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ALLBASE/SQL C
Application Programming Guide

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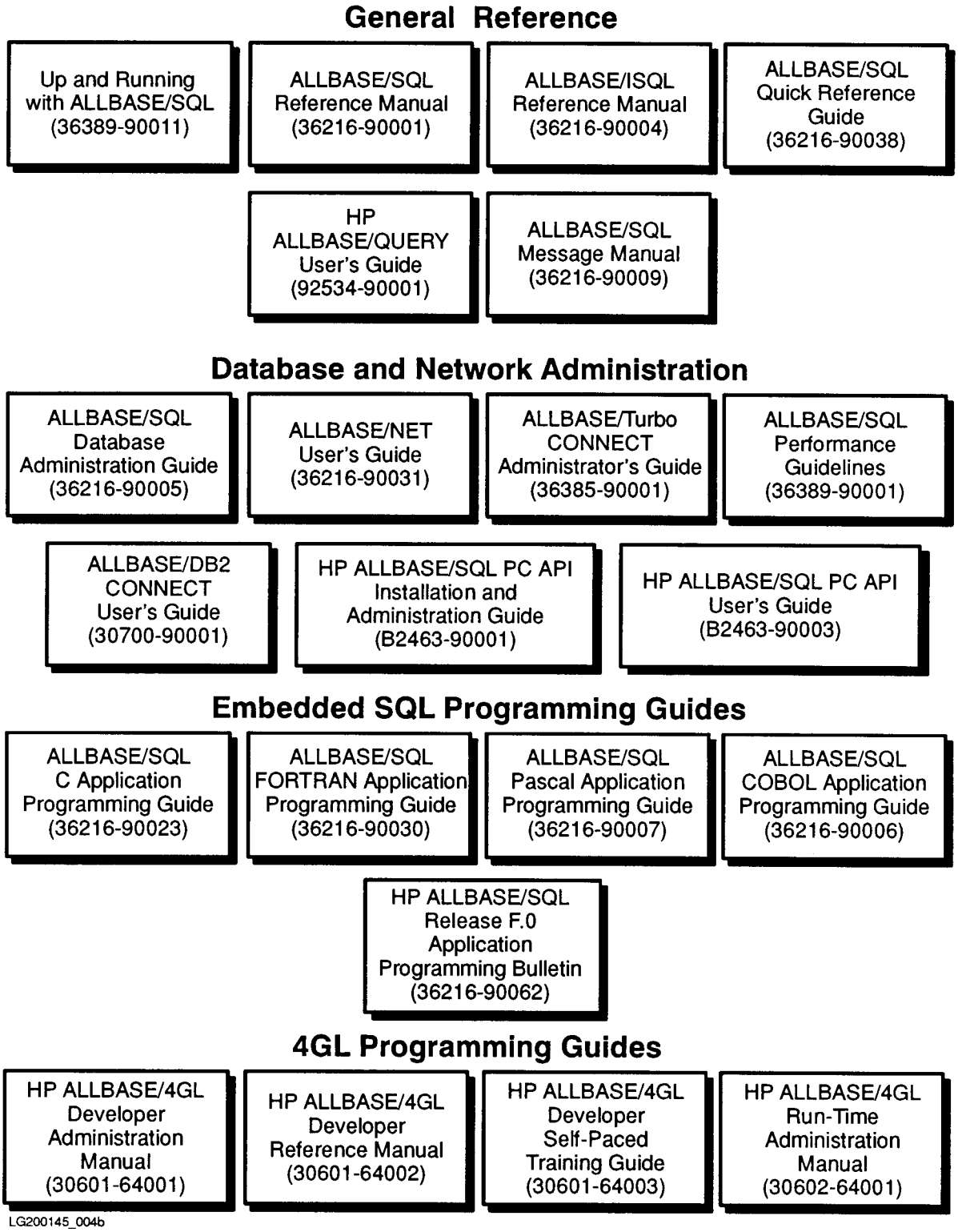
ALLBASE/SQL MPE XL Documents



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Preface

ALLBASE/SQL is a relational database management system for use on the HP 3000 Series 900 computer. ALLBASE/SQL (Structured Query Language) is the language you use to define and maintain data in an ALLBASE/SQL DBEnvironment. This manual presents the techniques of embedding ALLBASE/SQL within C language source code.

This manual is intended as a learning tool and a reference guide for C programmers. It presumes the reader has a working knowledge of C, the MPE/iX operating system, and ALLBASE/SQL relational database concepts.

MPE/iX, Multiprogramming Executive with Integrated POSIX, is the latest in a series of forward-compatible operating systems for the HP 3000 line of computers. In HP documentation and in talking with HP 3000 users, you will encounter references to MPE XL, the direct predecessor of MPE/iX. MPE/iX is a superset of MPE XL. All programs written for MPE XL will run without change under MPE/iX. You can continue to use MPE XL system documentation, although it may not refer to features added to the operating system to support POSIX (for example, hierarchical directories).

This manual contains both basic and in-depth information about embedding ALLBASE/SQL. Code examples are based, for the most part, on the sample database, PartsDBE, which accompanies ALLBASE/SQL. Refer to Appendix C in the *ALLBASE/SQL Reference Manual* for information about the structure of PartsDBE and for listings of the sample database.

- Chapter 1, "Getting Started with ALLBASE/SQL Programming in C," is an introduction to ALLBASE/SQL programming which includes information on developing, using, and maintaining programs on the MPE XL operating system.
- Chapter 2, "Using the Preprocessor," explains the ALLBASE/SQL preprocessor and how to invoke it.
- Chapter 3, "Host Variables," describes how to define and use variables to transfer data between your C program and an ALLBASE/SQL DBEnvironment.
- Chapter 4, "Runtime Status Checking and the sqlca," defines ways to monitor and handle successful and unsuccessful SQL command execution.

Chapters 5 through 11 address the various ways to manipulate data in an ALLBASE/SQL C program.

- Chapter 5, "Simple Data Manipulation," explains how to operate on one row at a time.
- Chapter 6, "Processing with Cursors," shows how to process a multiple row query result one row at a time.
- Chapter 7, "BULK Table Processing," examines the processing of multiple rows at a time.
- Chapter 8, "Using Dynamic Operations," describes the use of ALLBASE/SQL commands that are preprocessed at runtime.
- Chapter 9, "Programming with Constraints," compares the use of statement level integrity and row level integrity and discusses the use of integrity constraints.
- Chapter 10, "Programming with LONG Columns," discusses the LONG BINARY and LONG VARBINARY data types.
- Chapter 11, "Programming with ALLBASE/SQL Functions," describes the formatting functions to be used with date/time data types.

Conventions

`UPPERCASE` In a syntax statement, commands and keywords are shown in uppercase characters. The characters must be entered in the order shown; however, you can enter the characters in either uppercase or lowercase. For example:

```
COMMAND
```

can be entered as any of the following:

```
command        Command        COMMAND
```

It cannot, however, be entered as:

```
comm           com_mand       comamnd
```

italics In a syntax statement or an example, a word in italics represents a parameter or argument that you must replace with the actual value. In the following example, you must replace *filename* with the name of the file:

`COMMAND` *filename*

bold italics In a syntax statement, a word in bold italics represents a parameter that you must replace with the actual value. In the following example, you must replace ***filename*** with the name of the file:

`COMMAND(`***filename***`)`

punctuation In a syntax statement, punctuation characters (other than brackets, braces, vertical bars, and ellipses) must be entered exactly as shown. In the following example, the parentheses and colon must be entered:

(*filename*):(*filename*)

underlining Within an example that contains interactive dialog, user input and user responses to prompts are indicated by underlining. In the following example, yes is the user's response to the prompt:

```
Do you want to continue? >>  yes
```

`{ }` In a syntax statement, braces enclose required elements. When several elements are stacked within braces, you must select one. In the following example, you must select either `ON` or `OFF`:

`COMMAND` $\left\{ \begin{matrix} \texttt{ON} \\ \texttt{OFF} \end{matrix} \right\}$

`[ ]` In a syntax statement, brackets enclose optional elements. In the following example, `OPTION` can be omitted:

`COMMAND` *filename* `[OPTION]`

When several elements are stacked within brackets, you can select one or none of the elements. In the following example, you can select `OPTION` or *parameter* or neither. The elements cannot be repeated.

`COMMAND` *filename* $\left[\begin{matrix} \texttt{OPTION} \\ \textit{parameter} \end{matrix} \right]$

`[ ... ]` In a syntax statement, horizontal ellipses enclosed in brackets indicate that you can repeatedly select the element(s) that appear within the immediately preceding pair of brackets or braces. In the example below, you can select *parameter* zero or more times. Each instance of *parameter* must be preceded by a comma:

`[,`*parameter*`][...]`

In the example below, you only use the comma as a delimiter if *parameter* is repeated; no comma is used before the first occurrence of *parameter*:

`[`*parameter*`][,...]`

`| ... |` In a syntax statement, horizontal ellipses enclosed in vertical bars indicate that you can select more than one element within the immediately preceding pair of brackets or braces. However, each particular element can only be selected once. In the following example, you must select **`A, AB, BA`**, or **`B`**. The elements cannot be repeated.

$$\left\{ \begin{matrix} \texttt{A} \\ \texttt{B} \end{matrix} \right\} \texttt{| ... |}$$

`...` In an example, horizontal or vertical ellipses indicate where portions of an example have been omitted.

`Δ` In a syntax statement, the space symbol `Δ` shows a required blank. In the following example, *parameter* and *parameter* must be separated with a blank:

`(`*parameter*`)Δ(`*parameter*`)`

`[ ]` The symbol `[ ]` indicates a key on the keyboard. For example, `[RETURN]` represents the carriage return key or `[Shift]` represents the shift key.

`[CTRL]`*character* `[CTRL]`*character* indicates a control character. For example, `[CTRL]Y` means that you press the control key and the Y key simultaneously.

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Getting Started with ALLBASE/SQL Programming in C

ALLBASE/SQL is a relational database management system that uses SQL statements to access data within an ALLBASE/SQL DBEnvironment. Embedding SQL statements in your C program and preprocessing with the SQL preprocessor allows programmatic access to this data. Embedded statements are ALLBASE/SQL commands in the flow of what would otherwise be C source code. When embedded statements are present, the source code must be passed through an ALLBASE/SQL preprocessor to convert them to a form understood by the C compiler. This chapter examines the steps to follow as you begin to work with embedded SQL. It focuses on the programmer's tasks, which are presented in the following sections:

- Understanding ALLBASE/SQL Operations.
- Understanding the Program Life Cycle.
- Developing ALLBASE/SQL Applications.
- Moving Programs into Production.
- Maintaining ALLBASE/SQL Applications.
- Programming Under the MPE XL Operating System.
- Looking at an Embedded SQL Source Program

Embedded SQL programming is a simple process. You include SQL statements in a C source program, then you preprocess the code using the ALLBASE/SQL C preprocessor before compiling and linking. The preprocessor is fully described in Chapter 2, and the specific techniques of ALLBASE/SQL programming are presented in more detail in the succeeding chapters. Readers who are already familiar with the general process of embedded SQL programming should skip ahead to Chapter 2.

Understanding ALLBASE/SQL Operations

You can incorporate almost any ALLBASE/SQL command in an application program. Some commands can only be used in applications; others require special varieties of syntax that are only used in applications. All the ALLBASE/SQL commands and the places where you can use them are described in the *ALLBASE/SQL Reference Manual*.

Note You *cannot* use ISQL, SQLUtil, SQLGEN, or SQLMIGRATE commands programmatically. ISQL, SQLUtil, SQLGEN, and SQLMIGRATE are themselves independent applications.

There are several kinds of SQL operations you can perform from application programs:

- Accessing data using data manipulation language (DML).
- Creating ALLBASE/SQL objects using data definition language (DDL).
- Managing security with data control language (DCL).
- Handling transactions.
- Handling errors.
- Performing dynamic processing.

Using DML to Manipulate Data

You use DML to examine or modify the rows in the tables in a database. The chief DML command for creating queries is SELECT. For other kinds of data manipulation you use DELETE, INSERT, or UPDATE. Whether for OLTP (online transaction processing) or report-writer applications, DML commands are the heart of database access. Therefore, much of the programmer's time is spent using DML to create the most efficient queries and updates. Most of this manual is devoted to the task of coding effective DML statements.

The following example of a simple data manipulation statement reads a row of data into some host variables (host variables are described below, under "Creating Source Files").

```
EXEC SQL SELECT PartNumber, PartName, SalesPrice
     INTO :PartNumber, :PartName, :SalesPrice
     FROM PurchDB.Parts;
```

Using DDL to Define Database Objects

You use DDL to create database objects, including tables, views, indexes, and authorization groups. For these tasks, you use the SQL CREATE commands, including CREATE TABLE, CREATE VIEW, CREATE INDEX, and CREATE GROUP. DDL is not always used in application programs, since database objects frequently exist before coding starts. However, it is sometimes useful to define objects at run time. Or you might wish to create special applications to tailor the creation of objects for the specific needs of your system. For detailed information about DDL functions, refer to the *ALLBASE/SQL Database Administration Guide*.

The following example of a data definition statement shows the creation of an index on one column of the Parts table:

```
EXEC SQL CREATE UNIQUE INDEX PartNumIndex
     ON PurchDB.Parts (PartNumber);
```

Data definition also includes the DROP commands for database objects such as the index created in the previous example, and the ALTER TABLE command for making changes to these objects. It also includes SQL statements for creating files and filesets for storage of database information.

Using DCL to Manage Security

You use DCL to create a security scheme for your databases. Control statements are used to initiate access to a DBEnvironment and to provide security on specific database objects.

You may find it useful to assign permissions for newly created objects when the default permissions are not sufficient for the needs of your application. You can control the *ownership* of objects in ALLBASE/SQL DBEnvironments at creation time or through the TRANSFER OWNERSHIP command. Similarly, you can assign *authorization* for specific objects as you create them or through the GRANT and REVOKE commands.

Data control statements let you create groups, assign members to them, then grant all the authorities as needed. You can also grant and revoke authorities to individual users.

The following example of a data control statement assigns CONNECT authority to everyone for the current DBEnvironment:

```
EXEC SQL GRANT CONNECT TO ALL;
```

Handling Transactions

Transactions are the units of work in an ALLBASE/SQL application. Transactions are usually delimited by BEGIN WORK and COMMIT WORK or ROLLBACK WORK statements. During a transaction, ALLBASE/SQL obtains locks on data and index pages; this can cause others to wait for data access. ALLBASE/SQL lets you regulate the kinds of locking your transactions use so as to achieve the greatest concurrency possible while protecting data from the actions of other users. The *ALLBASE/SQL Reference Manual* contains information about managing the transactions in your applications.

Handling Errors

You use error handling to detect error conditions that arise while you are connected to an ALLBASE/SQL DBEnvironment. Error handling can be either implicit or explicit.

In implicit error handling, you use the WHENEVER SQLERROR and WHENEVER SQLWARNING statements to branch to a specific location following any error or warning. In this kind of processing, you do not test for a specific error condition.

In explicit error handling, it the programmer's responsibility to examine the specific error code returned by ALLBASE/SQL. For example, if the error number returned is -14024, ALLBASE/SQL has detected a deadlock and has rolled back a transaction. This means you can try the transaction again. On the other hand, an error of -2206 means that a table or view was not found. In this case, it does not make sense to reattempt the transaction.

Both implicit and explicit error handling techniques usually employ an error routine that incorporates the ALLBASE/SQL message command, SQLEXPLAIN. For example, a loop may be used to display to the user the text of each error or warning message related to a given SQL command.

Refer to Chapter 4 for complete details about error handling, including several examples.

Dynamic and Non-Dynamic Operations

Whether you are using DML, DDL, or DCL operations, you can structure embedded SQL statements as either dynamic or non-dynamic. Commands are **non-dynamic** when the syntax of the entire command is known and preprocessed prior to run time. For many non-dynamic commands, ALLBASE/SQL can speed up database access by storing runtime instructions in the DBEnvironment at preprocessing time. The following is a non-dynamic query.

```
printf("Enter the Part Number: ");
gets(PartNumber);

EXEC SQL SELECT PartName, SalesPrice
     INTO :PartName, :SalesPrice
     WHERE PartNumber = :PartNumber;
```

Commands are **dynamic** when they are preprocessed at run time. ALLBASE/SQL converts these commands into executable instructions at run time rather than at preprocessing time. For example, you might know which table and which columns you want to query with a SELECT, but you may not know until run time the name of the DBEnvironment itself. In such a case, the preprocessor cannot store instructions in the DBEnvironment prior to run time.

The following is an example of a dynamic CONNECT in which the user enters the name of the DBEnvironment at run time:

```
printf("Enter the DBEnvironment Name: ");
gets(DBEName);
sprintf(DynamicCommand,"CONNECT TO '%s';",DBEName);
EXEC SQL EXECUTE IMMEDIATE :DynamicCommand;
```

There are many techniques for dynamic processing of queries and non-queries. The topic is discussed fully in Chapter 8.

Understanding the Program Life Cycle

Each ALLBASE/SQL application program undergoes a number of phases in its useful life:

- Development: In the **development phase**, you create C source code procedures and integrate them into applications. Database access is provided through embedded SQL statements which are translated by a preprocessor into C procedures. After preprocessing the source, you compile, test, and debug, until the application is satisfactory. Then you install the application on a production system.
- Production: In the **production phase**, the application runs more or less continuously. The goals in this phase are to provide a high degree of concurrent access to data consistent with data security. The programmer can often enhance the performance of an application during production runs by using specific techniques as the code is developed. During production, the database administrator (DBA) can also help improve performance by monitoring the system's use of resources and by allocating additional disk space or shared memory as needed.
- Maintenance: In the **maintenance phase**, you modify the application in response to the changing needs of its users. This may mean updating the code, changing the security structure, or adding code to accomodate changes in the DBEnvironment. By careful coding to anticipate future developments in your databases, you can avoid the need to make extensive changes to production software.

Developing ALLBASE/SQL Applications

The basic steps in developing ALLBASE/SQL applications are as follows:

- Create a source file.
- Preprocess the source file.
- Compile and link the program.

These steps, shown in Figure 1-1, are further described in the following paragraphs.

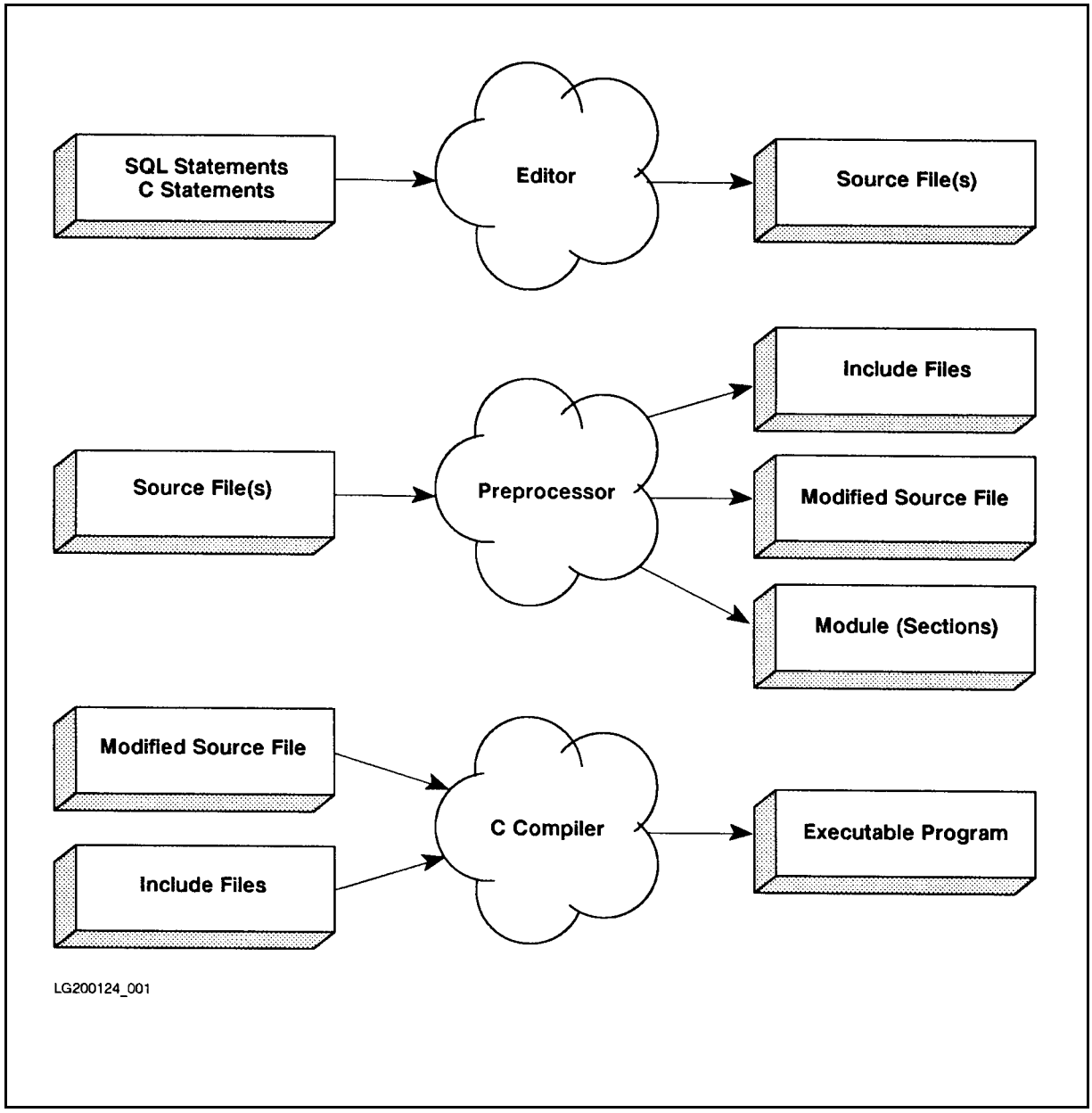

Figure 1-1. Creating an ALLBASE/SQL C Application Program

Creating Source Files

Using an editor, you create one or more files containing C source code and SQL commands, which are said to be **embedded** in the program. You can use multiple source files, but each file containing embedded SQL statements must be separately preprocessed.

Using Embedded SQL

The following SQL statements can be embedded in your program:

- Host variable declarations.
- INCLUDE SQLCA statements to let ALLBASE/SQL pass return codes to your program.
- A CONNECT command specifying the name of a DBEnvironment.
- BEGIN WORK and COMMIT WORK commands to delimit transactions (Note that if a transaction is not already started, *any* SQL command will automatically issue an implicit BEGIN WORK.).
- SELECT, INSERT, UPDATE, or DELETE commands; or cursor operations.
- Explicit or implicit error handling.

The *ALLBASE/SQL Reference Manual* describes the complete syntax for each kind of SQL statement.

Some SQL statements can only be used in application programs. These include the cursor commands (DECLARE, OPEN, FETCH, REFETCH, UPDATE WHERE CURRENT, DELETE WHERE CURRENT, and CLOSE); the bulk commands (BULK SELECT and BULK INSERT); and the error handling commands (WHENEVER and SQLEXPLAIN).

Moreover, some of the statements have a different effect when used in an application program than when used interactively. For example, the SELECT command in ISQL may be used when you wish to retrieve multiple rows, but in an application program a simple SELECT that retrieves more than one row results in an error.

General Rules for Embedding SQL

ALLBASE/SQL C programs often follow a pattern where a main program segment calls functions that include the embedded SQL code.

Declaring Special Data Structures

You must include the following instruction to the ALLBASE/SQL preprocessor in the global declarations area of each source file:

```
EXEC SQL INCLUDE SQLCA;
```

This incorporates into your program a data structure for handling return codes from ALLBASE/SQL, including numbered error conditions. You can use the information in the sqlca (SQL Communications Area) to test and branch. Refer to Chapter 4, "Runtime Status Checking and the sqlca," for complete information about using the sqlca.

If your program includes dynamic query processing for the FETCH command with a USING DESCRIPTOR clause, add the INCLUDE SQLDA statement to your global declarations, and define the appropriate data buffer and format array. These elements are described fully in Chapter 8.

All other SQL commands may appear in any part of your program.

Declaring Host Variables

In addition to the normal variable declarations, the source file contains variable declarations for host variables. These can appear wherever declarations are legal. However, it is recommended that you include them at the beginning of the file, since they are translated into global variables by the preprocessor anyway. If more than one source file references the same set of variables, you must declare them separately in each file, and you must preprocess each file separately. See Chapter 2 for more details. Host variable declarations appear within a pair of SQL statments:

```
EXEC SQL BEGIN DECLARE SECTION;
  .
  .
EXEC SQL END DECLARE SECTION;
```

Host variables can appear both in the embedded SQL statements in your code and in ordinary C statements. When they appear in embedded SQL statements, you prefix them with a colon, as shown in this example:

```
EXEC SQL SELECT PartName, SalesPrice
     INTO :PartName, :SalesPrice
     FROM PurchDB.Parts;
```

Host variables are treated fully in Chapter 3.

Skeleton Program

The skeleton program in Figure 1-2 illustrates the relationship between C constructs and embedded SQL commands in an application program. SQL commands may appear in the program at locations indicated by the comments.

```
.
/* STATIC VARIABLE DECLARATION PART */
sqlca Declaration
sqlda Declaration
.
/* Host Variable Declarations */
/* Host Variables can be global, local, or both */
.
/* main DECLARATION PART */
main(argc,argv)
/* Parameter Declaration */
{
.
/* Host Variable Declarations */
/* Host Variables can be local, or for called routines */

/* C statements, some containing SQL Commands */
EXEC SQL ...

int FunctionName();
.
}
/* FUNCTION DECLARATION PART */
FunctionName(parameter list)
/* Parameter Declaration */
  {
  .
  /* Host Variable Declarations */
  /* Host Variables can be local */

  /* C statements, some containing SQL Commands */
  EXEC SQL ...
  .
  }
```

Figure 1-2. Skeleton ALLBASE/SQL C Program

Most SQL commands appear within C functions in which you establish DBEnvironment access and manipulate data in a database. Variable declarations should follow rules for coding C programs without SQL statements. In addition to functions for various kinds of database access, you should code a CONNECT function, a RELEASE function, an error handling function, and transaction management functions containing BEGIN WORK and COMMIT WORK statements.

Rules of Syntax for Embedded SQL Statements

You must follow some simple rules when embedding SQL statements in C code:

- Commands must be of appropriate size:
  - An embedded SQL command has no maximum length.
  - A dynamic SQL command within a host variable is limited only by the size of the host variable's declaration.
  - A dynamic SQL command not within a host variable can be no longer than 2048 bytes.
- Use EXEC SQL as the prefix to each SQL statement. The entire prefix, EXEC SQL, must appear on one line, as follows:

```
EXEC SQL SELECT PartName INTO :PartName
     FROM PurchDB.Parts WHERE PartNumber = :PartNumber;
```

  The following is *not* legal:

```
EXEC
     SQL SELECT PartName INTO :PartName
     FROM PurchDB.Parts WHERE PartNumber = :PartNumber;
```

- Use a semicolon at the end of the SQL command, as shown above.
- C comments (those which begin with /* and end with */) may appear within or between embedded SQL commands, as in the following:

```
EXEC SQL SELECT PartNumber, PartName
     /* put the data into the following host variables  */
INTO :PartNumber, :PartName
     /* find the data in the following table */
FROM PurchDB.Parts
     /* retrieve only data that satisfies this search condition */
WHERE PartNumber = :PartNumber;
     /* end of command */
```

- SQL comments can be inserted in any line of an SQL statement, except the last line, by prefixing the comment character with at least one space followed by two hyphens followed by one space:

```
EXEC SQL SELECT * FROM PurchDB.Parts   -- This code selects Parts Table values
         WHERE SalesPrice > 500.;
```

  The comment terminates at the end of the line on which it appears. (The decimal point in the 500 improves performance when being compared to SalesPrice, which also has a decimal; no data type conversion is necessary.)

- Non-numeric literals in embedded commands may be continued from one line to another.
- When referring to a host variable within an embedded SQL statement, precede it with a colon (:). Do not use the colon outside the embedded SQL statement.

A sample source file appears at the end of this chapter. And more detailed explanation of coding for different types of embedded SQL statements appears in Chapters 4 through 8.

Preprocessing the Source File

After embedding SQL commands in the source code, *preprocess* it with the *ALLBASE/SQL C preprocessor*. Use the following command, which is described fully in Chapter 2:

```
:RUN PSQLC.PUB.SYS; INFO="DBEnvironmentName (MODULE (ModuleName))"
```

In addition to checking the syntax of your SQL statements, preprocessing also does the following:

- Creates a modified source file.
- Stores sections in the DBEnvironment.
- Generates a file, *SQLMSG*, for preprocessing messages. Creates an installable module file.

Creating the Modified Source File

The preprocessor translates embedded SQL statements into C language statements and comments out the SQL statements. Non-SQL statements in your code are not translated. As output, the preprocessor creates a **modified source file** which can then be compiled. The original source file is not changed.

The preprocessor also creates three **include files**, which contain variable declarations, type declarations, and external procedure declarations used by the preprocessor generated C code. The modified source file contains include statements which direct the compiler to incorporate these include files at compile time.

Creating Stored Sections

The preprocessor also stores runtime instructions in the system catalog of the DBEnvironment you specify when preprocessing. These instructions are called **sections** and are stored in a **module**, which contains a section for each DML, DDL, or DCL statement in your program that can be completely defined before run time. A module is referenced in the system catalog of the DBEnvironment.

Not all SQL statements cause the preprocessor to store a section. Only statements that access data cause a section to be stored.

A section has three parts:

- A stored form of the SQL command.
- Instructions for executing the command according to the best available access path.
- A flag indicating whether the section is *valid* or *invalid*.

These elements are illustrated in Figure 1-3.

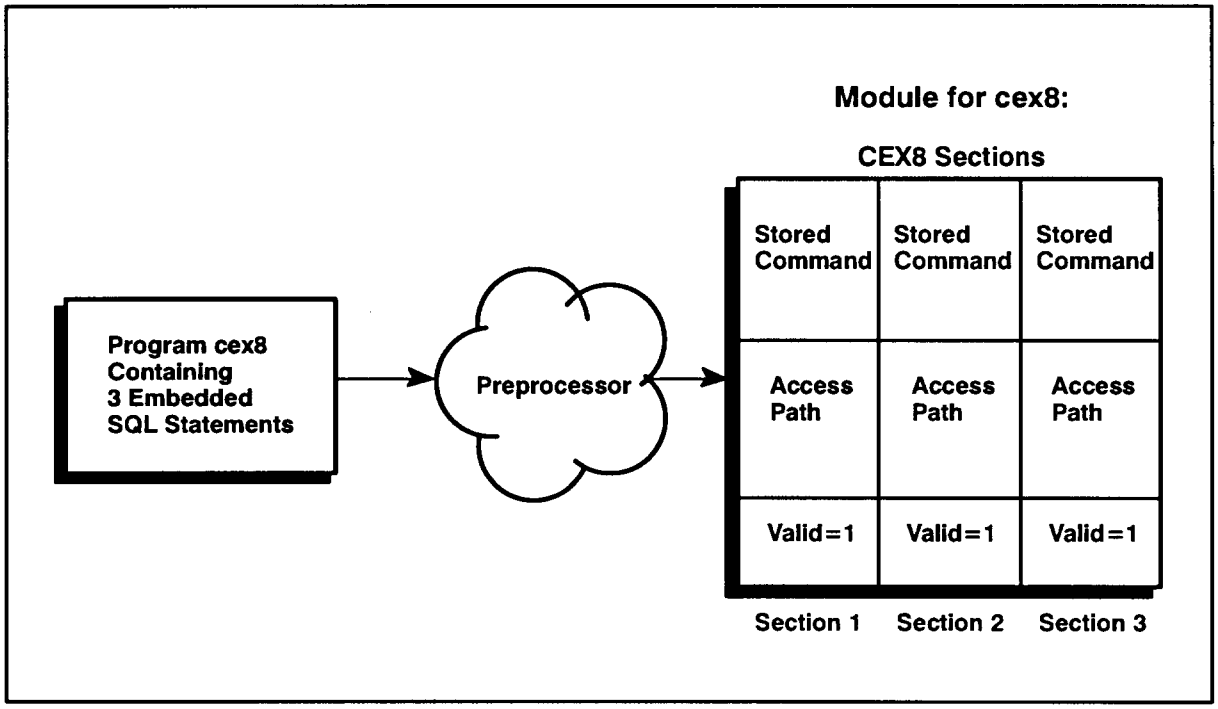

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Figure 1-3. Components of a Stored Section

Stored Form of the SQL Command. In addition to translating each SQL statement into C code, the preprocessor stores a version of the statement in a section. This version of the statement is used at a later time if it becomes necessary to revalidate the section.

Optimized Access Instructions. ALLBASE/SQL also chooses the best available path for accessing the data referred to in the statement. This process is called **optimization**. For example, the following query can be optimized:

```
EXEC SQL SELECT * FROM PurchDB.Parts
     WHERE PartNumber = :PartNumber;
```

ALLBASE/SQL first determines whether or not indexes exist on the PartNumber column. If there are indexes, ALLBASE/SQL then computes whether the use of an available index is more efficient than doing a serial scan of the entire table. The result of this decision whether or not to use the index (or which index to use, if there is more than one) is stored as part of the section for the query.

Validity Flag. The validity flag provides a way to ensure that any objects you reference in an SQL statement still exist and that runtime authorization criteria are satisfied. If the SQL command in a section references objects that exist at preprocessing time and the individual doing the preprocessing is authorized to issue the command, the stored section is marked as **valid**. If the SQL command references an object that does not exist at preprocessing time or if the individual doing the preprocessing is not authorized to issue the command, the stored section is marked as **invalid**.

After being stored by the preprocessor, a valid section is marked as invalid when activities such as the following occur:

- Changes in authorities of the module's owner.
- Alterations to tables accessed by the program.
- Deletions or creations of indexes.
- Updating a table's statistics.

In general, ALLBASE/SQL invalidates a section whenever there is a chance that the existing access path to the data might have changed. Suppose you drop an index on a column that appears in a query. In such a case, the section which contains that query and any other sections which reference that column are marked invalid.

Runtime Revalidation of Sections. At run time, ALLBASE/SQL checks each section for validity before executing it. When a section is found to be invalid, ALLBASE/SQL revalidates it to revalidate it (if possible), then executes it. You may notice a slight delay as the revalidation takes place. If you wish, you can re-preprocess the entire program to revalidate all sections at once, avoiding the delay of runtime revalidation. However, this is not required, since revalidation is done automatically and transparently.

If an invalid section cannot be validated, as when a table reference is invalid because the table owner name has changed, ALLBASE/SQL returns an error indication to the application program. The new owner can validate the section.

Generating the Message File

During preprocessing, messages are written to the file sqlmsg. If preprocessing is successful, the file contains a statement indicating the name of the module stored in the DBEnvironment and the number of sections stored.

Compiling and Linking the Program

Use the **C compiler** and **system linker** to create the **executable program** from the modified source code file and the include files. You can run both the compiler and the linker with the **CCXLLK** command. Alternatively, you can create object files by using the CCXL command. In this case, you must link objects in a separate step using the link editor. Figure 1-4 shows both techniques.

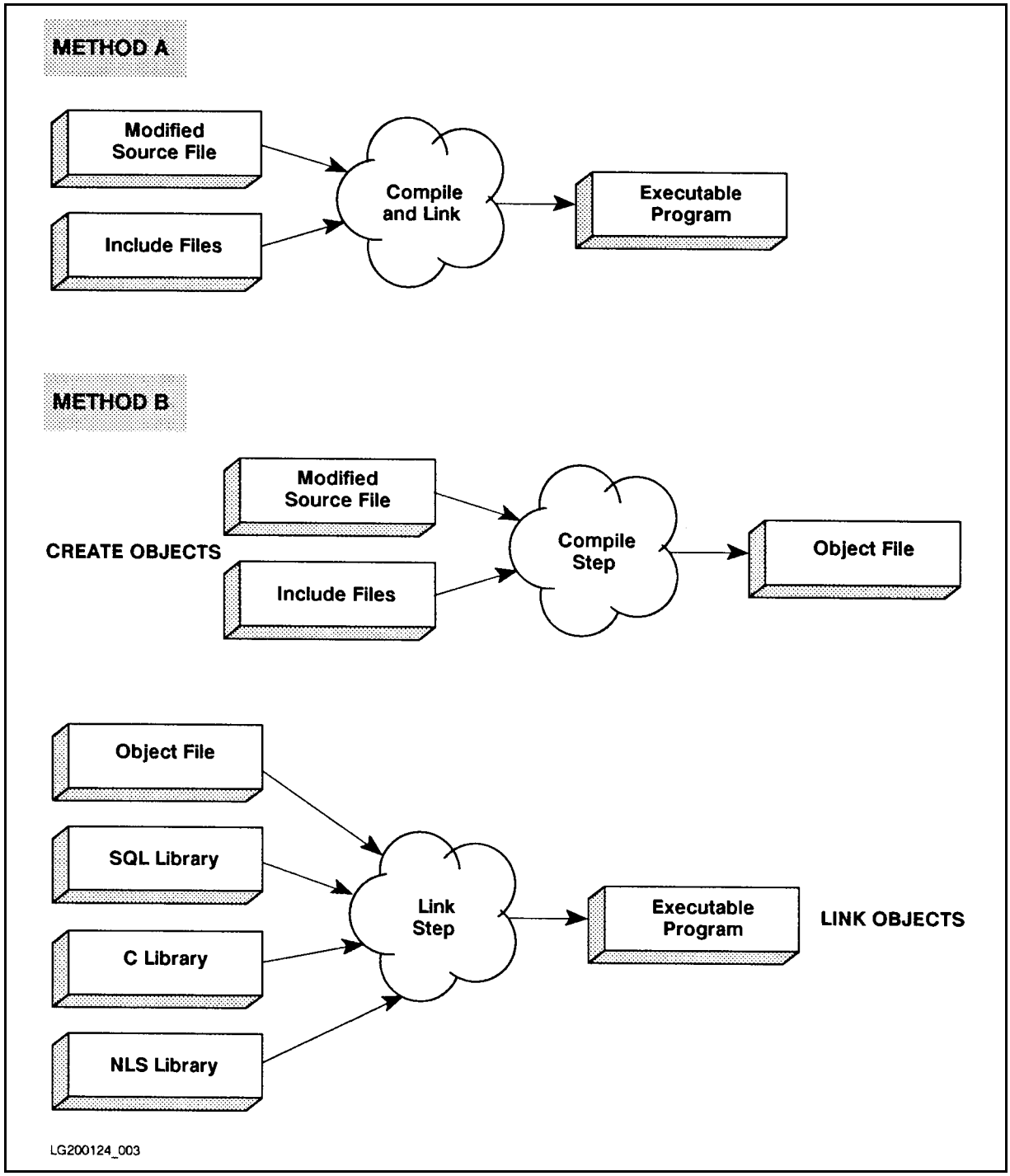

Figure 1-4. Ways of Compiling and Linking an ALLBASE/SQL C Program

Caution When correcting your programs during the compile process, be sure to edit the *original source file*, not the preprocessor output file. Note that when it encounters an error, the compiler returns line numbers for the *modified source file*, so you must extrapolate from these to the actual lines in your original source. Edit the original source, re-preprocess, then re-compile and re-link.

Running the Program

Once the preprocessing and compile steps have completed without error, you can run the application.

All the C constructs inserted by the preprocessor and the stored sections automatically handle database operations, including providing the application program with status information after each SQL command is executed. SQL commands that have a stored section are executed if the section is valid at run time or can be validated by ALLBASE/SQL at run time. As your program runs, it executes code that calls each section that was previously stored. If the section is valid, it is then executed to carry out the query or other SQL operation.

If the section cannot be executed for any reason, ALLBASE/SQL returns an error code to the sqlca. Your program can examine this data structure and print out the text of messages that correspond to the error codes sent back by ALLBASE/SQL. Using a standard error handling routine makes debugging the embedded SQL a straightforward process. Refer to Chapter 4, "Runtime Status Checking and the sqlca," for details and examples of incorporating error routines.

Note The error codes returned at run time are not the same as the errors shown in sqlmsg at preprocessing time. Runtime errors include such logical mistakes as issuing a BEGIN WORK when a transaction is already underway, OPENing a cursor that is already open, and so on.

If your program contains the SQLEXPLAIN command, you can display the text of an ALLBASE/SQL error message as an aid to debugging. SQLEXPLAIN obtains warning and error messages from the ALLBASE/SQL message catalog, which must be available at run time. The default message catalog is SQLCT000.PUB.SYS. For native language users, the catalog is SQLCTxxx.PUB.SYS, where *xxx* is the numerical value for the current language. (See the "Native Language Support" section for information about how to determine the number for the current language.) If this catalog is not available, ALLBASE/SQL issues a warning and then uses the default catalog instead.

Authorizations

ALLBASE/SQL authorization governs who can preprocess, execute, and maintain a program that accesses an ALLBASE/SQL DBEnvironment.

To preprocess a program for the *first* time, you need CONNECT or DBA authority in the DBEnvironment your program accesses. When you preprocess a program, your login name becomes the owner of that module. *Subsequently*, only you or someone else with DBA authority can re-preprocess the program.

To access an ALLBASE/SQL DBEnvironment through a program, you need the authority to execute the command used in the program to start the DBE session:

- If the program uses a CONNECT command to start a DBE session, you need CONNECT authority and RUN or module OWNER authority to run the program.
- If the program uses a START DBE command to start the DBE session, you need DBA authority to run the program.

At run time, any SQL command in the program is executed only if the original OWNER of the module has the authorization to execute the command at run time. However, any

dynamic command (an SQL command entered by the user at run time) is executed only if the login of the user running the program has the authority to execute the entered command.

Whoever runs the program must have either RUN authorization for the module or else be the OWNER or DBA. Granting authorizations is further described in Chapter 2 of this manual and in the *ALLBASE/SQL Database Administration Guide*.

Debugging and Testing

As you test the program, use a set of database tables that resembles the production DBEnvironment as closely as possible. This will let you judge the performance of the program as well as exercising each of the segments of code. Remember that in debugging and testing the application, you are also testing the DBEnvironment's parameters. Elements such as log size, buffer size, maximum number of transactions, and other configurable parameters may need to be adjusted for the needs of the application. Use SQLUtil to adjust the parameters of the DBEnvironment. (DBA authority is required.)

After testing in single user mode, run tests with multiple users to observe the level of concurrency and the degree of throughput your application achieves. If relevant, observe the performance of the application while other applications are running. Refer to the *ALLBASE/SQL Reference Manual* for additional guidelines on coding for performance.

Moving into the Production Phase

At the beginning of the production phase, you need to:

- Install the program module in the production DBEnvironment.
- Assign the appropriate security structure on the production system.

Installing Program Modules

Installation involves using the ISQL INSTALL command to store a module created in one DBEnvironment into a different DBEnvironment on the same or a different system. When the preprocessor stores a module in a DBEnvironment, it also creates a file containing a copy of the module, which can be installed into another DBEnvironment. The installable module file in the following example is SQLMOD. The module also has an internal, SQL name, in this case PGMR1@ACCOUNT.CEX8, which is saved as part of the module at preprocessing time. Use the INSTALL command in ISQL as shown in this example:

```
isql=> CONNECT TO 'SOMEDBE.SOMEGRP.SOMEACCT';
isql=> INSTALL SQLMOD;

Name of module in this file:  PGMR1@ACCOUNT.CEX8
Number of sections installed:  3
COMMIT WORK to save to DBEnvironment.

isql=> COMMIT WORK;
```

This process is illustrated in Figure 1-5.

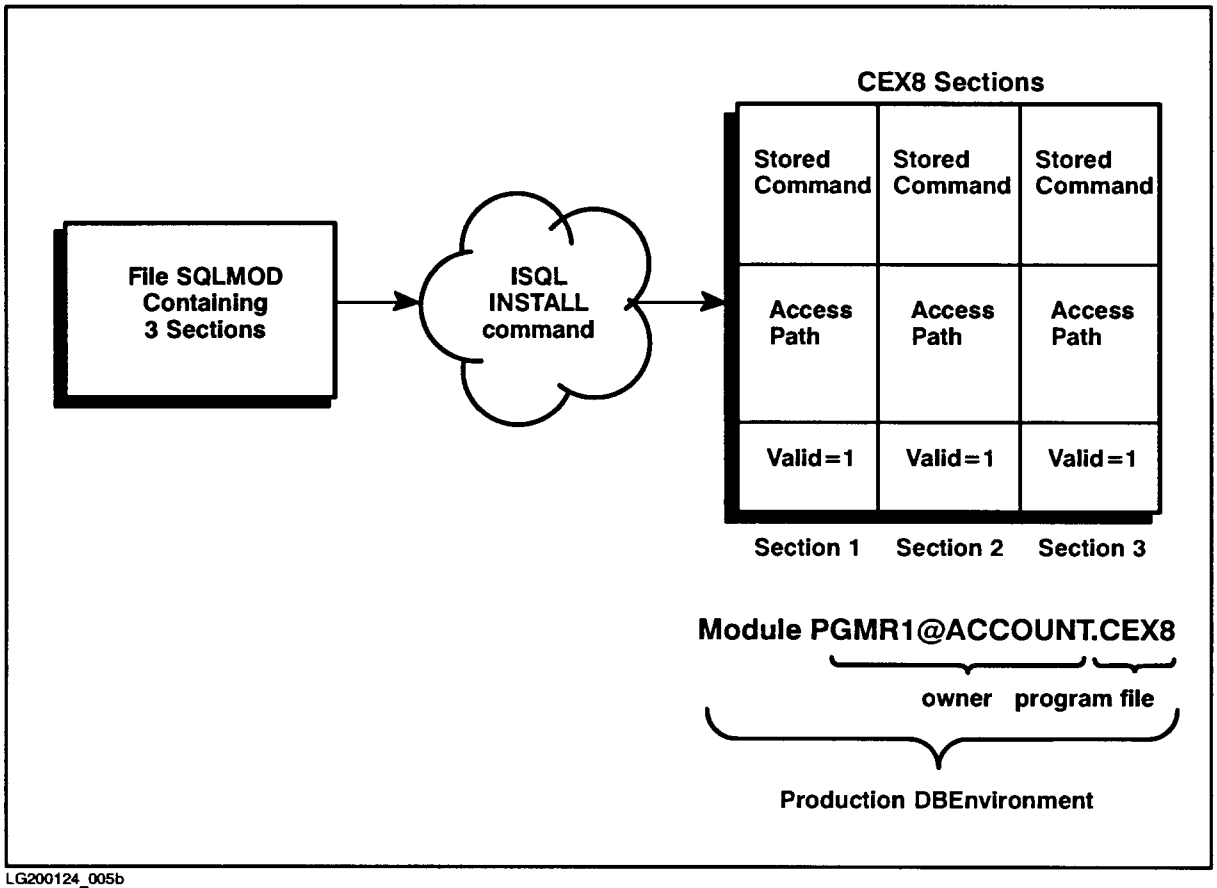

Figure 1-5. Moving an Application to a Production System

ISQL copies the module from the installable module file named **SQLMOD** into a DBEnvironment named **SOMEDBE.SOMEGRP.SOMEACCT**. During installation, ALLBASE/SQL marks each section in the module valid or invalid, depending on the current objects and authorities in **SOMEDBE.SOMEGRP.SOMEACCT**.

To use the INSTALL command, you need to be able to start a DBE session in the DBEnvironment that will contain the new module. If you are replacing a module with a new one of the same name, make sure no other users are accessing the module. To avoid problems, install modules while connected to the DBEnvironment in single-user mode. Before installing, you should DROP any existing module on the production machine that has the same name:

```
isql=> DROP MODULE PGMR1@ACCOUNT.CEX8;
```

Granting Module Owner Authorizations

The original module owner is the DBEUserID of the person who preprocesses the program or, if specified, the DBEUserID used with the OWNER option in the preprocessor command line. At run time, embedded SQL commands are executed only if the original module owner has the authority to execute them. Therefore, you need to grant required authority to a user in the production DBEnvironment with the same name as the original module owner in the development environment.

If module *PGMR1@ACCOUNT.CEX8* contains a SELECT command for table *PurchDB.Parts*, the following grant would ensure valid owner authorization in the development environment:

```
isql=> GRANT SELECT ON PurchDB.Parts TO Pgmr1;
```

Being the owner of the module, *Pgmr1* could have assigned ownership of the module to another owner at preprocessing time by using the -o option:

```
: RUN PSQLC.PUB.SYS;INFO="SOMEDBE.SOMEGRP.SOMEACCT (MODULE (CEX8) OWNER (PurchMgrs))
```

In this case, ownership belongs to a group, *PurchMgrs*. Only members of the group or an individual with DBA authority can maintain this program, and runtime authorization would be established as follows:

```
isql=> GRANT SELECT ON PurchDB.Parts TO PurchMgrs;
```

Note Keep in mind that the original module owner's name is coded into the module itself. Therefore, the original DBEUserId must exist on the production system and possess the appropriate CONNECT and object authorities. As a rule, it is wise to assign ownership of modules to a group name which can be used on both development and production systems. In this fashion, you can assign different membership to the group on the production system than you assigned on the development system.

Granting Program User Authorization

In order to execute an ALLBASE/SQL program, you must have CONNECT authority for any DBEnvironment accessed by the program. You must also have one of the following authorities in the DBEnvironment accessed by the program:

- RUN.
- Module OWNER.
- DBA.

A DBA must grant the authority to start a DBE session. In most cases, application programs start a DBE session with the CONNECT command, so CONNECT authorization is sufficient:

```
isql=> CONNECT TO 'SOMEDBE.SOMEGRP.SOMEACCT';
isql=> GRANT CONNECT TO USER@ACCOUNT;
isql=> COMMIT WORK;
```

If you have module OWNER or DBA authority, you can grant RUN authority:

```
isql=> CONNECT TO 'SOMEDBE.SOMEGRP.SOMEACCT';
isql=> GRANT RUN ON SOMEPROG TO USER@ACCOUNT;
isql=> COMMIT WORK;
```

Now USER.ACCOUNT can run program SOMEPROG:

```
: HELLO USER.ACCOUNT
.
.
: RUN SOMEPROG
```

Refer to the *ALLBASE/SQL Reference Manual* for complete information on the GRANT command.

Maintaining ALLBASE/SQL Applications

After ALLBASE/SQL C programs are in production use, changes in procedures, personnel, or databases may necessitate various changes in the application itself. Maintaining an ALLBASE/SQL program includes such activities as these:

- Tuning performance.
- Managing the source code.
- Updating a program in production use.
- Changing runtime authorizations as program users change.
- Obsoleting application programs.

For these activities, you need OWNER authority for the module or DBA authority.

Tuning Performance

When an application enters production, you can estimate the best allocation of system resources, but only after it has run for a while can you fine-tune the performance. Refer to the *ALLBASE/SQL Performance Guidelines* for additional information about "Controlling Performance."

The best performance also depends on good transaction management. Refer to the *ALLBASE/SQL Reference Manual* for additional discussion of transaction management.

Managing Source Code

You should carefully maintain the source code for each application program in case it should be necessary to re-preprocess and re-compile at a later time. In addition to C source, it is recommended that you keep copies of the ISQL command files used to create your DBEnvironments. This information is extremely useful when modifying existing code.

Use SQLGEN to create schema files for storage once you have configured the DBEnvironment on the production side. Refer to the *ALLBASE/SQL Database Administration Guide* for information about using SQLGEN.

Updating Application Programs

Minor modifications to programs in the production environment can be made while the program is not currently in use. Major program modifications, because they are more time-consuming, are usually made on a development machine in a development DBEnvironment.

In either case, the OWNER of the program's module (or a DBA) preprocesses the revised program and replaces the old module with a new one. Existing RUN authorities can be either preserved or revoked. Dropping old modules and preserving or revoking RUN authorities can be done by using the DROP MODULE command in ISQL or can be specified when you invoke the preprocessor.

The PRESERVE option of the DROP MODULE command retains any existing RUN authorities for the module when it is deleted from the system catalog:

```
isql=> DROP MODULE myprog PRESERVE;
```

To delete a module and any existing RUN authorities for that module, simply omit the PRESERVE option.

You can also drop a module and revoke any existing run authorities for it at preprocessing time:

```
: RUN PSQLC.PUB.SYS; INFO="SOMEDBE (MODULE (MODULENAME) DROP REVOKE)"
```

The DROP option tells the preprocessor to drop any existing module named *MODULENAME*; if you omit the DROP option, a new module is created only if a module named *MODULENAME* does not exist. This invocation line drops any existing module named *MODULENAME*, and revokes any related RUN authorities. To revoke the RUN authorities by specifying the REVOKE option in the INFO string, you must also drop the module by specifying the DROP option. The DROP MODULE command is also useful for revised programs whose modules must be installed in a DBEnvironment different from that on which preprocessing occurred. Before using the INSTALL command to store the new module, drop the existing module using the DROP MODULE command, preserving or dropping related RUN authorization as required.

Changing Program-Related Authorization

Once a program is in production use, you may need to grant and revoke RUN and CONNECT authority as program users change. Revoking CONNECT authority requires DBA authorization:

```
isql=> REVOKE CONNECT FROM OLDUSER@ACCOUNT;
```

Revoking RUN authority requires either module OWNER or DBA authority:

```
isql=> REVOKE RUN ON PGMR1@ACCOUNT.SOMEPGM FROM OLDUSER@ACCOUNT;
```

Dropping Obsolete Modules

When an application program becomes obsolete, you use the DROP MODULE command to both remove the module from any DBEnvironment where it is stored and revoke any related RUN authorities:

```
isql=> DROP MODULE myprog;
```

Related RUN authorities are automatically revoked when you do not use the PRESERVE option of this command.

Programming Under the MPE XL Operating System

You must take certain characteristics of the MPE XL operating system into account as you code ALLBASE/SQL C applications. These include the following:

- Security Considerations.
- File Naming Conventions.
- Native Language Support.

Security Considerations

In order to preprocess and compile embedded SQL applications, you must have SF capability in the group where the preprocessing is done. You also need the ability to execute programs.

File Naming Conventions

When you create a DBEnvironment, a DBECon file having the name of the DBEnvironment is created. The fully qualified name of this DBECon file is stored in the DBECon file itself. In all references to files, the group and account of the DBEnvironment are assumed. For example, if your application connects to a DBEnvironment named PARTSDBE.SAMPLEDB.SYS and if the application creates a DBEFile as follows:

```
CREATE DBEFILE ORDERS WITH PAGES=50, NAME='OrderF1'
```

the fully qualified name of the file will be ORDERF1.SAMPLEDB.SYS, regardless of what group and account the application is in. Fully qualified file names, enclosed in quotes, are restricted to a maximum length of 36 bytes.

Note that the DBEnvironment does not have to be in the same group and account as the user's application; if it is to be located in a group and account different from the group and account where the executable program resides, you should use a fully qualified DBEnvironment name, as in the following example:

```
: RUN PSQLC.PUB.SYS:INFO="PARTSDBE.SAMPLEDB.SYS (MODULE SOMEMOD (DROP))"
```

Native Language Support

ALLBASE/SQL lets you manipulate databases in a wide variety of native languages in addition to the default language, known as **NATIVE-3000**. You can use either 8-bit or 16-bit character data, as appropriate for the language you select. In addition, you can always include ASCII data in any database, since ASCII is a subset of each supported character set. The collating sequence for sorting and comparisons is that of the native language selected.

You can use native language characters in a wide variety of places, including the following:

- Character literals.
- Host variables for CHAR or VARCHAR data (but not variable names).
- ALLBASE/SQL object names.
- WHERE and VALUES clauses.

If your system has the proper message files installed, ALLBASE/SQL displays prompts, messages and banners in the language you select, and it displays dates and time according to local customs. In addition, ISQL accepts responses to its prompts in the native language selected. However, regardless of the native language used, the syntax of ISQL and SQL commands—including punctuation—remains in ASCII.

Note that MPE XL does not support native language file names nor DBEnvironment names.

In order to use a native language other than the default, you must do the following:

1. Make sure your I/O devices support the character set you wish to use.
2. Set the MPE job control word NLUSERLANG to the number (*LangNum*) of the native language you wish to use. Use the following MPE XL command:

   ```
   SETJCW NLUSERLANG = LangNum
   ```

   This language then becomes the current language. (If NLUSERLANG is not set, the current language is NATIVE-3000.)
3. Use the `LANG` = *LanguageName* option of the START DBE NEW command to specify the language of a DBEnvironment when you create it.

Run the MPE XL utility program NLUTIL.PUB.SYS to determine which native languages are supported on your system. Here is a list of some supported languages, preceded by the *LangNum* for each:

```
 0 NATIVE-3000        9 ITALIAN           52 ARABICW
 1 AMERICAN          10 NORWEGIAN         61 GREEK
 2 C-FRENCH          11 PORTUGUESE        71 HEBREW
 3 DANISH            12 SPANISH           81 TURKISH
 4 DUTCH             13 SWEDISH          201 CHINESE-S
 5 ENGLISH           14 ICELANDIC        211 CHINESE-T
 6 FINNISH           41 KATAKANA         221 JAPANESE
 7 FRENCH            51 ARABIC           231 KOREAN
 8 GERMAN
```

Resetting NLUSERLANG while you are connected to a DBEnvironment has no effect on the current DBE session.

Looking at an Embedded SQL Source Program

In every ALLBASE/SQL C program, you embed SQL commands in the declaration part and the procedure part of your program to carry out specific tasks. The program listing shown in Figure 1-7 illustrates where in a program you can embed SQL commands to accomplish these tasks:

(1) Declare the SQL Communications Area (sqlca).

The sqlca is an ALLBASE/SQL data structure that contains current information about a program's DBE session. Every ALLBASE/SQL C program must contain an sqlca declaration in the global declaration section. Use the following command:

```
EXEC SQL INCLUDE SQLCA;
```

(2) Declare host variables.

All host variables used in a program must be declared in a declaration part. You can put more than one such declaration section in a program, but all host variables must be declared between the BEGIN and END DECLARE SECTION commands.

(3) Display error and warning messages from the ALLBASE/SQL message catalog.

You can display messages for any errors encountered in execution as shown in the SQLStatusCheck function. Complete details about error and message handling are presented in Chapter 4.

(4) Start a DBE session.

In most application programs, you embed the CONNECT command to start a DBE session. This command must be executed before you can access the DBEnvironment

(5) Check the status of SQL command execution.

Your program should check for the success or failure of execution of each SQL command, as shown in the example program.

6 Terminate the DBE session.

You use the RELEASE command or the RELEASE option of the COMMIT WORK command to end a DBE session.

7 and 8 Define transactions.

You define transactions in a program to control concurrency and consistency in your database access. The transaction is bounded by the BEGIN WORK and COMMIT WORK or ROLLBACK WORK commands. When a COMMIT WORK is successfully executed, all operations performed by the transaction it ends are permanently committed to the DBEnvironment

9 Define or manipulate data in the DBEnvironment.

Nearly all programs access data in one or more databases. The SELECT command shown in the example program retrieves the row from PurchDB.Parts that contains a part number matching the value in the host variable named in the WHERE clause. Note, indicator variables such as *SalesPriceInd* are discussed in Chapter 3, and data manipulation is presented fully in Chapters 5 through 8.

```
Program to SELECT specified rows from the Parts Table - cex2

Event List:
 CONNECT to PartsDBE
 BEGIN WORK
 SELECT specified row from Parts Table
  until user enters a '/'
 COMMIT WORK
 RELEASE from PartsDBE

Connect to PartsDBE

Enter Part Number within Parts Table or '/' to STOP> 1243-P-01

Begin Work
SELECT PartNumber, PartName, SalesPrice

Row not found!

Commit Work

Enter Part Number within Parts Table or "/" to STOP> 1323-D-01

Begin Work
SELECT PartNumber, PartName, SalesPrice

Part Number:  1323-D-01
Part Name:    Floppy Diskette Drive
Sales Price:    200.00

Commit Work

Enter Part Number within Parts Table or "/" to STOP> /

Release PartsDBE
```

Figure 1-6. Runtime Dialog of Program cex2

```
/* Program cex2 */

/* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * */
/* This program illustrates the use of SQL's SELECT command to     */
/* retrieve one row or tuple of data at a time.                     */
/* BEGIN WORK is executed before the SELECT and a COMMIT WORK       */
/* is executed after the SELECT. An indicator variable is also      */
/* used for SalesPrice.                                             */
/* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * */

typedef int boolean;

char    response[2];
boolean Abort;

#include <stdio.h>

#define    OK                0
#define    NotFound        100
#define    MultipleRows  -10002
#define    DeadLock      -14024
#define    FALSE             0
#define    TRUE              1

EXEC SQL INCLUDE SQLCA;   /* SQL Communication Area */          (1)

      /* Begin Host Variable Declarations */
   EXEC SQL BEGIN DECLARE SECTION;                              (2)
   char       PartNumber[17];
   char       PartName[31];
   double     SalesPrice;
   sqlind     SalesPriceInd;
   char       SQLMessage[133];
   EXEC SQL END DECLARE SECTION;                                (2)
      /* End Host Variable Declarations */
```

Figure 1-7. Program cex2: Using Simple SELECT

```
int SQLStatusCheck()  /* Function to Display Error Messages */
{
Abort = FALSE;
if (sqlca.sqlcode < DeadLock)
   Abort = TRUE;
do {
  EXEC SQL SQLEXPLAIN :SQLMessage;                              (3)
  printf("\n");
  printf("%s\n",SQLMessage);
  } while (sqlca.sqlcode != 0);

if (Abort) {
  EndTransaction();
  ReleaseDBE();
  }
}  /* End SQLStatusCheck Function */


boolean ConnectDBE()  /* Function to Connect to PartsDBE            */
{
boolean ConnectDBE;

ConnectDBE = TRUE;

printf("\n connect to PartsDBE");

EXEC SQL CONNECT TO 'PartsDBE';

if (sqlca.sqlcode != OK) {
  ConnectDBE = FALSE;
  SQLStatusCheck();                                             (5)
  }  /* End if */
return (ConnectDBE);
}  /* End of ConnectDBE Function */


int ReleaseDBE()   /* Function to Release PartsDBE             */
{
printf("\n");
printf("\n Release PartsDBE");
printf ("\n);
EXEC SQL RELEASE;                                               (6)

if (sqlca.sqlcode != OK) SQLStatusCheck();
}  /* End ReleaseDBE Function */
```

Figure 1-7. Program cex2: Using Simple SELECT (page 2 of 5)

```
boolean BeginTransaction()    /* Function to Begin Work */
{
boolean BeginTransaction;
BeginTransaction = TRUE;

printf("\n");
printf("\n Begin Work");
EXEC SQL BEGIN WORK;                                          (7)

if (sqlca.sqlcode != OK) {
  BeginTransaction = FALSE;
  SQLStatusCheck();                                           (5)
  ReleaseDBE();
  }  /* End if */
return (BeginTransaction);
}  /* End BeginTransaction Function */


int EndTransaction()  /* Function to Commit Work */
{
printf("\n");
printf("\n Commit Work");
EXEC SQL COMMIT WORK;                                         (8)

if (sqlca.sqlcode != OK) SQLStatusCheck();                    (5)
}  /* End EndTransaction Function */


int DisplayRow()   /* Function to Display Parts Table Rows */
{
  printf("\n");
  printf("\n Part Number:   %s\n",   PartNumber);
  printf(" Part Name:     %s\n",   PartName);

  if (SalesPriceInd < 0) {
    printf(" Sales Price:   is NULL \n");
    }
  else
    printf(" Sales Price: %10.2f\n", SalesPrice);
}  /* End of DisplayRow */
```

Figure 1-7. Program cex2: Using Simple SELECT (page 3 of 5)

```
int Select()    /* Function to Query Parts Table */
{

do {
  printf("\n");
  printf("\n Enter Part Number within Parts Table or '/' to STOP > ");
  scanf("%s",PartNumber);

  if (PartNumber[0] != '/') {

    BeginTransaction();

    printf("\n SELECT PartNumber, PartName, SalesPrice");
    EXEC SQL SELECT PartNumber, PartName, SalesPrice            (9)
              INTO :PartNumber,
                   :PartName,
                   :SalesPrice :SalesPriceInd
              FROM  PurchDB.Parts
             WHERE  PartNumber = :PartNumber;

    if ((sqlca.sqlwarn[0] == 'W') || (sqlca.sqlwarn[0] == 'w')) {
      printf("\n SQL WARNING has occurred. The following row");
      printf("\n    of data may not be valid!");
      }
    if (sqlca.sqlcode == 0K) {
      DisplayRow();
      }
    else if (sqlca.sqlcode == NotFound) {
      printf("\n Row not found!");
     }
    else if (sqlca.sqlcode == MultipleRows) {
      printf("\n WARNING: More than one row qualifies!");
      }
    else {
      SQLStatusCheck();                                         (5)
}
    EndTransaction();
  }
}   /* End do */
while (PartNumber[0] != '/');

}/* End of Select Function */
```

Figure 1-7. Program cex2: Using Simple SELECT (page 4 of 5)

```
main()          /* Beginning of program */
{

printf("\n Program to SELECT specified rows from");
printf("\n  the Parts Table - cex2");
printf("\n");
printf("\n Event List:");
printf("\n  CONNECT TO PartsDBE");
printf("\n  BEGIN WORK");
printf("\n  SELECT the specified row from the Parts Table");
printf("\n    until the user enters a '/'");
printf("\n  COMMIT WORK");
printf("\n  RELEASE from PartsDBE");
printf("\n");

if (ConnectDBE())  {
  Select();
  ReleaseDBE();
  }
else
  printf("\n Error: Cannot Connect to PartsDBE!\n");
}  /* End of Program */
```

Figure 1-7. Program cex2: Using Simple SELECT (page 5 of 5)

2

Using the Preprocessor

This chapter shows how to use all the preprocessor's options, and it describes the inputs and outputs of the preprocessor command. Topics are:

- Invoking the C Preprocessor.
- Identifying Preprocessor Input.
- Identifying Preprocessor Output.
- Dealing with Preprocessor Errors.
- Looking at a Modified ALLBASE/SQL Source Program.
- Looking at Preprocessor Created INCLUDE Files.

An example of a modified source file appears at the end of the chapter along with listings of the preprocessor generated include files.

Invoking the C Preprocessor

You can use the preprocessor in two modes:

1. Full preprocessing mode: includes SQL syntax checking, creating compilable output, storing a module in a DBEnvironment, and creating a file that contains an installable copy of the stored module.
2. Syntax checking mode: checks your SQL syntax without doing any other preprocessor tasks.

As you develop the SQL portions of your C programs, syntax checking mode is quite useful. Preprocessing is quicker in this mode than in full preprocessing mode. In addition, you can start debugging your SQL commands before the DBEnvironment itself is in place.

Command syntax for both modes is presented below.

Full Preprocessing Mode

Use the following preprocessor command to:

- Check the embedded SQL command syntax.
- Create compilable output files that can be processed by the C compiler
- Store a module in the DBEnvironment named.
- Create a file containing an installable version of the module.

Preprocessor Syntax I

```
RUN PSQLC.PUB.SYS;INFO= "DBEnvironmentName [(
                        { MODULE(ModuleName)
                        { OWNER (OwnerName)
                        { { DROP { PRESERVE } }
                        {        { REVOKE   } }
                        { NODROP              }

|...|)]"
```

Parameters

DBEnvironmentName	Identifies the DBEnvironment in which a module is to be stored. You may use a backreference to a file defined in a file equation for this parameter.
ModuleName	Assigns a name to the stored module. Module names must follow the rules governing ALLBASE/SQL basic names as described in the *ALLBASE/SQL Reference Manual*. If a module name is not specified, the preprocessor uses the PROGRAM-ID as the module name.
OwnerName	Associates the stored module with a *User@Account*, a *ClassName*, or a *GroupName*. You can specify an owner name for the module only if you have DBA authority in the DBEnvironment where the module is to be stored. If not specified, the owner name is your log-on *User@Account*. Any object names in SQLIN not qualified with an owner name are qualified with the *OwnerName* specified by the preprocessor, or the user.
`DROP`	Deletes any module currently stored in the DBEnvironment by the *ModuleName* and *OwnerName* specified in the INFO string.
`NODROP`	Terminates preprocessing if any module currently exists in the DBEnvironment by the *ModuleName* and *OwnerName* specified in the INFO string. If not specified, NODROP is assumed.
`PRESERVE`	Is specified when the program being preprocessed already has a stored module and you want to preserve existing RUN authorities for that module. If not specified, PRESERVE is assumed. PRESERVE cannot be specified unless DROP is also specified.

`REVOKE` Is specified when the program being preprocessed already has a stored module and you want to revoke existing RUN authorities for that module. REVOKE cannot be specified unless DROP is also specified.

Description

1. Before invoking the preprocessor in this mode when the program being preprocessed already has a stored module, ensure that the earlier version of the program is not being executed.
2. The preprocessor starts a DBE session in the DBEnvironment named in the RUN command by issuing a `CONNECT TO` '*DBEnvironmentName*' command. If the autostart flag is OFF, the DBE session can be initiated only after a START DBE command has been processed.
3. If the DBEnvironment to be accessed is operating in single-user mode, preprocessing can occur only when another DBE session for the DBEnvironment does not exist.
4. When the preprocessor's DBE session begins, ALLBASE/SQL processes a BEGIN WORK command. When preprocessing is completed, the preprocessor submits a COMMIT WORK command, and any sections created are committed to the system catalog. If the preprocessor detects an error in SQLIN, it processes a ROLLBACK WORK command before terminating, and no sections are stored in the DBEnvironment. Preprocessor warnings do not prevent sections from being stored.
5. Since all preprocessor DBE sessions initiate only one transaction, any log file space used by the session is not available for re-use until after the session terminates. If *rollforward logging* is not in effect, you can issue the CHECKPOINT command in ISQL *before preprocessing* to increase the amount of available log space. Refer to the *Database Administration Guide* for additional information on log space management, such as using the START DBE NEWLOG command to increase the size of the log and recovering log space when *rollforward logging* is in effect.
6. During preprocessing, system catalog pages accessed for embedded commands are locked. In multiuser mode, other DBE sessions accessing the same objects must wait, and the potential for a deadlock exists. Therefore minimize competing transactions when preprocessing an application program. Refer to the appendix "Locks Held on the System Catalog by SQL Commands" in the *ALLBASE/SQL Database Administration Guide* for information on operations that lock system catalog pages.
7. For improved runtime performance, use ISQL to submit the UPDATE STATISTICS command *before preprocessing* for each table accessed in a data manipulation command when an index on that table has been added or dropped and when data in the table is often changed.
8. If you specify an OwnerName or ModuleName in a language other than NATIVE-3000 (ASCII), be sure that the language you are using is also the language of the DBEnvironment in which the module will be stored.

Authorization

To preprocess a program, you need DBA or CONNECT authority for the DBEnvironment specified in the preprocessor command line. You also need table and view authorities for the tables and views which the program will access at run time.

DBEnvironment CONNECT authority can also be explicitly GRANTed. If you have DBECreator or DBA authority or module OWNER authority, you have CONNECT authority by default.

Table authorities are implicitly specified at the time the table is CREATEd and depend on the table type (PUBLIC, PUBLICREAD, or PRIVATE). Once a table has been created, its implicit authorities can be changed by the table OWNER, the DBECreator, or another DBA. Table authorities are removed by using the REVOKE command and are added by using the GRANT command.

For example, for a PUBLIC table, you are implicitly GRANTed authority for any type of table access when the table is created. For a PUBLICREAD table, you must have explicitly GRANTed authority for any table access except READ access which is an implicit grant. For a PRIVATE table, there are no implicit grants at table creation time; only the table OWNER or a DBA can access a PRIVATE table, unless specific authorities are GRANTed to others.

Note, in the case of the sample database, PartsDBE, the creation script REVOKEs all implicit table authorities, and desired authorities must be explicitly GRANTed.

Note When preprocessing, you cannot name another user as module owner unless you are a DBA of the DBEnvironment or you are the current module owner.

Example

```
:FILE SQLIN=CEX2
:RUN PSQLC.PUB.SYS;INFO=&
"PartsDBE (MODULE(CEX2) OWNER(OwnerP@SomeAcct) REVOKE DROP)"

                                        WED, OCT 25, 1991,  1:38 PM
HP36216-02A.E1.02             C Preprocessor/3000         ALLBASE/SQL
(C)COPYRIGHT HEWLETT-PACKARD CO.  1982,1983,1984,1985,1986,1987,1988,
1989,1990,1991. ALL RIGHTS RESERVED.

 0 ERRORS     1 WARNINGS
END OF PREPROCESSING.


END OF PROGRAM
:EDITOR
HP32501A.07.20 EDIT/3000 FRI, OCT 27, 1991,  10:17 AM
(C)HEWLETT-PACKARD CO. 1990
/T SQLMSG;L ALL UNN
FILE UNNUMBERED

             .
             .
             .
SQLIN                = CEX2.SOMEGRP.SOMEACCT
DBEnvironment        = partsdbe
Module Name          = CEX2

        SELECT PARTNUMBER, PARTNAME, SALESPRICE INTO :PARTNUMBER, :PARTNAME,
        :SALESPRICE :SALESPRICEIND FROM PURCHDB.PARTS WHERE PARTNUMBER =
        :PARTNUMBER ;

******  ALLBASE/SQL warnings (DBWARN 10602)
******  in SQL statement ending in line 133
***     User SomeUser@SomeAcct does not have SELECT authority on PURCHDB.PARTS.
(DBERR 2301)

  1 Sections stored in DBEnvironment.

 0 ERRORS   1 WARNINGS
END OF PREPROCESSING

/
```

Syntax Checking Mode

The following command only checks the syntax of the SQL commands embedded in the source code file.

Preprocessor Syntax II

```
RUN PSQLC.PUB.SYS;INFO="(SYNTAX)"
```

Description

1. The preprocessor does not access a DBEnvironment when it is run in this mode.
2. When performing only syntax checking, the preprocessor does not convert the SQL commands into C statements. Therefore SQLOUT does not contain any preprocessor generated calls to ALLBASE/SQL external procedures.
3. SQLTYPE, SQLEXTN, SQLVAR, and SQLMOD are created, but incomplete.

Authorization

You do not need ALLBASE/SQL authorization when you use the preprocessor to only check SQL syntax.

Example

```
:FILE SQLIN=CEX2
:RUN PSQLC.PUB.SYS;INFO="(SYNTAX)"

                                          WED, OCT 25, 1991,  1:38 PM
HP36216-02A.E1.02              C Preprocessor/3000         ALLBASE/SQL
(C)COPYRIGHT HEWLETT-PACKARD CO.   1982,1983,1984,1985,1986,1987,1988,
1989,1990,1991. ALL RIGHTS RESERVED.

Syntax checked.
 1 ERRORS     0 WARNINGS
END OF PREPROCESSING.


PROGRAM TERMINATED IN AN ERROR STATE.  (CIERR 976)
:EDITOR
HP32501A.07.20 EDIT/3000 FRI, OCT 27, 1991,  9:35 AM
(C) HEWLETT-PACKARD CO. 1985
/T SQLMSG;L ALL UNN
FILE UNNUMBERED

               .
               .
               .
SQLIN                 = CEX2.SOMEGRP.SOMEACCT


        SELECT PARTNUMBER, PARTNAME, SALESPRICE INTO :PARTNUMBER, :PARTNAME,
        :SALESPRICE :SALESPRICEIND, FROM PURCHDB.PARTS WHERE PARTNUMBER =
        :PARTNUMBER ;

******  ALLBASE/SQL errors (DBERR 10977)
******  in SQL statement ending in line 176
***     Unexpected keyword.  (DBERR 1006)

Syntax checked.

 1 ERRORS   0 WARNINGS
END OF PREPROCESSING.

/
```

The line 176 referenced in SQLMSG is the line in SQLIN where the erroneous SQL command ends.

DBEnvironment Access

When you invoke the preprocessor in full preprocessing mode, you name an ALLBASE/SQL DBEnvironment. The preprocessor starts a DBE session for that DBEnvironment when preprocessing begins and terminates that session when preprocessing is completed. The preprocessor derives the name of the module from the source code file name unless you supply a different name when you invoke the preprocessor:

```
: RUN PSQLC.PUB.SYS; INFO="DBEnvironment (MODULE (ModuleName))"
```

When the preprocessor terminates its DBEnvironment session, it issues a COMMIT WORK command if it encountered no errors. Created sections are stored in the DBEnvironment and associated with the module name. See Figure 2-6 later in this chapter.

ALLBASE/SQL accesses the DBEnvironment you specify during preprocessing, even if your program does not use SQL statements that store sections in this DBEnvironment. Therefore, you must specify the name of a valid DBEnvironment.

In some cases an ALLBASE/SQL progam is used with one or more DBEnvironments in addition to the DBEnvironment accessed at preprocessing time. In these cases, use ISQL to install the installable module created by the preprocessor into each additional DBEnvironment accessed by your program. See the section "Installable Module File" in this chapter.

An alternative method of accessing more than one DBEnvironment from the same program would be to divide the program into separate compilable files. Each source file would access a DBEnvironment. In each file, start and terminate a DBE session for the DBEnvironment accessed. Then preprocess and compile each file separately. When you invoke the preprocessor, identify the DBEnvironment accessed by the source file being preprocessed. After a file is preprocessed, it must be either saved under a different file name than the usual preprocessor output, or compiled with no linking before the next source file is preprocessed. When all source files have been preprocessed and compiled, link them together to create an executable program.

For example if you want to preprocess several ALLBASE/SQL application programs in the same group and account and compile and link the programs later, or you plan to compile a preprocessed program during a future session, you should do the following for each program:

- Before running the preprocessor, equate SQLIN to the name of the file containing the application you want to preprocess:

  ```
  :FILE SQLIN = InFile
  ```

- After running the preprocessor, save and rename the output files if you do not want them overwritten. For example:

  ```
  :SAVE SQLOUTPUT
  :RENAME SQLOUT, OutFile
  :SAVE SQLMOD
  :RENAME SQLMOD, ModFile
  :SAVE SQLVAR
  :RENAME SQLVAR, VarFile
  ```

- When you are ready to compile the program, you must equate the include file name to its standard ALLBASE/SQL name (SQLVAR).

Note A program that accesses more than one DBEnvironment must do so in sequence since only one DBEnvironment can be accessed at a time. Such program design may adversely affect performance and requires special consideration.

To preprocess a program, or to use an already preprocessed ALLBASE/SQL application program, you must satisfy the authorization requirements for each DBEnvironment accessed.

Compiling and Linking

Figure 2-1 shows the process of compiling and linking an embedded SQL C program.

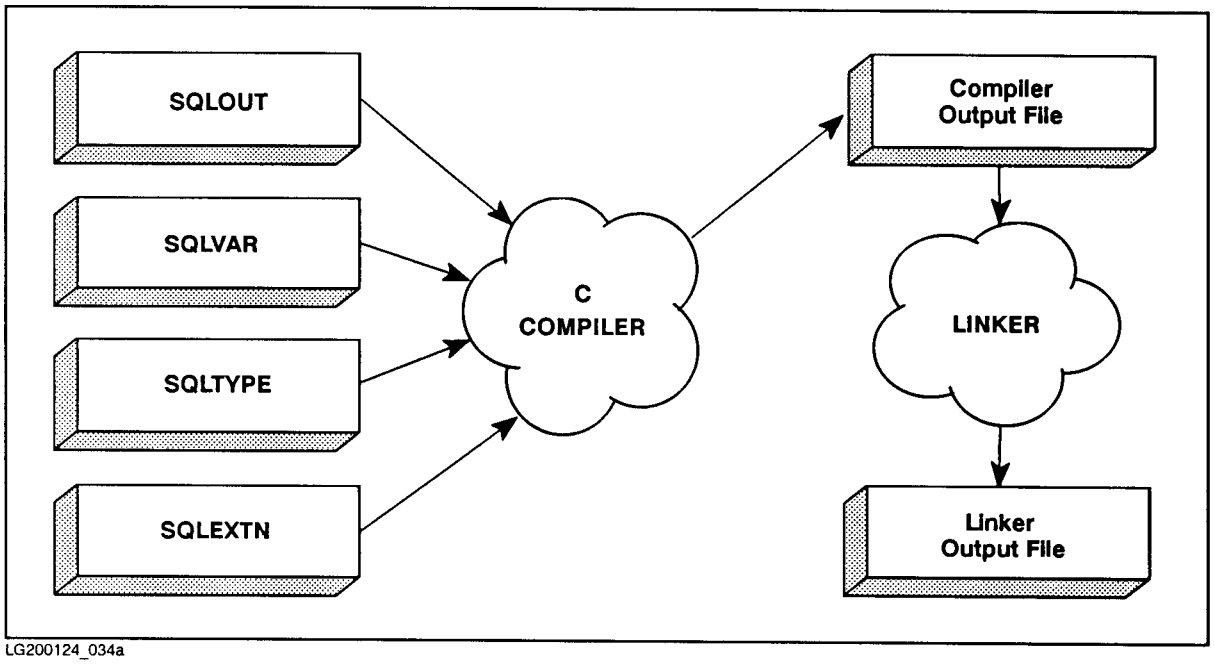

Figure 2-1. Compiling and Linking

As shown in the figure, you submit to the C compiler one or more modified source code files and the related include files created by the preprocessor. The compiler then generates object code.

To convert these object code files into an executable program, link them after compilation by invoking the link editor. This step creates an executable program file.

To expedite the process of compiling and linking your embedded SQL programs, use the preprocessor UDCs described below.

Using the Preprocessor UDCs

Two UDC's for invoking the C preprocessor are provided with ALLBASE/SQL in the HPSQLUDC.PUB.SYS file:

- **PC**, illustrated in Figure 2-2, invokes the preprocessor in full preprocessing mode. You specify the source file name, a DBEnvironment name, and a name for SQLMSG (if you do not want preprocessor messages to go to $STDLIST).

  `:PC` *SourceFileName,DBEnvironment*

  The PC UDC uses the following preprocessor INFO string parameters:

  ModuleName is the name of the source file.

  OwnerName is the log-on *User@Account*.

  PRESERVE and DROP are in effect.

- **PPC**, illustrated in Figure 2-3, invokes the preprocessor in full preprocessing mode, then invokes the C compiler if preprocessing is successful and the linker if compilation is successful.

To use this UDC, you specify the source file name, a DBEnvironment name, and an executable file name. You can specify a name for SQLMSG if you do not want preprocessor messages to go to $STDLIST:

`:PPC` *SourceFileName,DBEnvironment,ExecutableFileName*

This UDC uses the following preprocessor INFO string parameters:

ModuleName is the source file name.

OwnerName is the log-on *User@Account*.

PRESERVE and DROP are in effect.

If you make your own version of the UDC's, do not modify the record attributes for any of the preprocessor output files. Only modify the file limit (`disc=`*FileLimit*) if required.

Note Because the UDC's purge the preprocessor message file, if messages are sent to $STDLIST an error message appears when you use the UDC's, but preprocessing continues.

```
PC srcfile,dbefile,msgfile=$stdlist
continue
setvar _savefence hpmsgfence
setvar hpmsgfence 2
continue
purge !msgfile
purge sqlout
purge sqlmod
purge sqlvar
purge sqltype
purge sqlextn
setvar hpmsgfence _savefence
deletevar _savefence
file sqlin  = !srcfile
file sqlmsg = !msgfile; rec=-80,16,f,ascii
file sqlout;   disc=10000,32;  rec=-80,16,f,ascii
file sqlmod;   disc=1023,10,1; rec=250,,f,binary
file sqlvar;   disc=2048,32;   rec=-80,16,f,ascii
file sqltype;  disc=2048,32;   rec=-80,16,f,ascii
file sqlextn;  disc=2048,32;   rec=-80,16,f,ascii
continue
run psqlc.pub.sys;info="!dbefile (drop)"
reset sqlin
reset sqlmsg
reset sqlout
reset sqlmod
reset sqlvar
reset sqltype
reset sqlextn
```

Figure 2-2. UDC for Preprocessing SQLIN

```
PPC srcfile,dbefile,pgmfile,msgfile=$stdlist
continue
setvar _savefence hpmsgfence
setvar hpmsgfence 2
continue
purge !msgfile
purge sqlout
purge sqlmod
purge sqlvar
purge sqltype
purge sqlextn
setvar hpmsgfence _savefence
deletevar _savefence
file sqlin  = !srcfile
file sqlmsg = !msgfile; rec=-80,16,f,ascii
file sqlout;   disc=10000,32;  rec=-80,16,f,ascii
file sqlmod;   disc=1023,10,1; rec=250,,f,binary
file sqlvar;   disc=2048,32;   rec=-80,16,f,ascii
file sqltype;  disc=2048,32;   rec=-80,16,f,ascii
file sqlextn;  disc=2048,32;   rec=-80,16,f,ascii
continue
run psqlc.pub.sys;info="!dbefile (drop)"
if jcw <= warn  then
   continue
   ccxllk sqlout,!pgmfile,$null
endif
reset sqlin
reset sqlmsg
reset sqlout
reset sqlmod
reset sqlvar
reset sqltype
reset sqlextn
```

Figure 2-3. UDC for Preprocessing, Compiling, and Preparing SQLIN

The example in Figure 2-4 illustrates the use of PPC on an SQLIN that could be successfully preprocessed, but failed to compile because a C error exists in the file. In addition to generating an error message for the C error, the C compiler generates several warning messages. The warning messages are normal and will not cause runtime problems; they are due to the way the C preprocessor declares some of the variables in SQLVAR.

```
:PPC CEX2,PARTSDBE,CEX2P

                                        WED, OCT 25, 1991,  1:38 PM
HP36216-02A.E1.02          C Preprocessor/3000          ALLBASE/SQL
(C)COPYRIGHT HEWLETT-PACKARD CO. 1982,1983,1984,1985,1986,1987,1988,
1989,1990,1991. ALL RIGHTS RESERVED.

 SQLIN                = CEX2.SOMEGRP.SOMEACCT
 DBEnvironment        = partsdbe

 Module Name          = CEX2
1 Sections stored in DBEnvironment.

 0 ERRORS     0 WARNINGS
END OF PREPROCESSING.

END OF PROGRAM

END OF COMPILE

HP Link Editor/XL (HP30315A.04.04) Copyright Hewlett-Packard Co 1986

LinkEd> LINK FROM=$OLDPASS;RL= CCSTDRL.LIB.SYS;TO=c2p

END OF PROGRAM
:
```

Figure 2-4. Sample UDC Invocation

The line number referenced in the compiler output messages is the C statement number in the *compiler output listing*. Because PPC sends the compiler output listing to $null, you must reinvoke the compiler, sending the compiler listing to an output file, to identify the line in error:

```
:BUILD CLIST;DISC=10000,32;REC=-80,16,F,ASCII
:CCXL SQLOUT,$OLDPASS,CLIST
```

The C syntax error flagged in the example under "Syntax Checking Mode" appears as follows in CLIST:

```
00261              DISPAY "SELECT PartNumber, PartName and SalesPrice".
```

Using the Preprocessor in Job Mode

You can preprocess, compile, and prepare C ALLBASE/SQL programs in job mode. The following example illustrates a job file that uses the PPC UDC to preprocess several sample programs.

```
!JOB JIM,MGR.HPDB,CPROG;OUTCLASS=,1
!ppc cexp01,PartsDBE,cexp01p
!ppc cexp01a,PartsDBE,cexp01ap
!ppc cexp02,PartsDBE,cexp02p
     .
     .
!ppc cexp50,PartsDBE,cexp50p
!TELL JIM,MGR.HPDB; C Preprocessing is complete!
!EOJ''
```

Running the Program

When an ALLBASE/SQL program is first created, it can only be executed by the module OWNER or a DBA. In addition, it can only operate on the DBEnvironment used at preprocessing time if a module was generated. If no module was generated because the SQL commands embedded in the program are only commands for which no sections are created, the program can be run against any DBEnvironment.

The program created in the previous example can be executed as follows by the module owner:

```
: run someprog
```

To make the program executable by other users in other DBEnvironments:

- Load the executable program file onto the machine where the production DBEnvironment resides.
- Install any related module in the production DBEnvironment.
- Ensure necessary module owner authorities exist.
- Grant required authorities to program users.

Accessing Multiple DBEnvironments

An alternative method of accessing more than one DBEnvironment from the same program would be to divide the program into separate compilable files. Each source file would access a DBEnvironment. In each file, start and terminate a DBE session for the DBEnvironment accessed. Then preprocess and compile each file separately. When you invoke the preprocessor, identify the DBEnvironment accessed by the source file being preprocessed. After a file is preprocessed, it must be compiled so that no linking is performed before the next source file is preprocessed. When all source files have been preprocessed and compiled, link them together to create an executable program. An example of this technique follows:

```
:RUN PSQLC.PUB.SYS;INFO="DBEnvironment1 (MODULE (ModuleName))"
:CCXL SQLOUT, SQLOBJ1
    .
    .
:RUN PSQLC.PUB.SYS;INFO="DBEnvironment2 (MODULE (ModuleName))"
:CCXL SQLOUT, SQLOBJ2
    .
    .
:LINK FROM=SQLOBJ1,SQLOBJ2;RL=STDRL.LIB.SYS;TO=SOMEPROG
```

Note that a program which accesses more than one DBEnvironment must do so in sequence since only one DBEnvironment can be accessed at a time. Such program design may adversely affect performance and requires special consideration.

To preprocess a program, or to use an already preprocessed ALLBASE/SQL application program, you must satisfy the authorization requirements for each DBEnvironment accessed.

Identifying Preprocessor Input

In the simplest case, illustrated earlier in Figure 1-1, the ALLBASE/SQL C program consists of one source code file and, optionally, one or more user include files; both the source code and the include files can contain SQL commands. The preprocessor merges any include files into the source program, and preprocesses it. The resulting modified source code file is then compiled and linked in the same manner as a C program not containing embedded SQL statements. (Include files must either exist in the current group or be specified with an account and group name.)

Regardless of the preprocessing mode you use, the source file and the ALLBASE/SQL message catalog must be available when you invoke the C preprocessor, as shown in Figure 2-5.

Source File

The **source file** is a file containing the source code of the C ALLBASE/SQL program with embedded SQL commands for one or more DBEnvironments. The default input filename is:

```
SQLIN
```

An alternative name can be specified by using the DROP option in the preprocessor command line, as explained earlier in this chapter.

When parsing the source file, the C preprocessor ignores most C statements and C compiler directives in it. Only the following information is parsed by the C preprocessor:

- The C compiler directive, include.
- The source file name. Unless you specify a module name in the preprocessor command line, the preprocessor uses the source file name as the name for the module it stores. A module name can contain as many as 8 bytes and must follow the rules governing ALLBASE/SQL basic names (given in the *ALLBASE/SQL Reference Manual*).
- Constructs found between the prefix EXEC SQL and the suffix ;. These constructs follow the rules given in Chapter 1 for how and where to embed these constructs.
- Constructs found between the BEGIN DECLARE SECTION and END DECLARE SECTION commands. These commands delimit a declare section, which contains C data declarations for the host variables used in the program. Host variables are described in Chapter 3.

ALLBASE/SQL Message Catalog

The **ALLBASE/SQL message catalog**, contains preprocessor messages and ALLBASE/SQL error and warning messages. The fully qualified name for the default message catalog is:

```
SQLCT000.PUB.SYS
```

For native language users, the name of the catalog is:

```
SQLCTxxx.PUB.SYS
```

where *xxx* is the numerical value for the current language. If this catalog is not available, ALLBASE/SQL issues a warning and uses the default catalog instead.

When you run the preprocessor in full preprocessing mode, also ensure that the DBEnvironment accessed by the program is available.

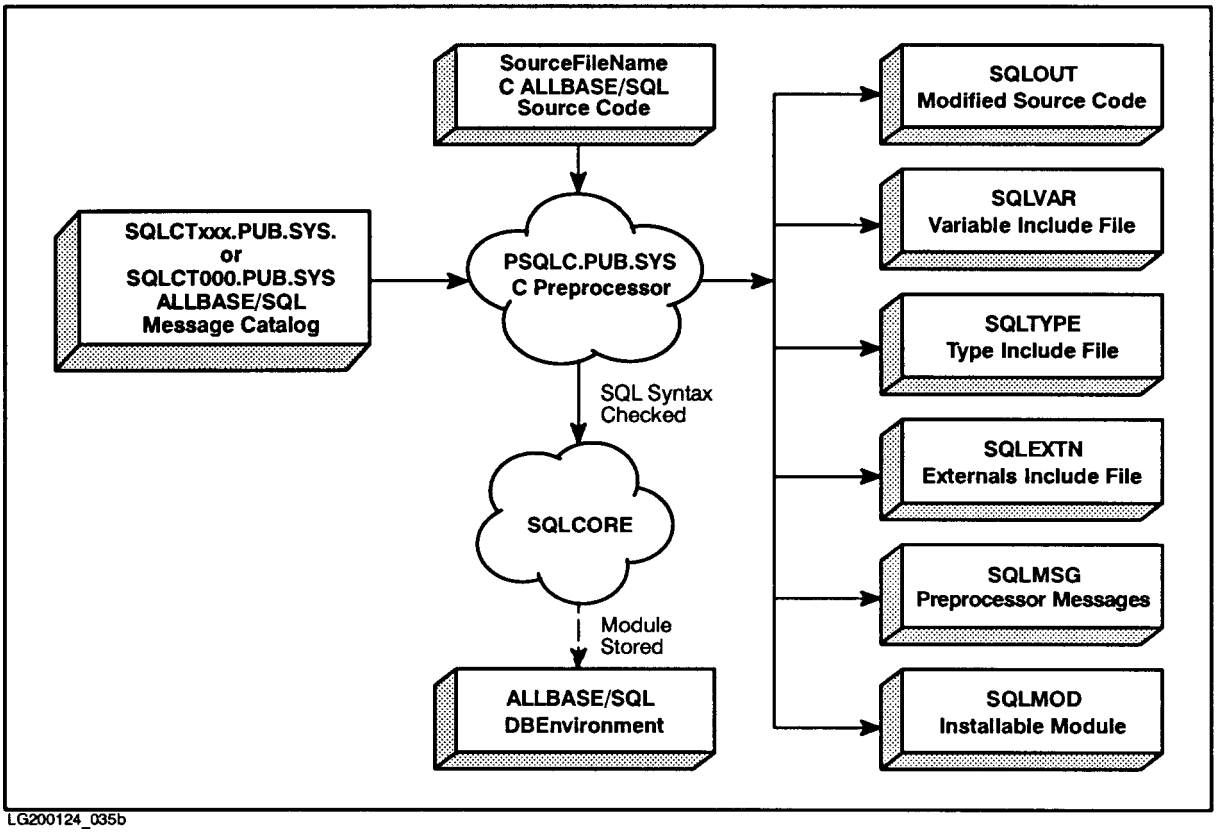

Figure 2-5. Full Preprocessing Mode Input and Output

Identifying Preprocessor Output

As Figure 2-5 points out, running the C preprocessor in full preprocessing mode creates the following output files:

- Modified source file.
- Include files.
- SQL message file.
- Installable module file.

Also, a module is stored in the DBEnvironment specified in the preprocessor invocation line. Each of these is described in the following sections.

Modified Source File

As the C preprocessor parses the source file, it copies lines from it and any include files into the modified source file, inserts conditional compiler directives around the embedded SQL commands, and inserts information around each embedded SQL command.

The default modified source file name is *SQLOUT*.

Figure 2-9 illustrates the modified source file generated for the source file pictured in Figure 1-8. The shaded lines contain information generated by the C preprocessor.

In both preprocessing modes, the C preprocessor:

- Inserts conditional compiler directives around embedded SQL commands to conditionally ignore the SQL commands.
- Inserts three #INCLUDE C compiler directives within the Declaration part. These directives reference the three preprocessor generated include files. These files are included at the beginning of the modified source file created by the preprocessor.
- Places comments on the line with an embedded command following the last line the embedded command generates. Note, for example, that the comment following the EXEC SQL INCLUDE SQLCA command in the source file is in the same column, but on a different line, in the modified source file.

In full preprocessing mode, the preprocessor also:

- Generates a C declaration of the sqlca and the sqlda in the type include file.
- Generates C statements providing conditional instructions following SQL commands encountered after one of the following SQL commands: WHENEVER SQLERROR, WHENEVER SQLWARNING, and WHENEVER NOT FOUND.
- Generates C statements that call ALLBASE/SQL external procedures at run time. These calls reference the module stored by the preprocessor in the DBEnvironment for execution at run time. Parameters used by these external calls are defined in the variable and type include files.

Caution Although you can access the preprocessor output files with an editor, you should *never* change the information generated by the C preprocessor. Your DBEnvironment or your system could be damaged at run time if preprocessor generated constructs are altered.

If you change non-preprocessor-generated constructs, make the changes to the source file, re-preprocess it, and re-compile the output files before putting the application program into production.

Include Files

There are three include files, which contain declarations and definitions used by the C functions created by the preprocessor and inserted into the modified source code file:

- type include file: the name for this file, which contains type declarations, is:

  ```
  SQLTYPE
  ```

- variable include file: the name for this file, which contains variable declarations, is:

  ```
  SQLVAR
  ```

- externals include file: the name for this file, which contains external procedure declarations, is:

  ```
  SQLEXTN
  ```

The sqlmodulename and ownername of sections are defined as global static variables in SQLVAR. It is advised that multiple source file applications be preprocessed all at one time so that only one SQLVAR file is generated. If the source files are preprocessed and compiled separately and combined at link time, runtime errors occur because the static global sqlmodulename variable from the first source file preprocessed is used and incorrect sections are executed. Therefore, all preprocessed sections in your program must reside in the same file for input to the C compiler.

When you use file equations to redirect the include files, remember that the preprocessor always inserts the same #INCLUDE directives. Therefore, insure that the applicable file equations are in effect when you preprocess and when you compile.

When the preprocessor is invoked, the following file equations must be in effect:

```
:FILE SQLTYPE = MYTYPE
:FILE SQLVAR = MYVAR
:FILE SQLEXTN = MYEXTN
```

Then when the C compiler is invoked, the following file equations must be in effect:

```
:FILE SQLTYPE = MYTYPE
:FILE SQLVAR = MYVAR
:FILE SQLEXTN = MYEXTN
:CC MYSQLPRG, $NEWPASS, $NULL
```

ALLBASE/SQL Message File

The ALLBASE/SQL message file is named **sqlmsg**. Messages placed in sqlmsg when you preprocess come from the ALLBASE/SQL message catalog. The default catalog is SQLCT000.PUB.SYS. For native language users, the name of the catalog is SQLCTxxx.PUB.SYS, where *xxx* is the number of the current language. If this catalog is not available, ALLBASE/SQL uses the default instead.

Sqlmsg messages contain four parts:

1. A banner:

   For Series 900 systems:

```
HP36216-02A.E1.02               C preprocessor/3000     ALLBASE/SQL
(C)COPYRIGHT HEWLETT-PACKARD CO. 1982,1983,1984,1985,1986,1987,1988,
1989,1990,1991.  ALL RIGHTS RESERVED.
```

   Banners are displayed when ISQL, SQLUtil, or a preprocessor is invoked.

2. A summary of the preprocessor invocation conditions:

```
DBEnvironment        = PARTSDBE.SOMEGRP.SOMEACCT

Module Name          = CEX2
```

3. Warnings and errors encountered during preprocessing:

```
  32       SalesPriceInd     : SQLID;
                               |
****** Unsupported type syntax for host variable.  (DBERR 10933)


       SELECT PartNumber, PartName, SalesPrice INTO :PartNumber, :PartName,
        :SalesPrice :SalesPriceInd FROM PurchDB.Parts WHERE PartNumber =
        :PartNumber;

****** ALLBASE/SQL query processing errors.  (DBERR 10952)
****** in SQL statement ending in line 128
*** ALLBASE/SQL alignment error on column 3 in buffer 5.  (DBERR 4200)

There are errors.  No sections stored.
```

4. A summary of the results of preprocessing:

```
2 ERRORS   0 WARNINGS
END OF PREPROCESSING.
```

Both the banner and the preprocessing summary results are also echoed to the terminal.

As illustrated in Figure 2-6, a **line number** is often provided in sqlmsg. This line number references the line in the program source file containing the command in question. A message accompanied by a number may also appear. You can refer to the *ALLBASE/SQL Message Manual* for additional information on the exception condition when these numbered messages appear.

```
: print sqlmsg
HP36216-02A.E1.02                C preprocessor/3000     ALLBASE/SQL
(C)COPYRIGHT HEWLETT-PACKARD CO.  1982,1983,1984,1985,1986,1987,1988,
1989,1990,1991.  ALL RIGHTS RESERVED.

DBEnvironment        = PARTSDBE.SOMEGRP.SOMEACCT
Module Name          = CEX2

     32       SalesPriceInd   : SQLID
                                |
******  Unsupported type syntax for host variable.  (DBERR 10933)


        SELECT PartNumber, PartName, SalesPrice INTO :PartNumber, :PartName,
         :SalesPrice :SalesPriceInd FROM PurchDB.Parts WHERE PartNumber=
         :PartNumber;

******  ALLBASE/SQL query processing errors. (DBERR 10952)
******  in SQL statement ending in line 128
*** ALLBASE/SQL alignment error on column 3 in buffer 5.  (DBERR 4200)

There are errors.  No sections stored.
  2 ERRORS   0 WARNINGS
 END OF PROCESSING.
 :
```

Figure 2-6. Sample sqlmsg Showing Errors

As Figure 2-7 illustrates, the preprocessor can terminate with the warning message

```
****** ALLBASE/SQL warnings. (DBWARN 10602)
```

when the name of an object in the source file does not match the name of any object in the system catalog. Although a section is stored for the semantically incorrect command, the section is marked as invalid and will not execute at run time if it cannot be validated.

```
: ppc cex2,partsdbe,cex2p
HP36216-02A.20.00.00              C preprocessor/3000      ALLBASE/SQL
(C)COPYRIGHT HEWLETT-PACKARD CO.  1982,1983,1984,1985,1986,1987,1988,
1989,1990,1991.  ALL RIGHTS RESERVED.

  0 ERRORS    1 WARNINGS
END OF PREPROCESSING

: print sqlmsg

HP36216-02A.E1.02                 C preprocessor/3000     ALLBASE/SQL
(C)COPYRIGHT HEWLETT-PACKARD CO.  1982,1983,1984,1985,1986,1987,1988,
1989,1990,1991.  ALL RIGHTS RESERVED.

DBEnvironment        = PARTSDBE.SOMEGRP.SOMEACCT
Module Name          = CEX2

       SELECT PartNumber, PartName, SalesPrice INTO :PartNumber, PartName,
        :SalesPrice :SalesPriceInd FROM PurchDB.Parts WHERE ParNumber =
        :PartNumber;

****** ALLBASE/SQL warnings. (DBWARN 10602)
****** in SQL statement ending in line 128
*** Column PARNUMBER not found. (DBERR 2211)

  1 Sections stored in DBEnvironment.

  0 ERRORS   1 WARNINGS
END OF PREPROCESSING
```

Figure 2-7. Sample sqlmsg Showing Warning

Stored Module Containing Sections

In full preprocessing mode, the preprocessor stores a module in the DBEnvironment you specify at preprocessing time. By default, the preprocessor uses the source file name as the name for the module it stores. You can specify a module name with the MODULE option of the preprocessor command.

The module contains a section for each embedded SQL command in your program *except*:

```
BEGIN DECLARE SECTION          INCLUDE
BEGIN WORK                     OPEN
CLOSE                          PREPARE
COMMIT WORK                    RELEASE
CONNECT                        ROLLBACK WORK
DECLARE CURSOR                 SAVEPOINT
DELETE WHERE CURRENT           START DBE
DESCRIBE                       STOP DBE
END DECLARE SECTION            SQLEXPLAIN
EXECUTE                        TERMINATE USER
EXECUTE IMMEDIATE              UPDATE WHERE CURRENT
FETCH                          WHENEVER
```

The commands listed above either require no authorization to execute or are executed based on information contained in the compilable preprocessor output files.

When the preprocessor stores a section, it actually stores what are known as an input tree and a run tree. The **input tree** consists of the uncompiled command. The **run tree** is the compiled, executable form of the command. If at run time a section is valid, ALLBASE/SQL executes the appropriate run tree when the SQL command is encountered in the application program. If a section is invalid, ALLBASE/SQL determines whether the objects referenced in the section exist and whether current authorization criteria are satisfied. When an invalid section can be validated, ALLBASE/SQL dynamically recompiles the input tree to create an executable run tree and executes the command. When a section cannot be validated, the command is not executed, and an error condition is returned to the program.

There are three types of sections:

1. Sections for executing the SELECT command associated with a DECLARE CURSOR command.
2. Sections for executing the SELECT command associated with a CREATE VIEW command.
3. Sections for all other commands for which the preprocessor stores a section.

Figure 2-8 illustrates the kind of information in the system catalog. All stored sections for each module in the DBEnvironment are referenced here. The query result illustrated was extracted from the system view named *SYSTEM.SECTION* by using ISQL. The columns in Figure 2-8 have the following meanings:

- NAME: This column contains the name of the module to which a section belongs. You can specify a module name when you invoke the preprocessor; or the module name will default to the source code file name of the C program. If you are supplying a module name in a native language other than NATIVE-3000 (ASCII), be sure it is in the same language as that of the DBEnvironment.

- OWNER: This column identifies the owner of the module. You can specify an owner name when you invoke the preprocessor,or the owner name will default to the login name associated with the preprocessing session. If you are supplying an owner name in a native language other than NATIVE-3000 (ASCII), be sure it is in the same language as that of the DBEnvironment.
- DBEFILESET: This column indicates the DBEFileSet which contains the DBEFile(s) which in turn contains the section(s).
- SECTION: This column gives the section number. Each section associated with a module is assigned a number by the preprocessor as it parses the related SQL command at preprocessing time.
- TYPE: This column identifies the type of section:

```
1 = SELECT associated with a cursor
2 = SELECT defining a view
0 = All other sections
```

- VALID: This column identifies whether a section is valid or invalid:

```
0 = invalid
1 = valid
```

```
isql=>  SELECT NAME,OWNER,DBEFILESET,SECTION,TYPE,VALID FROM SYSTEM.SECTION;

SELECT NAME,OWNER,DBEFILESET,SECTION,TYPE,VALID FROM SYSTEM.SECTION;
------------------------------------------------------------------------------
NAME              |OWNER        |DBEFILESET       |SECTION  |TYPE  |VALID
------------------------------------------------------------------------------
TABLE             |SYSTEM       |SYSTEM           |        0|     2|     0
COLUMN            |SYSTEM       |SYSTEM           |        0|     2|     0
INDEX             |SYSTEM       |SYSTEM           |        0|     2|     0
SECTION           |SYSTEM       |SYSTEM           |        0|     2|     0
DBEFILESET        |SYSTEM       |SYSTEM           |        0|     2|     0
DBEFILE           |SYSTEM       |SYSTEM           |        0|     2|     0
SPECAUTH          |SYSTEM       |SYSTEM           |        0|     2|     0
TABAUTH           |SYSTEM       |SYSTEM           |        0|     2|     0
COLAUTH           |SYSTEM       |SYSTEM           |        0|     2|     0
MODAUTH           |SYSTEM       |SYSTEM           |        0|     2|     0
GROUP             |SYSTEM       |SYSTEM           |        0|     2|     0
VIEWDEF           |SYSTEM       |SYSTEM           |        0|     2|     0
HASH              |SYSTEM       |SYSTEM           |        0|     2|     0
CONSTRAINT        |SYSTEM       |SYSTEM           |        0|     2|     0
CONSTRAINTCOL     |SYSTEM       |SYSTEM           |        0|     2|     0
CONSTRAINTINDEX   |SYSTEM       |SYSTEM           |        0|     2|     0
COLDEFAULT        |SYSTEM       |SYSTEM           |        0|     2|     0
TEMPSPACE         |SYSTEM       |SYSTEM           |        0|     2|     0
PARTINFO          |PURCHDB      |SYSTEM           |        0|     2|     0
VENDORSTATISTICS  |PURCHDB      |SYSTEM           |        0|     2|     0
CEX2              |PGMR1@ACCT2  |SYSTEM           |        1|     0|     1
CEX7              |PGMR1@ACCT2  |SYSTEM           |        1|     1|     1
CEX7              |PGMR1@ACCT2  |SYSTEM           |        2|     0|     1
------------------------------------------------------------------------------
Number of rows selected is 16.
U[p], d[own], l[eft], r[ight], t[op], b[ottom], pr[int] <n>,or e[nd]>
```

Figure 2-8. Information in SYSTEM.SECTION on Stored Sections

The first eleven rows in the query result shown in Figure 2-8 describe the sections stored for the system views. The next two rows describe the two views in the sample database: PurchDB.PartInfo and PurchDB.VendorStatistics. Views are always stored as invalid sections, because the run tree is always generated at run time.

The remaining rows describe sections associated with two preprocessed programs. CEX2 contains only one section, for executing the SELECT command in the program illustrated in Figure 2-9. CEX7 contains two sections, one for executing the SELECT command associated with a DECLARE CURSOR command and one for executing a FETCH command.

Stored sections remain in the DBEnvironment until they are deleted by using the ISQL DROP MODULE command:

```
isql=> DROP MODULE cex2;
```

or by invoking the preprocessor with the DROP option:

```
: RUN PSQLC.PUB.SYS;INFO="PARTSDBE (DROP)"
```

Stored sections are marked invalid when:

- The UPDATE STATISTICS command is executed.
- Tables accessed in the program are dropped, altered, or assigned new owners.
- Indexes or DBEFileSets related to tables accessed in the program are changed.
- Module owner authorization changes are made that affect the execution of embedded commands.

When an invalid section is validated at run time, the validated section is committed when the program issues a COMMIT WORK command. If a COMMIT WORK command is not executed, ALLBASE/SQL must re-validate the section again the next time the program is executed. For this reason, you should embed COMMIT WORK commands even following SELECT commands, since the COMMIT WORK command may be needed even when data is not changed by a program.

Installable Module File

When the preprocessor stores a module in the DBEnvironment you named at preprocessing time, it places a copy of the module in an installable module file. The module in this file can be installed into a DBEnvironment different from the DBEnvironment accessed at preprocessing time by using the INSTALL command in ISQL. In order to install the module, you need CONNECT or DBA authority in the target DBEnvironment.

The installable module file is named SQLMOD. The module also has an internal, SQL name, in this case PGMR1@ACCT2.CEX2 which is saved as part of the module at preprocessing time. PGMR1@ACCT2 is the login of the user who preprocessed source file cex2, and PGMR1@ACCT2 is the owner of the module.

```
: isql

isql=> CONNECT TO 'PARTSDBE.SOMEGRP.SOMEACCT';
isql=> INSTALL;

File name> SQLMOD;
Name of module in this file:  PGMR1@ACCT2.CEX2
Number of sections installed:  1
COMMIT WORK to save to DBEnvironment.

isql=> COMMIT WORK;
isql=>
```

Handling Preprocessor Errors

Several types of errors can occur while you are using the C preprocessor:

- Unexpected preprocessor or DBEnvironment termination.
- Preprocessor invocation errors.
- Source file errors.
- DBEnvironment errors.

Preprocessor or DBEnvironment Termination

Whenever the preprocessor stops running unexpectedly while you are using it in full preprocessing mode, sections stored during the preprocessor's DBE session are automatically dropped when the DBEnvironment is next started up. Unexpected preprocessor session termination occurs, for example, when a DBA issues a STOP DBE command during a preprocessor DBE session.

Preprocessor Invocation Errors

If the source file specified is currently being accessed, or if the source file named cannot be found, preprocessing terminates with the following messages, respectively:

```
System error in opening input source file.  (DBERR 10922)

       File open Error         (DBERR 10907)

sqlin
ERRORS  Processing terminated prematurely.  (DBERR 10923)
```

In addition, the invocation line may name a DBEnvironment that does not exist or the command may contain erroneous syntax:

```
******  Cannot connect to DBEnvironment.  (DBERR 10953)

ERRORS  Processing terminated prematurely.  (DBERR 10923)
```

Source File Errors

When the preprocessor encounters errors while parsing the source file, messages are placed in sqlmsg. Refer to the discussion earlier in this chapter under "ALLBASE/SQL Message File" for additional information on this category of errors.

DBEnvironment Errors

Some errors result because:

- A DBEnvironment is not yet started.
- Resources are insufficient.
- A deadlock has occurred.

Refer to the *ALLBASE/SQL Database Administration Guide* for information on handling DBEnvironment errors.

Sample Modified Source File

The following modified source file is the result of preprocessing program cex2 (shown at the end of Chapter 1). In the listing, the preprocessor-added code is shaded for easy reference. The numbers in the figure are the same as the numbers shown for program cex2.

```
#include "sqltype"
#include "sqlvar"
#include "sqlextn"
/* Program cex2 */

/* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * */
/* This program illustrates the use of SQL's SELECT command to     */
/* retrieve one row or tuple of data at a time.                     */
/* BEGIN WORK is executed before the SELECT and a COMMIT WORK       */
/* is executed after the SELECT. An indicator variable is also      */
/* used for SalesPrice.                                             */
/* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * */

typedef int boolean;

char    response[2];
boolean Abort;

#include <stdio.h>

#define    OK                0
#define    NotFound        100
#define    MultipleRows  -10002
#define    DeadLock      -14024
#define    FALSE             0
#define    TRUE              1


#if 0
EXEC SQL INCLUDE SQLCA;                                    (1)
#endif
sqlca_type sqlca;
```

Figure 2-9. Modified Source File For Program cex2

```
                              /* SQL Communication Area */
          /* Begin Host Variable Declarations */

#if 0
    EXEC SQL BEGIN DECLARE SECTION;                                    (2)
#endif

    char       PartNumber[17];
    char       PartName[31];
    double     SalesPrice;
    sqlind     SalesPriceInd;
    char       SQLMessage[133];

#if 0
    EXEC SQL END DECLARE SECTION;                                      (2)
#endif

          /* End Host Variable Declarations */

int SQLStatusCheck()     /* Function to Display Error Messages */
{
Abort = FALSE;
if (sqlca.sqlcode < DeadLock)
   Abort = TRUE;
do {

#if 0
EXEC SQL SQLEXPLAIN :SQLMessage;
#endif
{
sqlxplnc(&sqlca,&sqltempv,133,1);
sqltempv.rec1.
  SQLREC1_FIELD1[sqltempv.rec1.SQLREC1_FIELD1_LEN] = '\0';
strcpy(SQLMessage,
       sqltempv.rec1.SQLREC1_FIELD1);
}                                                                      (3)

printf("\n");
printf("%s\n",SQLMessage);
} while (sqlca.sqlcode != 0);

if (Abort)
  {
  EndTransaction();
  ReleaseDBE();
  }
}  /* End SQLStatusCheck Function */
```

Figure 2-9. Modified Source File For Program cex2 (page 2 of 6)

```
boolean ConnectDBE)()    /* Function to Connect to PartsDBE             */
{
boolean ConnectDBE;
ConnectDBE = TRUE;
printf("\n Connect to PartsDBE");

#if 0
EXEC SQL CONNECT TO 'PartsDBE';
#endif
{
sqlvar1 = "00AE000050617274734442452020202020202020202020\
20202020202020202020202020202020202020202020202020202020\
20202020202020202020202020202020202020202020202020202020\
20202020202020202020202020202020202020202020202020202020\
20202020202020202020202020202020";
sqlxconc(&sqlca,sqlvar1);
}                                                              4

if (sqlca.sqlcode != OK)
  {
  ConnectDBE = FALSE;
  SQLStatusCheck();                                            5
  }  /* End if */
return (ConnectDBE);
}  /* End of ConnectDBE Function */

int ReleaseDBE()     /* Fundtion to Release PartsDBE */
{
printf("\n");
printf("\n Release PartsDBE");
printf("\n");

#if  {
EXEC SQL RELEASE;
#endif
{
sqlvar2 = "00B2000020202020202020202020202020202020202020202020FFFFFFFF";
sqlxconc(&sqlca,sqlvar2);
}                                                                  6

if (sqlca.sqlcode != OK) SQLStatusCheck();
}  /* End ReleaseDBE Function */

boolean BeginTransaction()     /* Function to Begin Work */
{
boolean BeginTransaction;
BeginTransaction = TRUE;
```

Figure 2-9. Modified Source File For Program cex2 (page 3 of 6)

```
printf("\n");
printf("\n Begin Work");

#if 0
EXEC SQL BEGIN WORK;
#endif
{
sqlvar3 = "00A6007F00110061";
sqlxconc(&sqlca,sqlvar3);
}                                                    (7)


if (sqlca.sqlcode != OK)
  {
  BeginTransaction = FALSE;
  SQLStatusCheck();
  ReleaseDBE();                                      (5)
  }  /* End if */
return (BeginTransaction);
}  /* End BeginTransaction Function */

int EndTransaction()     /* Function to Commit Work */
{
printf("\n");
printf("\n Commit Work");

#if 0
EXEC SQL COMMIT WORK; {{#endif
{
sqlvar4 = "00A10000";
sqlxconc(&sqlca,sqlvar4);
}                                                    (8)

if (sqlca.sqlcode != OK) SQLStatusCheck();
}  /* End EndTransaction Function */                 (5)

int DisplayRow()     /* Function to Display Parts Table Rows */
{
  printf("\n");
  printf("\n Part Number:   %s\n",   PartNumber);
  printf(" Part Name:     %s\n",   PartName);

  if (SalesPriceInd < 0) {
    printf(" Sales Price:   is NULL \n");
    }
  else
    printf(" Sales Price: %10.2f\n", SalesPrice);
}  /* End of DisplayRow */
```

Figure 2-9. Modified Source File For Program cex2 (page 4 of 6)

```
int Select()     /* Function to Query Parts Table */
{
do {
  printf("\n");
  printf("\n Enter Part Number within Parts Table or '/' to STOP > ");
  scanf("%s",PartNumber);

  if (PartNumber[0] != '/') {

    BeginTransaction();

    printf("\n SELECT PartNumber, PartName, SalesPrice");

#if 0
    EXEC SQL SELECT PartNumber, PartName, SalesPrice
              INTO :PartNumber,
                   :PartName,
                   :SalesPrice :SalesPriceInd
              FROM  PurchDB.Parts
             WHERE  PartNumber = :PartNumber;
#endif
{
sqltempv.rec2.SQLREC2_FIELD1_LEN =
  strlen(PartNumber);
strcpy(sqltempv.rec2.SQLREC2_FIELD1,
       PartNumber);
sqlxfetc(&sqlca,sqlowner,sqlmodname,1,&sqltempv,24,80,1);
if (sqlca.sqlcode == 0)
  {
  sqltempv.rec3.
    SQLREC3_FIELD1[sqltempv.rec3.SQLREC3_FIELD1_LEN] = '
0';
  strcpy(PartNumber,
         sqltempv.rec3.SQLREC3_FIELD1);
  sqltempv.rec3.
    SQLREC3_FIELD2[sqltempv.rec3.SQLREC3_FIELD2_LEN] = '
0';
  strcpy(PartName,
         sqltempv.rec3.SQLREC3_FIELD2);
  SalesPriceInd =
    sqltempv.rec3.SQLREC3_FIELD3_IND;
  if (sqltempv.rec3.SQLREC3_FIELD3_IND >= 0)
  {
  SalesPrice =
    sqltempv.rec3.SQLREC3_FIELD3;
  }
  }
```

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Figure 2-9. Modified Source File For Program cex2 (page 5 of 6)

```
else
  {
  }
}
    if ((sqlca.sqlwarn[0] == 'W') || (sqlca.sqlwarn[0] == 'w')) {
      printf("\n SQL WARNING has occurred. The following row");
      printf("\n    of data may not be valid!");
      }
    if (sqlca.sqlcode == OK) {
      DisplayRow();
      }
    else if (sqlca.sqlcode == NotFound) {
      printf("\n Row not found!");
    }
    else if (sqlca.sqlcode == MultipleRows) {
      printf("\n WARNING: More than one row qualifies!");
    }
    else {
      SQLStatusCheck();
    }
    EndTransaction();
  }
}   /* End do */
while (PartNumber[0] != '/');

}/* End of Select Function */

main()          /* Beginning of program */
{

printf("\n Program to SELECT specified rows from");
printf("\n  the Parts Table - cex2");
printf("\n");
printf("\n Event List:");
printf("\n  CONNECT TO PartsDBE");
printf("\n  BEGIN WORK");
printf("\n  SELECT the specified row from the Parts Table");
printf("\n    until the user enters a '/'");
printf("\n  COMMIT WORK");
printf("\n  RELEASE from PartsDBE");
printf("\n");

if (ConnectDBE())  {
  Select();
  ReleaseDBE();
  }
else
  printf("\n Error: Cannot Connect to PartsDBE!\n");
}  /* End of Program */
```

Figure 2-9. Modified Source File For Program cex2 (page 6 of 6)

Sample Preprocessor Generated Include Files

Figures 2-10 through Figure 2-12 illustrate, respectively, the type, variable, and externals include files that correspond to the modified source file in Figure 2-9. Note that the preprocessor inserts the following three C compiler directives to reference the include files:

```
#include "sqltype"
#include "sqlvar"
#include "sqlextn"
```

These three directives are always inserted into the static or global declaration part of the program.

```
typedef char  ownername_type[21];
typedef char  modulename_type[21];
typedef short sqlind;
typedef unsigned char sqlbinary;
typedef int  sqlvarbinary;
typedef struct {
  int  f1;
  int  f2;
  } sqltid;
typedef struct {
  int    SQLREC1_FIELD1_LEN;
  char   SQLREC1_FIELD1[133];
  } SQLREC1;
typedef struct {
  int    SQLREC2_FIELD1_LEN;
  char   SQLREC2_FIELD1[20];
  } SQLREC2;
typedef struct {
  int    SQLREC3_FIELD1_LEN;
  char   SQLREC3_FIELD1[20];
  int    SQLREC3_FIELD2_LEN;
  char   SQLREC3_FIELD2[32];
  double SQLREC3_FIELD3;
  sqlind SQLREC3_FIELD3_IND;
  } SQLREC3;
typedef struct {
  SQLREC3  dummy1, dummy2;
  } SQLREC4;
#define sqlwarn0 sqlwarn[0]
#define sqlwarn1 sqlwarn[1]
#define sqlwarn2 sqlwarn[2]
#define sqlwarn3 sqlwarn[3]
#define sqlwarn4 sqlwarn[4]
#define sqlwarn5 sqlwarn[5]
#define sqlwarn6 sqlwarn[6]
#define sqlwarn7 sqlwarn[7]
typedef struct {
  char  sqlaid[8];
  int   sqlabc;
  int   sqlcode;
```

Figure 2-10. Sample Type Include File

```
    int   sqlerrl;
    char  sqlerrm[256];
    char  sqlerrp[8];
    int   sqlerrd[6];
    char  sqlwarn[8];
    char  sqlext[8];
    } sqlca_type;
  typedef struct {
    short sqlnty;
    short sqltype;
    short sqlprec;
    short sqlscale;
    int   sqltotallen;
    int   sqlvallen;
    int   sqlindlen;
    int   sqlvof;
    int   sqlnof;
    char  sqlname[20];
    } sqlformat_type;
  typedef struct {
    char  sqldaid[8];
    int   sqldabc;
    int   sqln;
    int   sqld;
    sqlformat_type *sqlfmtarr;
    int   sqlnrow;
    int   sqlrrow;
    int   sqlrowlen;
    int   sqlbuflen;
    int   sqlrowbuf;
    } sqlda_type;
  typedef union {
    int     dummy;
    SQLREC1 rec1;
    SQLREC2 rec2;
    SQLREC3 rec3;
    SQLREC4 rec4;
    } sqltempv_type;
```

Sample Type Include File (page 2 of 2)

```
static ownername_type  sqlowner   = "JOANN@ACCT1         ";
static modulename_type sqlmodname = "CEX2                ";
int sqlindex;
char  *sqlvar1;
char  *sqlvar2;
char  *sqlvar3;
char  *sqlvar4;
sqltempv_type   sqltempv;
```

Figure 2-11. Sample Variable Include File

```
extern sqlxbfec();
extern sqlxbinc();
extern sqlxcnhc();
extern sqlxconc();
extern sqlxdduc();
extern sqlxdexc();
extern sqlxdfec();
extern sqlxdopc();
extern sqlxdsbc();
extern sqlxexic();
extern sqlxexuc();
extern sqlxfetc();
extern sqlxiduc();
extern sqlxopkc();
extern sqlxopuc();
extern sqlxplnc();
extern sqlxprec();
extern sqlxsecc();
extern sqlxstpc();
extern sqlxsvpc();
```

Figure 2-12. Sample Externals Include File

3

Host Variables

Host variables are variables used to pass the following information between an application program and ALLBASE/SQL:

- Data values.
- Null value indicators.
- String truncation indicators.
- Bulk processing rows to process.
- Dynamic commands.
- Savepoint numbers.
- Messages from the ALLBASE/SQL message catalog.
- DBEnvironment names.

All host variables used in a C program must be **declared** in declaration parts of the program. The type descriptions of host variables must be compatible with ALLBASE/SQL **data types**. The type descriptions of host variables must also satisfy certain preprocessor criteria.

This chapter identifies where in a C program you can use host variables and then discusses how to write type descriptions that complement the way host variables are used. See the chapter, "Simple Data Manipulation", for a sample program that uses host variables.

Using Host Variables

Host variables are used in SQL commands as follows:

- To pass data values with the following data manipulation commands:

```
SELECT
INSERT
DELETE
UPDATE
DECLARE
FETCH
REFETCH
UPDATE WHERE CURRENT
```

- To hold null value indicators in these data manipulation commands:

  ```
  SELECT
  INSERT
  FETCH
  REFETCH
  UPDATE
  UPDATE WHERE CURRENT
  ```

- In queries to indicate string truncation and the string length before truncation
- To identify the starting row and the number of rows to process in the INTO clause of the following commands:

  ```
  BULK SELECT
  BULK INSERT
  ```

- To pass dynamic commands at run time with the following commands:

  ```
  PREPARE
  EXECUTE IMMEDIATE
  ```

- To hold savepoint numbers, which are used in the following commands:

  ```
  SAVEPOINT
  ROLLBACK WORK TO :savepoint
  ```

- To hold messages from the ALLBASE/SQL message catalog, obtained by using the SQLEXPLAIN command.
- To hold a DBEnvironment name in the CONNECT command.

Later in this section are examples illustrating where, in the commands itemized above, the SQL syntax supports host variables.

Host Variable Names

ALLBASE/SQL host variable names in C programs must do the following:

- Contain from 1 to 30 bytes.
- Conform to the rules for ALLBASE/SQL basic names.
- Contain characters chosen from the following set: the 26 letters of the ASCII alphabet, the 10 decimal digits, an underscore (_), or valid characters for any native language you are using.
- Begin with an alphabetic character, although the prefix **SQL** is not recommended.
- Not be the same as any ALLBASE/SQL or C reserved word.

In all SQL commands containing host variables, the host variable name must be preceded by a colon:

:*HostVariableName*

Input and Output Host Variables

Host variables can be used for input or for output:

- **Input host variables** provide data for ALLBASE/SQL.
- **Output host variables** contain data from ALLBASE/SQL.

Be sure to initialize an input host variable before using it. When using cursor operations with the SELECT command, initialize the input host variables in the select list and WHERE clause before you execute the OPEN command.

In the following SELECT command, the INTO clause contains two output host variables: PartNumber and PartName. ALLBASE/SQL puts data from the PurchDB.Parts table into these host variables. The WHERE clause contains one input host variable, PartNumber. ALLBASE/SQL reads data from this host variable to determine which row to retrieve.

```
EXEC SQL SELECT   PartNumber, PartName
           INTO  :PartNumber,
                 :PartName
           FROM   PurchDB.Parts
           WHERE  PartNumber = :PartNumber;
```

In this example, the host variable, PartNumber, is used for both input and output.

Indicator Variables

A special type of host variable called an **indicator variable**, is used in SELECT, FETCH, UPDATE, UPDATE WHERE CURRENT, and INSERT commands to identify null values and in SELECT and FETCH commands to identify truncated output strings.

An indicator variable must appear in an SQL command *immediately after* the host variable whose data it describes. The host variable and its associated indicator variable are *not* separated by a comma. In SELECT and FETCH commands, an indicator variable is an output host variable containing one of the following indicators, which describe data ALLBASE/SQL returns:

```
 0    value is not null
-1    value is null
>0    string value is truncated; number indicates data length
          before truncation.
```

In the INSERT, UPDATE, and UPDATE WHERE CURRENT commands, an indicator variable is an input host variable. The value you put in the indicator variable tells ALLBASE/SQL when to insert a null value in a column:

```
>=0    value is not null
 <0    value is null
```

The following SELECT command uses an indicator variable, PartNameInd, for data from the PartName column. When this column contains a null value, ALLBASE/SQL puts a negative number into PartNameInd:

```
EXEC SQL SELECT  PartNumber, PartName
           INTO :PartNumber,
                :PartName :PartNameInd
            FROM PurchDB.Parts
           WHERE PartNumber = :PartNumber;
```

Any column *not* defined with the NOT NULL attribute may contain null values. In the PurchDB.Parts table, ALLBASE/SQL prevents the PartNumber column from containing null values, because it was defined as NOT NULL. In the other two columns, however, null values are allowed:

```
CREATE PUBLIC TABLE PurchDB.Parts
  (PartNumber      CHAR(16)     NOT NULL,
   PartName        CHAR(30),
   SalesPrice      DECIMAL(10,2) );
```

Null values have certain properties that you need to remember when manipulating data that may be null. For example, ALLBASE/SQL ignores columns or rows containing null values when evaluating an aggregate function (except that COUNT (*) includes all null values). Refer to the *ALLBASE/SQL Reference Manual* for a complete account of the properties of null values.

Be sure to use an indicator variable in the SELECT and FETCH commands whenever columns accessed may contain null values. A *runtime error* results if ALLBASE/SQL retrieves a null value and the program contains no indicator variable.

An indicator variable will also detect truncated strings in the SELECT and FETCH commands. In the SELECT command illustrated above, PartNameInd contains a value >0 when a part name is too long for the host variable declared to hold it. The value in PartNameInd indicates the actual length of the string before truncation.

Bulk Processing Variables

Bulk processing variables can be used with the BULK option of the SELECT or the INSERT command.

When used with the BULK SELECT command, two input host variables may be named following the array name in the INTO clause to specify how ALLBASE/SQL should store the query result in the array:

```
INTO :ArrayName [,:StartIndex [,:NumberOfRows]]
```

The **StartIndex** value denotes at which array element the query result should start. The **NumberOfRows** value is the maximum, total number of rows ALLBASE/SQL should put into the array:

```
EXEC SQL BULK   SELECT PurchasePrice * :Discount,
                       OrderQty,
                       OrderNumber
                 INTO :OrdersArray,
                      :FirstRow,
                      :TotalRows
                 FROM  PurchDB.OrderItems
                WHERE  OrderNumber
                       BETWEEN :LowValue AND :HighValue
            GROUP BY  OrderQty, OrderNumber;
```

ALLBASE/SQL puts the entire query result, or the number of rows specified in *TotalRows*, whichever is less, into the array named *OrdersArray*, starting at the array subscript stored in *FirstRow*. If neither of these input host variables is specified, ALLBASE/SQL stores as many rows as the array can hold, starting at *OrdersArray[0]*. If *FirstRow* plus *TotalRows* is greater than the size of the array, a runtime error occurs and the program aborts.

Bulk processing variables may be used with the BULK INSERT command to direct ALLBASE/SQL to insert only certain rows from the input array:

```
EXEC SQL BULK INSERT INTO   PurchDB.Orders
                    VALUES (:OrdersArray,
                            :FirstRow,
                            :TotalRows);
```

If a starting index or total number of rows is not specified, ALLBASE/SQL inserts, starting at the beginning of the array, as many rows as there are elements in the array.

Declaring Host Variables

Host variables may be declared wherever you can declare variables in C programs. For the purpose of this discussion, we define **declaration part** as the portion of a C program where variables having the scope of a file, a function, or a block can be declared.

At run time, the scope of a host variable is the same as that of any other C variable declared in the same declaration part. At preprocessing time, however, *all* host variable declarations are treated as global declarations. Therefore host variables having the same name in different declaration parts must also have the same C type description in each variable declaration.

Creating Declaration Sections

Host variables must be declared in what is known as a **declare section**. A declare section consists of the SQL command BEGIN DECLARE SECTION, one or more variable declarations, and the SQL command END DECLARE SECTION (as shown in Figure 3-1). More than one declare section may appear in a given declaration part. However, a host variable name may appear only once in a given declaration part.

Each host variable is declared by using a C type declaration. The declaration contains the same components as any C variable declaration:

```
EXEC SQL BEGIN DECLARE SECTION;

    int             OrderNumber;
    |               |
    |               |
    |               data name
    |
    data type

EXEC SQL END DECLARE SECTION;
```

The data name must be the same as the host variable name in the corresponding SQL statement. The data type must satisfy ALLBASE/SQL data type and ALLBASE/SQL C preprocessor requirements.

```
.
.
.
EXEC SQL BEGIN DECLARE SECTION;
.
.   Declarations for global host variables.
.
EXEC SQL END DECLARE SECTION;
.
.
.
int query()
{
.
.
.
EXEC SQL BEGIN DECLARE SECTION;
.
.   Declarations for local host variables.
.
EXEC SQL END DECLARE SECTION;
.
.
.
.
EXEC SQL BEGIN DECLARE SECTION;
.
.   Declarations for local host variables.
.
EXEC SQL END DECLARE SECTION;
.
.
}
.
.
.
main()
{
.
.
.
}
```


Figure 3-1. Host Variable Declarations

Declaring Variables for Data Types

Any variable can be used as a host variable. Table 3-1 summarizes C data declarations for host variables of each ALLBASE/SQL data type. Only the type descriptions shown in Table 3-1 are supported by the C preprocessor. Note in particular that the preprocessor does not support user-defined data types.

CHAR Data

A CHAR column can be declared for character strings ranging from 1 to 3996 bytes.

A single byte of the char data type in ALLBASE/SQL is directly equivalent to a single byte of the CHAR data type in C. Strings greater than one byte in C are associated with the char array data type. Character arrays in C are not directly equivalent to the ALLBASE/SQL CHAR data type; however, they are compatible. ALLBASE/SQL handles the conversion between ALLBASE/SQL CHAR data types and C char array data types through code generated by the preprocessor and embedded in the application's modified source code file.

For C strings (character arrays), C has the convention of using an ASCII 0 ('\0'), the null character, to mark the end of the string. Therefore, char host variables declared in C must have a size one greater than their ALLBASE/SQL column definition, to allow for the null character at the end of the string. The PartNumber column in the PurchDB.Parts table is defined as CHAR(30). The associated host variable is therefore declared:

```
char     PartNumber[31];
```

When ALLBASE/SQL assigns CHAR data to a char array host variable, the total length of the ALLBASE/SQL CHAR field is stored in the host variable including any trailing blanks on the right of the data string. An ASCII 0 is then added after the last byte of the string.

VARCHAR Data

A VARCHAR column can be declared for strings ranging from 1 to 3996 bytes. ALLBASE/SQL stores only the actual value of the string, not any trailing blanks.

Strings greater than one character in C are equivalent to the VARCHAR data type in ALLBASE/SQL. C host variables for VARCHAR data types in ALLBASE/SQL are declared the same as variables declared for CHAR data types. The only difference is that when ALLBASE/SQL assigns VARCHAR data to a char array host variable, no trailing blanks are added. An ASCII 0 is placed after the last character of the C string based on the specified length of the string.

The VendorRemarks column in the PurchDB.Vendors table is defined as VARCHAR(60). It is therefore declared:

```
char       VendorRemarks[61];
```

Table 3-1. Data Type Declarations

SQL DATA TYPES	C DATA DECLARATIONS
CHAR(1)	char *dataname*;
CHAR(n)	char *dataname*[n+1];
VARCHAR(n)	char *dataname*[n+1]; *
SMALLINT	short *dataname*; or
	short int *dataname*;
INTEGER	int *dataname*; or
	long int *dataname*; or
	long *dataname*;
REAL	float *dataname*;
FLOAT(1..24)	float *dataname*;
FLOAT(25..53)	double *dataname*;
DOUBLE PRECISION	double *dataname*;
BINARY	sqlbinary *dataname*;
	sqlbinary *dataname*[n];
VARBINARY	sqlvarbinary *dataname*[m]; **
DECIMAL	double *dataname*;
DATE	char *dataname*[11];
TIME	char *dataname*[9];
DATETIME	char *dataname*[24];
INTERVAL	char *dataname*[21];
	* This declaration is for non-dynamic commands only. Refer to the chapter, "Using Dynamic Operations," for a description of how to use VARCHAR dynamically. ** See the "BINARY Data" section later in this chapter for the calculation of m.

Table 3-2. Program Element Declarations

PROGRAM ELEMENT	C DATA DECLARATIONS
Indicator variable	`sqlind` *indvarname*;
Array of n rows Data values Indicator variable	`struct` *structtypename*{ *validdatatype column1name*; *validdatatype column2name*; `sqlind` *indvarname*; }*structname*`[n];`
StartIndex	`short` *startindexname*; `or` `int` *startindexname*;
NumberOfRows	`short` *numrowsname*; `or` `int` *numrowsname*;
Dynamic commands	`char` *commandname*`[n+1];`
Savepoint numbers	`int` *savepointname*;
Message catalog messages	`char` *messagename*`[n+1];`
DBEnvironment name	`char` *DBEName*`[n+1];`

SMALLINT Data

You can assign values ranging from -32,768 to +32,767 to a column defined as SMALLINT.

INTEGER Data

You can assign values ranging from -2,147,483,648 to +2,147,483,647 to a column defined as INTEGER.

FLOAT Data

ALLBASE/SQL offers the option of specifying the precision of floating point data. You have the choice of a 4-byte or an 8-byte floating point number. (This conforms to ANSI SQL86 level 2 specifications.) The keyword REAL and FLOAT(1) through FLOAT(24) specifications map to a 4-byte float. The FLOAT(25) through FLOAT(53) and DOUBLE PRECISION specifications map to an 8-byte float.

The REAL data type could be useful when the number you are dealing with is very small, and you do not require a great deal of precision. However, it is subject to overflow and underflow errors if the value goes outside its range. It is also subject to greater rounding errors than double precision. With the DOUBLE PRECISION (8-byte float) data type, you can achieve significantly higher precision and have available a larger range of values.

By using the CREATE TABLE or ALTER TABLE command, you can define a floating point column by using a keyword from the following table. See the *ALLBASE/SQL Reference Manual* for complete syntax specifications.

Table 3-3. ALLBASE/SQL Floating Point Column Specifications

Possible Keywords	Range of Possible Values	Stored In and Boundary Aligned On
REAL or FLOAT(n) where n = 1 through 24	−3.402823 E+38 through −1.175495 E−38 and 1.175495 E−38 through 3.402823 E+38 and 0	4 bytes
DOUBLE PRECISION or FLOAT or FLOAT(n) where n = 25 through 53	−1.79769313486231 E+308 through −2.22507385850721 E−308 and +2.22507385850721 E−308 through +1.79769313486231 E+308 and 0	8 bytes

Floating Point Data Compatibility. Floating point data types are compatible with each other and with other ALLBASE/SQL numeric data types (DECIMAL, INTEGER, and SMALLINT). All arithmetic operations and comparisons and aggregate functions are supported.

BINARY Data

As with other data types, use the CREATE TABLE or ALTER TABLE statement to define a binary or varbinary column. Up to 3996 bytes can be stored in such a column.

BINARY data is stored as a fixed length of left-justified bytes. It is zero padded up to the fixed length you have specified. VARBINARY data is stored as a variable length of left-justified bytes. You specify the maximum possible length. (Note that CHAR and VARCHAR data is stored in the same manner except that CHAR data is blank padded.)

Binary Data Compatibility. BINARY and VARBINARY data types in an ALLBASE/SQL database are compatible with each other and with CHAR and VARCHAR data types. They can be used with all comparison operators and the aggregate functions MIN and MAX, but arithmetic operations are not allowed.

Using the LONG Phrase with Binary Data Types. If the amount of data in a given column of a row can exceed 3996 bytes, it must be defined as a LONG column. Use the CREATE TABLE or ALTER TABLE command to specify the column as either LONG BINARY or LONG VARBINARY.

LONG BINARY and LONG VARBINARY data is stored in the database just as BINARY and VARBINARY data, except that its maximum possible length is practically unlimited.

When deciding on whether to use LONG BINARY versus LONG VARBINARY, and if space is your main consideration, you would choose LONG VARBINARY. However, LONG BINARY offers faster data access.

LONG BINARY and LONG VARBINARY data types are compatible with each other, but not with other data types. Also, the concept of inputting and accessing LONG column data differs from that of other data types. Refer to the *ALLBASE/SQL Reference Manual* for detailed syntax and to the chapter in this document titled "Defining and Using Long Columns" for information about using LONG column data.

Declaring Host Variables for BINARY Data. Host variables for BINARY data columns must be declared as sqlbinary, as in the following example:

```
EXEC SQL BEGIN DECLARE SECTION;
⋮
sqlbinary    BinaryHostVariableName[n];
⋮
EXEC SQL END DECLARE SECTION;
```

The host variable array size *n* equals the length of the column as defined in the database.

At preprocessing time, the ALLBASE/SQL preprocessor sqlbinary data type is defined as an unsigned char with the following statement in the SQL Type Include File:

```
typedef unsigned char sqlbinary;
```

An sqlbinary host variable is used for fixed length data. It is your responsibility to appropriately load binary data into the host variable before an insert or update operation.

In the following example, data from a binary column defined with a length of 12 is selected into an sqlbinary host variable.

```
⋮

EXEC SQL BEGIN DECLARE SECTION;

sqlbinary   BinaryHV[12];

EXEC SQL END DECLARE SECTION;

⋮

EXEC SQL SELECT BinaryColumn
           INTO :BinaryHV
           FROM TableA;
⋮
```

Declaring Host Variables for VARBINARY Data. Host variables for VARBINARY data columns must be declared as sqlvarbinary, as in the following example:

```
EXEC SQL BEGIN DECLARE SECTION;
⋮
sqlvarbinary    VarbinaryHostVariableName[m]
⋮
EXEC SQL END DECLARE SECTION;
```

At preprocessing time, the ALLBASE/SQL preprocessor sqlvarbinary data type is defined as an integer with the following statement in the SQL Type Include File:

```
typedef int sqlvarbinary;
```

You specify the host variable array size m based on the following formula:

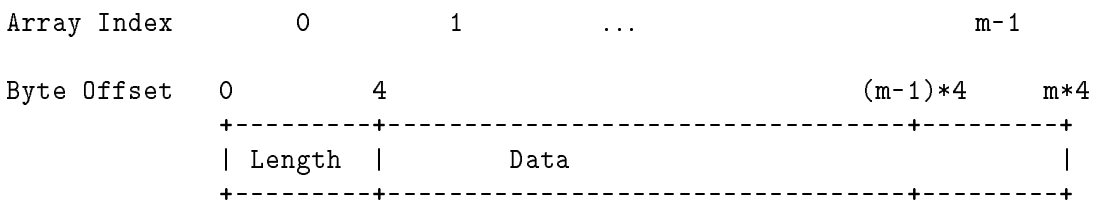
m = 1 + [n/4]

where:

- m = the host variable array size
- n = the length of the column as defined in the database
- $[n/4]$ = the LeastInteger of $(n/4)$

LeastInteger is the smallest integer >= $(n/4)$.

In order to pass information between an sqlvarbinary host variable and the database, a special format is used. The internal format of an sqlvarbinary host variable is illustrated below:



where:

- Length, in the first four bytes, represents the actual data length.
- Data starts from byte offset four and represents the varbinary data.
- (m-1)*4 equals the byte offset of the last element of the sqlvarbinary array.
- m*4 equals the end of the sqlvarbinary array.

For example, to declare an sqlvarbinary host variable for a varbinary column having a maximum length of nine, you define the host variable with an array size of four (one four byte element to hold the actual data length and three four byte elements for the data):

```
EXEC SQL BEGIN DECLARE SECTION;

sqlvarbinary   VarbinaryHV[4];

EXEC SQL END DECLARE SECTION;
```

Inserting and Updating VARBINARY Data. Before issuing an INSERT or UPDATE statement, you must load the sqlvarbinary host variable using the format mentioned in the previous section. Two examples of loading data into an sqlvarbinary host variable are presented below. The first example loads data from a buffer; the second example loads data from a union structure.

Using a Buffer

Suppose your varbinary column is defined in the database with a maximum length of 16. You want to to load it with data from a buffer called bbuff as follows:

```
⋮

int  length;
char bbuff[16];

EXEC SQL BEGIN DECLARE SECTION;

Derive the host variable length from the formula described in the previous section,
"Declaring Host Variables for Varbinary Data," as follows:
1 + the LeastInteger of (16/4).
sqlvarbinary   VarbinaryHV[5];

EXEC SQL END DECLARE SECTION;

⋮
```

Load the first array element with the actual data length.
Here we'll assume actual length to be 11 bytes.

```
VarbinaryHV[0] = 11;
```

Load the data in bbuff, starting at the second element of the array.

```
memcpy(&VarbinaryHV + 1, &bbuff, 11);

EXEC SQL INSERT INTO TableA VALUES (:VarbinaryHV,  ... );
```

⋮

Using a Union Structure

Here is another method of loading the same host variable. In the following example, the data length and data are loaded into a union structure and then into the sqlvarbinary host variable:

⋮

```
int  length;
char bbuff[16];

union u_t {
         struct {
             int   length;
             int   data[4];
             } s1;
         int ubuff[5];
         } u1;

EXEC SQL BEGIN DECLARE SECTION;
```

⋮

Derive the host variable length from the formula described in the previous section, "Declaring Host Variables for Varbinary Data," as follows:
1 + the LeastInteger of (16/4).

```
sqlvarbinary   VarbinaryHV[5];

EXEC SQL END DECLARE SECTION;
```

⋮

Load the length field of the structure with the actual column data length.
Here we'll assume actual length to be 11 bytes.

```
u1.s1.length = 11;
```

```
Load the data in bbuff, into the data field of the structure.
memcpy(u1.s1.data, &bbuff, 11);

Load the length and the data into the varbinary host variable.
memcpy(&VarbinaryHV, &(u1.ubuff), sizeof(u1.ubuff));

EXEC SQL INSERT INTO TableA VALUES (:VarbinaryHV,  ... );

⋮
```

Selecting and Fetching VARBINARY Data. After the successful execution of a SELECT or FETCH statement, the length of the data returned for any varbinary column is found in the first element of the related host variable array.

Two examples of retrieving data from an sqlvarbinary host variable are presented below. The first example loads retrieved data into a buffer; the second example loads retrieved data into a union structure. The same data declarations used for the examples in the previous section are assumed.

Using a Buffer

The following example selects data into an sqlvarbinary host variable, loads it into a buffer named bbuff, and saves the length of the data in an integer variable named length:

```
⋮

EXEC SQL SELECT * FROM TableA INTO :VarbinaryHV,  ... ;

memcpy (&bbuff, &VarbinaryHV+1, VarbinaryHV[0]);
length = VarbinaryHV[0];

⋮
```

Using a Union Structure

The following example selects data into an sqlvarbinary host variable, loads it into a union structure, saves the length of the data in an integer variable named length, and saves the data in a buffer named bbuff:

```
⋮

EXEC SQL SELECT * FROM TableA INTO :VarbinaryHV,  ...  ;

memcpy(&(u1.ubuff), &VarbinaryHV, sizeof(u1.ubuff));
length = u1.s1.length;
memcpy(&bbuff, &(u1.s1.data), u1.s1.length);

⋮
```

DECIMAL Data

The DECIMAL data type is not supported by ALLBASE/SQL C. The DECIMAL data type is compatible with an ALLBASE/SQL C double data type.

When you use DECIMAL values in arithmetic operations and certain aggregate functions, the precision and scale of the result are functions of the precisions and scales of the values in the operation. Refer to the *ALLBASE/SQL Reference Manual* for a complete account of how to calculate the precision and scale of DECIMAL results.

DATE, TIME, DATETIME, and INTERVAL Data

DATE, TIME, DATETIME, and INTERVAL data types are declared as character strings. (See the previous section, "CHAR Data.") For example:

```
/*  Declare host variables and, where applicable, indicator variables.  */

EXEC SQL BEGIN DECLARE SECTION;       /*    DATETIME DATA TYPE     */
     char  BatchStamp[24];            /*    DATE DATA TYPE         */
     char  TestDate[11];
     sqlind    TestDateInd;           /*    TIME DATA TYPE         */
     Char  TestStart[9];
     sqlind    TestStartInd;          /*    INTERVAL DATE TYPE     */
     char  LabTime[21];
     sqlind    LabTimeInd;
EXEC SQL END DECLARE SECTION;

/*DECLARE and OPEN CURSOR C1 here.  Nulls not allowed for BatchStamp.*/

EXEC SQL FETCH C1
     INTO :BatchStamp,
          :TestDate :TestDateInd,
          :TestSart :TestStartInd,
          :LabTime  :LabTimeInd;
```

See the chapter, "Understanding Date/Time Functions," for information on using date/time data types with date/time functions.

Using Default Data Values

You can choose a default value other than NULL when you create or alter a table by using the DEFAULT specification. Then when data is inserted, and a given column is not in the insert list, the specified default value is inserted. Or when you alter a table, adding a column to existing rows, every occurrence of the column is initialized to the default value. (This conforms to ANSI SQL1 level 2 with addendum-1 and FIPS 127 standards.)

When a table or column is defined with the DEFAULT specification, you will not get an error if a column defined as NOT NULL is not specified in the insert list of an INSERT command. Without the DEFAULT specification, if a column is defined as NOT NULL, it must have some value inserted into it. However, if the column is defined with the DEFAULT specification, it satisfies both the requirement that it be NOT NULL and have some value, in this case, the default value. If a column not in an insert list does allow a NULL, then a NULL is inserted instead of the default value. Your default specification options are:

- NULL.
- USER (this indicates the current DBEUser ID).
- A constant.
- The result of the CURRENT_DATE function.
- The result of the CURRENT_TIME function.
- The result of the CURRENT_DATETIME function.

Complete syntax for the CREATE TABLE and ALTER TABLE commands as well as definitions of the above options are found in the *ALLBASE/SQL Reference Manual* . In effect, by choosing any option other than NULL, you assure the column's value to be NOT NULL and of a particular format, unless and until you use the UPDATE command to enter another value.

In the following example, the OrderNumber column defaults to the constant 5, and it *is* possible to insert a NULL value into the column:

```
CREATE PUBLIC TABLE PurchDB.Orders (
                    OrderNumber INTEGER DEFAULT 5 ,
                    VendorNumber INTEGER,
                    OrderDate    CHAR(8))
                  IN OrderFS
```

However, suppose you want to define a column default and specify that the column cannot be null. In the next example, the OrderNumber column defaults to the constant 5, and it is *not* possible to insert a NULL value into this column:

```
CREATE PUBLIC TABLE PurchDB.Orders (
                    OrderNumber INTEGER DEFAULT 5 NOT NULL ,
                    VendorNumber INTEGER,
                    OrderDate    CHAR(8))
                  IN OrderFS
```

Coding Considerations

Any default value must be compatible with the data type of its corresponding column. For example, when the default is an integer constant, the column for which it is the default must be created with an ALLBASE/SQL data type of INTEGER, REAL, or FLOAT.

In your application, you input or access data for which column defaults have been defined just as you would data for which defaults are not defined. In this chapter, refer to the section, "Declaring Variables for Data Types", for information on using the data types in your program. Also refer to the section, "Declaring Variables for Compatibility", for information relating to compatibility.

When the DEFAULT Clause Cannot be Used

- You can specify a default value for any ALLBASE/SQL column except those defined as LONG BINARY or LONG VARBINARY. For information on these data types, see the section in this document titled "Using the LONG Phrase with Binary Data Types."
- With the CREATE TABLE command, you can use either a DEFAULT NULL specification or the NOT NULL specification. An *error* results if both are specified for a column as in the next example:

```
CREATE PUBLIC TABLE PurchDB.Orders (
                    OrderNumber INTEGER DEFAULT NULL NOT NULL ,
                    VendorNumber INTEGER,
                    OrderDate    CHAR(8))
                  IN OrderFS
```

Declaring Variables for Compatibility

Under the following conditions, ALLBASE/SQL performs data type conversion when executing SQL commands containing host variables under the following circumstances:

- When the data types of values transferred between your program and a DBEnvironment do not match.
- When data of one type is moved to a host variable of a different type.
- when values of different types appear in the same expression.

Data types for which type conversion can be performed are called **compatible** data types. Table 3-4 summarizes data type-host variable compatibility. It also points out which data type combinations are incompatible and which data type combinations are equivalent, i.e., require no type conversion. **E** describes an equivalent situation, **C** a compatible situation, and **I** an incompatible situation.

Table 3-4. C Data Type Equivalency and Compatibility

ALLBASE\SQL Data Types	char	char[n]	short shortint	int long longint	double longfloat
CHAR	E	C	I	I	I
VARCHAR	C	C	I	I	I
BINARY	C	C	I	I	I
VARBINARY	I	I	C	C	I
DATE	C	C	I	I	I
TIME	C	C	I	I	I
DATETIME	C	C	I	I	I
INTERVAL	C	C	I	I	I
SMALLINT	I	I	E	C	C
INTEGER	I	I	C	E	C
FLOAT	I	I	C	C	E
DECIMAL	I	I	C	C	C

As the following example illustrates, the ISQL INFO command provides the information you need to declare host variables compatible with or equivalent to ALLBASE/SQL data types. It also provides the information you need to determine whether an indicator variable is needed to handle null values:

```
isql=> INFO PurchDB.OrderItems;

Column Name         Data Type (length)                 Nulls Allowed
-------------------------------------------------------------------
ORDERNUMBER         Integer                                NO
ITEMNUMBER          Integer                                NO
VENDPARTNUMBER      Char (16)                              YES
PURCHASEPRICE       Decimal (10,2)                         NO
ORDERQTY            Smallint                               YES
ITEMDUEDATE         Char (    8)                           YES
RECEIVEDQTY         Smallint                               YES
```

For example, the query in Figure 3-2 produces a single-row query result. The declare section contains data types equivalent to or compatible with the data types in the PurchDB.OrderItems table:

- PurchasePrice is declared as a double variable because it holds the DECIMAL result of an aggregate function on a DECIMAL column.
- Discount is declared as a double variable because it is used in an arithmetic expression with a DECIMAL column, PurchasePrice.
- OrderQty is declared as a short int variable because it holds the result of a SMALLINT column, OrderQty.
- OrderQtyInd is an indicator variable, necessary because the resulting OrderQty can contain null values. Note in the INFO example above that this column allows null values.
- OrderNumber is an integer variable because the column whose data it holds is INTEGER.

```
.
EXEC SQL BEGIN DECLARE SECTION;
      double                    Discount  ;
      double                    PurchasePrice  ;
      short int                 OrderQty  ;
      sqlind                    OrderQtyInd  ;
      int                       OrderNumber  ;
.
.
EXEC SQL END DECLARE SECTION;
.
{
.
     EXEC SQL SELECT  PurchasePrice * :Discount  ,
                      OrderQty,
                 INTO :PurchasePrice,
                      :OrderQty :OrderQtyInd
                 FROM  PurchDB.OrderItems
                WHERE  OrderNumber = :OrderNumber
.
.
}
```

Figure 3-2. Declaring Host Variables for Single-Row Query Results

The example in Figure 3-3 is similar to that in Figure 3-2. This query, however, is a BULK query, which may return a multiple-row query result. And it incorporates a HAVING clause.

- OrdersArray is the name of the array for storing the query result. It can hold up to 26 rows. Each row in the array has the same format as that in the single-row query result just discussed.
- FirstRow and TotalRows are declared as short int variables, since their maximum value is the size of the array (in this case, 26).
- GroupCriterion is an integer variable because its value is compared in the HAVING clause with the result of a COUNT function, which is always an INTEGER value.

```
.
.
EXEC SQL BEGIN DECLARE SECTION;
      double                    Discount;
    struct {
          double                PurchasePrice;
          short int             OrderQty;
          sqlind                OrderQtyInd;
          int                   OrderNumber;
        } OrdersArray[26];
      short int                 FirstRow;
      short int                 TotalRows;
      int                       LowValue;
      int                       HighValue;
      int                       GroupCriterion;
.
.
EXEC SQL END DECLARE SECTION;
.
.
{
.
.
     EXEC SQL BULK SELECT  PurchasePrice * :Discount  ,
                           OrderQty,
                           OrderNumber
                    INTO :OrdersArray,
                         :FirstRow,
                         :TotalRows
                    FROM  PurchDB.OrderItems
                   WHERE  OrderNumber
                          BETWEEN :LowValue   AND :HighValue
                GROUP BY  OrderQty, OrderNumber
                  HAVING  COUNT(ItemNumber) > :GroupCriterion  ;
.
.
}
```

Figure 3-3. Declaring Host Variables for Multiple-Row Query Results

String Data Conversion

When ALLBASE/SQL stores the characters in a C string into a CHAR column, the final ASCII 0 is removed and any remaining positions to the right are padded with spaces. Internally, when ALLBASE/SQL stores the characters in a C string to a VARCHAR column, it only stores the string up to but not including the ASCII 0. The length of the string is stored in a four-byte header in the front of each VARCHAR data type.

When ALLBASE/SQL moves VARCHAR data to a character array variable, only the length of the string is moved, no trailing blanks are added. ALLBASE/SQL embeds preprocessor generated code into the modified source code file to place an ASCII 0 at the end of the string variable. Refer to the "Using Dynamic Operations" chapter in this manual for further information specific to dynamic operations.

String Data Truncation

If the target host variable used in a SELECT or FETCH operation is too small to hold an entire string, the string is truncated. You can use an indicator variable to determine the actual length of the string in bytes before truncation:

```
EXEC SQL BEGIN DECLARE SECTION;
    char          LittleString[n];
    sqlind        LittleStringInd;
.
.
.
EXEC SQL END DECLARE SECTION;
.
.
.
{
.
.
.
    EXEC SQL SELECT  BigString
                INTO :LittleString :LittleStringInd
                .
                .
                .
}
```

When the value in column *BigString* is too long to fit in host variable *LittleString*, ALLBASE/SQL puts the actual length of the string in bytes into indicator variable *LittleStringInd*. In this example, the maximum number of bytes that can be stored in LittleString is n-1, since the last byte is always reserved for the ASCII 0 null character.

If a column is too small to hold a string in an INSERT or an UPDATE operation, the string is truncated and stored. The sqlca sqlwarn[1] field is set to W when this occurs.

It is possible to store native language data in a character column defined as n-computer. It is the programmer's responsibility to verify the language definition of the column that is to receive data. If the character column is defined for a native language, truncation will always occur on a proper character boundary for that language.

Numeric Data Conversion

When you use numeric data of different types in an expression or comparison operation, data of the lesser type is converted into data of the greater type, and the result is expressed in the greater type. ALLBASE/SQL numeric types have the following precedence, from highest to lowest:

1. FLOAT
2. DECIMAL
3. INTEGER
4. SMALLINT

The following example illustrates numeric type conversion:

```
EXEC SQL BEGIN DECLARE SECTION;
    int          Discount;
    int          MaxPurchasePrice;
.
.
.
EXEC SQL END DECLARE SECTION;
.
.
.
{
.
.
.
    EXEC SQL SELECT  (MAX)PurchasePrice * :Discount
                INTO :MaxPurchasePrice
                FROM  PurchDB.OrderItems;
.
.
.
}
```

The select list of the query illustrated contains an aggregate function, *MAX*. The argument of the function is the *PurchasePrice* column, defined in the PartsDBE DBEnvironment as DECIMAL(10,2). Therefore the result of the function is DECIMAL. Since the host variable named *Discount* is declared as an integer, a data type compatible with DECIMAL, ALLBASE/SQL converts the value in Discount to a DECIMAL quantity having a precision of 10 and a scale of 0.

After subtraction, data conversion occurs again before the DECIMAL result is stored in the integer host variable *MaxPurchasePrice*. In this case, the fractional part of the DECIMAL value is truncated.

Refer to the *ALLBASE/SQL Reference Manual* for additional information on how type conversion can cause truncation and overflow of numeric values.

Declaring Variables for Program Elements

The following section discusses how to declare elements specific to ALLBASE/SQL programs. In addition, Table 3-2 provides examples of these special elements.

sqlca Array

Every ALLBASE/SQL C program must have the SQL Communications Area (sqlca) declared in the global declaration part. You can use the INCLUDE command to declare the sqlca:

```
EXEC SQL INCLUDE SQLCA;
```

When the C preprocessor parses this command, it inserts the following type definition into the modified source file:

```
sqlca_type sqlca;
```

Optionally, you can use this type definition in the global declaration part of your source file instead of using the INCLUDE command to declare the sqlca.

Refer to the chapter, "Runtime Status Checking," for further information regarding the sqlca.

Dynamic Processing Arrays

For programs which accept dynamic queries, you include three special declarations in a declaration part:

```
EXEC SQL INCLUDE SQLDA;
```

This command causes the preprocessor to declare the sqlda as type sqlda_type, defined in the preprocessor-generated type declaration include file.

```
sqlformat_type     sqlfmts[MaxFmtArray];
```

This declaration identifies the format array and its size. MaxFmtArray is a constant representing the maximum number of columns you expect in the query result. Sqlformat_type is defined in the type declaration include file.

```
char          DataBuffer[MaxDataBuff];
```

This declaration identifies a data buffer and its size. MaxDataBuff is a constant representing the maximum number of bytes you will need to hold the number of rows you request in the sqlnrow field of the sqlda.

See the chapter on "Using Dynamic Operations" for more information.

Bulk Processing Arrays

When you declare a structure array for holding the results of a BULK SELECT or BULK FETCH operation, ensure that you declare the fields in the same order as in the select list. (For single-row query results, however, the order of declaration does not have to match the select list order.) In addition, each indicator variable field must be declared in the declaration of the structure array immediately after the host variable field it describes. And if used, the bulk processing indicator variables (starting index and number of rows) are referenced in order, immediately following the reference to your array name. Figure 3-3 provides an example.

Indicator Variables

Each indicator variable field must be declared immediately following the host variable field it describes as shown in Figures 3-2 and 3-3. If a column allows nulls, a null indicator *must* be declared for it.

Dynamic Commands

The maximum size for the host variables used to hold dynamic commands is 32,762 bytes. In Figure 3-4, the host variable is declared to hold a command as large as 2048 bytes.

```
.
.
.

EXEC SQL BEGIN DECLARE SECTION;
      char          DynamicCommand[2048]  ;
.
.
.
EXEC SQL END DECLARE SECTION;
.
.
.
{
.
.
.
    EXEC SQL PREPARE  CommandOnTheFly
                FROM :DynamicCommand  ;
.
.
.
}
```

Figure 3-4. Declaring Host Variables for Dynamic Commands

Savepoint Numbers

Savepoint numbers are positive numbers ranging from 1 to 2,147,483,647. A host variable for holding a savepoint number should be declared as an integer.

```
.
.
.

EXEC SQL BEGIN DECLARE SECTION;
      int           SavePoint1  ;
.
.
.
EXEC SQL END DECLARE SECTION;
.
.
.
{
.
.
.
    EXEC SQL SAVEPOINT :Savepoint1  ;
.
.
.
    EXEC SQL ROLLBACK WORK TO :Savepoint1  ;
.
.
}
```

Figure 3-5. Declaring Host Variables for Savepoint Numbers

Messages from the Message Catalog

The maximum size of a message catalog message is 256 bytes. Figure 3-6 illustrates how a host variable for holding a message might be declared.

```
.
.
.
EXEC SQL BEGIN DECLARE SECTION;
      char         SQLMessage[256]  ;
.
.
.
EXEC SQL END DECLARE SECTION;
.
.
.
{
.
.
.
EXEC SQL SQLEXPLAIN :SQLMessage  ;
printf("%s\n",SQLMessage);
.
.
.
}
```

Figure 3-6. Declaring Host Variables for Message Catalog Messages

DBEnvironment Name

The maximum pathname (either relative or absolute) of a DBECon file is 128 bytes. The DBECon file name is the same as the DBEnvironment name. The name you store in this host variable does not have to be delimited by single quotation marks.

```
EXEC SQL BEGIN DECLARE SECTION;
char        SomeDBE[128];
.
.
.
EXEC SQL END DECLARE SECTION;
.
.
.
{
printf("\n Enter DBEnvironment name> ");
scanf("%s",SomeDBE);
EXEC SQL CONNECT to :SomeDBE;
.
.
.
}
```

Figure 3-7. Declaring Host Variables for DBEnvironment Names

This host variable can be declared as a string or as a character array. In the example, it is declared as a character array large enough to hold the absolute file name of any DBECon file.

4

Runtime Status Checking and the sqlca

This chapter examines the need for runtime status checking. It describes the sqlca and the conditions under which its data items are set by ALLBASE/SQL. It also gives several examples of implicit and explicit status checking, some of which use SQLEXPLAIN to display a status message. Examples of handling specific status checking tasks are included under "Approaches to Status Checking."

When an SQL command is executed, ALLBASE/SQL returns information describing how the command executed. This information signals one or more of the following status conditions:

- The command was successfully executed.
- The command could not be executed because an error condition occurred, but the current transaction will continue.
- No rows qualified for a data manipulation operation.
- A specific number of rows were placed into output host variables.
- A specific number of rows qualified for an INSERT, UPDATE, or DELETE operation.
- The command was executed, but a warning condition resulted.
- The command was executed, but a character string was truncated.
- The command was executed, but a null value was eliminated from an aggregate function.
- The command could not be executed because the number of variables in a SELECT or FETCH statement is unequal to the number of columns in the table being operated on. This applies to dynamic processing only.
- The command could not be executed because an error condition necessitated rolling back the current transaction.

Based on this runtime status information, a program can COMMIT WORK, ROLLBACK WORK, continue, terminate, display a message, or perform some other appropriate activity.

- You can use the WHENEVER command to perform **implicit status checking**. This means that ALLBASE/SQL checks the sqlcode and sqlwarn[0] values for you, then takes an action based on information you provide in the WHENEVER command.
- You can write C code that explicitly examines one or more of the seven sqlca elements, then proceeds on the basis of their values. This kind of status checking is called **explicit status checking**.
- You can use a *combination* of both implicit and explicit status checking.

In conjunction with status checking of any kind, you can use the SQLEXPLAIN command. This command retrieves a message from the ALLBASE/SQL message catalog that describes an error or warning condition.

When several errors or warnings occur, you can use SQLEXPLAIN to retrieve messages for all of them. Messages are available to your program in the order in which the errors or warnings occurred. When ALLBASE/SQL rolls back the current transaction, it does not continue to look for errors. This means that the last message retrieved will indicate the cause of the roll back. An example of this scenario is presented later in this chapter under "sqlcode." Refer to the *ALLBASE/SQL Message Manual* for an explanation of all error and warning messages.

Purposes of Status Checking

Status checking is performed primarily for the following reasons:

- To gracefully handle runtime error and warning conditions.
- To maintain data consistency.
- To return information about the most recently executed command.

Handling Runtime Errors and Warnings

A program is said to be **robust** if it anticipates common runtime errors and handles them gracefully. In online applications, robust programs may allow the user to decide what to do when an error occurs rather than just terminating. This approach is useful, for example, when a deadlock occurs.

If a deadlock occurs, sqlcode is set to -14024 and an SQLEXPLAIN call retrieves the following message:

```
Deadlock detected.  (DBERR 14024)
```

ALLBASE/SQL rolls back the transaction containing the SQL command that caused the deadlock. You may want to either give the user the option of restarting the transaction, automatically re-execute the transaction a finite number of times before notifying the user of the deadlock, or re-execute the transaction until the deadlock is resolved.

Maintaining Data Consistency

Two or more data values, rows, or tables are said to be **consistent** if they agree in some way. Changes to such interdependent values are either committed or rolled back *at the same time* in order to retain data consistency. In other words, the set of operations that form a transaction are considered as an **atomic operation**; either all or none of the operations are performed on the database. Status checking in this case determines whether to commit or roll back work.

For example, in the sample database (SampleDBE), each order is defined by rows in two tables: one row in the PurchDB.Orders table and one or more rows in the PurchDB.OrderItems table. A transaction that deletes orders from the database has to delete all the rows for a specific order from *both* tables to maintain data consistency. A program containing such a transaction should commit work to the database only if it is able to delete the row from the PurchDB.Orders table and delete all the rows for the same order from the PurchDB.OrderItems table:

```
EXEC SQL BEGIN WORK;
EXEC SQL DELETE FROM PurchDB.OrderItems
                WHERE OrderNumber = :OrderNumber;
```

If this command succeeds, the program submits the following command.

```
EXEC SQL DELETE FROM PurchDB.Orders
                WHERE OrderNumber = :OrderNumber;
```

If this command succeeds, the program submits a COMMIT WORK command. If this command does not succeed, the program submits a ROLLBACK WORK command. This ensures that the previous delete won't remove part of the information about this order when the rest of the information could not be deleted.

Checking the Most Recently Executed Command

Depending on which ALLBASE/SQL command was most recently executed, you can make checks to insure that the command executed in a manner appropriate to the program's context. The following section, "Using the sqlca," gives explanations based on each sqlca element. Later in this chapter, the section "Explicit Status Checking Techniques" provides examples based on specific programming tasks.

Using the sqlca

Every ALLBASE/SQL program must have the SQL Communications Area (sqlca) declared in the global declaration part. You can use the INCLUDE command to declare the sqlca:

```
EXEC SQL INCLUDE SQLCA;
```

When the C preprocessor parses this command, it inserts the following type definition into the modified source file:

```
sqlca_type sqlca;
```

Optionally, you can use this type definition in the global declaration part of your source file instead of using the INCLUDE command to declare the sqlca.

The C preprocessor generates the following record declaration for sqlca_type in the type declaration include file:

```
typedef  struct  {
  char   sqlaid[8];
  int    sqlabc;
  int    sqlcode;
  int    sqlerrl;
  char   sqlerrm[256];
  char   sqlerrp[8];
  int    sqlerrd[6];
  char   sqlwarn[8];
  char   sqlext[8];
}  sqlca_type;
```

The following elements in this record are available for you to use in status checking and are accessed as follows. The other elements are reserved for use by ALLBASE/SQL only.

```
sqlcode or sqlca.sqlcode
sqlca.sqlerrd[2]
sqlca.sqlwarn[0] or sqlca.sqlwarn0
sqlca.sqlwarn[1] or sqlca.sqlwarn1
sqlca.sqlwarn[2] or sqlca.sqlwarn2
sqlca.sqlwarn[3] or sqlca.sqlwarn3    (used only for dynamic commands)
sqlca.sqlwarn[6] or sqlca.sqlwarn6
```

Note In conformance with the ANSI standard, either *sqlcode* or *sqlca.sqlcode* may be used to address this particular element. And each sqlwarn element can be addressed in two different ways.

The following table gives an overview of how ALLBASE/SQL sets these fields. Each field is then described with brief examples of how you can use it, including examples for using SQLEXPLAIN. Methods of handling specific status checking tasks are found in the succeeding section, "Approaches to Status Checking."

Table 4-1. sqlca Status Checking Fields

FIELD NAME	SET TO	CONDITION
sqlca.sqlcode or sqlcode	0	no error occurred during command execution
	less than 0	error, command not executed
	100	no rows qualify for DML operation (does not apply to dynamic commands)
sqlca.sqlerrd[2]	number of rows put into output host variables	data retrieval operation
	number of rows processed	data change operation
	0	error in single row data change operation
	0	sqlcode equals 100
sqlca.sqlwarn[0] or sqlca.sqlwarn0	W	warning, command not properly executed
sqlca.sqlwarn[1] or sqlca.sqlwarn1	W	at least one character string value was truncated when being stored in a host variable
sqlca.sqlwarn[2] or sqlca.sqlwarn2	W	at least one null value was eliminated from the argument set of an aggregrate function
sqlca.sqlwarn[3] or sqlca.sqlwarn3	W	for dynamic commands only, when the number of host variables in a SELECT or FETCH is unequal to the number of columns in the table being operated on
sqlca.sqlwarn[6] or sqlca.sqlwarn6	W	the current transaction was rolled back

sqlcode

sqlcode can contain one of the following values:

- 0, when an SQL command executes without generating an error condition and without generating a no rows qualify condition.
- A negative number, when an error condition exists and an ALLBASE/SQL command cannot be executed.
- 100, when no rows qualify for one of the following commands, but no error condition exists:

```
SELECT
INSERT
UPDATE (non-dynamic execution only)
DELETE (non-dynamic execution only)
BULK SELECT
FETCH
BULK FETCH
UPDATE WHERE CURRENT
DELETE WHERE CURRENT
```

Note that the absolute value of sqlcode is the same as the absolute value associated with its corresponding message in the ALLBASE/SQL message catalog. This absolute value is part of the returned message. If an error occurs, the message number is preceded by DBERR. For example, the error message associated with an sqlcode of -2613 is:

```
Precision digits lost in decimal operation MULTIPLY.  (DBERR 2613)
```

Sqlcode is set by all SQL commands *except* the following directives:

```
BEGIN DECLARE SECTION
DECLARE
END DECLARE SECTION
INCLUDE
WHENEVER
```

When sqlcode is -4008, -14024, or a greater negative value than -14024, ALLBASE/SQL automatically rolls back the current transaction. When this condition occurs, ALLBASE/SQL also sets sqlwarn[6] to W. Refer to the discussion later in this chapter on sqlwarn[6] for more on this topic.

More than one sqlcode is returned when more than one error occurs. For example, if you attempt to execute the following SQL command, two negative sqlcode values result:

```
EXEC SQL ADD PUBLIC, GROUP1 TO GROUP GROUP1;
```

The sqlcodes associated with the two errors are:

```
-2308, which indicates the reserved name PUBLIC is invalid.
-2318, which indicates you cannot add a group to itself.
```

To obtain *all* sqlcodes associated with the execution of an SQL command, you execute the SQLEXPLAIN command until sqlcode is 0:

```
      if (sqlca.sqlcode == 100) {
        printf("No rows qualified for this operation.\n");
        }
      else
        if (sqlca.sqlcode < 0) SQLStatusCheck();
      .
      .
      .
int SQLStatusCheck()
{
  do {
  EXEC SQL SQLEXPLAIN :SQLMessage;
  printf("%s\n",SQLMessage);
  } while (sqlca.sqlcode != 0);
  }
```

The function named *SQLStatusCheck* is executed when sqlcode is a negative number. Before executing SQLEXPLAIN for the first time, the program has access to the *first* sqlcode returned. Each time SQLEXPLAIN is executed subsequently, the *next* sqlcode becomes available to the program, and so on until sqlcode equals 0.

This example *explicitly* tests the value of sqlcode twice: first to determine whether it is *equal to 100*, then to determine whether it is *less than 0*. If the value 100 exists, no error will have occurred and the program will display the message *No rows qualify for this operation*.

It is necessary for the program to display its own message in this case, because SQLEXPLAIN messages are available to your program only when sqlcode contains a negative number and when sqlwarn[0] contains a W.

The sqlcode is also used in *implicit* status checking:

- ALLBASE/SQL tests for the condition sqlcode less than 0 when you use the *SQLERROR* option of the WHENEVER command.
- ALLBASE/SQL tests for the condition sqlcode equal to 100 when you use the *NOT FOUND* option of the WHENEVER command.

In the following situation, when ALLBASE/SQL detects a negative sqlcode, the code routine at label a2000 is executed. When ALLBASE/SQL detects an sqlcode of 100, the code routine at label a4000 is executed instead:

```
EXEC SQL WHENEVER SQLERROR GOTO a2000;
EXEC SQL WHENEVER NOT FOUND GOTO a4000;
```

WHENEVER commands remain in effect for *all* SQL commands that appear physically after them in the source program until another WHENEVER command for the same condition appears.

The scope of WHENEVER commands is fully explained later in this chapter under "Implicit Error Handling Techniques."

sqlerrd[2]

sqlca.sqlerrd[2] can contain one of the following values:

- 0, when sqlcode is 100 or when one of the following commands causes an error condition:

  ```
  INSERT
  UPDATE
  DELETE
  UPDATE WHERE CURRENT
  DELETE WHERE CURRENT
  ```

  If an error occurs during execution of INSERT, UPDATE, or DELETE, one or more rows may have been processed prior to the error. In these cases, you may want to either COMMIT WORK or ROLLBACK WORK, depending on the transaction. For example, if all or no rows should be updated for logical data consistency, use ROLLBACK WORK. However, if logical data consistency is not an issue, COMMIT WORK may minimize re-processing time.

- A positive number, when sqlcode is 0. In this case, the positive number provides information about the number of rows processed in the following data manipulation commands.

  The number of rows inserted, updated, or deleted in one of the following operations:

  ```
  INSERT
  UPDATE
  DELETE
  UPDATE WHERE CURRENT
  DELETE WHERE CURRENT
  ```

  The number of rows put into output host variables when one of the following commands is executed:

  ```
  SELECT
  BULK SELECT
  FETCH
  BULK FETCH
  ```

- A positive number, when sqlcode is less than 0. In this case, sqlerrd[2] indicates the number of rows that were successfully retrieved or inserted prior to the error condition:

  ```
  BULK SELECT
  BULK FETCH
  BULK INSERT
  ```

  As in the case of INSERT, UPDATE, and DELETE, mentioned above, you can use either a COMMIT WORK or ROLLBACK WORK command, as appropriate.

sqlwarn[0]

A W in sqlwarn[0], in conjunction with a 0 in sqlcode, indicates that the SQL command just executed caused a warning condition.

Warning conditions flag unusual but not necessarily important conditions. For example, if a program attempts to submit an SQL command that grants an already existing authority, a message such as the following would be retrieved when SQLEXPLAIN is executed:

```
User PEG already has DBA authorization.  (DBWARN 2006)
```

In the case of the following warning, the situation may or may not indicate a problem:

```
A transaction in progress was aborted.  (DBWARN 2010)
```

This warning occurs when a program submits a RELEASE command without first terminating a transaction with a COMMIT WORK or ROLLBACK WORK. If the transaction did not perform any UPDATE, INSERT, or DELETE operations, this situation will not cause work to be lost. If the transaction *did* perform UPDATE, INSERT, or DELETE operations, the database changes are rolled back when the RELEASE command is processed.

You retrieve the appropriate warning message by using SQLEXPLAIN. Note that you *cannot* explicitly test sqlwarn[0] the way you can test sqlcode, since sqlwarn[0] always contains W when a warning occurs.

An error and a warning condition may exist at the same time. In this event, sqlcode is set to a negative number, and sqlwarn[0] is set to W. Messages describing all the warnings and errors can be displayed as follows:

```
      if (sqlca.sqlcode != 0) {
        do {
        DisplayMessage();
        } while (sqlca.sqlcode != 0);
      }
      .
      .
      .
int DisplayMessage()
{
  EXEC SQL SQLEXPLAIN :SQLMessage;
  printf("%s\n",SQLMessage);
}
```

If multiple warnings but no errors result when ALLBASE/SQL processes a command, sqlwarn[0] is set to W and remains set until the last warning message has been retrieved by SQLEXPLAIN or another SQL command is executed. In the following example, *DisplayWarning* is executed when this condition exists:

```
if ((sqlca.sqlcode == 0) & (sqlca.sqlwarn[0] == 'W')) {
  do {
  DisplayWarning();
  } while (sqlca.sqlwarn[0] == 'W');
  }
  .
  .
  .
int DisplayWarning()
{
  EXEC SQL SQLEXPLAIN :SQLMessage;
  printf("%s\n",SQLMessage);
}
```

When you use the SQLWARNING option of the WHENEVER command, ALLBASE/SQL checks for a W in sqlwarn[0]. You can use the WHENEVER command to do *implicit* status checking (equivalent to that done *explicitly* above) as follows:

```
EXEC SQL WHENEVER SQLWARNING GOTO a3000;
EXEC SQL WHENEVER SQLERROR GOTO a2000;
```

sqlwarn[1]

A W in sqlwarn[1] indicates truncation of at least one character string value when the string was stored in a host variable. Any associated indicator variable is set to the value of the string length before truncation.

For example:

```
EXEC SQL SELECT  PartNumber,
                 PartName
           INTO :PartNumber
                :PartName :PartNameInd
           FROM  PurchDB.Parts
          WHERE  PartNumber = :PartNumber;
```

If PartName was declared as a character array of 20 bytes, and the PartName column in the PurchDB.Parts table has a length of 30 bytes, then the following occurs:

- sqlwarn[1] is set to W.
- PartNameInd is set to 30 (the length of PartName in the table).
- sqlcode is set to 0.
- SQLEXPLAIN retrieves the message:

```
Character string truncation during storage in host variable.
(DBWARN 2040)
```

sqlwarn[2]

A W in sqlwarn[2] indicates that at least one null value was eliminated from the argument set of an aggregrate function.

For example:

```
EXEC SQL SELECT  MAX(OrderQty)
           INTO :MaxOrderQty
           FROM  PurchDB.OrderItems;
```

If any OrderQty values are null, the following occurs:

- sqlwarn[2] is set to W.
- sqlcode is set to 0.
- SQLEXPLAIN retrieves the message:

```
NULL values eliminated from the argument of an aggregate
function.   (DBWARN 2041)
```

sqlwarn[3]

A W in sqlwarn[3] indicates that the number of host variables specified in a *dynamic* SELECT or FETCH statement is unequal to the number of columns in the table being operated on.

For example:

```
EXEC SQL PREPARE DynamicCommand from 'SELECT PartNumber, PartName
                                       FROM PurchDB.Parts;';
.

EXEC SQL DESCRIBE DynamicCommand INTO SQLDA; /*sqlda.sqld is always set
                                              at DESCRIBE by ALLBASE/SQL.*/
EXEC SQL DECLARE DynamicCursor FOR DynamicCommand;
EXEC SQL OPEN DynamicCursor;
.
/* Set up the sqlda for a fetch. */
sqlda.sqlbuflen=sizeof(DataBuffer);
sqlda.sqlnrow=((sqlbuflen)/(sqlrowlen));
sqlda.sqlrowbuf=&databuffer;
sqlda.sqld=1;   / *sqlda.sqld is incorrectly reset by the program. */
.
/* Do the fetch. */
EXEC SQL FETCH DynamicCursor USING DESCRIPTOR SQLDA;
```

The FETCH will fail and the following occurs:

- sqlwarn[3] is set to W.
- sqlcode is set to -2762.
- SQLEXPLAIN retrieves the message:

```
Select list has ! items and host variable buffer has !.
(DBERR 2762)
```

sqlwarn[6]

When an error occurs that causes ALLBASE/SQL to roll back the current transaction, sqlwarn[6] is set to W. ALLBASE/SQL automatically rolls back transactions when sqlcode is equal to -4008, or equal to or less than -14024.

When such errors occur, ALLBASE/SQL does the following:

- Sets sqlwarn[6] to W.
- Sets sqlwarn[0] to W.
- Sets sqlcode to a negative number.

If you want to terminate your program any time ALLBASE/SQL has to roll back the current transaction, you can just test sqlwarn[6].

```
if (sqlca.sqlcode < 0) {
  if (sqlca.sqlwarn[6] == 'W') {
    SQLStatusCheck();
    TerminateProgram();
    }
  else
    SQLStatusCheck();
  }
```

In this example, the program executes the function SQLStatusCheck when an error occurs. The program terminates whenever ALLBASE/SQL has rolled back a transaction, but continues if an error has occurred but was not serious enough to cause transaction roll back.

Approaches to Status Checking

This section presents examples of how to use implicit and explicit status checking and to notify program users of the results of status checking.

Implicit status checking is useful when control to handle warnings and errors can be passed to *one predefined point* in the program. Explicit status checking is useful when you want to test for specific sqlca values before passing control to *one of several locations* in your program.

Error and warning conditions detected by either type of status checking can be conveyed to the program user in various ways:

- SQLEXPLAIN can be used one or more times after an SQL command is processed to retrieve warning and error messages from the ALLBASE/SQL message catalog. (The ALLBASE/SQL message catalog contains messages for every negative sqlcode and for every condition that sets sqlwarn[0].)
- Your own messages can be displayed when a certain condition occurs.
- You can choose not to display a message; for example, if a condition exists that is irrelevant to the program user or when an error is handled internally by the program.

Implicit Status Checking Techniques

The WHENEVER command has two components: a *condition* and an *action*. The command format is:

```
EXEC SQL WHENEVER Condition Action;
```

There are three possible WHENEVER conditions:

- SQLERROR

  If WHENEVER SQLERROR is in effect, ALLBASE/SQL checks for a negative sqlcode after processing any SQL command *except*:

  ```
  BEGIN DECLARE SECTION
  DECLARE
  END DECLARE SECTION
  INCLUDE
  SQLEXPLAIN
  WHENEVER
  ```

- SQLWARNING

  If WHENEVER SQLWARNING is in effect, ALLBASE/SQL checks for a W in sqlwarn[0] after processing any SQL command *except* the following:

  ```
  BEGIN DECLARE SECTION
  DECLARE
  END DECLARE SECTION
  INCLUDE
  SQLEXPLAIN
  WHENEVER
  ```

- NOT FOUND

  If WHENEVER NOT FOUND is in effect, ALLBASE/SQL checks for the value 100 in sqlcode after processing a SELECT or FETCH command.

A WHENEVER command for each of these conditions can be in effect at the same time.

There are three possible WHENEVER actions:

- STOP

  If WHENEVER *Condition* STOP is in effect, ALLBASE/SQL rolls back the current transaction and terminates the DBE session and the program when the *Condition* exists.

- CONTINUE

  If WHENEVER *Condition* CONTINUE is in effect, program execution continues when the *Condition* exists. Any earlier WHENEVER command for the same condition is cancelled.

- GOTO *LineLabel*.

  If WHENEVER *Condition* GOTO *LineLabel* is in effect, the code routine located at that alpha-numeric line label is executed when the *Condition* exists. The line label must appear in the function where the GOTO is executed. GOTO and GO TO forms of this action have exactly the same effect.

Any action may be specified for any condition.

The WHENEVER command causes the preprocessor to generate status-checking and status-handling code for each SQL command that comes after it *physically* in the program until another WHENEVER command for the same condition is found. In the following program sequence, for example, the WHENEVER command in *Procedure1* is in effect for *SQLCommand1*, but not for *SQLCommand2*, even though *SQLCommand1* is executed first at run time:

```
int Procedure2()
{
  EXEC SQL SQLCommand2;
}
int Procedure1()
{
  EXEC SQL WHENEVER SQLERROR GOTO a2000;
  EXEC SQL SQLCommand1;
}
.
.
.
{
  Procedure1();
  Procedure2();
}
  EXEC SQL WHENEVER SQLERROR CONTINUE;
```

The code that the preprocessor generates depends on the condition and action in a WHENEVER command. In the example above, the preprocessor inserts a test for a negative sqlcode and a statement that invokes the code routine located at *Line Label a2000*:

```
#if 0
EXEC SQL WHENEVER SQLERROR GOTO a2000;
#endif

#if 0
EXEC SQL SQLCommand1;
#endif

Statements for executing SQLCommand1 appear here

if (sqlca.sqlcode < 0) {
  goto a2000;
}
```

As the previous example illustrates, you pass control to an exception-handling routine with a WHENEVER command, by using a GOTO statement with an alpha-numeric line label rather than a function name. Therefore after the exception-handling routine is executed, control cannot *automatically* return to the statement which invoked it. You must use another GOTO statement to explicitly pass control to a specific point in your program:

```
/* WHENEVER Routine -- SQL Error */
a2000:
   if ((sqlca.sqlcode <= -14024) || (sqlca.sqlcode == -4008)) {
     TerminateProgram();
     }
   else
     do {
     EXEC SQL SQLEXPLAIN :SQLMessage;
     printf("%s\n",SQLMessage);
     } while (sqlca.sqlcode != 0);
     goto a500;     /* Goto Restart/Reentry point of function */
```

This exception-handling routine *explicitly* checks the first sqlcode returned. The program either terminates, or it continues from the Restart/Reentry point after all warning and error messages are displayed. Note that a GOTO statement was required in this routine in order to allow the program to continue. Using a GOTO statement may be impractical when you want execution to continue from different places in the program, depending on the part of the program that provoked the error. This situation is discussed under "Explicit Status Checking" later in the chapter.

Program Illustrating Implicit and Explicit Status Checking

The program in Figure 4-1 contains five WHENEVER commands to demonstrate implicit status checking. It also uses two explicit status checking routines.

- The WHENEVER command numbered (1) handles errors associated with the following commands:

```
CONNECT
BEGIN WORK
COMMIT WORK
RELEASE
```

- The WHENEVER command numbered (2) turns off the first WHENEVER command.
- The WHENEVER commands numbered (3) through (5) handle warnings and errors associated with the SELECT command.

The routine at *Label a1000* is executed when an error occurs during the processing of session-related and transaction-related commands. The program terminates after displaying all available error messages. If a warning condition occurs during the execution of these commands, the warning condition is ignored, because the WHENEVER SQLWARNING CONTINUE command is in effect by default.

The code routine located at *Label a2000* is executed when an error occurs during the processing of the SELECT command. This code routine *explicitly* examines the sqlcode value to determine whether it is -10002, in which case it displays a warning message. If sqlcode contains another value, function SQLStatusCheck is executed.

SQLStatusCheck *explicitly* examines sqlcode to determine whether a deadlock or shared memory problem occurred (sqlcode = -14024 or -4008) or whether the error was serious enough to warrant terminating the program (sqlcode less than -14024):

- If a deadlock or shared memory problem occurred, the program attempts to execute the SelectData function as many as three times before notifying the user of the situation.
- If sqlcode contains a value less than -14024, the program terminates after all available warnings and error messages from the ALLBASE/SQL message catalog have been displayed.

In the case of any other errors, the program displays all available messages, then prompts for another part number.

The code routine located at *Label a3000* is executed when only a warning condition results during execution of the SELECT command. This code routine displays a message and the row of data retrieved.

The NOT FOUND condition that may be associated with the SELECT command is handled by the code routine located at *Label a4000*. This code routine displays the message *Row not found!*, then passes control to *EndTransaction*. SQLEXPLAIN does not provide a message for the NOT FOUND condition, so the program must provide one.

```
/* Program cex5 */

/* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * */
/* This program illustrates the use of SQL's SELECT command to     */
/* retrieve one row or tuple of data at a time.                     */
/* This programs is the same as cex2 with added status checking    */
/* and deadlock routines.                                           */
/* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * */

typedef int boolean;

char    response[2];
boolean Abort;
boolean SQLCommandDone;
int     TryCounter;


#include <stdio.h>

#define    OK                0
#define    NotFound        100
#define    MultipleRows  -10002
#define    DeadLock      -14024
#define    FALSE             0
#define    TRUE              1
#define    NoMemory       -4008
#define    TryLimit          3

sqlca_type sqlca;    /* SQL Communication Area */

          /* Begin Host Variable Declarations */
    EXEC SQL BEGIN DECLARE SECTION;
    char       PartNumber[17];
    char       PartName[31];
    double     SalesPrice;
    sqlind     SalesPriceInd;
    char       SQLMessage[133];
    EXEC SQL END DECLARE SECTION;
          /* End Host Variable Declarations */
```

Figure 4-1. Program cex5: Implicit and Explicit Status Checking

```
int SQLStatusCheck()  /* Function to Display Error Messages */
{
if ((sqlca.sqlcode == DeadLock) || (sqlca.sqlcode == NoMemory)) {
  if (TryCounter == TryLimit) {
    SQLCommandDone = TRUE;
    printf("\n Could not complete transaction. You may want to try again.");
    }
  else
    SQLCommandDone = FALSE;
  }
else {
  Abort = FALSE;
  if ((sqlca.sqlwarn[6] = 'W') || (sqlca.sqlwarn[6] = 'w'))
    Abort = TRUE;
  }

do {
EXEC SQL SQLEXPLAIN :SQLMessage;
printf("%s\n",SQLMessage);
} while (sqlca.sqlcode != 0);

if (Abort) {

  EndTransaction();
  ReleaseDBE();
  }
}  /* End SQLStatusCheck Function */

EXEC SQL WHENEVER SQLERROR GOTO a1000;                          (1)


boolean ConnectDBE()  /* Function to Connect to PartsDBE */
{
boolean ConnectDBE;
ConnectDBE = TRUE;
printf("\n Connect to PartsDBE");
EXEC SQL CONNECT TO 'PartsDBE';
goto exit;

a1000:                /* WHENEVER SQLERROR entry point 1 */
  SQLStatusCheck();
  EndTransaction();
  ReleaseDBE();

exit:
  return (ConnectDBE);
}  /* End of ConnectDBE Function */
```

Figure 4-1. Program cex5: Implicit and Explicit Status Checking (page 2 of 6)

```
boolean BeginTransaction()    /* Function to Begin Work */
{
boolean BeginTransaction;
BeginTransaction = TRUE;

printf("\n");
printf("\n Begin Work");
EXEC SQL BEGIN WORK;
goto exit;

a1000:                /* WHENEVER SQLERROR entry point 1 */
  SQLStatusCheck();
  EndTransaction();
  ReleaseDBE();

exit:
  return (BeginTransaction);

}  /* End BeginTransaction Function */


int EndTransaction()  /* Function to Commit Work */
{
printf("\n");
printf("\n Commit Work");
EXEC SQL COMMIT WORK;
goto exit;

a1000:                /* WHENEVER SQLERROR entry point 1 */
  SQLStatusCheck();
  ReleaseDBE();

exit:
  return(0);
}  /* End EndTransaction Function */


int ReleaseDBE()   /* Function to Release PartsDBE */
{
printf("\n");
printf("\n Release PartsDBE");
printf("\n");
EXEC SQL RELEASE;
goto exit;
```

Figure 4-1. Program cex5: Implicit and Explicit Status Checking (page 3 of 6)

```
a1000:                /* WHENEVER SQLERROR entry point 1 */
  SQLStatusCheck();
  EndTransaction();

exit:
  return(0);
}  /* End ReleaseDBE Function */

EXEC SQL WHENEVER SQLERROR CONTINUE;                                    (2)

int DisplayRow()   /* Function to Display Parts Table Rows */
{

  printf("\n");
  printf(" Part Number:   %s\n", PartNumber);
  printf(" Part Name:     %s\n", PartName);

  if (SalesPriceInd < 0) {
    printf("\n Sales Price:   is NULL");
    }
  else
    printf(" Sales Price: %10.2f\n", SalesPrice);
}  /* End of DisplayRow Function */

EXEC SQL WHENEVER SQLERROR GOTO a2000;                                  (3)
EXEC SQL WHENEVER SQLWARNING GOTO a3000;                                (4)
EXEC SQL WHENEVER NOT FOUND GOTO a4000;                                 (5)


int Select()    /* Function to Query Parts Table */
{

do {
  if (SQLCommandDone) {
    printf("\n");
    printf("\n Enter Part Number within Parts Table or '/' to STOP > ");
    scanf("%s",PartNumber);
    printf("\n");

    TryCounter = 0;
    }

  if (PartNumber[0] != '/') {

    BeginTransaction();
    TryCounter = TryCounter + 1;
```

Figure 4-1. Program cex5: Implicit and Explicit Status Checking (page 4 of 6)

```
    printf("\n SELECT PartNumber, PartName, SalesPrice");
    EXEC SQL SELECT  PartNumber, PartName, SalesPrice
               INTO :PartNumber,
                    :PartName,
                    :SalesPrice :SalesPriceInd
               FROM  PurchDB.Parts
              WHERE  PartNumber = :PartNumber;

/* If no errors occur, set command done flag and display the row. */

    SQLCommandDone = TRUE;
    DisplayRow();
    EndTransaction();
  }  /* End if */
}   /* End do */
while (PartNumber[0] != '/');
goto exit;

a2000:                /* WHENEVER SQLERROR entry point 2 */
  if (sqlca.sqlcode == MultipleRows) {
    printf("\n");
    printf("\n WARNING: More than one row qualifies!");
    EndTransaction();
    SQLCommandDone = TRUE;
    Select();         /* Call Restart/Reentry point */
    }
  else
    SQLStatusCheck();
    Select();         /* Call Restart/Reentry point */

a3000:                 /* WHENEVER SQLWARNING entry point */
  printf("\n SQL WARNING has occurred. The following row");
  printf("\n     of data may not be valid!");
  DisplayRow();
  EndTransaction();
  SQLCommandDone = TRUE;
  Select();         /* Call Restart/Reentry point */

a4000:                /* WHENEVER NOT FOUND entry point */
  printf("\n");
  printf("\n Row not found!");
  EndTransaction();
  SQLCommandDone = TRUE;
  Select();         /* Call Restart/Reentry point */

exit:
  return(0);
}/* End of Select Function */
```

Figure 4-1. Program cex5: Implicit and Explicit Status Checking (page 5 of 6)

```
main()          /* Beginning of program */
{

printf("\n Program to SELECT specified rows from");
printf("\n   the Parts Table - cex5");
printf("\n");
printf("\n Event List:");
printf("\n   CONNECT TO PartsDBE");
printf("\n   BEGIN WORK");
printf("\n   SELECT the specified row from the Parts Table");
printf("\n     until the user enters a '/'");
printf("\n   COMMIT WORK");
printf("\n   RELEASE from PartsDBE");
printf("\n");

if (ConnectDBE())  {

  SQLCommandDone = TRUE;  /* Initialize command done flag */

  Select();
  ReleaseDBE();
  }
else
  printf("\n Error: Cannot Connect to PartsDBE!\n");

}  /* End of Program */
```

Figure 4-1. Program cex5: Implicit and Explicit Status Checking (page 6 of 6)

Explicit Status Checking Techniques

With explicit error handling, you invoke a function after *explicitly checking sqlca values* rather than using the WHENEVER command. The program in Figure 4-1 has already illustrated several uses of explicit error handling to:

- Isolate errors so critical that they caused ALLBASE/SQL to roll back the current transaction.
- Control the number of times SQLEXPLAIN is executed.
- Detect when more than one row qualifies for the SELECT operation.

The example in Figure 4-1 illustrates how implicit routines can sometimes reduce the amount of status checking code. As the number of SQL operations in a program increases, however, the likelihood of needing to return to *different* locations in the program after execution of such a routine increases.

The example shown in Figure 4-2 contains four data manipulation operations: INSERT, UPDATE, DELETE, and SELECT. Each of these operations is executed within its own function.

As in the program in Figure 4-1, one function is used for explicit status checking: *SQLStatusCheck*. Unlike the program in Figure 4-1, however, this function is invoked after an *explicit* test of sqlcode is made immediately following each data manipulation operation.

Because status checking is performed in a called function rather than in a routine following the embedded SQL command, control returns to the point in the program where *SQLStatusCheck* is invoked.

```
#define     Deadlock         -14024
#define     OK                   0
#define     NotFound           100
#define     MultipleRows     -10002
#define     NoMemory          -4008
.
.
.
int SelectActivity()
{
    This function prompts for a number that indicates
   whether the user wants to SELECT, UPDATE, DELETE,
   or INSERT rows, then invokes a function that
   accomplishes the selected activity.  The DONE flag
   is set when the user enters a slash.
}
.
.
.
int InsertData()
{
 Statements that accept data from the user appear here.

   EXEC SQL INSERT
              INTO PurchDB.Parts (PartNumber,
                                  PartName,
                                  SalesPrice)
                          VALUES (:PartNumber,
                                  :PartName,
                                  :SalesPrice);

   if (sqlca.sqlcode != OK) SQLStatusCheck();
.
.
.
}
```


Figure 4-2. Explicit Status Checking Procedures

```
int UpdateData()
{
  This function verifies that the row(s) to be changed
  exist, then invokes function DisplayUpdate to accept
  new data from the user.

    EXEC SQL SELECT  PartNumber, PartName, SalesPrice
               INTO :PartNumber,
                    :PartName,
                    :SalesPrice
               FROM  PurchDB.Parts
              WHERE  PartNumber = :PartNumber;

    switch(sqlca.sqlcode) {

    case OK:           DisplayUpdate();
                       break;
    case NotFound:     printf("\n");
                       printf("\n Row not found!");
                       break;
    case MultipleRows: printf("\n");
                       printf("WARNING: More than one row qualifies!")
                       DisplayUpdate();
                       break;
    default:           SQLStatusCheck();
                       break;
    }
  .
  .
  .
  }
.
.
.
int DisplayUpdate()
{
    Code that prompts the user for new data appears here.
      EXEC SQL UPDATE PurchDB.Parts
                  SET PartName = :PartName,
                      SalesPrice = :SalesPrice,
                WHERE PartNumber = :PartNumber;
      if (sqlca.sqlcode != OK) SQLStatusCheck();
.
.
.
}
```


Figure 4-2. Explicit Status Checking Procedures (page 2 of 5)

```
int DeleteData()
{
    This function verifies that the row(s) to be deleted
  exist, then invokes the function DisplayDelete to delete
  the row(s).

    EXEC SQL SELECT PartNumber, PartName, SalesPrice
             INTO :PartNumber,
                  :PartName,
                  :SalesPrice
              FROM PurchDB.Parts
             WHERE PartNumber = :PartNumber;

    switch(sqlca.sqlcode) {

    case OK:           DisplayDelete();
                       break;
    case NotFound:     printf("\n");
                       printf("\n Row not found!");
                       break;
    case MultipleRows: printf("\n");
                       printf("WARNING: More than one row qualifies!");
                       DisplayDelete();
                       break;
    default:           SQLStatusCheck();
                       break;
    }
.
.
.
}
.
.
.
int DisplayDelete()
{
    Statements that verify that the deletion should
  actually occur appear here.

    EXEC SQL DELETE FROM PurchDB.Parts
                    WHERE PartNumber = :PartNumber;
    if (sqlca.sqlcode != OK) SQLStatusCheck();
.
.
.
}
```


Figure 4-2. Explicit Status Checking Procedures (page 3 of 5)

```
    int SelectData()
    {
     Statements that prompt for a partnumber appear here.

       EXEC SQL SELECT PartNumber, PartName, SalesPrice
                 INTO :PartNumber,
                      :PartName,
                      :SalesPrice
                  FROM PurchDB.Parts
                 WHERE PartNumber = :PartNumber;

     switch(sqlca.sqlcode) {

     case OK:           DisplayRow();
                        break;
     case NotFound:     printf("\n");
                        printf("\n Row not found!");
                        break;
     case MultipleRows: printf("\n");
                        printf("WARNING: More than one row qualifies!");
                        DisplayDelete();
                        break;
     default:           SQLStatusCheck();
                        break;
     }
.
.
}
.
.
 int SQLStatusCheck()
{

if ((sqlca.sqlcode == DeadLock) || (sqlca.sqlcode=NoMemory)) {
   if (TryCounter == TryLimit) {
      SQLCommandDone = TRUE;
      printf("\n Could not complete transaction.  Try again if you
                                                          want.");
      }
   else
      SQLCommandDone = FALSE;
   }
```


Figure 4-2. Explicit Status Checking Procedures (page 4 of 5)

```
else
   {
   Abort = FALSE;
   if (sqlca.sqlwarn[6] == 'W') {    /* The transaction was rolled back
                                        due to other than deadlock or
                                        shared memory problems. */
   Abort = TRUE;
   do {
       EXEC SQL SQLEXPLAIN :SQLMessage;
       printf("%s\n",SQLMessage);

   } while (sqlca.sqlcode != 0);
   }
   if (Abort) {
      TerminateProgram();
      }
   else
     SQLCommandDone = TRUE;
   }
}
.
if (SQLCommandDone) {
.
    /* Prompt user for a part number. */
.
TryCounter = 0;
TryLimit = 3;
.
   /* A transaction is started. */
.
TryCounter = TryCounter + 1;

}   /* End SQLStatusCheck Procedure */
```

Figure 4-2. Explicit Status Checking Procedures (page 5 of 5)

Handling Deadlock and Shared Memory Problems

A deadlock exists when two transactions need data that the other transaction already has locked. When a deadlock occurs, ALLBASE/SQL rolls back the transaction with the larger priority number. If two deadlocked transactions have the same priority, ALLBASE/SQL rolls back the newer transaction.

An sqlcode of -14024 indicates that a deadlock has occurred:

```
Deadlock detected.  (DBERR 14024)
```

An sqlcode of -4008 indicates that ALLBASE/SQL does not have access to the amount of shared memory required to execute a command:

```
ALLBASE/SQL shared memory allocation failed in DBCORE. (DBERR 4008)
```

One way of handling deadlocks and shared memory problems is shown in the previous example, Figure 4-2. A SELECT command is executed, and, if an error occurs, function SQLStatusCheck is executed. If the first error detected was a deadlock or a shared memory problem, the SELECT command is automatically re-executed as many as three times before the user is notified of the situation. If other errors occurred before the deadlock or shared memory problem, the transaction is not automatically re-applied. If an error with an sqlcode less than -14024 occurred, the program is terminated after the error messages are displayed.

Determining Number of Rows Processed

Sqlerrd[2] is useful in the following ways:

- To determine how many rows were processed in one of the following operations, when the operation could be executed without error:

  ```
  SELECT
  INSERT
  UPDATE
  DELETE

  Cursor operations:

       FETCH
       UPDATE WHERE CURRENT
       DELETE WHERE CURRENT
  ```

  The sqlerrd[2] value can be used in these cases only when sqlcode does not contain a negative number. When sqlcode is 0, sqlerrd[2] is *always equal to 1* for SELECT, FETCH, UPDATE WHERE CURRENT, and DELETE WHERE CURRENT operations. Sqlerrd[2] may be *greater than 1* if more than one row qualifies for an INSERT, UPDATE, or DELETE operation. When sqlcode is 100, sqlerrd[2] is *0*.

- To determine how many rows were processed in one of the BULK operations:

  ```
  BULK SELECT
  BULK FETCH
  BULK INSERT
  ```

In this case, you also need to test sqlcode to determine whether the operation executed without error. If sqlcode is negative, sqlerrd[2] contains the number of rows that could be successfully retrieved or inserted *before* an error occurred. If sqlcode is 0, sqlerrd[2] contains the *total number* of rows that ALLBASE/SQL put into or took from the host variable array. If, in a BULK SELECT operation, more rows qualify than the array can accommodate, sqlcode will be 0.

Examples follow.

INSERT, UPDATE, and DELETE Operations. The example in Figure 4-2 could be modified to display the number of rows inserted, updated, or deleted by using sqlerrd[2]. In the case of the update operation, for example, the actual number of rows updated could be displayed after the UPDATE command is executed:

```
.
.
.
int DisplayUpdate()
{
    Code that prompts the user for new data appears here.
    EXEC SQL UPDATE PurchDB.Parts
                SET PartName = :PartName,
                    SalesPrice = :SalesPrice,
              WHERE PartNumber = :PartNumber;

    switch(sqlca.sqlcode) {
    case OK:    NumberOfRows = sqlerrd[2];
                printf("The number of rows updated was: %d\n" NumberOfRows);
                break;
    default:    printf("\n No rows could be updated!");
                SQLStatusCheck();
                break;
    }
}
```

. .

If the UPDATE command is successfully executed, sqlcode is 0 and sqlerrd[2] contains the number of rows updated. If the UPDATE command cannot be successfully executed, sqlcode contains a negative number and sqlerrd[2] contains a 0.

BULK Operations. When using the BULK SELECT, BULK FETCH, or BULK INSERT commands, you can use the sqlerrd[2] value in several ways:

- If the command executes without error, to determine the number of rows retrieved into an output host variable array or inserted from an input host variable array.
- If the command causes an error condition, to determine the number of rows that could be successfully put into or taken out of the host variable array *before* the error occurred.

In the code identified as (1) in Figure 4-3, the value in sqlerrd[2] is displayed when only some of the qualifying rows could be retrieved before an error occurred.

In the code identified as (2), the value in sqlerrd[2] is compared with the maximum array size to determine whether more rows might have qualified than the program could display. You could also use a cursor and execute the FETCH command until sqlcode=100.

In the code identified as (3), the value in sqlerrd[2] is used to control the number of times function *DisplayRow* is executed.

```
#define     OK             0
#define     NotFound     100
#define     MaximumRows  200

      /*Begin Host Variable Declarations */
EXEC SQL Begin Declare Section;
struct  {
  char            PartNumber[17];
  char            PartName[31];
  double          SalesPrice;
  } PartsTable[MaximumRows];
char               SQLMessage[133];
EXEC SQL End Declare Section;
      /* End Host Variable Declarations */

sqlca : sqlca_type;   /* SQL Communication Area */

int          i;
int          NumberOfRows;

int BulkSelect()
{
  EXEC SQL BULK SELECT PartNumber,
                       PartName,
                       SalesPrice
                INTO :PartsTable
                FROM  PurchDB.Parts;

  switch(sqlca.sqlcode) {
    case OK:        DisplayTable();
                    break;
    case NotFound:  printf("\n");
                    printf("\n No rows qualify for this operation!");
                    break;
    default:        NumberOfRows = sqlerrd[2];          (1)
                    printf("\nOnly %d rows were retrieved",NumberOfRows);
                    printf("\n   before an error occurred!");
                    DisplayTable();
                    SQLStatusCheck();
                    break;
  }
}
```

Figure 4-3. Determining Number of Rows Processed After a BULK SELECT

```
.
.
.
int DisplayTable()
{
  if (sqlerrd[2] == MaximumRows)                          (2)
  {
      printf("\n");
      printf("\nWARNING:  There may be additional rows that qualify!");
  }
  The column headings are displayed here.
  for (i = 0; i < sqlerrd[2]; i++)
    DisplayRow();                                         (3)
printf("\n");
}

int DisplayRow()
{
  printf(PartNumber[i], "%s\n |");
  printf(PartName[i],   "%s\n  |");
  printf(SalesPrice[i], "%.2f\n  |");
}
```


Determining Number of Rows Processed After a BULK SELECT (page 2 of 2)

Detecting End of Scan

Previous examples in this chapter have illustrated how an sqlcode of 100 can be detected and handled for data manipulation commands that do not use a cursor. When a cursor is being used, this sqlcode value can be used to determine when all rows in an active set have been fetched:

```
int FetchRow()
{
  EXEC SQL FETCH  CURSOR1
           INTO :PartNumber,
                :PartName,
                :SalesPrice;

  switch(sqlca.sqlcode) {
    case OK:           DisplayRow();
                       break;
    case NotFound:     DoneFetch = TRUE;
                       printf("\n Row not found or no more rows!");
                       break;
    default:           SQLStatusCheck();
                       break;
  }
}
.
.
.
     EXEC SQL OPEN CURSOR1;
.
.
.
     do {
     FetchRow();
     } while (DoneFetch != TRUE);
```

In this example, the active set is defined when the OPEN command is executed. The cursor is then positioned before the first row of the active set. When the FETCH command is executed, the first row in the active set is placed into the program's host variables, then displayed. The FETCH command retrieves one row at a time into the host variables until the last row in the active set has been retrieved. The next attempt to FETCH after the last row has been fetched from the active set, will set sqlcode to NotFound (defined as 100 in the declaration part). If no rows qualify for the active set, sqlcode is NotFound the first time function *FetchRow* is executed.

Determining When More Than One Row Qualifies

If more than one row qualifies for a non-BULK SELECT or FETCH operation, ALLBASE/SQL sets sqlcode to -10002. In the following example, when sqlcode is MultipleRows (defined as -10002 in the declaration part), a status checking function is not invoked; instead a warning message is displayed:

```
int UpdateData()
{
  This function verifies that the row(s) to be changed
  exist, then invokes the function DisplayUpdate to accept
  new data from the user.

  EXEC SQL SELECT  PartNumber, PartName, SalesPrice
             INTO :PartNumber,
                  :PartName,
                  :SalesPrice
             FROM  PurchDB.Parts
            WHERE  PartNumber = :PartNumber;

  switch(sqlca.sqlcode) {
  case OK:            DisplayUpdate();
                      break;
  case NotFound:      printf("\n");
                      printf("\n Row not found!");
                      break;
  case MultipleRows:  printf("\n");
                      printf("\n WARNING: More than one row qualifies!");
                      DisplayUpdate();
                      break;
   default:           SQLStatusCheck();
                      break;
   }
}
```

Note The PARTS table in the sample database has a unique index on PARTNUMBER, so a test for multiple rows is not required. This test is useful for the ORDERITEMS table which does not have a unique index.

Detecting Log Full Condition

When the log file is full, log space must be reclaimed before ALLBASE/SQL can process any additional transactions. Your program can detect the situation, and it can be corrected by the DBA.

SQLEXPLAIN retrieves the following message:

```
Log full.  (DBERR 14046)
```

In the following example, sqlcode is checked for a log full condition. If the condition is true, ALLBASE/SQL has rolled back the current transaction. The program issues a COMMIT WORK command, the SQLStatusCheck routine is executed to display any messages, and the program is terminated.

```
if (sqlca.sqlcode = -14046)
    COMMIT WORK;
    SQLStatusCheck();
    TerminateProgram();
```

Handling Out of Space Conditions

It is possible that data or index space may be exhausted in a DBEFileSet. This could happen as rows are being added or an index is being created or when executing queries which require that data be sorted. Your program can detect the problem, and the DBA must add index or data space to the appropriate DBEFileSet.

SQLEXPLAIN retrieves the following message:

```
Data or Index space exhaused in DBEFileSet.  (DBERR 2502)
```

In the following example, sqlcode is checked for an out of space condition. If the condition is true, the transaction is rolled back to an appropriate savepoint. The program issues a COMMIT WORK command, the SQLStatusCheck routine is executed to display any messages, and the program is terminated.

```
if (sqlca.sqlcode = -2502)
    ROLLBACK WORK TO :SavePoint;
    COMMIT WORK;
    SQLStatusCheck();
    TerminateProgram();
```

Checking for Authorizations

When the DBEUserID related to an ALLBASE/SQL command does not have the authority to execute the command, the following message is retreived by SQLEXPLAIN:

```
User ! does not have ! authorization.   (DBERR 2300)
```

In the following example, sqlcode is checked to determine if the user has proper connect authority. If the condition is true, the SQLStatusCheck routine is executed to display any messages, and the program is terminated.

```
EXEC SQL CONNECT TO 'PartsDBE';
if (sqlca.sqlcode = -2300)
    SQLStatusCheck();
    TerminateProgram();
```

5

Simple Data Manipulation

Simple data manipulation is a programming technique used to SELECT or INSERT a *single* row. It can also be used to INSERT, DELETE, or UPDATE one or more rows based on a *specific criterion*. These types of data manipulation operations are considered *simple* because they can be done with SQL data manipulation commands that staisfy the following conditions:

- Do not contain the BULK option; therefore, the host variables used are not arrays, and data references are simplified.
- Are not executed in conjunction with a cursor; therefore, additional SQL commands such as FETCH and OPEN are not required.
- Are not dynamically preprocessed; and therefore, do not require use of commands such as PREPARE, DESCRIBE, and EXECUTE IMMEDIATE.

This chapter reviews how to use the SELECT, INSERT, DELETE, and UPDATE commands for simple data manipulation. It then briefly examines transaction management considerations. For further discussion of transaction management, refer to the *ALLBASE/SQL Reference Manual* .

A program illustrating simple data manipulation is found at the end of the chapter.

SQL Commands

The SQL commands used for simple data manipulation are:

```
SELECT
INSERT
DELETE
UPDATE
```

Refer to the *ALLBASE/SQL Reference Manual* for the complete syntax and semantics of these commands.

SELECT

In simple data manipulation, you use the SELECT command to retrieve a single row, i.e., a one-row query result. The form of the SELECT command that describes a one-row query result is:

```
SELECT SelectList
  INTO HostVariables
  FROM TableNames
 WHERE SearchCondition
```

Note that the GROUP BY, HAVING, and ORDER BY clauses are not necessary, since these clauses usually describe multiple-row query results.

You may omit the WHERE clause from certain queries when the select list contains *only* aggregate functions:

```
EXEC SQL SELECT  AVG(SalesPrice)
           INTO :AvgSalesPrice
           FROM  PurchDB.Parts;
```

A WHERE clause may be used, however, to qualify the rows over which the aggregate function is applied:

```
EXEC SQL SELECT  AVG(SalesPrice)
           INTO :AvgSalesPrice
           FROM  PurchDB.Parts
          WHERE  SalesPrice > :SalesPrice;
```

If the select list does *not* contain aggregate functions, a WHERE clause is needed to restrict the query result to a single row:

```
EXEC SQL SELECT  PartName,  SalesPrice
           INTO :PartName, :SalesPrice
           FROM  PurchDB.Parts
          WHERE  PartNumber = :PartNumber;
```

Because the host variables that hold query results for a simple SELECT command are not arrays of records, they can hold only a single row. A runtime error occurs when multiple rows qualify for a simple SELECT command. You can test for an sqlcode value of -10002 to detect this condition:

```
#define MultipleRows    -10002
.
.
.
int GetRow()
{
.
.
.
     The SELECT command is executed here.

     if (sqlca.sqlcode == MultipleRows) {
        printf("\n WARNING:  More than one row qualifies!");
        }
}
```

When multiple rows qualify but the receiving host variables are not in an array of records and the BULK option is not specified, *none* of the rows are returned.

When a column named in the WHERE clause has a unique index on it, you can omit testing for multiple-row query results. A unique index prevents the key column(s) from having duplicate values. The following index, for example, ensures that only one row will exist for any part number in PurchDB.Parts:

```
CREATE UNIQUE INDEX PartNumIndex
                ON PurchDB.Parts (PartNumber)
```

If a key column of a unique index *can contain a null value*, the unique index insures that no more than one null value can exist for that column.

It is useful to execute the SELECT command *before* executing the INSERT, DELETE, or UPDATE commands in the following situations:

- When an application updates or deletes rows, the SELECT command can retrieve the target data for user verification before the data is changed. This technique minimizes inadvertent data changes:

  The program accepts a part number from the user into a host variable PartNumber, then retrieves a row for that part.

  ```
  EXEC SQL SELECT  PartNumber,  BinNumber
             INTO :PartNumber, :BinNumber
             FROM  PurchDB.Inventory
            WHERE  PartNumber = :PartNumber;
  ```

  The row is displayed, and the user is prompted whether to change the bin number. If not, the user is prompted for another part number. If so, the user is prompted for the new bin number which is accepted into the host variable named BinNumber. Then the UPDATE command is executed.

  ```
  EXEC SQL UPDATE PurchDB.Inventory
              SET BinNumber  = :BinNumber
            WHERE PartNumber = :PartNumber;
  ```

  Another method of qualifying the rows you want to select is to use the LIKE specification to search for a particular character string pattern.

  For example, suppose you want to search for all VendorRemarks that contain a reference to 6%. Since the percent sign (%) happens to be one of the wild card characters for the LIKE specification, you could use the following SELECT statement specifying the exclamation point (!) as your escape character.

  ```
  SELECT * FROM PurchDB.Vendors
   WHERE VendorRemarks LIKE '%6!%%' ESCAPE '!'
  ```

  The first and last percent sign character are the wildcard characters. The next to the last percent sign, preceded by an exclamation point, is the percent sign that you want to escape, so that it is actually used in the search pattern for the LIKE clause.

  The character following an escape character must be either a wild card character or the escape character itself. Complete syntax is presented in the *ALLBASE/SQL Reference Manual* .

- To prohibit the multiple-row changes possible if multiple rows qualify for an UPDATE or DELETE operation. If multiple rows qualify for the SELECT operation, the UPDATE or DELETE command would not be executed. Alternatively, the user could be advised that multiple rows would be affected and given a choice about whether to perform the change:

  The program prompts the user for an order number and a vendor part number in preparation for allowing the user to change the vendor part number. The following SELECT command determines whether more than one line at a time exists on the order for the specified vendor part number.

```
EXEC SQL SELECT  ItemNumber
           INTO :ItemNumber
           FROM  PurchDB.OrderItems
          WHERE  OrderNumber    = :OrderNumber
            AND  VendPartNumber = :VendPartNumber;
```

  When more than one row qualifies for this query, the program lets the user decide whether to proceed with the update operation.

- When an application lets the user INSERT a row that must contain a value higher than an existing value, the SELECT command can identify the highest existing value:

```
EXEC SQL SELECT  MAX(OrderNumber)
           INTO :MaxOrderNumber
           FROM  PurchDB.Orders;
```

  The program can increment the maximum order number by one, then the user with the new number and prompt for information describing the new order.

INSERT

In simple data manipulation, you use the INSERT command to either insert a single row or copy one or more rows into one table from another table.

Use the following form of the INSERT command to insert a single row:

```
INSERT INTO  TableName
            (ColumnNames)
      VALUES (DataValues)
```

You can omit *ColumnNames* when you provide values for all columns in the target table:

```
EXEC SQL INSERT INTO    PurchDB.Parts
               VALUES (:PartNumber,
                       :PartName   :PartNameInd,
                       :SalesPrice :SalesPriceInd);
```

Remember that when you *do* include Column Names but do not name all the columns in the target table, ALLBASE/SQL attempts to insert a null value into each unnamed column. If an unnamed column was defined as NOT NULL, the INSERT command fails.

To copy one or more rows from one or more tables to another table, use the following form of the INSERT command:

```
INSERT  INTO  TableName
             (ColumnNames)
       SELECT  SelectList
         FROM  TableNames
        WHERE  SearchCondition1
     GROUP BY  ColumnName
       HAVING  SearchCondition2
```

Note that the SELECT command embedded in this INSERT command *cannot* contain an INTO or ORDER BY clause. In addition, any host variables used must be within the WHERE or HAVING clauses.

The following example copies historical data for filled orders into table PurchDB.OldOrders, then deletes rows for these orders from PurchDB.Orders, keeping that table minimal in size.

The INSERT command copies rows from PurchDB.Orders to PurchDB.OldOrders.

```
EXEC SQL INSERT  INTO  PurchDB.OldOrders
                      (OldOrder, OldVendor, OldDate)
                SELECT  OrderNumber, VendorNumber, OrderDate
                  FROM  PurchDB.Orders
                 WHERE  OrderNumber = :OrderNumber;
```

Then the DELETE command deletes rows from PurchDB.Orders.

```
EXEC SQL DELETE  FROM  PurchDB.Orders
                 WHERE  OrderNumber: = OrderNumber;
```

UPDATE

In simple data manipulation, you use the UPDATE command to change data in one or more columns:

```
UPDATE TableName
   SET Columname = ColumnValue
       [,...]
WHERE SearchCondition
```

As in the case of the DELETE command, if you omit the WHERE clause, the value of any column specified is changed in *all* rows of the table.

If the WHERE clause is specified, all rows satisfying the search condition are changed, for example:

```
EXEC SQL UPDATE PurchDB.Vendors
            SET ContactName   = :ContactName :ContactNameInd,
                VendorStreet  = :VendorStreet,
                VendorCity    = :VendorCity,
                VendorState   = :VendorState,
                VendorZipCode = :VendorZipCode
          WHERE VendorNumber  = :VendorNumber;
```

In this example, column ContactName can contain a null value. To insert a null value, the program must assign a number less than zero to the indicator variable for this column, ContactNameInd:

The program prompts the user for new values for the four columns.

```
printf ("\n Enter Vendor Street > ");
getline(VendorStreet);
printf ("\n Enter Vendor City > ");
getline(VendorCity);

printf ("\n Enter Vendor State > ");
getline(VendorState);

printf ("\n Enter Vendor Zip Code > ");
getline(VendorZipCode);

printf ("\n Enter Contact Name (0 for null) > ");
getline(ContactName);
```

If the user enters a 0 to assign a null value to column ContactName, the program assigns a -1 to the indicator variable; otherwise, the program assigns a 0 to this variable:

```
if (ContactName[0] == '0') {
   ContactNameInd = -1;
   }
else
```

```
ContactNameInd =  0;
```

DELETE

In simple data manipulation, you use the DELETE command to delete one or more rows from a table:

```
DELETE FROM TableName
      WHERE SearchCondition
```

The WHERE clause specifies a *SearchCondition* that rows must meet to be deleted, for example:

```
EXEC SQL DELETE FROM PurchDB.Orders
                WHERE OrderDate < :OrderDate;
```

If the WHERE clause is omitted, *all* rows in the table are deleted.

Transaction Management for Simple Operations

The major objectives of transaction management are to minimize the contention for locks and to ensure logical data consistency. Minimizing lock contention implies short transactions and/or locking small, unique parts of a database. Logical data consistency implies keeping data manipulations that should all occur or all not occur within a single transaction. Defining your transactions should always be made with these two objectives in mind. For in depth transaction management information, refer to the *ALLBASE/SQL Reference Manual* .

Most simple data manipulation applications involve random operations on a minimal number of related rows that satisfy very specific criteria. To minimize lock contention, you should begin a new transaction each time these criteria change. For example, if an application displays order information for random orders, delimit each new query with a BEGIN WORK and a COMMIT WORK command:

The program accepts an order number from the user.

```
EXEC SQL BEGIN WORK;

EXEC SQL SELECT  OrderNumber,
                 VendorNumber,
                 OrderDate
           INTO :OrderNumber,
                :VendorNumber  :VendorNumberInd,
                :OrderDate     :OrderDateInd
           FROM  PurchDB.Orders
          WHERE  OrderNumber = :OrderNumber;
```

Error checking is done here.

```
EXEC SQL COMMIT WORK;
```

The program displays the row, then prompts for another order number.

Because SELECT commands are often executed prior to a related UPDATE, DELETE, or INSERT command, you must decide whether to make each command a separate transaction or combine commands within one transaction:

- If you combine SELECT and DELETE operations within one transaction, when the DELETE command is executed, the row deleted is guaranteed to be the same row retrieved and displayed for the user. However, if the program user goes to lunch between SELECT and DELETE commands, and the default isolation level (RR) is in effect, no other users can modify the page or table locked by the SELECT command until the transaction terminates.
- If you put the SELECT and DELETE operations in separate transactions, another transaction may change the target row(s) before the DELETE command is executed. Therefore the user may delete a row different from that originally intended. One way to handle this situation is as follows:

```
EXEC SQL BEGIN WORK;
```

The SELECT command is executed and the query result displayed.

```
EXEC SQL COMMIT WORK;
```

The program user requests that the row be deleted.

```
EXEC SQL BEGIN WORK;
```

The SELECT command is re-executed, and the program compares the original query result with the new one. If the query results match, the DELETE command is executed.

```
EXEC SQL COMMIT WORK;
```

If the new query result does not match the original query result, the program re-executes the SELECT command to display the query result.

In the case of some multi-command transactions, you must execute multiple data manipulation commands within a single transaction for the sake of logical data consistency:

In the following example, the DELETE and INSERT commands are used in place of the UPDATE command to insert null values into the target table.

```
EXEC SQL BEGIN WORK;
```

The DELETE command is executed.

If the DELETE command fails, the transaction can be terminated as follows:

```
EXEC SQL COMMIT WORK;
```

If the DELETE command succeeds, the INSERT command is executed.

If the INSERT command fails, the transaction is terminated as follows:

```
EXEC SQL ROLLBACK WORK;
```

If the INSERT command succeeds, the transaction is terminated as follows:

```
EXEC SQL COMMIT WORK;
```

Logical data consistency is also an issue when an UPDATE, INSERT, or DELETE command may operate on multiple rows. If one of these commands fails after only *some* of the target rows have been operated on, you must use a ROLLBACK WORK command to ensure that any row changes made before the failure are undone:

```
EXEC SQL DELETE FROM PurchDB.Orders
               WHERE OrderDate < :OrderDate;

if (sqlca.sqlcode != OK) {
  EXEC SQL ROLLBACK WORK;
  }
```

Sample Program Using Simple DML Commands

The flow chart shown in Figure 5-1 summarizes the functionality of program cex7. This program uses the four simple data manipulation commands to operate on the PurchDB.Vendors table. A function menu determines whether to execute one or more SELECT, UPDATE, DELETE, or INSERT operations. Each execution of a simple data manipulation command is done in a separate transaction.

The runtime dialog for program cex7 appears in Figure 5-2, and the source code in Figure 5-3.

Function *ConnectDBE* starts a DBE session (51). This function executes the CONNECT command (2) for the sample DBEnvironment, *PartsDBE*. The operation performed next depends on the number entered when a function menu is displayed (52):

- The program terminates if 0 is entered.
- Function *Select* is executed if 1 is entered.
- Function *Update* is executed if 2 is entered.
- Function *Delete* is executed if 3 is entered.
- Function *Insert* is executed if 4 is entered.

The *Select* function (9) prompts for a vendor number or a 0 (10). If a 0 is entered, the function menu is re-displayed. If a vendor number is entered, function *BeginTransaction* is executed (11) to issue the BEGIN WORK command (4). Then a SELECT command is executed to retrieve all data for the vendor specified from PurchDB.Vendors (12). The sqlca.sqlcode returned is examined to determine the next action:

- If no rows qualify for the SELECT operation, a message (14) is displayed and the transaction terminated (17). Function EndTransaction terminates the transaction by executing the COMMIT WORK command (5). The user is then re-prompted for a vendor number or a 0.
- If more than one row qualifies for the SELECT operation, a different message (15) is displayed and the transaction is terminated (17). The user is then re-prompted for a vendor number or a 0.
- If the SELECT command execution results in an error condition, function *SQLStatusCheck* is executed (16). This function executes SQLEXPLAIN (1) to display all error messages. Then the transaction is terminated (17) and the user re-prompted for a vendor number or a 0.
- If the SELECT command can be successfully executed, the *DisplayRow* function (13) is executed to display the row. This function examines the null indicators for each of the three potentially null columns (*ContactName*, *PhoneNumber*, and *VendorRemarks*). If any null indicator contains a value not equal to 0 (8), a message indicating that the value is null is displayed. After the row is completely displayed, the transaction is terminated (17) and the user re-prompted for a vendor number or a 0.

The *Update* function (23) lets the user UPDATE the value of a column only if it contains a null value. The function prompts (24) for a vendor number or a 0. If a 0 is entered, the function menu is re-displayed. If a vendor number is entered, function *BeginTransaction* is executed (25). Then a SELECT command is executed (26) to retrieve data from *PurchDB.Vendors* for the vendor specified. The sqlca.sqlcode returned is examined to determine the next action:

- If no rows qualify for the SELECT operation, a message (28) is displayed and the transaction is terminated (31). The user is then re-prompted for a vendor number or a 0.
- If more than one row qualifies for the SELECT operation, a different message (29) is displayed and the transaction is terminated (31). The user is then re-prompted for a vendor number or a 0.
- If the SELECT command execution results in an error condition, function *SQLStatusCheck* is executed (30). Then the transaction is terminated (31) and the user re-prompted for a vendor number or a 0.
- If the SELECT command can be successfully executed, function *DisplayUpdate* (27) is executed. This function executes function *DisplayRow* to display the row retrieved (18). Function *AnyNulls* is then executed to determine whether the row contains any null values. This boolean function evaluates to TRUE (6) if the indicator variable for any of the three potentially null columns contains a non-zero value.

  If function *AnyNulls* evaluates to FALSE, a message is displayed (7) and the transaction is terminated (31); the user is then re-prompted for a vendor number or a 0.

  If function *AnyNulls* evaluates to TRUE, the null indicators are examined to determine which of them contain a negative value (19). A negative null indicator means the column contains a null value, and the user is prompted for a new value (20). If the user enters a 0, the program assigns a -1 to the null indicator (21) so that when the UPDATE command (22) is executed, a null value is assigned to that column. If a non-zero value is entered, the program assigns a 0 to the null indicator so that the value specified is assigned to that column. After the UPDATE (22) command is executed, the transaction is terminated (31) and the user re-prompted for a vendor number or a 0.

Function *Delete* (35) lets the user DELETE one row. The function prompts for a vendor number or a 0 (36). If a 0 is entered, the function menu is re-displayed. If a vendor number is entered, function *BeginTransaction* is executed (37). Then a SELECT command is executed to retrieve all data for the vendor specified from PurchDB.Vendors (38). The sqlca.sqlcode returned is examined to determine the next action:

- If no rows qualify for the SELECT operation, a message (40) is displayed and the transaction is terminated (43). The user is then re-prompted for a vendor number or a 0.
- If more than one row qualifies for the SELECT operation, a different message (41) is displayed and the transaction is terminated (43). The user is then re-prompted for a vendor number or a 0.
- If the SELECT command execution results in an error condition, function *SQLStatusCheck* is executed (42). Then the transaction is terminated (43) and the user re-prompted for a vendor number or a 0.

- If the SELECT command can be successfully executed, the *DisplayDelete* function (39) is executed. This function executes function *DisplayRow* to display the row retrieved (32). Then the user is asked whether she wants to actually delete the row (33). If not, the transaction is terminated (43) and the user re-prompted for a vendor number or a 0. If so, the DELETE command (34) is executed before the transaction is terminated (43) and the user re-prompted.

The *Insert* function (44) lets the user INSERT one row. The function prompts for a vendor number or a 0 (45). If a 0 is entered, the function menu is re-displayed. If a vendor number is entered, the user is prompted for values for each column. The user can enter a 0 to specify a null value for potentially null columns (46); to assign a null value, the program assigns a -1 to the appropriate null indicator (47). After a transaction is started (48), an INSERT command (49) is used to insert a row containing the specified values. After the INSERT operation, the transaction is terminated (50), and the user re-prompted for a vendor number or a 0.

When the user enters a 0 in response to the function menu display, the program terminates by executing function *ReleaseDBE* (53). This function executes the RELEASE command (3).

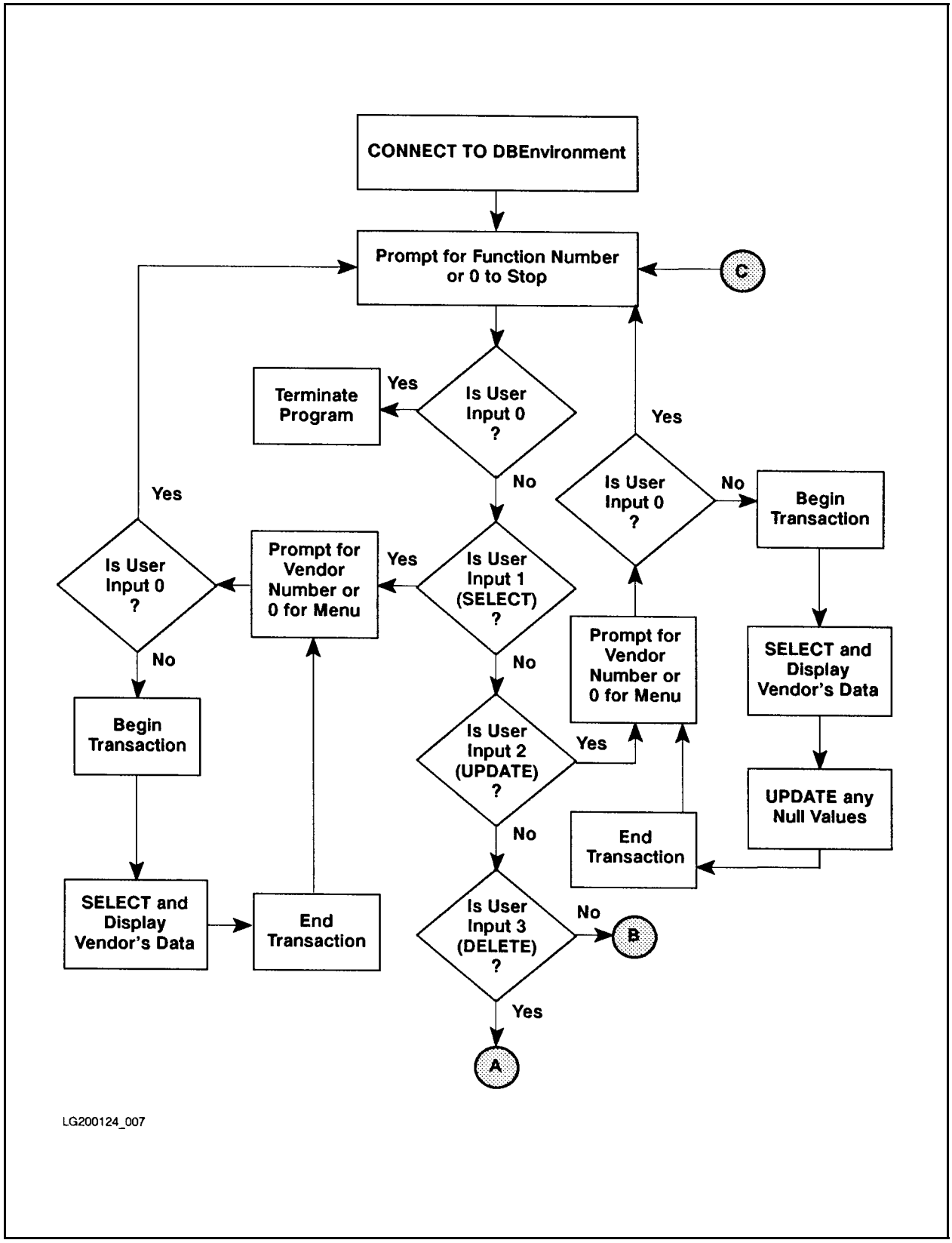


Figure 5-1. Flow Chart of Program cex7

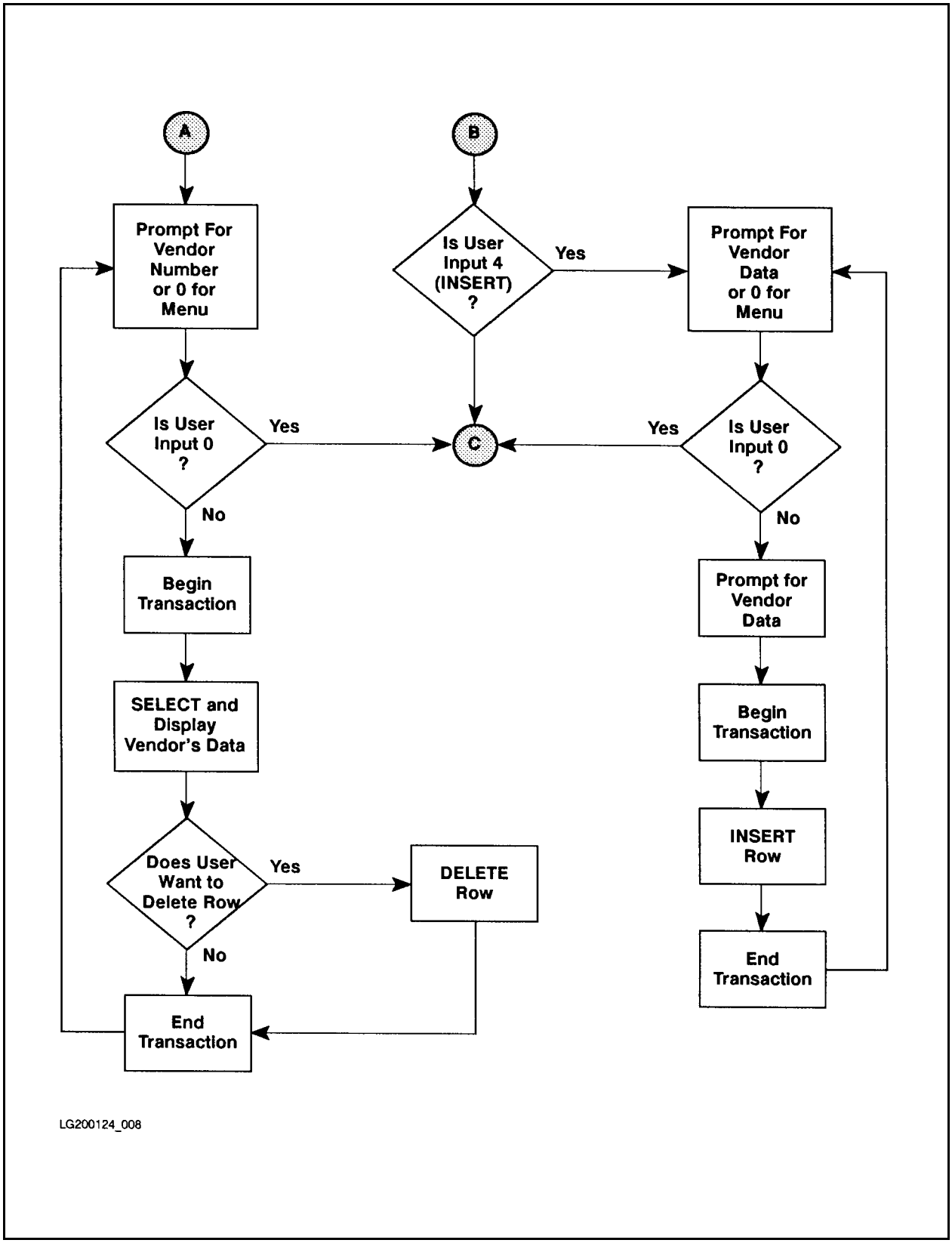


Figure 5-1. Flow Chart of Program cex7 (page 2 of 2)

```
Program for Simple Data Manipulation of Vendors Table - cex7

Connect to PartsDBE

   1 . . . . SELECT rows from PurchDB.Vendors table
   2 . . . . UPDATE rows with null values in PurchDB.Vendors table
   3 . . . . DELETE rows from PurchDB.Vendors table
   4 . . . . INSERT rows into PurchDB.Vendors table

Enter choice or 0 to STOP > 4

  *** Function to INSERT rows into PurchDB.Vendors ***

Enter Vendor Number to INSERT into Vendors Table or 0 for MENU > 9016

Enter Vendor Name > Wolfe Works

Enter Contact Name or a 0 for null > Stanley Wolfe

Enter Phone Number or a 0 for null > 408 975 6061

Enter Vendor Street > 7614 Canine Way

Enter Vendor City > San Jose

Enter Vendor State > CA

Enter Vendor Zip Code > 90016

Enter Vendor Remarks or a 0 for null > 0

Begin Work
INSERT row into PurchDB.Vendors
Commit Work

Enter Vendor Number to INSERT into Vendors Table or 0 for MENU > 0

   1 . . . SELECT rows from PurchDB.Vendors table
   2 . . . UPDATE rows with null values in PurchDB.Vendors table
   3 . . . DELETE rows from PurchDB.Vendors table
   4 . . . INSERT rows into PurchDB.Vendors table

Enter choice or 0 to STOP > 1
```

Figure 5-2. Runtime Dialog of Program cex7

```
  *** Function to SELECT a row from the Vendors Table ***

Enter Vendor Number to SELECT from Vendors Table or 0 for MENU > 9016

Begin Work
SELECT * from PurchDB.Vendors

  VendorNumber:           9016
  VendorName:     Wolfe Works
  ContactName:    Stanley Wolfe
  PhoneNumber:    408 975 6061
  VendorStreet:   7614 Canine Way
  VendorCity:     San Jose
  VendorState:    CA
  VendorZipCode:  90016
  VendorRemarks   is NULL

Commit Work

Enter Vendor Number to SELECT from Vendors Table or 0 for MENU > 0

   1 . . . SELECT rows from PurchDB.Vendors table
   2 . . . UPDATE rows with null values in PurchDB.Vendors table
   3 . . . DELETE rows from PurchDB.Vendors table
   4 . . . INSERT rows into PurchDB.Vendors table

Enter choice or 0 to STOP > 2

  *** Function to UPDATE rows in PurchDB.Vendors ***

Enter Vendor Number to UPDATE within Vendors Table or 0 for MENU > 9016

Begin Work
SELECT * from PurchDB.Vendors

  VendorNumber:           9016
  VendorName:     Wolfe Works
  ContactName:    Stanley Wolfe
  PhoneNumber:    408 975 6061
  VendorStreet:   7614 Canine Way
  VendorCity:     San Jose
  VendorState:    CA
  VendorZipCode:  90016
  VendorRemarks   is NULL

Enter new VendorRemarks or 0 for null > can expedite shipments
Commit Work
```

Figure 5-2. Runtime Dialog of Program cex7 (page 2 of 3)

```
Enter Vendor Number to UPDATE within Vendors Table or 0 for MENU > 0

   1 . . . SELECT rows from PurchDB.Vendors table
   2 . . . UPDATE rows with null values in PurchDB.Vendors table
   3 . . . DELETE rows from PurchDB.Vendors table
   4 . . . INSERT rows into PurchDB.Vendors table

Enter choice or 0 to STOP > 3

  *** Function to DELETE rows from PurchDB.Vendors ***

Enter Vendor Number to DELETE from Vendors Table or 0 for MENU > 9016

Begin Work
SELECT * from PurchDB.Vendors

  VendorNumber:           9016
  VendorName:     Wolfe Works
  ContactName:    Stanley Wolfe
  PhoneNumber:    408 975 6061
  VendorStreet:   7614 Canine Way
  VendorCity:     San Jose
  VendorState:    CA
  VendorZipCode:  90016
  VendorRemarks:  can expedite shipments

Is it OK to DELETE this row (N/Y)? > Y

DELETE row from PurchDB.Vendors
Commit Work

Enter Vendor Number to DELETE from Vendors Table or 0 for MENU > 0

   1 . . . SELECT rows from PurchDB.Vendors table
   2 . . . UPDATE rows with null values in PurchDB.Vendors table
   3 . . . DELETE rows from PurchDB.Vendors table
   4 . . . INSERT rows into PurchDB.Vendors table

Enter choice or 0 to STOP > 0
```

Figure 5-2. Runtime Dialog of Program cex7 (page 3 of 3)

```
/* Program cex7 */

/* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * */
/* This program illustrates the use of SQL's data manipulation     */
/* commands for simple operations.  It uses the UPDATE             */
/* command with indicator variables to update any row in the       */
/* Vendors table that contains null values. It also uses indicator */
/* variables in conjunction with SELECT and INSERT commands.       */
/* The DELETE command is also illustrated.                         */
/* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * */

typedef int boolean;

boolean     Abort;
int         response1;
char        response2[2];

#include <stdio.h>

#define    OK                0
#define    NotFound        100
#define    MultipleRows  -10002
#define    DeadLock      -14024
#define    FALSE             0
#define    TRUE              1

sqlca_type sqlca;    /* SQL Communication Area */

          /* Begin Host Variable Declarations */
    EXEC SQL BEGIN DECLARE SECTION;
    int       VendorNumber;
    char      VendorName[31];
    char      ContactName[31];
    sqlind    ContactNameInd;
    char      PhoneNumber[16];
    sqlind    PhoneNumberInd;
    char      VendorStreet[31];
    char      VendorCity[21];
    char      VendorState[3];
    char      VendorZipCode[11];
    char      VendorRemarks[61];
    sqlind    VendorRemarksInd;
    char      SQLMessage[133];
    EXEC SQL END DECLARE SECTION;
          /* End Host Variable Declarations */
```

Figure 5-3. Program cex7: Using INSERT, UPDATE, SELECT and DELETE

```
int getline(linebuff)   /* Function to get a line of characters */
char linebuff[80];
{
while (strlen(gets(linebuff)) == 0);
}     /* End of function to get a line of characters  */

int SQLStatusCheck()  /* Function to Display Error Messages */  (16)
{
Abort = FALSE;
if (sqlca.sqlcode < DeadLock) Abort = TRUE;

do {
EXEC SQL SQLEXPLAIN :SQLMessage;                                (1)
printf("%s\n",SQLMessage);
} while (sqlca.sqlcode != 0);

if (Abort) ReleaseDBE();
}  /* End SQLStatusCheck Function */

boolean ConnectDBE()  /* Function to Connect to PartsDBE */
                                                                (51)
{
boolean ConnectDBE;
printf("\n Connect to PartsDBE");
EXEC SQL CONNECT TO 'PartsDBE';                                 (2)

ConnectDBE = TRUE;
if (sqlca.sqlcode != OK) {
  ConnectDBE = FALSE;
  SQLStatusCheck();
  }  /* End if */
return (ConnectDBE);
}  /* End of ConnectDBE Function */


int ReleaseDBE()   /* Function to Release PartsDBE */
                                                                (53)
{
printf("\n Release PartsDBE");
printf("\n");
EXEC SQL RELEASE;                                               (3)

if (sqlca.sqlcode != OK) SQLStatusCheck();

}  /* End ReleaseDBE Function */
```

Figure 5-3. Program cex7: Using INSERT, UPDATE, SELECT and DELETE (page 2 of 12)

```
boolean BeginTransaction()    /* Function to Begin Work */        (11)
{
boolean BeginTransaction;
printf("\n");
printf("\n Begin Work");
EXEC SQL BEGIN WORK;                                              (4)
if (sqlca.sqlcode != OK)  {
  BeginTransaction = FALSE;
  SQLStatusCheck();
  ReleaseDBE();
  }
else
  BeginTransaction = TRUE;

return (BeginTransaction);

}  /* End BeginTransaction Function */


int EndTransaction()  /* Function to Commit Work */               (17)
{
printf("\n");
printf("\n Commit Work");
EXEC SQL COMMIT WORK;                                             (5)
if (sqlca.sqlcode != OK) {
  SQLStatusCheck();
  ReleaseDBE();
  }

}  /* End EndTransaction Function */


boolean AnyNulls()     /* Function to test a row for null values  */
{
boolean AnyNulls;
AnyNulls = TRUE;
if ((ContactNameInd == 0)&(PhoneNumberInd == 0)&(VendorRemarksInd == 0)) {
  /* All columns that might be null contain non-null values */    (6)
  printf("\n No null values exist for this vendor!");             (7)
  AnyNulls = FALSE;
  }
return (AnyNulls);

}  /* End of AnyNulls Function */
```

Figure 5-3. Program cex7: Using INSERT, UPDATE, SELECT and DELETE (page 3 of 12)

```
int DisplayRow()   /* Function to Display Parts Table Rows */    (13)
{
  printf("\n");
  printf("Vendor Number:      %10d\n", VendorNumber);
  printf("Vendor Name:        %s\n", VendorName);

  if (ContactNameInd != 0) {                                    (8)
    printf("Contact Name:       is NULL \n");
    }
  else
    printf("Contact Name:       %s\n", ContactName);

  if (PhoneNumberInd != 0) {                                    (8)
    printf("Phone Number:       is NULL \n");
    }
  else
    printf("PhoneNumber:        %s\n", PhoneNumber);

  printf("VendorStreet:       %s\n", VendorStreet);
  printf("VendorCity:         %s\n", VendorCity);
  printf("VendorState:        %s\n", VendorState);
  printf("VendorZipCode:      %s\n", VendorZipCode);
  if (VendorRemarksInd != 0) {                                  (8)
    printf("Vendor Remarks:     is NULL \n");
    }
  else
    printf("VendorRemarks:      %s\n", VendorRemarks);

}  /* End of DisplayRow */


int Select()    /* Function to Query Parts Table */             (9)
{
printf("\n");
printf("\n  *** Function to SELECT a row from the Vendors table. ***");
printf("\n");

do {
printf("\nEnter Vendor Number to SELECT from Vendors Table or 0 for
MENU>");
  while (scanf("%d%*c", &VendorNumber) == 0;                    (10)

  if (VendorNumber != 0) {

    BeginTransaction();                                         (11)
```

Figure 5-3. Program cex7: Using INSERT, UPDATE, SELECT and DELETE (page 4 of 12)

```
    printf("\n");
    printf("\n SELECT * from PurchDB.Vendors");
    EXEC SQL SELECT  VendorNumber,                                    (12)
                     VendorName,
                     ContactName,
                     PhoneNumber,
                     VendorStreet,
                     VendorCity,
                     VendorState,
                     VendorZipCode,
                     VendorRemarks
              INTO :VendorNumber,
                   :VendorName,
                   :ContactName :ContactNameInd,
                   :PhoneNumber :PhoneNumberInd,
                   :VendorStreet,
                   :VendorCity,
                   :VendorState,
                   :VendorZipCode,
                   :VendorRemarks :VendorRemarksInd
              FROM  PurchDB.Vendors
             WHERE  VendorNumber = :VendorNumber;

    switch(sqlca.sqlcode) {
      case  OK:           DisplayRow();                               (13)
                          break;
      case  NotFound:     printf("\n");
                          printf("\n Row not found!");                (14)
                          break;
      case  MultipleRows: printf("\n");
                          printf("\nWARNING: More than one row qualifies!");
                          break;                                      (15)
      default:            SQLStatusCheck();                           (16)
                          break;
      }  /* End switch */

    EndTransaction();                                                 (17)

    }  /* End if */
} while (VendorNumber != 0);

}   /* End of Select Function */
```

Figure 5-3. Program cex7: Using INSERT, UPDATE, SELECT and DELETE (page 5 of 12)

```
int DisplayUpdate()   /* Display & Update row in Parts Table */ (27)
{
DisplayRow();                                                  (18)
if (AnyNulls) {
  if (ContactNameInd != 0) {                                   (19)
    printf("\n");
    printf("\n Enter new Contact Name or 0 for NULL > ");      (20)
    getline(ContactName);
    }
  if (PhoneNumberInd != 0) {                                   (19)
    printf("\n");
    printf("\n Enter new Phone Number of 0 for NULL > ");      (20)
    getline(PhoneNumber);
    }
  if (VendorRemarksInd != 0) {                                 (19)
    printf("\n");
    printf("]\n Enter new Vendor Remarks or 0 for NULL > ");   (20)
    getline(VendorRemarks);
    }

  if (ContactName[0] == '0') ContactNameInd = -1;              (21)
  else
    ContactNameInd = 0;

  if (PhoneNumber[0] == '0') PhoneNumberInd = -1;              (21)
  else
    PhoneNumberInd = 0;

  if (VendorRemarks[0] == '0') VendorRemarksInd = -1;          (21)
  else
    VendorRemarksInd = 0;

printf("\n");
printf("\n UPDATE the Vendors Table");
EXEC SQL UPDATE PurchDB.Vendors                                (22)
            SET ContactName =   :ContactName :ContactNameInd,
                PhoneNumber =   :PhoneNumber :PhoneNumberInd,
                VendorRemarks = :VendorRemarks :VendorRemarksInd
          WHERE VendorNumber =  :VendorNumber;

if (sqlca.sqlcode != OK )  SQLStatusCheck();

}   /* End if AnyNulls */
}   /* End of DisplayUpdate Function */
```

Figure 5-3. Program cex7: Using INSERT, UPDATE, SELECT and DELETE (page 6 of 12)

```
int Update()    /* Update a row within the Parts Table */          (23)
{
printf("\n");
printf("\n  *** Function to UPDATE rows in PurchDB.Vendors ***");
printf("\n");

do {
printf("\n Enter Vendor Number to UPDATE in Vendors Table or 0 for MENU >");
while (scanf("%d%*c", &VendorNumber) == 0);                       (24)

if (VendorNumber != 0) {

  BeginTransaction();                                             (25)

  printf("\n");
  printf("\n SELECT * from PurchDB.Vendors");
    EXEC SQL SELECT  VendorNumber,                                (26)
                     VendorName,
                     ContactName,
                     PhoneNumber,
                     VendorStreet,
                     VendorCity,
                     VendorState,
                     VendorZipCode,
                     VendorRemarks
                INTO :VendorNumber,
                     :VendorName,
                     :ContactName :ContactNameInd,
                     :PhoneNumber :PhoneNumberInd,
                     :VendorStreet,
                     :VendorCity,
                     :VendorState,
                     :VendorZipCode,
                     :VendorRemarks :VendorRemarksInd
                FROM  PurchDB.Vendors
               WHERE  VendorNumber = :VendorNumber;

  if (sqlca.sqlcode == OK)
    DisplayUpdate();                                              (27)
  else if (sqlca.sqlcode == NotFound)
    printf("\n Row not found!");                                  (28)
  else if (sqlca.sqlcode == MultipleRows)
    printf("\n WARNING: More than one row qualifies!");           (29)
  else
    SQLStatusCheck();                                             (30)
```

Figure 5-3. Program cex7: Using INSERT, UPDATE, SELECT and DELETE (page 7 of 12)

```
EndTransaction();                                                    (31)

}  /* End if */
} while (VendorNumber != 0);

}  /* End of Update Function */


int DisplayDelete()   /* Display & optionally Delete Rows */         (39)
{

DisplayRow();                                                        (32)

printf("\n");
printf("\n Is it OK to DELETE this row (N/Y) ? > ");                 (33)
scanf("%s",response2);
if ((response2[0] == 'Y') || (response2[0] == 'y')) {
  printf("\n");
  printf("\n DELETE Row from PurchDB.Vendors Table");
  EXEC SQL DELETE FROM PurchDB.Vendors                               (34)
            WHERE VendorNumber = :VendorNumber;

  if (sqlca.sqlcode != OK)   SQLStatusCheck();
  }
}  /* End of DisplayDelete */


int Delete() /* Function to Delete a row from the Parts Table */    (35)
{
printf("\n");
printf("\n  *** Function to DELETE rows from PurchDB.Vendors ***");
printf("\n");

do {
printf("\nEnter Vendor Number to DELETE from Vendors Table or 0 for MENU>");
while(scanf("%d%*c", &VendorNumber) == 0);                           (36)
if (VendorNumber != 0) {

  BeginTransaction();                                                (37)
```

Figure 5-3. Program cex7: Using INSERT, UPDATE, SELECT and DELETE (page 8 of 12)

```
    printf("\n");
    printf("\n SELECT * from PurchDB.Vendors");
      EXEC SQL SELECT  VendorNumber,                                    (38)
                       VendorName,
                       ContactName,
                       PhoneNumber,
                       VendorStreet,
                       VendorCity,
                       VendorState,
                       VendorZipCode,
                       VendorRemarks
                 INTO :VendorNumber,
                      :VendorName,
                      :ContactName :ContactNameInd,
                      :PhoneNumber :PhoneNumberInd,
                      :VendorStreet,
                      :VendorCity,
                      :VendorState,
                      :VendorZipCode,
                      :VendorRemarks :VendorRemarksInd
                 FROM  PurchDB.Vendors
                WHERE  VendorNumber = :VendorNumber;

    if (sqlca.sqlcode == OK)
      DisplayDelete();                                                  (39)
    else if (sqlca.sqlcode == NotFound)
      printf("\n Row not found!");                                      (40)
    else if (sqlca.sqlcode == MultipleRows)
      printf("\n WARNING: More than one row qualifies!");               (41)
    else
      SQLStatusCheck();                                                 (42)

    EndTransaction ();                                                  (43)

    }  /* End if */

  } while (VendorNumber != 0);

  }  /* End of Delete */


  int Insert()     /* Insert a row into the Parts Table */              (44)
  {
  printf("\n");
  printf("\n  *** Function to INSERT rows into PurchDB.Vendors ***");
  printf("\n");
```

Figure 5-3. Program cex7: Using INSERT, UPDATE, SELECT and DELETE (page 9 of 12)

```
do {
VendorNumber = 0;
printf("\nEnter Vendor Number to INSERT into Vendors Table or 0 for MENU>");
while(scanf("%d%*c", &VendorNumber) == 0);                          (45)

if (VendorNumber != 0)  {

  printf("\n Enter Vendor Name > ");
  getline(VendorName);

  printf("\n Enter Contact Name or a 0 for NULL > ");                (46)
  getline(ContactName);

  if (ContactName[0] == '0') ContactNameInd = -1;                   (47)
  else
    ContactNameInd = 0;

  printf("\n Enter Phone Number or a 0 for NULL > ");                (46)
  getline(PhoneNumber);

  if (PhoneNumber[0] == '0') PhoneNumberInd = -1                    (47)
  else
    PhoneNumberInd = 0;

  printf("\n Enter Vendor Street > ");
  getline(VendorStreet);

  printf("\n Enter Vendor City > ");
  getline(VendorCity);

  printf("\n Enter Vendor State > ");
  getline(VendorState);

  printf("\n Enter Vendor Zip Code > ");
  getline(VendorZipCode);

  printf("\n Enter Vendor Remarks or a 0 for NULL > ");               (46)
  getline(VendorRemarks);

  if (VendorRemarks[0] == '0') VendorRemarksInd = -1;               (47)
  else
    VendorRemarksInd = 0;

  BeginTransaction();                                               (48)
```

Figure 5-3. Program cex7: Using INSERT, UPDATE, SELECT and DELETE (page 10 of 12)

```
  printf("\n");
  printf("\n INSERT row into PurchDB.Vendors");
  EXEC SQL INSERT                                                    (49)
             INTO  PurchDB.Vendors
                  (VendorNumber,
                   VendorName,
                   ContactName,
                   PhoneNumber,
                   VendorStreet,
                   VendorCity,
                   VendorState,
                   VendorZipCode,
                   VendorRemarks)
           VALUES (:VendorNumber,
                   :VendorName,
                   :ContactName :ContactNameInd,
                   :PhoneNumber :PhoneNumberInd,
                   :VendorStreet,
                   :VendorCity,
                   :VendorState,
                   :VendorZipCode,
                   :VendorRemarks :VendorRemarksInd);

  if (sqlca.sqlcode != OK) SQLStatusCheck();
  EndTransaction();                                                  (50)

  }  /* End if */
} while (VendorNumber != 0);

}  /* End of Insert */


main()          /* Beginning of program */
{
printf("\n Program for Simple Data Manipulation of Vendors Table-cex7")
printf("\n");

if (ConnectDBE())  {                                                 (51)
```

Figure 5-3. Program cex7: Using INSERT, UPDATE, SELECT and DELETE (page 11 of 12)

```
  do {
  printf("\n");                                                    52
  printf("\n 1 . . .SELECT rows from PurchDB.Vendors Table");
  printf("\n 2 . . .UPDATE rows with NULL values in PurchDB.Vendors Table");
  printf("\n 3 . . .DELETE rows from PurchDB.Vendors Table");
  printf("\n 4 . . .INSERT rows into PurchDB.Vendors Table");
  printf("\n");
  printf("\n Enter choice or 0 to STOP > ");
  scanf("%2d%*c", &response1);

  if (response1 != 0)  {

      switch (response1) {                                         50
       case  1:  Select();                                          9
                 break;
       case  2:  Update();                                         23
                 break;
       case  3:  Delete();                                         35
                 break;
       case  4:  Insert();                                         44
                 break;
       default:  printf("\n Enter 0-4 only, please!");
                 break;
      } /* switch */

    }  /* End if response1 */

  } while ( response1 != 0);

  ReleaseDBE();                                                    53
}  /* End if Connect */

else
  printf("\n Error: Cannot Connect to PartsDBE!\n");

}  /* End of Program */
```

Figure 5-3. Program cex7: Using INSERT, UPDATE, SELECT and DELETE (page 12 of 12)

6

Processing with Cursors

Processing with cursors gives you the option of operating on a **multiple-row query result, one row at a time**. The query result is referred to as an **active set**. You use a pointer called a **cursor** to move through the active set, retrieving a row at a time into host variables and optionally updating or deleting the row. Reporting applications may find this technique useful. Update applications such as those that periodically operate on tables not being concurrently accessed (for example, inventory adjustments) may also find this technique useful.

This chapter presents:

- SQL Cursor Commands.
- Transaction Management for Cursor Operations
- Sample Program Using Cursor Operations.

The emphasis in this chapter is on FETCHing one row at a time. For an example of using the FETCH command with the BULK option, see the *BULK FETCH* section of Chapter 7.

SQL Cursor Commands

The following ALLBASE/SQL commands are used in cursor processing:

- DECLARE CURSOR defines a cursor and associates it with a query.
- OPEN defines the active set.
- FETCH retrieves one row of the active set into host variables; when a row resides in host variables it is known as the **current row**. When a row is current and the active set is a query result derived from a single table, you can use one of the following two commands to change the row.
- UPDATE WHERE CURRENT updates the current row.
- DELETE WHERE CURRENT deletes the current row.
- CLOSE terminates access to the active set and frees up ALLBASE/SQL buffer space used to handle the cursor.

For a given cursor, the commands listed above (with the exception of DECLARE CURSOR) should be contained within the same transaction. Refer to the *ALLBASE/SQL Reference Manual* for the complete syntax and semantics of these commands.

DECLARE CURSOR

The DECLARE CURSOR command names a cursor and associates it with a particular SELECT command:

```
DECLARE CursorName
        [IN DBEFileSetName]
        CURSOR FOR
        SelectCommand
        [FOR UPDATE OF ColumnName [,ColumnName...]
```

Note that the DECLARE CURSOR command has two optional clauses:

- The *IN* clause defines the DBEFileSet in which the section generated by the preprocessor for this command is stored. If no IN clause is specified, file space in the SYSTEM DBEFileSet is used.
- The *FOR UPDATE OF* clause is used when you intend to use the UPDATE WHERE CURRENT command to update a current row. This command may offer the simplest way to update a current row, but it imposes certain restrictions on the SELECT command. Updating a current row is discussed fully later in this chapter under "Update Where Current."

The SELECT command for cursor declarations that do not include the FOR UPDATE clause can consist of any of the SELECT command clause *except* the INTO clause:

```
  SELECT SelectList
    FROM TableNames
   WHERE SearchCondition1
GROUP BY ColumnNames
  HAVING SearchCondition2
ORDER BY ColumnIdentifiers
```

A SELECT command associated with a cursor does not name output host variables, but may name input host variables in the select list, the WHERE clause, and the HAVING clause. In the following example, the rows qualifying for the query result will be those with a *CountCycle* matching that specified by the user in input host variable *CountCycle*:

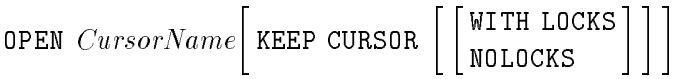
```
EXEC SQL DECLARE Inventory
          CURSOR FOR
          SELECT PartNumber,
                 BinNumber,
                 QtyOnHand,
                 AdjustmentQty
            FROM PurchDB.Inventory
           WHERE CountCycle = :CountCycle
        ORDER BY BinNumber;
```

When performing cursor processing, the ORDER BY clause may be useful. In the previous example, the rows in the query result will be in order by ascending bin number to help the program user, who will be moving from bin to bin, taking a physical inventory.

The DECLARE CURSOR command is actually a preprocessor directive. When the preprocessor parses this command, it stores a section in the target DBEnvironment. At run time, the section is not executed when the DECLARE CURSOR command is encountered. The section is executed when the OPEN command is encountered. Because the DECLARE CURSOR command is not executed at run time, you do not need to perform error status checking in your program following this command.

OPEN

The OPEN command allocates internal buffer space and defines the active set:



The following command opens the cursor defined earlier:

```
EXEC SQL OPEN Inventory;
```

Once the active set is defined, the FETCH command will retrieve data from it, one row at a time.

You can use the KEEP CURSOR WITH NOLOCKS option for a cursor that involves sorting, whether through the use of a DISTINCT, GROUP BY, or ORDER BY clause, or as the result of a union or a join operation. However, for kept cursors involving sorting, ALLBASE/SQL does not ensure data integrity.

It is your responsibility to ensure data integrity by verifying the continued existence of a row before updating it or using it as the basis for updating some other table. For an updatable cursor, you can use either the REFETCH or SELECT command to verify the continued existence of a row. For a cursor that is non-updatable, you must use the SELECT command.

A warning (DBWARN 2056) regarding the kept cursor on a sort with no locks is generated. You *must* check for this warning if you want to detect the execution of this type of cursor operation.

FETCH

The FETCH command defines a current row and delivers the row into output host variables:

```
FETCH CursorName INTO OutputHostVariables
```

Remember to include indicator variables when one or more columns in the query result may contain a null value, for example:

```
EXEC SQL FETCH  Inventory
          INTO :PartNumber,
               :BinNumber,
               :QtyOnHand     :QtyOnHandInd,
               :AdjustmentQty :AdjustmentQtyInd;
```

The first time you execute the FETCH command, the first row in the query result becomes the current row. With each subsequent execution of the FETCH command, each succeeding row in the query result becomes the current row. After the last row in the query result has been fetched, ALLBASE/SQL sets sqlca.sqlcode to 100. ALLBASE/SQL also sets sqlca.sqlcode to 100 if no rows qualify for the active set. You should test for an sqlca.sqlcode value of 100 after each execution of the FETCH command to determine whether to re-execute the command.

```
#define   TRUE    0
#define   FALSE   1
  .
  .
  .
int GetARow()
{
int  DoFetch;
.
.
.
DoFetch = TRUE;
do {
.
.      The FETCH command appears here.
.
switch (sqlca.sqlcode) {
  case 0:           DisplayRow();
                    break;
  case 100:         DoFetch = FALSE;
                    CloseCursor();
                    CommitWork();
                    break;
  default:          DoFetch = FALSE;
                    SQLStatusCheck();
                    CloseCursor();
                    RollBack();
                    break;
                    }
  } while (DoFetch == TRUE);
  }
```

When a row is current, you can update it by using the UPDATE WHERE CURRENT command or delete it by using the DELETE WHERE CURRENT command.

UPDATE WHERE CURRENT

This command can be used to update the current row when the SELECT command associated with the cursor does *not* contain one of the following:

- DISTINCT clause in the select list.
- Aggregate function in the select list.
- FROM clause with more than one table.
- ORDER BY clause.
- GROUP BY clause.

The UPDATE WHERE CURRENT command identifies the active set to be updated by naming the cursor and the column(s) to be updated:

```
UPDATE TableName
   SET ColumnName = ColumnValue [,...]
 WHERE CURRENT OF CursorName
```

Any columns you name in this command must also have been named in a FOR UPDATE clause in the related DECLARE CURSOR command, for example:

```
EXEC SQL DECLARE AdjustQtyOnHand
          CURSOR FOR
          SELECT PartNumber,
                 BinNumber,
                 QtyOnHand,
                 AdjustmentQty
            FROM PurchDB.Inventory
           WHERE QtyOnHand IS NOT NULL
             AND AdjustmentQty IS NOT NULL
   FOR UPDATE OF QtyOnHand,
                 AdjustmentQty;

EXEC SQL OPEN AdjustQtyOnHand;
.
In this case, the output host variables do not need to include
indicator variables, because the SELECT command associated with the
cursor eliminates any rows having null values from the active set.
.
EXEC SQL FETCH  AdjustQtyOnHand
          INTO :PartNumber,
               :BinNumber,
               :QtyOnHand,
               :AdjustmentQty;
.
.
EXEC SQL UPDATE PurchDB.Inventory
            SET QtyOnHand     = :QtyOnHand + :AdjustmentQty,
```

```
        AdjustmentQty = 0
    WHERE CURRENT OF AdjustQtyOnHand;
```

In the previous example, the order of the rows in the query result is not important. Therefore the SELECT command associated with the cursor *AdjustQtyOnHand* does not need to contain an ORDER BY clause and the UPDATE WHERE CURRENT command can be used.

In cases where order *is* important and the ORDER BY clause must be used, you can use the UPDATE command with the WHERE clause to update values in the current row, as well as other rows that qualify for the search condition:

```
EXEC SQL DECLARE Inventory
          CURSOR FOR
          SELECT PartNumber,
                 BinNumber,
                 QtyOnHand,
                 AdjustmentQty
            FROM PurchDB.Inventory
           WHERE CountCycle = :CountCycle
        ORDER BY BinNumber;
.
.
.
EXEC SQL FETCH  Inventory
          INTO :PartNumber,
               :BinNumber,
               :QtyOnHand     :QtyOnHandInd
               :AdjustmentQty :AdjustmentQtyInd;
.
```

The program displays the current row. If the QtyOnHand value is not null, the program prompts the user for an adjustment quantity. Adjustment quantity is the difference between the quantity actually in the bin and the QtyOnHand in the row displayed. If the QtyOnHand value is null, the program prompts the user for both QtyOnHand and AdjustmentQty. Any value entered is used in the following UPDATE command.

```
.
.
EXEC SQL UPDATE PurchDB.Inventory
            SET QtyOnHand =     :QtyOnHand :QtyOnHandInd,
                AdjustmentQty = :AdjustmentQty :AdjustmentQtyInd
          WHERE PartNumber = :PartNumber
            AND BinNumber  = :BinNumber;
```

After either the UPDATE WHERE CURRENT or the UPDATE command is executed, the current row remains the same until the FETCH command is re-executed.

If you want to execute UPDATE commands inside the FETCH loop, remember that more than one row in the active set may qualify for the UPDATE operation, as when the WHERE clause in the the UPDATE command does not specify a unique key. When more than one row qualifies for the UPDATE, you may not see a changed row unless you CLOSE and re-OPEN the cursor. To avoid this problem, either ensure that your UPDATE commands change only one row (the current row) or perform the UPDATE operations outside the FETCH loop.

DELETE WHERE CURRENT

This command can be used to delete the current row when the SELECT command associated with the cursor does *not* contain one of the following:

- DISTINCT clause in the select list.
- Aggregate function in the select list.
- FROM clause with more than one table.
- ORDER BY clause.
- GROUP BY clause.

The DELETE WHERE CURRENT command has a very simple structure:

```
DELETE FROM TableName
      WHERE CURRENT OF CursorName
```

The DELETE WHERE CURRENT command can be used in conjunction with a cursor declared with *or* without the FOR UPDATE clause:

The program displays the current row and asks the user whether to update or delete it. If the user wants to delete the row, the following command is executed.

```
EXEC SQL DELETE FROM PurchDB.Inventory
           WHERE CURRENT OF AdjustQtyOnHand;
```

Even though the SELECT command associated with cursor *Inventory* names only some of the columns in table *PurchDB.Inventory*, the entire current row is deleted.

After the DELETE WHERE CURRENT command is executed, there is no current row. You must re-execute the FETCH command to obtain another current row.

As with the UPDATE WHERE CURRENT command, if the SELECT command associated with the cursor contains an ORDER BY clause or other components listed earlier, you can use the DELETE command with the WHERE clause to delete a row:

```
EXEC SQL DELETE FROM PurchDB.Inventory
                WHERE PartNumber = :PartNumber
                  AND BinNumber  = :BinNumber;
```

If you use the DELETE command to delete a row while using a cursor to examine an active set, remember that more than one row will be deleted if multiple rows satisfy the conditions specified in the WHERE clause of the DELETE command. In addition, the row that is current when the DELETE command is executed remains the current row until the FETCH command is re-executed.

CLOSE

When you no longer want to operate on the active set, you use the CLOSE command:

`CLOSE` *CursorName*

The CLOSE command frees up ALLBASE/SQL internal buffers used to handle cursor operations. This command does *not* release any locks obtained since the cursor was opened; to release locks, you must terminate the transaction with a COMMIT WORK or a ROLLBACK WORK:

The program opens a cursor and operates on the active set. After the last row has been operated on, the cursor is closed.

```
EXEC SQL CLOSE Inventory;
```

Additional SQL commands are executed, then the transaction is terminated.

```
EXEC SQL COMMIT WORK;
```

You also use the CLOSE command when you want to re-access the active set. In this case, simply re-open the cursor after executing the CLOSE command. Because locks have not been released, any changes to the rows in the active set will be those made by your program since the cursor was first opened:

Cursor Inventory is used to update information in table PurchDB.Inventory. After the last row in the active set has been fetched and its information changed, the cursor is closed.

```
EXEC SQL CLOSE Inventory;
```

The cursor is then re-opened to allow the program user to review the information and optionally make last-minute adjustments.

```
EXEC SQL OPEN Inventory;
```

After the user has reviewed all rows in the active set, any changes made to the active set are made permanent as follows.

```
EXEC SQL COMMIT WORK;
```

When a transaction terminates, any cursors opened during that transaction are automatically closed unless you are using the KEEP CURSOR option of the OPEN command. To avoid possible confusion, it is good programming practice to *always* use the CLOSE command followed by COMMIT WORK to explicitly close any open cursors before ending a transaction.

Transaction Management for Cursor Operations

The time at which ALLBASE/SQL obtains locks during cursor processing depends on whether ALLBASE/SQL uses an index scan or a sequential scan to retrieve the query result.

When a cursor is based on a SELECT command for which ALLBASE/SQL can use an *index scan*, locks are obtained when the FETCH command is executed. In the following example, an index scan can be used, because the predicate is optimizable and an index exists on column *OrderNumber*:

```
EXEC SQL DECLARE OrderReview
          CURSOR FOR
          SELECT OrderNumber,
                 ItemNumber,
                 OrderQty,
                 ReceivedQty
            FROM PurchDB.OrderItems
           WHERE OrderNumber = :OrderNumber;
```

When the cursor is based on a SELECT command for which ALLBASE/SQL will use a *sequential* scan, locks are obtained when the OPEN command is executed. A sequential scan would be used in conjunction with the following cursor:

```
EXEC SQL DECLARE OrderReview
          CURSOR FOR
          SELECT OrderNumber,
                 ItemNumber
                 OrderQty,
                 ReceivedQty
            FROM PurchDB.OrderItems
      WHERE OrderNumber > :OrderNumber;
```

The scope and strength of any lock obtained depends in part on the automatic locking mode of the target table(s). If the lock obtained is a *shared* lock, as for PUBLIC or PUBLICREAD tables, ALLBASE/SQL elevates the lock to an *exclusive* lock when you update or delete a row in the active set.

The use of lock types, lock granularities, and isolation levels is discussed in the *ALLBASE/SQL Reference Manual* .

As mentioned in the previous section, when a transaction terminates, any cursors opened during that transaction are either automatically closed, or they remain open if you are using the KEEP CURSOR option of the OPEN command. To avoid possible confusion, it is good programming practice to *always* use the CLOSE command to explicitly close any open cursors before ending a transaction with the COMMIT WORK or ROLLBACK WORK command.

When the transaction terminates, any changes made to the active set during the transaction are either *all committed* or *all rolled back*, depending on how you terminate the transaction.

Using KEEP CURSOR

Cursor operations in an application program let you manipulate data in an *active set* associated with a SELECT command. The cursor is a pointer to a row in the active set. The KEEP CURSOR option of the OPEN command lets you maintain the cursor position in an active set beyond transaction boundaries. This means you can scan and update a large table without holding locks for the duration of the entire scan. You can also design transactions that avoid holding any locks around terminal reads. In general, use the KEEP CURSOR option when you wish to release locks periodically in long or complicated transactions.

After you specify KEEP CURSOR in an OPEN command, a COMMIT WORK does not close the cursor, as it normally does. Instead, COMMIT WORK releases locks not associated with the kept cursor and begins a new transaction without changing the current cursor position. This makes it possible to update tuples in a large active set, releasing locks as the cursor moves from page to page, instead of requiring you to reopen and manually reposition the cursor before the next FETCH.

Locks held on the page of data corresponding to the current cursor position are either held until the transaction ends (the default) or released depending on whether you specify WITH LOCKS or WITH NOLOCKS. (Pages held include data and system pages.)

KEEP CURSOR and Isolation Levels

The KEEP CURSOR option retains the current isolation level (RR, CS, or RC) that you have specified in the BEGIN WORK command. Moreover, the exact pattern of lock retention and release for cursors opened using KEEP CURSOR WITH LOCKS depends on the current isolation level. With the READ COMMITTED isolation level, no locks are maintained across transactions because locks are released at the end of the FETCH. Therefore, KEEP CURSOR WITH LOCKS does not make sense at a RC isolation level.

For additional information on isolation levels, refer to the chapter "Concurrency Control through Locks and Isolation Levels" in the *ALLBASE/SQL Reference Manual* .

OPEN Command Without KEEP CURSOR

Figure 6-1 shows the operation of cursors when you do *not* select the KEEP CURSOR option.

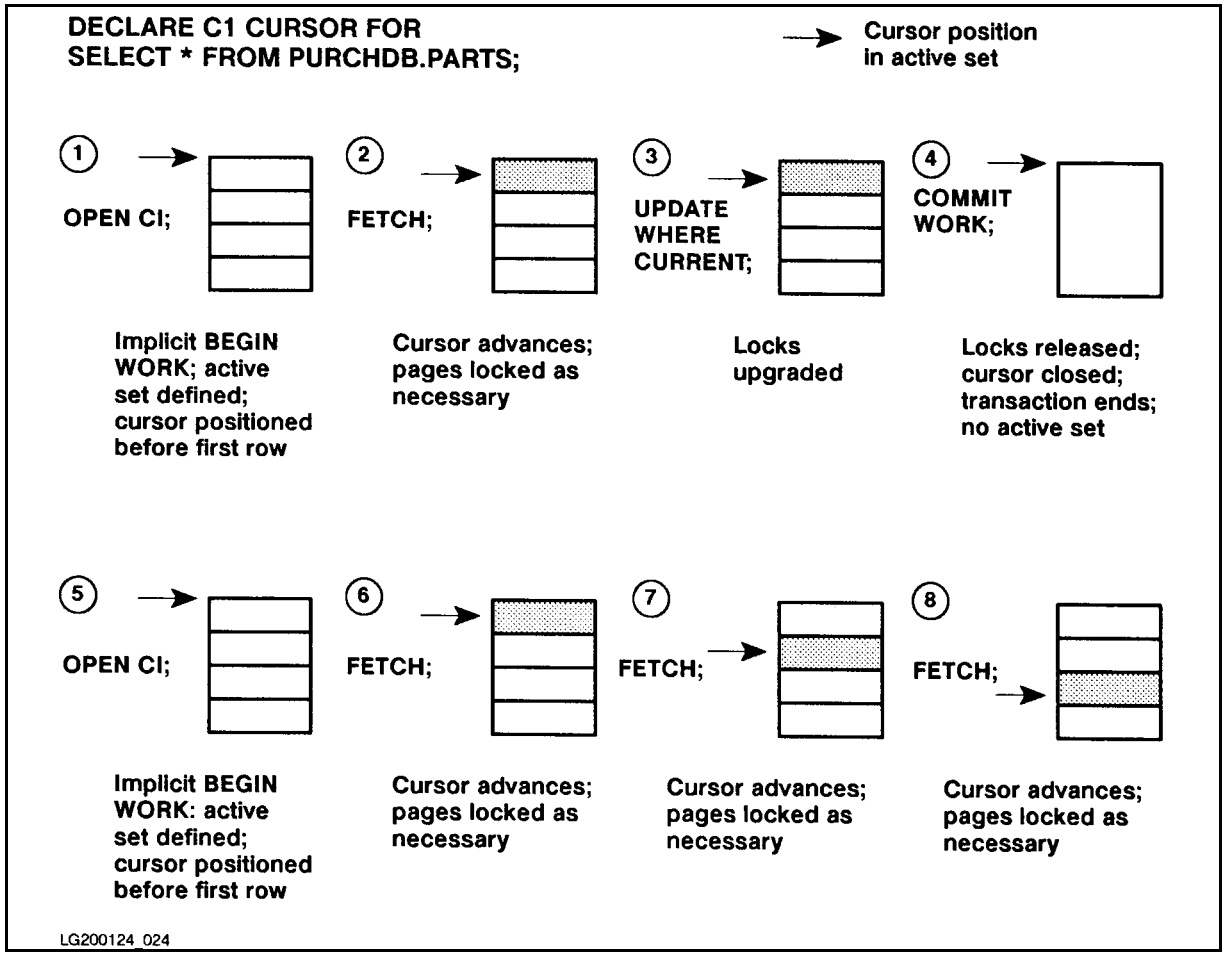


Figure 6-1. Cursor Operation without the KEEP CURSOR Feature

After the cursor is opened, successive FETCH commands advance the cursor position. Any exclusive locks acquired along the way are retained until the transaction ends. If you have selected the Cursor Stability option in the BEGIN WORK command, shared locks on pages that have not been updated are released when the cursor moves to a tuple on a new data page. Exclusive locks are not released until a COMMIT WORK, which also closes the cursor.

OPEN Command Using KEEP CURSOR WITH LOCKS and CS Isolation Level

The feature has the following effects:

- A COMMIT WORK command does not close the cursor. Instead, it ends the current transaction and immediately starts another one.
- When you issue a COMMIT WORK, locks accociated with the cursor are not released.
- Successive FETCHES advance the cursor position, which is retained in between transactions until the cursor is explicitly closed with the CLOSE command.
- After the CLOSE command, you use an additional COMMIT WORK command. This step is *essential*. The final COMMIT after the CLOSE is necessary to end the KEEP state, release all locks associated with the cursor, and prevent a new implicit BEGIN WORK.

Figure 6-2 shows the effect of the KEEP CURSOR WITH LOCKS.

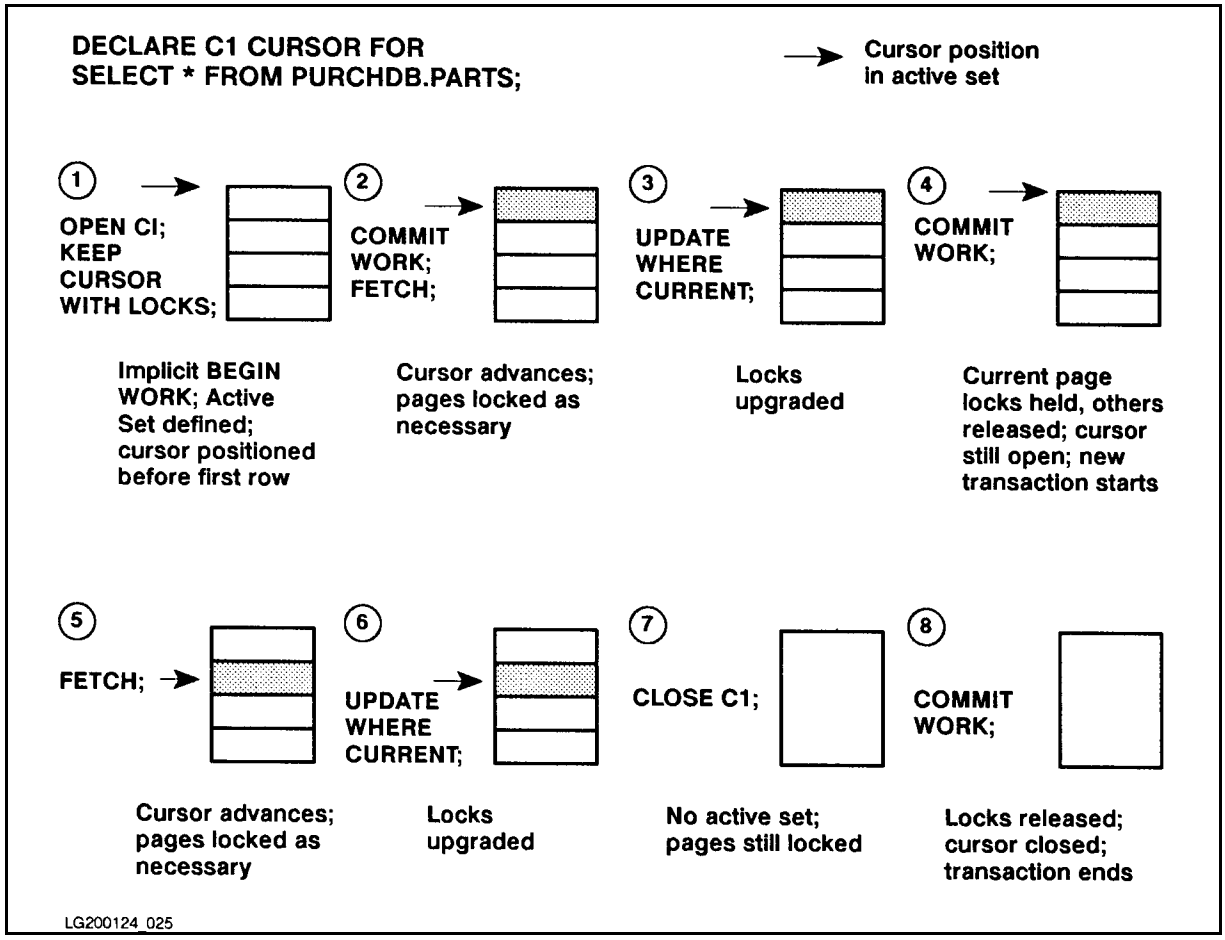


Figure 6-2. Cursor Operation Using KEEP CURSOR WITH LOCKS

OPEN Command Using KEEP CURSOR WITH NOLOCKS

The feature has the following effects:

- A COMMIT WORK command does not close the cursor. Instead, it ends the current transaction and immediately starts another one.
- When you issue a COMMIT WORK, all locks associated with the cursor position are released. This means that another transaction may delete or modify the next tuple in the active set before you have the chance to FETCH it.
- Successive FETCHES advance the cursor position, which is retained in between transactions until the cursor is explicitly closed with the CLOSE command.
- After the CLOSE command, you use an additional COMMIT WORK command. This step is *essential*. The final COMMIT after the CLOSE is necessary to end the KEEP state and prevent a new implicit BEGIN WORK.
- You cannot use the KEEP CURSOR option WITH NOLOCKS for a cursor declared as a SELECT with a DISTINCT or ORDER BY clause.
- When using KEEP CURSOR WITH NOLOCKS, be aware that data at the cursor position may be lost before the next FETCH:

- If another transaction deletes the current row, ALLBASE/SQL will return the next row. No error message is displayed.
- If another transaction deletes the table being accessed, the user will see the message `TABLE NOT FOUND (DBERR 137)`.

Figure 6-3 shows the effect of KEEP CURSOR WITH NOLOCKS.

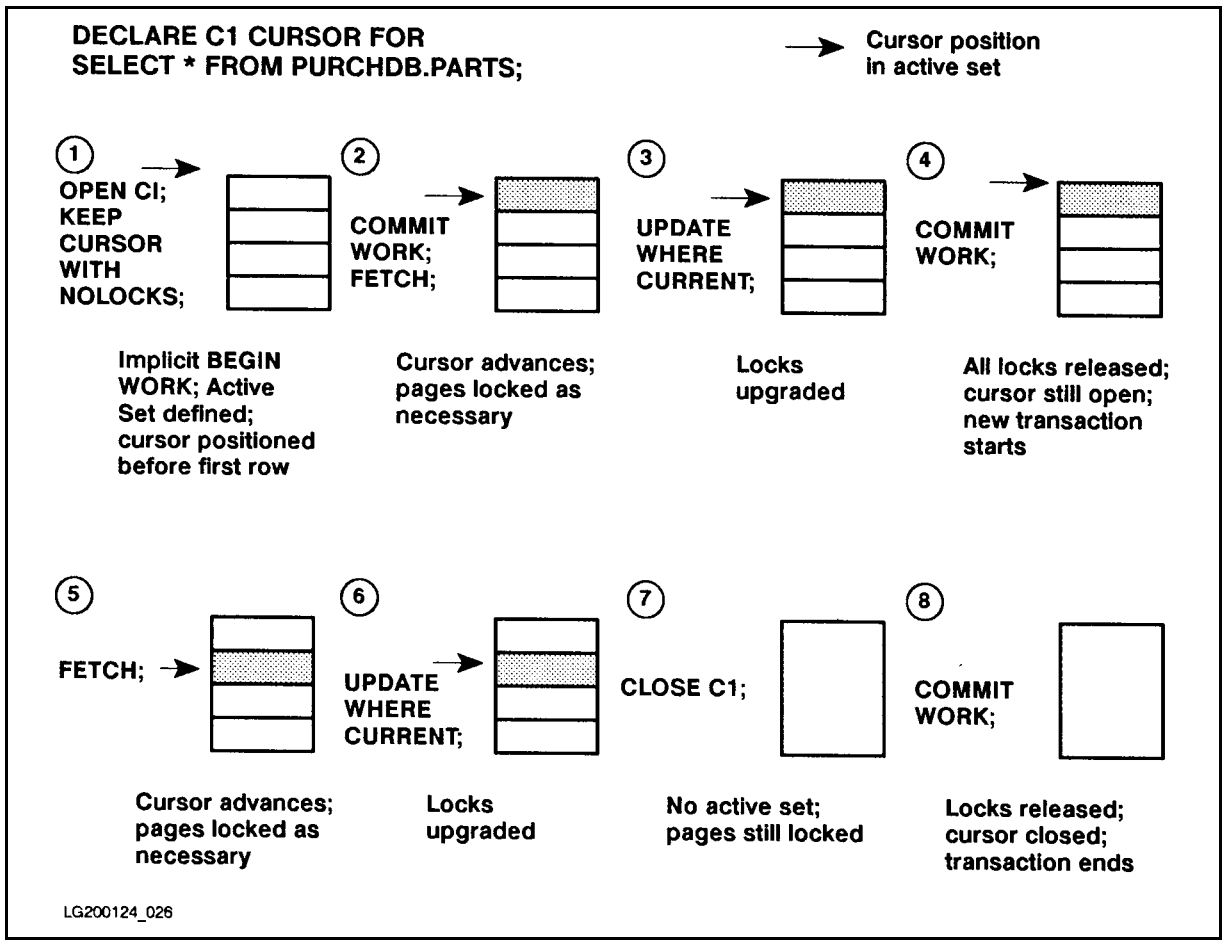


Figure 6-3. Cursor Operation Using KEEP CURSOR WITH NOLOCKS

KEEP CURSOR and BEGIN WORK

- ALLBASE/SQL automatically begins a transaction whenever you issue a command if a transaction is not already in progress. Thus, although you can code an explicit BEGIN WORK to start transactions, it is not necessary to do so unless you wish to specify an isolation level other than RR.
- With KEEP CURSOR, an implicit BEGIN WORK follows immediately after you perform a COMMIT WORK, so if you do an explicit BEGIN WORK, ALLBASE/SQL returns an error message stating that a transaction is already in progress. If this problem should arise, re-code to eliminate the BEGIN WORK from the loop.

KEEP CURSOR and COMMIT WORK

- When the KEEP CURSOR option of the OPEN command is activated for a cursor, COMMIT WORK may or may not release locks associated with the cursor depending on the setting of the WITH LOCKS/WITH NOLOCKS option.
- COMMIT WORK does not close cursors opened with the KEEP CURSOR option. COMMIT WORK does end the previous implicit transaction and starts an implicit transaction with the same isolation level as that specified with the BEGIN WORK command.
- Remember that COMMIT WORK will still close all cursors opened *without* the KEEP CURSOR option.

KEEP CURSOR and ROLLBACK WORK

- When the KEEP CURSOR option is activated for an opened cursor, all locks are released when you ROLLBACK WORK, whether or not you have specified WITH LOCKS or WITH NOLOCKS. The position of the cursor is restored to what it was at the beginning of the transaction being rolled back. The current transaction is ended and a new transaction is implicitly started with the same isolation level as specified in the BEGIN WORK command.
- Remember that ROLLBACK WORK closes all cursors that you opened during the current transaction, unless the cursor was opened with the KEEP CURSOR option and its position was saved with a COMMIT WORK command immediately following the OPEN command.
- When a cursor is opened with the KEEP CURSOR option, ROLLBACK WORK TO *SavePoint* is not allowed.

KEEP CURSOR and Aborted Transactions

- When a transaction is aborted by ALLBASE/SQL, the cursor position is retained, and a new transaction begins, as with ROLLBACK WORK.
- Remember that when a transaction aborts all cursors that you opened during the current transaction are closed, unless the cursor was opened with the KEEP CURSOR option and its position was saved with a COMMIT WORK command immediately following the OPEN command.
- The use of multiple cursors may require frequent examination of several system catalog tables. This means acquiring exclusive locks, which creates the potential for deadlock. However, the behavior of aborted transactions with KEEP CURSOR lets you create automatic deadlock handling routines. Simply repeat the operation until deadlock does not occur. The technique is shown under "Examples," below.

Writing Keep Cursor Applications

Because of the potential for deadlock, you must be careful to test for that condition frequently in applications using KEEP CURSOR. Use the following steps to create your code:

1. Declare all cursors to be used in the application.
2. Use a loop to test for a deadlock condition as you open all cursors that will use the KEEP CURSOR option. Start the loop with a BEGIN WORK statement that specifies the isolation level, then include a separate test for non-deadlock errors for each OPEN

statement. Create an *SQLStatusCheck* routine to display all error messages and RELEASE the DBEnvironment in the event of fatal errors. See the "Examples" section below.

3. Use the COMMIT WORK command. If you do not COMMIT at this point, an aborted transaction will roll back all the OPEN statements, and you will lose the cursor positions. The COMMIT starts a new transaction and keeps the cursor positions.
4. Use a loop to scan your data until all rows have been processed.
   - First, open any non-kept cursors. Do *not* include a COMMIT WORK after opening the non-kept cursors. If a deadlock is detected at this point, the transaction will automatically be reapplied.
   - Next, execute any FETCH, UPDATE WHERE CURRENT, or DELETE WHERE CURRENT commands. Be sure to test for unexpected errors and branch to *SQLStatusCheck* to display messages and RELEASE in the event of a non-deadlock error. In the event of deadlock, the transaction will automatically be reapplied.
   - At the end of the loop, include a COMMIT WORK. This will commit your data to the database, and it will close any non-kept cursors opened so far in the program. It will also start a new transaction and maintain the cursor position of all kept cursors.
   - Place any terminal or file I/O *after this COMMIT*, in order to prevent duplicate messages from appearing in the event of a rollback because of deadlock.
5. Once the program is finished scanning the tables, you should close all kept cursors within a final loop which tests for a deadlock condition. Once again, test for unexpected errors and branch to *SQLStatusCheck* if necessary.
6. Execute a final COMMIT WORK to release the KEEP state.

Figure 6-4 is a skeleton outline of a KEEP CURSOR application showing the sections outlined above. Specific examples follow in the next section.

```
/*   First, Declare all your Kept and Non-Kept Cursors   */ (1)

do {                              /* Open Kept Cursors */
    EXEC SQL BEGIN WORK [RR/CS/RC];
  /* Open Kept Cursors in a Loop  */
}while (!DeadLockFree);                                    (2)

EXEC SQL COMMIT WORK; /* COMMIT to Save Cursor Positions */ (3)

do {
  /* Open any Non-Kept Cursors */

  /* Execute SQL Commands, i.e., FETCH, UPDATE, etc */

     if (DeadLockFree)
        {
          EXEC SQL COMMIT WORK; /* Save Cursor Positions */
     /* Write any messages or output to file or terminal */
        };
}while (!EndofScan);                                       (4)

do {

/*    Close all Cursors Opened with KEEP CURSOR Option   */

}while (!DeadlockFree);                                    (5)

EXEC SQL COMMIT WORK;  /* Final COMMIT to end KEEP state */ (6)
```

Figure 6-4. Keep Cursor Application Program

Examples

This code is intended as a guide; you will want to customize it for your specific needs.

The code illustrates status checking techniques with emphasis on deadlock detection. Four generalized code segments are presented:

- A status checking routine to be used in conjunction with the other code segments.
- Using a single kept cursor with locks.
- Using multiple cursors and cursor stability.
- Avoiding locks on terminal reads.

Common StatusCheck Procedure

```
SQLStatusCheck ()
{
   /*************************************************************/
   /*  Deadlock occurred:  Set DeadLockFree to FALSE            */
   /*************************************************************/

   if (sqlca.sqlcode = -14024) {
      DeadLockFree = FALSE;

   /*************************************************************/
   /* If your program monopolizes CPU time by repeatedly        */
   /* reapplying a transaction, you could include a call        */
   /* to the XL PAUSE intrinsic at this point.                  */
   /*************************************************************/

   }

   /*************************************************************/
   /* Fatal Error: Show Messages, Release DBE, and terminate    */
   /*************************************************************/

   else if (sqlca.sqlcode < 0) {
      do {
         EXEC SQL SQLEXPLAIN :SQLMessage;
         printf(SQLMessage);
      } while (sqlca.sqlcode != 0);

      EXEC SQL RELEASE;
   }

   /*************************************************************/
   /* On fatal errors, halt program to avoid an endless loop    */
   /*************************************************************/

   halt ();

   /*************************************************************/
   /* No More Rows Found:  Set EndofScan to TRUE                */
   /*************************************************************/

   if (sqlca.sqlcode = 100)
      EndofScan = TRUE;
}  /* SQLStatusCheck function */
```

Single Cursor WITH LOCKS

```
SQLSingleCursor ()
{
   /*************************************************************/
   /*           First, declare the cursor:                      */
   /*************************************************************/

   EXEC SQL DECLARE C1 CURSOR FOR SELECT PartName,
               FROM PurchDB.Parts WHERE SalesPrice > 500.00;

   /*************************************************************/
   /*  Next, open the cursor using KEEP CURSOR WITH LOCKS option: */
   /*************************************************************/

   do {
      DeadLockFree = TRUE;
      EXEC SQL OPEN C1 KEEP CURSOR WITH LOCKS;
      if (sqlca.sqlcode != 0)
         SQLStatusCheck ();
   } while (!DeadLockFree);

   /*************************************************************/
   /*       COMMIT WORK in order to preserve the cursor position  */
   /*************************************************************/

   EXEC SQL COMMIT WORK;
   if (sqlca.sqlcode != 0)
      SQLStatusCheck ();

   /*************************************************************/
   /*    Execute BULK FETCH option until there is no deadlock     */
   /*************************************************************/

   EndofScan = FALSE;
   while (! EndofScan) {
      do {
         DeadlockFree = TRUE;
         EXEC SQL BULK FETCH C1 INTO :PriceList, 1, 20;
         if (sqlca.sqlcode != 0)
            SQLStatusCheck ();
         else {
            EXEC SQL COMMIT WORK;
            if (sqlca.sqlcode != 0)
               SQLStatusCheck ();
         }
      } while (!DeadLockFree);
```

```
   /*********************************************************/
   /*  Display qualified rows.  SQLERRD[3] contains the     */
   /*  number of qualified rows.                            */
   /*********************************************************/

      printf ("\n Part Name               Sales Price\n");
      for (i = 0; i < sqlca.sqlerrd[2]; i++)
         printf("%s       %10.2f",PriceList[i].PartName,PriceList[i].SalesPrice);

   } /* WHILE not EndofScan */
   /*************************************************************/
   /*      Execute the CLOSE command until no deadlock occurs     */
   /*************************************************************/

   do {
      EXEC SQL CLOSE C1;
      if (sqlca.sqlcode != 0)
         SQLStatusCheck();
   } while (!DeadLockFree);

   EXEC SQL COMMIT WORK;
   if (sqlca.sqlcode != 0)
      SQLStatusCheck();

}  /* SQLSingleCursor function */
```

Multiple Cursors and Cursor Stability

```
SQLMultiCursor ()
{
   /*************************************************************/
   /*           First, declare your cursors:                    */
   /*************************************************************/

   EXEC SQL DECLARE C1 CURSOR FOR SELECT BranchNo FROM Tellers
             WHERE TellerNo > 15000 FOR UPDATE OF Status;

   EXEC SQL DECLARE C2 CURSOR FOR SELECT BranchNo FROM Branches
             FOR UPDATE OF Credit;

   /*************************************************************/
   /* Next, Open cursor C1. Use explicit BEGIN WORK in do while loop. */
   /* loop to make sure ALLBASE/SQL will use the CS isolation level  */
   /* in case the program runs into a deadlock condition.            */
   /*************************************************************/

   do {
      DeadLockFree = TRUE;
      EXEC SQL BEGIN WORK CS;
      if (sqlca.sqlcode != 0)
         SQLStatusCheck();
      else {
         EXEC SQL OPEN C1 KEEP CURSOR WITH LOCKS;
         if (sqlca.sqlcode != 0)
            SQLStatusCheck();
      }
   } while (!DeadLockFree);

   /*************************************************************/
   /*   COMMIT WORK in order to preserve the cursor position      */
   /*************************************************************/

   EXEC SQL COMMIT WORK;
   if (sqlca.sqlcode != 0)
      SQLStatusCheck();

   /*************************************************************/
   /*  Initialize EndofScan to FALSE for the outer and inner loops */
   /*************************************************************/

   EndofScan = FALSE;
   while (! EndofScan) {
```

```
   /*********************************************************/
   /*   The following do while loop is executed once per    */
   /*   deadlock.  We FETCH again using Cursor C1, reopen   */
   /*   Cursor C2, then start to fetch rows using C2.       */
   /*   Note that there is a deadlock, and when the         */
   /*   transaction is aborted, Cursor                      */
   /*   C2 is closed and Cursor C1 returns to the beginning */
   /*   of the transaction.  Any work done by the current   */
   /*   transaction on the database is undone. This provides */
   /*   a method of reapplying the transaction when a       */
   /*   deadlock at any point rolls it back.                */
   /*********************************************************/

   do {
      DeadLockFree = TRUE;
      EXEC SQL FETCH C1 INTO :HostBranchNo1;
      if (sqlca.sqlcode != 0)
         SQLStatusCheck();
      else /*  1  */ {
         EXEC SQL OPEN C2;
         if (sqlca.sqlcode != 0)
            SQLStatusCheck();
         else /*  2  */ {
            while ((! EndofScan) && DeadLockFree) {
               EXEC SQL FETCH C2 INTO :HostBranchNo2;
               if (sqlca.sqlcode != 0)
                  SQLStatusCheck();
               else /*  3  */ {
               if (HostBranchNo1 == HostBranchNo2) {

/*********************************************************/
/*   Update the Branches table.  Note:  You might wish   */
/*   to include a DateUpdated column in the Branches     */
/*   table that can be updated with a timestamp every    */
/*   time the Credit column is updated.  Then, in case   */
/*   the program terminates abnormally, you will know    */
/*   which values in the Credit column were updated      */
/*   before termination.                                 */
/*********************************************************/

                  EXEC SQL UPDATE Branches
                           SET Credit = Credit*0.005
                           WHERE CURRENT OF C2;
                  if (sqlca.sqlcode != 0)
                     SQLStatusCheck();
               }  /* if HostBranchNo1 */
            }  /* else 3 */
         }  /* inner while not EndofScan clause */
```

```
                if (EndofScan) {
                   EndofScan = FALSE;
                   EXEC SQL CLOSE C2;
                   if (sqlca.sqlcode != 0)
                      SQLStatusCheck();
                      else  /*  4  */ {
                         EXEC SQL UPDATE TELLERS SET Status = :NewStatus
                                   WHERE CURRENT OF C1;
                         if (sqlca.sqlcode != 0)
                            SQLStatusCheck();
                         else  /*  5  */ {

      /*********************************************************/
      /*  Changes are committed and a new transaction begins.  */
      /*  Cursor C1 still open; locks associated with the page  */
      /*  pointed to by the cursor are kept.  All locks for C2  */
      /*  are released when the transaction is committed        */
      /*********************************************************/

                            EXEC SQL COMMIT WORK;
                            if (sqlca.sqlcode != 0)
                              SQLStatusCheck();
                         }  /* else 5 */
                      }  /* else 4 */
                }  /* if EndofScan */
             }  /* else 2 */
          }  /* else 1 */
       } while (!DeadLockFree);
    }  /* outer while not EndofScan clause */

    /*************************************************************/
    /*   Repeat the CLOSE command until no deadlock is found:    */
    /*************************************************************/

    do {
       EXEC SQL CLOSE C1;
       if (sqlca.sqlcode != 0)
          SQLStatusCheck();
    } while (!DeadLockFree);

    /*************************************************************/
    /*   Final COMMIT WORK:  current transaction ends, and no new  */
    /*   transaction begins.  THIS STEP IS ABSOLUTELY ESSENTIAL    */
    /*   TO END THE KEEP STATE!                                    */
    /*************************************************************/

    EXEC SQL COMMIT WORK;
    if (sqlca.sqlcode != 0)
       SQLStatusCheck();

  } /* SQLMultiCursor  function */
```

Avoiding Locks on Terminal Reads

```
SQLNoTermLock ()
{
   /*************************************************************/
   /*           First, declare the cursor:                      */
   /*************************************************************/
   EXEC SQL DECLARE C1 Cursor FOR
            SELECT PartNumber, SalesPrice FROM PurchDB.Parts;

   /*************************************************************/
   /* Execute the OPEN command until there is no deadlock:      */
   /*************************************************************/
   do {
      DeadLockFree = TRUE;
      EXEC SQL OPEN C1 KEEP CURSOR WITH NOLOCKS;
      if (sqlca.sqlcode != 0)
         SQLStatusCheck;
   } while (!DeadLockFree);

   /*************************************************************/
   /* COMMIT WORK to preserve the cursor position:              */
   /*************************************************************/
   EXEC SQL COMMIT WORK;
   if (sqlca.sqlcode != 0)
      SQLStatusCheck;

   /*************************************************************/
   /* Now FETCH a row from the active set until EndofScan       */
   /*************************************************************/
   while (! EndofScan) {
      do {
         DeadLockFree = TRUE;
         EXEC SQL FETCH C1 INTO :PartNumber, :PresentSalesPrice;
         if (sqlca.sqlcode != 0)
            SQLStatusCheck();
         else {
            EXEC SQL COMMIT WORK;
            if (sqlca.sqlcode != 0)
               SQLStatusCheck();
         }
      } while (!DeadLockFree);

      /*********************************************************/
      /* Display the present price and prompt for a new one:   */
      /*********************************************************/

      printf("\n Part Number:         %d", PartNumber);
      printf("\n Current Sales Price: %10.2f", PresentSalesPrice);
      scanf ("\n Enter New Sales Price: %10.2f", NewSalesPrice);
```

```
      /*********************************************************/
      /* Verify that the value of PresentSalesPrice has not    */
      /* changed.  If not, update with NewSalesPrice           */
      /*********************************************************/

      do {
         DeadLockFree = TRUE;
         EXEC SQL SELECT SalesPrice INTO :SalesPrice FROM PurchDB.Parts
         WHERE PartNumber = :PartNumber;
         if (sqlca.sqlcode < 0)
            SQLStatusCheck();
         if (sqlca.sqlcode = 100)
            printf("\n Part Number no longer in database. Not updated.")
         else {
            if (SalesPrice == PresentSalesPrice) {
               EXEC SQL UPDATE PurchDB.Parts
               SET SalesPrice = :NewSalesPrice
               WHERE PartNumber = :PartNumber;
               if (sqlca.sqlcode != 0)
                  SQLStatusCheck();
            }
            else printf("\n Current price has changed. Not updated.");
         }
      } while (!DeadLockFree);

   }  /* while not EndofScan  */

   /*************************************************************/
   /*  Execute the CLOSE command until there is no deadlock:    */
   /*************************************************************/

   do {
      EXEC SQL CLOSE C1;
      if (sqlca.sqlcode != 0)
         SQLStatusCheck();
   } while (!DeadLockFree);

   /*************************************************************/
   /*   Final COMMIT WORK:  current transaction ends, and no new   */
   /*   transaction begins.  THIS STEP IS ABSOLUTELY ESSENTIAL     */
   /*   TO END THE KEEP STATE!                                     */
   /*************************************************************/

   EXEC SQL COMMIT WORK;
   if (sqlca.sqlcode != 0)
      SQLStatusCheck();

}  /* SQLNoTermLock function */
```

Sample Program Using Cursor Operations

The flow chart in Figure 6-5 summarizes the functionality of program cex8. This program uses a cursor and the UPDATE WHERE CURRENT command to update column *ReceivedQty* in table *PurchDB.OrderItems*. The runtime dialog for cex8 appears in Figure 6-6, and the source code in Figure 6-7.

The program first executes function *DeclareCursor* (26), which contains the DECLARE CURSOR command (7). This command is a preprocessor directive and is not executed at run time. At run time, function *DeclareCursor* only displays the message Declare the Cursor. The DECLARE CURSOR command defines a cursor named *OrderReview*. The cursor is associated with a SELECT command that retrieves the following columns for all rows in table *PurchDB.OrderItems* having a specific order number but no null values in column *VendPartNumber*:

```
OrderNumber (defined NOT NULL)
ItemNumber  (defined NOT NULL)
VendPartNumber
ReceivedQty
```

Cursor *OrderReview* has a FOR UPDATE clause naming column *ReceivedQty* to allow the user to change the value in this column.

To establish a DBE session, program cex8 executes function *ConnectDBE* (27). This function evaluates to TRUE when the CONNECT command (1) for the sample DBEnvironment, *PartsDBE*, is successfully executed.

The program then executes function *FetchUpdate* until the *Done* flag is set to TRUE (28).

Function *FetchUpdate* prompts for an order number or a zero (17). When the user enters a zero, function FetchUpdate ends and the main program prompts the user to indicate whether another OrderNumber should be FETCHed. When the user enters an order number, the program begins a transaction by executing function *BeginTransaction* (18), which executes the BEGIN WORK command (3).

Cursor *OrderReview* is then opened by invoking function *OpenCursor* (19). This function, which executes the OPEN command (8), evaluates to TRUE when the command is successful.

A row at a time is retrieved and optionally updated until the *DoFetch* flag is set to FALSE (20). This flag becomes false when:

- the FETCH command fails. This command fails when no rows qualify for the active set, when the last row has already been fetched, or when ALLBASE/SQL cannot execute this command for some other reason.
- the program user wants to stop reviewing rows from the active set.

The FETCH command (21) names an indicator variable for *ReceivedQty*, the only column in the query result that may contain a null value. If the FETCH command is successful, the program executes function *DisplayUpdate* (22) to display the current row and optionally update it.

Function *DisplayUpdate* executes function *DisplayRow* (10) to display the current row (6). If column *ReceivedQty* in the current row contains a null value, the message *ReceivedQty is NULL* is displayed.

Function *DisplayUpdate* then prompts whether the user wants to update the current *ReceivedQty* value (11). If so, the user is prompted for a new value. The value accepted is used in an UPDATE WHERE CURRENT command (12). If the user entered a zero, a null value is assigned to this column.

The program then prompts whether to FETCH another row (13). If so, the FETCH command is re-executed. If not, the program prompts the user whether to make permanent any updates that may have made made to the active set (14). To keep any row changes, the program executes function *EndTransaction* (16) which executes the COMMIT WORK command (4). To undo any row changes, the program executes function *RollBack* (15), which executes the ROLLBACK WORK command (5).

The COMMIT WORK command is also executed when ALLBASE/SQL sets sqlca.sqlcode to 100 following execution of the FETCH command (23). Sqlca.sqlcode is set to 100 when no rows qualify for the active set or when the last row has already been fetched. If the FETCH command fails for some other reason, the ROLLBACK WORK command is executed instead (24).

Before any COMMIT WORK or ROLLBACK WORK command is executed, cursor *OrderReview* is closed (9). Although the cursor is automatically closed whenever a transaction is terminated, it is good programming practice to use the CLOSE command to close open cursors prior to terminating transactions.

When the program user enters an N in response to the main program's prompt to FETCH another order number, the program terminates by executing function *ReleaseDBE* (29), which executes the RELEASE command (2).

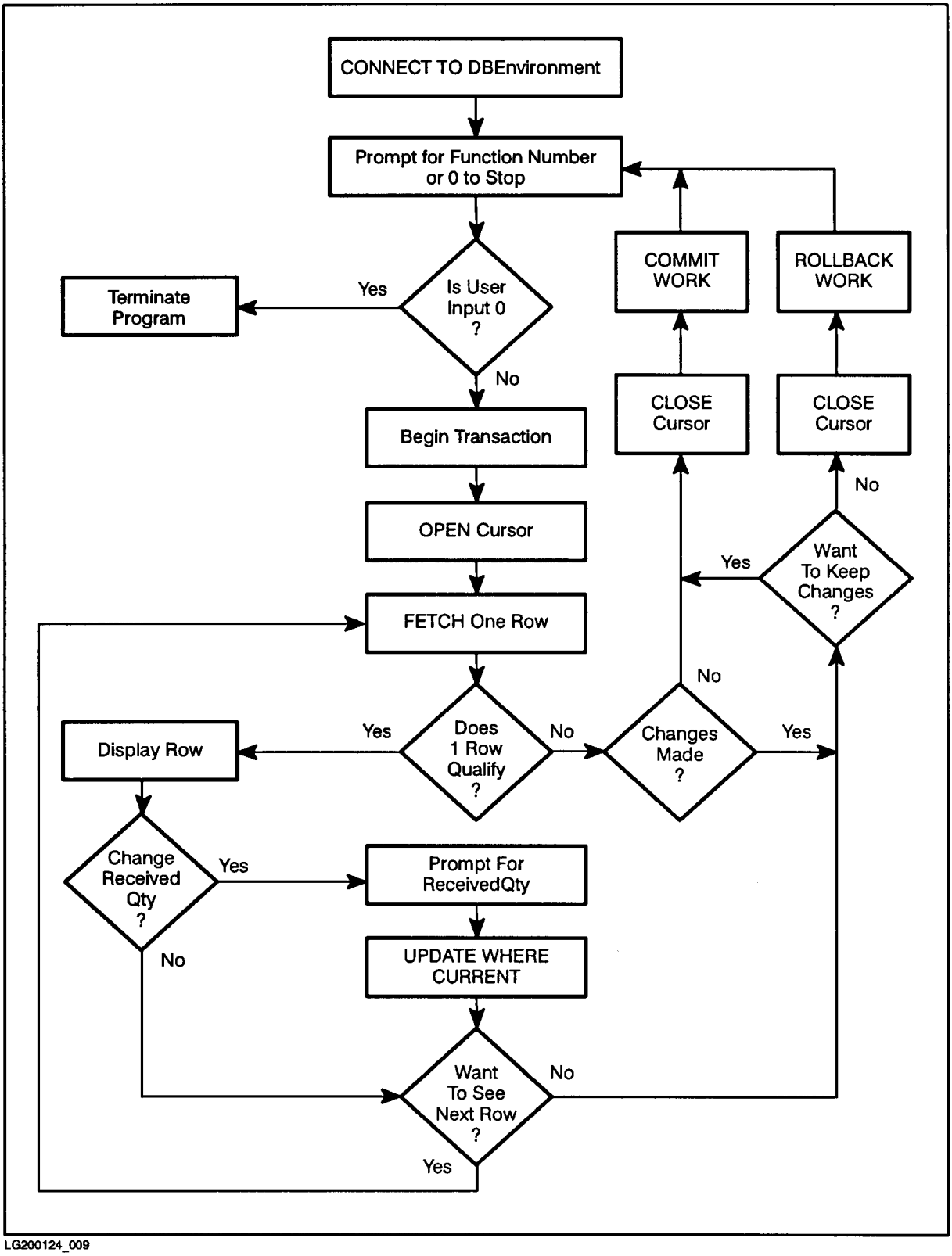


Figure 6-5. Flow Chart of Program cex8

```
Program to UPDATE OrderItems Table via a CURSOR - cex8
Event List:
  CONNECT TO PartsDBE
  Prompt for Order Number
  BEGIN WORK
  OPEN CURSOR
  FETCH a row
  Display the retrieved row
  Prompt for new Received Quantity
  UPDATE row within OrderItems table
  FETCH the next row, if any, with the same Order Number
  Repeat the above five steps until there are no more rows
  CLOSE CURSOR
  End Transaction
  Repeat the above eleven steps until user enters 0
  RELEASE the DBEnvironment

Connect to PartsDBE

Declare Cursor

Enter OrderNumber or 0 to STOP >  30520

Begin Work

Open the Cursor

Fetch the next row.
  Order Number:             30520
  Item Number:                  1
  Vendor Part Number:  9375
  Received Quantity:       9

Do you want to change ReceivedQty (Y/N)? >  n

Do you want to see another row (Y/N)? >  y

Fetch the next row.
  Order Number:             30520
  Item Number:                  2
  Vendor Part Number:  9105
  Received Quantity:       3

Do you want to change ReceivedQty (Y/N)? >  y

Enter New ReceivedQty or 0 for NULL >  15
```

Figure 6-6. Runtime Dialog of Program cex8

```
Update the PurchDB.OrderItems table

Do you want to see another row (Y/N)? >  y

Fetch the next row.
  Order Number:             30520
  Item Number:                  3
  Vendor Part Number:  9135
  Received Quantity:       3

Do you want to change ReceivedQty (Y/N)? >  n

Do you want to see another row (Y/N)? >  y

Fetch the next row.

Row not found or no more rows!

Do you want to save your changes (Y/N)? > y

Close the Cursor

Commit Work
1 rows changed!
Do you want to FETCH another OrderNumber (Y/N)? >  y

Enter an OrderNumber or a 0 to STOP >  30510

Begin Work

Open the Cursor

Fetch the next row.
  Order Number:             30510
  Item Number:                  1
  Vendor Part Number:  1001
  Received Quantity:       3

Do you want to change ReceivedQty (Y/N)? >  n

Do you want to see another row (Y/N)? >  n

Close Cursor

Commit Work
Do you want to FETCH another OrderNumber (Y/N)? >  n
Release PartsDBE
```

Figure 6-6. Runtime Dialog of Program cex8 (page 2 of 2)

```
/* Program cex8 */

/* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * */
/* This program illustrates the use of SQL's UPDATE WHERE          */
/* CURRENT command using a cursor to update a single row           */
/* at a time.                                                      */
/* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * */

typedef int boolean;

boolean     Abort;
boolean     Done;
boolean     DoFetch;
char        response[2];
int         RowCounter;

#include <stdio.h>

#define    OK                0
#define    NotFound        100
#define    MultipleRows  -10002
#define    DeadLock      -14024
#define    FALSE             0
#define    TRUE              1

sqlca_type sqlca;    /* SQL Communication Area */

          /* Begin Host Variable Declarations */
    EXEC SQL BEGIN DECLARE SECTION;
    int       OrderNumber;
    int       ItemNumber;
    char      VendPartNumber[17];
    int       ReceivedQty;
    sqlind    ReceivedQtyInd;
    char      SQLMessage[133];
    EXEC SQL END DECLARE SECTION;
          /* End Host Variable Declarations */
```

Figure 6-7. Program cex8: Using UPDATE WHERE CURRENT

```
int SQLStatusCheck()  /* Function to Display Error Messages */
{
Abort = FALSE;
if (sqlca.sqlcode < DeadLock) Abort = TRUE;

do {
EXEC SQL SQLEXPLAIN :SQLMessage;
printf("\n");
printf("%s\n",SQLMessage);
} while (sqlca.sqlcode != 0);

if (Abort) {

  ReleaseDBE();
  }

}  /* End SQLStatusCheck Function */

boolean ConnectDBE()  /* Function to Connect to PartsDBE */
                                                              (27)
{
boolean ConnectDBE;
printf("\n Connect to PartsDBE");
EXEC SQL CONNECT TO 'PartsDBE';                               (1)

ConnectDBE = TRUE;
if (sqlca.sqlcode != OK) {
  ConnectDBE = FALSE;
  SQLStatusCheck();
  }  /* End if */
return (ConnectDBE);
}  /* End of ConnectDBE Function */


int ReleaseDBE()   /* Function to Release PartsDBE */
                                                              (29)
{
printf("\n Release PartsDBE");
printf("\n");
EXEC SQL RELEASE;                                             (2)

Done = TRUE;
if (sqlca.sqlcode != OK) SQLStatusCheck();

}  /* End ReleaseDBE Function */
```

Figure 6-7. Program cex8: Using UPDATE WHERE CURRENT (page 2 of 8)

```
boolean BeginTransaction()    /* Function to Begin Work */        (18)
{
boolean BeginTransaction;
printf("\n");
printf("\n Begin Work");

EXEC SQL BEGIN WORK;                                              (3)

if (sqlca.sqlcode != OK)  {
  SQLStatusCheck();
  ReleaseDBE();
  }

}  /* End BeginTransaction Function */


int EndTransaction()  /* Function to Commit Work */               (16)
{
printf("\n");
printf("\n Commit Work");
EXEC SQL COMMIT WORK;                                             (4)
if (sqlca.sqlcode != OK) {
  SQLStatusCheck();
  ReleaseDBE();
  }

}  /* End EndTransaction Function */


int RollBack()     /* Function to RollBack work */                (15)
{
printf("\n");
printf("\n RollBack Work");
EXEC SQL ROLLBACK WORK;                                           (5)
if (sqlca.sqlcode != OK) {
  SQLStatusCheck();
  ReleaseDBE();
  }

}  /* End of RollBack Function */
```

Figure 6-7. Program cex8: Using UPDATE WHERE CURRENT (page 3 of 8)

```
int DisplayRow()   /* Function to Display Parts Table Rows */    10
{
  printf("\n");
  printf("Order Number:              %10d\n", OrderNumber);        6
  printf("Item Number:               %10d\n", ItemNumber);
  printf("Vendor Part Number:        %s\n", VendPartNumber);

  if (ReceivedQtyInd != 0)
    printf("Received Quantity:         is NULL \n");
  else
    printf("Received Quantity:         %5d\n", ReceivedQty);

}  /* End of DisplayRow */


int DeclareCursor()  /* Function to Declare the Cursor */         26
{
printf("\n");
printf("\n Declare the Cursor");
EXEC SQL DECLARE OrderReview                                      7
          CURSOR FOR
          SELECT OrderNumber,
                 ItemNumber,
                 VendPartNumber,
                 ReceivedQty
            FROM PurchDB.OrderItems
           WHERE OrderNumber = :OrderNumber
             AND VendPartNumber IS NOT NULL
   FOR UPDATE OF ReceivedQty;
}  /* End DeclareCursor Function */

boolean OpenCursor()  /* Function to Open the Declared Cursor */
                                                                  19
{
boolean OpenCursor;
OpenCursor = TRUE;

printf("\n");
printf("\n Open the Cursor");
EXEC SQL OPEN OrderReview;                                        8
if (sqlca.sqlcode != OK) {
  OpenCursor = FALSE;
  SQLStatusCheck();
  RollBack();
  }
return(OpenCursor);
}  /* End of OpenCursor Function */
```

Figure 6-7. Program cex8: Using UPDATE WHERE CURRENT (page 4 of 8)

```
int CloseCursor()  /* Function to Close the Declared Cursor */
{
printf("\n");
printf("\n Close the Cursor");
EXEC SQL CLOSE OrderReview;
if (sqlca.sqlcode != OK) {
  SQLStatusCheck();
  EndTransaction();
  }

}  /* End of CloseCursor Function */


int DisplayUpdate() /* Display & Update row in OrderItems Table*/
{                                                                    22
DisplayRow();                                                        10
printf("\n");

printf("\n Do you want to change ReceivedQty (Y/N)? > ");           11
scanf("%s",response);
if ((response[0] == 'Y') || (response[0] == 'y')) {
  printf("\n");
  printf("\n Enter new ReceivedQty or a 0 for NULL > ");
  scanf("%d5",&ReceivedQty);
  if (ReceivedQty == 0)
    ReceivedQtyInd = -1;
  else
    ReceivedQtyInd = 0;

  printf("\n UPDATE the PurchDB.OrderItems table");
  EXEC SQL UPDATE PurchDB.OrderItems                                 12
              SET ReceivedQty = :ReceivedQty :ReceivedQtyInd
            WHERE CURRENT OF OrderReview;

  if (sqlca.sqlcode != OK)
    SQLStatusCheck();
  else
    RowCounter = RowCounter + 1;
  }

printf("\n");
printf("\n Do you want to see another row (Y/N)? > ");              13
scanf("%s",response);
if ((response[0] == 'N') || (response[0] == 'n')) {
  if (RowCounter > 0) {
    printf("\n");
   printf("\n Do you want to save the changes you made (Y/N)?>");
    scanf("%s",response);                                            14
```

Figure 6-7. Program cex8: Using UPDATE WHERE CURRENT (page 5 of 8)

```
      if ((response[0] == 'N') || (response[0] == 'n')) {
        CloseCursor();
        RollBack();                                                    15
        DoFetch = FALSE;
        }
      else {
        CloseCursor();
        EndTransaction();                                              16
        printf(RowCounter,"  %d\n rows were changed!");
        DoFetch = FALSE;
        }
      }
    if (RowCounter == 0) {
      CloseCursor();
      EndTransaction();
      DoFetch = FALSE;
      }
    }

}  /* End DisplayUpdate Function */


int FetchUpdate()    /* Fetch a row to Update within OrderItems */
{                                                                      28
printf("\n");
printf("\n Enter an OrderNumber or a 0 to STOP > ");                    17
scanf("%d",&OrderNumber);
RowCounter = 0;
if (OrderNumber != 0) {
  BeginTransaction();                                                  18
  if (OpenCursor()) {                                                  19
    DoFetch = TRUE;
    do {
    printf("\n");
    printf("\n FETCH the next row.");

    EXEC SQL FETCH  OrderReview                                        21
              INTO :OrderNumber,
                   :ItemNumber,
                   :VendPartNumber,
                   :ReceivedQty :ReceivedQtyInd;
```

Figure 6-7. Program cex8: Using UPDATE WHERE CURRENT (page 6 of 8)

```
     switch(sqlca.sqlcode) {

     case  OK:       DisplayUpdate();                                  (22)
                     break;
     case  NotFound: DoFetch = FALSE;                                  (20)
                     printf("\n");
                     printf("\n Row not found or no more rows!");
                     if (RowCounter > 0) {
                       printf("\n");
              printf("\n Do you want to save your changes (Y/N)?>");
                       scanf("%s",response);
                       if ((response[0] == 'N') || (response[0] == 'n')) {
                         CloseCursor();                                (9)
                         RollBack();
                         }
                       else {
                         CloseCursor();                                (9)
                         EndTransaction();                             (23)
                         printf(RowCounter,"%d\n rows were changed!");
                         }
                       }
                     if (RowCounter == 0) {
                       CloseCursor();                                  (9)
                       EndTransaction();                               (23)
                       }
                     break;
      default:       DoFetch = FALSE;                                  (20)
                     SQLStatusCheck();
                     CloseCursor();                                    (9)
                     RollBack();                                       (24)
                     break;
       }  /* End switch */

} while (DoFetch != FALSE);  /* End do */

}  /* End if open */

}  /* End if OrderNumber */

}  /* End of FetchUpdate Function */
```

Figure 6-7. Program cex8: Using UPDATE WHERE CURRENT (page 7 of 8)

```
main()          /* Beginning of program */
{
printf("\n Program to UPDATE the OrderItems table via a CURSOR - cex8");
printf("\n");
printf("\n Event list:");
printf("\n   CONNECT TO PartsDBE");
printf("\n   Prompt for an Order Number");
printf("\n   BEGIN WORK");
printf("\n   OPEN CURSOR");
printf("\n   FETCH a row");
printf("\n   Display the retrieved row");
printf("\n   Prompt for new Received Quantity");
printf("\n   UPDATE row within the OrderItems table");
printf("\n   FETCH the next row, if any, with the same Order Number");
printf("\n   Repeat the above five steps until there are no more rows");
printf("\n   CLOSE CURSOR");
printf("\n   End Transaction");
printf("\n   Repeat the above eleven steps until the user enters a 0");
printf("\n   RELEASE the DBEnvironment");
printf("\n");

if (ConnectDBE()) {                                                    (27)

DeclareCursor();                                                       (26)

  Done = FALSE;
  do {
      FetchUpdate();                                                   (28)
   printf("\n Do you want to FETCH another OrderNumber (Y/N)?>");
      scanf("%s",response);
      if ((response[0] == 'N') || (response[0] == 'n')) Done = TRUE;
      } while (Done != TRUE);

  ReleaseDBE();                                                        (29)
}
else
  printf("\n Error: Cannot Connect to PartsDBE!\n");

}  /* End of Program */
```

Figure 6-7. Program cex8: Using UPDATE WHERE CURRENT (page 8 of 8)

7

BULK Table Processing

BULK table processing is the programming technique you use to SELECT, FETCH, or INSERT *multiple rows at a time*. This chapter describes the following aspects of BULK processing:

- Variables Used in BULK Processing.
- SQL BULK Commands.
- Transaction Management for BULK Operations.
- Sample Program Using BULK Processing.

Variables Used in BULK Processing

Rows are retrieved into or inserted from host variables declared as an array of records. Any column that may contain a null value *must* have an indicator variable immediately following the declaration for the column in the array:

```
struct StructName {
    data type           Column1Name;
    data type           Column2Name;
    sqlind               Col2IndVar;
    .
    .
    .
    data type           ColumnnName;
    sqlind               ColnIndVar;
    } ArrayName[n];
```

You reference the name of the array in the BULK SQL command:

```
EXEC SQL BEGIN DECLARE SECTION;
struct {
   char             PartNumber[17];
   char             PartName[31];
   sqlind           PartNameInd;
   } PartsArray[26];
double              SalesPrice;
EXEC SQL END DECLARE SECTION;
.
.
.
EXEC SQL BULK SELECT  PartNumber, PartName
                INTO :PartsArray
                FROM  PurchDB.Parts
               WHERE  SalesPrice < :SalesPrice;
```

Two additional host variables may be specified in conjunction with the array:

- A *StartIndex* variable: a SMALLINT or INTEGER variable that specifies an array subscript. The subscript identifies where in the array ALLBASE/SQL should store the first row in a group of rows retrieved. In the case of an INSERT operation, the subscript identifies where in the array the first row to be inserted is stored. If not specified, the assumed subscript is zero.
- A *NumberOfRows* variable: a SMALLINT or INTEGER variable that indicates to ALLBASE/SQL how many rows to transfer into or take from the array, starting at the array record designated by StartIndex. If not specified, the default number of rows is the number of records in the array from the StartIndex to the end of the array for an INSERT operation. For a retrieval operation, the default number of rows is the smaller of two values; 1) the number of records in the array from the StartIndex to the end of the array, or 2) the number of rows in the query result. NumberOfRows can be specified only if you specify the StartIndex variable.

In the BULK SELECT example shown earlier, these two variables would be declared and referenced as follows:

```
EXEC SQL BEGIN DECLARE SECTION;
struct {
   char             PartNumber[17];
   char             PartName[31];
   sqlind           PartNameInd;
   } PartsArray[26];
short int           StartIndex ;
short int           NumberOfRows ;
double              SalesPrice;
EXEC SQL END DECLARE SECTION;
.
.
.
EXEC SQL BULK SELECT  PartNumber, PartName
                INTO :PartsArray,
                     :StartIndex,
                     :NumberOfRows
                FROM  PurchDB.Parts
               WHERE  SalesPrice < :SalesPrice;
```

Note StartIndex and NumberOfRows must be referenced in that order and immediately following the array reference.

SQL Bulk Commands

The SQL commands used for BULK table processing are:

```
BULK SELECT
BULK FETCH
BULK INSERT
```

BULK SELECT

The BULK SELECT command is useful when the maximum number of rows in the query result is known at programming time and when the query result is not too large. For example, this command might be used in an application that retrieves a query result containing a row for each month of the year.

The form of the BULK SELECT command is:

```
BULK SELECT SelectList
       INTO ArrayName [,StartIndex [,NumberOfRows]]
       FROM TableNames
      WHERE SearchCondition1
   GROUP BY ColumnName
     HAVING SearchCondition2
   ORDER BY ColumnID
```

Remember, the WHERE, GROUP BY, HAVING, and ORDER BY clauses are optional. Note that the order of the select list items *must match* the order of the corresponding host variables in the array.

In the following example, parts are counted at one of three frequencies or cycles: 30, 60, or 90 days. The host variable array needs to contain only three records, since the query result will never exceed three rows.

```
EXEC SQL BEGIN DECLARE SECTION;
struct {
    short int             CountCycle;
    int                   PartCount;
    } PartsPerCycle[3];
EXEC SQL END DECLARE SECTION;
.
.
.
EXEC SQL BULK SELECT  CountCycle, COUNT(PartNumber)
                INTO :PartsPerCycle
                FROM  PurchDB.Inventory;
```

The query result is a three-row table that describes how many parts are counted per count cycle.

Multiple query results can be retrieved into the same host variable array by using StartIndex and NumberOfRows values and executing a BULK SELECT command multiple times:

```
.
.
```

```
.
EXEC SQL BEGIN DECLARE SECTION;
struct {
    short int             CountCycle;
    int                   PartCount;
    } PartsPerCycle[15];
short int                 StartIndex;
short int                 NumberOfRows;
char                      LowBinNumber[16];
char                      HighBinNumber[16];
EXEC SQL END DECLARE SECTION;
.
.
.
int DisplayRows()
{
int   i;

for (i = 0; i < StartIndex; i++) {
  printf("CountCycle:  %d\n", PartsPerCycle[i].CountCycle);
  printf("PartCount:   %d\n", PartsPerCycle[i].PartCount);
  }  /* end for */
}  /* end of procedure DisplayRows */
.
.
.
main()
{

#define   TRUE   1
#define   FALSE  0

typedef   int   boolean;

int       StartIndex;
int       NumberOfRows;
boolean   LessThanFive;

/*  Initialize variables.  */

StartIndex = 1;
NumberOfRows = 3;
LessThanFive = TRUE;

  do {
```

The user is prompted for a range of bin numbers or a 0. If bin numbers are entered, they are used in a BETWEEN predicate in the BULK SELECT command. This WHILE loop can be executed as many as five times, at which time the array would be filled.

```
  printf("\n Enter a low bin number or 0 to STOP > ");
  scanf("%d",LowBinNumber);

  if (LowBinNumber != 0) {
    printf("\n Enter a high bin number > ");
    scanf("%d\n",HighBinNumber);

    EXEC SQL BULK SELECT  CountCycle, COUNT(PartNumber)
                   INTO :PartsPerCycle,
                        :StartIndex,
                        :NumberOfRows
                   FROM  PurchDB.Inventory
                  WHERE  BinNumber
                BETWEEN :LowBinNumber AND :HighBinNumber;

    StartIndex = StartIndex + 3;
    if (StartIndex == 15) LessThanFive = FALSE;

    }  /* if LowBinNumber */
    else
      LessThanFive = FALSE;
  } while (LessThanFive == TRUE);
```

The final StartIndex value is used to display the final contents of the host variable array.

```
if (StartIndex > 0) {
  DisplayRows();
  }

}
```

The following example illustrates the use of sqlca.sqlerrd[2] to display rows stored in the host variable array. It also checks sqlca.sqlcode in conjunction with sqlca.sqlerrd[2], to determine whether or not the BULK SELECT executed without error and whether there may be additional qualified rows for which there was not room in the array. In each case, an appropriate message is displayed.

```
int DisplayRows()
{
int   i;

for (i = 0; i < sqlca.sqlerrd[2]; i++) {
  printf("OrderNumber:   %s\n", OrdersArray[i].OrderNumber);
  printf("VendorNumber:  %s\n", OrdersArray[i].VendorNumber);
  }
}     (* end of procedure DisplayRows *)
.
.
.
```

The variable MaximumRows is set to the number of records in the host variable array.

```
Main()
{
.
.
.
MaximumRows = 25;
.
.
.
EXEC SQL BULK SELECT  OrderNumber, VendorNumber
                INTO :OrdersArray
                FROM  PurchDB.Orders;

switch (sqlca.sqlcode) {
  case 0:     if (sqlca.sqlerrd[2] == MaximumRows) {
                 printf("\n There may be additional rows ");
                 printf("\n that cannot be displayed.");
                  }
              DisplayRows();
              break;
  case 100:   printf("\n No rows were found!");
              break;
  default:    if (sqlca.sqlerrd[2] > 0) {
                 printf("\n The following rows were retrieved ");
                 printf("\n before an error occurred:");
                 }
              DisplayRows();
              SQLStatusCheck();
              break;
  } /* End switch */
  .
  .
  .
  }
```

BULK FETCH

The BULK FETCH command is useful for reporting applications that operate on large query results or query results whose maximum size is unknown at programming time.

The form of the BULK FETCH command is:

```
BULK FETCH CursorName
      INTO ArrayName [,StartIndex [,NumberOfRows]]
```

You use this command in conjunction with the following cursor commands:

- DECLARE CURSOR: defines a cursor and associates with it a query. The cursor declaration should not contain a FOR UPDATE clause because the BULK FETCH command is designed to be used for active set *retrieval* only. The order of the select list items in the embedded SELECT command must match the order of the corresponding host variables in the host variable array.
- OPEN: opens the cursor.
- BULK FETCH: delivers rows into the host variable array and advances the cursor to the last row delivered. If a single execution of this command does not retrieve the entire active set, you re-execute it to retrieve subsequent rows in the active set.
- CLOSE: releases ALLBASE/SQL internal buffers used to handle cursor operations.

To retrieve all the rows in an active set larger than the host variable array, you can test for a value of 100 in sqlca.sqlcode to determine when you have fetched the last row in the active set:

```
.
.
int DisplayRows()
{
int   i;

for (i = 0; i < sqlca.sqlerrd[2]; i++) {

The values in each row returned by the BULK FETCH command are displayed here.
       }
if (sqlca.sqlcode != 0) {
  printf("\n Do you want to see additional rows? (yes/no) > ");
  scanf("%s", Response);
  if ((Response[0] == 'N') || (Response[0] == 'n')) {
    DoFetch = FALSE;
    }
}    (* end of DisplayRows procedure *)
.
.
main()
{
EXEC SQL BEGIN DECLARE SECTION;
struct {
    char              PartNumber[17];
    char              VendorName[31];
```

```
    short int         DeliveryDays;
    sqlind            DeliveryDaysInd;
    } SupplierBuffer[20];
EXEC SQL END DECLARE SECTION;
typedef int boolean;
boolean               DoFetch;
char                  Response[2];
#define  TRUE    1
#define  FALSE   0
.
.
EXEC SQL DECLARE SupplierInfo
          CURSOR FOR
          SELECT PartNumber,
                 VendorName,
                 DeliveryDays
            FROM PurchDB.Vendors,
                 PurchDB.SupplyPrice
           WHERE PurchDB.Vendors.VendorNumber =
                 PurchDB.SupplyPrice.VendorNumber
        ORDER BY PartNumber;

EXEC SQL OPEN SupplierInfo;

DoFetch = TRUE;
do {
  EXEC SQL BULK FETCH SupplierInfo
                 INTO :SupplierBuffer;

  switch (sqlca.sqlcode) {
    case 0:      DisplayRows();
                 break;
    case 100:    printf("\n No rows were found!");
                 DoFetch = FALSE;
                 break;
    default:     DisplayRows();
                 SQLStatusCheck();
                 DoFetch = FALSE;
                 break;
                 }   /* End switch */

    } while (DoFetch != TRUE);

EXEC SQL CLOSE SupplierInfo;
```

After the BULK FETCH command is executed, the last row ALLBASE/SQL put into the host variable array is the current row. If the BULK FETCH command is re-executed, the first row in the next set of rows fetched is the row following the current row, and the last

row fetched becomes the current row. When the last row in the active set has been fetched, ALLBASE/SQL sets sqlca.sqlcode to 100 the next time the BULK FETCH command is executed.

BULK INSERT

The BULK INSERT command is useful for multiple-row insert operations.

The form of the BULK INSERT command is:

```
BULK INSERT INTO   TableName
                  (ColumnNames)
           VALUES (ArrayName [,StartIndex [,NumberOfRows]]
```

As in the case of the simple INSERT command, you can omit *ColumnNames* when you provide values for all columns in the target table. ALLBASE/SQL attempts to assign a null value to any unnamed column.

In the following example, a user is prompted for multiple rows. When the host variable array is full and/or when the user is finished specifying values, the BULK INSERT command is executed:

```
EXEC SQL BEGIN DECLARE SECTION;
struct {
    char                PartNumber[17];
    char                PartName[31];
    sqlind              PartNameInd;
    double              SalesPrice;
    sqlind              SalesPriceInd;
    } NewParts[20];
short int               StartIndex;
short int               NumberOfRows;
EXEC SQL END DECLARE SECTION;

typedef int boolean;
boolean                 DoneEntry;
char                    Response[2];

#define       TRUE      1
#define       FALSE     0

StartIndex = 1;
NumberOfRows = 0;
DoneEntry = FALSE;

do {
  PartEntry();
  } while (DoneEntry != TRUE);
.
.
int BulkInsert()
{
```

```
EXEC SQL BULK INSERT INTO   PurchDB.Parts
                           (PartNumber,
                            PartName,
                            SalesPrice)
                  VALUES (:NewParts,
                          :StartIndex,
                          :NumberOfRows);
.
.
}    /* End of function BulkInsert */
int PartEntry()
{
.
.
```

The user is prompted for three column values, and the values are assigned to the appropriate record in the host variable array; then the array row counter (NumberOfRows) is incremented and the user asked whether s/he wants to specify another line item.

```
.
.
NumberOfRows = NumberOfRows + 1;
printf("\n Do you want to specify another line item (Y/N)? > ");
scanf("%s",Response);

if ((Response[0] == 'N') || (Response[0] == 'n')) {
  DoneEntry = TRUE;
  BulkInsert();
  }
else {
  if (NumberOfRows == 20) {
    BulkInsert();
    NumberOfRows = 0;
    }
  }   /* End else */
.
.
}     /* End of PartEntry Function */
```

Transaction Management for BULK Operations

Bulk processing, by using only one ALLBASE/SQL command to operate on multiple rows, provides a way of minimizing the time page or table locks are held. Locks are only held while moving rows between database tables and an array defined by the program, and operations can be done while holding data in that array without holding locks against the database.

Because the BULK FETCH command may need to be executed several times before an entire active set is retrieved, locks obtained to execute this command may be held longer than locks needed to execute the other BULK commands. Therefore this command is most useful for applications running when multi-user DBEnvironment access is minimal or when concurrent transactions do not need to update the table that is the target of the BULK FETCH.

Transaction management is further discussed in the *ALLBASE/SQL Reference Manual* .

Sample Program Using BULK Processing

The flow chart in Figure 7-1 summarizes the functionality of program cex9. This program creates orders in the sample DBEnvironment, PartsDBE. Each order is placed with a specific vendor, to obtain one or more parts supplied by that vendor.

An order consists of a row in table PurchDB.Orders, which comprises the order header:

```
OrderNumber (defined NOT NULL)
VendorNumber
OrderDate
```

An order usually consists of one or more line items, represented by one or more rows in the table PurchDB.OrderItems:

```
OrderNumber (defined NOT NULL)
ItemNumber (defined NOT NULL)
VendPartNumber
PurchasePrice (defined NOT NULL)
OrderQty
ItemDueDate
ReceivedQty
```

Program cex9 uses a simple INSERT command to create the order header and, optionally, a BULK INSERT command to insert line items.

The runtime dialog for program cex9 appears in Figure 7-2, and the source code in Figure 7-3.

To establish a DBE session (54), cex9 executes function *ConnectDBE*. This function evaluates to TRUE when the CONNECT command (5) is successfully executed.

The program then executes function *CreateOrder* until the *Done* flag is set to TRUE (55).

Function *CreateOrder* prompts for a vendor number or a zero (0) to stop the program (48). When the user enters a zero, *Done* is set to TRUE (53) and the program terminates. When the user enters a vendor number, program cex9:

- Validates the number entered.
- Creates an order header if the vendor number is valid.
- optionally inserts line items if the order header has been successfully created; the part number for each line item is validated to ensure the vendor actually supplies the part.
- Displays the order created.

To validate the vendor number, function *ValidateVendor* is executed (49). Function *ValidateVendor* starts a transaction by invoking function *BeginTransaction* (9), which executes the BEGIN WORK command (6). Then a SELECT command (10) is processed to determine whether the vendor number exists in column *VendorNumber* of table *PurchDB.Vendors*:

- If the number exists in table *PurchDB.Vendors*, the vendor number is valid. Flag *VendorOK* is set to TRUE, and the transaction is terminated by invoking function *EndTransaction* (11). *EndTransaction* executes the COMMIT WORK command (7).
- If the vendor number is not found, COMMIT WORK is executed and a message is displayed to inform the user that the number entered is invalid (12). Several flags are set to FALSE

so that when control returns to function *CreateOrder*, the user is again prompted for a vendor number.

- If the SELECT command fails, function *SQLStatusCheck* is invoked (13) to display any error messages (4). Then the COMMIT WORK command is executed, and the appropriate flags set to FALSE.

If the vendor number is valid, program cex9 invokes function *CreateHeader* to create the order header (50). The order header consists of a row containing the vendor number entered, plus two values computed by the program: *OrderNumber* and *OrderDate*.

Function *CreateHeader* starts a transaction (34), then obtains an exclusive lock on table *PurchDB.Orders* (35). Exclusive access to this table ensures that when the row is inserted, no row having the same number will have been inserted by another transaction. The unique index that exists on column *OrderNumber* prevents duplicate order numbers in table *PurchDB.Orders*. Therefore an INSERT operation fails if it attempts to insert a row having an order number with a value already in column *OrderNumber*.

In this case, the exclusive lock does not threaten concurrency. No operations conducted between the time the lock is obtained and the time it is released involve operator intervention:

- Function *CreateHeader* invokes function *ComputeOrderNumber* (36) to compute the order number and the order date.
- Function *ComputeOrderNumber* executes a SELECT command to retrieve the highest order number in *PurchDB.Orders* (30). The number retrieved is incremented by one (31) to assign a number to the order.
- Function *ComputeOrderNumber* then executes function *SystemDate* (32). This function calls the MPE XL system library nl_ctime (2) to retrieve and format the current date. The date retrieved is converted into YYYYMMDD format, the format in which dates are stored in the sample DBEnvironment.
- Function *ComputeOrderNumber* then executes function *InsertRow* (33). This function executes a simple INSERT command (22) to insert a row into *PurchDB.Orders*. If the INSERT command succeeds, the transaction is terminated with a COMMIT WORK command, and the *HeaderOK* flag is set to TRUE (24). If the INSERT command fails, the transaction is terminated with a COMMIT WORK command, but the *HeaderOK* flag is set to FALSE (23) so that the user is prompted for another vendor number when control returns to function *CreateOrder*.

To create line items, function *CreateOrder* executes function *CreateOrderItems* until the *DoneItems* flag is set to TRUE (51). Function *CreateOrderItems* prompts for whether the user wants to specify line items (44).

If the user wants to create line items, function *CreateOrderItems* executes function *ItemEntry* until the *DoneItems* flag is set to TRUE (46), then executes function *BulkInsert* (47):

- Function *ItemEntry* assigns values to the host variable structure array *OrderItems* (1); each record in the array corresponds to one line item, or row in *PurchDB.OrderItems*. The function first assigns the order number and a line number to each row (37), beginning at one. *ItemEntry* then prompts for a vendor part number (38), which is validated by invoking function *ValidatePart* (39).

Function ValidatePart starts a transaction (14). Then it executes a SELECT command (15) to determine whether the part number entered matches any part number known to be supplied by the vendor. If the part number is valid, the COMMIT WORK command is executed (16) and the *PartOK* flag set to TRUE. If the part number is invalid, COMMIT WORK is executed (17), and the user informed that the vendor does not supply any part having the number specified; then the *PartOK* flag is set to FALSE so that the user is prompted for another part number when control returns to function *ItemEntry*.

If the part number is valid, function *ItemEntry* completes the line item. It prompts for values to assign to columns *PurchasePrice*, *OrderQty*, and *ItemDueDate* (40). The function then assigns a negative value to the indicator variable for column *ReceivedQty* (41) in preparation for inserting a null value into this column.

Function ItemEntry terminates when the user indicates that the user does not want to specify any more line items (42) or when the host variable array is full (43).

- Function *BulkInsert* starts a transaction (25), then executes the BULK INSERT command (27). The line items in array *OrderItems* are inserted into table *PurchDB.OrderItems*, starting with the first record and continuing for as many records as there were line items specified (26). If the BULK INSERT command succeeds, the COMMIT WORK command is executed (29) and the *ItemsOK* flag set to TRUE. If the BULK INSERT command fails, function *RollBackWork* is executed (28) to process the ROLLBACK WORK command (8) so that any rows inserted prior to the failure are rolled back.

If the user does not want to create line items, function *CreateOrderItems* displays the order header by invoking function *DisplayHeader* (45). Function *DisplayHeader* displays the row (18) that was created earlier in function CreateHeader (50) and inserted into *PurchDB.Orders* in the function InsertRow (33).

If line items were successfully inserted into the *PurchDB.OrderItems* table in function BulkInsert, then function CreateOrder invokes function *DisplayOrder* (52) to display the order created. Function *DisplayOrder* invokes function *DisplayHeader* (20) to display the order header. Then it executes function *DisplayItems* (21) to display each row inserted into the *PurchDB.OrderItems* table. Function *DisplayItems* displays values from the structure array *OrderItems* (19).

When the program user enters a 0 in response to the vendor number prompt in function CreateOrder, *Done* is set to TRUE (53) and the program terminates by executing function *ReleaseDBE* (56), which executes the RELEASE command (3).

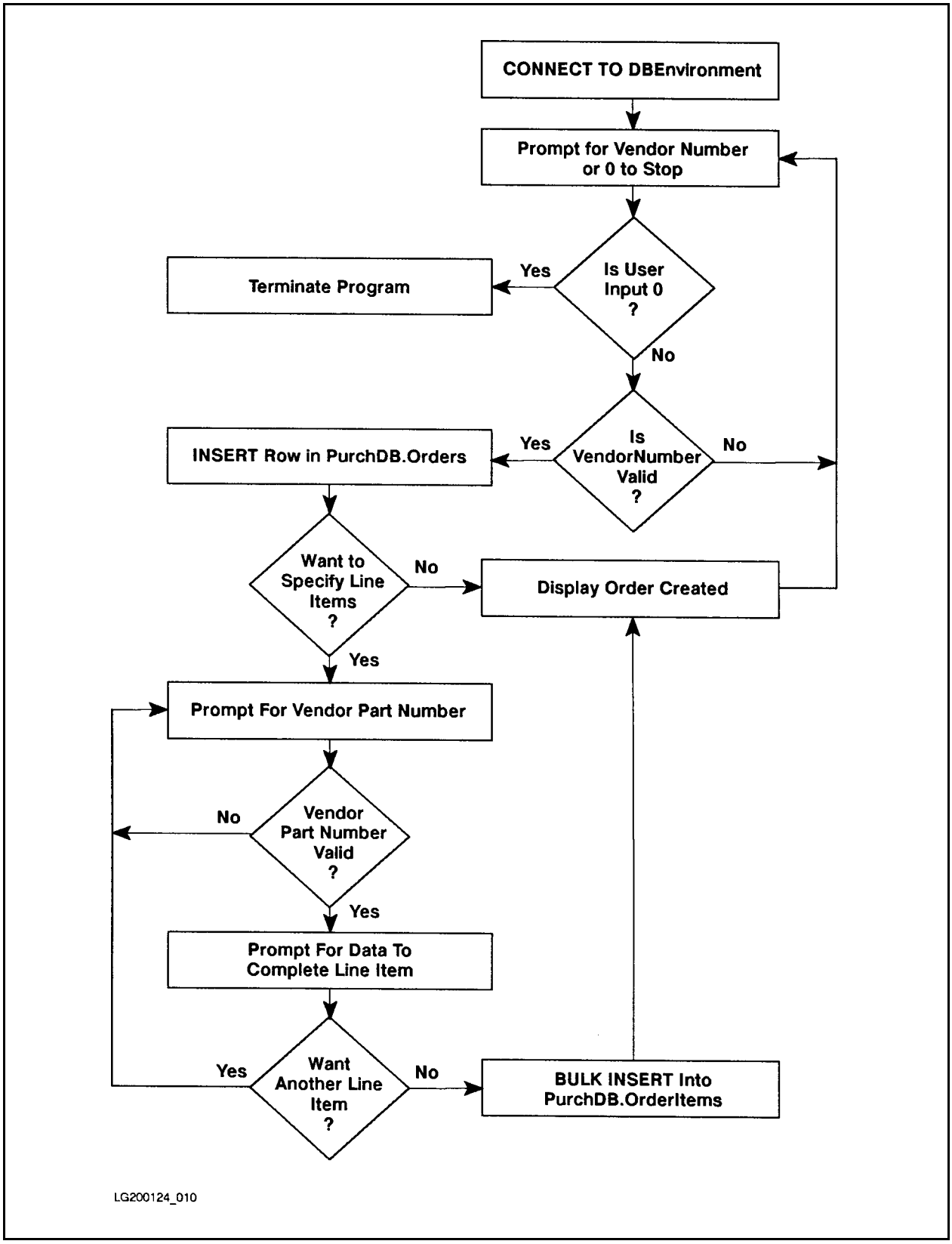


Figure 7-1. Flow Chart of Program cex9

```
Program to Create an Order - cex9

Event List:
  CONNECT TO PartsDBE
  Prompt for VendorNumber
  Validate VendorNumber
  BEGIN WORK
  INSERT a row into PurchDB.Orders
  Prompt for a line item
  Validate the Vendor Part Number for each line item
  BULK INSERT rows into PurchDB.OrderItems
  Repeat the above six steps until the user enters a 0
  RELEASE the DBEnvironment

Connect to PartsDBE

Enter a Vendor Number or a 0 to STOP> 9015

Begin Work
Validating VendorNumber

Commit Work

Begin Work
LOCK the PurchDB.Orders table.
Calculating OrderNumber
Calculating OrderDate

INSERT into PurchDB.Orders

Commit Work

Do you want to specify line items (Y/N)?> y

You can specify as many as 25 line items.

Enter data for ItemNumber:  1

 Vendor Part Number > 9040

Begin Work
Validating VendPartNumber

Commit Work

 Purchase Price > 1500
```

Figure 7-2. Runtime Dialog of Program cex9

```
 Order Quantity > 5

 Item Due Date (yyyymmdd) > 19860630

Do you want to specify another line item (Y/N)? > y

You can specify as many as 25 line items.

Enter data for ItemNumber:  2

 Vendor Part Number > 9055

Begin Work
Validating VendPartNumber

Commit Work

The vendor has no part with the number
    you specified!

Do you want to specify another line item (Y/N)? > y

You can specify as many as 25 line items.

Enter data for ItemNumber:  2

 Vendor Part Number > 9050

Begin Work
Validating VendPartNumber

Commit Work

 Purchase Price > 345

 Order Quantity > 2

 Item Due Date (yyyymmdd) > 19860801

Do you want to specify another line item (Y/N)?> n

Begin Work
BULK INSERT into PurchDB.OrderItems

Commit Work
```

Figure 7-2. Runtime Dialog of Program cex9 (page 2 of 3)

```
The following order has been created:
 Order Number:          30524
 Vendor Number:         9015
 Order Date:            19860603

   Item Number:         1
   Vendor Part Number:  9040
   Purchase Price:         1500.00
   Order Quantity:      5
   Item Due Date:       19860630
   Received Quantity:   is NULL

   Item Number:         2
   Vendor Part Number:  9050
   Purchase Price:          345.00
   Order Quantity:      2
   Item Due Date:       19860801
   Received Quantity:   is NULL

Enter a Vendor Number or a 0 to STOP > 0

Release PartsDBE
```

Figure 7-2. Runtime Dialog of Program cex9 (page 3 of 3)

```
/* Program cex9 */

/* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * */
/* This program illustrates the use of SQL's BULK INSERT           */
/* command to insert mulitple rows or tuples at a time.            */
/* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * */

typedef int boolean;

boolean     Abort;
boolean     Done;
boolean     DoneItems;
boolean     VendorOK;
boolean     HeaderOK;
boolean     PartOK;
boolean     ItemsOK;
char        response[2];
int         counter1;
int         counter2;
int         i,j,k;
long        sec;

char        *Date;

#include <stdio.h>
#include <time.h>

#define    OK                0
#define    NotFound        100
#define    MultipleRows  -10002
#define    DeadLock      -14024
#define    FALSE             0
#define    TRUE              1

sqlca_type sqlca;    /* SQL Communication Area */

          /* Begin Host Variable Declarations */
    EXEC SQL BEGIN DECLARE SECTION;
    int       OrderNumber1;
    int       VendorNumber;
    char      OrderDate[9];
    char      PartSpecified[17];
    int       MaxOrderNumber;
    short     StartIndex;
    short     NumberOfRows;
```

Figure 7-3. Program cex9: Using BULK INSERT

```
    struct    {
      int       OrderNumber2;
      int       ItemNumber;
      char      VendPartNumber[17];
      double    PurchasePrice;
      short     OrderQty;
      char      ItemDueDate[9];
      short     ReceivedQty;
      sqlind    ReceivedQtyInd;
      } OrderItems[25];                                          (1)
    char      SQLMessage[133];
    EXEC SQL END DECLARE SECTION;
         /* End Host Variable Declarations */


int SystemDate()  /* Function to get the system date */          (32)
{

sec = time(0);
printf("\n Calculating OrderDate");
ptr = localtime(&sec);
sprintf(OrderDate, "%2s%2.2d%2.2d%2.2d",
"19",ptr->tm_year,++ptr->tm_mon,ptr->tm_mday);

}  /* End of SystemDate Function */


int SQLStatusCheck()  /* Function to Display Error Messages */  (13)
{
Abort = FALSE;
if (sqlca.sqlcode < DeadLock) Abort = TRUE;

do {
EXEC SQL SQLEXPLAIN :SQLMessage;                                 (4)
printf("\n");
printf("%s\n",SQLMessage);
} while (sqlca.sqlcode != 0);

if (Abort) {
  ReleaseDBE();
  }

}  /* End SQLStatusCheck Function */
```

Figure 7-3. Program cex9: Using BULK INSERT (page 2 of 11)

```
boolean ConnectDBE()  /* Function to Connect to PartsDBE */
                                                                    54
{
boolean ConnectDBE;
printf("\n Connect to PartsDBE");
EXEC SQL CONNECT TO 'PartsDBE';                                     5

ConnectDBE = TRUE;
if (sqlca.sqlcode != OK) {
  ConnectDBE = FALSE;
  SQLStatusCheck();
  }  /* End if */
return (ConnectDBE);
}  /* End of ConnectDBE Function */


int ReleaseDBE() /* Function to Release PartsDBE */                 56
{
printf("\n Release PartsDBE");
EXEC SQL RELEASE;                                                   3
printf("\n");

Done = TRUE;
if (sqlca.sqlcode != OK)
  SQLStatusCheck();

}  /* End ReleaseDBE Function */


boolean BeginTransaction()    /* Function to Begin Work */          9
{
boolean BeginTransaction;
printf("\n");
printf("\n Begin Work");

EXEC SQL BEGIN WORK;                                                6

if (sqlca.sqlcode != OK)  {
  SQLStatusCheck();
  ReleaseDBE();
  }

}  /* End BeginTransaction Function */
```

Figure 7-3. Program cex9: Using BULK INSERT (page 3 of 11)

```
int EndTransaction()  /* Function to Commit Work */                    11
{
printf("\n");
printf("\n Commit Work");
EXEC SQL COMMIT WORK;                                                   7
if (sqlca.sqlcode != OK) {
  SQLStatusCheck();
  }

}  /* End EndTransaction Function */


int RollBackWork()     /* Function to RollBack work */                 28
{
printf("\n");
printf("\n RollBack Work");
EXEC SQL ROLLBACK WORK;                                                 8
if (sqlca.sqlcode != OK) {
  SQLStatusCheck();
  ReleaseDBE();
  }

}  /* End of RollBack Function */


int ValidateVendor()  /* Function that ensures vendor number is valid */
{                                                                       49
BeginTransaction();                                                     9

printf("\n Validating VendorNumber");
EXEC SQL SELECT  VendorNumber                                           10
           INTO :VendorNumber
           FROM  PurchDB.Vendors
          WHERE  VendorNumber = :VendorNumber;

switch (sqlca.sqlcode) {

  case OK:              VendorOK = TRUE;
                        EndTransaction();                               11
                        break;
  case NotFound:        EndTransaction();
                        printf("\n");
                        printf("\n No vendor has the VendorNumber you");
                        printf("\n     specified!");                    12
                        VendorOK = FALSE;
                        HeaderOK = FALSE;
                        ItemsOK = FALSE;
                        break;
```

Figure 7-3. Program cex9: Using BULK INSERT (page 4 of 11)

```
  default:              SQLStatusCheck();                          (13)
                        EndTransaction();
                        VendorOK = FALSE;
                        HeaderOK = FALSE;
                        ItemsOK = FALSE;
                        break;
  }  /* End switch */

}  /* End ValidateVendor Function */


\mf="Function"
int ValidatePart()  /* Function that ensures vendor part number is valid */
{                                                                  (39)
BeginTransaction();                                                (14)

sscanf(OrderItems[i].VendPartNumber,"%s",PartSpecified);

printf("\n Validating VendPartNumber");
EXEC SQL SELECT  VendPartNumber                                    (15)
           INTO :PartSpecified
           FROM  PurchDB.SupplyPrice
          WHERE  VendorNumber = :VendorNumber
            AND  VendPartNumber = :PartSpecified;

switch (sqlca.sqlcode) {

  case OK:              EndTransaction();                          (16)
                        PartOK = TRUE;
                        break;
  case NotFound:        EndTransaction();                          (17)
                        printf("\n");
                        printf("\n The vendor has no part with the number"
                        printf("\n     you specified!");
                        PartOK = FALSE;
                        break;
```

Figure 7-3. Program cex9: Using BULK INSERT (page 5 of 11)

```
  default:              SQLStatusCheck();
                        EndTransaction();
                        PartOK = FALSE;
                        break;
  }  /* End switch */

}  /* End ValidatePart Function */


int DisplayHeader()   /* Function to Display row from PurchDB.Orders */
{                                                                    45
  printf("\n");
  printf("\n The following order has been created.");
  printf("\n");
  printf("Order Number:             %d\n", OrderNumber1);          18
  printf("Vendor Number:            %d\n", VendorNumber);
  printf("Order Date:               %s\n", OrderDate);

}  /* End of DisplayRow Function */


int DisplayItems()  /* Function to Display Rows from PurchDB.OrderItems */
{                                                                    21
  j = counter2;
  printf("\n");                                                      19
  printf("Item Number:            %d\n", OrderItems[j].ItemNumber);
  printf("Vendor Part Number:     %s\n", OrderItems[j].VendPartNumber);
  printf("Purchase Price:         %10.2f\n", OrderItems[j].PurchasePrice)
  printf("Order Quantity:         %d\n", OrderItems[j].OrderQty);
  printf("Item Due Date:          %s\n", OrderItems[j].ItemDueDate);
  printf("Received Quantity:       is NULL \n");
  counter2 = j + 1;

}  /* End of DisplayRow */


int DisplayOrder()   /* Function to Display Order Created */         52
{
DisplayHeader();                                                     20
printf("\n");
i = counter1;
counter2 = 1;
do {
  DisplayItems();                                                    21
  j = j + 1;
  } while (j < i);

}  /* End of DisplayOrder Function */
```

Figure 7-3. Program cex9: Using BULK INSERT (page 6 of 11)

```
int InsertRow()  /* Function to insert row in PurchDB.Orders */ (33)
{
printf("\n");
printf("\n INSERT into PurchDB.Orders");
EXEC SQL INSERT INTO   PurchDB.Orders                          (22)
                      (OrderNumber,
                       VendorNumber,
                       OrderDate)
              VALUES (:OrderNumber1,
                      :VendorNumber,
                      :OrderDate);

if (sqlca.sqlcode != 0) {
  SQLStatusCheck();
  EndTransaction();
  HeaderOK = FALSE;                                            (23)
  }
else {
  EndTransaction();
  HeaderOK = TRUE;                                             (24)
  }

}  /* End of InsertRow Function */


int BulkInsert()    /* Function to bulk insert into PurchDB.OrderItems */
{                                                              (47)
BeginTransaction();                                            (25)
NumberOfRows = counter1;                                       (26)
StartIndex = 1;

printf("\n BULK INSERT into PurchDB.OrderItems");
EXEC SQL BULK INSERT INTO   PurchDB.OrderItems                 (27)
                           (OrderNumber,
                            ItemNumber,
                            VendPartNumber,
                            PurchasePrice,
                            OrderQty,
                            ItemDueDate,
                            ReceivedQty)
                    VALUES (:OrderItems,
                            :StartIndex,
                            :NumberOfRows);
```

Figure 7-3. Program cex9: Using BULK INSERT (page 7 of 11)

```
if (sqlca.sqlcode != 0) {
  SQLStatusCheck();
  RollBackWork();                                                    28
  ItemsOK = FALSE;
  }
else {
  EndTransaction();                                                  29
  ItemsOK = TRUE;
  }

}  /* End of BulkInsert Function */


int ComputeOrderNumber()   /* Function to assign a number to an order */
{                                                                    36
EXEC SQL SELECT  MAX(OrderNumber)                                    30
           INTO :MaxOrderNumber
           FROM  PurchDB.Orders;

if (sqlca.sqlcode != 0) {
  SQLStatusCheck();
  EndTransaction();
  HeaderOK = FALSE;
  }
else {
  printf("\n Calculating OrderNumber");
  OrderNumber1 = MaxOrderNumber + 1;                                 31
  SystemDate();                                                      32
  InsertRow();                                                       33
  }

}  /* End ComputeOrderNumber Function */


int CreateHeader()   /* Function to create order header */           50
{
BeginTransaction();                                                  34

printf("\n LOCK the PurchDB.Orders table.");
EXEC SQL LOCK TABLE PurchDB.Orders IN EXCLUSIVE MODE;                35

if (sqlca.sqlcode != 0) {
  SQLStatusCheck();
  EndTransaction();
  HeaderOK = FALSE;
  }
```

Figure 7-3. Program cex9: Using BULK INSERT (page 8 of 11)

```
else
  ComputeOrderNumber();                                          (36)

}  /* End CreateHeader Function */


int ItemEntry()  /* Function to put line items into OrderItems array */
{                                                                (46)
i = counter1;
OrderItems[i].OrderNumber2 = OrderNumber1;                       (37)
OrderItems[i].ItemNumber = i;
printf("\n");
printf("\n You can specify as many as 25 line items.");
printf("\n");
printf("\n Enter data for ItemNumber:  %d\n", OrderItems[i].ItemNumber);
printf("\n");
printf("\n Vendor Part Number > ");                                (38)
scanf("%s%*c",OrderItems[i].VendPartNumber);
ValidatePart();                                                  (39)
DoneItems = FALSE;
if (PartOK != FALSE) {
  printf("\n");
  printf("\n Purchase Price > ");                                 (40)
  scanf("%1f",&OrderItems[i].PurchasePrice);

  printf("\n Order Quantity > ");                                 (40)
  scanf("%5d%*c",&OrderItems[i].OrderQty);

  printf("\n Item Due Date (yyyymmdd) > ");                       (40)
  scanf("%s%*c",OrderItems[i].ItemDueDate);

  OrderItems[i].ReceivedQtyInd = -1;                             (41)

  counter1 = i + 1;
  }
  if (i < 25) {
    printf("\n");
  printf("\n Do you want to specify another line item (Y/N)? >");
    scanf("%s%*c",response);                                     (42)
    if ((response[0] == 'N') || (response[0] == 'n')) {
      DoneItems = TRUE;
      }
    }
  else
    DoneItems = TRUE;                                            (43)
}  /* End ItemEntry Function */
```

Figure 7-3. Program cex9: Using BULK INSERT (page 9 of 11)

```
int CreateOrderItems()   /* Function to create line items */     (51)
{
ItemsOK = FALSE;
printf("\n");
printf("\n Do you want to specify line items (Y/N)? > ");       (44)
scanf("%s%*c",response);
if ((response[0] == 'N') || (response[0] == 'n')) {
  DoneItems = TRUE;
  DisplayHeader();                                              (45)
  }
else {
  counter1 = 1;
  do {
    ItemEntry();                                                (46)
    } while (DoneItems == FALSE);
  if (counter1 != 1) {
    BulkInsert();                                               (47)
    ItemsOK = TRUE;
    }
 }
}  /* End of CreateOrderItems Function */


int CreateOrder()   /* Function to create an order */           (55)
{
printf("\n");
printf("\n Enter a Vendor Number or a 0 to STOP > ");          (48)
scanf("%10d%*c",&VendorNumber);
if (VendorNumber != 0) {
  ValidateVendor();                                             (49)
  if (VendorOK == TRUE) CreateHeader();                         (50)
  if (HeaderOK == TRUE) {
    DoneItems = FALSE;
    do {
      CreateOrderItems();                                       (51)
      } while (DoneItems == FALSE);
    }
  if (ItemsOK == TRUE) DisplayOrder();                          (52)
  }
  else
    Done = TRUE;                                                (53)

}  /* End CreateOrder Function */
```

Figure 7-3. Program cex9: Using BULK INSERT (page 10 of 11)

```
main()          /* Beginning of program */
{
printf("\n Program to CREATE an Order - cex9");
printf("\n");
printf("\n Event list:");
printf("\n   CONNECT TO PartsDBE");
printf("\n   Prompt for a Vendor Number");
printf("\n   Validate the Vendor Number");
printf("\n   BEGIN WORK");
printf("\n   INSERT a row into PurchDB.Orders");
printf("\n   Prompt for a line item");
printf("\n   Validate the Vendor Part Number for each line item");
printf("\n   BULK INSERT rows into PurchDB.OrderItems");
printf("\n   Repeat the above six steps until the user enters a 0");
printf("\n   RELEASE the DBEnvironment");
printf("\n");

if (ConnectDBE())  {                                                    (54)

  Done = FALSE;
  do {
      CreateOrder();                                                    (55)
      } while (Done != TRUE);

  ReleaseDBE();                                                         (56)
}
else
  printf("\n Error: Cannot Connect to PartsDBE!\n");

}  /* End of Program */
```

Figure 7-3. Program cex9: Using BULK INSERT (page 11 of 11)

8

Using Dynamic Operations

Dynamic operations are used to execute SQL commands that are not preprocessed until run time. Such commands, known as **dynamic SQL commands**, are submitted to ALLBASE/SQL through several special SQL statements: PREPARE, DESCRIBE, EXECUTE, and EXECUTE IMMEDIATE.

This chapter contrasts dynamic with non-dynamic operations and introduces the techniques used to handle dynamic operations from a program. It then focuses on dynamic non-queries and queries. The following topics are considered:

- Review of Preprocessing Events.
- Differences between Dynamic and Non-Dynamic Preprocessing.
- Preprocessing of Dynamic Non-Queries.
- Preprocessing of Dynamic Queries.
- Preprocessing of Dynamic Commands That May or May Not be Queries.
- Programs Using Dynamic Query Operations.

Review of Preprocessing Events

All embedded SQL statements must be preprocessed before they can be executed. Preprocessing may be done by running the C preprocessor during application development, or it may be done for dynamic commands when the program is run. Preprocessing does the following:

- Checks syntax: The syntax of SQL commands and host variable declarations must be correct.
- Verifies the existence of objects: Any object named in an SQL command must exist.
- Optimizes data access: If the statement accesses data, the fastest way to access the data must be determined.
- Checks authorizations: Both the program owner and the executor must have the required authorities.
- Creates sections: ALLBASE/SQL creates sections for SQL commands when this is appropriate. At run time, the section is executed.

These preprocessing events take place for all *non-dynamic* SQL commands when you run the ALLBASE/SQL preprocessor. Non-dynamic commands are fully defined in the source code and are preprocessed *before* run time. So far, most of the examples in this manual have shown non-dynamic preprocessing.

ALLBASE/SQL completes the preprocessing of dynamic commands at run time, in an event known as **dynamic preprocessing**. Any SQL command except the following, which do not require sections for execution, can be preprocessed at run time:

```
BEGIN DECLARE SECTION          FETCH
CLOSE CURSOR                   INCLUDE
DECLARE CURSOR                 OPEN CURSOR
DELETE WHERE CURRENT           PREPARE
DESCRIBE                       SQLEXPLAIN
END DECLARE SECTION            UPDATE WHERE CURRENT
EXECUTE                        WHENEVER
EXECUTE IMMEDIATE
```

Dynamic commands that are not queries can be preprocessed at run time using the PREPARE and EXECUTE statements or the EXECUTE IMMEDIATE statement. Dynamic queries are preprocessed using the PREPARE and DESCRIBE commands in conjunction with the SQLDA or **SQL Description Area** and other data structures. These statements and data structures, used with a cursor, are described further in a later section.

Differences between Dynamic and Non-Dynamic Preprocessing

The authorization checking and section creation activities for Non-dynamic and dynamic ALLBASE/SQL commands differ in the following ways:

- Authorization checking. A non-dynamic command is executed if the owner of the program module has the proper authority at run time. A dynamic command is executed if the program executor has the proper authority at run time.
- Section creation. Any section created for a non-dynamic command becomes part of a module permanently stored in a DBEnvironment by the C preprocessor. The module remains in that system catalog until you execute the DROP MODULE command or invoke the preprocessor with the DROP option. Any section created for a dynamic command is temporary. The section is created at run time, temporarily stored, then deleted at the end of the transaction in which it was created.

Permanently Stored vs. Temporary Sections

In some instances, you could code the same SQL statement as either dynamic or non-dynamic, depending on whether you wanted to store permanent sections. A program that has permanently stored sections associated with it can be executed only against DBEnvironments containing those sections. Figure 8-1 illustrates how you create and use such programs. Note that the sections can be permanently stored either by the preprocessor or by using the ISQL INSTALL command.

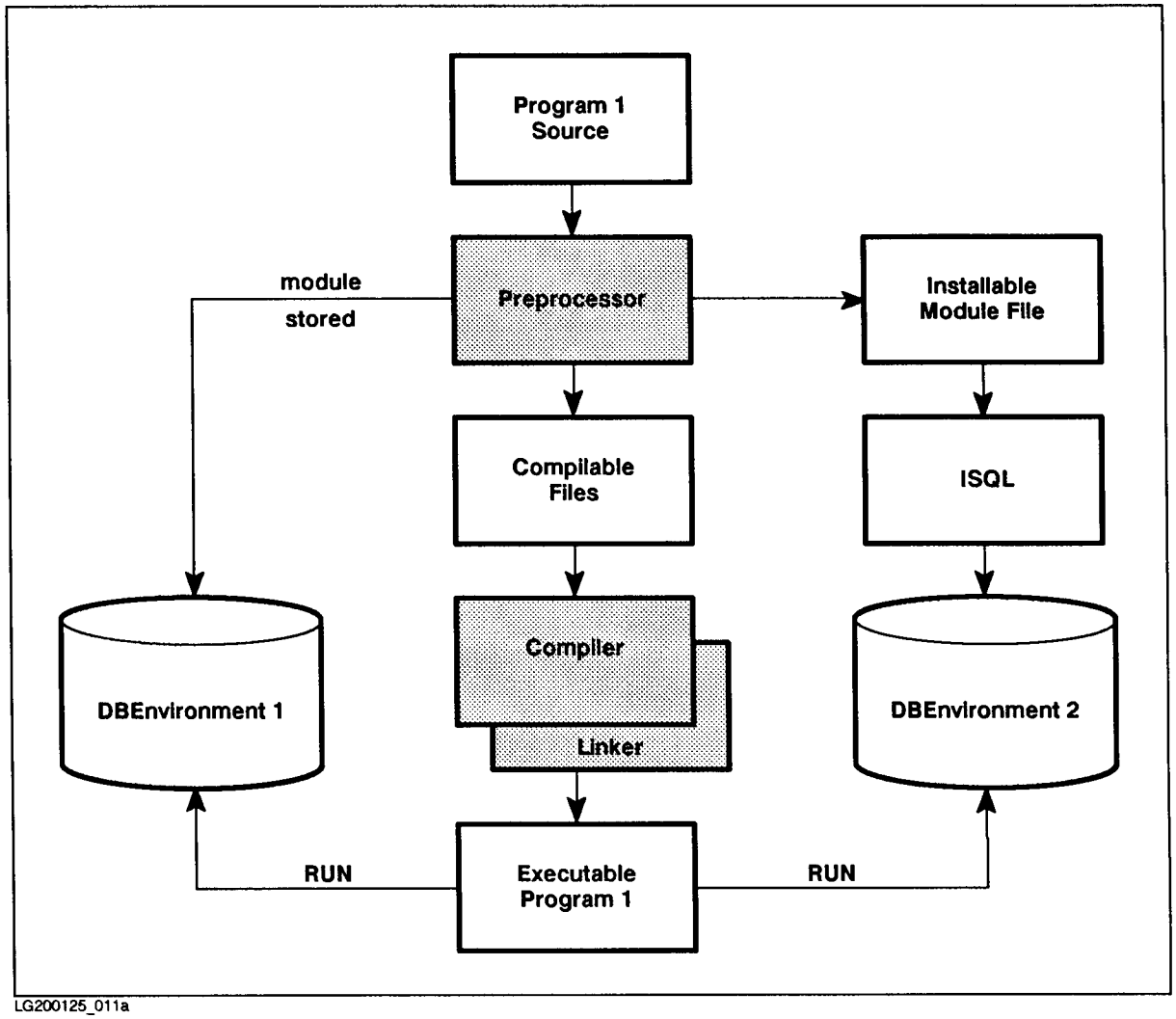


Figure 8-1. Creation and Use of a Program that has a Stored Module

Programs that contain only SQL commands that do not have permanently stored sections can be executed against *any* DBEnvironment without the prerequisite of storing a module in the DBEnvironment. Figure 8-2 illustrates how you create and use programs in this category. Note that the program must still be preprocessed, in order to create compilable files and generate ALLBASE/SQL external procedure calls.

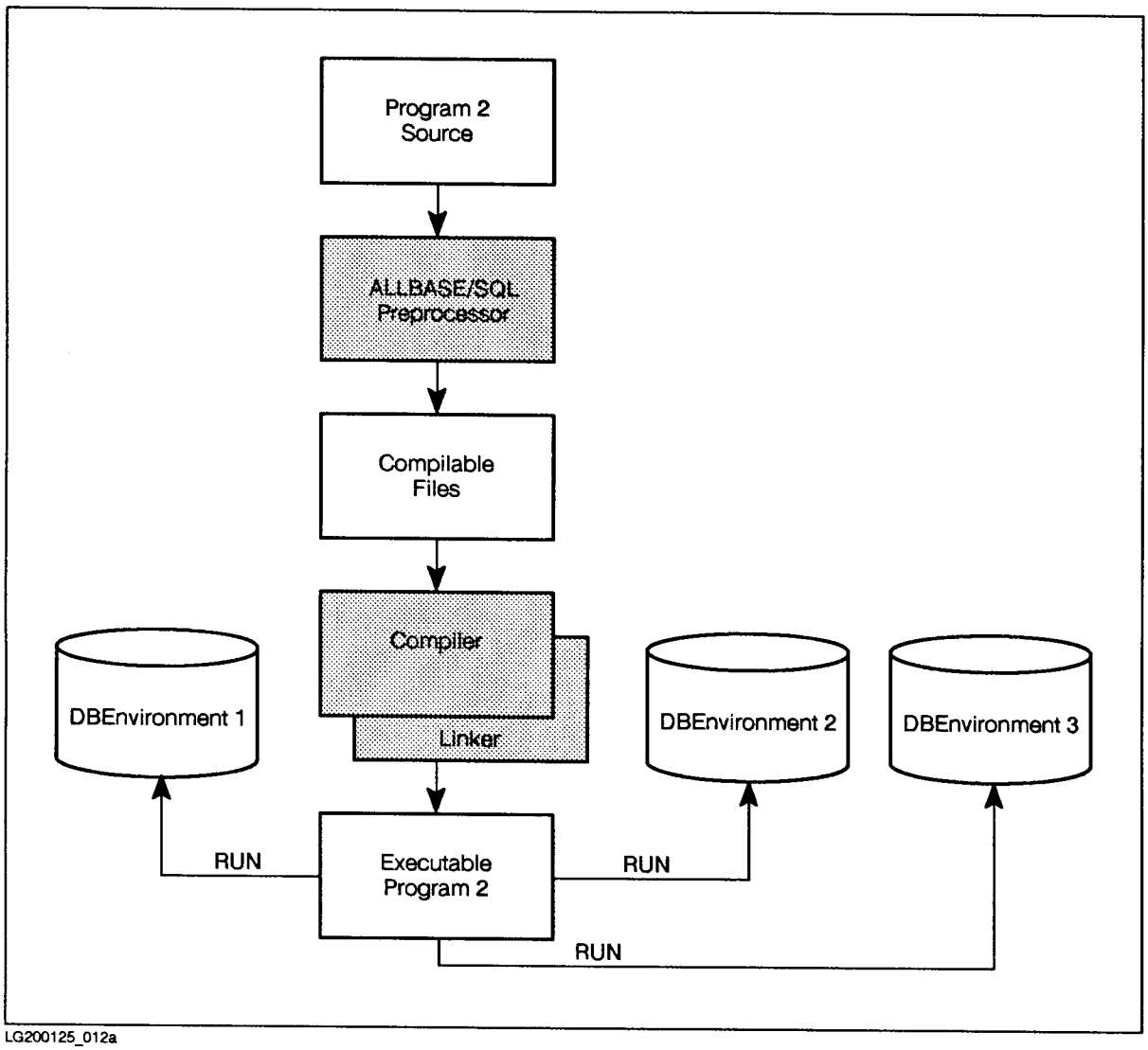


Figure 8-2. Creation and Use of a Program that has no Stored Module

Examples of Non-Dynamic and Dynamic SQL Statements

The following example shows an embedded SQL statement that is coded so as to generate a stored section before run time:

```
EXEC SQL UPDATE STATISTICS FOR TABLE PurchDB.Parts;
```

When you run the preprocessor on a source file containing this statement, a permanent section will be stored in the appropriate DBEnvironment.

The following example shows an SQL statement that is coded so as to generate a temporary section at run time:

```
DynamicCommand := 'UPDATE STATISTICS FOR TABLE PurchDB.Parts;';
EXEC SQL PREPARE MyCommand FROM :DynamicCommand;
EXEC SQL EXECUTE MyCommand;
```

In this case, the SQL statement is stored in a host variable which is passed to ALLBASE/SQL in the PREPARE statement at run time. A temporary section is then created and executed, and the section is not stored in the DBEnvironment.

Why Use Dynamic Preprocessing?

In some cases, it may *not* be desirable to preprocess an SQL command before run time:

- You may need to code an application that permits ad hoc queries requiring that SQL commands be entered by the user at run time. (ISQL is an example of an ad hoc query facility in which the command the user will submit is completely unknown at programming time.)
- You may need more specialized applications requiring SQL commands that are defined partly at programming time and partly by the user at run time. An application may, for example, perform UPDATE STATISTICS operations on tables the user specifies at run time.
- You may wish to run an application on different DBEnvironments at different times without the need to permanently store sections in those DBEnvironments.
- You may wish to code only one dynamic command (a CONNECT, for instance) and then preprocess or install the same application in several different DBEnvironments.

Passing Dynamic Commands to ALLBASE/SQL

A dynamic command is passed to ALLBASE/SQL either as a string literal or as a host variable containing a string. It must be terminated with a semicolon. The maximum length for such a string is 2048 bytes.

To pass a dynamic command that can be completely defined at programming time, you can use a delimited string:

```
EXEC SQL
PREPARE MyCommand FROM 'UPDATE STATISTICS FOR TABLE PurchDB.Parts;';
```

or

```
EXEC SQL
EXECUTE IMMEDIATE 'UPDATE STATISTICS FOR TABLE PurchDB.Parts;';
```

To pass a dynamic command that cannot be completely defined at programming time, you use a host variable declared as an array of char:

```
char              DynamicHostVar[2048];
.
.
EXECUTE IMMEDIATE :DynamicHostVar
```

Understanding the Types of Dynamic Operations

Dynamic operations in ALLBASE/SQL are of two major types:

- Dynamic Non-Queries: dynamic operations that do not retrieve rows from the database. Note that dynamic non-queries either do or do not require the use of sections at execution time. For example, a CONNECT does not require a section, but a DELETE does.
- Dynamic Queries: dynamic operations that do retrieve rows. Note that dynamic queries may have a query result whose format is known to you at programming time, or they may have a query result whose format is unknown. Dynamic queries always use sections at execution time.

It is sometimes necessary to define dynamic data structures that can accomodate *either* non-queries or queries at run time. An example is shown later in this chapter in program cex10a (Figures 8-7, 8-8, 8-9).

The following paragraphs examine each type of dynamic operation and present information on how to determine whether or not a dynamic command is a query.

Preprocessing of Dynamic Non-Queries

There are two methods for dynamic preprocessing of a non-query:

- Using EXECUTE IMMEDIATE.
- Using PREPARE and EXECUTE.

The first method can be used with any non-query; the second is only for those non-query commands that use sections at execution time.

Using EXECUTE IMMEDIATE

If you know in advance that a dynamic command will not be a query, you can dynamically preprocess and execute the command in one step, using the EXECUTE IMMEDIATE command. Figure 8-3 illustrates a procedure hosting a dynamic UPDATE STATISTICS command that can be handled in this fashion.

Function UpdateStatistics (1) prompts the user for a table name (2). The table name entered is assigned to the host variable CmdLine (3) to complete the UPDATE STATISTICS command. After the command is prepared and executed (4), the transaction is terminated with a COMMIT WORK command (5) or a ROLLBACK WORK command (6), depending on the value in SQLCA.SQLCODE. Terminating the transaction before accepting another

table name and re-executing the UPDATE STATISTICS command releases any locks obtained and improves concurrency.

If you do not know in advance whether a dynamic command will be a query or a non-query, you must use the PREPARE command to dynamically preprocess the command, the DESCRIBE command to distinguish between queries and non-queries, and the EXECUTE or EXECUTE IMMEDIATE command to execute the dynamic non-query. The program examined later in this chapter under "Program Using Dynamic Commands of Unknown Type" illustrates how to handle this situation.

```
.
.
.
  EXEC SQL BEGIN DECLARE SECTION;
  char              CmdLine[100];
  EXEC SQL END DECLARE SECTION;

  char              TableName[50];
.
.
.
int UpdateStatistics()                                              (1)
{

do {
    sprintf(CmdLine,"UPDATE STATISTICS FOR TABLE ");

printf("\n Enter name of table or / to terminate > ");              (2)
gets(TableName);
if (TableName[0] != '/') {

    sprintf(CmdLine+strlen(CmdLine)," %s;",TableName);              (3)

    EXEC SQL EXECUTE IMMEDIATE :CmdLine;                            (4)

    if (sqlca.sqlcode == 0)  {
      EXEC SQL COMMIT WORK;                                         (5)
      }
    else
      EXEC SQL ROLLBACK WORK;                                       (6)

  }                 /* End of if TableName */
} while (TableName[0] != '/');

}                  /* End of UpdateStatistics function */
.
.
.
```

Figure 8-3. Procedure Hosting Dynamic Non-Query Commands

Using PREPARE and EXECUTE

Use the PREPARE command to create and store a temporary section for the dynamic command:

```
PREPARE CommandName FROM CommandSource
```

Because the PREPARE command operates only on sections, it can be used to dynamically preprocess only SQL commands executed by using sections. The DBE session management and transaction management commands can only be dynamically preprocessed by using EXECUTE IMMEDIATE.

With PREPARE, ALLBASE/SQL creates a temporary section for the command that you can execute *one or more times in the same transaction* by using the EXECUTE command:

```
EXEC SQL PREPARE MyNonQuery FROM :DynamicCommand;

for i=0;i<MaxIterations;i++)
EXEC SQL EXECUTE MyNonQuery;
```

As soon as you process a COMMIT WORK or ROLLBACK WORK command, the temporary section is deleted.

Preprocessing of Dynamic Queries

Preprocessing of dynamic queries requires setting up a buffer to receive the query result and extracting the items you want from the buffer. For these operations, you use three special data structures:

- SQL Description Area (SQLDA). The SQLDA is a record used to pass information on the location and contents of the other two dynamic data structures, the format array and the data buffer. You set some fields in the SQLDA and pass them to ALLBASE/SQL; and ALLBASE/SQL passes values back to you in other fields.
- SQL Format Array. The format array is an array of records with one record for each select list item (column). The attributes of a column in the query result are described in a format array record. When you do not know the format of a query result at programming time, you use format array information to identify where in the data buffer to find each column value and how to interpret it.
- Data Buffer. The data buffer is an array for holding rows in a query result. ALLBASE/SQL puts rows into the data buffer each time you execute the FETCH command.

Figure 8-4 summarizes the relationships among the special data structures and when data is assigned to them. Note that status checking information for each SQL command can be found in the sqlca data structure. See the chapter "Runtime Status Checking and the SQLCA" for more details.

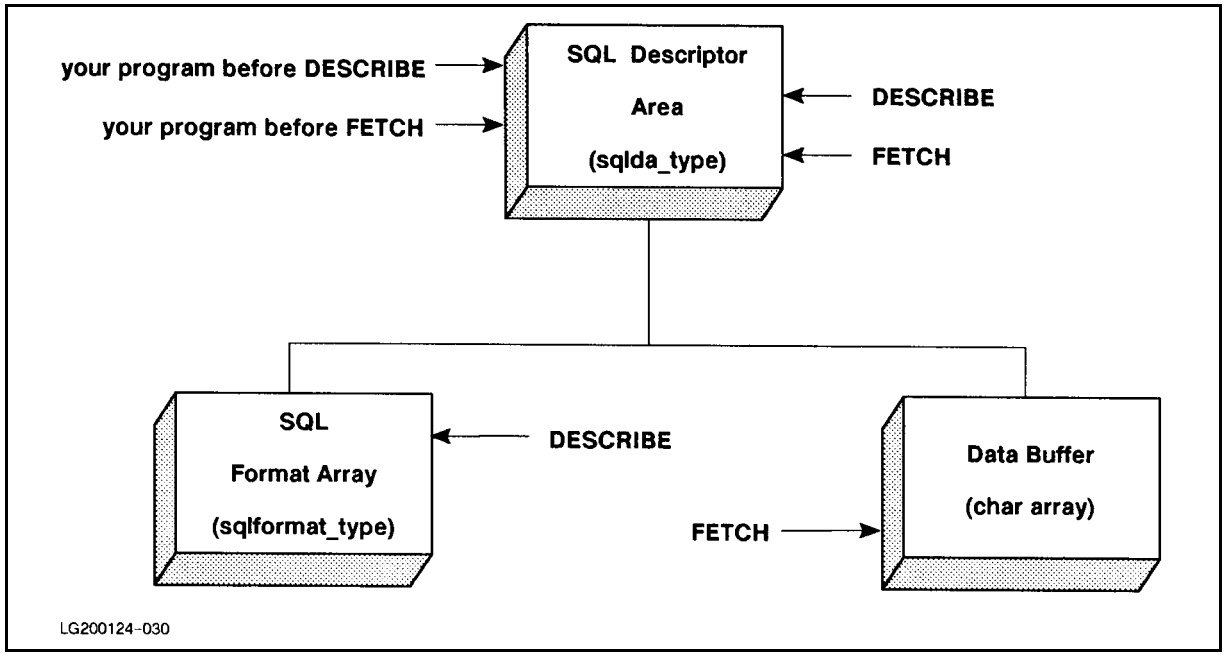


Figure 8-4. Dynamic Query Data Structures and Data Assignment

Though some specific details differ depending on the query type, in general you handle all types of dynamic query as follows:

- Define a host variable (or a string) to hold the SELECT statement to be used by the PREPARE command.
- The PREPARE command dynamically preprocesses the query. ALLBASE/SQL defines a temporary section, which includes a run tree for the SELECT command specified in the PREPARE command:

  ```
  EXEC SQL PREPARE MyQuery FROM :DynamicCommand;
  ```

- The DESCRIBE command makes available to your program information about each column in a query result:

  ```
  EXEC SQL DESCRIBE MyQuery INTO SQLDA
  ```

- The DECLARE CURSOR command maps the temporary section to a cursor so that the other cursor manipulation commands can be used:

  ```
  EXEC SQL DECLARE DynamicCursor CURSOR FOR MyQuery;
  ```

- The OPEN command allocates ALLBASE/SQL buffer space for holding qualifying rows and defines the active set:

  ```
  EXEC SQL OPEN DynamicCursor;
  ```

- The FETCH command evaluates any predicates in the query and transfers rows from the ALLBASE/SQL buffer into host variables:

  ```
  EXEC SQL FETCH DynamicCursor USING DESCRIPTOR SQLDA;
  ```

  The USING DESCRIPTOR clause indicates to ALLBASE/SQL that rows should be formatted in accord with a format array identified in the SQLDA and returned to a data

buffer identified in the SQLDA. The SQLDA, the format array, and the data buffer are discussed later in this section under "Using the Dynamic Query Data Structures."

Although you can fetch multiple rows with each execution of the FETCH command, you do *not* specify the BULK option when fetching rows that qualify for dynamic queries. Instead, you set a field in the SQLDA as shown later in this chapter to communicate to ALLBASE/SQL how many rows to fetch. You can repeatedly execute the FETCH command until ALLBASE/SQL sets sqlca.sqlcode to 100.

- The CLOSE command closes the cursor and frees previously allocated buffer space:

```
EXEC SQL CLOSE DynamicCursor;
```

The COMMIT WORK and ROLLBACK WORK commands also close any open cursors, unless you are using the KEEP CURSOR option of the OPEN command (see Chapter 6). In addition, these commands release locks obtained to execute the dynamic query. Therefore, to improve concurrency when repeatedly preparing dynamic queries, issue one of these commands before executing the PREPARE command for the second and each subsequent time.

Dynamically Updating and Deleting Data

You have the option of dynamically updating or deleting a row in conjunction with a dynamic FETCH statement. Any dynamic UPDATE WHERE CURRENT or DELETE WHERE CURRENT statement must be hard coded in your program just as you would code it for a non-dynamic FETCH statement. The statements *cannot* be defined at run time and prepared.

Whether your SELECT statement is completely user specified at run time, supplied by your program based on related user input, or completely defined by your program, here are some things to keep in mind:

- If you are using a dynamic cursor to update, be sure your SELECT statement contains a FOR UPDATE OF clause.
- An UPDATE WHERE CURRENT command must map to an appropriate SELECT statement. Be sure all of the columns you might possibly want to update are specified in the FOR UPDATE OF clause.

  For example, if the host variable or string from which you prepare contains the following statement, you can use the UPDATE WHERE CURRENT command to change the content of all the columns in qualifying rows of PurchDB.Parts.

```
        SELECT PartNumber FROM PurchDB.Parts
         WHERE PartNumber BETWEEN 9000 AND 9999
FOR UPDATE OF PartNumber, PartName, SalesPrice
```

  However, if your prepared command is based on a host variable or string containing the following statement, you will *only* be able to use UPDATE WHERE CURRENT to change column SalesPrice in any qualifying rows of PurchDB.Parts.

```
        SELECT PartNumber FROM PurchDB.Parts
         WHERE PartNumber BETWEEN 9000 AND 9999
FOR UPDATE OF SalesPrice
```

- Your error checking strategy might include routines to parse user input for an acceptable SELECT statement and/or routines to test specific sqlca field values and invoke SQLEXPLAIN. This error checking strategy may need to be modified, if the syntax of the SELECT statement has changed for a particular ALLBASE/SQL release.

Setting Up the SQLDA

You use the INCLUDE command to declare the SQLDA in the declaration section of your program:

```
EXEC SQL INCLUDE SQLDA;
```

When the C preprocessor parses this command, it inserts a type declaration for this data structure into the modified source code file:

```
# if 0
  EXEC SQL INCLUDE SQLDA;
# endif
sqlda_type   sqlda;
```

Alternatively, you can include the above type declaration in your source file and omit the INCLUDE command.

The Sqlda_Type record is defined as follows in the full preprocessor generated include file named SQLTYPE:

```
typedef struct {
  char       sqldaid[8];          reserved for ALLBASE/SQL
  int        sqldabe;             reserved for ALLBASE/SQL
  int        sqln;                number of format array records
  int        sqld;                number of columns
  sqlformat_type  *sqlfmtarr;     format array address
  int        sqlnrow;             number of rows to FETCH
  int        sqlrrow;             number of rows fetched
  int        sqlrowlen;           bytes in each row
  int        sqlbuflen;           bytes in data buffer
  int        sqlrowbuf;           data buffer address
} sqlda_type;
```

Values are assigned to SQLDA fields by you or by ALLBASE/SQL, as summarized in Table 8-1.

Table 8-1. SQLDA Fields

FIELD NAME	FIELD DESCRIPTION	C DATA TYPE	YOU SET BEFORE DESCRIBE	YOU SET BEFORE FETCH	ALLBASE/ SQL SETS AT DESCRIBE	ALLBASE/ SQL SETS AT FETCH
sqldaid	reserved	char[8]				
sqldabc	reserved	int				
sqln	number of format array records (one record (column) per select list item)	int	X			
sqld	number of columns in query result (0 if non-query)	int			X	
sqlfmtarr	address of format array	sqlformat_type*	X			
sqlnrow	number of rows to FETCH into the data buffer	int		X		
sqlrrow	number of rows put into the data buffer	int				X
sqlrowlen	number of bytes in each row	int			X	
sqlbuflen	number of bytes in the data buffer	int		X		
sqlrowbuf	address of data buffer	int		X		

Setting Up the Format Array

You declare the format array as an array of records having the type SqlFormat_Type:

```
sqlformat_type    sqlfmts[NbrFmtRecords];
```

You set the number of records in the format array (NbrFmtRecords in this example) to the largest number of select list items you expect. If you do not know this value at programming time, you can allow for as many as 1024 records, since 1024 is the maximum number of columns any query result can contain, as follows:

```
#define  NbrFmtRecords  1024;
```

On the other hand, if you know at programming time the maximum number of columns to expect, you may be able to declare a smaller format array:

```
#define  NbrFmtRecords  6;
```

The definition for the type SqlFormat_Type appears in the full preprocessor generated type include file:

```
typedef struct {
  short  sqlnty;
  short  sqltype;
  short  sqlprec;
  short  sqlscale;
  int    sqltotallen;
  int    sqlvallen;
  int    sqlindlen;
  int    sqlvof;
  int    sqlnof;
  char   sqlname[20];
}  sqlformat_type;
```

Each record in the format array describes one of the columns in the query result. The first record describes the first column, the second record describes the second column, and so forth. Table 8-2 explains the meaning of each field in a format array record.

Table 8-2. Fields in a Format Array Record

FIELD NAME	MEANING OF FIELD	C DATA TYPE
sqlnty	reserved; always set to 110	short
sqltype	data type of column: 0 = SMALLINT or INTEGER 1 = BINARY* 2 = CHAR* 3 = VARCHAR* 4 = FLOAT 5 = DECIMAL 8 = NATIVE CHAR * 9 = NATIVE VARCHAR * 10 = DATE* 11 = TIME* 12 = DATETIME* 13 = INTERVAL* 14 = VARBINARY* * Native CHAR or VARCHAR is what SQLCore uses internally when a CHAR or VARCHAR column is defined with a LANG = ColumnLanguageName clause. They possess the same characteristics as the related types CHAR and VARCHAR, except that data stored in native columns will be sorted, compared, or truncated using local language rules. Native and Date/Time/Interval character types are compatible with regular character types.	short
sqlprec	precision of DECIMAL data	short
sqlscale	scale of DECIMAL data	short
sqltotallen	byte sum of sqlvallen, sqlindlen, indicator alignment bytes, and next data value alignment bytes	int
sqlvallen	number of bytes in data value, including a 4-byte prefix containing actual length of VARCHAR data	int
sqlindlen	number of bytes null indicator occupies in the data buffer: 0 bytes: column defined NOT NULL 2 bytes: column allows null values	short
sqlvof	byte offset of value from the beginning of a row	int
sqlnof	byte offset of null indicator from the beginning of a row, dependent on the value of sqlindlen	int
sqlname	defined name of column or, for computed expression, EXPR	char[30]

Setting Up the Data Buffer

You use different approaches to setting up the data buffer depending on whether your dynamic query result has an unknown format or a known format. If the query result has an unknown format, you may not know the number of columns or their data types. If the query result has a *known format*, you know in advance the number of columns in the query result and the data type of each column.

Setting up a Buffer for Query Results of Unknown Format

For query results of unknown format, you declare the data buffer as a character array:

```
#define  MaxDataBuff  2500    /* bytes in data buffer  */
.
.
.
char  DataBuffer[MaxDataBuff]; /*  the data buffer  */
```

The data buffer must be large enough to hold all the rows ALLBASE/SQL retrieves each time you execute the FETCH command, i.e., the number of rows you specify in SQLDA.SqlNRow. The data buffer defined above can hold as many as 2500 bytes of data.

Although the data buffer above can hold 2500 bytes, it would not be able to hold 2500 bytes of column values if any of the values were null and/or VARCHAR:

- If a column can contain null values, ALLBASE/SQL appends a 2-byte suffix to the data value when it puts the data into the data buffer. This suffix, referred to as a **null indicator**, contains a 0 when the data value *is not null* and a negative number when the value *is null*. You use the sqlindlen field of the format array record to determine whether ALLBASE/SQL returned this suffix with the data.
- When ALLBASE/SQL puts VARCHAR data into the data buffer, it prefixes the data with 4 bytes containing the actual length of the VARCHAR string. You use the sqltype field of the format array record to identify VARCHAR values. This field is set to 3 when data returned to the data buffer has this prefix.

You can use the SQLDA.SqlRowLen value to compute how many rows will fit into the data buffer. Dividing SQLDA.SqlRowLen into SQLDA.SqlBufLen gives you the number of rows, including any VARCHAR prefixes and null indicator suffixes accompanying data values in the row:

```
sqlda.sqlnrow = ((sqlbuflen) / (sqlrowlen));
```

The data buffer declaration shown above is an array of char, because the format of the query result is unknown at programming time.

Setting up a Buffer for Query Results of Known Format

When you know the query result format in advance, you can declare a data buffer as an array of records having the expected format. When a column can contain null values, you *must* declare a 2-byte indicator variable, immediately following the variable for that column. The indicator variable will hold the 2-byte suffix ALLBASE/SQL returns with the data value. In the following example, Column3Ind is an indicator variable for Column3:

```
struct  {
  int     strlen_col1;  /* string length of column1  */
  char    column1[20];
  short   column2;
  int     column3;
  short   column3Ind;    /* indicator variable  */
} databuffer[MaxDataBuff];
```

When a column contains a VARCHAR data type, a 4 byte integer must be declared immediately before the variable for that column to hold the string length. The application itself needs to properly place the string terminator, ASCII 0, into the string.

```
struct  SQLVarChar {
  int length;                    /* actual length of VARCHAR value */
  char VarCharCol[MaxColSize];  /* VARCHAR value */
  };
```

The data types you declare for a query result of known format need not be equivalent to the data types of their corresponding columns, but they should be compatible. (DATE, TIME, DATETIME, and INTERVAL values are treated like CHAR values.) Refer to the *ALLBASE/SQL Reference Manual* for the rules governing data type compatibility and conversion for complete information on this topic. The *ALLBASE/SQL Reference Manual* also addresses type conversion that may occur when a select list item is an expression containing data of different types. When you expect truncation, the column must allow nulls in order to detect the truncation.

Using the Dynamic Query Data Structures

You use the sqlda, the format array, and the data buffer in the following sequence of operations:

- Declare a data buffer to hold the query result. This may be structured or not, depending on whether you know the format of the query result in advance. The following is unstructured:

  ```
  #define  MaxDataBuff  1000     /* bytes in data buffer */

  char  DataBuffer[MaxDataBuff]; /*  the data buffer */
  ```

  When the select list is known, you can define the data buffer as an array of records having the expected format:

  ```
   #define MaxNbrRows   200
  char DataBuffer[MaxNbrRows];

  struct {
     Column1DataType     Column1;
     Column2DataType     Column2;
     } DataBuffer[MaxNbrRows];
  ```

- You declare a format array as *sqlformat_type*. This type is defined for you in the preprocessor generated type include file. The number of records in the format array in this example is 1024, which allows for the maximum size query result of 1024 columns.

```
#define  NbrFmtRecords  1024    /* Columns expected */
.
.
sqlformat_type   sqlfmts[NbrFmtRecords]; /* sqlfmts is the format array */
```

- Use a host variable for the SELECT command, and pass it to ALLBASE/SQL in the PREPARE command:

```
EXEC SQL BEGIN DECLARE SECTION;
char    DynamicCommand[2048];
EXEC SQL END DECLARE SECTION;
.
.
.
EXEC SQL PREPARE Cmd1 FROM :DynamicCommand;
```

- Initialize two sqlda fields, **sqln** and **sqlfmtarr**. sqln is set to the size of the format array, and sqlfmtarr is set to its address.

```
.
sqlda.sqln      = NbrFmtRecords;  /* Maximum select list elements*/
sqlda.sqlfmtarr = sqlfmts;        /* Format array address */
```

- Execute the DESCRIBE command:

```
EXEC SQL DESCRIBE Cmd1 INTO sqlda;
```

  During the execution of the DESCRIBE command, ALLBASE/SQL returns to the format array and to the SQLDA the information you need later to parse and handle the query result. You use format array information to parse the data buffer when you do not know in advance the format of a query result.

Note When you know the format of the query result in advance, you can define a data buffer having the format you expect, and you do not need to use format array information to parse it. However, you still need to declare the format array.

- Declare and open a cursor for the prepared query:

```
EXEC SQL DECLARE Cursor1 CURSOR FOR Cmd1;
EXEC SQL OPEN Cursor1;
```

- Before retrieving rows into the data buffer, initialize three SQLDA fields. These fields identify your data buffer and specify how many rows you want retrieved into the data buffer each time the FETCH command is executed:

```
with SQLDA do
  begin
    sqlda.sqlbuflen = sizeof(DataBuffer);      /* bytes in data buffer */
    sqlda.sqlrowbuf = int(DataBuffer);         /* data buffer address */
                                               /* cast as INT   */
    sqlda.sqlnrow   = ((sqlda.sqlbuflen) / (sqlda.sqlrowlen));
                                               /* number of rows to FETCH */
  end;
```

- Execute the FETCH command. ALLBASE/SQL packs the data buffer with as many rows from the active set as you specified in SQLDA.SqlNRow. ALLBASE/SQL puts the first select list value into the data buffer, starting at the first byte of the format array and including any VARCHAR prefixes, ALLBASE/SQL null indicators for columns that can contain null values, and any alignment bytes provided by the C compiler. Then ALLBASE/SQL writes the second through last select list values for the first row. If the query result contains another row, the first through last select list values in that row are written to the data buffer. Data values are thus concatenated in the data buffer until the last row has been fetched. When the last row in the active set has been fetched, ALLBASE/SQL sets SQLCA.SQLCODE to 100.

  In Figure 8-5, two columns are selected from the vendors table in the sample database. Column VendorNumber is defined in the table as an INTEGER that cannot contain a null value. Column VendorRemarks is defined in the table as a VARCHAR that can contain a null value. Since the VendorRemarks column can contain a null value, a two byte null indicator needs to be provided immediately following this VARCHAR data column. Note the two byte filler that completes the VendorRemarks column definition. The figure illustrates the relationships between column definitions and the layout of data in the data buffer.

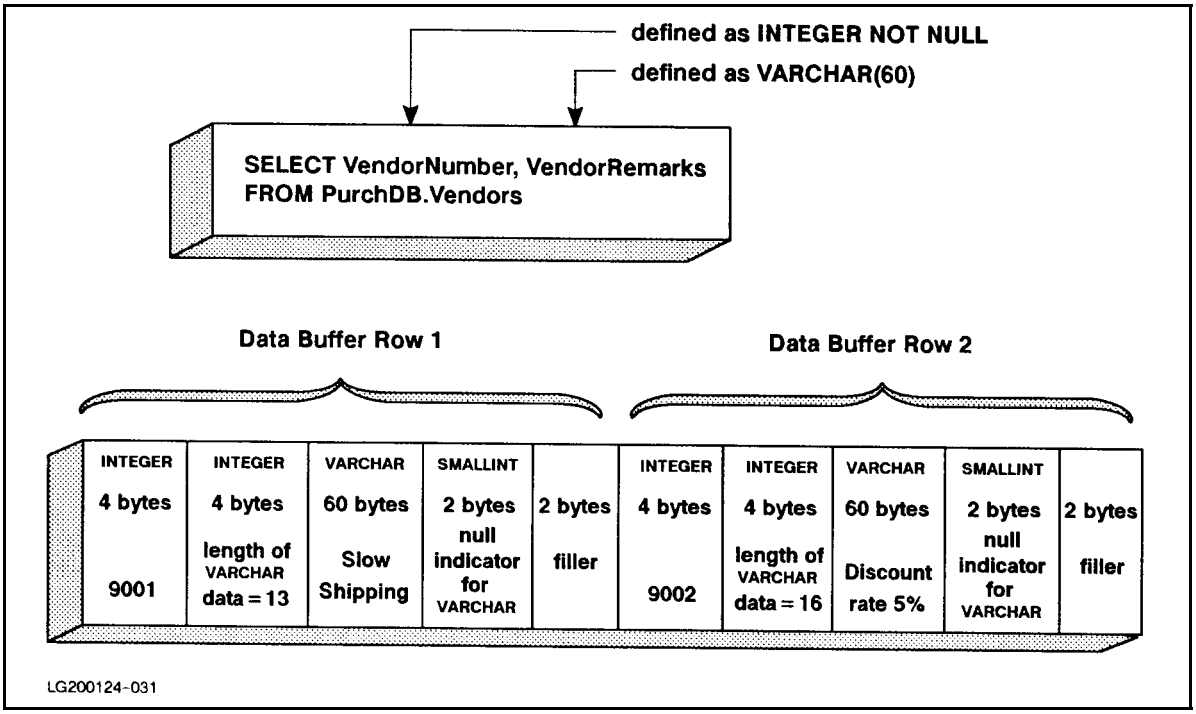


Figure 8-5. Format of the Data Buffer

Note that the number of rows to retrieve with each execution of the FETCH command is specified in SQLDA.SqlNRow. As shown in the above example, you can calculate the number of rows that will fit into the data buffer by dividing the row length (in bytes) into the number of bytes in the data buffer. Sqlrowlen, one of the SQLDA fields set by ALLBASE/SQL when you execute the DESCRIBE command, contains the number of bytes in each row.

```
do {
  EXEC SQL FETCH Cursor1 USING DESCRIPTOR sqlda;
  DisplayRow();
} while (sqlca.sqlcode !=100)
```

- If the query result is of unknown format, parse rows out of the data buffer after each execution of the FETCH command. The technique for parsing is shown in detail in the next section.

Parsing the Data Buffer

The technique for parsing the data buffer and assigning its contents to variables of appropriate types is illustrated in function DisplaySelect of program cex10a. The listing is found in Figure 8-9 in the following section, "cex10a: Program Using Dynamic Commands of Unknown Format." Essentially, you initialize an offset variable for the data buffer, then execute a loop for each row retrieved with the FETCH statement. For each column in the loop, you do the following:

- Check for null values, taking appropriate action when one is found.
- Examine the data type and length of the data element itself, assigning it to an appropriate variable of the corresponding size.
- Increment the offset variable by the value of SQLDA.SqlRowLen (the length of a complete row).

The following diagram summarizes the arithmetic used to parse the data buffer in function DisplaySelect in program cex10a. The data buffer shown is for the first query executed in the dialog in Figure 8-8.

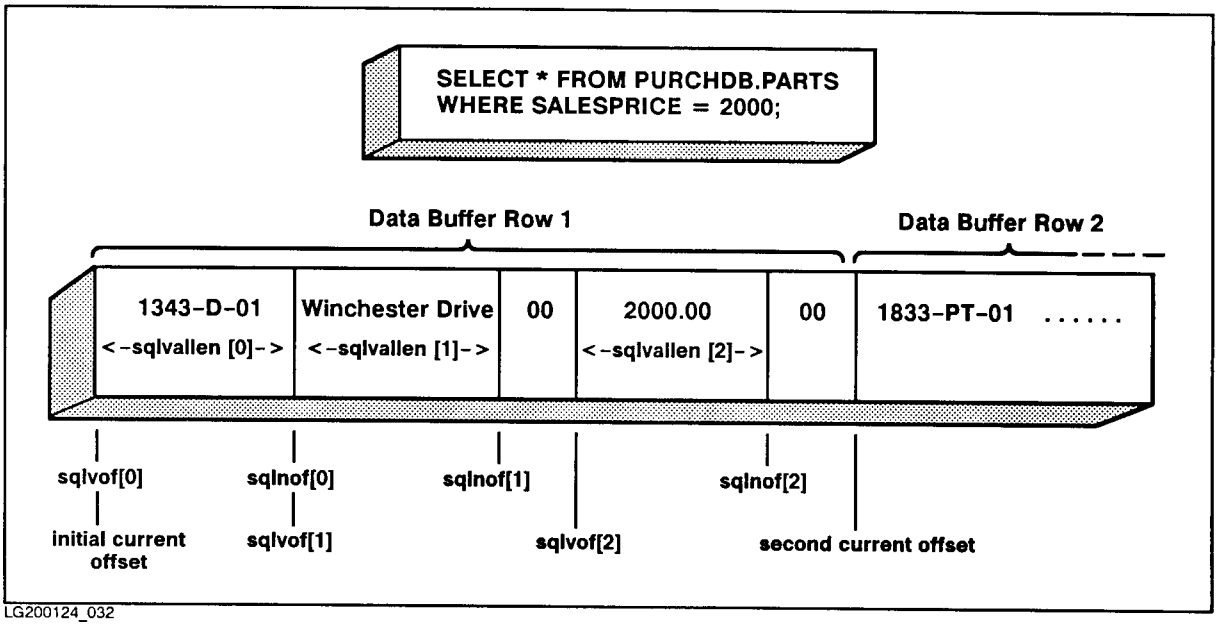


Figure 8-6. Parsing the Data Buffer in cex10a

Program cex10a uses the following assignment to set the start of a row:

```
CurrentOffset = CurrentOffset + SqlRowLen;
```

To find a null indicator, the program uses the following assignment:

```
NullIndOffset = CurrentOffset + sqlfmts[i].SqlNOf;
```

To move a data value into a variant record, cex10a uses the following statement:

```
StrMove(sqlfmts[1].(SqlValLen, DataBuffer,
CurrentOffset + sqlfmts[i].SqlVOf, OneColumn.CharData, 0);
```

Preprocessing of Commands That May or May Not Be Queries

You need special techniques to handle dynamic commands which may be either queries or non-queries. In a program that accepts both query and non-query SQL commands, you first PREPARE the command, then use the DESCRIBE command in conjunction with the *sqlda*, the data structure that lets you identify whether a command is a query. The PREPARE command must appear physically in your source program *before* the EXECUTE or DECLARE CURSOR command that uses the name you assign to the dynamic command in the PREPARE command.

The sqld field of the sqlda is set to 0 if the dynamic command is not a query and to a positive integer if it is a query. The sqlda data structure is used in any program that may host a dynamic query.

In the following example, if the command is not a query, you branch to function NonQuery() and use the EXECUTE or EXECUTE IMMEDIATE command to execute it. If it is a query, you branch to function Query(), where you declare a cursor, open it, then use FETCH to retrieve qualifying rows.

```
EXEC SQL PREPARE ThisCommand FROM :DynamicCommand;
EXEC SQL DESCRIBE ThisCommand INTO sqlda;

if (sqlda.sqld == 0) {
     Nonquery();
     }
else if (sqlda.sqld > 0) {
     Query();
     }
```

To handle a command entirely unknown at programming time, you accept the command into the host variable. In the following example, an SQL command is accepted into a host variable named *DynamicCommand*, declared large enough to accommodate the largest expected dynamic command. User input is accepted into *DynamicClause* and concatenated in *DynamicCommand* until the user enters a semicolon:

```
EXEC SQL BEGIN DECLARE SECTION;
char              DynamicCommand[2048];
EXEC SQL END DECLARE SECTION;
char              DynamicClause[80];
short int         Pos;
.
.
<newpage>
.
.
printf("\n Enter your SQL command or clause ");
printf("\n");
DynamicCommand[0] = '\0';
do {
   printf("\n > ");
   getline(DynamicClause);
   if (DynamicClause[0] != '/') {
      strcat(DynamicCommand," ");
      strcat(DynamicCommand,DynamicClause);
      i = 0;
      while (DynamicClause[i] != '\0' && DynamicClause[i++] !=';');
      if (DynamicClause[i-1] == ';') {
         DynamicClause[0] = '/';
         DynamicClause[1] = '\0';
         }
   }
   else {
      DynamicCommand[0] = '/';
      DynamicCommand[1] = '\0';
   }
} while (DynamicClause[0] != '/');
.
.
EXEC SQL PREPARE SQLCommand FROM :DynamicCommand;
```

Sample Programs Using Dynamic Query Operations

The rest of this chapter contains sample programs that illustrate the use of dynamic preprocessing techniques for queries. There are two complete programs:

- cex10a, which contains statements for executing *any* dynamic command (non-query or query with unknown format).
- cex10b, which contains statements for executing dynamic queries of known format.

For each program, there is a description of the code, a display of the runtime dialog with user input, and a listing.

cex10a: Program for Dynamic Commands of Unknown Format

Programs that host queries having query result formats unknown at programming time must use format array information to parse the data buffer. Figure 8-7 illustrates the logic for one such program, cex10a. The run-time dialog and source code for this program are shown in Figures 8-8 and 8-9, respectively.

Program cex10a executes function *ConnectDBE* (4) to invoke the CONNECT command (37) to start a DBE session in the sample database. It then executes the function named *Describe* (23). This function:

- Initializes the two sqlda fields (24) that must be set before executing the DESCRIBE command: sqlda.sqln (the number of elements in the format array) and sqlda.sqlfmtarr (the address of the format array). The number of elements in the format array is defined in the constant *NbrFmtRecords*, set to 1024 in this program to accommodate the maximum number of columns in any query result.
- Calls function *GetCommand* (25) and processes commands accepted from the user in that function until the user enters a slash (/).

Function *GetCommand* (25) accepts SQL commands into the host variable named *DynamicCommand*. This variable is declared (1) as *char DynamicCommand[2048]* to allow for a dynamic command of up to 2048 bytes, including the semicolon. *GetCommand* concatenates multiple lines of user input by accepting each line into a local variable, *DynamicClause* and adding it to the contents of *DynamicCommand* until the user enters a semicolon.

After SQL command entry is complete, control returns to function *Describe* (23), which:

- Starts a transaction by executing function *BeginTransaction* (6).
- Executes the PREPARE (26) and DESCRIBE (27) commands.
- Examines the sqlda.sqld field (number of columns in query result) to determine whether the dynamic command is a query (29). If this value is 0, the command is not a query and function *NonQuery* (28) is invoked to execute the command. If the sqlda.sqld value is not 0, function *Query* (29) is invoked to execute the command.

You must name a dynamic command in the PREPARE command before you reference it in the EXECUTE or DECLARE CURSOR commands. In this program, the PREPARE command is executed in function *Describe*, which calls both function *NonQuery* and function *Query*, which follow after function *Describe* sequentially in the source code.

Function *Query* (29):

- Displays the number of columns in the query result, by using the value ALLBASE/SQL assigned to sqlda.sqld when the DESCRIBE command was executed (31).
- Declares and opens a cursor for the dynamic query (32).
- Initializes the three sqlda fields that must be set before executing the FETCH command (33): sqlda.sqlbuflen (the size of the data buffer), sqlda.sqlnrow (the number of rows to put into the data buffer with each FETCH), and sqlda.sqlrowbuf (the address of the data buffer).

  Note that to set sqlda.sqlnrow, the program divides the row length into the data buffer size to determine how many rows can fit into the data buffer (34).
- Executes the FETCH command (35) and calls function *DisplaySelect* (36) until the last row in the active set has been fetched. When no more rows are available to fetch, ALLBASE/SQL sets sqlca.sqlcode to *100*.

Function *DisplaySelect* (36) parses the data buffer after each FETCH operation and displays the fetched rows:

- The function keeps track of the beginning of each row by using a local variable, *CurrentOffset*, as a pointer. *CurrentOffset* is initialized to *0* (10) at the beginning of function *DisplaySelect*.
- Column headings are written from the *sqlfmts[x].sqlname* field of each format array record (11). The loop that displays the headings uses the sqlda.sqld value (the number of columns in the query result) as the final value of a format array record counter (x).
- The first through last column values in each row are examined and displayed in a loop. The loop uses the sqlda.sqlrrow value (the number of rows fetched) as the final value of a row counter (12). The loop also uses the sqlda.sqld value (the number of select list items) as the final value of a column counter (13).
- The *sqlfmts[i].sqlindlen* field of each column's format array record is examined (14) to determine whether a null value may exist.
- If a column can contain null values, *sqlfmts[i].sqlindlen* is greater than zero, and the function must examine the indicator variable to determine whether a value is null. A local variable, *NullIndOffset*, is used to keep track of the first byte of the current indicator variable (15).
- Any null indicator can be located by adding the current value of *sqlnof* to the current value of *CurrentOffset*. *Sqlfmts[i].sqlnof* is the format array record field that contains the byte offset of a null indicator from the beginning of a row. Recall that *CurrentOffset* keeps track of the beginning of a row.
- *DataBuffer* and *NullIndOffset* are used to determine whether or not a null value exists. If a null value exists, the function displays the message *Column is NULL* (17).
- If a value is not null, it is moved (18) from the data buffer to *OneColumn.CharData*. The starting location of a value in the *StrMove* function (30) is computed by adding the current value of *sqlfmts[i].sqlvof* to the current value of *CurrentOffset*. *Sqlfmts[i].sqlvof* is the format array record field that contains the byte offset of a value from the beginning of a row. The number of bytes to move is the value stored in sqlfmts[i].sqlvallen. *OneColumn.CharData* is one of the variations of the variant record, *GenericType* (9).
- The *GenericType* type definition is used to write data values. This variant record has a record definition describing a format for writing data of each of the ALLBASE/SQL data

types. The record variation used depends on the value of *sqlfmts[i].sqltype* (19), the format array record field describing the data type of a select list item. In the case of DECIMAL data, a function named *BCDToString* (2) converts the binary coded decimal (BCD) information in the data buffer into ASCII format for display purposes.

- After each value in a row is displayed, *CurrentOffset* is incremented by *sqlda.sqlrowlen* (20) to point to the beginning of the next row.

When the dynamic command has been completely processed, function *Query* calls function *EndTransaction* (7) to process a COMMIT WORK command. Thus each dynamic query hosted by this program is executed in a separate transaction.

To determine whether each SQL command executed successfully, the program examines the value of sqlca.sqlcode after each SQL command is executed. Function *SQLStatusCheck* (3) is invoked to display one or more messages from the ALLBASE/SQL message catalog. Any other action taken depends on the SQL command:

- If the CONNECT command fails, function *ConnectDBE* (4) sets the *Connect* flag to *FALSE*, calls function *SQLStatusCheck*, and then terminates the program.
- If the BEGIN WORK command fails, function *BeginTransaction* (6) calls *SQLStatusCheck* to display messages, then calls function *ReleaseDBE* (5) to end the DBE session. The program then terminates because function *Describe* (23) sets *DynamicCommand* to a slash (31).
- If other SQL commands fail, function *SQLStatusCheck* terminates the program whenever the error is serious enough to return an sqlca.sqlcode less than -14024.

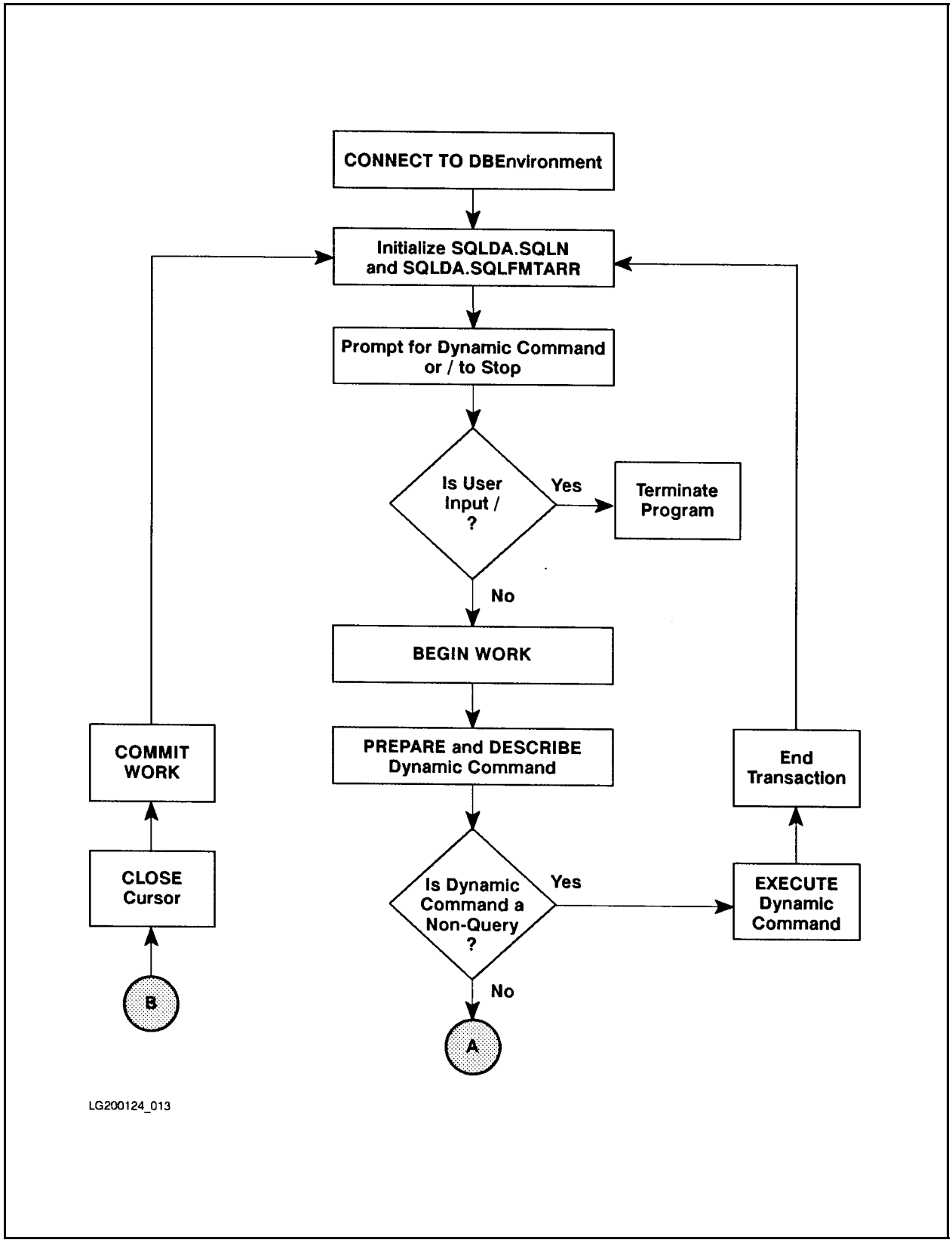


Figure 8-7. Flow Chart of Program cex10a

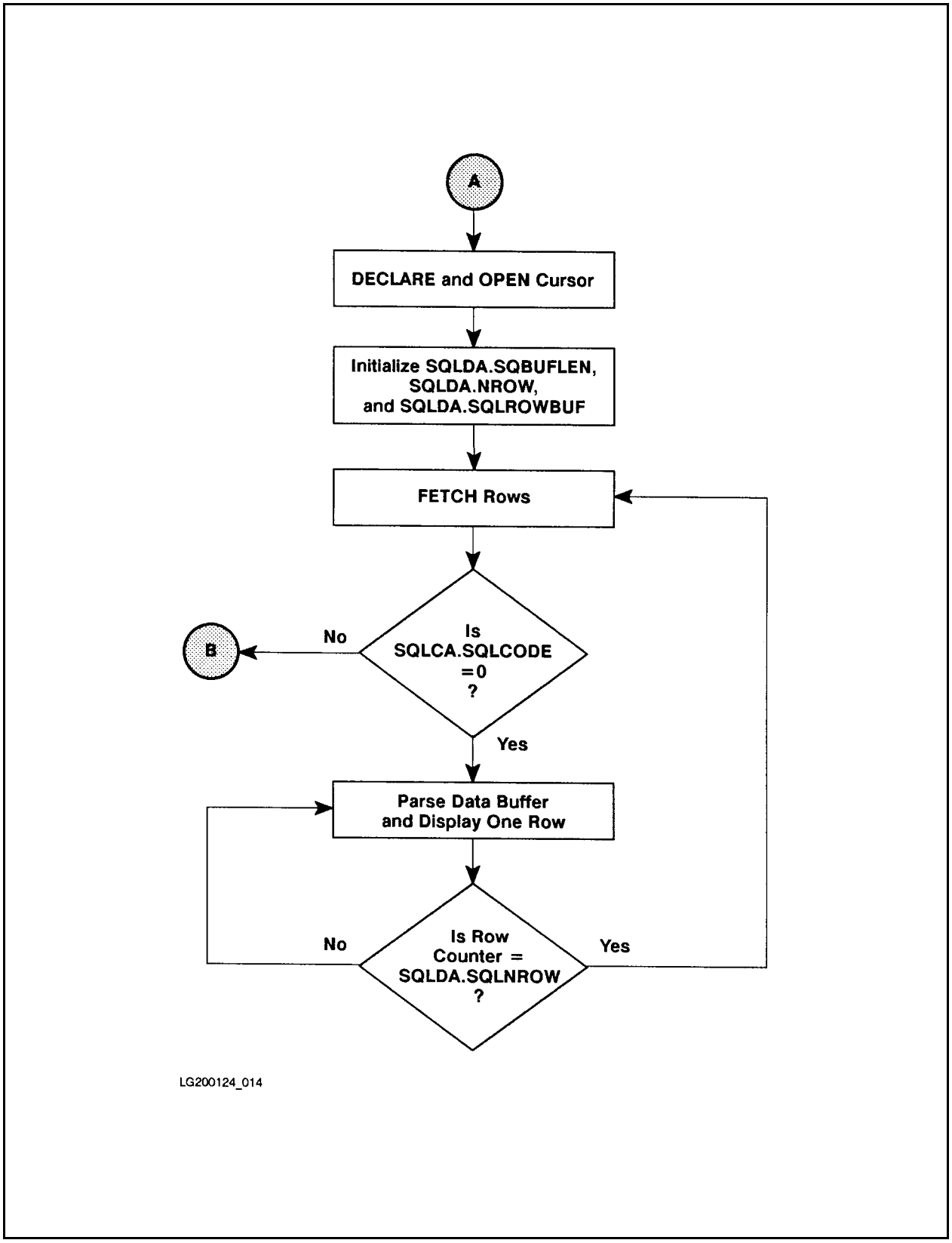


Figure 8-7. Flow Chart of Program cex10a (page 2 of 2)

```
C program illustrating dynamic command processing -- cex10a

Event List:
  CONNECT TO PartsDBE
  Prompt for any SQL command
  BEGIN WORK
  PREPARE
  DESCRIBE
  If the command is a non-query command, execute it;
    otherwise execute the following:
  DECLARE CURSOR
  OPEN Cursor
  FETCH a row
  CLOSE CURSOR
  COMMIT WORK
  Repeat the above ten steps until the user enters a /
  RELEASE PartsDBE

Connect to PartsDBE

You may enter any SQL command or '/' to STOP the program.
The command can be continued on the next line.  The command
must be terminated with a semicolon.

Enter your SQL command or clause >

> SELECT * FROM PURCHDB.PARTS WHERE SALESPRICE = 2000;

Begin Work
Prepare SELECT * FROM PURCHDB.PARTS WHERE SALESPRICE = 2000;

Describe
A Query SQL command was entered.

Number of columns:  3

PARTNUMBER       | PARTNAME                      | SALESPRICE       |
1343-D-01        | Winchester Drive              |          2000.00 |

Row not found or no more rows!

Commit Work

You may enter any SQL command or '/' to STOP the program.
The command can be continued on the next line.  The command
must be terminated with a semicolon.
```

Figure 8-8. Run Time Dialog of Program cex10a

```
Enter your SQL command or clause >

> DELETE FROM PURCHDB.PARTS WHERE PARTNUMBER = '1343-D-01';

Begin Work
Prepare DELETE FROM PURCHDB.PARTS WHERE PARTNUMBER = '1343-D-01';

Describe
A Non-Query SQL command was entered.
Execute
The Non-Query Command Executed Successfully!

Commit Work

You may enter any SQL command or '/' to STOP the program.
The command can be continued on the next line.  The command
must be terminated with a semicolon.

Enter your SQL command or clause >
> SELECT * FROM PURCHDB.PARTS WHERE SALESPRICE = 2000;

Begin Work
Prepare SELECT * FROM PURCHDB.PARTS WHERE SALESPRICE = 2000;

Describe
A Query SQL command was entered.

Number of columns:  3

Row not found or no more rows!

Commit Work

You may enter any SQL command or '/' to STOP the program.
The command can be continued on the next line.  The command
must be terminated with a semicolon.

Enter your SQL command or clause > /

Release PartsDBE
```

Figure 8-8. Run Time Dialog of Program cex10a (page 2 of 2)

```
/* Program cex10a */

/* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * */
/* This program illustrates dynamic preprocessing of SQL commands  */
/* including SELECT commands using the DESCRIBE command.           */
/* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * */

#include <stdio.h>
#include <malloc.h>

typedef int boolean;

#define  NotFound          100
#define  OK                  0
#define  DeadLock       -14024

/* NbrFmtRecords is number of columns expected in a dynamic SELECT. */
#define  NbrFmtRecords    1024
#define  EndOF             100
#define  MaxDataBuff      2500
#define  MaxColSize       3996
#define  MaxStr            132
#define  TRUE                1
#define  FALSE               0

          /* Begin Host Variable Declarations */
  EXEC SQL BEGIN DECLARE SECTION;
/* DynamicCommand is a String that will hold the dynamic command. */
  char  DynamicCommand[1023];                                      (1)
  EXEC SQL END DECLARE SECTION;
          /* End Host Variable Declarations */

EXEC SQL INCLUDE SQLCA;

/* SQLDA is the SQL DESCRIBE Area used by the DESCRIBE command. */
EXEC SQL INCLUDE SQLDA;

/* Each record in sqlfmts will hold information about each column */
/* in a dynamic SELECT. */

sqlformat_type sqlfmts[NbrFmtRecords];

/* Nibbles and BCDType are data types needed for decimal type */
int      Nibbles;
char     BCDType[20];
```

Figure 8-9. Program cex10a: Dynamic Queries of Unknown Format

```
/* DataBuffer is the buffer containing retrieved data as a result */
/* of a dynamic SELECT. */

char     DataBuffer[MaxDataBuff];
boolean  Abort;

struct SQLVarChar {
  int      Length;
  char     VarCharCol[MaxColSize];
  };

main()    /* Beginning of Program */
{
printf("\nC program illustrating dynamic command processing -- cex10a");
printf("\n");
printf("\nEvent List:");
printf("\n  CONNECT TO PartsDBE");
printf("\n  Prompt for any SQL command");
printf("\n  BEGIN WORK");
printf("\n  PREPARE");
printf("\n  DESCRIBE");
printf("\n  If command is a non-query command, EXECUTE it");
printf("\n  Otherwise execute the following:");
printf("\n  DECLARE CURSOR");
printf("\n  OPEN Cursor");
printf("\n  FETCH a row");
printf("\n  CLOSE Cursor");
printf("\n  COMMIT WORK");
printf("\n  Repeat the above ten steps");
printf("\n  RELEASE PartsDBE\n");

if (ConnectDBE()) {                                          (4)
    Describe();                                              (23)
    ReleaseDBE();
    printf("\n");
  }
  else
    printf("\nError: Cannot Connect to PartsDBE");
    printf("\n");
}   /* End of Main Program */


/* Function BCDToString converts a binary field in the "DataBuffer" */
/* buffer to its ACSII representation.  Input parameters are */
/* the Length, Precision and Scale.  The input decimal field is passed */
/* via "DataBuffer" and the output String is passed via "result".  */
```

Figure 8-9. Program cex10a: Dynamic Queries of Unknown Format (page 2 of 11)

```
int BCDToString(DataBuffer, Length, Precision, Scale, Result0)      (2)
char  DataBuffer[];
short Length, Precision, Scale;
char  Result0[];
{
#define  hexd        '0123456789ABCDEF'
#define  ASCIIZero   '0'
#define  PlusSign    12
#define  MinusSign   13
#define  UnSigned    14
#define  btod(d,i)   ((i&1)?((d[i/2])&0xf):((d[i/2]>>4)&0xf))

  int       i;
  int       DecimalPlace;
  int       PutPos=0;
  int       DataEnd;
  int       DataStart;
  boolean   done;
  char      space[MaxStr];
  char      *Result;

  Result = space;
  DataEnd = (Length*2) - 2;
  DataStart = (DataEnd - Precision);
  for (i = 0; i < MaxStr; i++) Result[i] = '\0';
  DecimalPlace = (Precision-Scale);

/* convert decimal to character String */
  if (DecimalPlace == 0) Result[PutPos++] = '.';

  /* convert each Nibble into a character */
  for (i = DataStart; i <= DataEnd; i++) {
    Result[PutPos] = ASCIIZero + btod(DataBuffer,i);
    if (PutPos == DecimalPlace) Result[++PutPos] = '.';
    PutPos++;
    }

  i    = 0;
  done = FALSE;
  while (i<strlen(Result) && Result[i]=='0') ++Result;

  if (Result[0] == '\0')
     Result[0] = '0';
  else {
     /* place a zero at the left of the decimal point */
     if (Result[0] == '.') StrInsert('0', Result);
```

Figure 8-9. Program cex10a: Dynamic Queries of Unknown Format (page 3 of 11)

```
      /* insert sign */
      switch (btod(DataBuffer,DataEnd + 1)) {
          case PlusSign:  StrInsert(' ', Result);
                          break;
          case MinusSign: StrInsert('-', Result);
                          break;
          default:        break;
          } /* End switch */
       } /* End else */
   strcpy(Result0, Result);
} /* End BCDToString */

int getline(linebuff)  /*Function to get a line of characters  */
char linebuff[80];
{
while (strlen(gets(linebuff)) ==0);
}  /* End of function to get a line of characters  */

int SQLStatusCheck()  /* Function to Display Error Messages */      (3)
{

Abort = FALSE;
if (sqlca.sqlcode < DeadLock) Abort = TRUE;

do {
EXEC SQL SQLEXPLAIN :SQLMessage;
printf("\n");
printf("%s\n",SQLMessage);
} while (sqlca.sqlcode != 0);

if (Abort) {

  EXEC SQL COMMIT WORK RELEASE;
  DynamicCommand[0] = '/';
  DynamicCommand[1] = '\0';
  }

}  /* End SQLStatusCheck Function */


int ConnectDBE()  /* Function to Connect to PartsDBE */
{                                                                   (4)
boolean Connect;
printf("\nConnect to PartsDBE");
EXEC SQL CONNECT TO 'PartsDBE';                                    (37)
```

Figure 8-9. Program cex10a: Dynamic Queries of Unknown Format (page 4 of 11)

```
Connect = TRUE;
if (sqlca.sqlcode != OK) {

  Connect = FALSE;
  SQLStatusCheck();
  }  /* End if */
  return(Connect);
}  /* End of ConnectDBE Function */

int ReleaseDBE()   /* Function to Release PartsDBE */                    (5)
{
printf("\nRelease PartsDBE");
EXEC SQL RELEASE;
if (sqlca.sqlcode != OK)  SQLStatusCheck();

}  /* End ReleaseDBE Function */

boolean BeginTransaction()    /* Function to Begin Work */              (6)
{
boolean BeginTransaction;
printf("\n");
printf("\nBegin Work");
EXEC SQL BEGIN WORK;
if (sqlca.sqlcode != OK) {

  BeginTransaction = FALSE;
  SQLStatusCheck();
  ReleaseDBE();                                                          (5)
  }
else
  BeginTransaction = TRUE;
return(BeginTransaction);

}  /* End BeginTransaction Function */


int EndTransaction()   /* Function to Commit Work */                     (7)
{

  printf("\n");
  printf("\nCommit Work");
  EXEC SQL COMMIT WORK;
  if (sqlca.sqlcode != OK) SQLStatusCheck();

}  /* End EndTransaction Function */
```

Figure 8-9. Program cex10a: Dynamic Queries of Unknown Format (page 5 of 11)

```
/* Function DisplaySelect deblocks the result of the dynamic */
/* SELECT in "DataBuffer".   */

int DisplaySelect()                                                    36
{

typedef union gt {                                                      9
  char               CharData[MaxColSize];
  char               VarCharData[MaxColSize];
  int                IntegerData;
  short              SmallIntData;
  double             FloatData;
  float              DecimalData;
  } GenericType;

  short          CurrentOffset;
  short          NullIndOffset;
  GenericType    OneColumn;
  char           DecString[20];
  boolean        IsNull;
  short          n,i,j,x;         /* local loop counters */

CurrentOffset = 0;                                                     10

for (x = 0; x < sqlda.sqld; x++) {    /* display column names */
    printf("%s | ",sqlfmts[x].sqlname);                                11
  }
printf("\n");

for (n = 0; n < sqlda.sqlrrow; n++) {     /* for each FETCHed row */
                                                                       12
  for (i = 0; i < sqlda.sqld; i++) {  /*for each column in a FETCHed row*/
                                                                       13
  /* Check to see if this column has the value NULL.  This is done */
  /* by checking the NULL indicator in the buffer.  This indicator */
  /* appears after the data value for this column.                 */

    IsNull = FALSE;
    if (sqlfmts[i].sqlindlen > 0) {                                    14

        NullIndOffset = CurrentOffset + sqlfmts[i].sqlnof;             15

        if ((DataBuffer[NullIndOffset] == '\0') &&                     16
          (DataBuffer[NullIndOffset+1] == '\0')) {
          IsNull = FALSE;
          }
        else
          IsNull = TRUE;
```

Figure 8-9. Program cex10a: Dynamic Queries of Unknown Format (page 6 of 11)

```
} /* End if sqlfmts[i].sqlindlen > 0 .. */

  if (IsNull) {
    printf(" Column is NULL |");                                    (17)
    }
  else {

      /* Now bring down the actual value of this column.  */

      StrMove(sqlfmts[i].sqlvallen,DataBuffer,                      (18)
        CurrentOffset + sqlfmts[i].sqlvof, OneColumn.CharData, 0);
                                                                    (30)
      switch (sqlfmts[i].sqltype) {                                 (19)
        case 0:                  /* Integer number         */
          switch (sqlfmts[i].sqlvallen) {
            case 2: printf("%d | ",OneColumn.SmallIntData);
                    break;
            case 4: printf("%d | ",OneColumn.IntegerData);
                    break;
            }  /* End switch statement */
          break;
        case 2:                  /* fixed-length character */
        case 8:                /* fixed-length native character */
            for (j = 0; j < sqlfmts[i].sqlvallen; j++)
              printf("%c",OneColumn.CharData[j]);
            printf(" | ");
            break;
        case 3:                  /* variable-length char   */
        case 9:                  /* variable-length native char */
            for (j = 4; j < sqlfmts[i].sqlvallen; j++)
            printf("%s | ",OneColumn.VarCharData[j]);
              printf(" | ");
          break;
        case 4:                  /* floating point         */
            printf("%f | ",OneColumn.FloatData);
          break;
        case 5:                  /* Packed decimal         */(2)
            BCDToString(OneColumn.CharData, sqlfmts[i].sqlvallen,
              sqlfmts[i].sqlprec, sqlfmts[i].sqlscale, DecString);
            printf("%s | ",DecString);
          break;
            default: printf("SQLType = %1s\n",sqlfmts[i].sqltype);
          break;
      }  /* End switch statement */

    }    /* End if IsNull else   */
```

Figure 8-9. Program cex10a: Dynamic Queries of Unknown Format (page 7 of 11)

```
        }   /* End for i/with sqlfmts[i] ...    */

    CurrentOffset = CurrentOffset + sqlda.sqlrowlen;                20

    printf("\n");

  }  /* End for n = ...  */

 printf("\n");

}   /* End of DisplaySelect function */

int GetCommand()                                                    25
{
  char       DynamicClause[80];
  short      i;

printf("\n");
printf("\nYou may enter any SQL command or a '/' to STOP the program.");
printf("\nThe command can be continued on the next line.  The command");
printf("\nmust be terminated with a semicolon.");
printf("\n");
printf("\nEnter your SQL command or clause ");
printf("\n");
DynamicCommand[0] = '\0';      /* @001 */
do {
printf("\n >");
getline(DynamicClause);
if (DynamicClause[0] != '/') {
    strcat(DynamicCommand," ");
    strcat(DynamicCommand,DynamicClause);
    i = 0;
    while (DynamicClause[i] != '\0'&& DynamicClause[i++] != ';');
    if (DynamicClause[i-1] == ';')  {

        DynamicClause[0] = '/';     /* @001 */
        DynamicClause[1] = '\0';    /* @001 */
      }
  }
else  {

    DynamicCommand[0] = '/';
    DynamicCommand[1] = '\0';     /* @001 */
  }
} while (DynamicClause[0] != '/');  /* End do */     /* @001 */
}  /* End of GetCommand function */
```

Figure 8-9. Program cex10a: Dynamic Queries of Unknown Format (page 8 of 11)

```
int Describe()   /* Describe Function */                                    23
{

/* set up SQLDA fields */                                                  24
    sqlda.sqln      = NbrFmtRecords;     /* number of columns expected */
    sqlda.sqlfmtarr = sqlfmts;

do {
  GetCommand();                                                            25

  if (DynamicCommand[0] != '/') {     /* @001 */

      if (BeginTransaction()) {                                             6

          printf("\nPrepare");
          printf("%s\n",DynamicCommand);
          EXEC SQL PREPARE CMD1 FROM :DynamicCommand;                      26
          if (sqlca.sqlcode != OK) {
              SQLStatusCheck();
              EndTransaction();
            }
          else  {

            printf("\nDescribe");
            EXEC SQL DESCRIBE CMD1 INTO SQLDA;                             27
            if (sqlca.sqlcode != OK) {
                SQLStatusCheck();
                EndTransaction();
              }
              else  {

                if (sqlda.sqld == 0) NonQuery();                           28
                else
                  Query();                                                 29
              } /* End if sqlca.sqlcode != OK after DESCRIBE  */

          }  /* End if sqlca.sqlcode != OK after PREPARE  */

      }  /* End if BeginTransaction */
      else  {                   /* BeginTransaction failed; */
                                                                           31
        DynamicCommand[0] = '/';   /* force logical to */   /* @001 */
        DynamicCommand[1] = '\0';  /* Describe function */  /* @001 */
      }
```

Figure 8-9. Program cex10a: Dynamic Queries of Unknown Format (page 9 of 11)

```
    }  /* End if DynamicCommand */

  } while (DynamicCommand[0] != '/');   /* End do */  /* @001 */

}  /* End of Describe function */


int NonQuery()                                                    29
{

printf("\nA Non Query SQL command was entered.");
printf("\nExecute");
EXEC SQL EXECUTE CMD1;
if (sqlca.sqlcode != OK) {
  SQLStatusCheck();
  EXEC SQL ROLLBACK WORK;
  }
else  {

  printf("\nThe Non-Query Command Executed Successfully.");
  EndTransaction();
  }
}  /* End of NonQuery function */


int Query()                                                       28
{
  short     RowLength;
  short     i;

printf("\nA Query SQL command was entered.");
printf("\n");
printf("\nNumber of columns:  %2d",sqlda.sqld);                   31
printf("\n");

EXEC SQL DECLARE CURSOR1 CURSOR FOR CMD1;                         32
EXEC SQL OPEN CURSOR1;
if (sqlca.sqlcode != OK) SQLStatusCheck();
  else {

    sqlda.sqlbuflen = sizeof(DataBuffer);                         33
    sqlda.sqlnrow = ((sqlda.sqlbuflen) / (sqlda.sqlrowlen));      34
    sqlda.sqlrowbuf = DataBuffer;

  while (sqlca.sqlcode == 0) {

  EXEC SQL FETCH CURSOR1 USING DESCRIPTOR SQLDA;                  35
  if (sqlca.sqlcode != OK) {
```

Figure 8-9. Program cex10a: Dynamic Queries of Unknown Format (page 10 of 11)

```
        if (sqlca.sqlcode == EndOF) {
          printf("\nRow not found or no more rows!");
          }
        else
          SQLStatusCheck();
      }
      else
        DisplaySelect();                                          (36)

    }    /* End of while sqlca.sqlcode = 0 */

  EXEC SQL CLOSE CURSOR1;
  if (sqlca.sqlcode != OK) SQLStatusCheck();
  }   /* End of if OPEN CURSOR is OK */

  EndTransaction();                                               (7)
  }  /* End of Query function */

  int StrMove(n,s1,p1,s2,p2)                                      (30)
  int n, p1, p2;
  char s1[], s2[];
  {
    int i = 1;

    while (i++ <= n)
      s2[p2++] = s1[p1++];
  }     /* StrMove */

  int StrInsert(c, string)
  char c;
  char *string;
  {
    char *temp;

    temp = malloc(MaxStr);
    strcpy(temp, string);
    *string++ = c;
    while ((*string++ = *temp++) != '\0');
  }     /* StrInsert */
```

Figure 8-9. Program cex10a: Dynamic Queries of Unknown Format (page 11 of 11)

cex10b: Program Using Dynamic Commands of Known Format

In some applications, you may know the format of a query result in advance, but may still want to dynamically preprocess the query to create a program that does not have a permanently stored module. Database administration utilities that include system catalog queries often fall into this category of application.

In programs hosting dynamic queries having query results of a known format, you do not need to use the format array to parse the data buffer. Because you know in advance the query result format, you can pre-define an array having a complementary format and read information from the array without having to determine where data is and the format in which it has been returned.

Program cex10b, whose flow chart is shown in Figure 8-10, whose execution is illustrated in Figure 8-11, and whose source code appears in Figure 8-12, executes two dynamic queries with select lists known at programming time. The program reads the *SYSTEM.TABLE* view and the *SYSTEM.COLUMN* view in order to re-create the SQL CREATE TABLE commands originally used to define the tables in the DBEnvironment. The CREATE TABLE commands are stored in a file you name when you execute the program. Such a file can be used as an ISQL command file in order to re-create the tables in some other DBEnvironment.

The program first prompts (6) for the name of the schema file in which to store the table definitions. It purges (7) any file that exists by the same name.

The program then prompts for a DBEnvironment name (8). The DBEnvironment name is used to build a CONNECT command (9) in host variable *CmdLine*. The CONNECT command is executed by using the EXECUTE IMMEDIATE command (10).

The program then prompts for an owner name (11). If an owner name is entered, it is upshifted (12), then added to the WHERE clause in the first dynamic query (14):

```
sprintf(CmdLine,"SELECT OWNER, NAME, DBEFILESET, RTYPE FROM SYSTEM.TABLE\
  WHERE TYPE = 0 AND OWNER = '%s';",OwnerName);
```

This query retrieves a row for every table (TYPE = 0) having an owner name as specified in the variable *OwnerName*. Each row consists of four columns: the owner name, the table name, the name of the DBEFileSet with which the table is associated, and the automatic locking mode.

To obtain a definition of all tables in a DBEnvironment *except* those owned by *SYSTEM*, the user enters ALL in response to the owner name prompt. In this case, the program uses the following form of the dynamic query (13):

```
sprintf(CmdLine,"SELECT OWNER, NAME, DBEFILESET, RTYPE FROM SYSTEM.TABLE\
  WHERE TYPE = 0 AND OWNER <> 'SYSTEM';");
```

The PREPARE command (15) creates a temporary section named *SelectCmd1* for the dynamic query from *CmdLine*.

Then the program initializes the two sqlda fields (16) needed by the DESCRIBE command (17). Because the number of columns in the query result is known to be *four* at programming time, *sqlda.sqln* is set to *4*. Four of the format array records will be needed, one per select list item.

The program then declares and opens a cursor named *TableList* for the dynamic query (18). Before using the cursor to retrieve rows, the program initializes several sqlda fields (19) as follows:

- The *sqlda.sqlnrow* field is set to *300*, as defined in the constant *MaxNbrTables* (1). This number is the maximum number of rows ALLBASE/SQL will return from the active set when the FETCH command is executed.
- The *sqlda.sqlbuflen* field is set to the size of the data buffer. In this program, the data buffer for the first query is a structure array of records named *TableList* (4). Note that each record in the array consists of four elements, one for each item in the select list. The elements are declared with types compatible with those in their corresponding SYSTEM.TABLE columns. Note also that each element in the array is declared as the same size as its corresponding column in the system table and not one character larger. It is up to the program to insert the ASCII 0 null character in the correct location to indicate the end of a character string.
- The *sqlda.sqlrowbuf* field is set to the address of the data buffer.

After initializing the required fields in the sqlda, the program executes the FETCH command (20). Because the FETCH command is executed only once, this program can re-create table definitions for a maximum of 300 tables.

After the FETCH command is executed, the value in sqlca.sqlerrd[2] is saved in variable *NumOfTables* (21). This value indicates the number of rows ALLBASE/SQL returned to the data buffer. *NumOfTables* is used later as the final value of a counter (23) to control the number of times the second dynamic query is executed; the second query must be executed once for each table qualifying for the first query.

After terminating the transaction that executes the first query (22), the program uses the *StrCpy* function (24) to move CHAR values to char array variables so that other C string functions can be used when formatting the CREATE TABLE commands and writing them to the output file.

The second query (26) retrieves information about each column in each table qualifying for the first query. This query contains a WHERE clause that identifies an owner and table name:

```
sprintf(CmdLine,"SELECT COLNAME, LENGTH, TYPECODE, NULLS, PRECISION,\
  SCALE FROM SYSTEM.COLUMN WHERE OWNER = '%s' AND TABLENAME = \
        '%s';",OwnerName, TableName);
```

These names are obtained from the *Owner* and *Table* values in the *TableList* array (4).

After each version of the second query is dynamically preprocessed (27), the program initializes two sqlda fields (28) before executing the DESCRIBE command (29). Then a cursor named *ColumnList* is declared and opened (30) to operate on the active set. Before fetching rows, the program initializes the necessary sqlda values (31):

- The *sqlda.sqlnrow* field is set to *255*, defined in the constant *MaxNbrColumns* (2). This number is the maximum number of rows ALLBASE/SQL will return from the active set when the FETCH command is executed.
- The *sqlda.sqlbuflen* field is set to the size of the data buffer. The data buffer for the second query is a structure array of records named *ColumnList* (5).
- The *sqlda.sqlrowbuf* field is set to the address of the data buffer.

The FETCH command (32) is executed only once for each table that qualified for the first query, since no more than 255 rows would *ever* qualify for the query because the maximum number of columns any table can have is 255.

After the active set has been fetched into data buffer *ColumnList*, a CREATE TABLE command for the table is written to the schema file (34):

```
CREATE LockMode TABLE OwnerName.TableName,
  (ColumnList[1].ColName   TypeInfo   NullInfo,
   ColumnList[2].ColName   TypeInfo   NullInfo,
   .
   .
   .  ColumnList[j].ColName   TypeInfo   NullInfo) IN TableList[i].FileSet;
```

Most of the information needed to reconstruct the CREATE TABLE commands is written directly from program variables. In three cases, however, data returned from the system views must be translated:

- *LockMode* is generated in a switch statement (33) based on the value ALLBASE/SQL put in *TableList[i].LockMode*. The SYSTEM.TABLE view stores the automatic locking mode for tables as an integer from 1 through 3. The switch statement equates these codes with the expressions that must appear in the CREATE TABLE command.
- *TypeCode* is generated in a switch statement (35) based on the value ALLBASE/SQL put in *ColumnList[i].TypeCode*. The SYSTEM.COLUMN view stores the data type of each column as an integer from 0 through 5. The switch statement equates these codes with the expressions that must appear in the CREATE TABLE command.
- *Nulls* is generated from the null indicator ALLBASE/SQL returned to *ColumnList[i].Nulls* (36). A value of 0 indicates the column cannot contain null values, and the program inserts *NOT NULL* into the table definition.

After a CREATE TABLE command has been written for each qualifying table, a COMMIT WORK command is executed (37) to release locks on SYSTEM.COLUMN before the PREPARE command is re-executed and before the DBE session terminates with a COMMIT WORK RELEASE command (38).

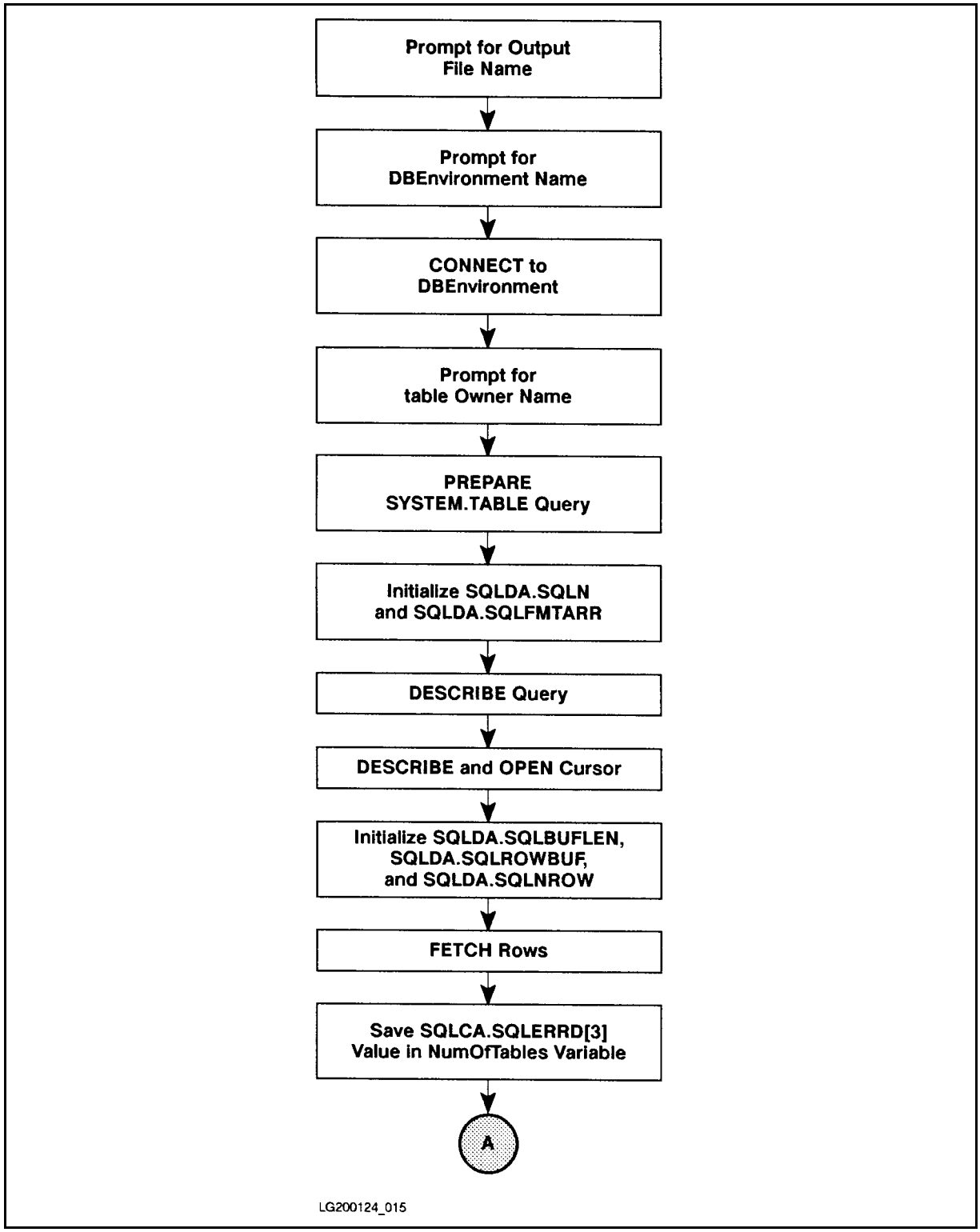
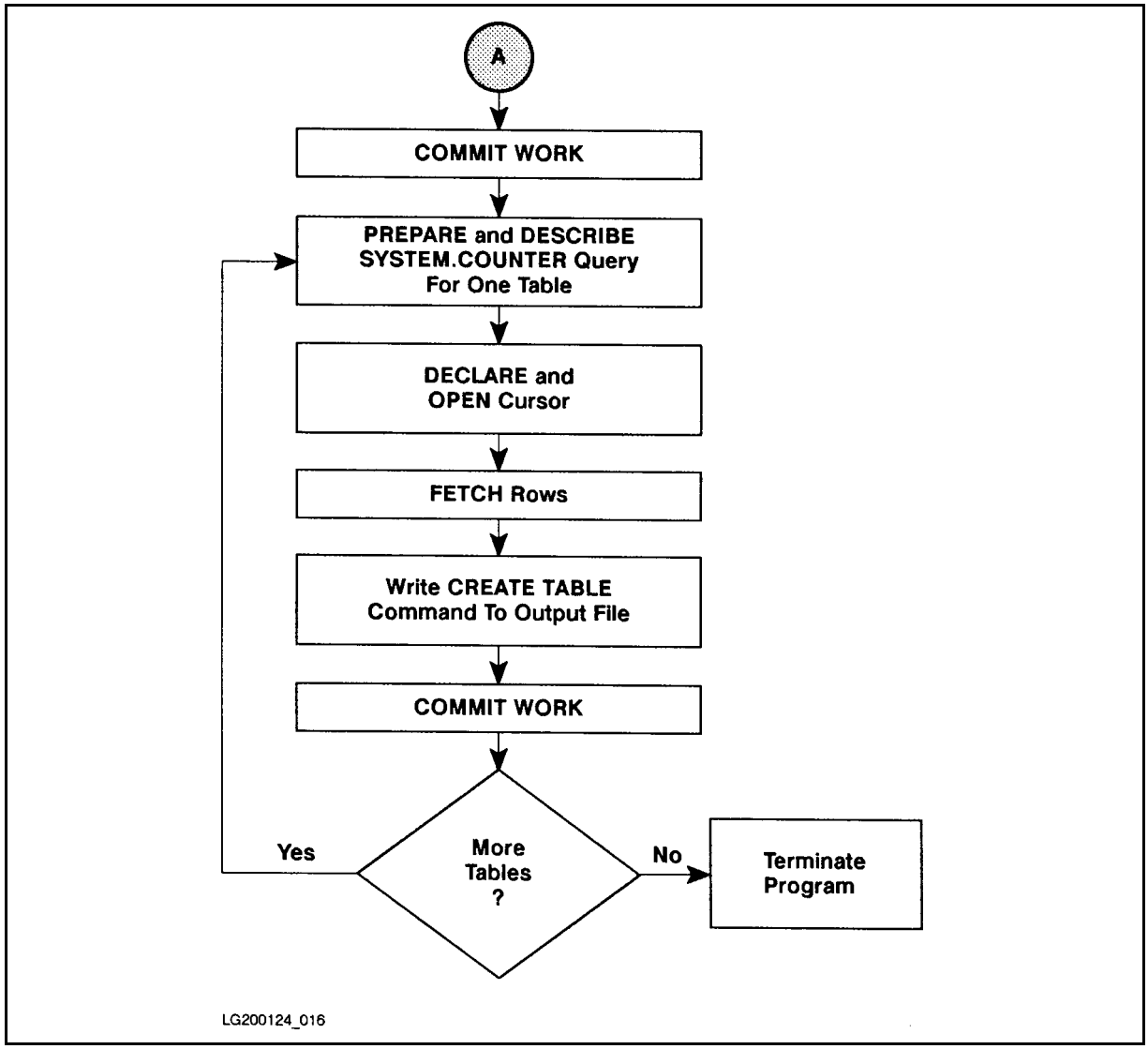


Figure 8-10. Flow Chart of Program cex10b



Flow Chart of Program cex10b (page 2 of 2)

```
C program illustrating dynamic command processing -- cex10b

ALLBASE/SQL/MPE XL SCHEMA Generator for Tables

Enter name of schema file to be generated > SCHM1
Enter name of DBEnvironment > PARTSDBE
Enter owner name or RETURN for all owners > PURCHDB

Generating SQL command to CREATE TABLE PURCHDB.INVENTORY
Generating SQL command to CREATE TABLE PURCHDB.ORDERITEMS
Generating SQL command to CREATE TABLE PURCHDB.ORDERS
Generating SQL command to CREATE TABLE PURCHDB.PARTS
Generating SQL command to CREATE TABLE PURCHDB.REPORTS
Generating SQL command to CREATE TABLE PURCHDB.SUPPLYPRICE
Generating SQL command to CREATE TABLE PURCHDB.VENDORS
:PRINT SCHM1

CREATE PUBLIC TABLE PURCHDB.INVENTORY
  (PARTNUMBER            CHAR(  16)     NOT NULL,
   BINNUMBER             SMALLINT       NOT NULL,
   QTYONHAND             SMALLINT,
   LASTCOUNTDATE         CHAR(   8),
   COUNTCYCLE            SMALLINT,
   ADJUSTMENTQTY         SMALLINT,
   REORDERQTY            SMALLINT,
   REORDERPOINT          SMALLINT) IN WAREHFS;

CREATE PUBLIC TABLE PURCHDB.ORDERITEMS
  (ORDERNUMBER           INTEGER        NOT NULL,
   ITEMNUMBER            INTEGER        NOT NULL,
   VENDPARTNUMBER        CHAR(  16),
   PURCHASEPRICE         DECIMAL(10, 2) NOT NULL,
   ORDERQTY              SMALLINT,
   ITEMDUEDATE           CHAR(   8),
   RECEIVEDQTY           SMALLINT) IN ORDERFS;

CREATE PUBLIC TABLE PURCHDB.ORDERS
  (ORDERNUMBER           INTEGER        NOT NULL,
   VENDORNUMBER          INTEGER,
   ORDERDATE             CHAR(   8)) IN ORDERFS;

CREATE PUBLIC TABLE PURCHDB.PARTS
  (PARTNUMBER            CHAR(  16)     NOT NULL,
   PARTNAME              CHAR(  30),
   SALESPRICE            DECIMAL(10, 2)) IN WAREHFS;

CREATE PUBLIC TABLE PURCHDB.REPORTS
  (REPORTNAME            CHAR(  20)     NOT NULL,
:
```

Figure 8-11. Run Time Dialog of Program cex10b

```
/* Program cex10b */

/* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * */
/* This program generates an ISQL command file that will re-create */
/* tables within a particular DBEnvironment. This program must be  */
/* preprocessed; however, it does not need to be installed.        */
/* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * */

#include <stdio.h>
#include <ctype.h>

#define   OK                 0
#define   MaxNbrTables     300                                          (1)
#define   MaxNbrColumns    255                                          (2)
#define   mode            0700
#define   NbrFmtRecords     32

sqlca_type sqlca;    /* SQL Communication Area */
sqlda_type sqlda;    /* SQL Describe Area */

sqlformat_type sqlfmts[NbrFmtRecords];  /* declaration of format nodes */

char      FileName[15];
char      OwnerName[21];
char      TableName[21];
char      DBEFileSet[21];
char      ColumnName[21];
char      DBEName[128];
char      OneLine[81];
int       FileNum;
short     i;
short     j;
short     NumOfTables;

  struct {
    char     Owner[20];
    char     Table[20];
    char     FileSet[20];
    short    LockMode;
    } TableList[MaxNbrTables];                                           (4)
```

Figure 8-12. Program cex10b: Dynamic Queries of Known Format

```
  struct {
    char          ColName[20];
    int           Length;
    short         TypeCode;
    short         Nulls;
    short         Precision;
    short         Scale;
    } ColumnList[MaxNbrColumns];                                    (5)

         /* Begin Host Variable Declarations */
    EXEC SQL BEGIN DECLARE SECTION;
    char     CmdLine[200];
    char     SQLMessage[133];
    EXEC SQL END DECLARE SECTION;
         /* End Host Variable Declarations */

main()  /* Beginning of Program */
{
printf("\n C program illustrating dynamic command processing -- cex10b");
printf("\n");
printf("\n  ALLBASE/SQL/MPE XL SCHEMA Generator for Tables");
printf("\n");
printf("\n Event List:");
printf("\n    Prompt for the name of the schema file to create");
printf("\n    Prompt for the name of the DBEnvironmet");
printf("\n    Prompt for the owner name");
printf("\n    Generate schema file");
printf("\n");

printf("\n Enter name of schema file to be generated > ");          (6)
scanf("%s",FileName);

FileNum = unlink(FileName);                                         (7)
FileNum = creat(FileName,mode);

printf("\n Enter name of DBEnvironment > ");                       (8)
scanf("%s",DBEName);

sprintf(CmdLine,"CONNECT TO '%s';",DBEName);                        (9)

EXEC SQL EXECUTE IMMEDIATE :CmdLine;                               (10)
if (sqlca.sqlcode != OK) {
    printf("\n Could not CONNECT to DBEnvironment!");
    EXEC SQL SQLEXPLAIN :SQLMessage;
    printf("%s\n",SQLMessage);
    goto a9999;
    }
```

Figure 8-12. Program cex10b: Dynamic Queries of Known Format (page 2 of 7)

```
printf("\n Enter database owner name or ALL for all owners > ");   (11)
scanf("%s",OwnerName);

  for (i = 0; i <= strlen(OwnerName); i++) {    /* Upshift OwnerName */
    if (islower(OwnerName[i])) {
      OwnerName[i] = toupper(OwnerName[i]);                          (12)
      }
    }

response = "ALL";

if (strcmp(response,OwnerName) == 0) {
sprintf(CmdLine,"SELECT OWNER,NAME,DBEFILESET,RTYPE FROM SYSTEM.TABLE\
 WHERE TYPE = 0 AND OWNER <> 'SYSTEM';");                            (13)

  }
else {
sprintf(CmdLine,"SELECT OWNER,NAME,DBEFILESET,RTYPE FROM SYSTEM.TABLE\
 WHERE TYPE = 0 AND OWNER = '%s';",OwnerName);                       (14)
  }

EXEC SQL PREPARE SelectCmd1 FROM :CmdLine;                           (15)
if (sqlca.sqlcode != OK) {
    printf("\n Problem PREPARING the SELECT #1 command!");
    EXEC SQL SQLEXPLAIN :SQLMessage;
    printf("%s\n",SQLMessage);
    goto a9999;
    }

/* set up SQLDA fields */
    sqlda.sqlfmtarr = sqlfmts;   /* pointer to format nodes */       (16)
    sqlda.sqln      = 4;         /* number of columns expected */

EXEC SQL DESCRIBE SelectCmd1 INTO SQLDA;                             (17)
if (sqlca.sqlcode != OK) {
    printf("\n Problem describing SelectCmd1!");
    EXEC SQL SQLEXPLAIN :SQLMessage;
    printf("%s\n",SQLMessage);
    goto a9999;
    }
```

Figure 8-12. Program cex10b: Dynamic Queries of Known Format (page 3 of 7)

```
EXEC SQL DECLARE TableList CURSOR for SelectCmd1;                    (18)
if (sqlca.sqlcode != OK) {
    printf("\n Problem declaring TableList cursor!");
    EXEC SQL SQLEXPLAIN :SQLMessage;
    printf("%s\n",SQLMessage);
    goto a9999;
    }

EXEC SQL OPEN TableList;                                             (18)
if (sqlca.sqlcode != OK) {
    printf("\n Problem opening TableList cursor!");
    EXEC SQL SQLEXPLAIN :SQLMessage;
    printf("%s\n",SQLMessage);
    goto a9999;
    }

/* set up SQLDA fields */
    sqlda.sqlnrow   = MaxNbrTables;                                  (19)
    sqlda.sqlbuflen = sizeof(TableList);
    sqlda.sqlrowbuf = TableList;

  /* Get Table List from SYSTEM.TABLE */
EXEC SQL FETCH TableList USING DESCRIPTOR SQLDA;                     (20)
if (sqlca.sqlcode == 100) {
    printf("\n No tables qualified!");
    goto a9999;
    }
else {
  if (sqlca.sqlcode != OK) {
    printf("\n Problem encountered when reading SYSTEM.TABLE!");
    EXEC SQL SQLEXPLAIN :SQLMessage;
    printf("%s\n",SQLMessage);
    goto a9999;
    }
   }

NumOfTables = sqlca.sqlerrd[2];                                      (21)
EXEC SQL COMMIT WORK;                                                (22)

/* do loop for i */

for (i = 0; i < NumOfTables; i ++) {                                 (23)
    TableList[i].Owner[19] = '\0';
    TableList[i].Table[19] = '\0';
    TableList[i].FileSet[19] = '\0';
```

Figure 8-12. Program cex10b: Dynamic Queries of Known Format (page 4 of 7)

```
    sscanf(TableList[i].Owner,"%s",OwnerName);                          24
    sscanf(TableList[i].Table,"%s",TableName);
    sscanf(TableList[i].FileSet,"%s",DBEFileSet);

    printf("\n Generating SQL command to CREATE TABLE ");
    printf("%s.%s",OwnerName,TableName);

sprintf(CmdLine,"SELECT COLNAME,LENGTH,TYPECODE,NULLS,PRECISION,\
 SCALE FROM SYSTEM.COLUMN WHERE OWNER = '%s' AND TABLENAME =\
 '%s';",OwnerName,TableName);                                           26

    EXEC SQL PREPARE SelectCmd2 FROM :CmdLine;                          27
    if (sqlca.sqlcode != OK) {
        printf("\n Problem PREPARING the SELECT #2 command!");
        EXEC SQL SQLEXPLAIN :SQLMessage;
        printf("%s\n",SQLMessage);
        goto a9999;
        }

    /* set up SQLDA fields */
    sqlda.sqlfmtarr = sqlfmts;   /* pointer to format nodes */          28
    sqlda.sqln      = 6;         /* number of columns expected */

    EXEC SQL DESCRIBE SelectCmd2 INTO SQLDA;                            29
    if (sqlca.sqlcode != OK) {
        printf("\n Problem describing SelectCmd2!");
        EXEC SQL SQLEXPLAIN :SQLMessage;
        printf("%s\n",SQLMessage);
        goto a9999;
        }

    EXEC SQL DECLARE ColumnList CURSOR for SelectCmd2;                  30
    if (sqlca.sqlcode != OK) {
        printf("\n Problem declaring ColumnList Cursor!");
        EXEC SQL SQLEXPLAIN :SQLMessage;
        printf("%s\n",SQLMessage);
        goto a9999;
        }

    EXEC SQL OPEN ColumnList;                                           30
    if (sqlca.sqlcode != OK) {
        printf("\n Problem opening ColumnList cursor!");
        EXEC SQL SQLEXPLAIN :SQLMessage;
        printf("%s\n",SQLMessage);
        goto a9999;
        }
```

Figure 8-12. Program cex10b: Dynamic Queries of Known Format (page 5 of 7)

```
  /* set up SQLDA fields */
  sqlda.sqlnrow   = MaxNbrColumns;                                    (31)
  sqlda.sqlbuflen = sizeof(ColumnList);
  sqlda.sqlrowbuf = ColumnList;

/* Get Column List from SYSTEM.COLUMN */

  EXEC SQL FETCH ColumnList USING DESCRIPTOR SQLDA;                   (32)
  if (sqlca.sqlcode != OK) {
      printf("\n Problem encountered when reading SYSTEM.COLUMN!");
      EXEC SQL SQLEXPLAIN :SQLMessage;
      printf("%s\n",SQLMessage);
      goto a9999;
      }

  switch (TableList[i].LockMode) {                                    (33)
  case 1:  sprintf(OneLine,"\nCREATE PUBLICREAD ");
           break;
  case 2:  sprintf(OneLine,"\nCREATE PRIVATE ");
           break;
  case 3:  sprintf(OneLine,"\nCREATE PUBLIC ");
           break;
  default: sprintf(OneLine,"\nUnrecognized Lock Mode ");
           break;
  }  /* end switch */

  sprintf(OneLine+strlen(OneLine),"TABLE %s.%s ",OwnerName,TableName);

  write(FileNum,OneLine,strlen(OneLine));                             (34)

  for (j = 0; j < sqlca.sqlerrd[2]; j++) {
      ColumnList[j].ColName[19] = '\0';
      strcpy(ColumnName,ColumnList[j].ColName);
      if (j==0) sprintf(OneLine,"\n (%s ",ColumnName);
      else sprintf(OneLine,"\n  (%s ",ColumnName);

      switch (ColumnList[j].TypeCode) {                               (35)
        case 0:  if (ColumnList[j].Length == 4) {
                   sprintf(OneLine+strlen(OneLine),"INTEGER         ");
                   }
                 else
                   sprintf(OneLine+strlen(OneLine),"SMALLINT        ");
                 break;
        case 2:
        case 8:  sprintf(OneLine+strlen(OneLine),"CHAR( %2d )",\
                                 ColumnList[j].Length);
                 break;
```

Figure 8-12. Program cex10b: Dynamic Queries of Known Format (page 6 of 7)

```
          case 3:
          case 9:  sprintf(OneLine+strlen(OneLine),"VARCHAR( %2d )",\
                                ColumnList[j].Length);
                   break;
          case 4:  sprintf(OneLine+strlen(OneLine),"FLOAT           ");
                   break;
          case 5:  sprintf(OneLine+strlen(OneLine),"DECIMAL( %2d,%2d )",\
                          ColumList[j].Precision,ColumnList[j].Scale);
                  break;
          default: sprintf(OneLine+strlen(OneLine)," **** ");
                   break;
          }  /* end switch */

        if (ColumnList[j].Nulls == 0) {                              (36)
          sprintf(OneLine+strlen(OneLine)," NOT NULL");
          }

        if (j != sqlca.sqlerrd[2]-1) {
          sprintf(OneLine+strlen(OneLine),",");
          }
        else {
        sprintf(OneLine+strlen(OneLine),") IN %s;\n",TableList[i].FileSet
          }

        write(FileNum,OneLine,strlen(OneLine));

        }    /* for j = 1 to sqlca.sqlerrd[2]  */

    EXEC SQL COMMIT WORK;                                            (37)

   }         /* for i = 1 to NumOfTables  */

a9999:

EXEC SQL COMMIT WORK RELEASE;                                        (38)
printf("\n");
}
```

Figure 8-12. Program cex10b: Dynamic Queries of Known Format (page 7 of 7)

9

Programming with Constraints

This chapter explains the use of statement level integrity versus row level integrity. Also, methods of implementing schema level unique and referential integrity contraints in your database are highlighted.

Integrity constraints allow you to have ALLBASE/SQL verify data integrity at the schema level. Thus you can avoid coding complex verification routines in application programs and avoid the increased execution time of additional queries. Your coding tasks are simplified, and performance is improved.

The following sections are presented in the chapter:

- Comparing Statement Level and Row Level Integrity.
- Using Unique and Referential Integrity Constraints.
- Designing an Application Using Statement Level Integrity Checks.

Comparing Statement Level and Row Level Integrity

In ALLBASE/SQL release E.1, enforcement of defined constraints is performed at statement level rather than at the row level of previous releases. This is called **statement level integrity**. Even though a constraint may be violated on a particular row, the check for that constraint is not made until the statement has completed processing. At that time, if there are one or more constraint errors, an error message is issued and the entire statement is rolled back with no rows being processed. You do not need to detect constraint errors yourself and code your program to respond to partially processed tables.

When a statement is rolled back, the appropriate sqlerrd field will be 0, reflecting that no rows were processed. If a constraint error is the cause of the rollback, this field will not be greated than zero indicating a partially processed table. Thus, applications written for ALLBASE/SQL may need to check for a different value in the sqlerrd field.

For information on status checking, see the chapter, "Runtime Status Checking and the sqlca." For information on deferring constraint error checking to the transaction level and other error checking enhancements related to releases after E.1, see the *ALLBASE/SQL Release F.0 Application Programming Bulletin for MPE/iX*.

Using Unique and Referential Integrity Constraints

Any database containing tables with interdependent data is a good candidate for the use of integrity constraints. You can profit from their use whether your data is volatile or stable in nature. For instance, your database might contain a table of employee and department data that is constantly changing, or it could contain a table of part number data that rarely changes even though it is frequently accessed. (Note that integrity constraints cannot be assigned to LONG columns. LONG columns are described in the chapter, *Programming with LONG Columns*.)

To implement unique and referential constraints, use the CREATE TABLE command and optionally the GRANT REFERENCES command in your schema file. The following table lists the commands you might use in dealing with integrity constraints.

Table 9-1. Commands Used with Integrity Constraints

DDL Operations	DCL Operations	DML Operations
CREATE TABLE	GRANT REFERENCES	[BULK] INSERT
DROP TABLE	GRANT DBA	UPDATE [WHERE CURRENT]
REMOVE FROM GROUP	REVOKE REFERENCES	DELETE [WHERE CURRENT]
DROP GROUP	REVOKE DBA	

The concepts and syntax of integrity contraints are fully discussed in the *ALLBASE/SQL Reference Manual* , and database administration considerations are found in the *ALLBASE/SQL Database Administration Guide* . This chapter contains techniques to use when coding applications that manipulate data upon which integrity constraints have been defined.

When executing the [BULK] INSERT, UPDATE [WHERE CURRENT], or DELETE [WHERE CURRENT] commands, ALLBASE/SQL considers applicable integrity constraints depending on what the overall effect of a statement would be once it completes execution. The syntax for UNIQUE or PRIMARY KEY requires unique constraint enforcement. The syntax for REFERENCES requires referential constraint enforcement on the referencing and referenced tables involved. For example, consider the following table showing what tests must be passed for a DML command to successfully complete.

Table 9-2. Constraint Test Matrix

DML Operations	UNIQUE or PRIMARY KEY	Referenced Table	Referencing Table
[BULK] INSERT or Type 2 INSERT	Must be unique in the table.		Must match a unique key in the referenced table.
UPDATE [WHERE CURRENT]	Must be unique in the table.	No foreign key can reference the unique key being updated.	Must match a unique key in the referenced table.
DELETE [WHERE CURRENT]		No foreign key can reference the unique key being deleted.	

Designing an Application Using Statement Level Integrity Checks

This section contains examples based on the recreation database, RecDB, which is supplied as part of the ALLBASE/SQL software package. The schema files used to create the database are found in appendix C of the *ALLBASE/SQL Reference Manual* .

The recreation database is made up of three tables (Clubs, Members, and Events). Two primary key constraints and two referential constraints were specified (when the tables were created) to secure the data integrity of these tables.

Figure 9-1 illustrates these contraint relationships by showing the name of each constraint and its referencing or referenced columns. Referencing columns are shaded. Referenced columns are clear white.

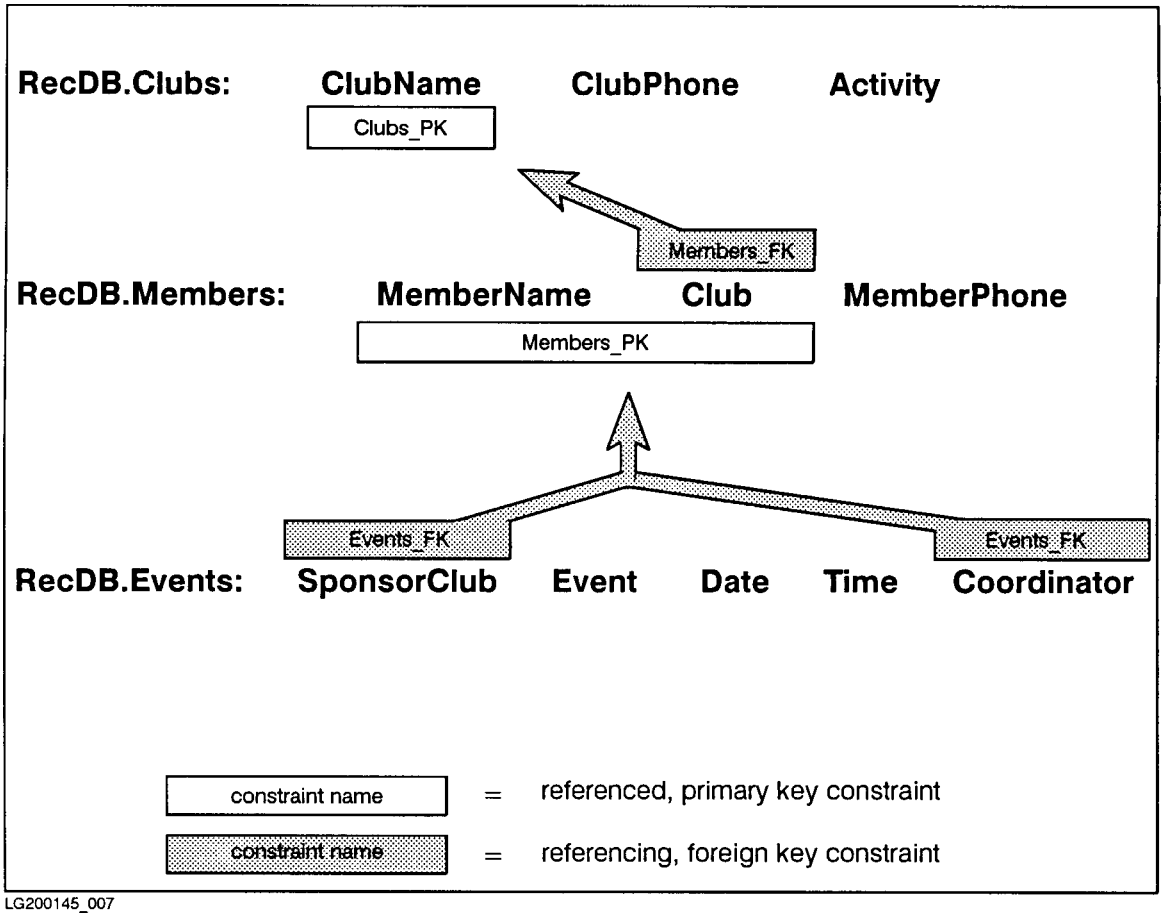


Figure 9-1. Constraints Enforced on the Recreation Database

Suppose you designed an application program providing a user interface to the recreation database. The interface gives choices for inserting, updating, and deleting data in any of the three tables. Your application is user friendly and guides the user with informational messages when their request is denied because it would violate data integrity. The main interface menu might look like this:

```
Main Menu for Recreation Database Maintenance
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

1. INSERT a Club          4. INSERT a Member          7. INSERT an Event
2. UPDATE a Club          5. UPDATE Member Info.      8. UPDATE Event Info.
3. DELETE a Club          6. DELETE a Member          9. DELETE an Event
```

When users make a selection (by number or by tabbing to a field), a screen displaying all the appropriate information allows them to insert, update, or delete.

The next sections provide generic examples of how you can code such an application. The error checking in these examples deals with constraint enforcement errors only. (For complete explanation of these errors, see the *ALLBASE/SQL Message Manual* .) Your error checking routine should also include a method of handling multiple errors per command and errors not related to constraint enforcement. (For more information on error coding techniques, see the chapter, "Runtime Status Checking and the sqlca.")

Insert a Member in the Recreation Database

The user chooses to insert a new member in the database. For this activity to complete, the foreign key (Club) which is being inserted into the Members table must exist in the primary key (ClubName) of the Clubs table.

Execute subroutines to display and prompt for information needed in the Members table.

Place user entered information in appropriate host variables.

```
INSERT INTO RecDB.Members
     VALUES (:MemberName,
             :Club,
             :MemberPhone :MemberPhoneInd)
```

Check the sqlcode field of the sqlca.

If sqlcode equals −2293, indicating no primary key match, display the error message and prompt the user to indicate whether or not to insert a new ClubName in the Clubs table, to reenter the Club for the new member, or to exit to the main menu. Execute the appropriate subroutine.

If sqlcode equals −2295, indicating that the user tried to insert a non-unique primary key, display the error message and prompt the user to enter a unique MemberName/Club combination or to exit to the main menu. Execute the appropriate subroutine.

Else, if sqlcode = 0, tell the user the member was inserted successfully, and prompt for another new member or a return to the main menu display.

Update an Event in the Recreation Database

The user now wants to update information in the Events table. For this activity to complete, the SponsorClub and Coordinator being updated in the Events table must exist in the primary key composed of MemberName and Club in the Members table.

Execute subroutines to display and prompt for information needed in the Events table.

Place user entered information in appropriate host variables.

```
UPDATE RecDB.Events
     SET SponsorClub = :SponsorClub :SponsorClubInd,
         Event = :Event :EventInd,
         Date = :Date :DateInd,
         Time = :Time :TimeInd,
         Coordinator = :Coordinator :CoordinatorInd
     WHERE Event = :Event
```

Check the sqlcode field of the sqlca.

If sqlcode equals −2293, indicating no primary key match, display the error message and prompt the user to indicate whether or not to insert a new MemberName/Club primary key in the Members table, to reenter update information for the Events table, or to exit to the main menu. Execute the appropriate subroutine.

Else, if sqlcode = 0, tell the user the event was updated successfully, and prompt for another event or a return to the main menu display.

Delete a Club in the Recreation Database

The user chooses to delete a club. For this activity to complete, no foreign key must reference the primary key (ClubName) that is being deleted.

Execute subroutines to display and prompt for a ClubName in the Clubs table.

Place user entered information in appropriate host variables.

```
DELETE FROM RecDB.Clubs
      WHERE ClubName = :ClubName
```

Check the sqlcode field of the sqlca.

If sqlcode equals −2293, indicating that referencing data exists for ClubName, display the error message and prompt the user to indicate whether or not to delete the Members table row or rows that reference the ClubName, to reenter the ClubName to be deleted, or to exit to the main menu. Execute the appropriate subroutine.

(If you execute the subroutine to delete those rows in the Members table which reference the Clubs table, be sure to test sqlcode. Depending on the result, you can prompt the user to delete referencing Events table rows, to reenter the Members table information, or to exit to the main menu. Execute the appropriate subroutine.)

Else, if sqlcode = 0, tell the user the club was deleted successfully, and prompt for another club or a return to the main menu display.

Delete an Event in the Recreation Database

The user chooses to delete an event. Because no primary key or unique constraints are defined in the Events table, no constraint enforcement is necessary.

Execute subroutines to display and prompt for an Event in the Events table.

Place user entered information in appropriate host variables.

```
DELETE FROM RecDB.Clubs
      WHERE Event = :Event
```

Check the sqlcode field of the sqlca.

If sqlcode = 0, tell the user the event was deleted successfully, and prompt for another event or a return to the main menu display.

10

Programming with LONG Columns

LONG columns in ALLBASE/SQL enable you to store a very large amount of binary data in your database, referencing that data via a table column name. You might use LONG columns to store text files, software application code, voice data, graphics data, facsimile data, or test vectors. You can easily SELECT or FETCH this data, and you have the advantages of ALLBASE/SQL's recoverability, concurrency control, locking strategies, and indexes on related columns.

You can use LONG columns in an application program to be preprocessed or with ISQL. This discussion focuses on application programming concerns. As you will see, great flexibility is provided so that you can custom design your application.

The chapter highlights methods of implementing LONG columns in your database as follows:

- General Concepts.
- Restrictions.
- Defining LONG Columns with CREATE TABLE or ALTER TABLE.
- Defining Input and Output with the LONG Column I/O String.
- Putting Data into a LONG Column with [BULK] INSERT.
- Changing a LONG Column with UPDATE [WHERE CURRENT].
- Retrieving LONG Column Data with [BULK] SELECT, FETCH, or REFETCH.
- Using the LONG Column Descriptor.
- Removing LONG Column Data with DELETE or DELETE WHERE CURRENT.
- Coding Considerations.

For every DDL and DML command that can be used with LONG columns, examples are included with discussion of related considerations. These examples pertain to the same logical table (PartsTable) and set of columns. In contrast to other examples in this document, PartsTable is a hypothetical table created and altered in this chapter. Refer to the *ALLBASE/SQL Reference Manual* which contains complete syntax specifications for using long columns.

Table 10-1. Commands You Can Use with LONG Columns

DDL Operations	DML Operations
ALTER TABLE	[BULK] INSERT
CREATE TABLE	UPDATE [WHERE CURRENT]
	[BULK] SELECT
	FETCH
	REFETCH
	DELETE [WHERE CURRENT]

General Concepts

ALLBASE/SQL stores LONG column data in a database for later retrieval. LONG column data is not processed by ALLBASE/SQL. Any formatting, viewing, or other processing must be accomplished by means of your program. For example, you might use a graphics application to create an intricate graphic display (or set of graphic displays). You could then write a program in which you embed ALLBASE/SQL commands to store each graphics file in your database along with related data in a given row. Your graphics application could be called from another program, this time to select a row and display the graphic. The graphic could be displayed on the upper portion of a screen, with related data from the same row displayed on the lower portion of a screen. The related data in standard columns or LONG columns could be a graphics explanation or an entire chapter.

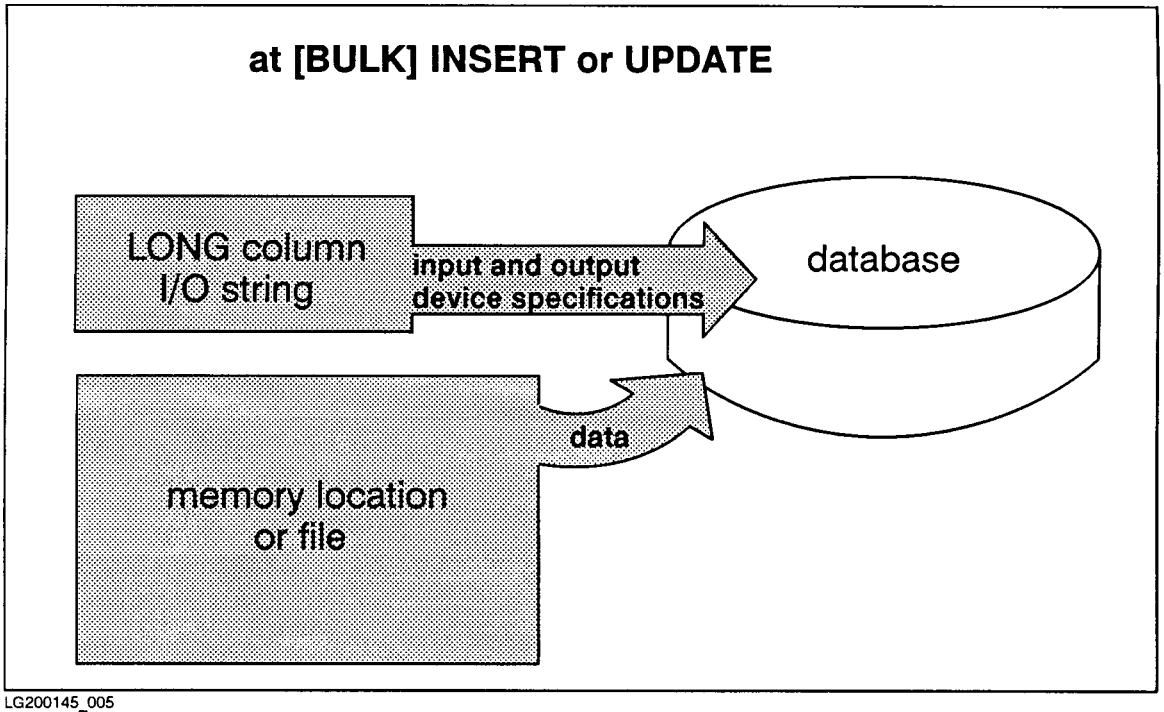
LONG column data can occupy a practically unlimited amount of space in the database, the maximum number of bytes being $2^{31}-1$ (or 2,147,483,647) per LONG column per row. Standard column data is restricted to 3996 bytes maximum.

The LONG specification is used with a given ALLBASE/SQL data type when you create the LONG column. Currently, LONG BINARY and LONG VARBINARY are available. Refer to the chapter on "Host Variables" for the details of BINARY and VARBINARY data types.

The concept of how LONG column data is stored in a row and retrieved differs from that of standard columns. Although LONG column data is associated with a particular row, it can be stored separately from the row. Thus you can specify a DBEFileSet in which to store data for a LONG column.

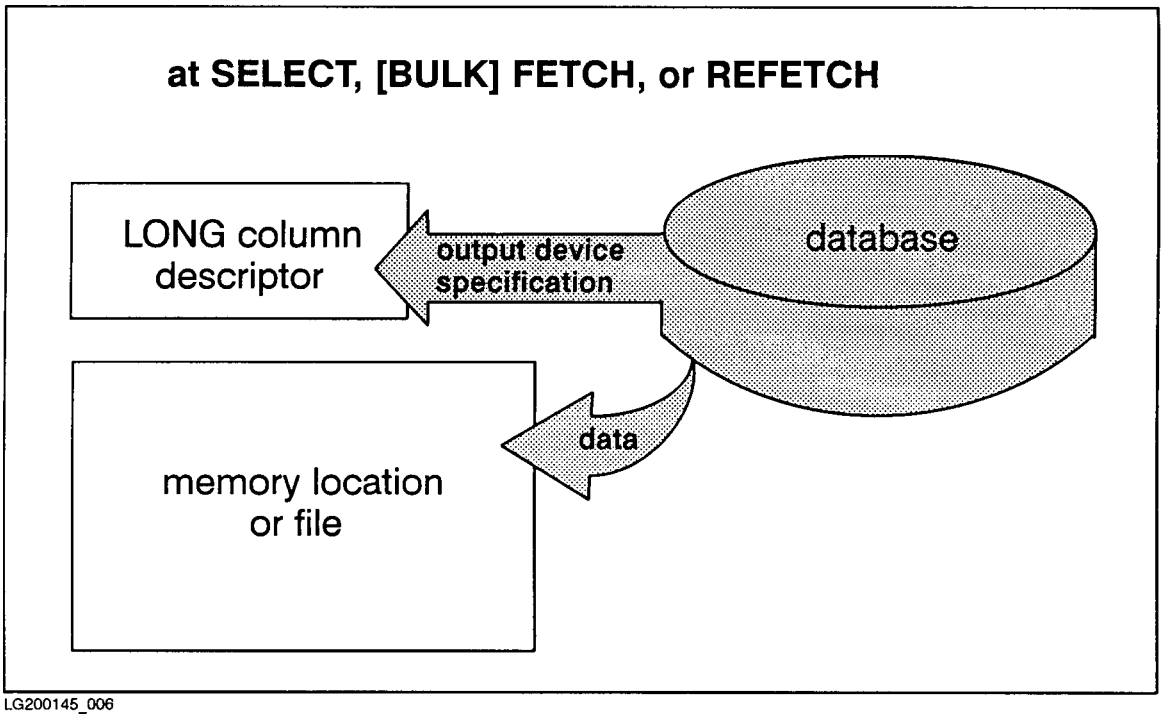
During an INSERT or UPDATE operation, you specify a **LONG column I/O string** to indicate where LONG column input data is located and where that data is to be placed when it is later selected or fetched. You indicate either an operating system file or random random heap space.

A **LONG column descriptor** (rather than the data itself) is selected or fetched into a host variable. Figure 10-1 and Figure 10-2 illustrate these concepts.



LG200145_005

Figure 10-1. Flow of LONG Column Data and Related Information to the Database



LG200145_006

Figure 10-2. Flow of LONG Column Data and Related Information from the Database

Restrictions

A LONG column can be referenced in a select list and/or a host variable declaration. Some restrictions do apply to LONG columns. However, related standard columns are not affected by these restrictions.

LONG columns cannot be used as follows:

- In a WHERE clause.
- In a type 2 INSERT command.
- Remotely through ALLBASE/NET.
- As hash or B-tree index key columns.
- In a GROUP BY, ORDER BY, DISTINCT, or UNION clause.
- In an expression.
- In a subquery.
- In aggregate functions (AVG, SUM, MIN, MAX).
- As columns to which integrity constraints are assigned.
- With the DEFAULT option of the CREATE or ALTER TABLE commands.

Defining LONG Columns with a CREATE TABLE or ALTER TABLE Command

Following is the new portion of the CREATE TABLE or ALTER TABLE command syntax for specifying a LONG column *column definition*. A maximum of 40 such LONG columns may be defined for a single table.

(*ColumnName* LONG { BINARY / VARBINARY } (*ByteSize*) [IN *DBEFileSet*] [NOT NULL]) [, ...]

When you create or add a LONG column to a table you have the option of specifying the DBEFileSet in which it is to be stored. Because LONG column data may take up a large chunk of a given DBEFile's data pages, placing LONG column data in a separate DBEFileSet is strongly advantageous from the standpoint of storage as well as performance.

If the IN *DBEFileSetName* clause is not specified for a LONG column, this column's data is by default stored in the same DBEFileSet as its related table.

Note It is recommended that you *do not* use the SYSTEM DBEFileSet in which to store your data, as this could severely impact database performance.

In the following example, LONG column data for PartPicture will be stored in PartPictureSet while data for columns PartName and PartNumber will be stored in PartsTableSet.

```
CREATE TABLE PartsTable (
             PartName CHAR(10),
             PartNumber INTEGER,
             PartPicture LONG VARBINARY(1000000) IN PartPictureSet)
           IN PartsTableSet
```

The next command specifies that data for new LONG column, PartModule, be stored in PartPictureSet.

```
ALTER TABLE PartsTable
        ADD PartModule LONG VARBINARY(70000) IN PartPictureSet
```

See the "BINARY Data" section of the "Host Variables" chapter for more information on using BINARY and VARBINARY data types in long columns.

Now that we have defined our table, let's see how to put data into it and to specify where data goes when it is retrieved.

Defining Input and Output with the LONG Column I/O String

Both the INSERT and the UPDATE commands allow you to define various input and output parameters for any LONG column. Parameters are specified with a **LONG column I/O string**. You'll need to understand this string in order to input, change, or retrieve LONG column data. This section offers an overview. See the *ALLBASE/SQL Reference Manual* for complete syntax.

Using the INSERT or UPDATE command, you pass the string to ALLBASE/SQL as either a host variable or a literal. Host variables are covered in detail in the "Host Variables" chapter.

Note The input and output portions of the I/O string are not positional. In the following examples, < indicates input, and > indicates output. See the *ALLBASE/SQL Reference Manual* for a full description of I/O operations with LONG columns.

The input portion of the LONG column I/O string specifies the location of data that you want written to the database. It is also referred to as an **input device specification**. You can indicate a file name or a random heap address.

Use the output portion of the I/O string (**output device specification**) to indicate where you want LONG column data to be placed when you use the SELECT or FETCH command. You have the option of specifying a file name, part of a file name, or having ALLBASE/SQL specify a file name. You also can direct output to a random heap address. Additional output parameters allow you to append to or overwrite an existing file. Information in the output device specification is stored in the database table and is available to you when a LONG column is selected or fetched (via a **LONG column descriptor**, discussed later in the section, "Using the LONG Column Descriptor").

It's important to note that files used for LONG column input and output are opened and closed by ALLBASE/SQL for its purposes. You need not open or close such files in your program unless you use them for additional purposes. ALLBASE/SQL does not control input or output device files once they are on the operating system. So, any operation on the file is valid, whether by your application or another application or user of the system. Such files are your responsibility, even before the transaction is complete.

The syntax for the INSERT and UPDATE commands is identical except that the input device is required for the INSERT command.

Putting Data into a LONG Column with a [BULK] INSERT Command

As with any column, use the INSERT command to initially put data into a LONG column. At the time of the insert, all input devices must be on the system in the locations you have specified. Should your insert operation fail, nothing is inserted, a relevant error message is returned to the program, and the transaction continues. Depending on your application, you might want to write a verification routine that reads a portion of each specified input device to make certain valid data exists prior to using the INSERT command.

The next examples are based on the PartsTable created and altered in the previous section, "Defining LONG Columns with CREATE TABLE or ALTER TABLE." Additional examples of LONG column I/O string usage are found in the *ALLBASE/SQL Reference Manual* .

Insert Using Host Variables for LONG Column I/O Strings

When inserting a single row, use a version of the LONG Column I/O String for each LONG column following the VALUES clause, as below.

```
INSERT INTO PartsTable VALUES (
            'bracket',
            200,
            :PartPictureIO,
            :PartModuleIO)
```

An example of the values that might be stored in the host variables, :PartPictureIO and :Part ModuleIO, are shown in the last two fields of a hypothetical record in the *Example Data File* that appears later in this chapter. In the above example, the values, bracket and 200, are coded as constants, rather than coming from the data file. The following represents a record could be read into host variables in preparation for the above INSERT statement. The constants, bracket and 200, in the statement could alternately be read into host variables.

```
bracket    200 0'<bracket.tools >hammer'       0'<mod88.module > mod88'       0
```

Bulk Insert Using Host Variables for LONG Column I/O Strings

The following example illustrates how to define and use an appropriate host variable for a BULK INSERT into PartsTable. Define an entry in your host variable array for each LONG column I/O string.

Example

```
/* This code segment reads a data file into a host variable array, one line */
/* at a time.  It parses the buffer and displays each record as it's        */
/* read and loaded.  Then a BULK INSERT to an ALLBASE/SQL database table is */
/* performed.  Maximum number of records per BULK INSERT is 25.             */

#include <stdio.h>

#define MAXSIZE 25

            .
            .
            .

/* PartNum is used to read in the PartNumber as a string.                   */

char PartNum[7];

/* Note that all of the columns allow null values, and an indicator         */
/* variable has been defined for each.                                      */

EXEC SQL BEGIN DECLARE SECTION;
struct    {
  char      PartName[11];
  sqlind    PartNameInd;
  int       PartNumber;
  sqlind    PartNumberInd;
  char      PartPictureIO[31];  /* IO string for LONG column PartPicture */
  sqlind    PartPictureInd;
  char      PartModuleIO[31];   /* IO string for LONG column PartModule  */
  sqlind    PartModuleInd;
  } PartsTableRows[25];         /* INSERT up to 25 rows at a time        */
char      SQLMessage[133];
EXEC SQL END DECLARE SECTION;
          /* End Host Variable Declarations */

            .
            .
            .
```

```
int InsertRows()              /* function to insert rows in PartsTable */
{

StartIndex = 1;
NumberOfRows = counter1;

EXEC SQL BULK INSERT INTO PartsTable
                         (PartName,
                          PartNumber,
                          PartPicture,
                          PartModule)
                   VALUES (:PartsTableRows,
                          :StartIndex,
                          :NumberOfRows);

if (sqlca.sqlcode != 0) {
   SQLStatusCheck();
   }

} /* End of InsertRows Function */


/* Here you could accept data from the user or from a file.        */
/* For this example, a file is used.                               */


int main()      /* function to initialize host variable array from */
                /* a file */
{

   char s[225];
   int  i = 0;

FILE *ptr;
ptr = fopen("data_file","r");

    while (fgets(s,225,ptr) && (i < MAXSIZE)) {
        sscanf (s, "%10c %2d%2c %2d%30c %2d%30
              PartsTableRows[i].PartName, &PartsTableRows[i].PartNameInd,
              PartNum, &PartsTableRows[i].PartNumberInd,
              PartsTableRows[i].PartPictureIO,
              &PartsTableRows[i].PartPictureInd,
              PartsTableRows[i].PartModuleIO, &PartsTableRows[i].PartModuleInd);
```

```
/* We read PartNumber as a string, but assign it as an integer.          */
/* atoi converts the ascii to integer.                                   */
        PartsTableRows[i].PartNumber = atoi(PartNum);

        printf ("%10s %2d %2d %2d %30s %2d %30s %2d\n",
              PartsTableRows[i].PartName, PartsTableRows[i].PartNameInd,
              PartsTableRows[i].PartNumber, PartsTableRows[i].PartNumberInd,
              PartsTableRows[i].PartPictureIO,
              PartsTableRows[i].PartPictureInd,
              PartsTableRows[i].PartModuleIO, PartsTableRows[i].PartModuleInd);
        i++;
   }
}             /* end of initialize function */

            .
            .
            .
```

Example Data File

The file, in this case named data_file, that your program reads might look something like this. Note that it is limited to 80 characters per record to facilitate documentation.

```
hammer     011 0'<hammer.tools >hammer'        0'<mod11.module > mod11'       0
file       022 0'<file.tools >file'            0'<mod22.module > mod22'       0
saw        033 0'<saw.tools > saw'             0'<mod33.module > mod33'       0
wrench     044 0'<wrench.tools >wrench'       0'<mod44.module > mod44'       0
lathe      055 0'<lathe.tools >lathe'          0'<mod55.module > mod55'       0
drill      066 0'<drill.tools >drill'          0'<mod66.module > mod66'       0
pliers     077 0'<pliers.tools >pliers'        0'<mod77.module > mod77'       0
            .
            .
            .
```

Retrieving LONG Column Data with a [BULK] SELECT, FETCH, or REFETCH Command

The following syntax represents the available subset when your select list includes one or more LONG columns. Remember, a LONG column can be referenced only in a select list and/or a host variable declaration.

```
[BULK]SELECT [ALL] { * | [Owner.]Table.* | CorrelationName.* | CorrelationName.ColumnName } [, ... ]
[INTO HostVariableDeclaration] FROM { [Owner.]FromTableName [CorrelationName] }
[, ... ]
```

As we noted earlier, the concept of how LONG column data is retrieved differs from that of standard columns. The LONG column descriptor (rather than the data itself) is selected or fetched into a host variable. In the case of a dynamic FETCH command, the LONG column descriptor information goes to the data buffer. In any case, the LONG column data is written to a file or random heap space.

When the following SELECT command is executed, :HostPartPic will contain the LONG column descriptor information for column PartPicture. LONG column data will go to the output device specified when column PartPicture was last inserted or updated.

```
SELECT PartNumber, PartPicture
  INTO :HostPartNum, :HostPartPic
  FROM PartsTable
 WHERE PartNumber = 200
```

Using the LONG Column Descriptor

ALLBASE/SQL does not swap LONG column data into or out of a host variable. Instead a 96-byte descriptor is available to your program at select or fetch time. It contains LONG column information for your program for which you must declare an appropriate host variable.

For example, if you do not know the output device type and its name or address, you obtain this information from the descriptor. Then open the appropriate file or call the operating system to access random heap space.

Note The LONG column descriptor must be declared whether or not you access its contents in your code.

Table 10-2. LONG Column Descriptor

Description	Possible Binary Values	Byte Range
Name or Address of Output Device	File name or heap address	1 through 44
Output Device Options	0 = no output specified 1 = overwrite 2 = append 3 = wildcard 4 = overwrite and wildcard 5 = append and wildcard	45
Output Device Type	0 = no device specified 1 = file 3 = random heap space	46
Input Device Type	0 = no device specified 1 = file 3 = random heap space	47
Reserved for Internal Use		48
Size in Bytes of LONG Column Data	1 to $2^{31}-1$ (or 2,147,483,647) per LONG column per row. Standard column data is restricted to 3996 bytes maximum.	49 through 52
Reserved for Internal Use		53 through 96

Example LONG Column Descriptor Declaration

```
/* Use this when you don't need to break down the descriptor. */

EXEC SQL BEGIN DECLARE SECTION;
char longdescriptor[96];
⋮
EXEC SQL END DECLARE SECTION;



/* If you want to access a portion of the descriptor, copy the */
/* longdescriptor host variable to the structure below. */

struct {
   char outputdevlocation[44];
   char outputdevop;
   char outputdevtype;
   char inputdevtype;
   char unused_A;
   int bytelength;
   char unused_B[44];
} longstruct
```

Using LONG Columns with a BULK SELECT Command

When you use the BULK SELECT command with LONG columns, should an error occur before completion of the BULK SELECT command, any operating system files written before the error occurred remain on the system, and LONG column descriptors written to a host variable array remain in the array. It is your responsibility to remove such files as appropriate.

Using LONG Columns with a Dynamic FETCH Command

If you have the need to dynamically retrieve LONG column data, the sqlrowbuf column of the sqlda, as always, contains the address of the data buffer. However, the data buffer, rather than containing LONG column data, holds the 96-byte LONG column descriptor.

The sqltype field of the format array holds a data type ID number of 15 for a LONG BINARY column and 16 for a LONG VARBINARY column. And the sqltotallen and sqlvallen columns will always contain a value of 96 (indicating the length of the descriptor).

When a NULL is fetched as the LONG column value, no external files are created, and the associated indicator variable for the LONG column descriptor is set to -1.

Changing a LONG Column with an UPDATE [WHERE CURRENT] Command

When you issue an UPDATE command on a LONG column, you have the following options:

- Change the stored data as well as the output device name and/or options.
- Change the stored data only.
- Change the output device name and/or options only.

Specify a LONG column I/O string (discussed earlier in this chapter) following the SET clause, for each LONG column to be updated. You must specify either the input device, the output device, or both. Complete syntax with examples is found in the *ALLBASE/SQL Reference Manual* .

In the following example, the LONG column I/O string is contained in host variable PartPictureIO.

```
UPDATE PartsTable
   SET PartPicture = :PartPictureIO
 WHERE PartName = 'saw'
```

Removing LONG Column Data with a DELETE [WHERE CURRENT] Command

Syntax for the DELETE and DELETE WHERE CURRENT commands is unchanged for use with LONG columns. It is limited for the DELETE command in that a LONG column cannot be used in the WHERE clause.

In the following example, any rows in PartsTable with the PartName of hammer are deleted.

```
DELETE FROM PartsTable WHERE PartName = 'hammer'
```

When LONG column data is deleted, the space it occupied in the DBEnvironment is released when your transaction ends. But any data file selected earlier still exists on the operating system. You may want to design a "cleanup" strategy for such files that are no longer needed.

Coding Considerations

File versus Random Heap Space

Depending on your application, you might want to use a file or random heap space as your input or output device. Random heap space may provide faster data access. Consider how much random heap space will be available.

What about using a file as an I/O device? You might ask yourself the following questions. Whom do you want to access the file during and after the application transaction is complete? How will it be "cleaned up" when it is no longer being used; perhaps the overwrite option would be helpful or another maintenance procedure.

File Naming Conventions

When a LONG column is selected or fetched, data goes to the output device you have specified at insert or update time. In the case of a file, because this output device name can be completely defined by you, partially defined by you, or assigned by ALLBASE/SQL, you may want to consider whether or not naming conventions are necessary. For instance, if your application is such that you can always give the same name to your LONG column output device as you give to the standard column you use in the WHERE clause, no need exists to extract the device name from the LONG column descriptor when you select or fetch it. For example, assuming your WHERE clause uses the PartsTable PartName column, the data_file example in the previous section, "Example Data File," uses this strategy. (Your application might still require information other than a file name from the descriptor area.)

Considering Multiple Users

With multiple users reading the same LONG column data, it is preferable for each user to run the application in a local area. This can prevent file access problems.

If several users must access the same data from the same group, you might want to use the wildcard option ($) and avoid using the overwrite option (!).

Deciding How Much Space to Allocate and Where

Remember to consider the space requirements of any DBEFileSet used for LONG column data. For example, suppose you execute an INSERT or UPDATE command for a LONG column defined as VARBINARY. If inadequate space is available in the database for the new data, an error message is returned to your program, and the transaction is rolled back. In this case, you can CREATE another DBEFile and add it to the appropriate DBEFileSet.

You will also want to consider the amount of random heap space available for your use in relation to the size and number of LONG columns to be selected or fetched.

11

Programming with ALLBASE/SQL Functions

Seven functions can be used with date/time data types. These functions provide flexibility for inputting and retrieving date/time data from the database.

These functions can be used with a preprocessed application or with ISQL. This chapter outlines basic principles for using date/time functions in an application program. The following sections are included:

- Where Date/Time Functions Can Be Used.
- Defining and Using Host Variables with Date/Time Functions.
- Using Date/Time Input Functions.
- Using Date/Time Output Functions.
- Using the Date/Time ADD_MONTHS Function.
- Coding Considerations.
- Program Examples for Date/Time Data.

Date/time functions are used as you would use an expression. And when used in a select list, all date/time functions produce data output. Refer to the section in this chapter, "Defining and Using Host Variables with Date/Time Functions."

Suppose for example that you are programming for an international corporation. Your database tables contain various date/time columns and the data is used by employees in several countries. You write a generic program on which you base a set of customized programs, one for each geographical location. Each customized program allows the employees at a given location to input and retrieve date/time information in the formats with which they are most comfortable.

Refer to the "Host Variables" chapter for more information on date/time data types. Complete syntax and format specifications for date/time functions are found in the *ALLBASE/SQL Reference Manual* in the "Expressions" and "Data Types" chapters.

Note For all date/time functions, character input and output values are in Native-3000 format.

Where Date/Time Functions Can Be Used

Use date/time functions, as you would an expression, in the DML operations listed below:

Table 11-1. Where to Use Date/Time Functions

DML Operation	Clause
[BULK]INSERT [1]	VALUES WHERE
UPDATE or UPDATE WHERE CURRENT	SET WHERE
DELETE or DELETE WHERE CURRENT	WHERE
[BULK]SELECT	Select list [2] WHERE
DECLARE	Select list [2] WHERE

[1] In the case of a [BULK] INSERT, output functions, TO_CHAR and TO_INTEGER, and the ADD_MONTHS function, are limited to use in the select list and the WHERE clause of a Type 2 INSERT.

[2] Input functions, TO_DATE, TO_TIME, TO_DATETIME, and TO_INTERVAL, are generally not appropriate in a select list.

Defining and Using Host Variables with Date/Time Functions

Date/time functions can be used in the way an expression is used; that is, in a select list to indicate the columns you want in the query result, in a search condition to define the set of rows to be operated on, and to define the value of a column when using the UPDATE command. (See the *ALLBASE/SQL Reference Manual* for in-depth information regarding expressions.)

Whether you use host variables or literal strings to specify the parameters of the date/time functions depends on the elements of your application and on how you are using the functions. This section focuses on the use of host variables.

You can use host variables to specify input or output format specifications. Use them as well to hold data input to and any resulting data output from the date/time functions. (Host variables cannot be used to indicate column names.)

Host variables for format specifications must be defined in your application to be compatible with ALLBASE/SQL CHAR or VARCHAR data types. The exception is the ADD_MONTHS function which requires an INTEGER compatible host variable.

As for host variables containing input and output data, define them to be CHAR or VARCHAR compatible with one exception. The TO_INTEGER function requires an INTEGER compatible host variable for its output.

Reference the chapter on defining host variables for additional information about defining a host variable to be compatible with a specific ALLBASE/SQL data type. Note that the declarations relate to the default format specification for each date/time data type. Your declaration must reflect the length of the format you are using.

Table 11-2 shows host variable data type compatibility for date/time functions.

Table 11-2. Host Variable Data Type Compatibility for Date/Time Functions

Date/Time Function	Input Format Specification	Output Format Specification	Input Data	Output Data
TO_DATE TO_TIME TO_DATETIME TO_INTERVAL	(VAR)CHAR		(VAR)CHAR	(VAR)CHAR [1]
TO_CHAR		(VAR)CHAR		(VAR)CHAR
TO_INTEGER		(VAR)CHAR		INTEGER
ADD_MONTHS	INTEGER			(VAR)CHAR [1]

[1] Applies only when used in a select list.

Using Date/Time Input Functions

The new input functions are designed so that you can easily input data for a given date/time data type in either the default format or a format of your choice. (When you do not include a format specification, the default is used.)

You have the option of choosing a literal string or a host variable to indicate a desired data value and/or optional format specification. See the *ALLBASE/SQL Reference Manual* for detailed syntax.

Following is the general syntax for date/time input functions:

```
{ TO_DATETIME (DataValue [ ,FormatSpecification])  }
{ TO_DATE (DataValue [ ,FormatSpecification])      }
{ TO_TIME (DataValue [ ,FormatSpecification])      }
{ TO_INTERVAL (DataValue [ ,FormatSpecification]) }
```

Input functions can be used in DML operations as shown in Table 11-1. It is most appropriate to use date/time input functions in a WHERE, VALUES, or SET clause. Although they can be used in a select list, it is generally not appropriate to do so. The data value returned to the function in this instance is not a column value but is identical to the value you specify as input to the function.

Examples of TO_DATETIME, TO_DATE, TO_TIME, and TO_INTERVAL Functions

Imagine a situation in which users will be inputting and retrieving date/time data in formats other than the default formats. (Refer to the *ALLBASE/SQL Reference Manual* for default format specifications.)

The data is located in the TestData table in the manufacturing database. (Reference appendix C in the *ALLBASE/SQL Reference Manual* .)

You are to provide them with the capability of keying and retrieving data in the formats shown in Table 11-3.

Table 11-3. Sample of User Requested Formats for Date/Time Data

Date/Time Data Type	Desired Format Specification	Length of Format Specification in ASCII Characters
DATETIME	MM-DD-YYYY HH:MM:SS.FFF	23
DATE	MM-DD-YYYY	10
TIME	HH:MM:SS [1]	8
INTERVAL	DDDDDDD HH:MM:SS	16

[1] This is the default time data format.

You might use the following generic code examples to meet their needs.

Example Using the INSERT Command

Your application allows users to enter data in their desired formats with a minimum of effort on your part.

```
BEGIN DECLARE SECTION

Declare input host variables (:BatchStamp, :BatchStamp-Format, :TestDate,
:TestDate-Format, :TestStart, :LabTime, and LabTime-Format) to be compatible
with data type CHAR or VARCHAR.

Declare input indicator variables (:TestDateInd and :LabTimeInd).

END DECLARE SECTION
.
.
.
```

```
INSERT
  INTO MANUFDB.TESTDATA
       (BatchStamp,
        TestDate,
        TestStart,
        TestEnd,
        LabTime,
        PassQty,
        TestQty)
 VALUES (TO_DATETIME (:BatchStamp, :BatchStamp-Format),
         TO_DATE (:TestDate :TestDateInd, :TestDate-Format),
         TO_TIME (:TestStart :TestStartInd),
         :TestEnd :TestEndInd,
         TO_INTERVAL (:LabTime :LabTimeInd, :LabTime-Format),
         :PassQty :PassQtyInd,
         :TestQty :TestQtyInd)
```

Note that the user requested time data format is the default format. Using the two time data columns in the TestData table (TestStart and TestEnd), the above example illustrates two ways of specifying a default format. Specify a date/time function without a format, or simply do not use a date/time function.

Example Using the UPDATE Command

These users want the capability of updating data based on the BatchStamp column.

```
BEGIN DECLARE SECTION

Declare input host variables (:TestDate, :TestDate-Format, :BatchStamp,
and :BatchStamp-Format) to be compatible with data type CHAR or VARCHAR.

Declare input indicator variable (:TestDateInd).

END DECLARE SECTION
.
.
.
UPDATE MANUFDB.TESTDATA
   SET TESTDATE = TO_DATE
                  (:TestDate :TestDateInd, :TestDate-Format),
                   TestStart = :TestStart :TestStartInd,,
                   TestEnd = :TestEnd :TestEndInd,,
                   LabTime = :LabTime :LabTimeInd,
                   PassQty = :PassQty :PassQtyInd,
                   TestQty = :TestQty :TestQtyInd
   WHERE BatchStamp = TO_DATETIME
```

```
(:BatchStamp, :BatchStamp-Format)
```

Example Using the SELECT Command

The users are planning to select data from the TestData table based on the lab time interval between the start and end of a given set of tests.

```
BEGIN DECLARE SECTION

Declare input host variables (:BatchStamp, :BatchStamp-Format,
LabTime, and LabTime-Format) to be compatible with data type
CHAR or VARCHAR.

END DECLARE SECTION
.
.
.
SELECT BatchStamp
       Testdate
       TestStart,
       TestEnd,
       LabTime
       PassQty,
       TestQty
  INTO :BatchStamp,
       :TestDate :TestDateInd,
       :TestStart :TestStartInd,
       :TestEnd :TestEndInd,
       :LabTime :LabTimeInd,
       :PassQty : PassQtyInd,
       :TestQty TestQtyInd
  FROM MANUFDB.TESTDATA
 WHERE LabTime > TO_INTERVAL (:LabTime, :LabTime-Format)
   AND TO_DATETIME (:BatchStamp, :BatchStamp-Format),
BETWEEN :StampOne AND :StampTwo
```

Example Using the DELETE Command

The users want to delete data from the TestData table by entering a value for the BatchStamp column.

```
BEGIN DECLARE SECTION

Declare input host variables (:BatchStamp and :BatchStamp-Format)
to be compatible with data type CHAR or VARCHAR.

END DECLARE SECTION
.
.
.
DELETE FROM MANUFDB.TESTDATA
```

```
WHERE BatchStamp = TO_DATETIME (:BatchStamp, :BatchStamp-Format)
```

Using Date/Time Output Functions

Specify the output format of any type of date/time column by using a date/time output function. Use an output function with any DML operation listed in Table 11-2 with one exception. In the case of a [BULK] INSERT command, output functions are limited to use in the select list and the WHERE clause of a Type 2 INSERT command.

As with date/time input functions, use a host variable or a literal string to indicate a format specification. See the *ALLBASE/SQL Reference Manual* for detailed syntax.

Following is the general syntax for date/time output functions:

```
{ TO_CHAR (ColumnName [,FormatSpecification]) }
{ TO_INTEGER (ColumnName, FormatSpecification) }
```

Example TO_CHAR Function

The default format for the DATETIME data type specifies the year followed by the month followed by the day. The default format for the TIME data type specifies a 24-hour clock. (Refer to the *ALLBASE/SQL Reference Manual* .)

Suppose users located in Italy want to input a specified batch stamp to obtain the start and end times of the related test in 12-hour format. They will key the batch stamp in this format, "DD-MM-YYYY HH12:MM:SS:FFF AM or PM." The times returned will be in this format, "HH12:MM:SS.FFF AM or PM."

Data is located in the TestData table in the manufacturing database. (Refer to appendix C in the *ALLBASE/SQL Reference Manual* .) The following code could be used:

```
BEGIN DECLARE SECTION

Declare input host variables (:TwelveHourClockFormat, :BatchStamp,
:ItalianFormat, and :SpecifiedInput) to be compatible with data type
CHAR or VARCHAR.

Declare output host variables (:TestStart and :TestEnd) to be compatible
with data type CHAR or VARCHAR .

Declare output indicator variables (:TestStartInd and :TestEndInd).

END DECLARE SECTION
.
.
.
SELECT TO_CHAR(TestStart, :TwelveHourClock),
       TO_CHAR(TestEnd, :TwelveHourClock)
  INTO :TestStart :TestStartInd,
```

```
     :TestEnd :TestEndInd,
FROM ManufDB.TestData
WHERE TO_DATETIME(:BatchStamp, :ItalianFormat) = :SpecifiedInput
```

Note the use of indicator variables in the above example. Because the TO_CHAR function is used in the select list, no need exists to specify an indicator variable as part of the function.

Example TO_INTEGER Function

The TO_INTEGER format specification is mandatory and differs from that of other date/time functions in that it must consist of a single element only. See the *ALLBASE/SQL Reference Manual* for detailed format specifications.

Perhaps you are writing a management report that indicates the quarter of the year in which tests were performed. (As in the previous example, data is located in the TestData table in the manufacturing database.) You could use the following code:

```
BEGIN DECLARE SECTION

Use the ALLBASE/SQL Reference Manual  to determine your desired format
specification.  (In this case it is Q.)

Declare the input host variable, :QuarterlyFormat, to be compatible with data
types CHAR or VARCHAR.

In the ReportBuffer array, declare an output host variable (:TestDateQuarter)
to be compatible with data type INTEGER.  Declare other output host
variables (:BatchStamp, :LabTime, :PassQty, and :TestQty) to be
compatible with data type CHAR or VARCHAR.

Remember to declare output indicator variables (:TestDateQuarterInd,
LabTimeInd, PassQtyInd, and :TestQtyInd) in the ReportBuffer array.

END DECLARE SECTION
.
.
.
DECLARE ReportInfo CURSOR FOR
                        SELECT BatchStamp,
                               TO_INTEGER(TestDate, :QuarterlyFormat),
                               LabTime,
                               PassQty,
                               TestQty
                          FROM ManufDB.TestData
.
.
.
BULK FETCH ReportInfo
      INTO ReportBuffer
```

Using the Date/Time ADD_MONTHS Function

This function allows you to add an integer number of months to a DATE or DATETIME column. Do so by indicating the number of months as a positive, negative, or unsigned integer value. (An unsigned value is assumed positive.) Also, you can specify the integer in a host variable of type INTEGER.

The ADD_MONTHS function can be used in both input and output operations as shown in Table 11-1.

Following is the general syntax for the ADD_MONTHS function:

{ ADD_MONTHS (*ColumnName*, *IntegerValue*) }

As with date/time output functions, use the ADD_MONTHS function with any DML operation listed in Table 11-2 with one exception. In the case of a [BULK] INSERT command, the ADD_MONTHS function is limited to use in the select list and the WHERE clause of a Type 2 INSERT command.

Example ADD_MONTHS Function

Perhaps you want to increment each date in the TestDate column by one month in the ManufDB.TestData table of the manufacturing database. The following command could be used:

```
UPDATE ManufDB.TestData
   SET TestDate = ADD_MONTHS (TestDate, 1);
```

Coding Considerations

The following list provides helpful reminders when you are using date/time functions:

- Input functions require leading zeros to match the fixed format of an element. (Z is not supported.)
- For all date/time functions, when you provide only some elements of the complete format in your format specification, any unspecified elements are filled with default values.
- Arithmetic operations are possible with functions of type INTEGER.
- The length of the data cannot exceed the length of the format specification for that data. The maximum size of a format specification is 72 bytes.
- Because LIKE works only with CHAR and VARCHAR values, if you want to use LIKE with date/time data, you must first convert it to CHAR or VARCHAR. For this you can use the TO_CHAR conversion function.
- MIN, MAX, COUNT can be used with any DATE/TIME column type. SUM, AVG can be used with INTERVAL data only.
- Do not specify an indicator variable as a parameter of a date/time function used in the select list of a query.

- When using the ADD_MONTHS function, if the addition of a number of months (positive or negative) would result in an invalid day, the day field is set to the last day of the month for the appropriate year, and a warning is generated indicating the adjustment.

Program Example for Date/Time Data

The example program shown in Figure 11-1 is based on the manufacturing database and the purchasing database that are a part of the sample database environment, PartsDBE. (Reference the *ALLBASE/SQL Reference Manual* , appendix C.)

The program shows how to convert a column data type from CHAR to DATE. Informative comments and explanations are present throughout the listing.

Example Program cex9a

```
/* Program cex9a */

/** * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * */
/*This program uses BULK FETCH and BULK INSERT commands to select all rows*/
/*from the Orders table (part of the sample DBEnvironment, PartsDBE),     */
/*convert the order date column from the CHAR data type to the DATE data  */
/*type default format, and write all Orders table information to another  */
/*table called NewOrders table (created previously by you as described in */
/*this chapter).                                                          */
/** * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * */

#include <stdio.h>

typedef int boolean;

boolean   DoneConvert;
boolean   OrdersOK;
boolean   Abort;
boolean   ConnectDBE();

int       counter1;

#define   OK           0
#define   NotFound     100
#define   DeadLock     -14024
#define   NoMemory     -4008
#define   FALSE        0
#define   TRUE         1

sqlca_type sqlca;   /* SQL Communication Area */

          /* Begin Host Variable Declarations */
    EXEC SQL BEGIN DECLARE SECTION;

    struct   {
        int      OrderNumber;
        int      VendorNumber;
        sqlind   VendorNumInd;
        char     OrderDate[9];       /* Add a byte for end of char array. */
        sqlind   OrderDateInd;
        } Orders[25];
    short   StartIndex;
    short   NumberOfRows;
```

Figure 11-1. Program cex9a: Using Date/Time Functions

```
    struct   {
        int      NewOrderNumber;
        int      NewVendorNumber;
        sqlind   NewVendorNumInd;
        char     NewOrderDate[11];  /*Add a byte for end of char array.*/
        sqlind   NewOrderDateInd;
      } NewOrders[25];
    short   StartIndex2;
    short   NumberOfRows2;

    char    SQLMessage[133];        /*Add a byte for end of char array.*/

    EXEC SQL END DECLARE SECTION;
          /* End Host Variable Declarations */

/*************************************************************************/
/*The cursor for the BULK FETCH is declared in a function that is never   */
/*executed at run time.  The section for this cursor is created and stored*/
/*in the program module at preprocess time.                               */
/*************************************************************************/

boolean DeclareCursor(){

  EXEC SQL DECLARE OrdersCursor
              CURSOR FOR
     SELECT *
              FROM PurchDB.Orders;
}

/*************************************************************************/
/*Function to rollback the transaction.                                  */
/*************************************************************************/

int RollBackWork(){

printf("Rollback Work\n");
EXEC SQL ROLLBACK WORK;
  if (sqlca.sqlcode != OK){
    SQLStatusCheck();
    TerminateProgram();
    }

}  /* End RollBackWork Function */
```

Figure 11-1. Program cex9a: Using Date/Time Functions (2 of 7)

```
/*************************************************************************/
/*                          Beginning of program.                        */
/*************************************************************************/
main() {

printf("Program to convert date from CHAR to DATE data type.\n");
printf("Event List:\n");
printf("  Connect to PartsDBE\n");
printf("  BULK FETCH all rows from Orders Table.\n");
printf("  Convert the date.\n");
printf("  BULK INSERT all fetched rows into NewOrders Table \n");
printf("  with converted date.\n");
printf("  Release PartsDBE\n\n");

if (ConnectDBE()) {

   DoneConvert = FALSE;
   OrdersOK = TRUE;

   BeginTransaction();

   EXEC SQL OPEN OrdersCursor KEEP CURSOR WITH LOCKS;

   if (sqlca.sqlcode != OK) {
      SQLStatusCheck();
      RollBackWork();
      OrdersOK = FALSE;
      DoneConvert = TRUE;
   }

   do {
     FetchOld();
   } while (! DoneConvert);/* DoneConvert is TRUE when all data has been  */
            /* converted and inserted or when an error     */
                           /* condition not serious enough for ALLBASE/SQL*/
                           /* to rollback work was encountered.           */

if (OrdersOK)              /* If there were no errors in processing, data */
   CommitWork();           /* is committed to the database.               */

TerminateProgram();

}       /* END if */

}   /* End of Main Program */
```

Figure 11-1. Program cex9a: Using Date/Time Functions (3 of 7)

```
/*************************************************************************/
/*                      Function to release PartsDBE.                    */
/*************************************************************************/

int TerminateProgram()   /* Function to Release PartsDBE */
{

EXEC SQL RELEASE;

}  /* End TerminateProgram Function */

/*************************************************************************/
/*Function to display error messages and terminate the program when the  */
/*transaction has been rolled back by ALLBASE/SQL.                       */
/*************************************************************************/

int SQLStatusCheck()  /* Function to Display Error Messages */
{

Abort = FALSE;

if (sqlca.sqlcode <= DeadLock) Abort = TRUE;
if (sqlca.sqlcode = NoMemory) Abort = TRUE;

do {
   EXEC SQL SQLEXPLAIN :SQLMessage;
   printf(SQLMessage);
} while (sqlca.sqlcode != 0);
if (Abort) TerminateProgram();

}  /* End SQLStatusCheck Function */

/*************************************************************************/
/*Function to connect to the sample database environment, PartsDBE.      */
/*************************************************************************/

boolean ConnectDBE(){
boolean rv;    /* return value */

  printf("Connect to PartsDBE\n");

  EXEC SQL CONNECT TO 'PartsDBE';

  rv = TRUE;
    if (sqlca.sqlcode != OK){
      rv = FALSE;
```

Figure 11-1. Program cex9a: Using Date/Time Functions (4 of 7)

```
      SQLStatusCheck();

     }  /* End if */
return(rv);
}  /* End of ConnectDBE Function */
/*************************************************************************/
/*Function to begin the transaction with cursor stability specified.     */
/*************************************************************************/

int BeginTransaction(){
EXEC SQL BEGIN WORK CS;

  if (sqlca.sqlcode != OK){
    SQLStatusCheck();
    TerminateProgram();
  }

}  /* End BeginTransaction Function */

/*************************************************************************/
/*Function to commit work to the database OR save the cursor position.   */
/*************************************************************************/

int CommitWork(){
printf("Commit Work\n");
EXEC SQL COMMIT WORK;
  if (sqlca.sqlcode != OK){
    SQLStatusCheck();
    TerminateProgram();
    }

}  /* End CommitWork Function */

/*************************************************************************/
/*Function to BULK INSERT into PurchDB.NewOrders table.                  */
/*************************************************************************/

int InsertNew(){
NumberOfRows2 = counter1;
StartIndex2   = 0;

printf("BULK INSERT INTO  PurchDB.NewOrders\n");

EXEC SQL BULK INSERT INTO  PurchDB.NewOrders
                   VALUES (:NewOrders,
                           :StartIndex2,
                           :NumberOfRows2);
```

Figure 11-1. Program cex9a: Using Date/Time Functions (5 of 7)

```
switch (sqlca.sqlcode){
       case     OK:      break;

           default:      SQLStatusCheck();
                         RollBackWork();
                         OrdersOK = FALSE;
                         DoneConvert = TRUE;
       }     /* switch */

}                /* End of Function InsertNew */

/*********************************************************************/
/*Function to convert OrderDate from CHAR to DATE data type and transfer */
/*data to an array in preparation for BULK INSERT into a new table.      */
/*********************************************************************/

int TransferData()
{
   int i,j;

   NumberOfRows = counter1;

   for (i = 0; i <= NumberOfRows; i++){
     NewOrders[i].NewOrderNumber = Orders[i].OrderNumber;
     NewOrders[i].NewVendorNumber = Orders[i].VendorNumber;
   }

                            /* Convert Date */

   for (i = 0; i <= NumberOfRows; i++){
      for (j = 0; j < 4; j++){
            NewOrders[i].NewOrderDate[j] = Orders[i].OrderDate[j];
      }
      NewOrders[i].NewOrderDate[4] = '-';
      for (j = 5; j < 7; j++)
            NewOrders[i].NewOrderDate[j] = Orders[i].OrderDate[j-1];
            NewOrders[i].NewOrderDate[7] = '-';
      for (j = 8; j < 10; j++)
            NewOrders[i].NewOrderDate[j] = Orders[i].OrderDate[j-2];
   }

}   /* End of Function TransferData */
```

Figure 11-1. Program cex9a: Using Date/Time Functions (6 of 7)

```
/*************************************************************************/
/*Function to BULK FETCH Orders table data 25 rows at a time into an array*/
/*************************************************************************/

int FetchOld()
{

NumberOfRows = 25;
StartIndex  = 0;

printf("BULK FETCH PurchDB.Orders\n");

EXEC SQL BULK FETCH OrdersCursor
        INTO :Orders, :StartIndex, :NumberOfRows;

counter1 = sqlca.sqlerrd[2];    /* Set counter1 to number of rows fetched.*/

  switch (sqlca.sqlcode){
     case  OK:  CommitWork();              /* SAVE THE CURSOR POSITION */
                break;                     /* Used in conjunction with */
                                           /* cursor stability.        */
     case  NotFound:  CommitWork();
               printf("\nThere are no Orders Table rows to FETCH.\n");
                      DoneConvert = TRUE;
                      break;

     default:  SQLStatusCheck();
               RollBackWork();
               OrdersOK = FALSE;
               DoneConvert = TRUE;

  }     /* switch */

if (! DoneConvert)
TransferData();

if (! DoneConvert)
InsertNew();

}     /* End of Function FetchOld */
```

Figure 11-1. Program cex9a: Using Date/Time Functions (7 of 7)

Programming with TID Data Access

Each row (tuple) in an ALLBASE/SQL table is stored at a database address on disk. This unique address is called the **tuple identifier** or **TID**. When using a SELECT statement, you can obtain the TID of any row. In turn, you can use this TID to specify the target row for a SELECT, UPDATE, or DELETE statement. TID functionality provides the fastest possible data access to a single row at a time (TID access) in conjunction with maximum coding flexibility. The following options are available:

- Rapid read and write access to a specific row without the use of a cursor (less overhead).
- Rapid update and delete capability based on TIDs returned by a nested query, a union query, a join query, or a query specifying sorted data.

Other ALLBASE/SQL functionality provides a method of processing a multiple row query result sequentially, one row at a time. This involves the use of a cursor with the UPDATE WHERE CURRENT, DELETE WHERE CURRENT, and REFETCH commands which internally utilize TID access. (See the *ALLBASE/SQL Reference Manual* for more details.)

The nature of your applications will determine how valuable TID functionality can be to you. It could be most useful for applications designed for interactive users and applications that must update a set of related rows atomically.

A TID function and host variable data type are provided. The TID function is used in the select list and/or the WHERE clause of a SELECT statement and in the WHERE clause of an UPDATE or DELETE statement. The new host variable data type is used in an application program to hold data input to and output from the TID function.

Understanding TID Function Input and Output

The next sections describe how TID output is accessed via a select list and how you provide TID input via a WHERE clause. Topics discussed are as follows:

- Using the TID Function in a Select List.
- Using the TID Function in a WHERE Clause.
- Declaring TID Host Variables.
- Understanding the SQLTID Data Format.

Using the TID Function in a Select List

When using the TID function in a select list, specify it as you would a column name. In an application, you could use a statement like the following:

```
SELECT TID(), VendorNumber, VendorName, PhoneNumber
       INTO   :TidHostVar, :VendorNumber,
              :VendorName, :PhoneNumber;
       FROM   Purchdb.Vendors
       WHERE  VendorName = :VendorName
```

The resulting TID and column data is placed in the host variable array, VendorsArray.

The next example illustrates how to obtain TID values for qualifying rows of a two table join. Correlation names are used.

```
SELECT        TID(sp), TID(o)
FROM          PurchDB.SupplyPrice sp,
              PurchDB.Orders o
WHERE         sp.VendorNumber = :VendorNumber
AND           o.VendorNumber = :VendorNumber
```

Using the TID Function in a WHERE Clause

When using the TID function in a WHERE clause, you provide an input parameter. For application programs, this parameter can be specified as a host variable, or a constant. The input parameter is a constant. For example:

DELETE FROM PurchDB.Parts WHERE TID() = 3:3:30;

In an application, you could use a statement like the following to verify the data integrity of a previously accessed row:

```
SELECT PartNumber, PartName, SalesPrice
       INTO   :PartNumber, :PartName, :SalesPrice
       FROM   purchdb.Parts
       WHERE  TID() = :PartsTID
```

You might use the following statement in an application to update a row:

```
UPDATE PurchDB.Parts
SET PartNumber = :PartNumber,
    PartName = :PartName,
    SalesPrice = :SalesPrice
WHERE TID() = :PartsTID
```

Declaring TID Host Variables

Host variables for TID function input and output must be declared in your application as SQLTID host variables. You would declare an SQLTID host variable as follows:

```
sqltid       tidvarname;
```

Understanding the SQLTID Data Format

The data in SQLTID host variables has its own unique format which is not compatible with any other ALLBASE/SQL data type. It is *not* necessary to know the internal format of SQLTID data to use the TID function. The information in this section is provided in case you require the TID value to be broken into its components.

For instance, you might want to know the page numbers of all TID's in a table in order to analyze data distribution. To do this, you must parse the SQLTID host variable.

ALLBASE/SQL does allow you to unload SQLTID data. However, you cannot use the LOAD command to load TID data back into a table. The TID is a unique identifier generated internally by ALLBASE/SQL, and cannot be assigned by users.

An SQLTID host variable consists of eight bytes of binary data and has the following format:

Table 11-4. SQLTID Data Internal Format

Content	Byte Range
Version Number	1 through 2
File Number	3 through 4
Page Number	5 through 7
Slot Number	8

The SQLTID version number is an optional input parameter. If not specified, the version number defaults to 0. If you do specify the version, it must always be 0. If a version other than 0 is specified, no rows will qualify for the operation.

TID function application output always contains a version number of 0.

Transaction Management with TID Access

TID data access is fast, and it must be used with care. A great deal of flexibility of use is possible, and exactly how it should be used depends on your application programming needs.

The next sections look at performance, concurrency and data integrity issues involved in designing database transactions that use TID access. Although a possible usage scenario is given, you must decide how to combine the elements of transaction management to best suit your purposes. The following concepts are highlighted:

- Comparing TID Access to Other Types of Data Access.
- Insuring that the Optimizer Chooses TID Access.
- Verifying Data that is Accessed by TID.
- Stable versus Volatile Data.
- Using Isolation Levels with the TID Function.
- Considering Interactive User Applications.
- Coding Strategies.

TID access requires an initial SELECT, BULK SELECT, FETCH or BULK FETCH to obtain TID values. You can then SELECT, UPDATE or DELETE data by TID.

Comparing TID Access to Other Types of Data Access

When using TID functionality, data access speed is always improved compared to the speed of other ALLBASE/SQL access methods, for the following reasons:

- Index access must lock more pages (i.e. index pages).
- Relation access locks more pages to find the TID of any qualifying row.
- Hash access employs more search overhead.

Note that use of the TID function in a WHERE clause does *not* guarantee that TID access will be chosen by the optimizer. For example, the following statement would utilize TID access:

```
DELETE FROM PurchDB.Parts
       WHERE TID() = :PartsTID AND PartName = 'Winchester Drive'
```

However, in the next statement TID access would not be used:

```
DELETE FROM PurchDB.Parts
       WHERE TID() = :PartsTID1 OR TID() = :PartsTID2
```

See the "Expressions" chapter of the *ALLBASE/SQL Reference Manual* for an explanation of the above and additional optimization criteria.

Verifying Data that is Accessed by TID

It is important to note that a TID in ALLBASE/SQL is unique and is valid until its related data is deleted. You must take precautions to assure that the data you are selecting or changing exists when your statement executes. (Note that a TID can be reassigned after its data has been deleted.)

You can rely on the existence of a given TID, if you *know* its data won't be deleted. That is, you know the nature of the data is non-volatile. In this case, you can select the TID and update by TID with the assurance that data integrity will be maintained. An example might be a table that has been created as private. Another example might be a table that you know is currently being accessed only by your application. (You have begun the transaction with the RR isolation level, or you have used the LOCK TABLE command.)

By contrast, you may be dealing with data that changes frequently. In cases where you are using the CS, RC, or RU isolation levels, you must verify that your data has not changed between the time you select it and the time you update or delete it. A method is to end the transaction in which you selected the data, and begin an RR transaction in which you use a SELECT statement with the TID function in the WHERE clause. See the following section titled "Coding Strategies" for an example.

When you attempt to access a row for update or delete, status checking procedure is the same as for a statement that does not contain the TID function. An application must check the sqlcode field of the sqlca for a value of 100. ISQL displays, "Number of rows selected is 0" for a SELECT statement and "Number of rows processed is 0" for an UPDATE or DELETE statement.

Status checking is discussed in detail in the ALLBASE/SQL application programming guides. Refer to the guide for the language you are using.

Considering Interactive User Applications

Some transaction management basics that apply to TID functionality when used in interactive applications are listed below:

- Be sure to avoid holding locks against the database within a transaction driven by interactive user input. This is sometimes termed "holding locks around terminal reads." It means that the speed at which the user enters required data determines the execution time of your transaction and thus the time span of transaction locks.
- Does your transaction use the RR isolation level? If so, there is no need to verify your data prior to updating or deleting within the same transaction.
- Does your transaction use the CS, RC, or RU isolation level? If so, in order to maintain data integrity, you *must* verify that the data has not changed before you attempt to

update or delete it. By verifying the data in this way, you insure that it still exists and can determine whether or not it has changed from the time it was last presented to the user.

Coding Strategies

Suppose you are writing an application that will be executed by many simultaneous users in an online transaction processing environment. You want each user to be able to locate and update just a few rows in a table that is frequently accessed by many users.

The following scenario illustrates the use of two transactions with different isolation levels. Figure 11-2 uses the RC isolation level with a BULK SELECT statement to obtain data and the RR isolation level with a SELECT statement based on TID access to verify the data before it is updated.

Define two arrays, one (OrdersArray) to hold the qualifying rows of the Orders table and another (NewOrdersArray) to hold the rows that the user wants to change. Be sure to define an element in each array to hold the TID value.

Begin the transaction with RC isolation level. This ensures maximum concurrency for committed data. Locks are released immediately following data access.

```
BEGIN WORK RC

BULK SELECT TID(), OrderNumber, VendorNumber, OrderDate
            INTO   :OrdersArray, :StartIndex, :NumberOfRows;
            FROM   PurchDB.Orders
            WHERE  OrderNumber BETWEEN 30510 AND 30520

COMMIT WORK
```

Once all qualifying rows have been loaded into OrdersArray, end the transaction. Then loop through the array displaying the rows and accepting any user entered changes in NewOrdersArray. Include the appropriate TID values with each NewOrdersArray entry.

Figure 11-2. Using RC and RR Transactions with BULK SELECT, SELECT, and UPDATE

```
When all user changes have been entered, use a loop to compare the previously
fetched rows (in OrdersArray) with the same rows as they now exist in the
database.

Begin your transaction with the RR isolation level.  No other transaction can
access the locked data until this transaction ends, providing maximum data
integrity.

BEGIN WORK RR

        For each entry in NewOrdersArray, do the following:

        SELECT TID(), *
               INTO   :TIDvalue, :OrderNumber, :VendorNumber, :OrderDate
               FROM   PurchDB.Orders
               WHERE  TID() = :TIDHostVariable

        Verify the selected data against the corresponding data in OrdersArray.
        If the row is unchanged, update it using TID access.

        UPDATE PurchDB.Orders
               SET   OrderNumber = :NewOrderNumber :NewOrderNumberInd,
                     VendorNumber = :NewVendorNumber :NewVendorNumberInd,
                     OrderDate = :NewOrderDate :NewOrderDateInd
                     WHERE TID() = :TIDHostVariable

        If the row has changed or has been deleted, inform the user and offer
        appropriate options.

COMMIT WORK
```

Figure 11-2. Using RC and RR Transactions with BULK SELECT, SELECT, and UPDATE (2 of 2)

Reducing Commit Overhead for Multiple Updates with TID Access

Figure 11-3 shows how to reduce COMMIT overhead when performing multiple updates following a BULK FETCH. Two loops are used, each with its own cursor and own set of locks.

In the outer loop, a BULK FETCH is performed with a cursor to load an array. The transaction enveloping the outer loop uses an RC isolation level to allow maximum concurrency while the user is entering data at the terminal. The locks associated with the BULK FETCH cursor are released after each fetch.

The inner loop uses another cursor to FETCH a single row of data based on the TID value. Since an RC isolation is being used, the data must be refetched to prevent other transactions from modifying it. The data is verified, and an UPDATE is performed.

After the inner loop has finished updating the rows of data, a COMMIT WORK is issued to actually commit the updates to the data base and to release the exclusive locks held by the

updates in the inner loop. This use of a single COMMIT WORK for the multiple updates in the inner loop reduces overhead.

Define two arrays, one (PartsArray) to hold the qualifying rows of the Parts table and another (NewPartsArray) to hold the rows that the user wants to change. Be sure to define an element in each array to hold the TID value.

Declare the cursor (BulkCursor) used by the BULK FETCH (4) *that loads the PartsArray.*

```
DECLARE BulkCursor CURSOR FOR
        SELECT TID(), PartNumber, PartName, SalesPrice
        FROM PurchDB.Parts
```

Declare the cursor (TidCursor) used to UPDATE (11) *an individual row based on the TID value.*

```
DECLARE TidCursor CURSOR FOR                                    (1)
        SELECT PartName, SalesPrice
        FROM PurchDB.Parts
        WHERE TID() = :HostPartTid
        FOR UPDATE OF PartName, SalesPrice
```

Begin the transaction with a RC isolation level. This ensures maximum concurrency while assuring that only commited data is read.

```
BEGIN WORK RC                                                   (2)
```

OPEN the cursor associated with the BULK FETCH (4) *. The KEEP CURSOR parameter maintains the cursor position across transactions until the CLOSE* (6) *statement. The WITH NOLOCKS parameter releases all locks associated with the cursor when the COMMIT WORK* (7) *statement is executed.*

```
OPEN BulkCursor KEEP CURSOR WITH NOLOCKS
```

The following COMMIT WORK (3) *statement preserves the open cursor position and automatically starts a new transaction with an RC isolation level.*

```
COMMIT WORK                                                     (3)
```

Loop until no more rows are fetched

```
   BULK FETCH BulkCursor INTO :PartsArray                       (4)
```

Display the rows in PartsArray and move any changes entered by the user to NewPartsArrray. Include the appropriate TID value with each NewPartsArray entry.

For each row in the NewPartsArray
VerifyAndUpdate (8)
End For

Figure 11-3. Using TID Access to Reduce Commit Overhead

The following COMMIT WORK (5) statement commits the updates (11) in VerifyAndUpdate and releases the locks held.

```
COMMIT WORK                                                    (5)
```

End Loop

```
CLOSE BulkCursor                                               (6)
```

The final COMMIT WORK (7) statement ends the transaction started by the BEGIN WORK RC (2). Any locks still held are released.

```
COMMIT WORK                                                    (7)
```
Begin the VerifyAndUpdate routine. (8)

Assign to HostPartTid the TID value in NewPartsArray.

```
OPEN TidCursor
```

Using the cursor declared above (1) as TidCursor, perform a FETCH (9) and REFETCH (10) to verify the data. The REFETCH (10) places a lock on the data page, to prevent another transaction from modifying the data. The lock is held until all the rows in the NewPartsArray have been updated and when the COMMIT WORK (5) is performed.

```
FETCH TidCursor INTO :PartName, :SalesPrice                    (9)

REFETCH TidCursor INTO :PartName, :SalesPrice                  (10)
```

Verify the fetched data against the corresponding row in PartsArray. If the row is unchanged, update it using the TID cursor.

```
   UPDATE PurchDB.Parts                                        (11)
          SET PartName   = :NewPartName,
              SalesPrice = :NewSalesPrice
          WHERE CURRENT OF TidCursor
```

If the row has changed or has been deleted, inform the user and offer appropriate options.

```
CLOSE TidCursor
```

End the VerifyAndUpdate routine.

Figure 11-3. Using TID Access to Reduce Commit Overhead (2 of 2)

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