere also supports wide puts and inserts. For information on these, see "PUT statement [ESQL]" on page 499 of the book *ASA SQL Reference Manual* and "EXECUTE statement [ESQL]" on page 414 of the book *ASA SQL Reference Manual*.

To use wide fetches in embedded SQL, include the fetch statement in your code as follows:

```
EXEC SQL FETCH . . . ARRAY nnn
```

where ARRAY *nnn* is the last item of the FETCH statement. The fetch count *nnn* can be a host variable. The number of variables in the SQLDA must be the product of *nnn* and the number of columns per row. The first row is placed in SQLDA variables 0 to (columns per row) – 1, and so on.

Each column must be of the same type in each row of the SQLDA, or a SQLDA_INCONSISTENT error is returned.

The server returns in SQLCOUNT the number of records that were fetched, which is always greater than zero unless there is an error or warning. On a wide fetch, a SQLCOUNT of one with no error condition indicates that one valid row has been fetched.

Example

The following example code illustrates the use of wide fetches. You can also find this code as *samples\ASA\esql\widefetch\widefetch.sqc* in your SQL Anywhere directory.

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include "sqldef.h"
EXEC SQL INCLUDE SQLCA;

EXEC SQL WHENEVER SQLERROR { PrintSQLError();
              goto err; };

static void PrintSQLError()
/*************************/
{
    char buffer[200];

    printf( "SQL error %d -- %s\n",
       SQLCODE,
       sqlerror_message( &sqlca,
               buffer,
               sizeof( buffer ) ) );
}

static SQLDA * PrepareSQLDA(
   a_sql_statement_number stat0,
   unsigned     width,
   unsigned     *cols_per_row )
/*****************************************/
/* Allocate a SQLDA to be used for fetching from
   the statement identified by "stat0". "width"
   rows will be retrieved on each FETCH request.
   The number of columns per row is assigned to
   "cols_per_row". */
{
    int                     num_cols;
    unsigned                row, col, offset;
    SQLDA *                 sqlda;
    EXEC SQL BEGIN DECLARE SECTION;
    a_sql_statement_number  stat;
    EXEC SQL END DECLARE SECTION;

    stat = stat0;
    sqlda = alloc_sqlda( 100 );
    if( sqlda == NULL ) return( NULL );
    EXEC SQL DESCRIBE :stat INTO sqlda;
    *cols_per_row = num_cols = sqlda->sqld;
    if( num_cols * width > sqlda->sqln ) {
        free_sqlda( sqlda );
        sqlda = alloc_sqlda( num_cols * width );
        if( sqlda == NULL ) return( NULL );
        EXEC SQL DESCRIBE :stat INTO sqlda;
    }
    // copy first row in SQLDA setup by describe
    // to following (wide) rows
```

```
    sqlda->sqld = num_cols * width;
    offset = num_cols;
    for( row = 1; row < width; row++ ) {
        for( col = 0;
        col < num_cols;
             col++, offset++ ) {
            sqlda->sqlvar[offset].sqltype =
      sqlda->sqlvar[col].sqltype;
            sqlda->sqlvar[offset].sqllen =
      sqlda->sqlvar[col].sqllen;
       // optional: copy described column name
            memcpy( &sqlda->sqlvar[offset].sqlname,
                    &sqlda->sqlvar[col].sqlname,
                    sizeof( sqlda->sqlvar[0].sqlname )
);
        }
    }
    fill_s_sqlda( sqlda, 40 );
    return( sqlda );

err:
    return( NULL );
}

static void PrintFetchedRows( SQLDA * sqlda,
                unsigned cols_per_row )
/*****************************************/
/* Print rows already wide fetched in the SQLDA */
{
    long                    rows_fetched;
    int             row, col, offset;

    if( SQLCOUNT == 0 ) {
   rows_fetched = 1;
    } else {
   rows_fetched = SQLCOUNT;
    }
    printf( "Fetched %d Rows:\n", rows_fetched );
    for( row = 0; row < rows_fetched; row++ ) {
   for( col = 0; col < cols_per_row; col++ ) {
       offset = row * cols_per_row + col;
       printf( " \"%s\"",
          (char *)sqlda->sqlvar[offset]
               .sqldata );
   }
   printf( "\n" );
    }
}

static int DoQuery( char * query_str0,
               unsigned fetch_width0 )
/*****************************************/
```

```
/* Wide Fetch "query_str0" select statement
 * using a width of "fetch_width0" rows" */
{
    SQLDA *                 sqlda;
    unsigned        cols_per_row;
    EXEC SQL BEGIN DECLARE SECTION;
    a_sql_statement_number  stat;
    char *          query_str;
    unsigned        fetch_width;
    EXEC SQL END DECLARE SECTION;

    query_str = query_str0;
    fetch_width = fetch_width0;

    EXEC SQL PREPARE :stat FROM :query_str;
    EXEC SQL DECLARE QCURSOR CURSOR FOR :stat
      FOR READ ONLY;
    EXEC SQL OPEN QCURSOR;
    sqlda = PrepareSQLDA( stat,
           fetch_width,
           &cols_per_row );
    if( sqlda == NULL ) {
        printf( "Error allocating SQLDA\n" );
        return( SQLE_NO_MEMORY );
    }
    for( ;; ) {
        EXEC SQL FETCH QCURSOR INTO DESCRIPTOR sqlda
          ARRAY :fetch_width;
        if( SQLCODE != SQLE_NOERROR ) break;
   PrintFetchedRows( sqlda, cols_per_row );
    }
    EXEC SQL CLOSE QCURSOR;
    EXEC SQL DROP STATEMENT :stat;
    free_filled_sqlda( sqlda );
err:
    return( SQLCODE );
}

void main( int argc, char *argv[] )
/*********************************/
/* Optional first argument is a select statement,
 * optional second argument is the fetch width */
{
    char *query_str =
   "select emp_fname, emp_lname from employee";
    unsigned fetch_width = 10;

    if( argc > 1 ) {
   query_str = argv[1];
   if( argc > 2 ) {
       fetch_width = atoi( argv[2] );
       if( fetch_width < 2 ) {
```

```
        fetch_width = 2;
         }
      }
     }
     db_init( &sqlca );
     EXEC SQL CONNECT "dba" IDENTIFIED BY "sql";

     DoQuery( query_str, fetch_width );

     EXEC SQL DISCONNECT;
err:
     db_fini( &sqlca );
}
```

Notes on using wide fetches

- In the function **PrepareSQLDA**, the SQLDA memory is allocated using the **alloc_sqlda** function. This allows space for indicator variables, rather than using the **alloc_sqlda_noind** function.
- If the number of rows fetched is fewer than the number requested, but is not zero (at the end of the cursor for example), the SQLDA items corresponding to the rows that were not fetched are returned as NULL by setting the indicator value. If no indicator variables are present, an error is generated (SQLE_NO_INDICATOR: no indicator variable for NULL result).
- If a row being fetched has been updated, generating a SQLE_ROW_UPDATED_WARNING warning, the fetch stops on the row that caused the warning. The values for all rows processed to that point (including the row that caused the warning) are returned. SQLCOUNT contains the number of rows that were fetched, including the row that caused the warning. All remaining SQLDA items are marked as NULL.
- If a row being fetched has been deleted or is locked, generating an SQLE_NO_CURRENT_ROW or SQLE_LOCKED error, SQLCOUNT contains the number of rows that were read prior to the error. This does not include the row that caused the error. The SQLDA does not contain values for any of the rows since SQLDA values are not returned on errors. The SQLCOUNT value can be used to reposition the cursor, if necessary, to read the rows.

Static and dynamic SQL

There are two ways to embed SQL statements into a C program:

- Static statements
- Dynamic statements

Until now, we have been discussing static SQL. This section compares static and dynamic SQL.

Static SQL statements

All standard SQL data manipulation and data definition statements can be embedded in a C program by prefixing them with EXEC SQL and suffixing the command with a semicolon (;). These statements are referred to as **static** statements.

Static statements can contain references to host variables, as described in "Using host variables" on page 181. All examples to this point have used static embedded SQL statements.

Host variables can only be used in place of string or numeric constants. They cannot be used to substitute column names or table names; dynamic statements are required to perform those operations.

Dynamic SQL statements

In the C language, strings are stored in arrays of characters. Dynamic statements are constructed in C language strings. These statements can then be executed using the PREPARE and EXECUTE statements. These SQL statements cannot reference host variables in the same manner as static statements since the C language variables are not accessible by name when the C program is executing.

To pass information between the statements and the C language variables, a data structure called the **SQL Descriptor Area** (**SQLDA**) is used. This structure is set up for you by the SQL preprocessor if you specify a list of host variables on the EXECUTE command in the USING clause. These variables correspond by position to place holders in the appropriate positions of the prepared command string.

For information on the SQLDA, see "The SQL descriptor area (SQLDA)" on page 206.

A **place holder** is put in the statement to indicate where host variables are to be accessed. A place holder is either a question mark (?) or a host variable reference as in static statements (a host variable name preceded by a colon). In the latter case, the host variable name used in the actual text of the statement serves only as a place holder indicating a reference to the SQL descriptor area.

A host variable used to pass information to the database is called a **bind variable**.

Example

For example:

```
EXEC SQL BEGIN DECLARE SECTION;
   char comm[200];
   char address[30];
   char city[20];
   short int cityind;
   long empnum;
EXEC SQL END DECLARE SECTION;
. . .
   sprintf( comm, "update %s set address = :?,
                       city = :?"
             " where employee_number = :?",
             tablename );
EXEC SQL PREPARE S1 FROM :comm;
EXEC SQL EXECUTE S1 USING :address, :city:cityind,
:empnum;
```

This method requires the programmer to know how many host variables there are in the statement. Usually, this is not the case. So, you can set up your own SQLDA structure and specify this SQLDA in the USING clause on the EXECUTE command.

The DESCRIBE BIND VARIABLES statement returns the host variable names of the bind variables that are found in a prepared statement. This makes it easier for a C program to manage the host variables. The general method is as follows:

```
EXEC SQL BEGIN DECLARE SECTION;
   char comm[200];
EXEC SQL END DECLARE SECTION;
. . .
sprintf( comm, "update %s set address = :address,
          city = :city"
         " where employee_number = :empnum",
         tablename );
EXEC SQL PREPARE S1 FROM :comm;
/* Assume that there are no more than 10 host variables.
See next example if you can't put
a limit on it */
sqlda = alloc_sqlda( 10 );
```

```
EXEC SQL DESCRIBE BIND VARIABLES FOR S1 USING DESCRIPTOR
sqlda;
/* sqlda->sqld will tell you how many host variables
there were. */
/* Fill in SQLDA_VARIABLE fields with values based on
name fields in sqlda */
. . .
EXEC SQL EXECUTE S1 USING DESCRIPTOR sqlda;
free_sqlda( sqlda );
```

SQLDA contents

The SQLDA consists of an array of variable descriptors. Each descriptor describes the attributes of the corresponding C program variable or the location that the database stores data into or retrieves data from:

- data type
- length if **type** is a string type
- precision and scale if **type** is a numeric type
- memory address
- indicator variable

For a complete description of the SQLDA structure, see "The SQL descriptor area (SQLDA)" on page 206

Indicator variables and NULL

The indicator variable is used to pass a NULL value to the database or retrieve a NULL value from the database. The indicator variable is also used by the database server to indicate truncation conditions encountered during a database operation. The indicator variable is set to a positive value when not enough space was provided to receive a database value.

For more information, see "Indicator variables" on page 185.

Dynamic SELECT statement

A SELECT statement that returns only a single row can be prepared dynamically, followed by an EXECUTE with an INTO clause to retrieve the one-row result. SELECT statements that return multiple rows, however, are managed using dynamic cursors.

With dynamic cursors, results are put into a host variable list or a SQLDA that is specified on the FETCH statement (FETCH INTO and FETCH USING DESCRIPTOR). Since the number of select list items is usually unknown to the C programmer, the SQLDA route is the most common. The DESCRIBE SELECT LIST statement sets up a SQLDA with the types of the select list items. Space is then allocated for the values using the **fill_sqlda()** function, and the information is retrieved by the FETCH USING DESCRIPTOR statement.

The typical scenario is as follows:

```
EXEC SQL BEGIN DECLARE SECTION;
   char comm[200];
EXEC SQL END DECLARE SECTION;
   int actual_size;
   SQLDA * sqlda;

. . .
sprintf( comm, "select * from %s", table_name );
EXEC SQL PREPARE S1 FROM :comm;
/* Initial guess of 10 columns in result. If it is
   wrong, it is corrected right after the first
   DESCRIBE by reallocating sqlda and doing DESCRIBE
   again. */
sqlda = alloc_sqlda( 10 );
EXEC SQL DESCRIBE SELECT LIST FOR S1 USING DESCRIPTOR
sqlda;
if( sqlda->sqld > sqlda->sqln ){
   actual_size = sqlda->sqld;
   free_sqlda( sqlda );
   sqlda = alloc_sqlda( actual_size );
   EXEC SQL DESCRIBE SELECT LIST FOR S1
      USING DESCRIPTOR sqlda;
}
fill_sqlda( sqlda );
EXEC SQL DECLARE C1 CURSOR FOR S1;
EXEC SQL OPEN C1;
EXEC SQL WHENEVER NOTFOUND {break};
for( ;; ){
   EXEC SQL FETCH C1 USING DESCRIPTOR sqlda;
   /* do something with data */
}
EXEC SQL CLOSE C1;
EXEC SQL DROP STATEMENT S1;
```

Drop statements after use
To avoid consuming unnecessary resources, ensure that statements are dropped after use.

For a complete example using cursors for a dynamic select statement, see "Dynamic cursor sample" on page 174.

For details of the functions mentioned above, see "Library function reference" on page 230.

The SQL descriptor area (SQLDA)

The SQLDA (SQL Descriptor Area) is an interface structure that is used for dynamic SQL statements. The structure passes information regarding host variables and SELECT statement results to and from the database. The SQLDA is defined in the header file *sqlda.h*.

There are functions in the database interface library or DLL that you can use to manage SQLDAs. For descriptions, see "Library function reference" on page 230.

When host variables are used with static SQL statements, the preprocessor constructs a SQLDA for those host variables. It is this SQLDA that is actually passed to and from the database server.

The SQLDA header file

The contents of *sqlda.h* are as follows:

```
#ifndef _SQLDA_H_INCLUDED
#define _SQLDA_H_INCLUDED
#define II_SQLDA

#include "sqlca.h"

#if defined( _SQL_PACK_STRUCTURES )
#include "pshpk1.h"
#endif

#define SQL_MAX_NAME_LEN  30

#define _sqldafar   _sqlfar

typedef      short int   a_SQL_type;
struct sqlname {
    short int length; /* length of char data */
    char         data[ SQL_MAX_NAME_LEN ]; /* data */
};

struct sqlvar {    /* array of variable descriptors   */
    short int   sqltype; /* type of  host variable    */
    short int   sqllen; /* length of host variable    */
    void _sqldafar  *sqldata; /* address of variable  */
    short int _sqldafar *sqlind; /* indicator variable pointer */
    struct sqlname  sqlname;
};
```

```
struct sqlda{
    unsigned char  sqldaid[8]; /* eye catcher "SQLDA"*/
    a_SQL_int32  sqldabc; /* length of sqlda structure*/
    short int  sqln; /* descriptor size in number of entries */
    short int  sqld; /* number of variables found by DESCRIBE*/
    struct sqlvar       sqlvar[1]; /* array of variable descriptors */
};

#define SCALE(sqllen)           ((sqllen)/256)
#define PRECISION(sqllen)       ((sqllen)&0xff)
#define SET_PRECISION_SCALE(sqllen,precision,scale)     \
                                sqllen = (scale)*256 + (precision)
#define DECIMALSTORAGE(sqllen)  (PRECISION(sqllen)/2 + 1)

typedef struct sqlda    SQLDA;
typedef struct sqlvar   SQLVAR, SQLDA_VARIABLE;
typedef struct sqlname  SQLNAME, SQLDA_NAME;

#ifndef SQLDASIZE
#define SQLDASIZE(n)    ( sizeof( struct sqlda ) +  \
                          (n-1) * sizeof( struct sqlvar) )
#endif

#if defined( _SQL_PACK_STRUCTURES )
#include "poppk.h"
#endif

#endif
```

SQLDA fields

The SQLDA fields have the following meanings:

Field	Description
sqldaid	An 8-byte character field that contains the string **SQLDA** as an identification of the SQLDA structure. This field helps in debugging when you are looking at memory contents.
sqldabc	A long integer containing the length of the SQLDA structure.
sqln	The number of variable descriptors in the **sqlvar** array.
sqld	The number of variable descriptors which are valid (contain information describing a host variable). This field is set by the DESCRIBE statement and sometimes by the programmer when supplying data to the database server.
sqlvar	An array of descriptors of type **struct sqlvar,** each describing a host variable.

SQLDA host variable descriptions

Each **sqlvar** structure in the SQLDA describes a host variable. The fields of the **sqlvar** structure have the following meanings:

- **sqltype** The type of the variable that is described by this descriptor (see "Embedded SQL data types" on page 177).

  The low order bit indicates whether NULL values are allowed. Valid types and constant definitions can be found in the *sqldef.h* header file.

  This field is filled by the DESCRIBE statement. You can set this field to any type when supplying data to the database server or retrieving data from the database server. Any necessary type conversion is done automatically.

- **sqllen** The length of the variable. What the length actually means depends upon the type information and how the SQLDA is being used.

  For DECIMAL types, this field is divided into two 1-byte fields. The high byte is the precision and the low byte is the scale. The precision is the total number of digits. The scale is the number of digits that appear after the decimal point.

  For LONG VARCHAR and LONG BINARY data types, the **array_len** field of the DT_LONGBINARY and DT_LONGVARCHAR data type structure is used instead of the **sqllen** field.

  For more information on the length field, see "SQLDA sqllen field values" on page 209.

- **sqldata** A four-byte pointer to the memory occupied by this variable. This memory must correspond to the **sqltype** and **sqllen** fields.

  For storage formats, see "Embedded SQL data types" on page 177.

  For UPDATE and INSERT commands, this variable is not involved in the operation if the **sqldata** pointer is a null pointer. For a FETCH, no data is returned if the **sqldata** pointer is a null pointer. In other words, the column returned by the **sqldata** pointer is an **unbound column**.

  If the DESCRIBE statement uses LONG NAMES, this field holds the long name of the result set column. If, in addition, the DESCRIBE statement is a DESCRIBE USER TYPES statement, then this field holds the long name of the user-defined data type, instead of the column. If the type is a base type, the field is empty.

- **sqlind** A pointer to the indicator value. An indicator value is a **short int**. A negative indicator value indicates a NULL value. A positive indicator value indicates that this variable has been truncated by a FETCH statement, and the indicator value contains the length of the data before truncation. A value of –2 indicates a conversion error if the CONVERSION_ERROR database option is set to OFF.

  For more information, see "Indicator variables" on page 185.

  If the **sqlind** pointer is the null pointer, no indicator variable pertains to this host variable.

  The **sqlind** field is also used by the DESCRIBE statement to indicate parameter types. If the type is a user-defined data type, this field is set to DT_HAS_USERTYPE_INFO. In such a case, you may wish to carry out a DESCRIBE USER TYPES to obtain information on the user-defined data types.

- **sqlname** A VARCHAR structure that contains a length and character buffer. It is filled by a DESCRIBE statement and is not otherwise used. This field has a different meaning for the two formats of the DESCRIBE statement:

  - **SELECT LIST** The name buffer is filled with the column heading of the corresponding item in the select list.
  - **BIND VARIABLES** The name buffer is filled with the name of the host variable that was used as a bind variable, or "?" if an unnamed parameter marker is used.

  On a DESCRIBE SELECT LIST command, any indicator variables present are filled with a flag indicating whether the select list item is updatable or not. More information on this flag can be found in the *sqldef.h* header file.

  If the DESCRIBE statement is a DESCRIBE USER TYPES statement, then this field holds the long name of the user-defined data type instead of the column. If the type is a base type, the field is empty.

SQLDA sqllen field values

The **sqllen** field length of the **sqlvar** structure in a SQLDA is used in the following kinds of interactions with the database server:

- **describing values** The DESCRIBE statement gets information about the host variables required to store data retrieved from the database, or host variables required to pass data to the database.

  See "Describing values" on page 210.

- **retrieving values** Retrieving values from the database.

  See "Retrieving values" on page 212.

- **sending values** Sending information to the database.

  See "Sending values" on page 211.

These interactions are described in this section.

The following tables detail each of these interactions. These tables list the interface constant types (the **DT_** types) found in the *sqldef.h* header file. These constants would be placed in the SQLDA **sqltype** field.

For information about **sqltype** field values, see "Embedded SQL data types" on page 177.

In static SQL, a SQLDA is still used but it is generated and completely filled in by the SQL preprocessor. In this static case, the tables give the correspondence between the static C language host variable types and the interface constants.

Describing values

The following table indicates the values of the **sqllen** and **sqltype** structure members returned by the DESCRIBE command for the various database types (both SELECT LIST and BIND VARIABLE DESCRIBE statements). In the case of a user-defined database data type, the base type is described.

Your program can use the types and lengths returned from a DESCRIBE, or you may use another type. The database server performs type conversions between any two types. The memory pointed to by the **sqldata** field must correspond to the **sqltype** and **sqllen** fields.

For information on embedded SQL data types, see "Embedded SQL data types" on page 177.

Database field type	Embedded SQL type returned	Length returned on describe
BIGINT	DT_BIGINT	8
BINARY(n)	DT_BINARY	n
BIT	DT_BIT	1
CHAR(n)	DT_FIXCHAR	n
DATE	DT_DATE	length of longest formatted string
DECIMAL(p,s)	DT_DECIMAL	high byte of length field in SQLDA set to p, and low byte set to s

Database field type	Embedded SQL type returned	Length returned on describe
DOUBLE	DT_DOUBLE	8
FLOAT	DT_FLOAT	4
INT	DT_INT	4
LONG BINARY	DT_LONGBINARY	32767
LONG VARCHAR	DT_LONGVARCHAR	32767
REAL	DT_FLOAT	4
SMALLINT	DT_SMALLINT	2
TIME	DT_TIME	length of longest formatted string
TIMESTAMP	DT_TIMESTAMP	length of longest formatted string
TINYINT	DT_TINYINT	1
UNSIGNED BIGINT	DT_UNSBIGINT	8
UNSIGNED INT	DT_UNSINT	4
UNSIGNED SMALLINT	DT_UNSSMALLINT	2
VARCHAR(n)	DT_VARCHAR	n

Sending values

The following table indicates how you specify lengths of values when you supply data to the database server in the SQLDA.

Only the data types displayed in the table are allowed in this case. The DT_DATE, DT_TIME, and DT_TIMESTAMP types are treated the same as DT_STRING when supplying information to the database; the value must be a NULL-terminated character string in an appropriate date format.

Embedded SQL Data Type	Program action to set the length
DT_BIGINT	No action required
DT_BINARY(n)	Length taken from field in BINARY structure
DT_BIT	No action required
DT_DATE	Length determined by terminating \0
DT_DECIMAL(p,s)	high byte of length field in SQLDA set to p, and low byte set to s

Embedded SQL Data Type	Program action to set the length
DT_DOUBLE	No action required
DT_FIXCHAR(n)	Length field in SQLDA determines length of string
DT_FLOAT	No action required
DT_INT	No action required
DT_LONGBINARY	Length field ignored. See "Sending LONG data" on page 217
DT_LONGVARCHAR	Length field ignored. See "Sending LONG data" on page 217
DT_SMALLINT	No action required
DT_STRING	Length determined by terminating \0
DT_TIME	Length determined by terminating \0
DT_TIMESTAMP	Length determined by terminating \0
DT_TIMESTAMP_STRUCT	No action required
DT_UNSBIGINT	No action required
DT_UNSINT	No action required
DT_UNSSMALLINT	No action required
DT_VARCHAR(n)	Length taken from field in VARCHAR structure
DT_VARIABLE	Length determined by terminating \0

Retrieving values

The following table indicates the values of the length field when you retrieve data from the database using a SQLDA. The **sqllen** field is never modified when you retrieve data.

Only the interface data types displayed in the table are allowed in this case. The DT_DATE, DT_TIME, and DT_TIMESTAMP data types are treated the same as DT_STRING when you retrieve information from the database. The value is formatted as a character string in the current date format.

Embedded SQL Data Type	What the program must set length field to when receiving	How the database returns length information after fetching a value
DT_BIGINT	No action required	No action required
DT_BINARY(n)	Maximum length of BINARY structure (n+2)	**len** field of BINARY structure set to actual length
DT_BIT	No action required	No action required
DT_DATE	Length of buffer	\0 at end of string
DT_DECIMAL(p,s)	High byte set to p and low byte set to s	No action required
DT_DOUBLE	No action required	No action required
DT_FIXCHAR(n)	Length of buffer	Padded with blanks to length of buffer
DT_FLOAT	No action required	No action required
DT_INT	No action required	No action required
DT_LONGBINARY	Length field ignored. See "Retrieving LONG data" on page 215	Length field ignored. See "Retrieving LONG data" on page 215
DT_LONGVARCHAR	Length field ignored. See "Retrieving LONG data" on page 215	Length field ignored. See "Retrieving LONG data" on page 215
DT_SMALLINT	No action required	No action required
DT_STRING	Length of buffer	\0 at end of string
DT_TIME	Length of buffer	\0 at end of string
DT_TIMESTAMP	Length of buffer	\0 at end of string
DT_TIMESTAMP_STRUCT	No action required	No action required
DT_UNSBIGINT	No action required	No action required
DT_UNSINT	No action required	No action required
DT_UNSSMALLINT	No action required	No action required
DT_VARCHAR(n)	Maximum length of VARCHAR structure (n+2)	**len** field of VARCHAR structure set to actual length

Sending and retrieving long values

The method for sending and retrieving LONG VARCHAR and LONG BINARY values in embedded SQL applications is different from that for other data types. Although the standard SQLDA fields can be used, they are limited to 32 kb data as the fields holding the information (sqldata, sqllen, sqlind) are 16-bit values. Changing these values to 32-bit values would break existing applications.

The method of describing LONG VARCHAR and LONG BINARY values is the same as for other data types.

For information about how to retrieve and send values, see "Retrieving LONG data" on page 215, and "Sending LONG data" on page 217.

Static SQL usage

Separate structures are used to hold the allocated, stored, and untruncated lengths of LONG BINARY and LONG VARCHAR data types. The static SQL data types are defined in *sqlca.h* as follows:

```
#define DECL_LONGVARCHAR( size )         \
  struct { a_sql_uint32    array_len;    \
           a_sql_uint32    stored_len;   \
           a_sql_uint32    untrunc_len;  \
           char            array[size+1];\
         }

#define DECL_LONGBINARY( size )          \
  struct { a_sql_uint32    array_len;    \
           a_sql_uint32    stored_len;   \
           a_sql_uint32    untrunc_len;  \
           char            array[size];  \
         }
```

Dynamic SQL usage

For dynamic SQL, set the **sqltype** field to DT_LONGVARCHAR or DT_LONGBINARY as appropriate. The associated LONGBINARY and LONGVARCHAR structures are as follows:

```
typedef struct LONGVARCHAR {
    a_sql_uint32    array_len;
           /* number of allocated bytes in array */
    a_sql_uint32    stored_len;
           /* number of bytes stored in array
            * (never larger than array_len)
            */
    a_sql_uint32    untrunc_len;
           /* number of bytes in untruncated expression
            * (may be larger than array_len)
            */
    char            array[1];   /* the data */
} LONGVARCHAR, LONGBINARY;
```

☞ For information about how to implement this feature in your applications, see "Retrieving LONG data" on page 215, and "Sending LONG data" on page 217.

Retrieving LONG data

This section describes how to retrieve LONG values from the database. For background information, see "Sending and retrieving long values" on page 214.

The procedures are different depending on whether you are using static or dynamic SQL.

❖ **To receive a LONG VARCHAR or LONG BINARY value (static SQL):**

1. Declare a host variable of type DECL_LONGVARCHAR or DECL_LONGBINARY, as appropriate.
2. Retrieve the data using FETCH, GET DATA, or EXECUTE INTO. Adaptive Server Anywhere sets the following information:
   - **indicator variable** The indicator variable is negative if the value is NULL, 0 if there is no truncation, and is the positive untruncated length in bytes up to a maximum of 32767.

     ☞ For more information, see "Indicator variables" on page 185.
   - **stored_len** This DECL_LONGVARCHAR or DECL_LONGBINARY field holds the number of bytes retrieved into the array. It is never greater than **array_len**.
   - **untrunc_len** This DECL_LONGVARCHAR or DECL_LONGBINARY field holds the number of bytes held by the database server. It is at least equal to the **stored_len** value. It is set even if the value is not truncated.

❖ **To receive a value into a LONGVARCHAR or LONGBINARY structure (dynamic SQL):**

1. Set the **sqltype** field to DT_LONGVARCHAR or DT_LONGBINARY as appropriate.
2. Set the **sqldata** field to point to the LONGVARCHAR or LONGBINARY structure.

   You can use the `LONGVARCHARSIZE( n )` or `LONGBINARYSIZE( n )` macros to determine the total number of bytes to allocate to hold `n` bytes of data in the array field.

3 Set the **array_len** field of the LONGVARCHAR or LONGBINARY structure to the number of bytes allocated for the array field.

4 Retrieve the data using FETCH, GET DATA, or EXECUTE INTO. Adaptive Server Anywhere sets the following information:

- *** sqlind** This **sqlda** field is negative if the value is NULL, 0 if there is no truncation, and is the positive untruncated length in bytes up to a maximum of 32767.
- **stored_len** This LONGVARCHAR or LONGBINARY field holds the number of bytes retrieved into the array. It is never greater than **array_len**.
- **untrunc_len** This LONGVARCHAR or LONGBINARY field holds the number of bytes held by the database server. It is at least equal to the stored_len value. It is set even if the value is not truncated.

The following code snippet illustrates the mechanics of retrieving LONG VARCHAR data using dynamic embedded SQL. It is not intended to be a practical application:

```
#define DATA_LEN 128000
void get_test_var()
/*****************/
{
    LONGVARCHAR *longptr;
    SQLDA *sqlda;
    SQLVAR *sqlvar;

    sqlda = alloc_sqlda( 1 );
    longptr = (LONGVARCHAR *)malloc(
                LONGVARCHARSIZE( DATA_LEN ) );
    if( sqlda == NULL || longptr == NULL ) {
        fatal_error( "Allocation failed" );
    }

    // init longptr for receiving data
    longptr->array_len = DATA_LEN;

    // init sqlda for receiving data
    // (sqllen is unused with DT_LONG types)
    sqlda->sqld = 1;  // using 1 sqlvar
    sqlvar = &sqlda->sqlvar[0];
    sqlvar->sqltype = DT_LONGVARCHAR;
    sqlvar->sqldata = longptr;

    printf( "fetching test_var\n" );
    EXEC SQL PREPARE select_stmt FROM 'SELECT test_var';
    EXEC SQL EXECUTE select_stmt INTO DESCRIPTOR sqlda;
    EXEC SQL DROP STATEMENT select_stmt;
    printf( "stored_len: %d, untrunc_len: %d,
       1st char: %c, last char: %c\n",
        longptr->stored_len,
        longptr->untrunc_len,
        longptr->array[0],
        longptr->array[DATA_LEN-1] );
    free_sqlda( sqlda );
    free( longptr );
}
```

Sending LONG data

This section describes how to send LONG values to the database from embedded SQL applications. For background information, see "Sending and retrieving long values" on page 214.

The procedures are different depending on whether you are using static or dynamic SQL.

❖ **To send a LONG VARCHAR or LONG BINARY value (static SQL):**

1 Declare a host variable of type DECL_LONGVARCHAR or DECL_LONGBINARY, as appropriate.

2 If you are sending NULL and using an indicator variable, set the indicator variable to a negative value.

For more information, see "Indicator variables" on page 185.

3 Set the **stored_len** field of the DECL_LONGVARCHAR or DECL_LONGBINARY structure to the number of bytes of data in the array field.

4 Send the data by opening the cursor or executing the statement.

The following code snippet illustrates the mechanics of sending a LONG VARCHAR using static embedded SQL. It is not intended to be a practical application.

```
#define DATA_LEN 12800
EXEC SQL BEGIN DECLARE SECTION;
// SQLPP initializes longdata.array_len
DECL_LONGVARCHAR(128000) longdata;
EXEC SQL END DECLARE SECTION;

void set_test_var()
/*****************/
{
    // init longdata for sending data
    memset( longdata.array, 'a', DATA_LEN );
    longdata.stored_len = DATA_LEN;

    printf( "Setting test_var to %d a's\n", DATA_LEN );
    EXEC SQL SET test_var = :longdata;
}
```

❖ **To send a value using a LONGVARCHAR or LONGBINARY structure (dynamic SQL):**

1 Set the sqltype field to DT_LONGVARCHAR or DT_LONGBINARY as appropriate.

2 If you are sending NULL, set *** sqlind** to a negative value.

3 Set the **sqldata** field to point to the LONGVARCHAR or LONGBINARY structure.

You can use the `LONGVARCHARSIZE( n )` or `LONGBINARYSIZE( n )` macros to determine the total number of bytes to allocate to hold `n` bytes of data in the array field.

4 Set the **array_len** field of the LONGVARCHAR or LONGBINARY structure to the number of bytes allocated for the array field.

5 Set the **stored_len** field of the LONGVARCHAR or LONGBINARY structure to the number of bytes of data in the array field. This must not be more than **array_len**.

6 Send the data by opening the cursor or executing the statement.

Using stored procedures

This section describes the use of SQL procedures in embedded SQL.

Using simple stored procedures

You can create and call stored procedures in embedded SQL.

You can embed a CREATE PROCEDURE just like any other data definition statement, such as CREATE TABLE. You can also embed a CALL statement to execute a stored procedure. The following code fragment illustrates both creating and executing a stored procedure in embedded SQL:

```
EXEC SQL CREATE PROCEDURE pettycash( IN amount
   DECIMAL(10,2) )
BEGIN
   UPDATE account
   SET balance = balance - amount
   WHERE name = 'bank';

   UPDATE account
   SET balance = balance + amount
   WHERE name = 'pettycash expense';
END;
EXEC SQL CALL pettycash( 10.72 );
```

If you wish to pass host variable values to a stored procedure or to retrieve the output variables, you prepare and execute a CALL statement. The following code fragment illustrates the use of host variables. Both the USING and INTO clauses are used on the EXECUTE statement.

```
EXEC SQL BEGIN DECLARE SECTION;
   double  hv_expense;
   double  hv_balance;
EXEC SQL END DECLARE SECTION;
```

```
// code here
EXEC SQL CREATE PROCEDURE pettycash(
         IN expense   DECIMAL(10,2),
         OUT endbalance DECIMAL(10,2) )
   BEGIN
      UPDATE account
      SET balance = balance - expense
      WHERE name = 'bank';

      UPDATE account
      SET balance = balance + expense
      WHERE name = 'pettycash expense';

      SET endbalance = ( SELECT balance FROM account
                         WHERE name = 'bank' );
   END;

EXEC SQL PREPARE S1 FROM 'CALL pettycash( ?, ? )';
EXEC SQL EXECUTE S1 USING :hv_expense INTO :hv_balance;
```

For more information, see "EXECUTE statement [ESQL]" on page 414 of the book *ASA SQL Reference Manual*, and "PREPARE statement [ESQL]" on page 495 of the book *ASA SQL Reference Manual*.

Stored procedures with result sets

Database procedures can also contain SELECT statements. The procedure is declared using a RESULT clause to specify the number, name, and types of the columns in the result set. Result set columns are different from output parameters. For procedures with result sets, the CALL statement can be used in place of a SELECT statement in the cursor declaration:

```
EXEC SQL BEGIN DECLARE SECTION;
   char  hv_name[100];
EXEC SQL END DECLARE SECTION;

EXEC SQL CREATE PROCEDURE female_employees()
   RESULT( name char(50) )
   BEGIN
      SELECT emp_fname || emp_lname FROM employee
      WHERE sex = 'f';
   END;

EXEC SQL PREPARE S1 FROM 'CALL female_employees()';

EXEC SQL DECLARE C1 CURSOR FOR S1;
EXEC SQL OPEN C1;
for(;;) {
   EXEC SQL FETCH C1 INTO :hv_name;
   if( SQLCODE != SQLE_NOERROR ) break;
```

```
    printf( "%s\\n", hv_name );
}
EXEC SQL CLOSE C1;
```

In this example, the procedure has been invoked with an OPEN statement rather than an EXECUTE statement. The OPEN statement causes the procedure to execute until it reaches a SELECT statement. At this point, C1 is a cursor for the SELECT statement within the database procedure. You can use all forms of the FETCH command (backward and forward scrolling) until you are finished with it. The CLOSE statement terminates execution of the procedure.

If there had been another statement following the SELECT in the procedure, it would not have been executed. In order to execute statements following a SELECT, use the RESUME cursor-name command. The RESUME command either returns the warning SQLE_PROCEDURE_COMPLETE or it returns SQLE_NOERROR indicating that there is another cursor. The example illustrates a two-select procedure:

```
EXEC SQL CREATE PROCEDURE people()
RESULT( name char(50) )
BEGIN

    SELECT emp_fname || emp_lname
    FROM employee;

    SELECT fname || lname
    FROM customer;
END;

EXEC SQL PREPARE S1 FROM 'CALL people()';

EXEC SQL DECLARE C1 CURSOR FOR S1;
EXEC SQL OPEN C1;
while( SQLCODE == SQLE_NOERROR ) {
    for(;;) {
        EXEC SQL FETCH C1 INTO :hv_name;
        if( SQLCODE != SQLE_NOERROR ) break;
        printf( "%s\\n", hv_name );
    }
    EXEC SQL RESUME C1;
}
EXEC SQL CLOSE C1;
```

Dynamic cursors for CALL statements

These examples have used static cursors. Full dynamic cursors can also be used for the CALL statement.

For a description of dynamic cursors, see "Dynamic SELECT statement" on page 204.

The DESCRIBE statement works fully for procedure calls. A DESCRIBE OUTPUT produces a SQLDA that has a description for each of the result set columns.

If the procedure does not have a result set, the SQLDA has a description for each INOUT or OUT parameter for the procedure. A DESCRIBE INPUT statement produces a SQLDA having a description for each IN or INOUT parameter for the procedure.

DESCRIBE ALL

DESCRIBE ALL describes IN, INOUT, OUT, and RESULT set parameters. DESCRIBE ALL uses the indicator variables in the SQLDA to provide additional information.

The DT_PROCEDURE_IN and DT_PROCEDURE_OUT bits are set in the indicator variable when a CALL statement is described. DT_PROCEDURE_IN indicates an IN or INOUT parameter and DT_PROCEDURE_OUT indicates an INOUT or OUT parameter. Procedure RESULT columns have both bits clear.

After a describe OUTPUT, these bits can be used to distinguish between statements that have result sets (need to use OPEN, FETCH, RESUME, CLOSE) and statements that do not (need to use EXECUTE).

For a complete description, see "DESCRIBE statement [ESQL]" on page 392 of the book *ASA SQL Reference Manual*.

Multiple result sets

If you have a procedure that returns multiple result sets, you must re-describe after each RESUME statement if the result sets change shapes.

You need to describe the cursor, not the statement, to re-describe the current position of the cursor.

Embedded SQL programming techniques

This section contains a set of tips for developers of embedded SQL programs.

Implementing request management

The default behavior of the interface DLL is for applications to wait for completion of each database request before carrying out other functions. This behavior can be changed using request management functions. For example, when using Interactive SQL, the operating system is still active while Interactive SQL is waiting for a response from the database and Interactive SQL carries out some tasks in that time.

You can achieve application activity while a database request is in progress by providing a **callback function**. In this callback function you must not do another database request except **db_cancel_request**. You can use the **db_is_working** function in your message handlers to determine if you have a database request in progress.

The **db_register_a_callback** function is used to register your application callback functions.

For more information, see the following:

- "db_register_a_callback function" on page 237
- "db_cancel_request function" on page 233
- "db_is_working function" on page 236

Backup functions

The **db_backup** function provides support for online backup in embedded SQL applications. The backup utility makes use of this function. You should only need to write a program to use this function if your backup requirements are not satisfied by the Adaptive Server Anywhere backup utility.

BACKUP statement is recommended
Although this function provides one way to add backup features to an application, the recommended way to accomplish this task is to use the BACKUP statement. For more information, see "BACKUP statement" on page 245 of the book *ASA SQL Reference Manual*.

☞ You can also access the backup utility directly using the Database Tools DBBackup function. For more information on this function, see "DBBackup function" on page 293.

☞ For more information, see "db_backup function" on page 230.

The SQL preprocessor

The SQL preprocessor processes a C or C++ program containing embedded SQL, before the compiler is run.

Syntax

sqlpp [*options*] *SQL-filename* [*output-filename*]

Option	Description
–c *"keyword=value;..."*	Supply reference database connection parameters [UltraLite]
–d	Favor data size
–e *level*	Flag non-conforming SQL syntax as an error
–f	Put the far keyword on generated static data
–g	Do not display UltraLite warnings
–h *line–width*	Limit the maximum line length of output
–k	Include user declaration of SQLCODE
–m *version*	Specify the version name for generated synchronization scripts
–n	Line numbers
–o *operating–sys*	Target operating system.
–p *project*	UltraLite project name
–q	Quiet mode—do not print banner
–r	Generate reentrant code
–s *string–len*	Maximum string length for the compiler
–w *level*	Flag non-conforming SQL syntax as a warning
–x	Change multibyte SQL strings to escape sequences
–z *sequence*	Specify collation sequence

See also

"Introduction" on page 164

Description

The SQL preprocessor processes a C or C++ program containing embedded SQL before the compiler is run. SQLPP translates the SQL statements in the *input-file* into C language source that is put into the *output-file*. The normal extension for source programs with embedded SQL is *.sqc*. The default output filename is the **SQL-filename** with an extension of *.c*. If the **SQL-filename** has a *.c* extension, the default output filename extension is *.cc*.

Options

–c Required when preprocessing files that are part of an UltraLite application. The connection string must give the SQL preprocessor access to read and modify your reference database.

–d Generate code that reduces data space size. Data structures are reused and initialized at execution time before use. This increases code size.

–e This option flags any embedded SQL that is not part of a specified set of SQL/92 as an error.

The allowed values of *level* and their meanings are as follows:

- **e** flag syntax that is not entry-level SQL/92 syntax
- **i** flag syntax that is not intermediate-level SQL/92 syntax
- **f** flag syntax that is not full-SQL/92 syntax
- **t** flag non-standard host variable types
- **u** flag syntax that is not supported by UltraLite
- **w** allow all supported syntax

–g Do not display warning specific to UltraLite code generation.

–h Limits the maximum length of lines output by *sqlpp* to *num*. The continuation character is a backslash (\) and the minimum value of *num* is ten.

–k Notifies the preprocessor that the program to be compiled includes a user declaration of SQLCODE.

–m Specify the version name for generated synchronization scripts. The generated synchronization scripts can be used in a MobiLink consolidated database for simple synchronization.

–n Generate line number information in the C file. This consists of *#line* directives in the appropriate places in the generated C code. If the compiler that you are using supports the *#line* directive, this option makes the compiler report errors on line numbers in the SQC file (the one with the embedded SQL) as opposed to reporting errors on line numbers in the C file generated by the SQL preprocessor. Also, the *#line* directives are used indirectly by the source level debugger so that you can debug while viewing the SQC source file.

–o Specify the target operating system. Note that this option must match the operating system where you run the program. A reference to a special symbol is generated in your program. This symbol is defined in the interface library. If you use the wrong operating system specification or the wrong library, an error is detected by the linker. The supported operating systems are:

- **WINDOWS** Windows 95/98/Me, Windows CE
- **WINNT** Microsoft Windows NT/2000/XP
- **NETWARE** Novell NetWare
- **UNIX** UNIX

–p Identifies the UltraLite project to which the embedded SQL files belong. Applies only when processing files that are part of an UltraLite application.

–q Do not print the banner.

–r For more information on re-entrant code, see "SQLCA management for multi-threaded or reentrant code" on page 190.

–s Set the maximum size string that the preprocessor puts into the C file. Strings longer than this value are initialized using a list of characters (*'a','b','c'*, etc). Most C compilers have a limit on the size of string literal they can handle. This option is used to set that upper limit. The default value is 500.

–w This option flags any embedded SQL that is not part of a specified set of SQL/92 as a warning.

The allowed values of *level* and their meanings are as follows:

- **e** flag syntax that is not entry-level SQL/92 syntax
- **i** flag syntax that is not intermediate-level SQL/92 syntax
- **f** flag syntax that is not full-SQL/92 syntax
- **t** flag non-standard host variable types
- **u** flag syntax that is not supported by UltraLite
- **w** allow all supported syntax

–x Change multibyte strings to escape sequences so that they can pass through compilers.

–z This option specifies the collation sequence. For a listing of recommended collation sequences, type **dbinit –l** at the command prompt.

The collation sequence is used to help the preprocessor understand the characters used in the source code of the program, for example, in identifying alphabetic characters suitable for use in identifiers. If `-z` is not specified, the preprocessor attempts to determine a reasonable collation to use based on the operating system and SQLLOCALE environment variable.

Library function reference

The SQL preprocessor generates calls to functions in the interface library or DLL. In addition to the calls generated by the SQL preprocessor, a set of library functions is provided to make database operations easier to perform. Prototypes for these functions are included by the EXEC SQL INCLUDE SQLCA command.

This section contains a reference description of these various functions.

DLL entry points

The DLL entry points are the same except that the prototypes have a modifier appropriate for DLLs.

You can declare the entry points in a portable manner using **_esqlentry_**, which is defined in *sqlca.h*. It resolves to the value __stdcall:

alloc_sqlda function

Prototype

SQLDA ***alloc_sqlda(** unsigned *numvar* **);**

Description

Allocates a SQLDA with descriptors for *numvar* variables. The **sqln** field of the SQLDA is initialized to *numvar*. Space is allocated for the indicator variables, the indicator pointers are set to point to this space, and the indicator value is initialized to zero. A null pointer is returned if memory cannot be allocated. It is recommended that you use this function instead of **alloc_sqlda_noind function**.

alloc_sqlda_noind function

Prototype

SQLDA ***alloc_sqlda_noind(** unsigned *numvar* **);**

Description

Allocates a SQLDA with descriptors for *numvar* variables. The **sqln** field of the SQLDA is initialized to *numvar*. Space is not allocated for indicator variables; the indicator pointers are set to the null pointer. A null pointer is returned if memory cannot be allocated.

db_backup function

Prototype

void **db_backup(**
SQLCA * *sqlca***,**
int *op***,**
*int file_num***,**
unsigned long *page_num***,**
SQLDA * *sqlda***);**

Authorization

Must be connected to a user ID with DBA authority or REMOTE DBA authority (SQL Remote).

Description

> **BACKUP statement is recommended**
> Although this function provides one way to add backup features to an application, the recommended way to accomplish this task is to use the BACKUP statement. For more information, see "BACKUP statement" on page 245 of the book *ASA SQL Reference Manual*.

The action performed depends on the value of the *op* parameter:

- **DB_BACKUP_START** Must be called before a backup can start. Only one backup can be running at one time against any given database server. Database checkpoints are disabled until the backup is complete (**db_backup** is called with an *op* value of DB_BACKUP_END). If the backup cannot start, the SQLCODE is SQLE_BACKUP_NOT_STARTED. Otherwise, the SQLCOUNT field of the *sqlca* is set to the size of each database page. (Backups are processed one page at a time.)

  The *file_num*, *page_num* and *sqlda* parameters are ignored.

- **DB_BACKUP_OPEN_FILE** Open the database file specified by *file_num*, which allows pages of the specified file to be backed up using DB_BACKUP_READ_PAGE. Valid file numbers are 0 through DB_BACKUP_MAX_FILE for the root database files, DB_BACKUP_TRANS_LOG_FILE for the transaction log file, and DB_BACKUP_WRITE_FILE for the database write file if it exists. If the specified file does not exist, the SQLCODE is SQLE_NOTFOUND. Otherwise, SQLCOUNT contains the number of pages in the file, SQLIOESTIMATE contains a 32-bit value (POSIX **time_t**) which identifies the time that the database file was created, and the operating system file name is in the *sqlerrmc* field of the SQLCA.

  The *page_num* and *sqlda* parameters are ignored.

- **DB_BACKUP_READ_PAGE** Read one page of the database file specified by *file_num*. The *page_num* should be a value from 0 to one less than the number of pages returned in SQLCOUNT by a successful call to **db_backup** with the DB_BACKUP_OPEN_FILE operation. Otherwise, SQLCODE is set to SQLE_NOTFOUND. The *sqlda* descriptor should be set up with one variable of type DT_BINARY pointing to a buffer. The buffer should be large enough to hold binary data of the size returned in the SQLCOUNT field on the call to **db_backup** with the DB_BACKUP_START operation.

DT_BINARY data contains a two-byte length followed by the actual binary data, so the buffer must be two bytes longer than the page size.

Application must save buffer
This call makes a copy of the specified database page into the buffer, but it is up to the application to save the buffer on some backup media.

- **DB_BACKUP_READ_RENAME_LOG** This action is the same as DB_BACKUP_READ_PAGE, except that after the last page of the transaction log has been returned, the database server renames the transaction log and starts a new one.

  If the database server is unable to rename the log at the current time (for example in version 7.x or earlier databases there may be incomplete transactions), the SQLE_BACKUP_CANNOT_RENAME_LOG_YET error is set. In this case, do not use the page returned, but instead reissue the request until you receive SQLE_NOERROR and then write the page. Continue reading the pages until you receive the SQLE_NOTFOUND condition.

  The SQLE_BACKUP_CANNOT_RENAME_LOG_YET error may be returned multiple times and on multiple pages. In your retry loop, you should add a delay so as not to slow the server down with too many requests.

  When you receive the SQLE_NOTFOUND condition, the transaction log has been backed up successfully and the file has been renamed. The name for the old transaction file is returned in the *sqlerrmc* field of the SQLCA.

  You should check the **sqlda->sqlvar[0].sqlind** value after a **db_backup** call. If this value is greater than zero, the last log page has been written and the log file has been renamed. The new name is still in **sqlca.sqlerrmc**, but the SQLCODE value is SQLE_NOERROR.

  You should not call **db_backup** again after this, except to close files and finish the backup. If you do, you get a second copy of your backed up log file and you receive SQLE_NOTFOUND.

- **DB_BACKUP_CLOSE_FILE** Must be called when processing of one file is complete to close the database file specified by *file_num*.

  The *page_num* and *sqlda* parameters are ignored.

- **DB_BACKUP_END** Must be called at the end of the backup. No other backup can start until this backup has ended. Checkpoints are enabled again.

The *file_num*, *page_num* and *sqlda* parameters are ignored.

The *dbbackup* program uses the following algorithm. Note that this is *not* C code, and does not include error checking.

```
db_backup( ... DB_BACKUP_START ... )
allocate page buffer based on page size in SQLCODE
sqlda = alloc_sqlda( 1 )
sqlda->sqld = 1;
sqlda->sqlvar[0].sqltype = DT_BINARY
sqlda->sqlvar[0].sqldata = allocated buffer
for file_num = 0 to DB_BACKUP_MAX_FILE
  db_backup( ... DB_BACKUP_OPEN_FILE, file_num ... )
  if SQLCODE == SQLE_NO_ERROR
    /* The file exists */
    num_pages = SQLCOUNT
    file_time = SQLE_IO_ESTIMATE
    open backup file with name from sqlca.sqlerrmc
    for page_num = 0 to num_pages - 1
      db_backup( ... DB_BACKUP_READ_PAGE,
                 file_num, page_num, sqlda )
      write page buffer out to backup file
    next page_num
    close backup file
    db_backup( ... DB_BACKUP_CLOSE_FILE, file_num ... )
  end if
next file_num
backup up file DB_BACKUP_WRITE_FILE as above
backup up file DB_BACKUP_TRANS_LOG_FILE as above
free page buffer
db_backup( ... DB_BACKUP_END ... )
```

db_cancel_request function

Prototype

int **db_cancel_request(** SQLCA **sqlca* **);**

Description

Cancels the currently active database server request. This function checks to make sure a database server request is active before sending the cancel request. If the function returns 1, then the cancel request was sent; if it returns 0, then no request was sent.

A non-zero return value does not mean that the request was canceled. There are a few critical timing cases where the cancel request and the response from the database or server "cross". In these cases, the cancel simply has no effect, even though the function still returns TRUE.

The **db_cancel_request** function can be called asynchronously. This function and **db_is_working** are the only functions in the database interface library that can be called asynchronously using an SQLCA that might be in use by another request.

If you cancel a request that is carrying out a cursor operation, the position of the cursor is indeterminate. You must locate the cursor by its absolute position or close it, following the cancel.

db_delete_file function

Prototype

void **db_delete_file(**
SQLCA * *sqlca***,**
char * filename **);**

Authorization

Must be connected to a user ID with DBA authority or REMOTE DBA authority (SQL Remote).

Description

The **db_delete_file** function requests the database server to delete *filename*. This can be used after backing up and renaming the transaction log (see DB_BACKUP_READ_RENAME_LOG in "db_backup function" on page 230) to delete the old transaction log. You must be connected to a user ID with DBA authority.

db_find_engine function

Prototype

unsigned short **db_find_engine(**
SQLCA **sqlca***,*
char **name* **);**

Description

Returns an unsigned short value, which indicates status information about the database server whose name is *name*. If no server can be found with the specified name, the return value is 0. A non-zero value indicates that the server is currently running.

Each bit in the return value conveys some information. Constants that represent the bits for the various pieces of information are defined in the *sqldef.h* header file. If a null pointer is specified for *name*, information is returned about the default database environment.

db_fini function

Prototype

unsigned short **db_fini(** SQLCA **sqlca* **);**

Description

This function frees resources used by the database interface or DLL. You must not make any other library calls or execute any embedded SQL commands after **db_fini** is called. If an error occurs during processing, the error code is set in SQLCA and the function returns 0. If there are no errors, a non-zero value is returned.

You need to call **db_fini** once for each SQLCA being used.

> ***Caution***
> *Failure to call **db_fini** for each **db_init** on NetWare can cause the database server to fail and the NetWare file server to fail.*

See also For information on using db_init in UltraLite applications, see "db_fini function" on page 231 of the book *UltraLite User's Guide*.

db_get_property function

Prototype

unsigned int **db_get_property(**
SQLCA * *sqlca***,**
a_db_property *property***,**
char * *value_buffer***,**
int *value_buffer_size* **);**

Description This function is used to obtain the address of the server to which you are currently connected. It is used by the *dbping* utility to print out the server address.

The function can also be used to obtain the value of database properties. Database properties can also be obtained in an interface-independent manner by executing a SELECT statement, as described in "Database properties" on page 618 of the book *ASA Database Administration Guide*.

The arguments are as follows:

- **a_db_property** An **enum** with the value DB_PROP_SERVER_ADDRESS. DB_PROP_SERVER_ADDRESS gets the current connection's server network address as a printable string. Shared memory and NamedPipes protocols always return the empty string for the address. TCP/IP and SPX protocols return non-empty string addresses.
- **value_buffer** This argument is filled with the property value as a null terminated string.
- **value_buffer_size** The maximum length of the string **value_buffer**, including the terminating null character.

See also "Database properties" on page 618 of the book *ASA Database Administration Guide*

db_init function

Prototype

unsigned short **db_init(** SQLCA *_sqlca_ **);**

Description

This function initializes the database interface library. This function must be called before any other library call is made and before any embedded SQL command is executed. The resources the interface library requires for your program are allocated and initialized on this call.

Use **db_fini** to free the resources at the end of your program. If there are any errors during processing, they are returned in the SQLCA and 0 is returned. If there are no errors, a non-zero value is returned and you can begin using embedded SQL commands and functions.

In most cases, this function should be called only once (passing the address of the global **sqlca** variable defined in the *sqlca.h* header file). If you are writing a DLL or an application that has multiple threads using embedded SQL, call **db_init** once for each SQLCA that is being used.

For more information, see "SQLCA management for multi-threaded or reentrant code" on page 190.

> ***Caution***
> *Failure to call **db_fini** for each **db_init** on NetWare can cause the database server to fail, and the NetWare file server to fail.*

See also

For information on using db_init in UltraLite applications, see "db_init function" on page 231 of the book *UltraLite User's Guide*.

db_is_working function

Prototype

unsigned **db_is_working(** SQLCA *_sqlca_ **);**

Description

Returns 1 if your application has a database request in progress that uses the given sqlca and 0 if there is no request in progress that uses the given sqlca.

This function can be called asynchronously. This function and **db_cancel_request** are the only functions in the database interface library that can be called asynchronously using an SQLCA that might be in use by another request.

db_locate_servers function

Prototype

unsigned int **db_locate_servers(**
SQLCA **sqlca***,*
SQL_CALLBACK_PARM *callback_address***,**
void **callback_user_data* **);**

Description

Provides programmatic access to the information displayed by the *dblocate* utility, listing all the Adaptive Server Anywhere database servers on the local network that are listening on TCP/IP.

The callback function must have the following prototype:

```
int (*)( SQLCA *sqlca,
    a_server_address *server_addr,
    void *callback_user_data );
```

The callback function is called for each server found. If the callback function returns 0, **db_locate_servers** stops iterating through servers.

The **sqlca** and **callback_user_data** passed to the callback function are those passed into **db_locate_servers**. The second parameter is a pointer to an **a_server_address** structure. **a_server_address** is defined in *sqlca.h*, with the following definition:

```
typedef struct a_server_address {
    a_SQL_uint32   port_type;
    a_SQL_uint32   port_num;
    char     *name;
    char     *address;
} a_server_address;
```

- **port_type** Is always PORT_TYPE_TCP at this time (defined to be 6 in *sqlca.h*).
- **port_num** Is the TCP port number on which this server is listening.
- **name** Points to a buffer containing the server name.
- **address** Points to a buffer containing the IP address of the server.

For more information, see "The Server Location utility" on page 498 of the book *ASA Database Administration Guide*.

db_register_a_callback function

Prototype

void **db_register_a_callback(**
SQLCA **sqlca***,*
a_db_callback_index *index***,**
(SQL_CALLBACK_PARM) *callback* **);**

Description

This function registers callback functions.

If you do not register a DB_CALLBACK_WAIT callback, the default action is to do nothing. Your application blocks, waiting for the database response, and Windows changes the cursor to an hourglass.

To remove a callback, pass a null pointer as the *callback* function.

The following values are allowed for the *index* parameter:

- **DB_CALLBACK_DEBUG_MESSAGE** The supplied function is called once for each debug message and is passed a null-terminated string containing the text of the debug message. The string normally has a newline character (\n) immediately before the terminating null character. The prototype of the callback function is as follows:

  ```
  void SQL_CALLBACK debug_message_callback(
      SQLCA *sqlca,
      char * message_string );
  ```

- **DB_CALLBACK_START** The prototype is as follows:

  ```
  void SQL_CALLBACK start_callback( SQLCA *sqlca );
  ```

  This function is called just before a database request is sent to the server. DB_CALLBACK_START is used only on Windows.

- **DB_CALLBACK_FINISH** The prototype is as follows:

  ```
  void SQL_CALLBACK finish_callback( SQLCA * sqlca );
  ```

  This function is called after the response to a database request has been received by the interface DLL. DB_CALLBACK_FINISH is used only on Windows operating systems.

- **DB_CALLBACK_CONN_DROPPED** The prototype is as follows:

  ```
  void SQL_CALLBACK conn_dropped_callback (
      SQLCA *sqlca,
      char *conn_name );
  ```

  This function is called when the database server is about to drop a connection because of a liveness timeout, through a DROP CONNECTION statement, or because the database server is being shut down. The connection name **conn_name** is passed in to allow you to distinguish between connections. If the connection was not named, it has a value of NULL.

- **DB_CALLBACK_WAIT** The prototype is as follows:

  ```
  void SQL_CALLBACK wait_callback( SQLCA *sqlca );
  ```

This function is called repeatedly by the interface library while the database server or client library is busy processing your database request.

You would register this callback as follows:

```
db_register_a_callback( &sqlca,
   DBCALLBACK_WAIT,
   (SQL_CALLBACK_PARM)&db_wait_request );
```

- **DB_CALLBACK_MESSAGE** This is used to enable the application to handle messages received from the server during the processing of a request.

  The callback prototype is as follows:

  ```
  void SQL_CALLBACK message_callback(
      SQLCA* sqlca,
      unsigned short msg_type,
      an_SQL_code code,
      unsigned length,
      char*  msg
      );
  ```

  The **msg_type** parameter states how important the message is and you may wish to handle different message types in different ways. The available message types are MESSAGE_TYPE_INFO, MESSAGE_TYPE_WARNING, MESSAGE_TYPE_ACTION, and MESSAGE_TYPE_STATUS. These constants are defined in *sqldef.h*. The **code** field is an identifier. The **length** field tells you how long the message is. The message is *not* null-terminated.

  For example, the Interactive SQL callback displays STATUS and INFO message in the Messages pane, while messages of type ACTION and WARNING go to a dialog. If an application does not register this callback, there is a default callback, which causes all messages to be written to the server logfile (if debugging is on and a logfile is specified). In addition, messages of type MESSAGE_TYPE_WARNING and MESSAGE_TYPE_ACTION are more prominently displayed, in an operating system-dependent manner.

db_start_database function

Prototype unsigned int **db_start_database(** SQLCA * *sqlca*, char * *parms* **);**

Arguments

sqlca A pointer to a SQLCA structure. For information, see "The SQL Communication Area (SQLCA)" on page 188.

parms A NULL-terminated string containing a semi-colon-delimited list of parameter settings, each of the form KEYWORD=**value**. For example,

```
"UID=DBA;PWD=SQL;DBF=c:\\db\\mydatabase.db"
```

☞ For an available list of connection parameters, see "Connection parameters" on page 164 of the book *ASA Database Administration Guide*.

Description

Start a database on an existing server if the database is not already running. The steps carried out to start a database are described in "Starting a personal server" on page 79 of the book *ASA Database Administration Guide*

The return value is true if the database was already running or successfully started. Error information is returned in the SQLCA.

If a user ID and password are supplied in the parameters, they are ignored.

☞ The permission required to start and stop a database is set on the server command line. For information, see "The database server" on page 120 of the book *ASA Database Administration Guide*.

db_start_engine function

Prototype

unsigned int **db_start_engine(** SQLCA * *sqlca***,** char * *parms* **);**

Arguments

sqlca A pointer to a SQLCA structure. For information, see "The SQL Communication Area (SQLCA)" on page 188.

parms A NULL-terminated string containing a semi-colon-delimited list of parameter settings, each of the form KEYWORD=**value**. For example,

```
"UID=DBA;PWD=SQL;DBF=c:\\db\\mydatabase.db"
```

☞ For an available list of connection parameters, see "Connection parameters" on page 164 of the book *ASA Database Administration Guide*.

Description

Starts the database server if it is not running. The steps carried out by this function are those listed in "Starting a personal server" on page 79 of the book *ASA Database Administration Guide*.

The return value is true if a database server was either found or successfully started. Error information is returned in the SQLCA.

The following call to **db_start_engine** starts the database server and names it **asademo**, but does not load the database, despite the DBF connection parameter:

```
db_start_engine( &sqlca, "DBF=c:\\asa8\\asademo.db;
Start=dbeng8" );
```

If you wish to start a database as well as the server, include the database file in the START connection parameter:

```
db_start_engine( &sqlca,"ENG=eng_name;START=dbeng8
c:\\asa\\asademo.db" );
```

This call starts the server, names it **eng_name**, and starts the **asademo** database on that server.

The **db_start_engine** function attempts to connect to a server before starting one, to avoid attempting to start a server that is already running.

The FORCESTART connection parameter is used only by the **db_start_engine** function. When set to YES, there is no attempt to connect to a server before trying to start one. This enables the following pair of commands to work as expected:

1 Start a database server named server_1:

```
start dbeng8 -n server_1 asademo.db
```

2 Force a new server to start and connect to it:

```
db_start_engine( &sqlda, "START=dbeng8 -n server_2 asademo.db;ForceStart=YES" )
```

If FORCESTART was not used, and without an ENG parameter, the second command would have attempted to connect to *server_1*. The **db_start_engine** function does not pick up the server name from the -n option of the START parameter.

db_stop_database function

Prototype

unsigned int **db_stop_database(** SQLCA * *sqlca***,** char * parms **);**

Arguments

sqlca A pointer to a SQLCA structure. For information, see "The SQL Communication Area (SQLCA)" on page 188.

parms A NULL-terminated string containing a semi-colon-delimited list of parameter settings, each of the form KEYWORD=**value**. For example,

```
"UID=DBA;PWD=SQL;DBF=c:\\db\\mydatabase.db"
```

For an available list of connection parameters, see "Connection parameters" on page 164 of the book *ASA Database Administration Guide*.

Description

Stop the database identified by **DatabaseName** on the server identified by **EngineName**. If **EngineName** is not specified, the default server is used.

By default, this function does not stop a database that has existing connections. If **Unconditional** is **yes**, the database is stopped regardless of existing connections.

A return value of TRUE indicates that there were no errors.

☞ The permission required to start and stop a database is set on the server command line. For information, see "The database server" on page 120 of the book *ASA Database Administration Guide*.

db_stop_engine function

Prototype

unsigned int **db_stop_engine(** SQLCA * *sqlca***,** char * *parms* **);**

Arguments

sqlca A pointer to a SQLCA structure. For information, see "The SQL Communication Area (SQLCA)" on page 188.

parms A NULL-terminated string containing a semi-colon-delimited list of parameter settings, each of the form KEYWORD=**value**. For example,

```
"UID=DBA;PWD=SQL;DBF=c:\\db\\mydatabase.db"
```

☞ For an available list of connection parameters, see "Connection parameters" on page 164 of the book *ASA Database Administration Guide*.

Description

Terminates execution of the database server. The steps carried out by this function are:

- Look for a local database server that has a name that matches the **EngineName** parameter. If no **EngineName** is specified, look for the default local database server.
- If no matching server is found, this function fails.
- Send a request to the server to tell it to checkpoint and shut down all databases.
- Unload the database server.

By default, this function does not stop a database server that has existing connections. If **Unconditional** is *yes*, the database server is stopped regardless of existing connections.

A C program can use this function instead of spawning DBSTOP. A return value of TRUE indicates that there were no errors.

The use of **db_stop_engine** is subject to the permissions set with the -gk server option.

☞ For more information, see "–gk server option" on page 140 of the book *ASA Database Administration Guide*.

db_string_connect function

Prototype unsigned int **db_string_connect(** SQLCA * *sqlca***,** char * *parms* **);**

Arguments

sqlca A pointer to a SQLCA structure. For information, see "The SQL Communication Area (SQLCA)" on page 188.

parms A NULL-terminated string containing a semi-colon-delimited list of parameter settings, each of the form KEYWORD=**value**. For example,

```
"UID=DBA;PWD=SQL;DBF=c:\\db\\mydatabase.db"
```

For an available list of connection parameters, see "Connection parameters" on page 164 of the book *ASA Database Administration Guide*.

Description Provides extra functionality beyond the embedded SQL CONNECT command. This function carries out a connection using the algorithm described in "Troubleshooting connections" on page 73 of the book *ASA Database Administration Guide*.

The return value is true (non-zero) if a connection was successfully established and false (zero) otherwise. Error information for starting the server, starting the database, or connecting is returned in the SQLCA.

db_string_disconnect function

Prototype unsigned int **db_string_disconnect(** SQLCA * *sqlca***,** char * *parms* **);**

Arguments

sqlca A pointer to a SQLCA structure. For information, see "The SQL Communication Area (SQLCA)" on page 188.

parms A NULL-terminated string containing a semi-colon-delimited list of parameter settings, each of the form KEYWORD=**value**. For example,

```
"UID=DBA;PWD=SQL;DBF=c:\\db\\mydatabase.db"
```

For an available list of connection parameters, see "Connection parameters" on page 164 of the book *ASA Database Administration Guide*.

Description This function disconnects the connection identified by the **ConnectionName** parameter. All other parameters are ignored.

If no **ConnectionName** parameter is specified in the string, the unnamed connection is disconnected. This is equivalent to the embedded SQL DISCONNECT command. The Boolean return value is true if a connection was successfully ended. Error information is returned in the SQLCA.

This function shuts down the database if it was started with the **AutoStop**=**yes** parameter and there are no other connections to the database. It also stops the server if it was started with the **AutoStop**=**yes** parameter and there are no other databases running.

db_string_ping_server function

Prototype

unsigned int **db_string_ping_server(**
SQLCA * *sqlca***,**
char * *connect_string***,**
unsigned int *connect_to_db* **);**

Description

The *connect_string* is a normal connect string that may or may not contain server and database information.

If *connect_to_db* is non-zero (true), then the function attempts to connect to a database on a server. It returns a non-zero (true) value only if the connect string is sufficient to connect to the named database on the named server.

If *connect_to_db* is zero, then the function only attempts to locate a server. It returns a non-zero value only if the connect string is sufficient to locate a server. It makes no attempt to connect to the database.

fill_s_sqlda function

Prototype

struct sqlda * **fill_s_sqlda(**
struct sqlda * *sqlda***,**
unsigned int *maxlen* **);**

Description

The same as **fill_sqlda,** except that it changes all the data types in *sqlda* to type DT_STRING. Enough space is allocated to hold the string representation of the type originally specified by the SQLDA, up to a maximum of *maxlen* bytes. The length fields in the SQLDA (**sqllen**) are modified appropriately. Returns *sqlda* if successful and returns the null pointer if there is not enough memory available.

fill_sqlda function

Prototype

struct sqlda * **fill_sqlda(** struct sqlda * *sqlda* **);**

Description

Allocates space for each variable described in each descriptor of *sqlda*, and assigns the address of this memory to the **sqldata** field of the corresponding descriptor. Enough space is allocated for the database type and length indicated in the descriptor. Returns *sqlda* if successful and returns the null pointer if there is not enough memory available.

free_filled_sqlda function

Prototype void **free_filled_sqlda(** struct sqlda * *sqlda* **);**

Description Free the memory allocated to each **sqldata** pointer and the space allocated for the SQLDA itself. Any null pointer is not freed.

Calling this function causes **free_sqlda** to be called automatically, and so any descriptors allocated by **alloc_sqlda** are freed.

free_sqlda function

Prototype void **free_sqlda(** struct sqlda * *sqlda* **);**

Description Free space allocated to this *sqlda* and free the indicator variable space, as allocated in **fill_sqlda**. Do not free the memory referenced by each **sqldata** pointer.

free_sqlda_noind function

Prototype void **free_sqlda_noind(** struct sqlda * *sqlda* **);**

Description Free space allocated to this *sqlda*. Do not free the memory referenced by each **sqldata** pointer. The indicator variable pointers are ignored.

"Database properties" on page 618 of the book *ASA Database Administration Guide*
"The Ping utility" on page 494 of the book *ASA Database Administration Guide*

sql_needs_quotes function

Prototype unsigned int **sql_needs_quotes(** SQLCA **sqlca*,* char **str* **);**

Description Returns a Boolean value that indicates whether the string requires double quotes around it when it is used as a SQL identifier. This function formulates a request to the database server to determine if quotes are needed. Relevant information is stored in the **sqlcode** field.

There are three cases of return value/code combinations:

- **return = FALSE, sqlcode = 0** In this case, the string definitely does not need quotes.
- **return = TRUE** In this case, sqlcode is always SQLE_WARNING, and the string definitely does need quotes.

- **return = FALSE** If sqlcode is something other than SQLE_WARNING, the test is inconclusive.

sqlda_storage function

Prototype unsigned long **sqlda_storage(** struct sqlda *_sqlda_**,** int _varno_ **);**

Description Returns the amount of storage required to store any value for the variable described in **sqlda->sqlvar[varno]**.

sqlda_string_length function

Prototype unsigned long **sqlda_string_length(** SQLDA *_sqlda_**,** int _varno_ **);**

Description Returns the length of the C string (type DT_STRING) that would be required to hold the variable **sqlda->sqlvar[varno]** (no matter what its type is).

sqlerror_message function

Prototype char ***sqlerror_message(** SQLCA *_sqlca_**,** char * _buffer_**,** int _max_ **);**

Description Return a pointer to a string that contains an error message. The error message contains text for the error code in the SQLCA. If no error was indicated, a null pointer is returned. The error message is placed in the buffer supplied, truncated to length *max* if necessary.

Embedded SQL command summary

EXEC SQL
ALL embedded SQL statements must be preceded with EXEC SQL and end with a semicolon (;).

There are two groups of embedded SQL commands. Standard SQL commands are used by simply placing them in a C program enclosed with EXEC SQL and a semi-colon (;). CONNECT, DELETE, SELECT, SET, and UPDATE have additional formats only available in embedded SQL. The additional formats fall into the second category of embedded SQL specific commands.

For descriptions of the standard SQL commands, see "SQL Statements" on page 199 of the book *ASA SQL Reference Manual*.

Several SQL commands are specific to embedded SQL and can only be used in a C program.

For more information about these embedded SQL commands, see "SQL Language Elements" on page 3 of the book *ASA SQL Reference Manual*.

Standard data manipulation and data definition statements can be used from embedded SQL applications. In addition the following statements are specifically for embedded SQL programming:

- **ALLOCATE DESCRIPTOR** allocate memory for a descriptor

  See "ALLOCATE DESCRIPTOR statement [ESQL]" on page 203 of the book *ASA SQL Reference Manual*

- **CLOSE** close a cursor

  See "CLOSE statement [ESQL] [SP]" on page 261 of the book *ASA SQL Reference Manual*

- **CONNECT** connect to the database

  See "CONNECT statement [ESQL] [Interactive SQL]" on page 268 of the book *ASA SQL Reference Manual*

- **DEALLOCATE DESCRIPTOR** reclaim memory for a descriptor

  See "DEALLOCATE DESCRIPTOR statement [ESQL]" on page 376 of the book *ASA SQL Reference Manual*

- **Declaration Section** declare host variables for database communication

See "Declaration section [ESQL]" on page 377 of the book *ASA SQL Reference Manual*

- **DECLARE CURSOR** declare a cursor

  See "DECLARE CURSOR statement [ESQL] [SP]" on page 379 of the book *ASA SQL Reference Manual*

- **DELETE (positioned)** delete the row at the current position in a cursor

  See "DELETE (positioned) statement [ESQL] [SP]" on page 390 of the book *ASA SQL Reference Manual*

- **DESCRIBE** describe the host variables for a particular SQL statement

  See "DESCRIBE statement [ESQL]" on page 392 of the book *ASA SQL Reference Manual*

- **DISCONNECT** disconnect from database server

  See "DISCONNECT statement [ESQL] [Interactive SQL]" on page 396 of the book *ASA SQL Reference Manual*

- **DROP STATEMENT** free resources used by a prepared statement

  See "DROP STATEMENT statement [ESQL]" on page 405 of the book *ASA SQL Reference Manual*

- **EXECUTE** execute a particular SQL statement

  See "EXECUTE statement [ESQL]" on page 414 of the book *ASA SQL Reference Manual*

- **EXPLAIN** explain the optimization strategy for a particular cursor

  See "EXPLAIN statement [ESQL]" on page 422 of the book *ASA SQL Reference Manual*

- **FETCH** fetch a row from a cursor

  See "FETCH statement [ESQL] [SP]" on page 424 of the book *ASA SQL Reference Manual*

- **GET DATA** fetch long values from a cursor

  See "GET DATA statement [ESQL]" on page 437 of the book *ASA SQL Reference Manual*

- **GET DESCRIPTOR** retrieve information about a variable in a SQLDA.

  See "GET DESCRIPTOR statement [ESQL]" on page 439 of the book *ASA SQL Reference Manual*

- **GET OPTION** get the setting for a particular database option

See "GET OPTION statement [ESQL]" on page 441 of the book *ASA SQL Reference Manual*

- **INCLUDE** include a file for SQL preprocessing

  See "INCLUDE statement [ESQL]" on page 458 of the book *ASA SQL Reference Manual*

- **OPEN** open a cursor

  See "OPEN statement [ESQL] [SP]" on page 485 of the book *ASA SQL Reference Manual*

- **PREPARE** prepare a particular SQL statement

  See "PREPARE statement [ESQL]" on page 495 of the book *ASA SQL Reference Manual*

- **PUT** insert a row into a cursor

  See "PUT statement [ESQL]" on page 499 of the book *ASA SQL Reference Manual*

- **SET CONNECTION** change active connection

  See "SET CONNECTION statement [Interactive SQL] [ESQL]" on page 536 of the book *ASA SQL Reference Manual*

- **SET DESCRIPTOR** describe the variables in a SQLDA and place data into the SQLDA

  See "SET DESCRIPTOR statement [ESQL]" on page 537 of the book *ASA SQL Reference Manual*

- **SET SQLCA** use an SQLCA other than the default global one

  See "SET SQLCA statement [ESQL]" on page 545 of the book *ASA SQL Reference Manual*

- **UPDATE (positioned)** update the row at the current location of a cursor

  See "UPDATE (positioned) statement [ESQL] [SP]" on page 580 of the book *ASA SQL Reference Manual*

- **WHENEVER** specify actions to occur on errors in SQL statements

  See "WHENEVER statement [ESQL]" on page 589 of the book *ASA SQL Reference Manual*

CHAPTER 7

ODBC Programming

About this chapter

This chapter presents information for developing applications that call the ODBC programming interface directly.

The primary documentation for ODBC application development is the Microsoft ODBC SDK documentation, available as part of the Microsoft Data Access Components (MDAC) SDK. This chapter provides introductory material and describes features specific to Adaptive Server Anywhere, but is not an exhaustive guide to ODBC application programming.

Some application development tools that already have ODBC support provide their own programming interface that hides the ODBC interface. This chapter is not intended for users of those tools.

Contents

Introduction to ODBC

The **Open Database Connectivity** (**ODBC**) interface is an application programming interface defined by Microsoft Corporation as a standard interface to database-management systems on Windows operating systems. ODBC is a call-based interface.

To write ODBC applications for Adaptive Server Anywhere, you need:

- Adaptive Server Anywhere.
- A C compiler capable of creating programs for your environment.
- Microsoft ODBC Software Development Kit. This is available on the Microsoft Developer Network, and provides documentation and additional tools for testing ODBC applications.

Supported platforms

Adaptive Server Anywhere supports the ODBC API on UNIX and Windows CE, in addition to Windows. Having multi-platform ODBC support makes portable database application development much easier.

For information on enlisting the ODBC driver in distributed transactions, see "Three-tier Computing and Distributed Transactions" on page 361.

ODBC conformance

Adaptive Server Anywhere provides support for ODBC 3.52.

Levels of ODBC support

ODBC features are arranged according to level of conformance. Features are either **Core**, **Level 1**, or **Level 2**, with Level 2 being the most complete level of ODBC support. These features are listed in the *ODBC Programmer's Reference*, which is available from Microsoft Corporation as part of the ODBC software development kit or from the Microsoft Web site, at http://msdn.microsoft.com/library/default.asp?url=/library/en-us/odbc/htm/odbcabout_this_manual.asp.

Features supported by Adaptive Server Anywhere

Adaptive Server Anywhere supports the ODBC 3.52 specification.

- **Core conformance** Adaptive Server Anywhere supports all Core level features.
- **Level 1 conformance** Adaptive Server Anywhere supports all Level 1 features, except for asynchronous execution of ODBC functions.

  Adaptive Server Anywhere supports multiple threads sharing a single connection. The requests from the different threads are serialized by Adaptive Server Anywhere.

- **Level 2 conformance** Adaptive Server Anywhere supports all Level 2 features, except for the following:
  - Three part names of tables and views. This is not applicable for Adaptive Server Anywhere.
  - Asynchronous execution of ODBC functions for specified individual statements.
  - Ability to time out login request and SQL queries.

ODBC backwards compatibility

Applications developed using older versions of ODBC continue to work with Adaptive Server Anywhere and the newer ODBC Driver Manager. The new ODBC features are not provided for older applications.

The ODBC Driver Manager

The ODBC Driver Manager is part of the ODBC software supplied with Adaptive Server Anywhere. The ODBC Version 3 Driver Manager has a new interface for configuring ODBC data sources.

Building ODBC applications

This section describes how to compile and link simple ODBC applications.

Including the ODBC header file

Every C source file that calls ODBC functions must include a platform-specific ODBC header file. Each platform-specific header file includes the main ODBC header file *odbc.h*, which defines all the functions, data types and constant definitions required to write an ODBC program.

❖ **To include the ODBC header file in a C source file:**

1. Add an include line referencing the appropriate platform-specific header file to your source file. The lines to use are as follows:

Operating system	Include line
Windows	`#include "ntodbc.h"`
UNIX	`#include "unixodbc.h"`
Windows CE	`#include "ntodbc.h"`

2. Add the directory containing the header file to the include path for your compiler.

   Both the platform-specific header files and *odbc.h* are installed in the *h* subdirectory of your SQL Anywhere directory.

Linking ODBC applications on Windows

This section does not apply to Windows CE. For more information see "Linking ODBC applications on Windows CE" on page 255.

When linking your application, you must link against the appropriate import library file to have access to the ODBC functions. The import library defines entry points for the ODBC Driver Manager *odbc32.dll*. The Driver Manager in turn loads the Adaptive Server Anywhere ODBC driver *dbodbc8.dll*.

Separate import libraries are supplied for Microsoft, Watcom, and Borland compilers.

❖ **To link an ODBC application (Windows):**

♦ Add the directory containing the platform-specific import library to the list of library directories.

The import libraries are stored in the *lib* subdirectory of the directory containing your Adaptive Server Anywhere executables and are named as follows:

Operating system	Compiler	Import library
Windows	Microsoft	*odbc32.lib*
Windows	Watcom C/C++	*wodbc32.lib*
Windows	Borland	*bodbc32.lib*
Windows CE	Microsoft	*dbodbc8.lib*

Linking ODBC applications on Windows CE

On Windows CE operating systems there is no ODBC Driver Manager. The import library (*dbodbc8.lib*) defines entry points directly into the Adaptive Server Anywhere ODBC driver *dbodbc8.dll.*

Separate versions of this DLL are provided for the different chips on which Windows CE is available. The files are in operating-system specific subdirectories of the *ce* directory in your SQL Anywhere directory. For example, the ODBC driver for Windows CE on the SH3 chip is in the following location:

```
C:\Program Files\Sybase\SQL Anywhere 8\ce\SH3
```

☞ For a list of supported versions of Windows CE, see "Adaptive Server Anywhere supported operating systems" on page 138 of the book *Introducing SQL Anywhere Studio*.

❖ **To link an ODBC application (Windows CE):**

1 Add the directory containing the platform-specific import library to the list of library directories.

The import library is named *dbodbc8.lib* and is stored in an operating-system specific location under the *ce* directory in your SQL Anywhere directory. For example, the import library for Windows CE on the SH3 chip is in the following location:

```
C:\Program Files\Sybase\SQL Anywhere 8\ce\SH3\lib
```

2 Specify the **DRIVER=** parameter in the connection string supplied to the **SQLDriverConnect** function.

```
szConnStrIn =
"driver=ospath\dbodbc8.dll;dbf=c:\asademo.db"
```

where *ospath* is the full path to the chip-specific subdirectory of your SQL Anywhere directory on the Windows CE device. For example:

```
\Program Files\Sybase\SQL Anywhere 8\ce\SH3\lib
```

The sample program (*odbc.c*) uses a File data source (FileDSN connection parameter) called *ASA 8.0 Sample.dsn*. You can create File data sources on your desktop system from the ODBC Driver Manager and copy them to your Windows CE device.

Windows CE and Unicode

Adaptive Server Anywhere uses an encoding known as UTF-8, a multi-byte character encoding which can be used to encode Unicode.

The Adaptive Server Anywhere ODBC driver supports either ASCII (8-bit) strings or Unicode code (wide character) strings. The UNICODE macro controls whether ODBC functions expect ASCII or Unicode strings. If your application must be built with the UNICODE macro defined, but you want to use the ASCII ODBC functions, then the SQL_NOUNICODEMAP macro must also be defined.

The *Samples\ASA\C\odbc.c* sample file illustrates how to use the Unicode ODBC features.

Linking ODBC applications on UNIX

An ODBC Driver Manager is not included with Adaptive Server Anywhere, but there are third party Driver Managers available. This section describes how to build ODBC applications that do not use an ODBC Driver Manager.

ODBC driver

The ODBC driver is a shared object or shared library. Separate versions of the Adaptive Server Anywhere ODBC driver are supplied for single-threaded and multi-threaded applications.

The ODBC drivers are the following files:

Operating system	Threading model	ODBC driver
Solaris/Sparc	Single threaded	*dbodbc8.so* (*dbodbc8.so.1*)
Solaris/Sparc	Multi-threaded	*dbodbc_r.so* (*dbodbc_r.so.1*)

The libraries are installed as symbolic links to the shared library with a version number (in parentheses).

❖ **To link an ODBC application (UNIX):**

1. Link your application directly against the appropriate ODBC driver.
2. When deploying your application, ensure that the appropriate ODBC driver is available in the user's library path.

Data source information

If Adaptive Server Anywhere does not detect the presence of an ODBC Driver Manager, it uses *~/.odbc.ini* for data source information.

Using an ODBC Driver Manager on UNIX

Third-party ODBC Driver Managers for UNIX are available. An ODBC Driver Manager includes the following files:

Operating system	Files
Solaris/Sparc	*libodbc.so* (*libodbc.so.1*)
	libodbcinst.so (*libodbcinst.so.1*)
Solaris/Sparc	*libodbc.so* (*libodbc.so.1*)
	libodbcinst.so (*libodbcinst.so.1*)

If your are deploying an application that requires an ODBC Driver Manager and you are not using a third-party Driver Manager, create symbolic links for both the *libodbc* and *libodbcinst* shared libraries to the Adaptive Server Anywhere ODBC driver.

If an ODBC Driver Manager is present, Adaptive Server Anywhere queries the Driver Manager rather than *~/.odbc.ini* for data source information.

Standard ODBC applications do not link directly against the ODBC driver. Instead, ODBC function calls go through the ODBC Driver Manager. On UNIX and Windows CE operating systems, Adaptive Server Anywhere does not include an ODBC Driver Manager. You can still create ODBC applications by linking directly against the Adaptive Server Anywhere ODBC driver, but you can then access only Adaptive Server Anywhere data sources.

ODBC samples

Several ODBC samples are included with Adaptive Server Anywhere. You can find the samples in the *Samples\ASA* subdirectory of your SQL Anywhere directory. By default, this is

```
C:\Program Files\Sybase\SQL Anywhere 8\Samples\ASA
```

The samples in directories starting with *ODBC* illustrate separate and simple ODBC tasks, such as connecting to a database and executing statements. A complete sample ODBC program is supplied as *Samples\ASA\C\odbc.c*. The program performs the same actions as the embedded SQL dynamic cursor example program that is in the same directory.

For a description of the associated embedded SQL program, see "Sample embedded SQL programs" on page 171.

Building the sample ODBC program

The ODBC sample program in *Samples\ASA\C* includes a batch file (shell script for UNIX) that can be used to compile and link the sample application.

❖ **To build the sample ODBC program:**

1. Open a command prompt and change directory to the *Samples\ASA\C* subdirectory of your SQL Anywhere directory.
2. Run the *makeall* batch file or shell script

   The format of the command is as follows:

   ```
   makeall api platform compiler
   ```

   The parameters are as follows:

   - *API* Specify **odbc** to compile the ODBC example rather than an embedded SQL version of the application.
   - *Platform* Specify **WINNT** to compile for Windows operating systems.
   - *Compiler* Specify the compiler to use to compile the program. The compiler can be one of the following:
     - **WC** use Watcom C/C++
     - **MC** use Microsoft Visual C++
     - **BC** use Borland C++ Builder

Running the sample ODBC program

The sample program *odbc.c*, when compiled for versions of Windows that support services, runs optionally as a service.

The two files containing the example code for Windows services are the source file *ntsvc.c* and the header file *ntsvc.h*. The code allows the linked executable to be run either as a regular executable or as a Windows service.

❖ **To run the ODBC sample:**

1. Start the program:
   - Run the file *Samples\ASA\C\odbcwnt.exe*.
2. Choose a table:
   - Choose one of the tables in the sample database. For example, you may enter **Customer** or **Employee**.

❖ **To run the ODBC sample as a Windows service:**

1. Start Sybase Central and open the Services folder.
2. Click Add Service. Follow the instructions for adding the sample program as a service.
3. Right-click the service icon and click Start to start the service.

When run as a service, the program displays the normal user interface if possible. It also writes the output to the Application Event Log. If it is not possible to start the user interface, the program prints one page of data to the Application Event Log and stops.

ODBC handles

ODBC applications use a small set of **handles** to define basic features such as database connections and SQL statements. A handle is a 32-bit value.

The following handles are used in essentially all ODBC applications.

- **Environment** The environment handle provides a global context in which to access data. Every ODBC application must allocate exactly one environment handle upon starting, and must free it at the end.

  The following code illustrates how to allocate an environment handle:

  ```
  SQLHENV env;
  SQLRETURN rc;
  rc = SQLAllocHandle( SQL_HANDLE_ENV, SQL
     _NULL_HANDLE, &env );
  ```

- **Connection** A connection is specified by an ODBC driver and a data source. An application can have several connections associated with its environment. Allocating a connection handle does not establish a connection; a connection handle must be allocated first and then used when the connection is established.

  The following code illustrates how to allocate a connection handle:

  ```
  SQLHDBC  dbc;
  SQLRETURN rc;
  rc = SQLAllocHandle( SQL_HANDLE_DBC, env, &dbc );
  ```

- **Statement** A statement handle provides access to a SQL statement and any information associated with it, such as result sets and parameters. Each connection can have several statements. Statements are used both for cursor operations (fetching data) and for single statement execution (e.g. INSERT, UPDATE, and DELETE).

  The following code illustrates how to allocate a statement handle:

  ```
  SQLHSTMT stmt;
  SQLRETURN rc;
  rc = SQLAllocHandle( SQL_HANDLE_STMT, dbc, &stmt );
  ```

Allocating ODBC handles

The handle types required for ODBC programs are as follows:

Item	Handle type
Environment	SQLHENV
Connection	SQLHDBC
Statement	SQLHSTMT
Descriptor	SQLHDESC

❖ **To use an ODBC handle:**

1 Call the **SQLAllocHandle** function.

SQLAllocHandle takes the following parameters:

- an identifier for the type of item being allocated
- the handle of the parent item
- a pointer to the location of the handle to be allocated

For a full description, see SQLAllocHandle in the Microsoft *ODBC Programmer's Reference*.

2 Use the handle in subsequent function calls.

3 Free the object using **SQLFreeHandle**.

SQLFreeHandle takes the following parameters:

- an identifier for the type of item being freed
- the handle of the item being freed

For a full description, see SQLFreeHandle in the Microsoft ODBC Programmer's Reference.

Example

The following code fragment allocates and frees an environment handle:

```
SQLHENV env;
SQLRETURN retcode;
retcode = SQLAllocHandle( SQL_HANDLE_ENV, SQL_NULL_HANDLE, &env );
if( retcode == SQL_SUCCESS || retcode == SQL_SUCCESS_WITH_INFO ) {
  // success: application code here
}
SQLFreeHandle( SQL_HANDLE_ENV, env );
```

For more information on return codes and error handling, see "Handling errors" on page 278.

A first ODBC example

The following is a simple ODBC program that connects to the Adaptive Server Anywhere sample database and immediately disconnects.

You can find this sample as *Samples\ASA\ODBCConnect\odbcconnect.cpp* in your SQL Anywhere directory.

```
#include <stdio.h>
#include "ntodbc.h"

int main(int argc, char* argv[])
{
  SQLHENV  env;
  SQLHDBC  dbc;
  SQLRETURN retcode;

  retcode = SQLAllocHandle( SQL_HANDLE_ENV, SQL_NULL_HANDLE, &env );
  if (retcode == SQL_SUCCESS || retcode == SQL_SUCCESS_WITH_INFO) {
    printf( "env allocated\n" );
    /* Set the ODBC version environment attribute */
    retcode = SQLSetEnvAttr( env, SQL_ATTR_ODBC_VERSION, (void*)SQL_OV_ODBC3, 0);
      retcode = SQLAllocHandle( SQL_HANDLE_DBC, env, &dbc );
      if (retcode == SQL_SUCCESS || retcode == SQL_SUCCESS_WITH_INFO) {
        printf( "dbc allocated\n" );
        retcode = SQLConnect( dbc,
          (SQLCHAR*) "ASA 8.0 Sample", SQL_NTS,
          (SQLCHAR* ) "DBA", SQL_NTS,
          (SQLCHAR*) "SQL", SQL_NTS );
        if (retcode == SQL_SUCCESS || retcode == SQL_SUCCESS_WITH_INFO) {
          printf( "Successfully connected\n" );
        }
        SQLDisconnect( dbc );
      }
      SQLFreeHandle( SQL_HANDLE_DBC, dbc );
    }
    SQLFreeHandle( SQL_HANDLE_ENV, env );
  return 0;
}
```

Connecting to a data source

This section describes how to use ODBC functions to establish a connection to an Adaptive Server Anywhere database.

Choosing an ODBC connection function

ODBC supplies a set of connection functions. Which one you use depends on how you expect your application to be deployed and used:

- **SQLConnect** The simplest connection function.

  SQLConnect takes a data source name and optional user ID and password. You may wish to use **SQLConnect** if you hard-code a data source name into your application.

  For more information, see SQLConnect in the Microsoft *ODBC Programmer's Reference*.

- **SQLDriverConnect** Connects to a data source using a connection string.

  SQLDriverConnect allows the application to use Adaptive Server Anywhere-specific connection information that is external to the data source. Also, you can use **SQLDriverConnect** to request that the Adaptive Server Anywhere driver prompt for connection information.

  SQLDriverConnect can also be used to connect without specifying a data source.

  For more information, see SQLDriverConnect in the Microsoft *ODBC Programmer's Reference*.

- **SQLBrowseConnect** Connects to a data source using a connection string, like **SQLDriverConnect**.

  SQLBrowseConnect allows your application to build its own dialog boxes to prompt for connection information and to browse for data sources used by a particular driver (in this case the Adaptive Server Anywhere driver).

  For more information, see SQLBrowseConnect in the Microsoft *ODBC Programmer's Reference*.

The examples in this chapter mainly use **SQLDriverConnect**.

For a complete list of connection parameters that can be used in connection strings, see "Connection parameters" on page 164 of the book *ASA Database Administration Guide*.

Establishing a connection

Your application must establish a connection before it can carry out any database operations.

❖ **To establish an ODBC connection:**

1 Allocate an ODBC environment.

For example:

```
SQLHENV   env;
SQLRETURN retcode;
retcode = SQLAllocHandle( SQL_HANDLE_ENV,
  SQL_NULL_HANDLE, &env );
```

2 Declare the ODBC version.

By declaring that the application follows ODBC version 3, SQLSTATE values and some other version-dependent features are set to the proper behavior. For example:

```
retcode = SQLSetEnvAttr( env,
  SQL_ATTR_ODBC_VERSION, (void*)SQL_OV_ODBC3, 0);
```

3 If necessary, assemble the data source or connection string.

Depending on your application, you may have a hard-coded data source or connection string, or you may store it externally for greater flexibility.

4 Allocate an ODBC connection item.

For example:

```
retcode = SQLAllocHandle( SQL_HANDLE_DBC, env, &dbc );
```

5 Set any connection attributes that must be set before connecting.

Some connection attributes must be set before establishing a connection, while others can be set either before or after. For example:

```
retcode = SQLSetConnectAttr( dbc,
   SQL_AUTOCOMMIT, (SQLPOINTER)SQL_AUTOCOMMIT_OFF, 0 );
```

For more information, see "Setting connection attributes" on page 265.

6 Call the ODBC connection function.

For example:

```
if (retcode == SQL_SUCCESS || retcode ==
SQL_SUCCESS_WITH_INFO) {
   printf( "dbc allocated\n" );
   retcode = SQLConnect( dbc,
      (SQLCHAR*) "ASA 8.0 Sample", SQL_NTS,
      (SQLCHAR* ) "DBA", SQL_NTS,
      (SQLCHAR*) "SQL", SQL_NTS );
   if (retcode == SQL_SUCCESS
         || retcode == SQL_SUCCESS_WITH_INFO){
   // successfully connected.
```

You can find a complete sample as *Samples\ASA\ODBCConnect\odbcconnect.cpp* in your SQL Anywhere directory.

Notes

- **SQL_NTS** Every string passed to ODBC has a corresponding length. If the length is unknown, you can pass SQL_NTS indicating that it is a **Null Terminated String** whose end is marked by the null character (\0).
- **SQLSetConnectAttr** By default, ODBC operates in auto-commit mode. This mode is turned off by setting SQL_AUTOCOMMIT to false.

  For more information, see "Setting connection attributes" on page 265.

Setting connection attributes

You use the SQLSetConnectAttr function to control details of the connection. For example, the following statement turns off ODBC autocommit behavior.

```
retcode = SQLSetConnectAttr( dbc, SQL_AUTOCOMMIT,
   (SQLPOINTER)SQL_AUTOCOMMIT_OFF, 0 );
```

For more information including a list of connection attributes, see SQLSetConnectAttr in the Microsoft *ODBC Programmer's Reference* .

Many aspects of the connection can be controlled through the connection parameters. For information, see "Connection parameters" on page 70 of the book *ASA Database Administration Guide*.

Threads and connections in ODBC applications

You can develop multi-threaded ODBC applications for Adaptive Server Anywhere. It is recommended that you use a separate connection for each thread.

You can use a single connection for multiple threads. However, the database server does not allow more than one active request for any one connection at a time. If one thread executes a statement that takes a long time, all other threads must wait until the request is complete.

Executing SQL statements

ODBC includes several functions for executing SQL statements:

- **Direct execution** Adaptive Server Anywhere parses the SQL statement, prepares an access plan, and executes the statement. Parsing and access plan preparation are called **preparing** the statement.
- **Prepared execution** The statement preparation is carried out separately from the execution. For statements that are to be executed repeatedly, this avoids repeated preparation and so improves performance.

  See "Executing prepared statements" on page 269.

Executing statements directly

The **SQLExecDirect** function prepares and executes a SQL statement. The statement may be optionally include parameters.

The following code fragment illustrates how to execute a statement without parameters. The **SQLExecDirect** function takes a statement handle, a SQL string, and a length or termination indicator, which in this case is a null-terminated string indicator.

The procedure described in this section is straightforward but inflexible. The application cannot take any input from the user to modify the statement. For a more flexible method of constructing statements, see "Executing statements with bound parameters" on page 268.

❖ **To execute a SQL statement in an ODBC application:**

1. Allocate a handle for the statement using **SQLAllocHandle**.

   For example, the following statement allocates a handle of type `SQL_HANDLE_STMT` with name `stmt`, on a connection with handle `dbc`:

   ```
   SQLAllocHandle( SQL_HANDLE_STMT, dbc, &stmt );
   ```

2. Call the SQLExecDirect function to execute the statement:

   For example, the following lines declare a statement and execute it. The declaration of `deletestmt` would usually occur at the beginning of the function:

   ```
   SQLCHAR deletestmt[ STMT_LEN ] =
     "DELETE FROM department WHERE dept_id = 201";
   SQLExecDirect( stmt, deletestmt, SQL_NTS) ;
   ```

For a complete sample with error checking, see *Samples\ASA\ODBCExecute\odbcexecute.cpp*.

For more information on **SQLExecDirect**, see SQLExecDirect in the Microsoft *ODBC Programmer's Reference*.

Executing statements with bound parameters

This section describes how to construct and execute a SQL statement, using bound parameters to set values for statement parameters at runtime.

❖ To execute a SQL statement with bound parameters in an ODBC application:

1 Allocate a handle for the statement using **SQLAllocHandle**.

For example, the following statement allocates a handle of type `SQL_HANDLE_STMT` with name `stmt`, on a connection with handle `dbc`:

```
SQLAllocHandle( SQL_HANDLE_STMT, dbc, &stmt );
```

2 Bind parameters for the statement using **SQLBindParameter**.

For example, the following lines declare variables to hold the values for the department ID, department name, and manager ID, as well as for the statement string itself. They then bind parameters to the first, second, and third parameters of a statement executed using the **stmt** statement handle.

```
#defined DEPT_NAME_LEN 20
SQLINTEGER cbDeptID = 0,
   cbDeptName = SQL_NTS, cbManagerID = 0;
SQLCHAR deptname[ DEPT_NAME_LEN ];
SQLSMALLINT deptID, managerID;
SQLCHAR insertstmt[ STMT_LEN ] =
  "INSERT INTO department "
  "( dept_id, dept_name, dept_head_id )"
  "VALUES (?, ?, ?,)";
SQLBindParameter( stmt, 1, SQL_PARAM_INPUT,
    SQL_C_SSHORT, SQL_INTEGER, 0, 0,
    &deptID, 0, &cbDeptID);
SQLBindParameter( stmt, 2, SQL_PARAM_INPUT,
    SQL_C_CHAR, SQL_CHAR, DEPT_NAME_LEN, 0,
    deptname, 0,&cbDeptName);
SQLBindParameter( stmt, 3, SQL_PARAM_INPUT,
    SQL_C_SSHORT, SQL_INTEGER, 0, 0,
    &managerID, 0, &cbManagerID);
```

3 Assign values to the parameters.

For example, the following lines assign values to the parameters for the fragment of step 2.

```
deptID = 201;
strcpy( (char * ) deptname, "Sales East" );
managerID = 902;
```

Commonly, these variables would be set in response to user action.

4 Execute the statement using **SQLExecDirect**.

For example, the following line executes the statement string held in `insertstmt` on the statement handle `stmt`.

```
SQLExecDirect( stmt, insertstmt, SQL_NTS) ;
```

Bind parameters are also used with prepared statements to provide performance benefits for statements that are executed more than once. For more information, see "Executing prepared statements" on page 269

☞ The above code fragments to not include error checking. For a complete sample, including error checking, see *Samples\ASA\ODBCExecute\odbcexecute.cpp*.

☞ For more information on **SQLExecDirect**, see SQLExecDirect in the Microsoft *ODBC Programmer's Reference*.

Executing prepared statements

Prepared statements provide performance advantages for statements that are used repeatedly. ODBC provides a full set of functions for using prepared statements.

☞ For an introduction to prepared statements, see "Preparing statements" on page 12.

❖ To execute a prepared SQL statement:

1 Prepare the statement using **SQLPrepare**.

For example, the following code fragment illustrates how to prepare an INSERT statement:

```
SQLRETURN   retcode;
SQLHSTMT    stmt;
retcode = SQLPrepare( stmt,
            "INSERT INTO department
             ( dept_id, dept_name, dept_head_id )
             VALUES (?, ?, ?,)",
           SQL_NTS);
```

In this example:

- **retcode** Holds a return code that should be tested for success or failure of the operation.
- **stmt** Provides a handle to the statement so that it can be referenced later.
- **?** The question marks are placeholders for statement parameters.

2 Set statement parameter values using **SQLBindParameter**.

For example, the following function call sets the value of the *dept_id* variable:

```
SQLBindParameter( stmt,
                  1,
                  SQL_PARAM_INPUT,
                  SQL_C_SSHORT,
                  SQL_INTEGER,
                  0,
                  0,
                  &sDeptID,
                  0,
                  &cbDeptID);
```

In this example:

- **stmt** is the statement handle
- **1** indicates that this call sets the value of the first placeholder.
- **SQL_PARAM_INPUT** indicates that the parameter is an input statement.
- **SQL_C_SHORT** indicates the C data type being used in the application.
- **SQL_INTEGER** indicates SQL data type being used in the database.
- The next two parameters indicate the column precision and the number of decimal digits: both zero for integers.
- **&sDeptID** is a pointer to a buffer for the parameter value.
- **0** indicates the length of the buffer, in bytes.
- **&cbDeptID** is a pointer to a buffer for the length of the parameter value.

3 Bind the other two parameters and assign values to **sDeptId**.

4 Execute the statement:

```
retcode = SQLExecute( stmt);
```

Steps 2 to 4 can be carried out multiple times.

5 Drop the statement.

Dropping the statement frees resources associated with the statement itself. You drop statements using **SQLFreeHandle**.

For a complete sample, including error checking, see *Samples\ASA\ODBCPrepare\odbcprepare.cpp*.

For more information on **SQLPrepare**, see SQLPrepare in the Microsoft *ODBC Programmer's Reference*.

Working with result sets

ODBC applications use cursors to manipulate and update result sets. Adaptive Server Anywhere provides extensive support for different kinds of cursors and cursor operations.

For an introduction to cursors, see "Working with cursors" on page 19.

Choosing a cursor characteristics

ODBC functions that execute statements and manipulate result sets use cursors to carry out their tasks. Applications open a cursor implicitly whenever they execute a **SQLExecute** or **SQLExecDirect** function.

For applications that move through a result set only in a forward direction and do not update the result set, cursor behavior is relatively straightforward. By default, ODBC applications request this behavior. ODBC defines a read-only, forward-only cursor, and Adaptive Server Anywhere provides a cursor optimized for performance in this case.

For a simple example of a forward-only cursor, see "Retrieving data" on page 273.

For applications that need to scroll both forward and backward through a result set, such as many graphical user interface applications, cursor behavior is more complex. What does the application when it returns to a row that has been updated by some other application? ODBC defines a variety of **scrollable cursors** to allow you to build in the behavior that suits your application. Adaptive Server Anywhere provides a full set of cursors to match the ODBC scrollable cursor types.

You set the required ODBC cursor characteristics by calling the **SQLSetStmtAttr** function that defines statement attributes. You must call **SQLSetStmtAttr** before executing a statement that creates a result set.

You can use SQLSetStmtAttr to set many cursor characteristics. The characteristics that determine the cursor type that Adaptive Server Anywhere supplies include the following:

- **SQL_ATTR_CURSOR_SCROLLABLE** Set to SQL_SCROLLABLE for a scrollable cursor and SQL_NONSCROLLABLE for a forward-only cursor. SQL_NONSCROLLABLE is the default.
- **SQL_ATTR_CONCURRENCY** Set to one of the following values:
  - **SQL_CONCUR_READ_ONLY** Disallow updates. SQL_CONCUR_READ_ONLY is the default.

- **SQL_CONCUR_LOCK** Use the lowest level of locking sufficient to ensure that the row can be updated.
- **SQL_CONCUR_ROWVER** Use optimistic concurrency control, comparing row versions such as SQLBase ROWID or Sybase TIMESTAMP.
- **SQL_CONCUR_VALUES** Use optimistic concurrency control, comparing values.

For more information, see SQLSetStmtAttr in the Microsoft *ODBC Programmer's Reference*.

Example

The following fragment requests a read-only, scrollable cursor:

```
SQLAllocHandle( SQL_HANDLE_STMT, dbc, &stmt );
SQLSetStmtAttr( stmt, SQL_ATTR_CURSOR_SCROLLABLE,
      SQL_SCROLLABLE, 0 );
```

Retrieving data

To retrieve rows from a database, you execute a SELECT statement using SQLExecute or SQLExecDirect. This opens a cursor on the statement. You then use **SQLFetch** or **SQLExtendedFetch** to fetch rows through the cursor. When an application free the statement using **SQLFreeHandle** it closes the cursor.

To fetch values from a cursor, your application can use either **SQLBindCol** or **SQLGetData**. If you use **SQLBindCol**, values are automatically retrieved on each fetch. If you use **SQLGetData**, you must call it for each column after each fetch.

SQLGetData is used to fetch values in pieces for columns such as LONG VARCHAR or LONG BINARY. As an alternative, you can set the SQL_MAX_LENGTH statement attribute to a value large enough to hold the entire value for the column. The default value for SQL_ATTR_MAX_LENGTH is 256 kb.

The following code fragment opens a cursor on a query and retrieves data through the cursor. Error checking has been omitted to make the example easier to read. The fragment is taken from a complete sample, which can be found at *Samples\ASA\ODBCSelect\odbcselect.cpp*.

```
SQLINTEGER      cbDeptID = 0, cbDeptName = SQL_NTS, cbManagerID = 0;
SQLCHAR deptname[ DEPT_NAME_LEN ];
SQLSMALLINT deptID, managerID;
SQLHENV      env;
SQLHDBC      dbc;
SQLHSTMT stmt;
SQLRETURN retcode;

SQLAllocHandle( SQL_HANDLE_ENV, SQL_NULL_HANDLE, &env );
SQLSetEnvAttr( env, SQL_ATTR_ODBC_VERSION, (void*)SQL_OV_ODBC3, 0);
SQLAllocHandle( SQL_HANDLE_DBC, env, &dbc );
SQLConnect( dbc,
                        (SQLCHAR*) "ASA 8.0 Sample", SQL_NTS,
                        (SQLCHAR*) "DBA", SQL_NTS,
                        (SQLCHAR*) "SQL", SQL_NTS );
SQLAllocHandle( SQL_HANDLE_STMT, dbc, &stmt );
SQLBindCol( stmt, 1, SQL_C_SSHORT, &deptID, 0, &cbDeptID);
SQLBindCol( stmt, 2, SQL_C_CHAR, deptname, sizeof(deptname),
&cbDeptName);
SQLBindCol( stmt, 3, SQL_C_SSHORT, &managerID, 0, &cbManagerID);

SQLExecDirect( stmt, (SQLCHAR * )
"SELECT dept_id, dept_name, dept_head_id FROM DEPARTMENT "
                            "ORDER BY dept_id", SQL_NTS );
while( ( retcode = SQLFetch( stmt ) ) != SQL_NO_DATA ){
             printf( "%d %20s %d\n", deptID, deptname, managerID );
}
SQLFreeHandle( SQL_HANDLE_STMT, stmt );
SQLDisconnect( dbc );
SQLFreeHandle( SQL_HANDLE_DBC, dbc );
SQLFreeHandle( SQL_HANDLE_ENV, env );
```

The number of row positions you can fetch in a cursor is governed by the size of an integer. You can fetch rows numbered up to number 2147483646, which is one less than the value that can be held in an integer. When using negative numbers (rows from the end) you can fetch down to one more than the largest negative value that can be held in an integer.

Updating and deleting rows through a cursor

The Microsoft ODBC Programmer's Reference suggests that you use SELECT... FOR UPDATE to indicate that a query is updateable using positioned operations. You do not need to use the FOR UPDATE clause in Adaptive Server Anywhere: SELECT statements are automatically updateable as long as the following conditions are met:

- The underlying query supports updates.

  That is to say, as long as a data modification statement on the columns in the result is meaningful, then positioned data modification statements can be carried out on the cursor.

The ANSI_UPDATE_CONSTRAINTS database option limits the type of queries that are updateable.

For more information, see "ANSI_UPDATE_CONSTRAINTS option" on page 552 of the book *ASA Database Administration Guide*.

- The cursor type supports updates.

  If you are using a read-only cursor, you cannot update the result set.

ODBC provides two alternatives for carrying out positioned updates and deletes:

- Use the **SQLSetPos** function.

  Depending on the parameters supplied (SQL_POSITION, SQL_REFRESH, SQL_UPDATE, SQL_DELETE) **SQLSetPos** sets the cursor position and allows an application to refresh data, or update, or delete data in the result set.

  This is the method to use with Adaptive Server Anywhere.

- Send positioned UPDATE and DELETE statements using **SQLExecute**. This method should not be used with Adaptive Server Anywhere.

Using bookmarks

ODBC provides **bookmarks**, which are values used to identify rows in a cursor. Adaptive Server Anywhere supports bookmarks for all kinds of cursors except dynamic cursors.

Before ODBC 3.0, a database could specify only whether it supported bookmarks or not: there was no interface to provide this information for each cursor type. There was no way for a database server to indicate for what kind of cursor bookmarks were supported. For ODBC 2 applications, Adaptive Server Anywhere returns that it does support bookmarks. There is therefore nothing to prevent you from trying to use bookmarks with dynamic cursors; however, you should not use this combination.

Calling stored procedures

This section describes how to create and call stored procedures and process the results from an ODBC application.

☞ For a full description of stored procedures and triggers, see "Using Procedures, Triggers, and Batches" on page 507 of the book *ASA SQL User's Guide*.

Procedures and result sets

There are two types of procedures: those that return result sets and those that do not. You can use **SQLNumResultCols** to tell the difference: the number of result columns is zero if the procedure does not return a result set. If there is a result set, you can fetch the values using **SQLFetch** or **SQLExtendedFetch** just like any other cursor.

Parameters to procedures should be passed using parameter markers (question marks). Use **SQLBindParameter** to assign a storage area for each parameter marker, whether it is an INPUT, OUTPUT, or INOUT parameter.

To handle multiple result sets, ODBC must describe the currently executing cursor, not the procedure-defined result set. Therefore, ODBC does not always describe column names as defined in the RESULT clause of the stored procedure definition. To avoid this problem, you can use column aliases in your procedure result set cursor.

Example

This example creates and calls a procedure that does not return a result set. The procedure takes one INOUT parameter, and increments its value. In the example, the variable **num_col** will have the value zero, since the procedure does not return a result set. Error checking has been omitted to make the example easier to read.

```
HDBC dbc;
HSTMT stmt;
long i;
SWORD num_col;

/* Create a procedure */
SQLAllocStmt( dbc, &stmt );
SQLExecDirect( stmt,
       "CREATE PROCEDURE Increment( INOUT a INT )" \
       " BEGIN" \
          " SET a = a + 1" \
       " END", SQL_NTS );

/* Call the procedure to increment 'i' */
i = 1;
SQLBindParameter( stmt, 1, SQL_C_LONG, SQL_INTEGER, 0,
            0, &i, NULL );
SQLExecDirect( stmt, "CALL Increment( ? )",
```

```
                SQL_NTS );
    SQLNumResultCols( stmt, &num_col );
    do_something( i );
```

Example

This example calls a procedure that returns a result set. In the example, the variable **num_col** will have the value 2 since the procedure returns a result set with two columns. Again, error checking has been omitted to make the example easier to read.

```
HDBC dbc;
HSTMT stmt;
SWORD num_col;
RETCODE retcode;
char emp_id[ 10 ];
char emp_lame[ 20 ];

/* Create the procedure */
SQLExecDirect( stmt,
      "CREATE PROCEDURE employees()" \
      " RESULT( emp_id CHAR(10), emp_lname CHAR(20))"\
      " BEGIN" \
      " SELECT emp_id, emp_lame FROM employee" \
      " END", SQL_NTS );

/* Call the procedure - print the results */
SQLExecDirect( stmt, "CALL employees()", SQL_NTS );
SQLNumResultCols( stmt, &num_col );
SQLBindCol( stmt, 1, SQL_C_CHAR, &emp_id,
            sizeof(emp_id), NULL );
SQLBindCol( stmt, 2, SQL_C_CHAR, &emp_lname,
            sizeof(emp_lname), NULL );

for( ;; ) {
   retcode = SQLFetch( stmt );
   if( retcode == SQL_NO_DATA_FOUND ) {
      retcode = SQLMoreResults( stmt );
   if( retcode == SQL_NO_DATA_FOUND ) break;
}  else {
      do_something( emp_id, emp_lname );
   }
}
```

Handling errors

Errors in ODBC are reported using the return value from each of the ODBC function calls and either the **SQLError** function or the **SQLGetDiagRec** function. The **SQLError** function was used in ODBC versions up to, but not including, version 3. As of version 3 the **SQLError** function has been deprecated and replaced by the **SQLGetDiagRec** function.

Every ODBC function returns a **SQLRETURN**, which is one of the following status codes:

Status code	Description
SQL_SUCCESS	No error.
SQL_SUCCESS_WITH_INFO	The function completed, but a call to **SQLError** will indicate a warning. The most common case for this status is that a value being returned is too long for the buffer provided by the application.
SQL_ERROR	The function did not complete because of an error. Call **SQLError** to get more information on the problem.
SQL_INVALID_HANDLE	An invalid environment, connection, or statement handle was passed as a parameter. This often happens if a handle is used after it has been freed, or if the handle is the null pointer.
SQL_NO_DATA_FOUND	There is no information available. The most common use for this status is when fetching from a cursor; it indicates that there are no more rows in the cursor.
SQL_NEED_DATA	Data is needed for a parameter. This is an advanced feature described in the ODBC SDK documentation under **SQLParamData** and **SQLPutData**.

Every environment, connection, and statement handle can have one or more errors or warnings associated with it. Each call to **SQLError** or **SQLGetDiagRec** returns the information for one error and removes the information for that error. If you do not call **SQLError** or **SQLGetDiagRec** to remove all errors, the errors are removed on the next function call that passes the same handle as a parameter.

Each call to **SQLError** passes three handles for an environment, connection, and statement. The first call uses SQL_NULL_HSTMT to get the error associated with a connection. Similarly, a call with both SQL_NULL_DBC and SQL_NULL_HSTMT get any error associated with the environment handle.

Each call to **SQLGetDiagRec** can pass either an environment, connection or statement handle. The first call passes in a handle of type SQL_HANDLE_DBC to get the error associated with a connection. The second call passes in a handle of type SQL_HANDLE_STMT to get the error associated with the statement that was just executed.

SQLError and **SQLGetDiagRec** return SQL_SUCCESS if there is an error to report (*not* SQL_ERROR), and SQL_NO_DATA_FOUND if there are no more errors to report.

Example 1

The following code fragment uses **SQLError** and return codes:

```
/* Declare required variables */
SQLHDBC dbc;
SQLHSTMT stmt;
SQLRETURN retcode;
UCHAR errmsg[100];
/* code omitted here */
retcode = SQLAllocHandle(SQL_HANDLE_STMT, dbc, &stmt );
if( retcode == SQL_ERROR ){
   SQLError( env, dbc, SQL_NULL_HSTMT, NULL, NULL,
         errmsg, sizeof(errmsg), NULL );
   /* Assume that print_error is defined */
   print_error( "Allocation failed", errmsg );
   return;
}

/* Delete items for order 2015 */
retcode = SQLExecDirect( stmt,
       "delete from sales_order_items where id=2015",
       SQL_NTS );
if( retcode == SQL_ERROR ) {
   SQLError( env, dbc, stmt, NULL, NULL,
```

```
            errmsg, sizeof(errmsg), NULL );
   /* Assume that print_error is defined */
   print_error( "Failed to delete items", errmsg );
   return;
}
```

Example 2

The following code fragment uses **SQLGetDiagRec** and return codes:

```
/* Declare required variables */
SQLHDBC dbc;
SQLHSTMT stmt;
SQLRETURN retcode;
SQLSMALLINT errmsglen;
SQLINTEGER errnative;
UCHAR errmsg[255];
UCHAR errstate[5];
/* code omitted here */
retcode = SQLAllocHandle(SQL_HANDLE_STMT, dbc, &stmt );
if( retcode == SQL_ERROR ){
   SQLGetDiagRec(SQL_HANDLE_DBC, dbc, 1, errstate,
       &errnative, errmsg, sizeof(errmsg), &errmsglen);
    /* Assume that print_error is defined */
   print_error( "Allocation failed", errstate,
errnative, errmsg );
   return;

}
/* Delete items for order 2015 */
retcode = SQLExecDirect( stmt,
       "delete from sales_order_items where id=2015",
       SQL_NTS );
if( retcode == SQL_ERROR ) {
   SQLGetDiagRec(SQL_HANDLE_STMT, stmt, recnum,
errstate,
       &errnative, errmsg, sizeof(errmsg), &errmsglen);
```

```
   /* Assume that print_error is defined */
   print_error("Failed to delete items", errstate,
errnative, errmsg );
   return;
}
```

CHAPTER 8

The Database Tools Interface

About this chapter

This chapter describes how to use the database tools library that is provided with Adaptive Server Anywhere to add database management features to C or C++ applications.

Contents

Introduction to the database tools interface

Sybase Adaptive Server Anywhere includes Sybase Central and a set of utilities for managing databases. These database management utilities carry out tasks such as backing up databases, creating databases, translating transaction logs to SQL, and so on.

Supported platforms

All the database management utilities use a shared library called the database tools library. It is supplied for each of the Windows operating systems. The name of this library is *dbtool8.dll*.

You can develop your own database management utilities or incorporate database management features into your applications by calling the database tools library. This chapter describes the interface to the database tools library. In this chapter, we assume you are familiar with how to call DLLs from the development environment you are using.

The database tools library has functions, or entry points, for each of the database management utilities. In addition, functions must be called before use of other database tools functions and when you have finished using other database tools functions.

Windows CE

The *dbtool8.dll* library is supplied for Windows CE, but includes only entry points for DBToolsInit, DBToolsFini, DBRemoteSQL, and DBSynchronizeLog. Other tools are not provided for Windows CE.

The dbtools.h header file

The dbtools header file included with Adaptive Server Anywhere lists the entry points to the DBTools library and also the structures used to pass information to and from the library. The *dbtools.h* file is installed into the *h* subdirectory under your installation directory. You should consult the *dbtools.h* file for the latest information about the entry points and structure members.

The *dbtools.h* header file includes two other files:

- **sqlca.h** This is included for resolution of various macros, not for the SQLCA itself.
- **dllapi.h** Defines preprocessor macros for operating-system dependent and language-dependent macros.

Also, the *sqldef.h* header file includes error return values.

Using the database tools interface

This section provides an overview of how to develop applications that use the DBTools interface for managing databases.

Using the import libraries

In order to use the DBTools functions, you must link your application against a DBTools **import library** which contains the required function definitions.

Supported platforms

Import libraries are compiler-specific and are supplied for Windows operating systems with the exception of Windows CE. Import libraries for the DBTools interface are provided with Adaptive Server Anywhere, and can be found in the *lib* subdirectory of each operating system's directory, under your installation directory. The provided DBTools import libraries are as follows:

Compiler	Library
Watcom	*win32\dbtlstw.lib*
Microsoft	*win32\dbtlstM.lib*
Borland	*win32\dbtlstB.lib*

Starting and finishing the DBTools library

Before using any other DBTools functions, you must call DBToolsInit. When you are finished using the DBTools DLL, you must call DBToolsFini.

The primary purpose of the DBToolsInit and DBToolsFini functions is to allow the DBTools DLL to load the Adaptive Server Anywhere language DLL. The language DLL contains localized versions of all error messages and prompts that DBTools uses internally. If DBToolsFini is not called, the reference count of the language DLL is not decremented and it will not be unloaded, so be careful to ensure there is a matched pair of DBToolsInit/DBToolsFini calls.

The following code fragment illustrates how to initialize and clean up DBTools:

```
// Declarations
a_dbtools_info  info;
short           ret;
```

```
//Initialize the a_dbtools_info structure
memset( &info, 0, sizeof( a_dbtools_info) );
info.errorrtn = (MSG_CALLBACK)MyErrorRtn;

// initialize DBTools
ret = DBToolsInit( &info );
if( ret != EXIT_OKAY ) {
   // DLL initialization failed
   …
}
// call some DBTools routines . . .
…
// cleanup the DBTools dll
DBToolsFini( &info );
```

Calling the DBTools functions

All the tools are run by first filling out a structure, and then calling a function (or **entry point**) in the DBTools DLL. Each entry point takes a pointer to a single structure as argument.

The following example shows how to use the DBBackup function on a Windows operating system.

```
// Initialize the structure
a_backup_db backup_info;
memset( &backup_info, 0, sizeof( backup_info ) );

// Fill out the structure
backup_info.version = DB_TOOLS_VERSION_NUMBER;
backup_info.output_dir = "C:\BACKUP";
backup_info.connectparms
="uid=DBA;pwd=SQL;dbf=asademo.db";
backup_info.startline = "dbeng8.EXE";
backup_info.confirmrtn = (MSG_CALLBACK) ConfirmRtn ;
backup_info.errorrtn = (MSG_CALLBACK) ErrorRtn ;
backup_info.msgrtn = (MSG_CALLBACK) MessageRtn ;
backup_info.statusrtn = (MSG_CALLBACK) StatusRtn ;
backup_info.backup_database = TRUE;

// start the backup
DBBackup( &backup_info );
```

For information about the members of the DBTools structures, see "DBTools structures" on page 304.

Software component return codes

All database tools are provided as entry points in a DLL. These entry points use the following return codes:

Code	Explanation
0	Success
1	General failure
2	Invalid file format
3	File not found, unable to open
4	Out of memory
5	Terminated by the user
6	Failed communications
7	Missing a required database name
8	Client/server protocol mismatch
9	Unable to connect to the database server
10	Database server not running
11	Database server not found
254	Reached stop time
255	Invalid parameters on the command-line

Using callback functions

Several elements in DBTools structures are of type MSG_CALLBACK. These are pointers to callback functions.

Uses of callback functions

Callback functions allow DBTools functions to return control of operation to the user's calling application. The DBTools library uses callback functions to handle messages sent to the user by the DBTools functions for four purposes:

- **Confirmation** Called when an action needs to be confirmed by the user. For example, if the backup directory does not exist, the tools DLL asks if it needs to be created.
- **Error message** Called to handle a message when an error occurs, such as when an operation is out of disk space.
- **Information message** Called for the tools to display some message to the user (such as the name of the current table being backed up).

- **Status information** Called for the tools to display the status of an operation (such as the percentage done when unloading a table).

Assigning a callback function to a structure

You can directly assign a callback routine to the structure. The following statement is an example using a backup structure:

```
backup_info.errorrtn = (MSG_CALLBACK) MyFunction
```

MSG_CALLBACK is defined in the *dllapi.h* header file supplied with Adaptive Server Anywhere. Tools routines can call back to the Calling application with messages that should appear in the appropriate user interface, whether that be a windowing environment, standard output on a character-based system, or other user interface.

Confirmation callback function example

The following example confirmation routine asks the user to answer YES or NO to a prompt and returns the user's selection:

```
extern short _callback ConfirmRtn(
       char far * question )
{
   int ret;
   if( question != NULL ) {
      ret = MessageBox( HwndParent, question,
      "Confirm", MB_ICONEXCLAMTION|MB_YESNO );
   }
   return( 0 );
}
```

Error callback function example

The following is an example of an error message handling routine, which displays the error message in a message box.

```
extern short _callback ErrorRtn(
       char far * errorstr )
{
   if( errorstr != NULL ) {
      ret = MessageBox( HwndParent, errorstr,
      "Backup Error", MB_ICONSTOP|MB_OK );
   }
   return( 0 );
}
```

Message callback function example

A common implementation of a message callback function outputs the message to the screen:

```
extern short _callback MessageRtn(
       char far * errorstr )
{
   if( messagestr != NULL ) {
   OutputMessageToWindow( messagestr );
   }
   return( 0 );
}
```

Status callback function example

A status callback routine is called when the tools needs to display the status of an operation (like the percentage done unloading a table). Again, a common implementation would just output the message to the screen:

```
extern short _callback StatusRtn(
       char far * statusstr )
{
   if( statusstr == NULL ) {
      return FALSE;
   }
   OutputMessageToWindow( statustr );
   return TRUE;
}
```

Version numbers and compatibility

Each structure has a member that indicates the version number. You should use this version member to hold the version of the DBTools library that your application was developed against. The current version of the DBTools library is included as the constant in the *dbtools.h* header file.

❖ **To assign the current version number to a structure:**

- Assign the version constant to the version member of the structure before calling the DBTools function. The following line assigns the current version to a backup structure:

```
backup_info.version = DB_TOOLS_VERSION_NUMBER;
```

Compatibility

The version number allows your application to continue working against newer versions of the DBTools library. The DBTools functions use the version number supplied by your application to allow the application to work, even if new members have been added to the DBTools structure.

Applications will not work against older versions of the DBTools library.

Using bit fields

Many of the DBTools structures use bit fields to hold Boolean information in a compact manner. For example, the backup structure has the following bit fields:

```
a_bit_field     backup_database : 1;
a_bit_field     backup_logfile  : 1;
a_bit_field     backup_writefile: 1;
a_bit_field     no_confirm   : 1;
a_bit_field     quiet     : 1;
```

```
a_bit_field     rename_log   : 1;
a_bit_field     truncate_log : 1;
a_bit_field     rename_local_log: 1;
```

Each bit field is one bit long, indicated by the 1 to the right of the colon in the structure declaration. The specific data type used depends on the value assigned to **a_bit_field**, which is set at the top of *dbtools.h*, and is operating system-dependent.

You assign an integer value of 0 or 1 to a bit field to pass Boolean information to the structure.

A DBTools example

You can find this sample and instructions for compiling it in the *Samples\ASA\DBTools* subdirectory of your SQL Anywhere directory. The sample program itself is *Samples\ASA\DBTools\main.c*. The sample illustrates how to use the DBTools library to carry out a backup of a database.

```
# define WINNT

#include <stdio.h>
#include "windows.h"
#include "string.h"
#include "dbtools.h"

extern short _callback ConfirmCallBack(char far * str){
   if( MessageBox( NULL, str, "Backup",
       MB_YESNO|MB_ICONQUESTION ) == IDYES ) {
      return 1;
   }
   return 0;
}

extern short _callback MessageCallBack( char far * str){
   if( str != NULL ) {
      fprintf( stdout, "%s", str );
      fprintf( stdout, "\n" );
      fflush( stdout );
   }
   return 0;
}
```

```
extern short _callback StatusCallBack( char far * str ){
   if( str != NULL ) {
      fprintf( stdout, "%s", str );
      fprintf( stdout, "\n" );
      fflush( stdout );
   }
   return 0;
}

extern short _callback ErrorCallBack( char far * str ){
   if( str != NULL ) {
      fprintf( stdout, "%s", str );
      fprintf( stdout, "\n" );
      fflush( stdout );
   }
   return 0;
}

// Main entry point into the program.
int main( int argc, char * argv[] ){
   a_backup_db     backup_info;
   a_dbtools_info  dbtinfo;
   char         dir_name[ _MAX_PATH + 1];
   char         connect[ 256 ];
   HINSTANCE    hinst;
   FARPROC         dbbackup;
   FARPROC         dbtoolsinit;
   FARPROC         dbtoolsfini;

   // Always initialize to 0 so new versions
   //of the structure will be compatible.
   memset( &backup_info, 0, sizeof( a_backup_db ) );
   backup_info.version = DB_TOOLS_VERSION_8_0_00;
   backup_info.quiet = 0;
   backup_info.no_confirm = 0;
   backup_info.confirmrtn =
                        (MSG_CALLBACK)ConfirmCallBack;
   backup_info.errorrtn = (MSG_CALLBACK)ErrorCallBack;
   backup_info.msgrtn = (MSG_CALLBACK)MessageCallBack;
   backup_info.statusrtn = (MSG_CALLBACK)StatusCallBack;

   if( argc > 1 ) {
      strncpy( dir_name, argv[1], _MAX_PATH );
   } else {
      // DBTools does not expect (or like) the
      // trailing slash
      strcpy( dir_name, "c:\\temp" );
   }
   backup_info.output_dir = dir_name;
```

```
    if( argc > 2 ) {
       strncpy( connect, argv[2], 255 );
    } else {
       // Assume that the engine is already running.
       strcpy( connect, "DSN=ASA 8.0 Sample" );
    }
    backup_info.connectparms = connect;
    backup_info.startline = "";
    backup_info.quiet = 0;
    backup_info.no_confirm = 0;
    backup_info.backup_database = 1;
    backup_info.backup_logfile = 1;
    backup_info.backup_writefile = 1;
    backup_info.rename_log = 0;
    backup_info.truncate_log = 0;

    hinst = LoadLibrary( "dbtool8.dll" );
    if( hinst == NULL ) {
       // Failed
       return 0;
    }
    dbtinfo.errorrtn = (MSG_CALLBACK)ErrorCallBack;
    dbbackup = GetProcAddress( (HMODULE)hinst,
       "_DBBackup@4" );
    dbtoolsinit = GetProcAddress( (HMODULE)hinst,
       "_DBToolsInit@4" );
    dbtoolsfini = GetProcAddress( (HMODULE)hinst,
       "_DBToolsFini@4" );
    (*dbtoolsinit)( &dbtinfo );
    (*dbbackup)( &backup_info );
    (*dbtoolsfini)( &dbtinfo );
    FreeLibrary( hinst );
    return 0;
}
```

DBTools functions

This section describes the functions available in the DBTools library. The functions are listed alphabetically.

DBBackup function

Function Database backup function. This function is used by the *dbbackup* command-line utility.

Prototype short **DBBackup (** const a_backup_db * *backup-db* **);**

Parameters

Parameter	Description
backup-db	Pointer to "a_backup_db structure" on page 304

Return value A return code, as listed in "Software component return codes" on page 287.

Usage The DBBackup function manages all database backup tasks.

☞ For descriptions of these tasks, see "The Backup utility" on page 438 of the book *ASA Database Administration Guide*.

See also "a_backup_db structure" on page 304

DBChangeLogName function

Function Changes the name of the transaction log file. This function is used by the *dblog* command-line utility.

Prototype short **DBChangeLogName (** const a_change_log * *change-log* **);**

Parameters

Parameter	Description
change-log	Pointer to "a_change_log structure" on page 306

Return value A return code, as listed in "Software component return codes" on page 287.

Usage The `-t` option of the *dblog* command-line utility changes the name of the transaction log. DBChangeLogName provides a programmatic interface to this function.

☞ For descriptions of the *dblog* utility, see "The Transaction Log utility" on page 507 of the book *ASA Database Administration Guide*.

See also "a_change_log structure" on page 306

DBChangeWriteFile function

Function Changes a write file to refer to another database file. This function is used by the *dbwrite* command-line utility when the -d option is applied.

Prototype short **DBChangeWriteFile (** const a_writefile * *writefile* **);**

Parameters

Parameter	Description
writefile	Pointer to "a_writefile structure" on page 332

Return value A return code, as listed in "Software component return codes" on page 287.

Usage For information about the Write File utility and its features, see "The Write File utility" on page 530 of the book *ASA Database Administration Guide*.

See also
"DBCreateWriteFile function" on page 295
"DBStatusWriteFile function" on page 299
"a_writefile structure" on page 332

DBCollate function

Function Extracts a collation sequence from a database.

Prototype short **DBCollate (** const a_db_collation * *db-collation* **);**

Parameters

Parameter	Description
db-collation	Pointer to "a_db_collation structure" on page 312

Return value A return code, as listed in "Software component return codes" on page 287.

Usage For information about the collation utility and its features, see "The Collation utility" on page 442 of the book *ASA Database Administration Guide*

See also
"a_db_collation structure" on page 312

DBCompress function

Function Compresses a database file. This function is used by the *dbshrink* command-line utility.

Prototype short **DBCompress (** const a_compress_db * *compress-db* **);**

Parameters

Parameter	Description
compress-db	Pointer to "a_compress_db structure" on page 307

Return value A return code, as listed in "Software component return codes" on page 287.

Usage For information about the Compression utility and its features, see "The Compression utility" on page 448 of the book *ASA Database Administration Guide*.

See also "a_compress_db structure" on page 307

DBCreate function

Function Creates a database. This function is used by the *dbinit* command-line utility.

Prototype short **DBCreate (** const a_create_db * *create-db* **);**

Parameters

Parameter	Description
create-db	Pointer to "a_create_db structure" on page 309

Return value A return code, as listed in "Software component return codes" on page 287.

Usage For information about the initialization utility, see "The Initialization utility" on page 465 of the book *ASA Database Administration Guide*.

See also "a_create_db structure" on page 309

DBCreateWriteFile function

Function Creates a write file. This function is used by the *dbwrite* command-line utility when the `-c` option is applied.

Prototype short **DBCreateWriteFile (** const a_writefile * *writefile* **);**

Parameters

Parameter	Description
writefile	Pointer to "a_writefile structure" on page 332

Return value A return code, as listed in "Software component return codes" on page 287.

Usage For information about the Write File utility and its features, see "The Write File utility" on page 530 of the book *ASA Database Administration Guide*.

See also "DBChangeWriteFile function" on page 294

"DBStatusWriteFile function" on page 299
"a_writefile structure" on page 332

DBCrypt function

Function Encrypts a database file. This function is used by the *dbinit* command-line utility when `-e` options are applied.

Prototype short **DBCrypt (** const a_crypt_db * *crypt-db* **);**

Parameters

Parameter	Description
crypt-db	Pointer to "a_crypt_db structure" on page 311

Return value A return code, as listed in "Software component return codes" on page 287.

Usage For information about encrypting databases, see "Creating a database using the dbinit command-line utility" on page 466 of the book *ASA Database Administration Guide*.

See also "a_crypt_db structure" on page 311

DBErase function

Function Erases a database file and/or transaction log file. This function is used by the *dberase* command-line utility.

Prototype short **DBErase (** const an_erase_db * *erase-db* **);**

Parameters

Parameter	Description
erase-db	Pointer to "an_erase_db structure" on page 317

Return value A return code, as listed in "Software component return codes" on page 287.

Usage For information about the Erase utility and its features, see "The Erase utility" on page 458 of the book *ASA Database Administration Guide*.

See also "an_erase_db structure" on page 317

DBExpand function

Function Uncompresses a database file. This function is used by the *dbexpand* command-line utility.

Prototype short **DBExpand (** const an_expand_db * *expand-db* **);**

Parameters

Parameter	Description
expand_db	Pointer to "an_expand_db structure" on page 318

Return value A return code, as listed in "Software component return codes" on page 287.

Usage For information about the Uncompression utility and its features, see "The Uncompression utility" on page 511 of the book *ASA Database Administration Guide*.

See also "an_expand_db structure" on page 318

DBInfo function

Function Returns information about a database file. This function is used by the *dbinfo* command-line utility.

Prototype short **DBInfo (** const a_db_info * *db-info* **);**

Parameters

Parameter	Description
db-info	Pointer to "a_db_info structure" on page 314

Return value A return code, as listed in "Software component return codes" on page 287.

Usage For information about the Information utility and its features, see "The Information utility" on page 463 of the book *ASA Database Administration Guide*.

See also "DBInfoDump function" on page 297
"DBInfoFree function" on page 298
"a_db_info structure" on page 314

DBInfoDump function

Function Returns information about a database file. This function is used by the *dbinfo* command-line utility when the `-u` option is used.

Prototype short **DBInfoDump (** const a_db_info * *db-info* **);**

Parameters

Parameter	Description
db-info	Pointer to "a_db_info structure" on page 314

Return value A return code, as listed in "Software component return codes" on page 287.

Usage For information about the Information utility and its features, see "The Information utility" on page 463 of the book *ASA Database Administration Guide*.

See also
"DBInfo function" on page 297
"DBInfoFree function" on page 298
"a_db_info structure" on page 314

DBInfoFree function

Function Called to free resources after the DBInfoDump function is called.

Prototype short **DBInfoFree (** const a_db_info * *db-info* **);**

Parameters

Parameter	Description
db-info	Pointer to "a_db_info structure" on page 314

Return value A return code, as listed in "Software component return codes" on page 287.

Usage For information about the Information utility and its features, see "The Information utility" on page 463 of the book *ASA Database Administration Guide*.

See also
"DBInfo function" on page 297
"DBInfoDump function" on page 297
"a_db_info structure" on page 314

DBLicense function

Function Called to modify or report the licensing information of the database server.

Prototype short **DBLicense (** const a_db_lic_info * *db-lic-info* **);**

Parameters

Parameter	Description
db-lic-info	Pointer to "a_dblic_info structure" on page 316

Return value A return code, as listed in "Software component return codes" on page 287.

Usage For information about the Information utility and its features, see "The Information utility" on page 463 of the book *ASA Database Administration Guide*.

See also "a_dblic_info structure" on page 316

DBStatusWriteFile function

Function Gets the status of a write file. This function is used by the *dbwrite* command-line utility when the `-s` option is applied.

Prototype short **DBStatusWriteFile (** const a_writefile * *writefile* **);**

Parameters

Parameter	Description
writefile	Pointer to "a_writefile structure" on page 332

Return value A return code, as listed in "Software component return codes" on page 287.

Usage For information about the Write File utility and its features, see "The Write File utility" on page 530 of the book *ASA Database Administration Guide*.

See also
"DBChangeWriteFile function" on page 294
"DBCreateWriteFile function" on page 295
"a_writefile structure" on page 332

DBSynchronizeLog function

Function Synchronize a database with a MobiLink synchronization server.

Prototype short **DBSynchronizeLog(** const a _sync_db * *sync-db* **);**

Parameters

Parameter	Description
sync-db	Pointer to "a_sync_db structure" on page 320

Return value A return code, as listed in "Software component return codes" on page 287.

Usage For information about the features you can access, see "Initiating synchronization" on page 138 of the book *MobiLink Synchronization User's Guide*.

DBToolsFini function

Function Decrements the counter and frees resources when an application is finished with the DBTools library.

Prototype short **DBToolsFini (** const a_dbtools_info * *dbtools-info* **);**

Parameters

Parameter	Description
dbtools-info	Pointer to "a_dbtools_info structure" on page 317

Return value A return code, as listed in "Software component return codes" on page 287.

Usage The DBToolsFini function must be called at the end of any application that uses the DBTools interface. Failure to do so can lead to lost memory resources.

See also "DBToolsInit function" on page 300
"a_dbtools_info structure" on page 317

DBToolsInit function

Function Prepares the DBTools library for use.

Prototype short **DBToolsInit t(** const a_dbtools_info * *dbtools-info* **);**

Parameters

Parameter	Description
dbtools-info	Pointer to "a_dbtools_info structure" on page 317

Return value A return code, as listed in "Software component return codes" on page 287.

Usage The primary purpose of the DBToolsInit function is to load the Adaptive Server Anywhere language DLL. The language DLL contains localized versions of error messages and prompts that DBTools uses internally.

The DBToolsInit function must be called at the start of any application that uses the DBTools interface, before any other DBTools functions.

Example

- The following code sample illustrates how to initialize and clean up DBTools:

```
a_dbtools_info  info;
short       ret;

memset( &info, 0, sizeof( a_dbtools_info) );
info.errorrtn = (MSG_CALLBACK)MakeProcInstance(
         (FARPROC)MyErrorRtn, hInst );

// initialize DBTools
ret = DBToolsInit( &info );
if( ret != EXIT_OKAY ) {
      // DLL initialization failed
      …
   }
   // call some DBTools routines . . .
   …
   // cleanup the DBTools dll
   DBToolsFini( &info );
```

See also "DBToolsFini function" on page 299
"a_dbtools_info structure" on page 317

DBToolsVersion function

Function Returns the version number of the DBTools library.

Prototype short **DBToolsVersion (** void **);**

Return value A short integer indicating the version number of the DBTools library.

Usage Use the DBToolsVersion function to check that the DBTools library is not older than one against which your application is developed. While applications can run against newer versions of DBTools, they cannot run against older versions.

See also "Version numbers and compatibility" on page 289

DBTranslateLog function

Function Translates a transaction log file to SQL. This function is used by the *dbtran* command-line utility.

Prototype short **DBTranslateLog (** const a_translate_log * *translate-log* **);**

Parameters

Parameter	Description
translate-log	Pointer to "a_translate_log structure" on page 324

Return value A return code, as listed in "Software component return codes" on page 287.

Usage For information about the log translation utility, see "The Log Translation utility" on page 488 of the book *ASA Database Administration Guide*.

See also "a_translate_log structure" on page 324

DBTruncateLog function

Function Truncates a transaction log file. This function is used by the *dbbackup* command-line utility.

Prototype short **DBTruncateLog (** const a_truncate_log * *truncate-log* **);**

Parameters

Parameter	Description
truncate-log	Pointer to "a_truncate_log structure" on page 326

Return value A return code, as listed in "Software component return codes" on page 287.

Usage For information about the backup utility, see "The Backup utility" on page 438 of the book *ASA Database Administration Guide*

See also "a_truncate_log structure" on page 326

DBUnload function

Function Unloads a database. This function is used by the *dbunload* command-line utility and also by the *dbxtract* utility for SQL Remote.

Prototype short **DBUnload (** const an_unload_db * *unload-db* **);**

Parameters

Parameter	Description
unload-db	Pointer to "an_unload_db structure" on page 327

Return value A return code, as listed in "Software component return codes" on page 287.

Usage For information about the Unload utility, see "The Unload utility" on page 513 of the book *ASA Database Administration Guide*.

See also "an_unload_db structure" on page 327

DBUpgrade function

Function Upgrades a database file. This function is used by the *dbupgrade* command-line utility.

Prototype short **DBUpgrade (** const an_upgrade_db * *upgrade-db* **);**

Parameters

Parameter	Description
upgrade-db	Pointer to "an_upgrade_db structure" on page 329

Return value A return code, as listed in "Software component return codes" on page 287.

Usage For information about the upgrade utility, see "The Upgrade utility" on page 521 of the book *ASA Database Administration Guide*.

See also "an_upgrade_db structure" on page 329

DBValidate function

Function Validates all or part of a database. This function is used by the *dbvalid* command-line utility.

Prototype short **DBValidate (** const a_validate_db * *validate-db* **);**

Parameters

Parameter	Description
validate-db	Pointer to "a_validate_db structure" on page 330

Return value

A return code, as listed in "Software component return codes" on page 287.

Usage

For information about the upgrade utility, see "The Validation utility" on page 526 of the book *ASA Database Administration Guide*.

See also

"a_validate_db structure" on page 330

DBTools structures

This section lists the structures that are used to exchange information with the DBTools library. The structures are listed alphabetically.

Many of the structure elements correspond to command-line options on the corresponding utility. For example, several structures have a member named quiet, which can take on values of 0 or 1. This member corresponds to the quiet operation (`-q`) command-line option used by many of the utilities.

a_backup_db structure

Function

Holds the information needed to carry out backup tasks using the DBTools library.

Syntax

```
typedef struct a_backup_db {
    unsigned short          version;
    const char *            output_dir;
    const char *            connectparms;
    const char *            startline;
    MSG_CALLBACK            confirmrtn;
    MSG_CALLBACK            errorrtn;
    MSG_CALLBACK            msgrtn;
    MSG_CALLBACK            statusrtn;
    a_bit_field             backup_database: 1;
    a_bit_field             backup_logfile  : 1;
    a_bit_field             backup_writefile: 1;
    a_bit_field             no_confirm      : 1;
    a_bit_field             quiet           : 1;
    a_bit_field             rename_log      : 1;
    a_bit_field             truncate_log    : 1;
    a_bit_field             rename_local_log: 1;
    const char *            hotlog_filename;
    char                    backup_interrupted;
    } a_backup_db;
```

Parameters

Member	Description
Version	DBTools version number
output_dir	Path to the output directory. For example: `"c:\backup"`
connectparms	Parameters needed to connect to the database. They take the form of connection strings, such as the following: `"UID=DBA;PWD=SQL;DBF=c:\asa\asademo.db"` ☞ For the full range of connection string options, see "Connection parameters" on page 70 of the book *ASA Database Administration Guide*
startline	Command-line used to start the database engine. The following is an example start line: `"c:\asa\win32\dbeng8.exe"` The default start line is used if this member is NULL
confirmrtn	Callback routine for confirming an action
errorrtn	Callback routine for handling an error message
msgrtn	Callback routine for handling an information message
statusrtn	Callback routine for handling a status message
backup_database	Backup the database file (1) or not (0)
backup_logfile	Backup the transaction log file (1) or not (0)
backup_writefile	Backup the database write file (1) or not (0), if a write file is being used
no_confirm	Operate with (0) or without (1) confirmation
quiet	Operate without printing messages (1), or print messages (0)
rename_log	Rename the transaction log
truncate_log	Delete the transaction log
rename_local_log	Rename the local backup of the transaction log
hotlog_filename	File name for the live backup file
backup_interrupted	Indicates that the operation was interrupted

See also

"DBBackup function" on page 293

☞ For more information on callback functions, see "Using callback functions" on page 287.

a_change_log structure

Function

Holds the information needed to carry out *dblog* tasks using the DBTools library.

Syntax

```
typedef struct a_change_log {
    unsigned short          version;
    const char *            dbname;
    const char *            logname;
    MSG_CALLBACK            errorrtn;
    MSG_CALLBACK            msgrtn;
    a_bit_field             query_only          : 1;
    a_bit_field             quiet               : 1;
    a_bit_field             mirrorname_present  : 1;
    a_bit_field             change_mirrorname   : 1;
    a_bit_field             change_logname      : 1;
    a_bit_field             ignore_ltm_trunc    : 1;
    a_bit_field             ignore_remote_trunc : 1;
    a_bit_field             set_generation_number : 1;
    a_bit_field             ignore_dbsync_trunc : 1;
    const char *            mirrorname;
    unsigned short          generation_number;
    const char *            key_file;
    char *                  zap_current_offset;
    char *                  sap_starting_offset;
    char *                  encryption_key;
    } a_change_log;
```

Parameters

Member	Description
version	DBTools version number
dbname	Database file name
logname	The name of the transaction log. If set to NULL, there is no log
errorrtn	Callback routine for handling an error message
msgrtn	Callback routine for handling an information message
query_only	If 1, just display the name of the transaction log. If 0, permit changing of the log name
quiet	Operate without printing messages (1), or print messages (0)
mirrorname_present	Set to 1. Indicates that the version of DBTools is recent enough to support the mirrorname field
change_mirrorname	If 1, permit changing of the log mirror name
change_logname	If 1, permit changing of the transaction log name

Member	Description
ignore_ltm_trunc	When using the Log Transfer Manager, performs the same function as the dbcc settrunc('ltm', 'gen_id', n) Replication Server function: ☞ For information on dbcc, see your Replication Server documentation
ignore_remote_trunc	For SQL Remote. Resets the offset kept for the purposes of the DELETE_OLD_LOGS option, allowing transaction logs to be deleted when they are no longer needed
set_generation_number	When using the Log Transfer Manager, used after a backup is restored to set the generation number
ignore_dbsync_trunc	When using dbmlsync, resets the offset kept for the purposes of the DELETE_OLD_LOGS option, allowing transaction logs to be deleted when they are no longer needed
mirrorname	The new name of the transaction log mirror file
generation_number	The new generation number. Used together with set_generation_number
key_file	A file holding the encryption key
zap_current_offset	Change the current offset to the specified value. This is for use only in resetting a transaction log after an unload and reload to match *dbremote* or *dbmlsync* settings.
zap_starting_offset	Change the starting offset to the specified value. This is for use only in resetting a transaction log after an unload and reload to match *dbremote* or *dbmlsync* settings.
encryption_key	The encryption key for the database file.

See also

"DBChangeLogName function" on page 293

☞ For more information on callback functions, see "Using callback functions" on page 287.

a_compress_db structure

Function

Holds the information needed to carry out database compression tasks using the DBTools library.

Syntax

```
typedef struct a_compress_db {
    unsigned short          version;
    const char *            dbname;
    const char *            compress_name;
    MSG_CALLBACK            errorrtn;
    MSG_CALLBACK            msgrtn;
    MSG_CALLBACK            statusrtn;
    a_bit_field             display_free_pages      : 1;
    a_bit_field             quiet                   : 1;
    a_bit_field             record_unchanged        : 1;
    a_compress_stats *      stats;
    MSG_CALLBACK            confirmrtn;
    a_bit_field             noconfirm               : 1;
    const char *            encryption_key
    } a_compress_db;
```

Parameters

Member	Description
version	DBTools version number
dbname	The file name of the database to compress
compress_name	The file name of the compressed database
errorrtn	Callback routine for handling an error message
msgrtn	Callback routine for handling an information message
statusrtn	Callback routine for handling a status message
display_free_pages	Display the free page information.
quiet	Operate without printing messages (1), or print messages (0)
record_unchanged	Set to 1. Indicates that the a_compress_stats structure is recent enough to have an **unchanged** member
a_compress_stats	Pointer to a structure of type a_compress_stats. This is filled in if the member is not NULL and display_free_pages is not zero
confirmrtn	Callback routine for confirming an action
noconfirm	Operate with (0) or without (1) confirmation
encryption_key	The encryption key for the database file.

See also

"DBCompress function" on page 294
"a_compress_stats structure" on page 309

For more information on callback functions, see "Using callback functions" on page 287.

a_compress_stats structure

Function Holds information describing compressed database file statistics.

Syntax

```
typedef struct a_compress_stats {
    a_stats_line        tables;
    a_stats_line        indices;
    a_stats_line        other;
    a_stats_line        free;
    a_stats_line        total;
    a_sql_int32         free_pages;
    a_sql_int32         unchanged;
    } a_compress_stats;
```

Parameters

Member	Description
tables	Holds compression information regarding tables
indices	Holds compression information regarding indexes
other	Holds other compression information
free	Holds information regarding free space
total	Holds overall compression information
free_pages	Holds information regarding free pages
unchanged	The number of pages that the compression algorithm was unable to shrink

See also

"DBCompress function" on page 294
"a_compress_db structure" on page 307

a_create_db structure

Function Holds the information needed to create a database using the DBTools library.

Syntax

```
typedef struct a_create_db {
    unsigned short          version;
    const char *            dbname;
    const char *            logname;
    const char *            startline;
    short                   page_size;
    const char *            default_collation;
    MSG_CALLBACK            errorrtn;
    MSG_CALLBACK            msgrtn;
    short                   database_version;
    char                    verbose;
    a_bit_field             blank_pad               : 2;
    a_bit_field             respect_case            : 1;
    a_bit_field             encrypt                 : 1;
    a_bit_field             debug                   : 1;
    a_bit_field             dbo_avail               : 1;
    a_bit_field             mirrorname_present      : 1;
    a_bit_field             avoid_view_collisions   : 1;
    short                   collation_id;
    const char *            dbo_username;
    const char *            mirrorname;
    const char *            encryption_dllname;
    a_bit_field             java_classes : 1;
    a_bit_field             jconnect : 1;
    const char *            data_store_type
    const char *            encryption_key;
    const char *            encryption_algorithm;
    const char *            jdK_version;
    } a_create_db;
```

Parameters

Member	Description
version	DBTools version number
dbname	Database file name
logname	New transaction log name
startline	The command-line used to start the database engine. The following is an example start line: `"c:\asa\win32\dbeng8.exe"` The default start line is used if this member is NULL
page_size	The page size of the database
default_collation	The collation for the database
errorrtn	Callback routine for handling an error message
msgrtn	Callback routine for handling an information message
database_version	The version number of the database
verbose	Run in verbose mode

Member	Description
blank_pad	Treat blanks as significant in string comparisons and hold index information to reflect this
respect_case	Make string comparisons case sensitive and hold index information to reflect this
encrypt	Encrypt the database
debug	Reserved
dbo_avail	Set to 1. The dbo user is available in this database
mirrorname_present	Set to 1. Indicates that the version of DBTools is recent enough to support the mirrorname field
avoid_view_collisions	Omit the generation of Watcom SQL compatibility views SYS.SYSCOLUMNS and SYS.SYSINDEXES
collation_id	Collation identifier
dbo_username	No longer used: set to NULL
mirrorname	Transaction log mirror name
encryption_dllname	The DLL used to encrypt the database.
java_classes	Create a Java-enabled database.
jconnect	Include system procedures needed for jConnect
data_store_type	Reserved. Use NULL.
encryption_key	The encryption key for the database file.
encryption_algorithm	Either **AES** or **MDSR**.
jdk_version	One of the values for the *dbinit* `-jdk` option.

See also

"DBCreate function" on page 295

For more information on callback functions, see "Using callback functions" on page 287.

a_crypt_db structure

Function

Holds the information needed to encrypt a database file as used by the *dbinit* command-line utility.

Syntax

```
typedef struct a_crypt_db {
    const char _fd_ *   dbname;
    const char _fd_ *   dllname;
    MSG_CALLBACK    errorrtn;
    MSG_CALLBACK    msgrtn;
    MSG_CALLBACK    statusrtn;
    char                verbose;
    a_bit_field     quiet   : 1;
    a_bit_field     debug   : 1;
    } a_crypt_db;
```

Parameters

Member	Description
dbname	Database file name
dllname	The name of the DLL used to carry out the encryption
errorrtn	Callback routine for handling an error message
msgrtn	Callback routine for handling an information message
statusrtn	Callback routine for handling a status message
verbose	Operate in verbose mode
quiet	Operate without messages
debug	Reserved

See also

"DBCrypt function" on page 296
"Creating a database using the dbinit command-line utility" on page 466 of the book *ASA Database Administration Guide*

a_db_collation structure

Function

Holds the information needed to extract a collation sequence from a database using the DBTools library.

Syntax

```
typedef struct a_db_collation {
    unsigned short      version;
    const char *        connectparms;
    const char *        startline;
    const char *        collation_label;
    const char *        filename;
    MSG_CALLBACK        confirmrtn;
    MSG_CALLBACK        errorrtn;
    MSG_CALLBACK        msgrtn;
    a_bit_field         include_empty       : 1;
    a_bit_field         hex_for_extended    : 1;
    a_bit_field         replace             : 1;
    a_bit_field         quiet               : 1;
    const char *        input_filename;
    const char _fd_ *   mapping_filename;
    } a_db_collation;
```

Parameters

Member	Description
version	DBTools version number
connectparms	The parameters needed to connect to the database. They take the form of connection strings, such as the following: `"UID=DBA;PWD=SQL;DBF=c:\asa\asademo.db"` For the full range of connection string options, see "Connection parameters" on page 70 of the book *ASA Database Administration Guide*
startline	The command-line used to start the database engine. The following is an example start line: `"c:\asa\win32\dbeng8.exe"` The default start line is used if this member is NULL
confirmrtn	Callback routine for confirming an action
errorrtn	Callback routine for handling an error message
msgrtn	Callback routine for handling an information message
include_empty	Write empty mappings for gaps in the collations sequence
hex_for_extended	Use two-digit hexadecimal numbers to represent high-value characters
replace	Operate without confirming actions
quiet	Operate without messages
input_filename	Input collation definition
mapping_filename	syscollationmapping output

See also

"DBCollate function" on page 294

☞ For more information on callback functions, see "Using callback functions" on page 287.

a_db_info structure

Function

Holds the information needed to return *dbinfo* information using the DBTools library.

Syntax

```
typedef struct a_db_info {
    unsigned short          version;
    MSG_CALLBACK            errorrtn;
    const char *            dbname;
    unsigned short          dbbufsize;
    char *                  dbnamebuffer;
    unsigned short          logbufsize;
    char *                  lognamebuffer;
    unsigned short          wrtbufsize;
    char *                  wrtnamebuffer;
    a_bit_field             quiet : 1;
    a_bit_field             mirrorname_present : 1;
    a_sysinfo               sysinfo;
    unsigned long           free_pages;
    a_bit_field             compressed : 1;
    const char *            connectparms;
    const char *            startline;
    MSG_CALLBACK            msgrtn;
    MSG_CALLBACK            statusrtn;
    a_bit_field             page_usage : 1;
    a_table_info *          totals;
    unsigned long           file_size;
    unsigned long           unused_pages;
    unsigned long           other_pages;
    unsigned short          mirrorbufsize;
    char *                  mirrornamebuffer;
    char *                  unused_field;
    char *                  collationnamebuffer;
    unsigned short          collationnamebufsize;
    char *                  classesversionbuffer;
    unsigned short          classesversionbufsize;
     } a_db_info;
```

Parameters

Member	Description
version	DBTools version number
errortrn	Callback routine for handling an error message
dbname	Database file name
dbbufsize	The length of the dbnamebuffer member

Member	Description
dbnamebuffer	Database file name
logbufsize	The length of the lognamebuffer member
lognamebuffer	Transaction log file name
wrtbufsize	The length of the wrtnamebuffer member
wrtnamebuffer	The write file name
quiet	Operate without confirming messages
mirrorname_present	Set to 1. Indicates that the version of DBTools is recent enough to support the mirrorname field
sysinfo	Pointer to a_sysinfo structure
free_pages	Number of free pages
compressed	1 if compressed, otherwise 0
connectparms	The parameters needed to connect to the database. They take the form of connection strings, such as the following: `"UID=DBA;PWD=SQL;DBF=c:\Program Files\Sybase\SQL Anywhere 8\asademo.db"` For the full range of connection string options, see "Connection parameters" on page 70 of the book *ASA Database Administration Guide*
startline	The command-line used to start the database engine. The following is an example start line: `"c:\asa\win32\dbeng8.exe"` The default start line is used if this member is NULL
msgrtn	Callback routine for handling an information message
statusrtn	Callback routine for handling a status message
page_usage	1 to report page usage statistics, otherwise 0
totals	Pointer to a_table_info structure
file_size	Size of database file
unused_pages	Number of unused pages
other_pages	Number of pages that are neither table nor index pages
mirrorbufsize	The length of the mirrornamebuffer member

Member	Description
mirrornamebuffer	The transaction log mirror name
collationnamebuffer	The database collation name and label (the maximum size is 128+1)
collationnamebufsize	The length of the collationnamebuffer member
classesversionbuffer	The JDK version of the installed Java classes, such as 1.1.3, 1.1.8, 1.3, or an empty string if Java classes are not installed in the database (the maximum size is 10+1)
classesversionbufsize	The length of the classesversionbuffer member

See also

"DBInfo function" on page 297

For more information on callback functions, see "Using callback functions" on page 287.

a_dblic_info structure

Function

Holds information containing licensing information. You must use this information only in a manner consistent with your license agreement.

Syntax

```
typedef struct a_dblic_info {
    unsigned short      version;
    char        *       exename;
    char        *       username;
    char        *       compname;
    char        *       platform_str;
    a_sql_int32         nodecount;
    a_sql_int32         conncount;
    a_license_type      type;
    MSG_CALLBACK        errorrtn;
    MSG_CALLBACK        msgrtn;
    a_bit_field         quiet : 1;
    a_bit_field         query_only : 1;
    } a_dblic_info;
```

Parameters

Member	Description
version	DBTools version number
exename	Executable name
username	User name for licensing
compname	Company name for licensing
platform_str	Operating system: WinNT or NLM or UNIX
nodecount	Number of nodes licensed.

Member	Description
conncount	Must be 1000000L
type	See *lictype.h* for values
errorrtn	Callback routine for handling an error message
msgrtn	Callback routine for handling an information message
quiet	Operate without printing messages (1), or print messages (0)
query_only	If 1, just display the license information. If 0, permit changing the information

a_dbtools_info structure

Function

Holds the information needed to start and finish working with the DBTools library.

Syntax

```
typedef struct a_dbtools_info {
    MSG_CALLBACK    errorrtn;
    } a_dbtools_info;
```

Parameters

Member	Description
errorrtn	Callback routine for handling an error message

See also

"DBToolsFini function" on page 299
"DBToolsInit function" on page 300

For more information on callback functions, see "Using callback functions" on page 287.

an_erase_db structure

Function

Holds information needed to erase a database using the DBTools library.

Syntax

```
typedef struct an_erase_db {
    unsigned short          version;
    const char *            dbname;
    MSG_CALLBACK            confirmrtn;
    MSG_CALLBACK            errorrtn;
    MSG_CALLBACK            msgrtn;
    a_bit_field             quiet : 1;
    a_bit_field             erase : 1;
    const char *            encryption_key;
    } an_erase_db;
```

Parameters

Member	Description
version	DBTools version number
dbname	Database file name to erase
confirmrtn	Callback routine for confirming an action
errorrtn	Callback routine for handling an error message
msgrtn	Callback routine for handling an information message
quiet	Operate without printing messages (1), or print messages (0)
erase	Erase without confirmation (1) or with confirmation (0)
encryption_key	The encryption key for the database file.

See also

"DBErase function" on page 296

For more information on callback functions, see "Using callback functions" on page 287.

an_expand_db structure

Function

Holds information needed for database expansion using the DBTools library.

Syntax

```
typedef struct an_expand_db {
    unsigned short          version;
    const char *            compress_name;
    const char *            dbname;
    MSG_CALLBACK            errorrtn;
    MSG_CALLBACK            msgrtn;
    MSG_CALLBACK            statusrtn;
    a_bit_field             quiet : 1;
    MSG_CALLBACK            confirmrtn;
    a_bit_field             noconfirm       : 1;
    const char *            key_file;
    const char *            encryption_key;
    } an_expand_db;
```

Parameters

Member	Description
version	DBTools version number
compress_name	Name of compressed database file
dbname	Database file name
errorrtn	Callback routine for handling an error message
msgrtn	Callback routine for handling an information message
statusrtn	Callback routine for handling a status message

Member	Description
quiet	Operate without printing messages (1), or print messages (0)
confirmrtn	Callback routine for confirming an action
noconfirm	Operate with (0) or without (1) confirmation
key_file	A file holding the encryption key
encryption_key	The encryption key for the database file.

See also

"DBExpand function" on page 296

For more information on callback functions, see "Using callback functions" on page 287.

a_name structure

Function

Holds a linked list of names. This is used by other structures requiring lists of names.

Syntax

```
typedef struct a_name {
    struct a_name *     next;
    char                name[1];
    } a_name, * p_name;
```

Parameters

Member	Description
next	Pointer to the next a_name structure in the list
name	The name
p_name	Pointer to the previous a_name structure

See also

"a_translate_log structure" on page 324
"a_validate_db structure" on page 330
"an_unload_db structure" on page 327

a_stats_line structure

Function

Holds information needed for database compression and expansion using the DBTools library.

Syntax

```
typedef struct a_stats_line {
    long        pages;
    long        bytes;
    long        compressed_bytes;
    } a_stats_line;
```

Parameters

Member	Description
pages	Number of pages
bytes	Number of bytes for uncompressed database
compressed_bytes	Number of bytes for compressed database

See also "a_compress_stats structure" on page 309

a_sync_db structure

Function Holds information needed for the *dbmlsync* utility using the DBTools library.

Syntax

```
typedef struct a_sync_db {
    unsigned short          version;
    char _fd_ *             connectparms;
    char _fd_ *    publication;
    const char _fd_ *       offline_dir;
    char _fd_ *             extended_options;
    char _fd_ *             script_full_path;
    const char _fd_ *       include_scan_range;
    const char _fd_ *       raw_file;
    MSG_CALLBACK            confirmrtn;
    MSG_CALLBACK            errorrtn;
    MSG_CALLBACK            msgrtn;
    MSG_CALLBACK            logrtn;
    a_SQL_uint32            debug_dump_size;
    a_SQL_uint32            dl_insert_width;
    a_bit_field             verbose         : 1;
    a_bit_field             debug       : 1;
    a_bit_field             debug_dump_hex      : 1;
    a_bit_field             debug_dump_char     : 1;
    a_bit_field             debug_page_offsets  : 1;
    a_bit_field             use_hex_offsets     : 1;
    a_bit_field             use_relative_offsets  : 1;
    a_bit_field             output_to_file      : 1;
    a_bit_field             output_to_mobile_link  : 1;
    a_bit_field             dl_use_put      : 1;
    a_bit_field             dl_use_upsert     : 1;
    a_bit_field             kill_other_connections  : 1;
    a_bit_field             retry_remote_behind  : 1;
    a_bit_field             ignore_debug_interrupt  : 1;
    SET_WINDOW_TITLE_CALLBACK set_window_title_rtn;
    char *                  default_window_title;
    MSG_QUEUE_CALLBACK   msgqueuertn;
    MSG_CALLBACK        progress_msg_rtn;
    SET_PROGRESS_CALLBACK progress_index_rtn;
    char **                 argv;
    char **                 ce_argv;
    a_bit_field             connectparms_allocated  : 1;
    a_bit_field             entered_dialog      : 1;
    a_bit_field             used_dialog_allocation  : 1;
    a_bit_field             ignore_scheduling  : 1;
    a_bit_field             ignore_hook_errors  : 1;
    a_bit_field             changing_pwd      : 1;
    a_bit_field             prompt_again      : 1;
    a_bit_field             retry_remote_ahead    : 1;
    a_bit_field             rename_log      : 1;
    a_bit_field             hide_conn_str      : 1;
    a_bit_field             hide_ml_pwd      : 1;
    a_bit_field             delay_ml_disconn   : 1;
    a_SQL_uint32            dlg_launch_focus;
    char _fd_ *             mlpassword;
    char _fd_ *             new_mlpassword;
```

```
    char _fd_ *             verify_mlpassword;
    a_SQL_uint32            pub_name_cnt;
    char **                 pub_name_list;
    USAGE_CALLBACK          usage_rtn;
    a_sql_uint32            hovering_frequency;
    a_bit_short             ignore_hovering       : 1;
    a_bit_short             verbose_upload        : 1;
    a_bit_short             verbose_upload_data   : 1;
    a_bit_short             verbose_download      : 1;
    a_bit_short             verbose_download_data : 1;
    a_bit_short             autoclose             : 1;
    a_bit_short             ping                  : 1;
    a_bit_short             _unused               : 9;
    char _fd_ *             encryption_key;
    a_syncpub _fd_ *        upload_defs;
    char _fd_ *             log_file_name;
    char _fd_ *             user_name;
    } a_sync_db;
```

Parameters

The parameters correspond to features accessible from the *dbmlsync* command-line utility.

See the *dbtools.h* header file for additional comments.

For more information, see "MobiLink synchronization client" on page 410 of the book *MobiLink Synchronization User's Guide*.

See also

"DBSynchronizeLog function" on page 299

a_syncpub structure

Function

Holds information needed for the *dbmlsync* utility.

Syntax

```
typedef struct a_syncpub {
        struct a_syncpub _fd_ *     next;
        char _fd_ *                 pub_name;
        char _fd_ *                 ext_opt;
        a_bit_field                 alloced_by_dbsync: 1;
    } a_syncpub;
```

Parameters

Member	Description
a_syncpub	pointer to the next node in the list, NULL for the last node
pub_name	publication name(s) specified for this `-n` option. This is the exact string following -n on the command line.
ext_opt	extended options specified using the `-eu` option
encryption	1 if the database is encrypted, 0 otherwise
alloced_by_dbsync	FALSE, except for nodes created in *dbtool8.dll*

a_sysinfo structure

Function Holds information needed for *dbinfo* and *dbunload* utilities using the DBTools library.

```
typedef struct a_sysinfo {
    a_bit_field         valid_data          : 1;
    a_bit_field         blank_padding       : 1;
    a_bit_field         case_sensitivity    : 1;
    a_bit_field         encryption          : 1;
    char                default_collation[11];
    unsigned short      page_size;
     } a_sysinfo;
```

Parameters

Member	Description
valid_date	Bit-field indicating whether the following values are set
blank_padding	1 if blank padding is used in this database, 0 otherwise
case_sensitivity	1 if the database is case-sensitive, 0 otherwise
encryption	1 if the database is encrypted, 0 otherwise
default_collation	The collation sequence for the database
page_size	The page size for the database

See also "a_db_info structure" on page 314

a_table_info structure

Function Holds information about a table needed as part of the a_db_info structure.

Syntax

```
typedef struct a_table_info {
    struct a_table_info *   next;
    unsigned short          table_id;
    unsigned long           table_pages;
    unsigned long           index_pages;
    unsigned long           table_used;
    unsigned long           index_used;
    char *                  table_name;
    a_sql_uint32            table_used_pct;
    a_sql_uint32            index_used_pct;
    } a_table_info;
```

Parameters

Member	Description
next	Next table in the list
table_id	ID number for this table
table_pages	Number of table pages
index_pages	Number of index pages
table_used	Number of bytes used in table pages
index_used	Number of bytes used in index pages
table_name	Name of the table
table_used_pct	Table space utilization as a percentage
index_used_pct	Index space utilization as a percentage

See also

"a_db_info structure" on page 314

a_translate_log structure

Function

Holds information needed for transaction log translation using the DBTools library.

Syntax

```
typedef struct a_translate_log {
    unsigned short          version;
    const char *            logname;
    const char *            sqlname;
    p_name                  userlist;
    MSG_CALLBACK            confirmrtn;
    MSG_CALLBACK            errorrtn;
    MSG_CALLBACK            msgrtn;
    char                    userlisttype;
    a_bit_field             remove_rollback : 1;
    a_bit_field             ansi_SQL    : 1;
    a_bit_field             since_checkpoint: 1;
    a_bit_field             omit_comments   : 1;
    a_bit_field             replace       : 1;
    a_bit_field             debug       : 1;
    a_bit_field             include_trigger_trans : 1;
    a_bit_field             comment_trigger_trans : 1;
    unsigned long           since_time;
    const char _fd_ *       reserved_1;
    const char _fd_ *       reserved_2;
    a_sql_uint32            debug_dump_size;
    a_bit_field             debug_sql_remote       : 1;
    a_bit_field             debug_dump_hex         : 1;
    a_bit_field             debug_dump_char        : 1;
    a_bit_field             debug_page_offsets     : 1;
    a_bit_field             reserved_3             : 1;
    a_bit_field             use_hex_offsets        : 1;
    a_bit_field             use_relative_offsets   : 1;
    a_bit_field             include_audit          : 1;
    a_bit_field             chronological_order    : 1;
    a_bit_field             force_recovery         : 1;
    a_bit_field             include_subsets        : 1;
    a_bit_field             force_chaining         : 1;
    a_sql_uint32            recovery_ops;
    a_sql_uint32            recovery_bytes;
    const char _fd_ *       include_source_sets;
    const char _fd_ *       include_destination_sets;
    const char _fd_ *       include_scan_range;
    const char _fd_ *       repserver_users;
    const char _fd_ *       include_tables;
    const char _fd_ *       include_publications;
    const char _fd_ *       queueparms;
    a_bit_field             generate_reciprocals   :1;
    a_bit_field             match_mode             :1;
    const char _fd_ *       match_pos;
    MSG_CALLBACK            statusrtn;
    const char _fd_ *       encryption_key;
    a_bit_field             show_undo              :1;
    const char _fd_ *       logs_dir;
    } a_translate_log;
```

Parameters

The parameters correspond to features accessible from the *dbtran* command-line utility.

See the *dbtools.h* header file for additional comments.

See also

"DBTranslateLog function" on page 301
"a_name structure" on page 319
"dbtran_userlist_type enumeration" on page 335
For more information on callback functions, see "Using callback functions" on page 287.

a_truncate_log structure

Function

Holds information needed for transaction log truncation using the DBTools library.

Syntax

```
typedef struct a_truncate_log {
    unsigned short      version;
    const char *        connectparms;
    const char *        startline;
    MSG_CALLBACK        errorrtn;
    MSG_CALLBACK        msgrtn;
    a_bit_field         quiet      : 1;
    char                truncate_interrupted;
    } a_truncate_log;
```

Parameters

Member	Description
version	DBTools version number.
connectparms	The parameters needed to connect to the database. They take the form of connection strings, such as the following: `"UID=DBA;PWD=SQL;DBF=c:\asa\asademo.db"` For the full range of connection string options, see "Connection parameters" on page 70 of the book *ASA Database Administration Guide*
startline	The command-line used to start the database engine. The following is an example start line: `"c:\asa\win32\dbeng8.exe"` The default start line is used if this member is NULL
errorrtn	Callback routine for handling an error message
msgrtn	Callback routine for handling an information message
quiet	Operate without printing messages (1), or print messages (0)
truncate_interrupted	Indicates that the operation was interrupted

See also

"DBTruncateLog function" on page 301

For more information on callback functions, see "Using callback functions" on page 287.

an_unload_db structure

Function

Holds information needed to unload a database using the DBTools library or extract a remote database for SQL Remote. Those fields used by the *dbxtract* SQL Remote extraction utility are indicated.

Syntax

```
typedef struct an_unload_db {
    unsigned short          version;
    const char *            connectparms;
    const char *            startline;
    const char *            temp_dir;
    const char *            reload_filename;
    MSG_CALLBACK            errorrtn;
    MSG_CALLBACK            msgrtn;
    MSG_CALLBACK            statusrtn;
    MSG_CALLBACK            confirmrtn;
    char                    unload_type;
    char                    verbose;
    a_bit_field             unordered : 1;
    a_bit_field             no_confirm : 1;
    a_bit_field             use_internal_unload : 1;
    a_bit_field             dbo_avail : 1;
    a_bit_field             extract : 1;
    a_bit_field             table_list_provided : 1;
    a_bit_field             exclude_tables : 1;
    a_bit_field             more_flag_bits_present : 1;
    a_sysinfo                       sysinfo;
    const char *            remote_dir;
    const char *            dbo_username;
    const char *            subscriber_username;
    const char *            publisher_address_type;
    const char *            publisher_address;
    unsigned short          isolation_level;
    a_bit_field             start_subscriptions : 1;
    a_bit_field             exclude_foreign_keys : 1;
    a_bit_field             exclude_procedures : 1;
    a_bit_field             exclude_triggers : 1;
    a_bit_field             exclude_views : 1;
    a_bit_field             isolation_set : 1;
    a_bit_field             include_where_subscribe : 1;
    a_bit_field             debug : 1;
    p_name                  table_list;
    a_bit_short             escape_char_present : 1;
    a_bit_short             view_iterations_present : 1;
    unsigned short          view_iterations;
    char                    escape_char;
    char _fd_ *             reload_connectparms;
    char _fd_ *             reload_db_filename;
    a_bit_field             output_connections:1;
    char                    unload_interrupted;
    a_bit_field             replace_db:1;
    const char _fd_ *       locale;
    const char _fd_ *       site_name;
    const char _fd_ *       template_name;
    a_bit_field             preserve_ids:1;
    a_bit_field             exclude_hooks:1;
    char _fd_ *             reload_db_logname;
```

```
    const char _fd_ *       encryption_key;
    const char _fd_ *       encryption_algorithm;
    a_bit_field             syntax_version_7:1;
    a_bit_field             remove_java:1;
    } an_unload_db;
```

Parameters

The parameters correspond to features accessible from the *dbunload* and *dbxtract*, and *mlxtract* command-line utilities.

See the *dbtools.h* header file for additional comments.

See also

"DBUnload function" on page 302
"a_name structure" on page 319
"dbunload type enumeration" on page 335

For more information on callback functions, see "Using callback functions" on page 287.

an_upgrade_db structure

Function

Holds information needed to upgrade a database using the DBTools library.

Syntax

```
typedef struct an_upgrade_db {
    unsigned short          version;
    const char *            connectparms;
    const char *            startline;
    MSG_CALLBACK            errorrtn;
    MSG_CALLBACK            msgrtn;
    MSG_CALLBACK            statusrtn;
    a_bit_field             quiet : 1;
    a_bit_field             dbo_avail : 1;
    const char *            dbo_username;
    a_bit_field             java_classes       : 1;
    a_bit_field             jconnect : 1;
    a_bit_field             remove_java        : 1;
    a_bit_field             java_switch_specified : 1;
    const char *            jdk_version;
    } an_upgrade_db;
```

Parameters

Member	Description
version	DBTools version number.
connectparms	The parameters needed to connect to the database. They take the form of connection strings, such as the following: `"UID=DBA;PWD=SQL;DBF=c:\asa\asademo.db"` For the full range of connection string options, see "Connection parameters" on page 70 of the book *ASA Database Administration Guide*
startline	The command-line used to start the database engine. The following is an example start line: `"c:\asa\win32\dbeng8.exe"` The default start line is used if this member is NULL
errorrtn	Callback routine for handling an error message
msgrtn	Callback routine for handling an information message
statusrtn	Callback routine for handling a status message
quiet	Operate without printing messages (1), or print messages (0)
dbo_avail	Set to 1. Indicates that the version of DBTools is recent enough to support the dbo_username field
dbo_username	The name to use for the dbo
java_classes	Upgrade the database to be Java-enabled
jconnect	Upgrade the database to include jConnect procedures
remove_java	Upgrade the database, removing the Java features
jdk_version	One of the values for the *dbinit* `-jdk` option.

See also

"DBUpgrade function" on page 302

For more information on callback functions, see "Using callback functions" on page 287.

a_validate_db structure

Function

Holds information needed for database validation using the DBTools library.

Syntax

```
typedef struct a_validate_db {
    unsigned short      version;
    const char *        connectparms;
    const char *        startline;
    p_name              tables;
    MSG_CALLBACK        errorrtn;
    MSG_CALLBACK        msgrtn;
    MSG_CALLBACK        statusrtn;
    a_bit_field         quiet : 1;
    a_bit_field         index : 1;
    a_validate_type     type;
    } a_validate_db;
```

Parameters

Member	Description
version	DBTools version number.
connectparms	The parameters needed to connect to the database. They take the form of connection strings, such as the following: `"UID=DBA;PWD=SQL;DBF=c:\asa\asademo.db"` For the full range of connection string options, see "Connection parameters" on page 70 of the book *ASA Database Administration Guide*
startline	The command-line used to start the database engine. The following is an example start line: `"c:\Program Files\Sybase\SA\win32\dbeng8.exe"` The default start line is used if this member is NULL
tables	Pointer to a linked list of table names
errorrtn	Callback routine for handling an error message
msgrtn	Callback routine for handling an information message
statusrtn	Callback routine for handling a status message
quiet	Operate without printing messages (1), or print messages (0)
index	Validate indexes
type	See "a_validate_type enumeration" on page 335

See also

"DBValidate function" on page 302
"a_name structure" on page 319

For more information on callback functions, see "Using callback functions" on page 287.

a_writefile structure

Function

Holds information needed for database write file management using the DBTools library.

Syntax

```
typedef struct a_writefile {
    unsigned short          version;
    const char *            writename;
    const char *            wlogname;
    const char *            dbname;
    const char *            forcename;
    MSG_CALLBACK            confirmrtn;
    MSG_CALLBACK            errorrtn;
    MSG_CALLBACK            msgrtn;
    char                    action;
    a_bit_field             quiet   : 1;
    a_bit_field             erase   : 1;
    a_bit_field             force   : 1;
    a_bit_field             mirrorname_present      : 1;
    const char *            wlogmirrorname;
    a_bit_field             make_log_and_mirror_names: 1;
    const char *            encryption_key;
    } a_writefile;
```

Parameters

Member	Description
version	DBTools version number
writename	Write file name
wlogname	Used only when creating write files
dbname	Used when changing and creating write files
forcename	Forced file name reference
confirmrtn	Callback routine for confirming an action. Only used when creating a write file
errorrtn	Callback routine for handling an error message
msgrtn	Callback routine for handling an information message
action	Reserved for use by Sybase
quiet	Operate without printing messages (1), or print messages (0)
erase	Used for creating write files only. Erase without confirmation (1) or with confirmation (0)

Member	Description
force	If 1, force the write file to point to a named file
mirrorname_present	Used when creating only. Set to 1. Indicates that the version of DBTools is recent enough to support the mirrorname field
wlogmirrorname	Name of the transaction log mirror
make_log_and_mirror_names	If TRUE, use the values in wlogname and wlogmirrorname to determine filenames.
encryption_key	The encryption key for the database file.

See also

"DBChangeWriteFile function" on page 294
"DBCreateWriteFile function" on page 295
"DBStatusWriteFile function" on page 299
For more information on callback functions, see "Using callback functions" on page 287.

DBTools enumeration types

This section lists the enumeration types that are used by the DBTools library. The enumerations are listed alphabetically.

Verbosity enumeration

Function Specifies the volume of output.

Syntax

```
enum {
    VB_QUIET,
    VB_NORMAL,
    VB_VERBOSE
    };
```

Parameters

Value	Description
VB_QUIET	No output
VB_NORMAL	Normal amount of output
VB_VERBOSE	Verbose output, useful for debugging

See also "a_create_db structure" on page 309
"an_unload_db structure" on page 327

Blank padding enumeration

Function Used in the "a_create_db structure" on page 309, to specify the value of blank_pad.

Syntax

```
enum {
    NO_BLANK_PADDING,
    BLANK_PADDING
    };
```

Parameters

Value	Description
NO_BLANK_PADDING	Does not use blank padding
BLANK_PADDING	Uses blank padding

See also "a_create_db structure" on page 309

dbtran_userlist_type enumeration

Function The type of a user list, as used by an "a_translate_log structure" on page 324.

Syntax

```
typedef enum dbtran_userlist_type {
    DBTRAN_INCLUDE_ALL,
    DBTRAN_INCLUDE_SOME,
    DBTRAN_EXCLUDE_SOME
    } dbtran_userlist_type;
```

Parameters

Value	Description
DBTRAN_INCLUDE_ALL	Include operations from all users
DBTRAN_INCLUDE_SOME	Include operations only from the users listed in the supplied user list
DBTRAN_EXCLUDE_SOME	Exclude operations from the users listed in the supplied user list

See also "a_translate_log structure" on page 324

dbunload type enumeration

Function The type of unload being performed, as used by the "an_unload_db structure" on page 327.

Syntax

```
enum {
    UNLOAD_ALL,
    UNLOAD_DATA_ONLY,
    UNLOAD_NO_DATA
    };
```

Parameters

Value	Description
UNLOAD_ALL	Unload both data and schema
UNLOAD_DATA_ONLY	Unload data. Do not unload schema
UNLOAD_NO_DATA	Unload schema only

See also "an_unload_db structure" on page 327

a_validate_type enumeration

Function The type of validation being performed, as used by the "a_validate_db structure" on page 330.

Syntax

```
typedef enum {
    VALIDATE_NORMAL = 0,
    VALIDATE_DATA,
    VALIDATE_INDEX,
    VALIDATE_EXPRESS,
    VALIDATE_FULL
    } a_validate_type;
```

Parameters

Value	Description
VALIDATE_NORMAL	Validate with the default check only.
VALIDATE_DATA	Validate with data check in addition to the default check.
VALIDATE_INDEX	Validate with index check in addition to the default check.
VALIDATE_EXPRESS	Validate with express check in addition to the default and data checks.
VALIDATE_FULL	Validate with both data and index check in addition toe the default check.

See also

"Validating a database using the dbvalid command-line utility" on page 527 of the book *ASA Database Administration Guide*
"VALIDATE TABLE statement" on page 586 of the book *ASA SQL Reference Manual*

CHAPTER 9

The OLE DB and ADO Programming Interfaces

About this chapter

This chapter describes how to use the OLE DB interface to Adaptive Server Anywhere.

Many applications that use the OLE DB interface do so through the Microsoft ActiveX Data Objects (ADO) programming model, rather than directly. This chapter also describes ADO programming with Adaptive Server Anywhere.

Contents

Introduction to OLE DB

OLE DB is a data access model from Microsoft. It uses the Component Object Model (COM) interfaces and, unlike ODBC, OLE DB does not assume that the data source uses a SQL query processor.

Adaptive Server Anywhere includes an **OLE DB provider** named **ASAProv**. This provider is available for current Windows and Windows CE platforms.

You can also access Adaptive Server Anywhere using the Microsoft OLE DB Provider for ODBC (MSDASQL), together with the Adaptive Server Anywhere ODBC driver.

Using the Adaptive Server Anywhere OLE DB provider brings several benefits:

- Some features, such as updating through a cursor, are not available using the OLE DB/ODBC bridge.
- If you use the Adaptive Server Anywhere OLE DB provider, ODBC is not required in your deployment.
- MSDASQL allows OLE DB clients to work with any ODBC driver but does not guarantee that you can use the full range of functionality of each ODBC driver. Using the Adaptive Server Anywhere provider, you can get full access to Adaptive Server Anywhere features from OLE DB programming environments.

Supported platforms

The Adaptive Server Anywhere OLE DB provider is designed to work with OLE DB 2.5 and later. For Windows CE and its successors, the OLE DB provider is designed for ADOCE 3.0 and later.

ADOCE is the Microsoft ADO for Windows CE SDK and provides database functionality for applications developed with the Windows CE Toolkits for Visual Basic 5.0 and *Visual* Basic 6.0.

For a list of supported platforms, see "Operating system versions" on page 136 of the book *Introducing SQL Anywhere Studio*.

Distributed transactions

The OLE DB driver can be used as a resource manager in a distributed transaction environment.

For more information, see "Three-tier Computing and Distributed Transactions" on page 361.

ADO programming with Adaptive Server Anywhere

ADO (ActiveX Data Objects) is a data access object model exposed through an Automation interface, which allows client applications to discover the methods and properties of objects at runtime without any prior knowledge of the object. Automation allows scripting languages like Visual Basic to use a standard data access object model. ADO uses OLE DB to provide data access.

Using the Adaptive Server Anywhere OLE DB provider, you get full access to Adaptive Server Anywhere features from an ADO programming environment.

This section describes how to carry out basic tasks while using ADO from Visual Basic. It is not a complete guide to programming using ADO.

Code samples from this section can be found in the following files:

Development tool	Sample
Microsoft Visual Basic 6.0	*Samples\ASA\VBSampler\vbsampler.vbp*
Microsoft eMbedded Visual Basic 3.0	*Samples\ASA\ADOCE\OLEDB_PocketPC.ebp*

For information on programming in ADO, see your development tool documentation.

For a detailed discussion of how to use ADO and Visual Basic to access data in an Adaptive Server Anywhere database, see the whitepaper *Accessing Data in Adaptive Server Anywhere Using ADO and Visual Basic*, which is available at http://www.sybase.com/detail?id=1017429.

Connecting to a database with the Connection object

This section describes a simple Visual Basic routine that connects to a database.

Sample code

You can try this routine by placing a command button named **Command1** on a form, and pasting the routine into its **Click** event. Run the program and click the button to connect and then disconnect.

```
Private Sub cmdTestConnection_Click()
    ' Declare variables
    Dim myConn As New ADODB.Connection
    Dim myCommand As New ADODB.Command
    Dim cAffected As Long

    On Error GoTo HandleError

    ' Establish the connection
    myConn.Provider = "ASAProv"
    myConn.ConnectionString = _
      "Data Source=ASA 8.0 Sample"
    myConn.Open
    MsgBox "Connection succeeded"
    myConn.Close
    Exit Sub

HandleError:
    MsgBox "Connection failed"
    Exit Sub
End Sub
```

Notes

The sample carries out the following tasks:

- It declares the variables used in the routine.
- It establishes a connection, using the Adaptive Server Anywhere OLE DB provider, to the sample database.
- It uses a Command object to execute a simple statement, which displays a message on the database server window.
- It closes the connection.

When the **ASAProv** provider is installed, it registers itself. This registration process includes making registry entries in the COM section of the registry, so that ADO can locate the DLL when the **ASAProv** provider is called. If you change the location of your DLL, you must reregister it.

❖ **To register the OLE DB provider:**

1. Open a command prompt.
2. Change to the directory where the OLE DB provider is installed.
3. Enter the following command to register the provider:

```
regsvr32 dboledb8.dll
```

☞ For more information about connecting to a database using OLE DB, see "Connecting to a database using OLE DB" on page 68 of the book *ASA Database Administration Guide*.

Executing statements with the Command object

This section describes a simple routine that sends a simple SQL statement to the database.

Sample code

You can try this routine by placing a command button named **Command2** on a form, and pasting the routine into its **Click** event. Run the program and click the button to connect, display a message on the database server window, and then disconnect.

```
Private Sub cmdUpdate_Click()
    ' Declare variables
    Dim myConn As New ADODB.Connection
    Dim myCommand As New ADODB.Command
    Dim cAffected As Long
    ' Establish the connection
    myConn.Provider = "ASAProv"
    myConn.ConnectionString = _
      "Data Source=ASA 8.0 Sample"
    myConn.Open

    'Execute a command
    myCommand.CommandText = _
    "update customer set fname='Liz' where id=102"
    Set myCommand.ActiveConnection = myConn
    myCommand.Execute cAffected
    MsgBox CStr(cAffected) +
   " rows affected.", vbInformation

    myConn.Close
End Sub
```

Notes

After establishing a connection, the example code creates a Command object, sets its **CommandText** property to an update statement, and sets its **ActiveConnection** property to the current connection. It then executes the update statement and displays the number of rows affected by the update in a message box.

In this example, the update is sent to the database and committed as soon as it is executed.

For information on using transactions within ADO, see "Using transactions" on page 346.

You can also carry out updates through a cursor.

For more information, see "Updating data through a cursor" on page 344.

Querying the database with the Recordset object

The ADO **Recordset** object represents the result set of a query. You can use it to view data from a database.

Sample code

You can try this routine by placing a command button named **cmdQuery** on a form and pasting the routine into its **Click** event. Run the program and click the button to connect, display a message on the database server window, execute a query and display the first few rows in message boxes, and then disconnect.

```
Private Sub cmdQuery_Click()
' Declare variables
    Dim myConn As New ADODB.Connection
    Dim myCommand As New ADODB.Command
    Dim myRS As New ADODB.Recordset

    On Error GoTo ErrorHandler:

    ' Establish the connection
    myConn.Provider = "ASAProv"
    myConn.ConnectionString = _
      "Data Source=ASA 8.0 Sample"
    myConn.CursorLocation = adUseServer
    myConn.Mode = adModeReadWrite
    myConn.IsolationLevel = adXactCursorStability
    myConn.Open

    'Execute a query
    Set myRS = New Recordset
    myRS.CacheSize = 50
    myRS.Source = "Select * from customer"
    myRS.ActiveConnection = myConn
    myRS.CursorType = adOpenKeyset
    myRS.LockType = adLockOptimistic
    myRS.Open

    'Scroll through the first few results
    myRS.MoveFirst
    For i = 1 To 5
      MsgBox myRS.Fields("company_name"), vbInformation
      myRS.MoveNext
    Next

    myRS.Close
    myConn.Close
    Exit Sub
ErrorHandler:
    MsgBox Error(Err)
    Exit Sub
End Sub
```

Notes

The **Recordset** object in this example holds the results from a query on the *Customer* table. The **For** loop scrolls through the first several rows and displays the *company_name* value for each row.

This is a simple example of using a cursor from ADO.

For more advanced examples of using a cursor from ADO, see "Working with Recordset object" on page 344.

Working with Recordset object

When working with Adaptive Server Anywhere, the ADO **Recordset** represents a cursor. You can choose the type of cursor by declaring a **CursorType** property of the **Recordset** object before you open the **Recordset**. The choice of cursor type controls the actions you can take on the **Recordset** and has performance implications.

Cursor types

The set of cursor types supported by Adaptive Server Anywhere is described in "Cursor properties" on page 24. ADO has its own naming convention for cursor types.

The available cursor types, the corresponding cursor type constants, and the Adaptive Server Anywhere types they are equivalent to, are as follows:

ADO cursor type	ADO constant	Adaptive Server Anywhere type
Dynamic cursor	adOpenDynamic	Dynamic scroll cursor
Keyset cursor	adOpenKeyset	Scroll cursor
Static cursor	adOpenStatic	Insensitive cursor
Forward only	adOpenForwardOnly	No-scroll cursor

For information on choosing a cursor type that is suitable for your application, see "Choosing cursor types" on page 24.

Sample code

The following code sets the cursor type for an ADO **Recordset** object:

```
Dim myRS As New ADODB.Recordset
myRS.CursorType = adOpenDynamic
```

Updating data through a cursor

The Adaptive Server Anywhere OLE DB provider lets you update a result set through a cursor. This capability is not available through the MSDASQL provider.

Updating record sets

You can update the database through a record set.

```
Private Sub Command6_Click()
    Dim myConn As New ADODB.Connection
    Dim myRS As New ADODB.Recordset
    Dim SQLString As String
    ' Connect
    myConn.Provider = "ASAProv"
    myConn.ConnectionString = _
        "Data Source=ASA 8.0 Sample"
    myConn.Open
    myConn.BeginTrans
    SQLString = "Select * from customer"
    myRS.Open SQLString, _
      myConn, adOpenDynamic, adLockBatchOptimistic

    If myRS.BOF And myRS.EOF Then
        MsgBox "Recordset is empty!", _
        16, "Empty Recordset"
    Else
        MsgBox "Cursor type: " + _
        CStr(myRS.CursorType), vbInformation
        myRS.MoveFirst
        For i = 1 To 3
            MsgBox "Row: " + CStr(myRS.Fields("id")), _
             vbInformation
            If i = 2 Then
                myRS.Update "City", "Toronto"
                myRS.UpdateBatch
            End If
            myRS.MoveNext
        Next i
'        myRS.MovePrevious
        myRS.Close
    End If
    myConn.CommitTrans
    myConn.Close
End Sub
```

Notes

If you use the adLockBatchOptimistic setting on the recordset, the **myRS.Update** method does not make any changes to the database itself. Instead, it updates a local copy of the **Recordset**.

The **myRS.UpdateBatch** method makes the update to the database server, but does not commit it, because it is inside a transaction. If an **UpdateBatch** method was invoked outside a transaction, the change would be committed.

The **myConn.CommitTrans** method commits the changes. The **Recordset** object has been closed by this time, so there is no issue of whether the local copy of the data is changed or not.

Using transactions

By default, any change you make to the database using ADO is committed as soon as it is executed. This includes explicit updates, as well as the **UpdateBatch** method on a **Recordset**. However, the previous section illustrated that you can use the **BeginTrans** and **RollbackTrans** or **CommitTrans** methods on the **Connection** object to use transactions.

Transaction isolation level is set as a property of the Connection object. The IsolationLevel property can take on one of the following values:

ADO isolation level	Constant	ASA level
Unspecified	adXactUnspecified	Not applicable. Set to 0
Chaos	adXactChaos	Unsupported. Set to 0
Browse	adXactBrowse	0
Read uncommitted	adXactReadUncommitted	0
Cursor stability	adXactCursorStability	1
Read committed	adXactReadCommitted	1
Repeatable read	adXactRepeatableRead	2
Isolated	adXactIsolated	3
Serializable	adXactSerializable	3

☞ For more information on isolation levels, see "Isolation levels and consistency" on page 94 of the book *ASA SQL User's Guide*.

Supported OLE DB interfaces

The OLE DB API consists of a set of interfaces. The following table describes the support for each interface in the Adaptive Server Anywhere OLE DB driver.

Interface	Purpose	Limitations
IAccessor	Define bindings between client memory and data store values.	DBACCESSOR_PASSBYREF not supported. DBACCESSOR_OPTIMIZED not supported.
IAlterIndex IAlterTable	Alter tables, indexes, and columns.	Not supported.
IChapteredRowset	A chaptered rowset allows rows of a rowset to be accessed in separate chapters.	Not supported. Adaptive Server Anywhere does not support chaptered rowsets.
IColumnsInfo	Get simple information about the columns of a rowset.	Not on CE.
IColumnsRowset	Get information about optional metadata columns in a rowset, and get a rowset of column metadata.	Not on CE.
ICommand	Execute SQL commands.	Does not support calling. IcommandProperties: GetProperties with DBPROPSET_PROPERTIESINERROR to find properties that could not have been set.
ICommandPersist	Persist the state of a command object (but not any active rowsets). These persistent command objects can subsequently be enumerated using the PROCEDURES or VIEWS rowset.	Not on CE.
ICommandPrepare	Prepare commands.	Not on CE.

Interface	Purpose	Limitations
ICommandProperties	Set Rowset properties for rowsets created by a command. Most commonly used to specify the interfaces the rowset should support.	Supported.
ICommandText	Set the SQL command text for ICommand.	Only the DBGUID_DEFAULT SQL dialect is supported.
IcommandWithParameters	Set or get parameter information for a command.	No support for parameters stored as vectors of scalar values. No support for BLOB parameters. Not on CE.
IConvertType		Supported. Limited on CE.
IDBAsynchNotify	Asynchronous processing.	Not supported.
IDBAsyncStatus	Notify client of events in the asynchronous processing of data source initialization, populating rowsets, and so on.	
IDBCreateCommand	Create commands from a session.	Supported.
IDBCreateSession	Create a session from a data source object.	Supported.
IDBDataSourceAdmin	Create/destroy/modify data source objects, which are COM objects used by clients. This interface is not used to manage data stores (databases).	Not supported.

Interface	Purpose	Limitations
IDBInfo	Find information about keywords unique to this provider (that is, to find non-standard SQL keywords). Also, find information about literals, special characters used in text matching queries, and other literal information.	Not on CE.
IDBInitialize	Initialize data source objects and enumerators.	Not on CE.
IDBProperties	Manage properties on a data source object or enumerator.	Not on CE.
IDBSchemaRowset	Get information about system tables, in a standard form (a rowset).	Not on CE.
IErrorInfo IErrorLookup IErrorRecords	ActiveX error object support.	Not on CE.
IGetDataSource	Returns an interface pointer to the session's data source object.	Supported.
IIndexDefinition	Create or drop indexes in the data store.	Not supported.
IMultipleResults	Retrieve multiple results (rowsets or row counts) from a command.	Supported.
IOpenRowset	Non-SQL way to access a database table by its name.	Supported. Opening a table by its name is supported, not by a GUID.
IParentRowset	Access chaptered/hierarchical rowsets.	Not supported.
IRowset	Access rowsets.	Supported.

Interface	Purpose	Limitations
IRowsetChange	Allow changes to rowset data, reflected back to the data store. InsertRow/SetData for blobs not yet implemented.	Not on CE.
IRowsetChapterMember	Access chaptered/hierarchical rowsets.	Not supported.
IRowsetCurrentIndex	Dynamically change the index for a rowset.	Not supported.
IRowsetFind	Find a row within a rowset matching a specified value.	Not supported.
IRowsetIdentity	Compare row handles.	Not supported.
IRowsetIndex	Access database indexes.	Not supported.
IRowsetInfo	Find information about a rowset properties or to find the object that created the rowset.	Not on CE.
IRowsetLocate	Position on rows of a rowset, using bookmarks.	Not on CE.
IRowsetNotify	Provides a COM callback interface for rowset events.	Supported.
IRowsetRefresh	Get the latest value of data that is visible to a transaction.	Not supported.
IRowsetResynch	Old OLEDB 1.x interface, superseded by IRowsetRefresh.	Not supported.
IRowsetScroll	Scroll through rowset to fetch row data.	Not supported.
IRowsetUpdate	Delay changes to rowset data until Update is called.	Supported. Not on CE.
IRowsetView	Use views on an existing rowset.	Not supported.

Interface	Purpose	Limitations
ISequentialStream	Retrieve a blob column.	Supported for reading only. No support for SetData with this interface. Not on CE.
ISessionProperties	Get session property information.	Supported.
ISourcesRowset	Get a rowset of data source objects and enumerators.	Not on CE.
ISQLErrorInfo ISupportErrorInfo	ActiveX error object support.	Optional on CE.
ITableDefinition ITableDefinitionWithConstraints	Create, drop, and alter tables, with constraints.	Not on CE.
ITransaction	Commit or abort transactions.	Not all the flags are supported. Not on CE.
ITransactionJoin	Support distributed transactions.	Not all the flags are supported. Not on CE.
ITransactionLocal	Handle transactions on a session. Not all the flags are supported.	Not on CE.

Interface	Purpose	Limitations
ITransactionOptions	Get or set options on a transaction.	Not on CE.
IViewChapter	Work with views on an existing rowset, specifically to apply post-processing filters/sorting on rows.	Not supported.
IViewFilter	Restrict contents of a rowset to rows matching a set of conditions.	Not supported.
IViewRowset	Restrict contents of a rowset to rows matching a set of conditions, when opening a rowset.	Not supported.
IViewSort	Apply sort order to a view.	Not supported.

CHAPTER 10

The Open Client Interface

About this chapter

This chapter describes the Open Client programming interface for Adaptive Server Anywhere.

The primary documentation for Open Client application development is the Open Client documentation, available from Sybase. This chapter describes features specific to Adaptive Server Anywhere, but it is not an exhaustive guide to Open Client application programming.

Contents

What you need to build Open Client applications

To run Open Client applications, you must install and configure Open Client components on the machine where the application is running. You may have these components present as part of your installation of other Sybase products or you can optionally install these libraries with Adaptive Server Anywhere, subject to the terms of your license agreement.

Open Client applications do not need any Open Client components on the machine where the database server is running.

To build Open Client applications, you need the development version of Open Client, available from Sybase.

By default, Adaptive Server Anywhere databases are created as case-insensitive, while Adaptive Server Enterprise databases are case sensitive.

☞ For more information on running Open Client applications with Adaptive Server Anywhere, see "Adaptive Server Anywhere as an Open Server" on page 105 of the book *ASA Database Administration Guide*.

Data type mappings

Open Client has its own internal data types, which differ in some details from those available in Adaptive Server Anywhere. For this reason, Adaptive Server Anywhere internally maps some data types between those used by Open Client applications and those available in Adaptive Server Anywhere.

To build Open Client applications, you need the development version of Open Client. To use Open Client applications, the Open Client runtimes must be installed and configured on the computer where the application runs.

The Adaptive Server Anywhere server does not require any external communications runtime in order to support Open Client applications.

Each Open Client data type is mapped onto the equivalent Adaptive Server Anywhere data type. All Open Client data types are supported

Adaptive Server Anywhere data types with no direct counterpart in Open Client

The following table lists the mappings of data types supported in Adaptive Server Anywhere that have no direct counterpart in Open Client.

ASA data type	Open Client data type
unsigned short	int
unsigned int	bigint
unsigned bigint	bigint
date	smalldatetime
time	smalldatetime
serialization	longbinary
java	longbinary
string	varchar
timestamp struct	datetime

Range limitations in data type mapping

Some data types have different ranges in Adaptive Server Anywhere than in Open Client. In such cases, overflow errors can occur during retrieval or insertion of data.

The following table lists Open Client application data types that can be mapped to Adaptive Server Anywhere data types, but with some restriction in the range of possible values.

In most cases, the Open Client data type is mapped to an Adaptive Server Anywhere data type that has a greater range of possible values. As a result, it is possible to pass a value to Adaptive Server Anywhere that will be accepted and stored in a database, but one that is too large to be fetched by an Open Client application.

Data type	Open Client lower range	Open Client upper range	ASA lower range	ASA upper range
MONEY	–922 377 203 685 477.5808	922 377 203 685 477.5807	–1e15 + 0.0001	1e15 – 0.0001
SMALLMONEY	–214 748.3648	214 748.3647	–214 748.3648	214 748.3647
DATETIME	Jan 1, 1753	Dec 31, 9999	Jan 1, 0001	Dec 31, 9999
SMALLDATETIME	Jan 1, 1900	June 6, 2079	March 1, 1600	Dec 31, 7910

Example

For example, the Open Client MONEY and SMALLMONEY data types do not span the entire numeric range of their underlying Adaptive Server Anywhere implementations. Therefore, it is possible to have a value in an Adaptive Server Anywhere column which exceeds the boundaries of the Open Client data type MONEY. When the client fetches any such offending values via Adaptive Server Anywhere, an error is generated.

Timestamps

The Adaptive Server Anywhere implementation of the Open Client TIMESTAMP data type, when such a value is passed in Adaptive Server Anywhere, is different from that of Adaptive Server Enterprise. In Adaptive Server Anywhere, the value is mapped to the Adaptive Server Anywhere DATETIME data type. The default value is NULL in Adaptive Server Anywhere and no guarantee is made of its uniqueness. By contrast, Adaptive Server Enterprise ensures that the value is monotonically increasing in value, and so, is unique.

By contrast, the Adaptive Server Anywhere TIMESTAMP data type contains year, month, day, hour, minute, second, and fraction of second information. In addition, the DATETIME data type has a greater range of possible values than the Open Client data types that are mapped to it by Adaptive Server Anywhere.

Using SQL in Open Client applications

This section provides a very brief introduction to using SQL in Open Client applications, with a particular focus on Adaptive Server Anywhere-specific issues.

☞ For an introduction to the concepts, see "Using SQL in Applications" on page 9. For a complete description, see your Open Client documentation.

Executing SQL statements

You send SQL statements to a database by including them in Client Library function calls. For example, the following pair of calls executes a DELETE statement:

```
ret = ct_command(cmd, CS_LANG_CMD,
                  "DELETE FROM employee
                   WHERE emp_id=105"
                 CS_NULLTERM,
                 CS_UNUSED);
ret = ct_send(cmd);
```

The **ct_command** function is used for a wide range of purposes.

Using prepared statements

The **ct_dynamic** function is used to manage prepared statements. This function takes a *type* parameter which describes the action you are taking.

❖ **To use a prepared statement in Open Client:**

1. Prepare the statement using the **ct_dynamic** function, with a CS_PREPARE *type* parameter.
2. Set statement parameters using **ct_param**.
3. Execute the statement using **ct_dynamic** with a CS_EXECUTE *type* parameter.
4. Free the resources associated with the statement using **ct_dynamic** with a CS_DEALLOC *type* parameter.

☞ For more information on using prepared statements in Open Client, see your Open Client documentation

Using cursors

The **ct_cursor** function is used to manage cursors. This function takes a *type* parameter which describes the action you are taking.

Supported cursor types

Not all the types of cursor that Adaptive Server Anywhere supports are available through the Open Client interface. You cannot use scroll cursors, dynamic scroll cursors, or insensitive cursors through Open Client.

Uniqueness and updateability are two properties of cursors. Cursors can be unique (each row carries primary key or uniqueness information, regardless of whether it is used by the application) or not. Cursors can be read only or updateable. If a cursor is updateable and not unique, performance may suffer, as no prefetching of rows is done in this case, regardless of the CS_CURSOR_ROWS setting (see below).

The steps in using cursors

In contrast to some other interfaces, such as Embedded SQL, Open Client associates a cursor with a SQL statement expressed as a string. Embedded SQL first prepares a statement and then the cursor is declared using the statement handle.

❖ **To use cursors in Open Client:**

1. To declare a cursor in Open Client, you use **ct_cursor** with CS_CURSOR_DECLARE as the *type* parameter.
2. After declaring a cursor, you can control how many rows are prefetched to the client side each time a row is fetched from the server using **ct_cursor** with CS_CURSOR_ROWS as the *type* parameter.

   Storing prefetched rows at the client side cuts down the number of calls to the server and this improves overall throughput as well as turnaround time. Prefetched rows are not immediately passed on to the application; they are stored in a buffer at the client side ready for use.

   The setting of the PREFETCH database option controls prefetching of rows for other interfaces. It is ignored by Open Client connections. The CS_CURSOR_ROWS setting is ignored for non-unique, updateable cursors.
3. To open a cursor in Open Client, you use **ct_cursor** with CS_CURSOR_OPEN as the *type* parameter.
4. To fetch each row in to the application, you use **ct_fetch**.
5. To close a cursor, you use ct_cursor with CS_CURSOR_CLOSE.

6 In Open Client, you also need to deallocate the resources associated with a cursor. You do this using ct_cursor with CS_CURSOR_DEALLOC. You can also use CS_CURSOR_CLOSE with the additional parameter CS_DEALLOC to carry out these operations in a single step.

Modifying rows through a cursor

With Open Client, you can delete or update rows in a cursor, as long as the cursor is for a single table. The user must have permissions to update the table and the cursor must be marked for update.

❖ **To modify rows through a cursor:**

- Instead of carrying out a fetch, you can delete or update the current row of the cursor using ct_cursor with CS_CURSOR_DELETE or CS_CURSOR_UPDATE, respectively.

You cannot insert rows through a cursor in Open Client applications.

Describing query results in Open Client

Open Client handles result sets in a different way than some other Adaptive Server Anywhere interfaces.

In Embedded SQL and ODBC, you **describe** a query or stored procedure in order to set up the proper number and types of variables to receive the results. The description is done on the statement itself.

In Open Client, you do not need to describe a statement. Instead, each row returned from the server can carry a description of its contents. If you use **`ct_command`** and **`ct_send`** to execute statements, you can use the **`ct_results`** function to handle all aspects of rows returned in queries.

If you do not wish to use this row-by-row method of handling result sets, you can use **`ct_dynamic`** to prepare a SQL statement and use **`ct_describe`** to describe its result set. This corresponds more closely to the describing of SQL statements in other interfaces.

Known Open Client limitations of Adaptive Server Anywhere

Using the Open Client interface, you can use an Adaptive Server Anywhere database in much the same way as you would an Adaptive Server Enterprise database. There are some limitations, including the following:

- **Commit Service** Adaptive Server Anywhere does not support the Adaptive Server Enterprise Commit Service.
- **Capabilities** A client/server connection's **capabilities** determine the types of client requests and server responses permitted for that connection. The following capabilities are not supported:
  - CS_REG_NOTIF
  - CS_CSR_ABS
  - CS_CSR_FIRST
  - CS_CSR_LAST
  - CS_CSR_PREV
  - CS_CSR_REL
  - CS_DATA_BOUNDARY
  - CS_DATA_SENSITIVITY
  - CS_PROTO_DYNPROC
  - CS_REQ_BCP
- Security options, such as SSL and encrypted passwords, are not supported.
- Open Client applications may connect to Adaptive Server Anywhere using TCP/IP or using local machine NamedPipes protocol where available.

  For more information on capabilities, see the *Open Server Server-Library C Reference Manual*.

CHAPTER 11

Three-tier Computing and Distributed Transactions

About this chapter

This chapter describes how to use Adaptive Server Anywhere in a three-tier environment with an application server. It focuses on how to enlist Adaptive Server Anywhere in distributed transactions.

Contents

Introduction

You can use Adaptive Server Anywhere as a database server or **resource manager**, participating in distributed transactions coordinated by a transaction server.

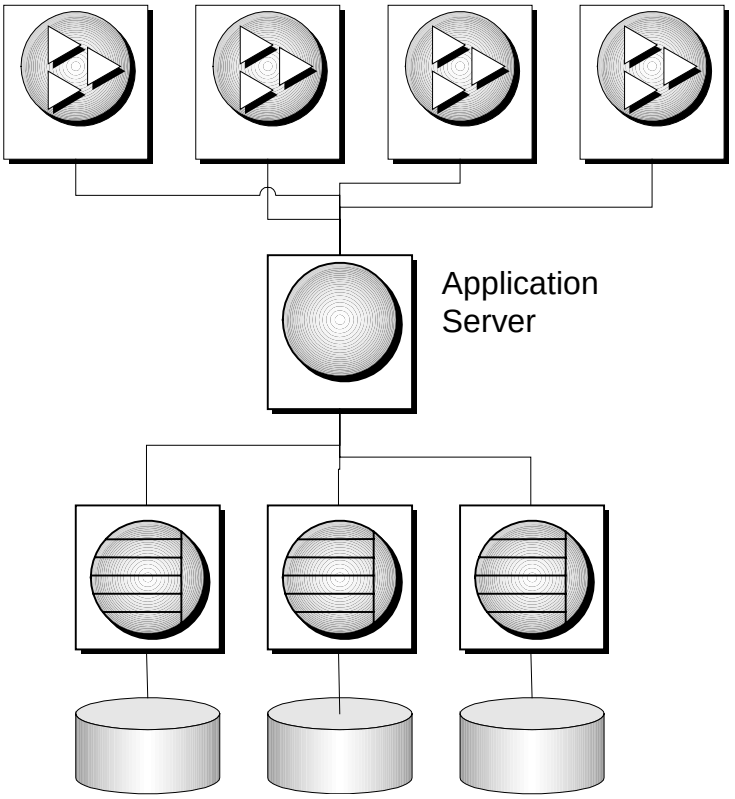
A three-tier environment, where an application server sits between client applications and a set of resource managers, is a common distributed-transaction environment. Sybase EAServer and some other application servers are also transaction servers.

Sybase EAServer and Microsoft Transaction Server both use the Microsoft Distributed Transaction Coordinator (DTC) to coordinate transactions. Adaptive Server Anywhere provides support for distributed transactions controlled by the DTC service, so you can use Adaptive Server Anywhere with either of these application servers, or any other product based on the DTC model.

When integrating Adaptive Server Anywhere into a three-tier environment, most of the work needs to be done from the Application Server. This chapter provides an introduction to the concepts and architecture of three-tier computing, and an overview of relevant Adaptive Server Anywhere features. It does not describe how to configure your Application Server to work with Adaptive Server Anywhere. For more information, see your Application Server documentation.

Three-tier computing architecture

In three-tier computing, application logic is held in an application server, such as Sybase EAServer, which sits between the resource manager and the client applications. In many situations, a single application server may access multiple resource managers. In the Internet case, client applications are browser-based, and the application server is generally a Web server extension.



Sybase EAServer stores application logic in the form of components, and makes these components available to client applications. The components may be PowerBuilder components, JavaBeans, or COM components.

For more information, see the Sybase EAServer documentation.

Distributed transactions in three-tier computing

When client applications or application servers work with a single transaction processing database, such as Adaptive Server Anywhere, there is no need for transaction logic outside the database itself, but when working with multiple resource managers, transaction control must span the resources involved in the transaction. Application servers provide transaction logic to their client applications—guaranteeing that sets of operations are executed atomically.

Many transaction servers, including Sybase EAServer, use the Microsoft Distributed Transaction Coordinator (DTC) to provide transaction services to their client applications. DTC uses **OLE transactions**, which in turn use the **two-phase commit** protocol to coordinate transactions involving multiple resource managers. You must have DTC installed in order to use the features described in this chapter.

Adaptive Server Anywhere in distributed transactions

Adaptive Server Anywhere can take part in transactions coordinated by DTC, which means that you can use Adaptive Server Anywhere databases in distributed transactions using a transaction server such as Sybase EAServer or Microsoft Transaction Server. You can also use DTC directly in your applications to coordinate transactions across multiple resource managers.

The vocabulary of distributed transactions

This chapter assumes some familiarity with distributed transactions. For information, see your transaction server documentation. This section describes some commonly used terms.

- **Resource managers** are those services that manage the data involved in the transaction.

  The Adaptive Server Anywhere database server can act as a resource manager in a distributed transaction when accessed through OLE DB or ODBC. The ODBC driver and OLE DB provider act as resource manager proxies on the client machine.

- Instead of communicating directly with the resource manager, application components may communicate with **resource dispensers**, which in turn manage connections or pools of connections to the resource managers.

  Adaptive Server Anywhere supports two resource dispensers: the ODBC driver manager and OLE DB.

- When a transactional component requests a database connection (using a resource manager), the application server **enlists** each database connection takes part in the transaction. DTC and the resource dispenser carry out the enlistment process.

Two-phase commit

Distributed transactions are managed using two-phase commit. When the work of the transaction is complete, the transaction manager (DTC) asks all the resource managers enlisted in the transaction whether they are ready to commit the transaction. This phase is called **preparing** to commit.

If all the resource managers respond that they are prepared to commit, DTC sends a commit request to each resource manager, and responds to its client that the transaction is completed. If one or more resource manager does not respond, or responds that it cannot commit the transaction, all the work of the transaction is rolled back across all resource managers.

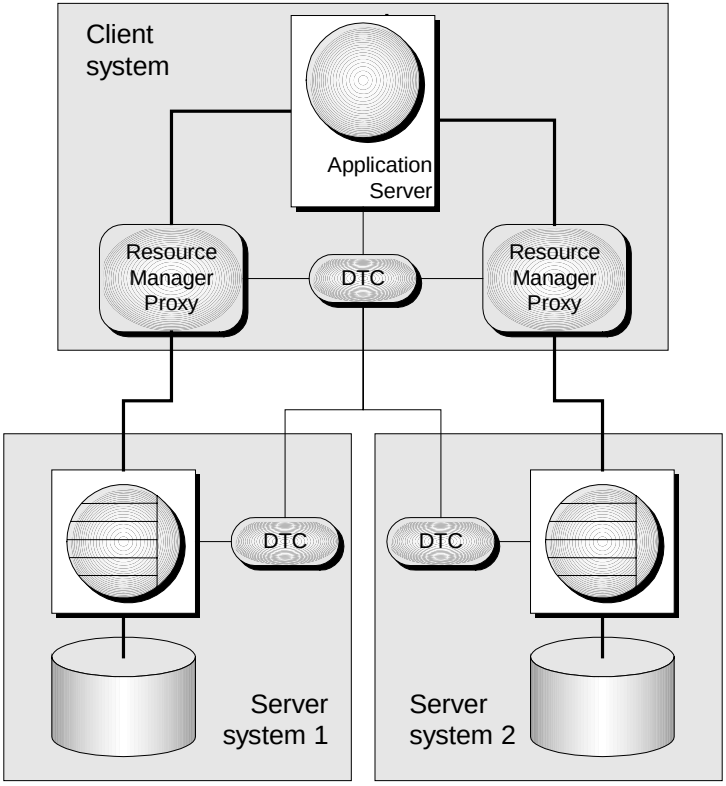
How application servers use DTC

Sybase EAServer and Microsoft Transaction Server are both component servers. The application logic is held in the form of components, and made available to client applications.

Each component has a transaction attribute that indicates how the component participates in transactions. The application developer building the component must program the work of the transaction into the component—the resource manager connections, the operations on the data for which each resource manager is responsible. However, the application developer does not need to add transaction management logic to the component. Once the transaction attribute is set, to indicate that the component needs transaction management, EAServer uses DTC to enlist the transaction and manage the two-phase commit process.

Distributed transaction architecture

The following diagram illustrates the architecture of distributed transactions. In this case, the resource manager proxy is either ODBC or OLE DB.



In this case, a single resource dispenser is used. The Application Server asks DTC to prepare a transaction. DTC and the resource dispenser enlist each connection in the transaction. Each resource manager must be in contact with both DTC and the database, so as to carry out the work and to notify DTC of its transaction status when required.

A DTC service must be running on each machine in order to operate distributed transactions. You can control DTC services from the Services icon in the Windows control panel; the DTC service is named **MSDTC**.

For more information, see your DTC or EAServer documentation.

Using distributed transactions

While Adaptive Server Anywhere is enlisted in a distributed transaction, it hands transaction control over to the transaction server, and Adaptive Server Anywhere ensures that it does not carry out any implicit transaction management. The following conditions are imposed automatically by Adaptive Server Anywhere when it participates in distributed transactions:

- Autocommit is automatically turned off, if it is in use.
- Data definition statements (which commit as a side effect) are disallowed during distributed transactions.
- An explicit COMMIT or ROLLBACK issued by the application directly to Adaptive Server Anywhere, instead of through the transaction coordinator, generates an error. The transaction is not aborted, however.
- A connection can participate in only a single distributed transaction at a time.
- There must be no uncommitted operations at the time the connection is enlisted in a distributed transaction.

DTC isolation levels

DTC has a set of isolation levels, which the application server specifies. These isolation levels map to Adaptive Server Anywhere isolation levels as follows:

DTC isolation level	Adaptive Server Anywhere isolation level
ISOLATIONLEVEL_UNSPECIFIED	0
ISOLATIONLEVEL_CHAOS	0
ISOLATIONLEVEL_READUNCOMMITTED	0
ISOLATIONLEVEL_BROWSE	0
ISOLATIONLEVEL_CURSORSTABILITY	1
ISOLATIONLEVEL_READCOMMITTED	1
ISOLATIONLEVEL_REPEATABLEREAD	2
ISOLATIONLEVEL_SERIALIZABLE	3
ISOLATIONLEVEL_ISOLATED	3

Recovery from distributed transactions

If the database server faults while uncommitted operations are pending, it must either rollback or commit those operations on startup to preserve the atomic nature of the transaction.

If uncommitted operations from a distributed transaction are found during recovery, the database server attempts to connect to DTC and requests that it be re-enlisted in the pending or in-doubt transactions. Once the re-enlistment is complete, DTC instructs the database server to roll back or commit the outstanding operations.

If the reenlistment process fails, Adaptive Server Anywhere has no way of knowing whether the in-doubt operations should be committed or rolled back, and recovery fails. If you want the database in such a state to recover, regardless of the uncertain state of the data, you can force recovery using the following database server options:

- **-tmf** If DTC cannot be located, the outstanding operations are rolled back and recovery continues.

  For more information, see "–tmf server option" on page 151 of the book *ASA Database Administration Guide*.

- **-tmt** If re-enlistment is not achieved before the specified time, the outstanding operations are rolled back and recovery continues.

  For more information, see "–tmt server option" on page 151 of the book *ASA Database Administration Guide*.

Using EAServer with Adaptive Server Anywhere

This section provides an overview of the actions you need to take in EAServer 3.0 or later to work with Adaptive Server Anywhere. For more detailed information, see the EAServer documentation.

Configuring EAServer

All components installed in a Sybase EAServer share the same transaction coordinator.

EAServer 3.0 and later offer a choice of transaction coordinators. You must use DTC as the transaction coordinator if you are including Adaptive Server Anywhere in the transactions. This section describes how to configure EAServer 3.0 to use DTC as its transaction coordinator.

The component server in EAServer is named Jaguar.

❖ **To configure an EAServer to use the Microsoft DTC transaction model:**

1 Ensure that your Jaguar server is running.

On Windows, the Jaguar server commonly runs as a service. To manually start the installed Jaguar server that comes with EAServer 3.0, select Start➤Programs➤Sybase➤EAServer➤EAServer.

2 Start Jaguar Manager.

From the Windows desktop, select Start➤Programs➤Sybase➤EAServer➤Jaguar Manager.

3 Connect to the Jaguar server from Jaguar Manager.

From the Sybase Central menu, choose Tools➤Connect➤Jaguar Manager. In the connection dialog, enter **jagadmin** as the User Name, leave the Password field blank, and enter a Host Name of **localhost**. Click OK to connect.

4 Set the transaction model for the Jaguar server.

In the left pane, open the Servers folder. In the right pane, right click on the server you wish to configure, and select Server Properties from the drop down menu. Click the Transactions tab, and choose Microsoft DTC as the transaction model. Click OK to complete the operation.

Setting the component transaction attribute

In EAServer you may implement a component that carries out operations on more than one database. You assign a **transaction attribute** to this component that defines how it participates in transactions. The transaction attribute can have the following values:

- **Not Supported** The component's methods never execute as part of a transaction. If the component is activated by another component that is executing within a transaction, the new instance's work is performed outside the existing transaction. This is the default.
- **Supports Transaction** The component can execute in the context of a transaction, but a connection is not required in order to execute the component's methods. If the component is instantiated directly by a base client, EAServer does not begin a transaction. If component A is instantiated by component B, and component B is executing within a transaction, component A executes in the same transaction.
- **Requires Transaction** The component always executes in a transaction. When the component is instantiated directly by a base client, a new transaction begins. If component A is activated by component B, and B is executing within a transaction, then A executes within the same transaction; if B is not executing in a transaction, then A executes in a new transaction.
- **Requires New Transaction** Whenever the component is instantiated, a new transaction begins. If component A is activated by component B, and B is executing within a transaction, then A begins a new transaction that is unaffected by the outcome of B's transaction; if B is not executing in a transaction, then A executes in a new transaction.

For example, in the Sybase Virtual University sample application, included with EAServer as the SVU package, the **SVUEnrollment** component **enroll()** method carries out two separate operations (reserves a seat in a course, bills the student for the course). These two operations need to be treated as a single transaction.

Microsoft Transaction Server provides the same set of attribute values.

❖ **To set the transaction attribute of a component:**

1. In Jaguar Manager, locate the component.

   To find the **SVUEnrollment** component in the Jaguar sample application, connect to the Jaguar server, open the Packages folder, and open the SVU package. The components in the package are listed in the right pane.

2. Set the transaction attribute for the desired component.

Right click the component, and select Component Properties from the popup menu. Click the Transaction tab, and choose the transaction attribute value from the list. Click OK to complete the operation.

The **SVUEnrollment** component is already marked as Requires Transaction.

Once the component transaction attribute is set, you can carry out Adaptive Server Anywhere operations from that component, and be assured of transaction processing at the level you have specified.

CHAPTER 12

Deploying Databases and Applications

About this chapter

This chapter describes how to deploy Adaptive Server Anywhere components. It identifies the files required for deployment, and addresses related issues such as connection settings.

Check your license agreement
Redistribution of files is subject to your license agreement. No statements in this document override anything in your license agreement. Please check your license agreement before considering deployment.

Contents

Deployment overview

When you have completed a database application, you must **deploy** the application to your end users. Depending on the way in which your application uses Adaptive Server Anywhere (as an embedded database, in a client/server fashion, and so on) you may have to deploy components of the Adaptive Server Anywhere software along with your application. You may also have to deploy configuration information, such as data source names, that enable your application to communicate with Adaptive Server Anywhere.

Check your license agreement
Redistribution of files is subject to your license agreement with Sybase. No statements in this document override anything in your license agreement. Please check your license agreement before considering deployment.

The following deployment steps are examined in this chapter:

- Determining required files based on the choice of application platform and architecture.
- Configuring client applications.

Much of the chapter deals with individual files and where they need to be placed. However, the recommended way of deploying Adaptive Server Anywhere components is to use the Installshield objects or to use a silent installation. For information, see "Using InstallShield objects and templates for deployment" on page 380, and "Using a silent installation for deployment" on page 382.

Deployment models

The files you need to deploy depend on the deployment model you choose. Here are some possible deployment models:

- **Client deployment** You may deploy only the client portions of Adaptive Server Anywhere to your end-users, so that they can connect to a centrally located network database server.
- **Network server deployment** You may deploy network servers to offices, and then deploy clients to each of the users within those offices.

- **Embedded database deployment** You may deploy an application that runs with the personal database server. In this case, both client and personal server need to be installed on the end-user's machine.
- **SQL Remote deployment** Deploying a SQL Remote application is an extension of the embedded database deployment model.
- **Database tools deployment** You may deploy Interactive SQL, Sybase Central and other management tools.

Ways to distribute files

There are two ways to deploy Adaptive Server Anywhere:

- **Use the Adaptive Server Anywhere installation** You can make the Setup program available to your end-users. By selecting the proper option, each end-user is guaranteed of getting the files they need.

  This is the simplest solution for many deployment cases. In this case, you must still provide your end users with a method for connecting to the database server (such as an ODBC data source).

  For more information, see "Using a silent installation for deployment" on page 382.

- **Develop your own installation** There may be reasons for you to develop your own installation program that includes Adaptive Server Anywhere files. This is a more complicated option, and most of this chapter addresses the needs of those who are developing their own installation.

  If Adaptive Server Anywhere has already been installed for the server type and operating system required by the client application architecture, the required files can be found in the appropriately named subdirectory, located in the Adaptive Server Anywhere installation directory.

  For example, assuming the default installation directory was chosen, the *win32* subdirectory of your installation directory contains the files required to run the server for Windows operating systems.

  As well, users of InstallShield Professional 5.5 and up can use the SQL Anywhere Studio InstallShield Template Projects to deploy their own application. This feature allows you to quickly build your application's installation using the entire template project, or just the parts that apply to your install.

Whichever option you choose, you must not violate the terms of your license agreement.

Understanding installation directories and file names

For a deployed application to work properly, the database server and client libraries must each be able to locate the files they need. The deployed files should be located relative to each other in the same fashion as your Adaptive Server Anywhere installation.

In practice, this means that on PCs, most files belong in a single directory. For example, on Windows both client and database server required files are installed in a single directory, which is the *win32* subdirectory of the Adaptive Server Anywhere installation directory.

☞ For a full description of the places where the software looks for files, see "How Adaptive Server Anywhere locates files" on page 206 of the book *ASA Database Administration Guide*.

UNIX deployment issues

UNIX deployments are different from PC deployments in some ways:

- **Directory structure** For UNIX installations, the directory structure is as follows:

Directory	Contents
/opt/sybase/SYBSsa8/bin	Executable files
/opt/sybase/SYBSsa8/lib	Shared objects and libraries
/opt/sybase/SYBSsa8/res	String files

  On AIX, the default root directory is */usr/lpp/sybase/SYBSsa8* instead of */opt/sybase/SYBSsa8*.

- **File extensions** In the tables in this chapter, the shared objects are listed with an extension *.so*. For HP-UX, the extension is *.sl*.

  On the AIX operating system, shared objects that applications need to link to are given the extension *.a*.

- **Symbolic links** Each shared object is installed as a symbolic link to a file of the same name with the additional extension *.1* (one). For example, the *libdblib8.so* is a symbolic link to the file *libdblib8.so.1* in the same directory.

If patches are required to the Adaptive Server Anywhere installation, these will be supplied with extension *.2*, and the symbolic link must be redirected.

- **Threaded and unthreaded applications** Most shared objects are provided in two forms, one of which has the additional characters *_r* before the file extension. For example, in addition to *libdblib8.so*, there is a file named *libdblib8_r.so*. In this case, threaded applications must be linked to the *_r* shared object, while non-threaded applications must be linked to the shared object without the *_r* characters.
- **Character set conversion** If you want to use database server character set conversion (the `-ct` server option), you need to include the following files:
  - libunic.so
  - charsets/ directory subtree
  - asa.cvf

For a description of the places where the software looks for files, see "How Adaptive Server Anywhere locates files" on page 206 of the book *ASA Database Administration Guide*.

File naming conventions

Adaptive Server Anywhere uses consistent file naming conventions to help identify and group system components.

These conventions include:

- **Version number** The Adaptive Server Anywhere version number is indicated in the filename of the main server components (*.exe* and *.dll* files).

  For example, the file *dbeng8.exe* is a Version 8 executable.
- **Language** The language used in a language resource library is indicated by a two-letter code within its filename. The two characters before the version number indicate the language used in the library. For example, *dblgen8.dll* is the language resource library for English. These two-letter codes are specified by ISO standard 639.

  For more information about language labels, see "Understanding the locale language" on page 263 of the book *ASA Database Administration Guide*.

You can download an International Resources Deployment Kit containing language resource deployment DLLs free of charge from the Sybase Web site.

❖ **To download the International Resources Deployment Kit from the Sybase Web site:**

1. Open the following URL in your Web browser:

   ```
   http://www.sybase.com/products/anywhere/
   ```

2. Under the heading SQL Anywhere Studio on the left hand side of the page, click Downloads.
3. Under the heading Emergency Bug Fix/Updates, click An assortment of Emergency Bug Fixes and Updates for SQL Anywhere Studio.
4. Login to your Sybase Web account.

   Click Create a New Account to create a Sybase Web account if you do not have one already.
5. From the list of available downloads, select the International Resources Deployment Kit that matches the platform and version of Adaptive Server Anywhere that you are currently using.

☞ For a list of the languages available in Adaptive Server Anywhere, see "Supplied collations" on page 269 of the book *ASA Database Administration Guide*.

Identifying other file types

The following table identifies the platform and function of Adaptive Server Anywhere files according to their file extension. Adaptive Server Anywhere follows standard file extension conventions where possible.

File extension	Platform	File type
.nlm	Novell NetWare	NetWare Loadable Module
.cnt, .ftg, .fts, .gid, .hlp, .chm, .chw	Windows	Help system file
.lib	Varies by development tool	Static runtime libraries for the creation of embedded SQL executables
.cfg, .cpr, .dat, .loc, .spr, .srt, .xlt	Windows	Sybase Adaptive Server Enterprise components
.cmd .bat	Windows	Command files
.res	NetWare, UNIX	Language resource file for non-Windows environments
.dll	Windows	Dynamic Link Library
.so .sl .a	UNIX	Shared object (Sun Solaris and IBM AIX) or shared library (HP-UX) file. The equivalent of a DLL on PC platforms.

Database file names

Adaptive Server Anywhere databases are composed of two elements:

- **Database file** This is used to store information in an organized format. This file uses a *.db* file extension.
- **Transaction log file** This is used to record all changes made to data stored in the database file. This file uses a *.log* file extension, and is generated by Adaptive Server Anywhere if no such file exists and a log file is specified to be used. A mirrored transaction log has the default extension of *.mlg*.
- **Write file** If your application uses a write file, it typically has a *.wrt* file extension.
- **Compressed database file** If you supply a read-only compressed database file, it typically has extension *.cdb*.

These files are updated, maintained and managed by the Adaptive Server Anywhere relational database-management system.

Using InstallShield objects and templates for deployment

If you are using InstallShield 6 and up, you can include SQL Anywhere Studio InstallShield Objects in your install program. The objects for deploying clients, personal database servers, network servers, and administration tools are found in the *deployment\Object* directory under your SQL Anywhere directory.

Users of InstallShield Professional 5.5 and up can use SQL Anywhere Studio InstallShield Template Projects to ease the deployment workload. Templates for deploying a network server, personal server, client interfaces, and administration tools can be found in the *SQL Anywhere 8\deployment\Templates* folder.

If you have InstallShield 6 or later, the Objects are recommended rather than the templates, as they are more easily incorporated into an install along with other components.

❖ **To add a template project to your InstallShield IDE:**

1. Start InstallShield IDE.
2. Choose File➤Open.
3. Navigate to your SQL Anywhere 8 installation and to the deployment folder

   For example, navigate to

   ```
   C:\Program Files\Sybase\SQL Anywhere 8\deployment
   ```
4. Open the Template folder corresponding to the type of object you want to deploy.

   You can choose NetworkServer, PersonalServer, Client, or JavaTools.
5. Select the file with the *.ipr* extension.

   The project opens in the InstallShield IDE. The Projects pane displays an icon for the template.

   The templates will be modified at install time so that the paths to the individual files listed in all of the *.fgl* files point to the actual install of ASA. Simply load the template in the InstallShield IDE, build the media, and the template will run immediately.

Notes:

When building the media, you will see warnings about empty file groups. These warnings are caused by empty file groups which have been added to the templates as placeholders for your application's files. To remove these warnings, you can either add your application's files to the file groups, or delete or rename the file groups.

Using a silent installation for deployment

Silent installations run without user input and with no indication to the user that an installation is occurring. On Windows operating systems you can call the Adaptive Server Anywhere InstallShield setup program from your own setup program in such a way that the Adaptive Server Anywhere installation is silent. Silent installs are also used with Microsoft's Systems Management Server (see "SMS Installation" on page 384).

You can use a silent installation for any of the deployment models described in "Deployment models" on page 374. You can also use a silent installation for deploying MobiLink synchronization servers.

Creating a silent install

The installation options used by a silent installation are obtained from a **response file**. The response file is created by running the Adaptive Server Anywhere *setup* program using the `-r` option. A silent install is performed by running *setup* using the `-s` option.

Do not use the browse buttons
When creating a silent install do not use the browse buttons. The recording of the browse buttons is not reliable.

❖ **To create a silent install:**

1. (Optional) Remove any existing installations of Adaptive Server Anywhere.
2. Open a system command prompt, and change to the directory containing the install image (including *setup.exe*, *setup.ins*, and so on).
3. Install the software, using Record mode.

   Type the following command:

   ```
   setup -r
   ```

   This command runs the Adaptive Server Anywhere setup program and creates the response file from your selections. The response file is named *setup.iss*, and is located in your *Windows* directory. This file contains the responses you made to the dialog boxes during installation.

   When run in record mode, the installation program does not offer to reboot your operating system, even if a reboot is needed.

4 Install Adaptive Server Anywhere using the options, and settings that you want to be used when you deploy Adaptive Server Anywhere on the end-user's machine for use with your application. You can override the paths during the silent install.

Running a silent install

Your own installation program must call the Adaptive Server Anywhere silent install using the `-s` option. This section describes how to use a silent install.

❖ **To use a silent install:**

1 Add the command to invoke the Adaptive Server Anywhere silent install to your installation procedure.

If the response file is present in the install image directory, you can run the silent install by entering the following command from the directory containing the install image:

```
setup -s
```

If the response file is located elsewhere you must specify the response file location using the `-f1` option. There must be no space between `f1` and the quotation mark in the following command line.

```
setup -s -f1"c:\winnt\setup.iss"
```

To invoke the install from another InstallShield script you could use the following:

```
DoInstall( "ASA_install_image_path\SETUP.INS",
   "-s", WAIT );
```

You can use options to override the choices of paths for both the Adaptive Server Anywhere directory and the shared directory:

```
setup TARGET_DIR=dirname SHARED_DIR=shared_dir -s
```

The TARGET_DIR and SHARED_DIR arguments must precede all other options.

2 Check whether the target computer needs to reboot.

Setup creates a file named *silent.log* in the target directory. This file contains a single section called **ResponseResult** containing the following line:

```
Reboot=value
```

This line indicates whether the target computer needs to be rebooted to complete the installation, and has a value of 0 or 1, with the following meanings.

- **Reboot=0** No reboot is needed.
- **Reboot=1** The BATCH_INSTALL flag was set during the installation, and the target computer does need to be rebooted. The installation procedure that called the silent install is responsible for checking the Reboot entry and for rebooting the target computer, if necessary.

3 Check that the setup completed properly.

Setup creates a file named *setup.log* in the directory containing the response file. The log file contains a report on the silent install. The last section of this file is called **ResponseResult**, and contains the following line:

```
ResultCode=value
```

This line indicates whether the installation was successful. A non-zero ResultCode indicates an error occurred during installation. For a description of the error codes, see your InstallShield documentation.

SMS Installation

Microsoft System Management Server (SMS) requires a silent install that does not reboot the target computer. The Adaptive Server Anywhere silent install does not reboot the computer.

Your SMS distribution package should contain the response file, the install image and the *asa8.pdf* package definition file (provided on the Adaptive Server Anywhere CD ROM in the *\extras* folder). The setup command in the PDF file contains the following options:

- The `-s` option for a silent install
- The `-SMS` option to indicate that it is being invoked by SMS.
- The `-m` option to generate a MIF file. The MIF file is used by SMS to determine whether the installation was successful.

Deploying client applications

In order to deploy a client application that runs against a network database server, you must provide each end user with the following items:

- **Client application** The application software itself is independent of the database software, and so is not described here.
- **Database interface files** The client application requires the files for the database interface it uses (ODBC, JDBC, embedded SQL, or Open Client).
- **Connection information** Each client application needs database connection information.

The interface files and connection information required varies with the interface your application is using. Each interface is described separately in the following sections.

The simplest way to deploy clients is to use the supplied InstallShield objects. For more information, see "Using InstallShield objects and templates for deployment" on page 380.

Deploying OLE DB and ADO clients

The simplest way to deploy OLE DB client libraries is to use the InstallShield objects or templates. For information, see "Using InstallShield objects and templates for deployment" on page 380. If you wish to create your own installation, this section describes the files to deploy to the end users.

Each OLE DB client machine must have the following:

- **A working OLE DB installation** OLE DB files and instructions for their redistribution are available for redistribution from Microsoft Corporation. They are not described in detail here.
- **The Adaptive Server Anywhere OLE DB provider** The following table shows the files needed for a working Adaptive Server Anywhere OLE DB provider. These files should be placed in a single directory. The Adaptive Server Anywhere installation places them all in the operating-system subdirectory of your SQL Anywhere installation directory (for example: *win32*).

Description	Windows	Windows CE
OLE DB driver file	*dboledb8.dll*	*dboledb8.dll*
OLE DB driver file	*dboledba8.dll*	*dboledba8.dll*
Language-resource library	*dblgen8.dll*	*dblgen8.dll*
Connect dialog	*dbcon8.dll*	*N/A*

OLE DB providers require many registry entries. You can make these by self-registering the DLLs using the *regsvr32* utility on Windows or the *regsvrce* utility on Windows CE.

For more information, see "Creating databases for Windows CE" on page 273 of the book *ASA Database Administration Guide*, and "Linking ODBC applications on Windows CE" on page 255.

Deploying ODBC clients

The simplest way to deploy ODBC clients is to use the InstallShield objects or templates. For information, see "Using InstallShield objects and templates for deployment" on page 380.

Each ODBC client machine must have the following:

- **A working ODBC installation** ODBC files and instructions for their redistribution are available for redistribution from Microsoft Corporation. They are not described in detail here.

  Microsoft provides their ODBC Driver Manager for Windows operating systems. SQL Anywhere Studio includes an ODBC Driver Manager for UNIX. There is no ODBC Driver Manager for Windows CE.

  ODBC applications can run without the driver manager. On platforms for which an ODBC driver manager is available, this is not recommended.

  Update ODBC if needed
  The SQL Anywhere Setup program updates old installations of the Microsoft Data Access Components, including ODBC. If you are deploying your own application, you must ensure that the ODBC installation is sufficient for your application.

- **The Adaptive Server Anywhere ODBC driver** This is the file *dbodbc8.dll* together with some additional files.

For more information, see "ODBC driver required files" on page 387.

- **Connection information** The client application must have access to the information needed to connect to the server. This information is typically included in an ODBC data source.

ODBC driver required files

The following table shows the files needed for a working Adaptive Server Anywhere ODBC driver. These files should be placed in a single directory. The Adaptive Server Anywhere installation places them all in the operating-system subdirectory of your SQL Anywhere installation directory (for example: *win32*).

Description	Windows	Windows CE	UNIX
ODBC driver	*dbodbc8.dll*	*dbodbc8.dll*	*libdbodbc8.so* *libdbtasks8.so*
Language-resource library	*dblgen8.dll*	*dblgen8.dll*	*dblgen8.res*
Connect dialog	*dbcon8.dll*	*N/A*	*N/A*

Notes

- Your end user must have a working ODBC installation, including the driver manager. Instructions for deploying ODBC are included in the Microsoft ODBC SDK.
- The Connect dialog is needed if your end users are to create their own data sources, if they need to enter user IDs and passwords when connecting to the database, or if they need to display the Connect dialog for any other purpose.
- For multi-threaded applications on UNIX, use *libdbodbc8_r.so* and *libdbtasks8_r.so*.

Configuring the ODBC driver

In addition to copying the ODBC driver files onto disk, your Setup program must also make a set of registry entries to install the ODBC driver properly.

Windows

The Adaptive Server Anywhere Setup program makes changes to the Registry to identify and configure the ODBC driver. If you are building a setup program for your end users, you should make the same settings.

You can use the *regedit* utility to inspect registry entries.

The Adaptive Server Anywhere ODBC driver is identified to the system by a set of registry values in the following registry key:

```
HKEY_LOCAL_MACHINE\
    SOFTWARE\
        ODBC\
            ODBCINST.INI\
                Adaptive Server Anywhere 8.0
```

The values are as follows:

Value name	Value type	Value data
Driver	String	*path*\dbodbc8.dll
Setup	String	*path*\dbodbc8.dll

There is also a registry value in the following key:

```
HKEY_LOCAL_MACHINE\
    SOFTWARE\
        ODBC\
            ODBCINST.INI\
                ODBC Drivers
```

The value is as follows:

Value name	Value type	Value data
Adaptive Server Anywhere 8.0	String	Installed

Third party ODBC drivers

If you are using a third-party ODBC driver on an operating system other than Windows, consult the documentation for that driver on how to configure the ODBC driver.

Deploying connection information

ODBC client connection information is generally deployed as an ODBC data source. You can deploy an ODBC data source in one of the following ways:

- **Programmatically** Add a data source description to your end-user's Registry or ODBC initialization files.
- **Manually** Provide your end-users with instructions, so that they can create an appropriate data source on their own machine.

You create a data source manually using the ODBC Administrator, from the User DSN tab or the System DSN tab. The Adaptive Server Anywhere ODBC driver displays the configuration dialog for entering settings. Data source settings include the location of the database file, the name of the database server, as well as any start up parameters and other options.

This section provides you with the information you need to know for either approach.

Types of data source

There are three kinds of data sources: User data sources, System data sources, and File data sources.

User data source definitions are stored in the part of the registry containing settings for the specific user currently logged on to the system. System data sources, however, are available to all users and to Windows services, which run regardless of whether a user is logged onto the system or not. Given a correctly configured System data source named MyApp, any user can use that ODBC connection by providing DSN=MyApp in the ODBC connection string.

File data sources are not held in the registry, but are held in a special directory. A connection string must provide a FileDSN connection parameter to use a File data source.

Data source registry entries

Each user data source is identified to the system by registry entries.

You must enter a set of registry values in a particular registry key. For User data sources the key is as follows:

```
HKEY_CURRENT_USER\
    SOFTWARE\
        ODBC\
            ODBC.INI\
                userdatasourcename
```

For System data sources the key is as follows:

```
HKEY_LOCAL_MACHINE\
    SOFTWARE\
        ODBC\
            ODBC.INI\
                systemdatasourcename
```

The key contains a set of registry values, each of which corresponds to a connection parameter. For example, the ASA 8.0 Sample key corresponding to the ASA 8.0 Sample data source contains the following settings:

Value name	Value type	Value data
Autostop	String	Yes
DatabaseFile	String	*Path*\asademo.db
Description	String	Adaptive Server Anywhere Sample Database
Driver	String	*Path*\win32\dbodbc8.dll
PWD	String	sql
Start	String	*Path*\win32\dbeng8.exe -c 8m
UID	String	dba

In these entries, *path* is the Adaptive Server Anywhere installation directory.

In addition, you must add the data source to the list of data sources in the registry. For User data sources, you use the following key:

```
HKEY_CURRENT_USER\
    SOFTWARE\
        ODBC\
            ODBC.INI\
                ODBC Data Sources
```

For System data sources, use the following key:

```
HKEY_LOCAL_MACHINE\
    SOFTWARE\
        ODBC\
            ODBC.INI\
                ODBC Data Sources.
```

The value associates each data source with an ODBC driver. The value name is the data source name, and the value data is the ODBC driver name. For example, the User data source installed by Adaptive Server Anywhere is named ASA 8.0 Sample, and has the following value:

Value name	Value type	Value data
ASA 8.0 Sample	String	Adaptive Server Anywhere 8.0

Caution: ODBC settings are easily viewed
User data source configurations can contain sensitive database settings such as a user's ID and password. These settings are stored in the registry in plain text, and can be view using the Windows registry editors regedit.exe *or* regedt32.exe, *which are provided by Microsoft with the operating system. You can choose to encrypt passwords, or require users to enter them on connecting.*

Required and optional connection parameters

You can identify the data source name in an ODBC configuration string in this manner,

```
DSN=userdatasourcename
```

When a DSN parameter is provided in the connection string, the Current User data source definitions in the Registry are searched, followed by System data sources. File data sources are searched only when FileDSN is provided in the ODBC connection string.

The following table illustrates the implications to the user and developer when a data source exists and is included in the application's connection string as a DSN or FileDSN parameter.

When the data source…	The connection string must also identify…	The user must supply…
Contains the ODBC driver name and location; the name of the database file/server; startup parameters; and the user ID and password.	No additional information	No additional information.
Contains only the name and location of the ODBC driver.	The name of the database file/ server; and, optionally, the user ID and the password.	User ID and password if not provided in the DSN or ODBC connection string.
Does not exist	The name of the ODBC driver to be used, in the following format: `Driver={ODBCdrivername}` Also, the name of the database, the database file or the database server; and, optionally, other connection parameters such as user ID and password.	User ID and password if not provided in the ODBC connection string.

For more information on ODBC connections and configurations, see the following:

- "Connecting to a Database" on page 37 of the book *ASA Database Administration Guide*.
- The Open Database Connectivity (ODBC) SDK, available from Microsoft.

Deploying embedded SQL clients

The simplest way to deploy embedded SQL clients is to use the InstallShield objects or templates. For information, see "Using InstallShield objects and templates for deployment" on page 380.

Deploying embedded SQL clients involves the following:

- **Installed files** Each client machine must have the files required for an Adaptive Server Anywhere embedded SQL client application.
- **Connection information** The client application must have access to the information needed to connect to the server. This information may be included in an ODBC data source.

Installing files for embedded SQL clients

The following table shows which files are needed for embedded SQL clients.

Description	Windows	UNIX
Interface library	*dblib8.dll*	*libdblib8.so, libdbtasks8.so*
Language resource library	*dblgen8.dll*	*dblgen8.res*
IPX network communications	*dbipx8.dll*	*N/A*
Connect dialog	*dbcon8.dll*	*N/A*

Notes

- The network ports DLL is not required if the client is working only with the personal database server.
- If the client application uses an ODBC data source to hold the connection parameters, your end user must have a working ODBC installation. Instructions for deploying ODBC are included in the Microsoft ODBC SDK.

  For more information on deploying ODBC information, see "Deploying ODBC clients" on page 386.
- The Connect dialog is needed if your end users will be creating their own data sources, if they will need to enter user IDs and passwords when connecting to the database, or if they need to display the Connect dialog for any other purpose.
- For multi-threaded applications on UNIX, use *libdblib8_r.so* and *libdbtasks8_r.so*.

Connection information

You can deploy embedded SQL connection information in one of the following ways:

- **Manual** Provide your end-users with instructions for creating an appropriate data source on their machine.
- **File** Distribute a file that contains connection information in a format that your application can read.
- **ODBC data source** You can use an ODBC data source to hold connection information. In this case, you need a subset of the ODBC redistributable files, available from Microsoft. For details see "Deploying ODBC clients" on page 386.
- **Hard coded** You can hard code connection information into your application. This is an inflexible method, which may be limiting, for example when databases are upgraded.

Deploying JDBC clients

In addition to a Java Runtime Environment, each JDBC client requires the Sybase jConnect JDBC driver or the JDBC-ODBC bridge.

For instructions on deploying jConnect see http://manuals.sybase.com/onlinebooks/group-jc/jcg0420e/jconnig on the Sybase Web site.

To deploy the JDBC-ODBC bridge, you must deploy the following files:

- *jodbc.jar* This must be in the application's classpath.
- *dbjodbc8.dll* This must be in the system path. On UNIX or Linux environments, the file is a shared library (*dbjodbc8.so*).
- The ODBC driver files. For more information, see "ODBC driver required files" on page 387.

Your Java application needs a URL in order to connect to the database. This URL specifies the driver, the machine to use, and the port on which the database server is listening.

For more information on URLs, see "Supplying a URL for the server" on page 138.

Deploying Open Client applications

In order to deploy Open Client applications, each client machine needs the Sybase Open Client product. You must purchase the Open Client software separately from Sybase. It contains its own installation instructions.

☞ Connection information for Open Client clients is held in the interfaces file. For information on the interfaces file, see the Open Client documentation and "Configuring Open Servers" on page 110 of the book *ASA Database Administration Guide*.

Deploying administration tools

Subject to your license agreement, you can deploy a set of administration tools including Interactive SQL, Sybase Central, and the dbconsole monitoring utility.

The simplest way to deploy the administration tools is to use the supplied InstallShield objects. For more information, see "Using InstallShield objects and templates for deployment" on page 380.

Deploying Interactive SQL

If your customer application is running on machines with limited resources, you may want to deploy the C version of Interactive SQL, (*dbisqlc.exe*) instead of the standard version (*dbisql.exe* and its associated Java classes).

The *dbisqlc* executable requires the standard embedded SQL client-side libraries.

For information on system requirements for administration tools, see "Administration tool system requirements" on page 139 of the book *Introducing SQL Anywhere Studio.*

Deploying database servers

You can deploy a database server by making the SQL Anywhere Studio Setup program available to your end-users. By selecting the proper option, each end-user is guaranteed of getting the files they need.

The simplest way to deploy a personal database server or a network database server is to use the supplied InstallShield objects. For more information, see "Using InstallShield objects and templates for deployment" on page 380.

In order to run a database server, you need to install a set of files. The files are listed in the following table. All redistribution of these files is governed by the terms of your license agreement. You must confirm whether you have the right to redistribute the database server files before doing so.

Windows	UNIX	NetWare
dbeng8.exe	*dbeng8*	N/A
dbsrv8.exe	*dbsrv8*	*dbsrv8.nlm*
dbserv8.dll	*libdbserv8.so, libdbtasks8_r.so*	N/A
dblgen8.dll	*dblgen8.res*	*dblgen8.res*
dbjava8.dll (1)	*libdbjava8.so* (1)	*dbjava8.nlm* (1)
dbctrs8.dll	N/A	N/A
dbextf.dll (2)	*libdbextf.so* (2)	*dbextf.nlm* (2)
asajdbc.zip (1,3)	*asajdbc.zip* (1,3)	*asajdbc.zip* (1,3)
asajrt12.zip (1,3)	*asajrt12.zip* (1,3)	*asajrt12.zip* (1,3)
classes.zip (1,3)	*classes.zip* (1,3)	*classes.zip* (1,3)
dbmem.vxd (4)	N/A	N/A
libunic.dll	*libunic.so*	N/A
asa.cvf	*asa.cvf*	*asa.cvf*
charsets\ directory	*charsets/ directory*	N/A

1. Required only if using Java in the database. For databases initialized using JDK 1.1, distribute asajdbc.zip. For databases initialized using JDK 1.2 or JDK 1.3, distribute asajrt13.zip.
2. Required only if using system extended stored procedures and functions (xp_).
3. Install such that the CLASSPATH environment variable can locate classes in this file.
4. Required on Windows 95/98/Me if using dynamic cache sizing.

Notes

- Depending on your situation, you should choose whether to deploy the personal database server (*dbeng8*) or the network database server (*dbsrv8*).

- The Java DLL (*dbjava8.dll*) is required only if the database server is to use the Java in the Database functionality.
- The table does not include files needed to run utilities such as *dbbackup*.

  For information about deploying utilities, see "Deploying administration tools" on page 395.
- The zip files are required only for applications that use Java in the database, and must be installed into a location in the user's CLASSPATH environment variable.

Deploying databases

You deploy a database file by installing the database file onto your end user's disk.

As long as the database server shuts down cleanly, you do not need to deploy a transaction log file with your database file. When your end-user starts running the database, a new transaction log is created.

For SQL Remote applications, the database should be created in a properly synchronized state, in which case no transaction log is needed. You can use the Extraction utility for this purpose.

Deploying databases on read-only media

You can distribute databases on read-only media, such as a CD-ROM, as long as you run them in read-only mode or use a write file.

For more information on running databases in read-only mode, see "–r server option" on page 149 of the book *ASA Database Administration Guide*.

To enable changes to be made to Adaptive Server Anywhere databases distributed on read-only media such as a CD-ROM, you can use a **write file**. The write file records changes made to a read-only database file, and is located on a read/write storage media such as a hard disk.

In this case, the database file is placed on the CD-ROM, while the write file is placed on disk. The connection is made to the write file, which maintains a transaction log file on disk.

For more information on write files, see "Working with write files" on page 224 of the book *ASA Database Administration Guide*.

Deploying embedded database applications

This section provides information on deploying embedded database applications, where the application and the database both reside on the same machine.

An embedded database application includes the following:

- **Client application** This includes the Adaptive Server Anywhere client requirements.

  For information on deploying client applications, see "Deploying client applications" on page 385.

- **Database server** The Adaptive Server Anywhere personal database server.

  For information on deploying database servers, see "Deploying database servers" on page 396.

- **SQL Remote** If your application uses SQL Remote replication, you must deploy the SQL Remote Message Agent.

- **The database** You must deploy a database file holding the data the application uses.

Deploying personal servers

When you deploy an application that uses the personal server, you need to deploy both the client application components and the database server components.

The language resource library (*dblgen8.dll*) is shared between the client and the server. You need only one copy of this file.

It is recommended that you follow the Adaptive Server Anywhere installation behavior, and install the client and server files in the same directory.

Remember to provide the Java zip files and the Java DLL if your application takes advantage of Java in the Database.

Deploying database utilities

If you need to deploy database utilities (such as *dbbackup.exe*) along with your application, then you need the utility executable together with the following additional files:

Description	Windows	UNIX
Database tools library	*dbtool8.dll*	*libdbtools8.so, libdbtasks8.so*
Additional library	*dbwtsp8.dll*	*libdbwtsp8.so*
Language resource library	*dblgen8.dll*	*dblgen8.res*
Connect dialog (dbisqlc only)	*dbcon8.dll*	

Notes

- The database tools are embedded SQL applications, and you must supply the files required for such applications, as listed in "Deploying embedded SQL clients" on page 392.
- For multi-threaded applications on UNIX, use *libdbtools8_r.so* and *libdbtasks8_r.so*.

Deploying SQL Remote

If you are deploying the SQL Remote Message Agent, you need to include the following files:

Description	Windows	UNIX
Message Agent	*dbremote.exe*	*dbremote*
Database tools library	*dbtool8.dll*	*libdbtools8.so, libdbtasks8.so*
Additional library	*dbwtsp8.dll*	*libdbwtsp8.so*
Language resource library	*dblgen8.dll*	*dblgen8.res*
VIM message link library [1]	*dbvim8.dll*	
SMTP message link library [1]	*dbsmtp8.dll*	
FILE message link library [1]	*dbfile8.dll*	*libdbfile8.so*
FTP message link library [1]	*dbftp8.dll*	
MAPI message link library [1]	*dbmapi8.dll*	
Interface Library	*dblib8.dll*	

1 Only deploy the library for the message link you are using.

It is recommended that you follow the Adaptive Server Anywhere installation behavior, and install the SQL Remote files in the same directory as the Adaptive Server Anywhere files.

For multi-threaded applications on UNIX, use *libdbtools8_r.so* and *libdbtasks8_r.so*.

CHAPTER 13

SQL Preprocessor Error Messages

About this chapter

This chapter presents a list of all SQL preprocessor errors and warnings.

Contents

SQL Preprocessor error messages indexed by error message value

Message value	Message
2601	"subscript value %1 too large" on page 419
2602	"combined pointer and arrays not supported for host types" on page 411
2603	"only one dimensional arrays supported for char type" on page 418
2604	"VARCHAR type must have a length" on page 410
2605	"arrays of VARCHAR not supported" on page 410
2606	"VARCHAR host variables cannot be pointers" on page 409
2607	"initializer not allowed on VARCHAR host variable" on page 415
2608	"FIXCHAR type must have a length" on page 407
2609	"arrays of FIXCHAR not supported" on page 410
2610	"arrays of this type not supported" on page 411
2611	"precision must be specified for decimal type" on page 419
2612	"arrays of decimal not allowed" on page 410
2613	"Unknown hostvar type" on page 409
2614	"invalid integer" on page 416
2615	"'%1' host variable must be a C string type" on page 406
2617	"'%1' symbol already defined" on page 406
2618	"invalid type for sql statement variable" on page 416

Message value	Message
2619	"Cannot find include file '%1'" on page 407
2620	"host variable '%1' is unknown" on page 413
2621	"indicator variable '%1' is unknown" on page 414
2622	"invalid type for indicator variable '%1'" on page 416
2623	"invalid host variable type on '%1'" on page 416
2625	"host variable '%1' has two different definitions" on page 413
2626	"statement '%1' not previously prepared" on page 419
2627	"cursor '%1' not previously declared" on page 411
2628	"unknown statement '%1'" on page 421
2629	"host variables not allowed for this cursor" on page 413
2630	"host variables specified twice - on declare and open" on page 414
2631	"must specify a host list or using clause on %1" on page 417
2633	"no INTO clause on SELECT statement" on page 418
2634	"incorrect SQL language usage -- that is a '%1' extension" on page 414
2635	"incorrect Embedded SQL language usage -- that is a '%1' extension" on page 414
2636	"incorrect Embedded SQL syntax" on page 414
2637	"missing ending quote of string" on page 417
2639	"token too long" on page 420
2640	"'%1' host variable must be an integer type" on page 406

Message value	Message
2641	"must specify an SQLDA on a DESCRIBE" on page 417
2642	"Two SQLDAs specified of the same type (INTO or USING)" on page 409
2646	"cannot describe static cursors" on page 411
2647	"Macros cannot be redefined" on page 409
2648	"Invalid array dimension" on page 408
2649	"invalid descriptor index" on page 415
2650	"invalid field for SET DESCRIPTOR" on page 415
2651	"field used more than once in SET DESCRIPTOR statement" on page 412
2652	"data value must be a host variable" on page 411
2660	"Into clause not allowed on declare cursor - ignored" on page 408
2661	"unrecognized SQL syntax" on page 421
2662	"unknown sql function '%1'" on page 420
2663	"wrong number of parms to sql function '%1'" on page 421
2664	"static statement names will not work properly if used by 2 threads" on page 419
2665	"host variable '%1' has been redefined" on page 413
2666	"vendor extension" on page 421
2667	"intermediate SQL feature" on page 415
2668	"full SQL feature" on page 412
2669	"transact SQL extension" on page 420

Message value	Message
2680	"no declare section and no INCLUDE SQLCA statement" on page 418
2681	"unable to open temporary file" on page 420
2682	"error reading temporary file" on page 412
2683	"error writing output file" on page 412
2690	"Inconsistent number of host variables for this cursor" on page 408
2691	"Inconsistent host variable types for this cursor" on page 407
2692	"Inconsistent indicator variables for this cursor" on page 408
2693	"Feature not available with UltraLite" on page 407
2694	"no OPEN for cursor '%1'" on page 418
2695	"no FETCH or PUT for cursor '%1'" on page 417
2696	"Host variable '%1' is in use more than once with different indicators" on page 407
2697	"long binary/long varchar size limit is 65535 for UltraLite" on page 417

SQLPP errors

This section lists messages generated by the SQL preprocessor. The messages may be errors or warnings, or either depending on which command-line options are set.

For more information about the SQL Preprocessor and its command-line options, see "The SQL preprocessor" on page 226.

'%1' host variable must be a C string type

Message value	Message Type
2615	Error

Probable cause

A C string was required in an embedded SQL statement (for a cursor name, option name etc.) and the value supplied was not a C string.

'%1' host variable must be an integer type

Message value	Message Type
2640	Error

Probable cause

You have used a host variable that is not of integer type in a statement where only an integer type host variable is allowed.

'%1' symbol already defined

Message value	Message Type
2617	Error

Probable cause

You defined a host variable twice.

Cannot find include file '%1'

Message value	Message Type
2619	Error

Probable cause The specified include file was not found. Note that the preprocessor will use the INCLUDE environment variable to search for include files.

FIXCHAR type must have a length

Message value	Message Type
2608	Error

Probable cause You have used the DECL_FIXCHAR macro to declare a host variable of type FIXCHAR but have not specified a length.

Feature not available with UltraLite

Message value	Message Type
2693	Flag (warning or error)

Probable cause You have used a feature that is not supported by UltraLite.

Host variable '%1' is in use more than once with different indicators

Message value	Message Type
2696	Error

Probable cause You have used the same host variable multiple times with different indicator variables in the same statement. This is not supported.

Inconsistent host variable types for this cursor

Message value	Message Type
2691	Error

Probable cause You have used a host variable with a different type or length than the type or length previously used with the cursor. Host variable types must be consistent for the cursor.

Inconsistent indicator variables for this cursor

Message value	Message Type
2692	Error

Probable cause You have used an indicator variable when one was not previously used with the cursor, or you have not used an indicator variable when one was previously used with the cursor. Indicator variable usage must be consistent for the cursor.

Inconsistent number of host variables for this cursor

Message value	Message Type
2690	Error

Probable cause You have used a different number of host variables than the number previously used with the cursor. The number of host variables must be consistent for the cursor.

Into clause not allowed on declare cursor - ignored

Message value	Message Type
2660	Warning

Probable cause You have used an INTO clause on a DECLARE CURSOR statement. The INTO clause will be ignored.

Invalid array dimension

Message value	Message Type
2648	Error

Probable cause The array dimension of the variable is negative.

Macros cannot be redefined

Message value	Message Type
2647	Error

Probable cause A preprocessor macro has been defined twice, possibly in a header file.

Two SQLDAs specified of the same type (INTO or USING)

Message value	Message Type
2642	Error

Probable cause You have specified two INTO DESCRIPTOR or two USING DESCRIPTOR clauses for this statement.

Unknown hostvar type

Message value	Message Type
2613	Error

Probable cause You declared a host variable of a type not understood by the SQL preprocessor.

VARCHAR host variables cannot be pointers

Message value	Message Type
2606	Error

Probable cause You have attempted to declare a host variable as a pointer to a VARCHAR or BINARY. This is not a legal host variable type.

VARCHAR type must have a length

Message value	Message Type
2604	Error

Probable cause You have attempted to declare a VARCHAR or BINARY host variable using the DECL_VARCHAR or DECL_BINARY macro but have not specified a size for the array.

arrays of FIXCHAR not supported

Message value	Message Type
2609	Error

Probable cause You have attempted to declare a host variable as an array of FIXCHAR arrays. This is not a legal host variable type.

arrays of VARCHAR not supported

Message value	Message Type
2605	Error

Probable cause You have attempted to declare a host variable as an array of VARCHAR or BINARY. This is not a legal host variable type.

arrays of decimal not allowed

Message value	Message Type
2612	Error

Probable cause You have attempted to declare a host variable as an array of DECIMAL. A decimal array is not a legal host variable type.

arrays of this type not supported

Message value	Message Type
2610	Error

Probable cause You have attempted to declare a host variable array of a type that is not supported.

cannot describe static cursors

Message value	Message Type
2646	Error

Probable cause You have described a static cursor. When describing a cursor, the cursor name must be specified in a host variable.

combined pointer and arrays not supported for host types

Message value	Message Type
2602	Error

Probable cause You have used an array of pointers as a host variable. This is not legal.

cursor '%1' not previously declared

Message value	Message Type
2627	Error

Probable cause An embedded SQL cursor name has been used (in a FETCH, OPEN, CLOSE etc.) without first being declared.

data value must be a host variable

Message value	Message Type
2652	Error

Probable cause The variable used in the SET DESCRIPTOR statement hasn't been declared as a host variable.

error reading temporary file

Message value	Message Type
2682	Error

Probable cause An error occurred while reading from a temporary file.

error writing output file

Message value	Message Type
2683	Error

Probable cause An error occurred while writing to the output file.

field used more than once in SET DESCRIPTOR statement

Message value	Message Type
2651	Error

Probable cause The same keyword has been used more than once inside a single SET DESCRIPTOR statement.

full SQL feature

Message value	Message Type
2668	Flag (warning or error)

Probable cause You have used a full-SQL/92 feature and preprocessed with the -ee, -ei, -we or -wi flagging switch.

host variable '%1' has been redefined

Message value	Message Type
2665	Warning

Probable cause

You have redefined the same host variable with a different host type. As far as the preprocessor is concerned, host variables are global; two host variables with different types cannot have the same name.

host variable '%1' has two different definitions

Message value	Message Type
2625	Error

Probable cause

The same host variable name was defined with two different types within the same module. Note that host variable names are global to a C module.

host variable '%1' is unknown

Message value	Message Type
2620	Error

Probable cause

You have used a host variable in a statement and that host variable has not been declared in a declare section.

host variables not allowed for this cursor

Message value	Message Type
2629	Error

Probable cause

Host variables are not allowed on the declare statement for the specified cursor. If the cursor name is provided through a host variable, then you should use full dynamic SQL and prepare the statement. A prepared statement may have host variables in it.

host variables specified twice - on declare and open

Message value	Message Type
2630	Error

Probable cause You have specified host variables for a cursor on both the declare and the open statements. In the static case, you should specify the host variables on the declare statement. In the dynamic case, specify them on the open.

incorrect Embedded SQL language usage -- that is a '%1' extension

Message value	Message Type
2635	Error

incorrect Embedded SQL syntax

Message value	Message Type
2636	Error

Probable cause An embedded SQL specific statement (OPEN, DECLARE, FETCH etc.) has a syntax error.

incorrect SQL language usage -- that is a '%1' extension

Message value	Message Type
2634	Error

indicator variable '%1' is unknown

Message value	Message Type
2621	Error

Probable cause You have used a indicator variable in a statement and that indicator variable has not been declared in a declare section.

initializer not allowed on VARCHAR host variable

Message value	Message Type
2607	Error

Probable cause You can not specify a C variable initializer for a host variable of type VARCHAR or BINARY. You must initialize this variable in regular C executable code.

intermediate SQL feature

Message value	Message Type
2667	Flag (warning or error)

Probable cause You have used an intermediate-SQL/92 feature and preprocessed with the -ee or -we flagging switch.

invalid descriptor index

Message value	Message Type
2649	Error

Probable cause You have allocated less than one variable with the ALLOCATE DESCRIPTOR statement.

invalid field for SET DESCRIPTOR

Message value	Message Type
2650	Error

Probable cause An invalid or unknown keyword is present in a SET DESCRIPTOR statement. The keywords can only be TYPE, PRECISION, SCALE, LENGTH, INDICATOR, or DATA.

invalid host variable type on ’%1’

Message value	Message Type
2623	Error

Probable cause

You have used a host variable that is not a string type in a place where the preprocessor was expecting a host variable of a string type.

invalid integer

Message value	Message Type
2614	Error

Probable cause

An integer was required in an embedded SQL statement (for a fetch offset, or a host variable array index, etc.) and the preprocessor was unable to convert what was supplied into an integer.

invalid type for indicator variable ’%1’

Message value	Message Type
2622	Error

Probable cause

Indicator variables must be of type short int. You have used a variable of a different type as an indicator variable.

invalid type for sql statement variable

Message value	Message Type
2618	Error

Probable cause

A host variable used as a statement identifier should be of type a_sql_statement_number. You attempted to use a host variable of some other type as a statement identifier.

long binary/long varchar size limit is 65535 for UltraLite

Message value	Message Type
2697	Error

Probable cause When using DECL_LONGBINARY or DECL_LONGVARCHAR with UltraLite, the maximum size for the array is 64K.

missing ending quote of string

Message value	Message Type
2637	Error

Probable cause You have specified a string constant in an embedded SQL statement, but there is no ending quote before the end of line or end of file.

must specify a host list or using clause on %1

Message value	Message Type
2631	Error

Probable cause The specified statement requires host variables to be specified either in a host variable list or from an SQLDA.

must specify an SQLDA on a DESCRIBE

Message value	Message Type
2641	Error

no FETCH or PUT for cursor '%1'

Message value	Message Type
2695	Error

Probable cause A cursor is declared and opened, but is never used.

no INTO clause on SELECT statement

Message value	Message Type
2633	Error

Probable cause You specified an embedded static SELECT statement but you did not specify an INTO clause for the results.

no OPEN for cursor '%1'

Message value	Message Type
2694	Error

Probable cause A cursor is declared, and possibly used, but is never opened.

no declare section and no INCLUDE SQLCA statement

Message value	Message Type
2680	Error

Probable cause The EXEC SQL INCLUDE SQLCA statement is missing from the source file.

only one dimensional arrays supported for char type

Message value	Message Type
2603	Error

Probable cause You have attempted to declare a host variable as an array of character arrays. This is not a legal host variable type.

precision must be specified for decimal type

Message value	Message Type
2611	Error

Probable cause You must specify the precision when declaring a packed decimal host variable using the DECL_DECIMAL macro. The scale is optional.

statement '%1' not previously prepared

Message value	Message Type
2626	Error

Probable cause An embedded SQL statement name has been used (EXECUTE) without first being prepared.

static statement names will not work properly if used by 2 threads

Message value	Message Type
2664	Warning

Probable cause You have used a static statement name and preprocessed with the -r reentrancy switch. Static statement names cause static variables to be generated that are filled in by the database. If two threads use the same statement, contention arises over this variable. Use a local host variable as the statement identifier instead of a static name.

subscript value %1 too large

Message value	Message Type
2601	Error

Probable cause You have attempted to index a host variable that is an array with a value too large for the array.

token too long

Message value	Message Type
2639	Error

Probable cause The SQL preprocessor has a maximum token length of 2K. Any token longer than 2K will produce this error. For constant strings in embedded SQL commands (the main place this error shows up) use string concatenation to make a longer string.

transact SQL extension

Message value	Message Type
2669	Flag (warning or error)

Probable cause You have used a Sybase Transact SQL feature that is not defined by SQL/92 and preprocessed with the -ee, -ei, -ef, -we, -wi or -wf flagging switch.

unable to open temporary file

Message value	Message Type
2681	Error

Probable cause An error occurred while attempting to open a temporary file.

unknown sql function '%1'

Message value	Message Type
2662	Warning

Probable cause You have used a SQL function that is unknown to the preprocessor and will probably cause an error when the statement is sent to the database engine.

unknown statement '%1'

Message value	Message Type
2628	Error

Probable cause You attempted to drop an embedded SQL statement that doesn't exist.

unrecognized SQL syntax

Message value	Message Type
2661	Warning

Probable cause You have used a SQL statement that will probably cause a syntax error when the statement is sent to the database engine.

vendor extension

Message value	Message Type
2666	Flag (warning or error)

Probable cause You have used an Adaptive Server Anywhere feature that is not defined by SQL/92 and preprocessed with the -ee, -ei, -ef, -we, -wi or -wf flagging switch.

wrong number of parms to sql function '%1'

Message value	Message Type
2663	Warning

Probable cause You have used a SQL function with the wrong number of parameters. This will likely cause an error when the statement is sent to the database engine.

Index

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

S

T

U

V

W

Z