InterBase User’s Guide

Delphi for Windows

Preface

Copyright Agreement

This preface describes the documentation set, the printing conventions used to display information in text and in code examples, and the conventions a user should employ when specifying database objects and files by name in applications.

The InterBase Documentation Set

The InterBase documentation set is an integrated package designed for all levels of users. The InterBase server documentation consists of a five-book core set and a platform-specific installation guide. Information on the InterBase Client for Windows is provided in a single book.

The InterBase core documentation set consists of the following books:

Table 1: InterBase Core Documentation

Book	Description
[illegible]ng Started	Provides a basic introduction to InterBase and roadmap for using the documentation and a tutorial for learning basic SQL through **isql**. Introduces more advanced topics such as creating stored procedures and triggers.
Data Definition Guide	Explains how to create, alter, and delete database objects through **isql**.
Language Reference	Describes SQL and DSQL syntax and usage.
Programmer’s Guide	Describes how to write embedded SQL and DSQL database applications in a host language, precompiled through **gpre**.
API Guide	Explains how to write database applications using the InterBase API.
Installing and Running on . . .	Platform-specific information on installing and running InterBase.

Printing Conventions

The InterBase documentation set uses different fonts to distinguish various kinds of text and syntax.

Text Conventions

The following table describes font conventions used in text, and provides examples of their use:

Table 2: Text Conventions

Convention	Purpose	Example
UPPERCASE	SQL keywords, names of all database objects such as tables, columns, indexes, stored procedures, and SQL functions.	The following SELECT statement retrieves data from the CITY column in the CITIES table.
italic	Introduces new terms, and emphasizes words. Also used for file names and host-language variables.	The *ISC4.GDB* security database is *not* accessible without a valid *username* and *password*.
bold	Utility names, user-defined and host-language function names. Function names are always followed by parentheses to distinguish them from utility names.	To back up and restore a database, use **gbak** or the server manager. The **datediff()** function can be used to calculate the number of days between two dates.

Syntax Conventions

The following table describes the conventions used in syntax statements and sample code, and offers examples of their use:

Table 3: Syntax Conventions

Convention	Purpose	Example
UPPERCASE	Keywords that must be typed exactly as they appear when used.	SET TERM !!;

Table 3: Syntax Conventions (Continued)

Convention	**Purpose**	**Example**
italic	Parameters that *cannot* be broken into smaller units. For example, a table name cannot be subdivided.	CREATE TABLE *name* (*<col>* [**,** *<col>* ...]);
<italic>	Parameters in angle brackets that *can* be broken into smaller syntactic units. For example, column definitions (*<col>*) can be subdivided into a name, data type and constraint definition.	CREATE TABLE *name* (*<col>* [**,** *<col>* ...])**;** *<col>* = *name <datatype>* [CONSTRAINT *name <type>*]
[ ]	Square brackets enclose optional syntax.	*<col>* [**,** *<col>* ...]
...	Closely spaced ellipses indicate that a clause within brackets can be repeated as many times as necessary.	(*<col>* [**,** *<col>* ...]);
|	The pipe symbol indicates that either of two syntax clauses that it separates may be used, but not both. Inside curly braces, the pipe symbol separates multiple choices, one of which *must* be used.	SET TRANSACTION {SNAPSHOT [TABLE STABILITY] | READ COMMITTED};
{ }	Curly braces indicate that one of the enclosed options *must* be included in actual statement use.	SET TRANSACTION {SNAPSHOT [TABLE STABILITY] | READ COMMITTED};

Database Object-naming Conventions

InterBase database objects, such as tables, views, and column names, appear in text and code in uppercase in the InterBase documentation set because this is the way such information is stored in a database's system tables.

When an applications programmer or end user creates a database object or refers to it by name, case is unimportant. The following limitations on naming database objects must be observed:

- Start each name with an alphabetic character (A-Z or a-z).

- Restrict object names to 31 characters, including dollar signs ($), underscores (_), 0 to 9, A to Z, and a to z. Some objects, such as constraint names, are restricted to 27 bytes in length.
- Keep object names unique. In all cases, objects of the same type, for example, tables and views, *must* be unique. In most cases, object names must also be unique within the database.

For more information about naming database objects with CREATE or DECLARE statements, see the *Language Reference*.

File-naming Conventions

InterBase is available on a wide variety of platforms. In most cases users in a heterogenous networking environment can access their InterBase database files regardless of platform differences between client and server machines if they know the target platform's file naming conventions.

Because file-naming conventions differ widely from platform to platform, and because the core InterBase documentation set is the same for each of these platforms, all file names in text and in examples are restricted to a base name with a maximum of eight characters, with a maximum extension length of three characters. For example, the example database on all servers is referred to as *employee.gdb*.

Generally, InterBase fully supports each platform's file-naming conventions, including the use of node and path names. InterBase, however, recognizes two categories of file specification in commands and statements that accept more than one file name. The first file specification is called the *primary file specification*. Subsequent file specifications are called *secondary file specifications*. Some commands and statements place restrictions on using node names with secondary file specifications.

In syntax, file specification is denoted as follows:

```
"<filespec>"
```

Primary File Specifications

InterBase syntax always supports a full file specification, including optional node name and full path, for primary file specifications. For example, the syntax notation for CREATE DATABASE appears as follows:

```
CREATE {DATABASE | SCHEMA} "<filespec>"
   [USER "username" [PASSWORD "password"]]
   [PAGE_SIZE [=] int]
   [LENGTH [=] int [PAGE[S]]]
   [DEFAULT CHARACTER SET charset]
   . . .
```

In this syntax, the *<filespec>* that follows CREATE DATABASE supports a node name and path specification, including a platform-specific drive or volume specification.

Secondary File Specifications

For InterBase syntax that supports multiple file specification, such as CREATE DATABASE, all file specifications after the first are secondary. Secondary file specifications generally cannot include a node name, but may specify a full path name. For example, the syntax notation for CREATE DATABASE appears as follows:

```
CREATE {DATABASE | SCHEMA} "<filespec>"
   [USER "username" [PASSWORD "password"]]
   [PAGE_SIZE [=] int]
   [LENGTH [=] int [PAGE[S]]]
   [DEFAULT CHARACTER SET charset]
   [<secondary_file>]

<secondary_file> = FILE "<filespec>" [<fileinfo>] [<secondary_file>]

<fileinfo> = LENGTH [=] int [PAGE[S]] | STARTING [AT [PAGE]] int
   [<fileinfo>]
```

In the secondary file specification, *<filespec>* does not support specification of a node name.

PART 1

Overview

Part 1 provides an introduction to the Local InterBase Server and describes its features.

Chapter 1: "Introduction" gives a general overview of the Local InterBase Server and introduces each of the features.

Chapter 2: "Building InterBase Databases"describes how to build databases.

Chapter 3: "Working With Transactions" describes InterBase's transaction processing features.

CHAPTER 1

Introduction

This chapter provides a high-level introduction to the Local InterBase Server.

What is the Borland Local InterBase Server?

The Borland Local InterBase Server is a single-user Windows-based version of Borland's InterBase Workgroup Server, an SQL-compliant relational database management system (RDBMS). The Local InterBase Server includes Windows ISQL and the Server Manager, a Windows tool that can be used with Local InterBase Server or a remote InterBase server. Using the Local Interbase Server, you can access local databases through Windows ISQL or through a SQL application program.

Figure 1-1 shows the relationships between the Local InterBase Server and the associated connections for data access.

The Local InterBase Server can be used in three ways:

- As an intermediate step in upsizing, between the desktop and server, providing a local SQL engine for development of SQL-specific features.
- As a local database engine for stand-alone desktop SQL applications.
- As a local environment for developing a client/server application.

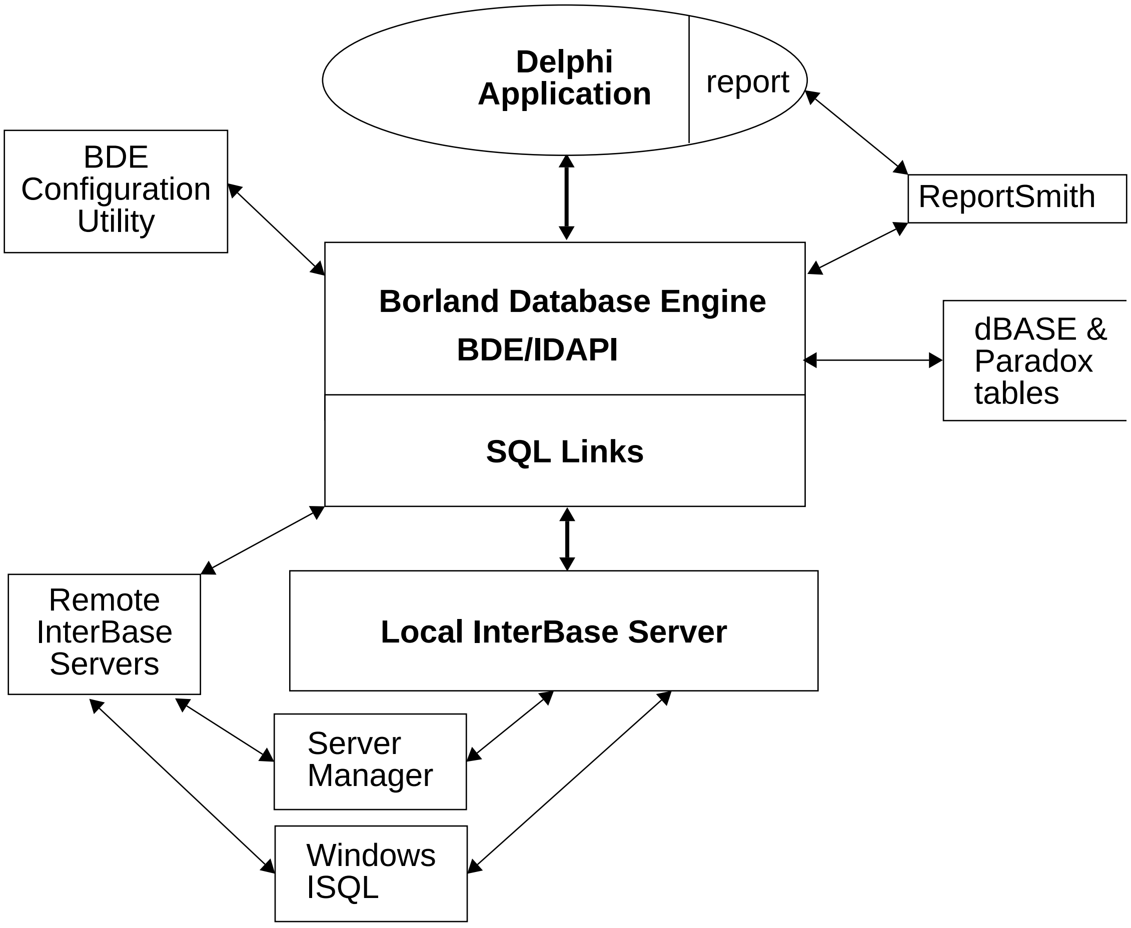
Delphi applications can access a Local InterBase Server database through the Borland Database Engine (BDE) and the InterBase SQL Link. For more information on creating Delphi applications for SQL servers, see the Delphi *Database Application Developer's Guide*.

Note To access remote databases, make sure that the InterBase Client for Windows and the proper communications protocols are installed. See the *InterBase Client for Windows User's Guide*.

Installation

The Local InterBase Server is installed as part of Delphi. The installation program for Delphi enables you to install a minimum configuration, a maximum configuration, or to install a custom configuration using only a subset of the complete Delphi package. See the Delphi documentation and online help for complete information on installing the software.

Figure 1-1: InterBase Client/Server Connections



InterBase Features

InterBase offers all the benefits of a fully relational DBMS. The following table lists some of the key InterBase features:

Table 1-1: InterBase 4.0 Features

Feature	Description
SQL-92 entry-level conformance	ANSI standard SQL, available through an Interactive SQL tool and Borland desktop applications.
Simultaneous access to multiple databases	One application can access many databases at the same time.
Multi-generational architecture	Server maintains older versions of records (as needed) so that transactions can see a consistent view of data.
Query optimization	Server optimizes queries automatically, or user may manually specify query plan.
BLOB data type	Binary Large Objects can contain unformatted data such as graphics and text.
Declarative referential integrity	Automatic enforcement of cross-table relationships (between FOREIGN and PRIMARY KEYs.)
Stored procedures	Programmatic elements in the database for advanced queries and data manipulation actions.
Triggers	Self-contained program modules that are activated when data in a specific table is inserted, updated, or deleted.
Updatable views	Views can reflect data changes as they occur.
Outer joins	Relational construct between two tables that enables complex operations.
Explicit transaction management	Full control of transaction start, commit, and rollback, including named transactions.
Concurrent multiple application access to data	One application reading a table does not necessarily block others from it.
Automatic two-phase commit	Multi-database transactions check that changes to all databases happen before committing.
Multi-dimensional arrays	Column data types arranged in an indexed list of elements.
Server Manager	Windows tool for database backup, restoration, maintenance, and security.
Windows ISQL	Interactive data definition and query tool for Windows.

SQL Support

InterBase conforms to entry-level SQL-92 requirements. It supports declarative referential integrity, updatable views, and outer joins.

InterBase also supports extended SQL features, some of which anticipate SQL3 extensions to the SQL standard. These include stored procedures, triggers, and segmented BLOB support.

InterBase provides an interactive SQL data definition and data manipulation tool, Windows ISQL.

Delphi applications can use all of Local InterBase Server SQL features with pass-through SQL. For more information see the Delphi *Database Application Developer's Guide*

Transaction Management

Client applications can start multiple simultaneous transactions. InterBase provides full and explicit transaction control for starting, committing, and rolling back transactions. The statements and functions that control starting a transaction also control transaction behavior.

InterBase transactions can be isolated from changes made by other concurrent transactions. For the life of these transactions, the database will appear to be unchanged except for the changes made by the transaction. Records deleted by another transaction will exist, newly stored records will not appear to exist, and updated records will remain in the original state.

Multi-generational Architecture

InterBase provides expedient handling of time-critical transactions through support of data concurrency and consistency in mixed use (query and update) environments. InterBase uses a *multi-generational architecture*, which creates and stores multiple versions of each data record. By creating a new version of a record, InterBase allows all users to read a version of any record at any time, even if another user is changing that record. InterBase also uses transactions to isolate groups of database changes from other changes.

Database Administration

Interbase provides Windows-based tools for managing databases and servers. *Server Manager* is a Windows application for performing database administration.

For more information about Server Manager, see the *Windows Client User's Guide*.

Server Manager and the command-line utilities enable the DBA to:

- Manage server security.
- Back up and restore a database.
- Perform database maintenance.
- View database and lock manager statistics.

Managing Server Security

InterBase maintains a list of user names and passwords in a security database. The security database allows clients to connect to an InterBase database on a server if a user name and password supplied by the client match a valid user name and password combination in the security database on the server.

You can add and delete user names and modify a user's parameters, such as password and user ID.

Performing Database Backup and Recovery

Server Manager can back up a database and then restore it on any supported operating system. A backup can run concurrently with other processes because it does not require exclusive access to the database.

Database backup and restoration can also be used for:

- Erasing obsolete versions of database records
- Changing the database page size
- Changing the database from single-file to multi-file
- Transferring a database from one operating system to another

Server Manager and the command-line backup tool also have an option for backing up only a database's metadata to recreate an empty database.

Maintaining a Database

Server Manager can also be used for maintaining a database and preparing it for shutdown. If a database incurs minor problems, such as an operating system write error, these tools enable you to sweep a database without taking the database offline.

Some of the tasks that are part of database maintenance are:

- Sweeping a database
- Shutting down the database to provide exclusive access to it
- Validating table fragments
- Preparing a corrupt database for backup
- Resolving transactions “in limbo” from a two-phase commit
- Validating and repairing the database structure

Viewing Statistics

Server Manager enables the DBA to monitor the status of a database by viewing statistics from the database header page, and an analysis of tables and indexes.

CHAPTER 2

Building InterBase Databases

This chapter introduces important database building concepts.

Building Databases

To create a database and its components, InterBase uses an implementation of SQL which conforms to the ANSI SQL-89 entry-level standard and follows SQL-92 and SQL3 beta specifications for advanced features.

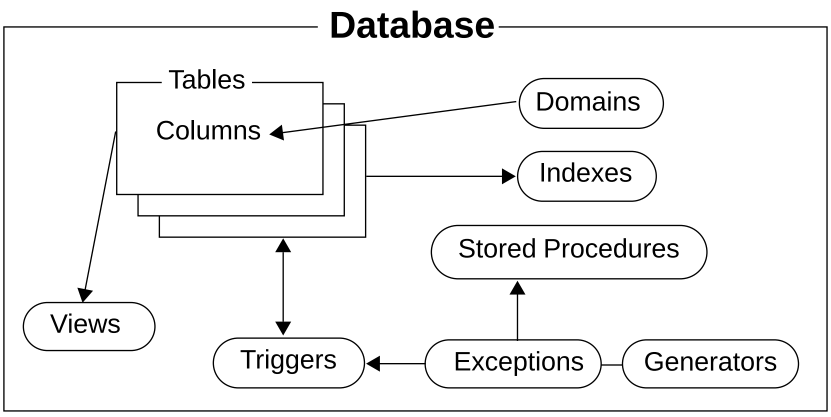
Building a database involves *defining the data*. For this purpose InterBase provides a set of statements called the Data Definition Language (DDL).

A database consists of a variety of database objects, such as tables, views, domains, stored procedures, triggers, and so on. *Database objects* contain all the information about the structure of the database and the data. Because they encapsulate information about the data, database objects are sometimes referred to as *metadata*.

An InterBase database is a single file comprising all the metadata and data in the database. To create a new database for the Local InterBase Server, use Windows ISQL. For more detailed information, see Chapter 4: "Using Windows ISQL."

The following sections provide an overview of the InterBase database objects. For more information on databases and database objects, see the *Data Definition Guide*. For the complete syntax of data definition statements, see the *Language Reference*.

Figure 2-1: Database Objects



Tables

Relational databases store all their data in tables. A *table* is a data structure consisting of an unordered set of horizontal *rows*, each containing the same number of vertical *columns*. The intersection of an individual row and column is a *field* that contains a specific piece of information. Much of the power of relational databases comes from defining the *relations* among the tables.

InterBase stores information about metadata in special tables, called *system tables*. System tables have predefined columns that store information about the type of metadata in that table. All system tables begin with "RDB$". An example of a system table is RDB$RELATIONS, which stores information about each table in the database.

System tables have the same structure as user-defined tables and are stored in the same database as the user-defined tables. Because the metadata, user-defined tables, and data are all stored in the same database file, each database is a complete unit and can be easily transported between machines.

System tables can be modified like any other database tables. Unless you understand all the interrelationships between the system tables, however, modifying them directly may adversely affect other system tables and disrupt your database. For more information about system tables, see the *Language Reference*.

Columns

Creating a table mainly involves defining the columns in the table. The main attributes of a column include:

- The name of the column
- Data type of the column or the domain on which it is based
- Whether or not the column is allowed to be NULL
- Optional referential integrity constraints

Data Types

Data is stored in a predefined format called a data type. Data types can be classified into four categories: numeric, character, date, and BLOB. Numeric data types handle everything from integers to double-precision floating point values. Character data types hold strings of text. Date data types are used for storing date and time values. InterBase also supports arrays of these standard data types.

While numeric, character, and date are standard data types, the BLOB data type and arrays of standard data types deserve special mention.

Numeric Data Types

Numeric data types are: SMALLINT, INTEGER, FLOAT, DOUBLE PRECISION, NUMERIC, and DECIMAL. Most of these correspond in size and precision to similar data types in C. For example, SMALLINT typically corresponds to a short in C, and DOUBLE PRECISION corresponds to a double. When comparing or assigning values of different numeric types, InterBase handles many conversions automatically. Others can be coerced using the CAST() function.

Character Data Types

Character data types are CHAR and VARCHAR. They allow strings of multiple characters to be stored in a column. CHAR and VARCHAR differ in the way extra characters are treated. The CHAR data type uses all characters up to the end of the array, but the VARCHAR data type is significant only to the first NULL character.

Date Data Types

The DATE data type is used to store date and time values. InterBase handles assignment and comparison between strings and dates. String values representing dates can be in a variety of formats, such as “12-1-94” and “December 1, 1994”. Certain date constants are also supported, such as “TODAY” and “TOMORROW”.

BLOB Data Types

InterBase supports a *binary large object* (BLOB) data type, that can hold data of unlimited size. The BLOB is an extension of the standard relational model, which ordinarily provides only for data types of fixed width.

The BLOB data type is analogous to a flat file because BLOB data can be stored in any format (for example, binary or ASCII). A BLOB, however, is not a separate file. BLOB data is stored in the database with all other data. Because BLOB columns often contain large, variable amounts of data, BLOB columns are stored and retrieved in segments.

Conversion of BLOB data to other data types in InterBase is not directly supported, but on some platforms, BLOB filters can translate BLOB data from one BLOB format to another.

Arrays of Data Types

InterBase supports arrays of all data types except BLOB. An *array* is a collection of values, or elements, each of the same data type. Individual array elements, blocks of contiguous elements, or the entire array can be accessed using standard SQL statements and API calls.

An array in InterBase can be up to 16 dimensions. Because InterBase arrays are multidimensional, you can store arrays as a whole in a single field, making accessing and retrieval fast and simple. An element of array data is referenced through the use of coordinates, or offsets, into the array.

Domains

In addition to explicitly stating the data type of columns, InterBase allows global column definitions, or *domains*, upon which column definitions can be based. A domain specifies a data type, and a set of column attributes and constraints. Subsequent table definitions can use the domain to define columns.

Referential Integrity Constraints

InterBase allows you to define referential integrity rules for a column, called *referential integrity constraints*. Integrity constraints govern column-to-table and table-to-table relationships and validate data entries. They are implemented through primary keys, foreign keys, and check constraints. Basically, a *primary key* is a column (or group of columns) that uniquely identifies a row in a table. A *foreign key* is a column whose value must match a value of a column in another table. A *check constraint* limits data entry to a specific range or set of values.

For example, an EMPLOYEE table could be defined to have a foreign key column named DEPT_NO that is defined to match the department number column in a DEPARTMENT table. This would ensure that each employee in the EMPLOYEE table is assigned to an existing department in the DEPARTMENT table.

For more information about referential integrity, see the *Data Definition Guide*.

Indexes

Indexes are mechanisms for improving the speed of data retrieval. An index identifies columns that can be used to retrieve and sort rows efficiently in the table. It provides a means to scan only a specific subset of the rows in a table, improving the speed of data access.

InterBase automatically defines unique indexes for a table's PRIMARY KEY and FOREIGN KEY constraints. For more information about indexes, see the *Data Definition Guide*.

Views

A *view* is a virtual table that is not physically stored in the database, but appears exactly like a "real" table. A view can contain data from one or more tables or other views and is used to store often-used queries or query sets in a database.

Views can also provide a limited means of security, because they can provide users access to a subset of available data while hiding other related and sensitive data. For more information about views, see the *Data Definition Guide*.

Stored Procedures

A *stored procedure* is a self-contained program written in InterBase procedure and trigger language, an extension of SQL. Stored procedures are part of a database's metadata. Stored procedures can receive input parameters from and return values to applications and can be executed explicitly from applications, or substituted for a table name in a SELECT statement.

Stored procedures provide:

- Modular design: stored procedures can be shared by applications that access the same database, eliminating duplicate code, and reducing the size of applications.

- Streamlined maintenance: when a procedure is updated, the changes are automatically reflected in all applications that use it without the need to recompile and relink them. They are compiled and optimized only once for each client.
- Improved performance: especially for remote client access. Stored procedures are executed by the server, not the client, which reduces network traffic.

Triggers

A *trigger* is a self-contained routine associated with a table or view that automatically performs an action when a row in the table or view is inserted, updated, or deleted.

Triggers can provide:

- Automatic enforcement of data restrictions to ensure that users enter only valid values into columns.
- Reduced application maintenance, because changes to a trigger are automatically reflected in all applications that use the associated table without the need to recompile and relink them.
- Automatic logging of changes to tables. An application can keep a running log of changes with a trigger that fires whenever a table is modified.
- Event alerters in triggers can automatically notify applications of changes to the database.

When a trigger is invoked, it has immediate access to data being stored, modified, or erased. The trigger may also access data in other tables. Using the available data, you can design the trigger to:

- Abort an operation, possibly with an error message.
- Set values in the accessed record.
- Insert, update, or delete rows in other tables.
- Signal that an event has occurred using an event alerter.

CHAPTER 3

Working With Transactions

All SQL data definition and data manipulation statements take place within the context of a *transaction*, a set of SQL statements that works to carry out a single task. This chapter explains how to open, control, and close transactions using the following SQL transaction management statements:

Table 3-1: SQL Transaction Management Statements

Statement	Purpose
SET TRANSACTION	Starts a transaction, assigns it a name, and specifies its behavior. The following behaviors can be specified: • *Access mode* describes the actions a transaction's statements can perform. • *Lock resolution* describes how a transaction should react if a lock conflict occurs. • *Isolation level* describes the view of the database given a transaction as it relates to actions performed by other simultaneously occurring transactions. • *Table reservation*, an optional list of tables to lock for access at the start of the transaction rather than at the time of explicit reads or writes. • *Database specification*, an optional list limiting the open databases to which a transaction may have access.
COMMIT	Saves a transaction's changes to the database and ends the transaction.
ROLLBACK	Undoes a transaction's changes before they have been committed to the database, and ends the transaction.

Transaction management statements define the beginning and end of a transaction. They also control its behavior and interaction with other simultaneously running transactions that share access to the same data within and across applications.

Starting a Transaction With SET TRANSACTION

SET TRANSACTION issued without parameters starts a transaction with the following default behavior:

```
READ WRITE WAIT ISOLATION LEVEL SNAPSHOT
```

The following table summarizes these settings:

Table 3-2: Transaction Default Behavior

Parameter	Setting	Purpose
Access Mode	READ WRITE	Access mode. This transaction can select, insert, update, and delete data.
Lock Resolution	WAIT	Lock resolution. This transaction waits for locked tables and rows to be released to see if it can then update them before reporting a lock conflict.
Isolation Level	ISOLATION LEVEL SNAPSHOT	This transaction receives a stable, unchanging view of the database as it is at the moment the transaction starts; it never sees changes made to the database by other active transactions.

The following statements are equivalent. They both start a transaction with default behavior.

```
SET TRANSACTION;

SET TRANSACTION READ WRITE WAIT ISOLATION LEVEL SNAPSHOT;
```

To start a transaction, but change its characteristics, SET TRANSACTION must be used to specify those characteristics that differ from the default. Characteristics that do not differ from the default can be omitted. For example, the following statement starts a transaction for READ ONLY access, WAIT lock resolution, and ISOLATION LEVEL SNAPSHOT:

```
SET TRANSACTION READ ONLY;
```

Specifying SET TRANSACTION Behavior

Use SET TRANSACTION to start a transaction, and optionally specify its behavior.

The following table lists the optional SET TRANSACTION parameters for specifying the behavior of the default transaction:

Table 3-3: SET TRANSACTION Parameters

Parameter	Setting	Purpose
Access Mode	READ ONLY or READ WRITE	Describes the type of access this transaction is permitted for a table. For more information about access mode, see “Access Mode,” in this chapter.
Lock Resolution	WAIT or NO WAIT	Specifies what happens when this transaction encounters a locked row during an update or delete. It either waits for the lock to be released so it can attempt to complete its actions, or it returns an immediate lock conflict error message. For more information about lock resolution, see “Lock Resolution,” in this chapter.
Isolation Level	• SNAPSHOT provides a view of the database at the moment this transaction starts, but prevents viewing changes made by other active transactions. • SNAPSHOT TABLE STABILITY prevents other transactions from making changes to tables that this transaction is reading and updating, but permits them to read rows in the table. • READ COMMITTED reads the most recently committed version of a row during updates and deletions, and allows this transaction to make changes if there is no update conflict with other transactions.	Determines this transaction’s interaction with other simultaneous transactions attempting to access the same tables. READ COMMITTED isolation level also enables a user to specify which version of a row it can read. There are two options: • RECORD_VERSION specifies that the transaction immediately read the latest committed version of a row, even if a more recent uncommitted version also resides on disk. • NO RECORD_VERSION specifies that the transaction can only read the latest version of a row. If WAIT lock resolution is also specified, then the transaction waits until the latest version of a row is committed or rolled back, and retries its read.
Table Reservation	RESERVING	RESERVING specifies a subset of available tables to lock immediately for this transaction to access.

The complete syntax of SET TRANSACTION is:

```
SET TRANSACTION
   [READ WRITE| READ ONLY]
   [WAIT | NO WAIT]
   [[ISOLATION LEVEL] {SNAPSHOT [TABLE STABILITY]
      | READ COMMITTED [[NO] RECORD_VERSION]}]
   [RESERVING <reserving_clause>
```

```
<reserving_clause> = table [, table ...]
   [FOR [SHARED | PROTECTED] {READ | WRITE}] [, <reserving_clause>]
```

Transaction options are fully described in the following sections.

Access Mode

The access mode parameter specifies the type of access a transaction has for the tables it uses. There are two possible settings:

- READ ONLY specifies that a transaction can select data from a table, but cannot insert, update, or delete table data.
- READ WRITE specifies that a transaction can select, insert, update, and delete table data. This is the default setting if none is specified.

InterBase assumes that most transactions both read and write data. When starting a transaction for reading and writing, READ WRITE can be omitted from SET TRANSACTION statement. For example, the following statements start a transaction for READ WRITE access:

```
SET TRANSACTION;

SET TRANSACTION READ WRITE;
```

Tip It is good programming practice to specify a transaction’s access mode, even when it is READ WRITE. It makes an application’s source code easier to read and debug because the program’s intentions are clearly spelled out.

Start a transaction for READ ONLY access when you only need to read data. READ ONLY *must* be specified. For example, the following statement starts a transaction for read-only access:

```
SET TRANSACTION READ ONLY;
```

Isolation Level

The isolation level parameter specifies the control a transaction exercises over table access. It determines the:

- View of a database the transaction can see.
- Table access allowed to this and other simultaneous transactions.

The following table describes the three isolation levels supported by InterBase:

Table 3-4: ISOLATION LEVEL Options

Isolation Level	**Purpose**
SNAPSHOT	The default isolation level, provides a stable, committed view of the database at the time the transaction starts. Other simultaneous transactions can UPDATE and INSERT rows, but this transaction cannot see those changes. For updated rows, this transaction sees versions of those rows as they existed at the start of the transaction. If this transaction attempts to update or delete rows changed by another transaction, an update conflict is reported.
SNAPSHOT TABLE STABILITY	Provides a transaction sole insert, update, and delete access to the tables it uses. Other simultaneous transactions may still be able to select rows from those tables.
READ COMMITTED	Enables the transaction to see all committed data in the database, and to update rows updated and committed by other simultaneous transactions without causing lost update problems.

The isolation level for most transactions should be either SNAPSHOT or READ COMMITTED. These levels enable simultaneous transactions to select, insert, update, and delete data in shared databases, and they minimize the chance for lock conflicts. Lock conflicts occur in two situations:

- When a transaction attempts to update a row already updated or deleted by another transaction. A row updated by a transaction is effectively locked for update to all other transactions until the controlling transaction commits or rolls back. READ COMMITTED transactions can read and update rows updated by simultaneous transactions after they commit.
- When a transaction attempts to insert, update, or delete a row in a table locked by another transaction with an isolation level of SNAPSHOT TABLE STABILITY. SNAPSHOT TABLE STABILITY locks entire tables for write access, although concurrent reads by other SNAPSHOT and READ COMMITTED transactions are permitted.

Using SNAPSHOT TABLE STABILITY guarantees that only a single transaction can make changes to tables, but increases the chance of lock conflicts where there are simultaneous transactions attempting to access the same tables. For more information about the likelihood of lock conflicts, see “Isolation Level Interactions,” in this chapter.

Comparing Isolation Levels

There are five classic problems all transaction management statements must address:

- *Lost updates,* which can occur if an update is overwritten by a simultaneous transaction unaware of the last updates made by another transaction.
- *Dirty reads*, which can occur if the system allows one transaction to select uncommitted changes made by another transaction.
- *Non-reproducible reads,* which can occur if one transaction is allowed to update or delete rows that are repeatedly selected by another transaction. READ COMMITTED transactions permit non-reproducible reads by design, because they can see committed deletes made by other transactions.
- *Phantom rows,* which can occur if one transaction is allowed to select some, but not all, new rows written by another transaction. READ COMMITTED transactions do not prevent phantom rows.
- *Update side effects,* which can occur when row values are interdependent, and their dependencies are not adequately protected or enforced by locking, triggers, or integrity constraints. These conflicts occur when two or more simultaneous transactions randomly and repeatedly access and update the same data; such transactions are called *interleaved transactions*.

Except as noted, all three InterBase isolation levels control these problems. The following table summarizes how a transaction with a particular isolation level controls access to its data for other simultaneous transactions:

Table 3-5: InterBase Management of Classic Transaction Conflicts

Problem	**SNAPSHOT, READ COMMITTED**	**SNAPSHOT TABLE STABILITY**
Lost updates	Other transactions cannot update rows already updated by this transaction.	Other transactions cannot update tables controlled by this transaction.
Dirty reads	Other SNAPSHOT transactions can only read a previous version of a row updated by this transaction. Other READ COMMITTED transactions can only read a previous version, or committed updates.	Other transactions cannot access tables updated by this transaction.

Table 3-5: InterBase Management of Classic Transaction Conflicts (Continued)

Problem	SNAPSHOT, READ COMMITTED	SNAPSHOT TABLE STABILITY
Non-reproducible reads	SNAPSHOT and SNAPSHOT TABLE STABILITY transactions can only read versions of rows committed when they started. READ COMMITTED transactions must expect that reads cannot be reproduced.	SNAPSHOT and SNAPSHOT TABLE STABILITY transactions can only read versions of rows committed when they started. Other transactions cannot access tables updated by this transaction.
Phantom rows	READ COMMITTED transactions may encounter phantom rows.	Other transactions cannot access tables controlled by this transaction.
Update side effects	Other SNAPSHOT transactions can only read a previous version of a row updated by this transaction. Other READ COMMITTED transactions can only read a previous version, or committed updates. Use triggers and integrity constraints to try to avoid any problems with interleaved transactions.	Other transactions cannot update tables controlled by this transaction. Use triggers and integrity constraints to avoid any problems with interleaved transactions.

Choosing Between SNAPSHOT and READ COMMITTED

The choice between SNAPSHOT and READ COMMITTED isolation levels depends on an application's needs. SNAPSHOT is the default InterBase isolation level. READ COMMITTED duplicates SNAPSHOT behavior, but can read subsequent changes committed by other transactions. In many cases, using READ COMMITTED reduces data contention.

SNAPSHOT transactions receive a stable view of a database as it exists the moment the transactions start. READ COMMITTED transactions can see the latest committed versions of rows. Both types of transactions can use SELECT statements unless they encounter the following conditions:

- Table locked by SNAPSHOT TABLE STABILITY transaction for UPDATE.
- Uncommitted inserts made by other simultaneous transactions. In this case, a SELECT is allowed, but changes cannot be seen.

READ COMMITTED transactions can read the latest committed version of rows. A SNAPSHOT transaction can read only a prior version of the row as it existed before the update occurred.

SNAPSHOT and READ COMMITTED transactions with READ WRITE access can use INSERT, UPDATE, and DELETE unless they encounter tables locked by SNAPSHOT TABLE STABILITY transactions.

SNAPSHOT transactions cannot update or delete rows previously updated or deleted and then committed by other simultaneous transactions. Attempting to update a row previously updated or deleted by another transaction results in an update conflict error.

A READ COMMITTED READ WRITE transaction can read changes committed by other transactions, and subsequently update those changed rows.

Occasional update conflicts may occur when simultaneous SNAPSHOT and READ COMMITTED transactions attempt to update the same row at the same time. When update conflicts occur, expect the following behavior:

- For *mass* or *searched updates*, updates where a single UPDATE modifies multiple rows in a table, all updates are undone on conflict. The UPDATE can be retried. For READ COMMITTED transactions, the NO RECORD_VERSION option can be used to narrow the window between reads and updates or deletes. For more information, see "Starting a Transaction With READ COMMITTED Isolation Level," in this chapter.
- For *cursor* or *positioned updates*, where rows are retrieved and updated from an active set one row at a time, only a single update is undone. To retry the update, the cursor must be closed, then reopened, and updates resumed at the point of previous conflict.

Starting a Transaction With SNAPSHOT Isolation Level

InterBase assumes that the default isolation level for transactions is SNAPSHOT. Therefore, SNAPSHOT need not be specified in SET TRANSACTION to set the isolation level. For example, the following statements are equivalent. They both start a transaction for READ WRITE access and set isolation level to SNAPSHOT.

```
SET TRANSACTION;

SET TRANSACTION READ WRITE SNAPSHOT;
```

When an isolation level is specified, it must follow the access and lock resolution modes.

Tip It is good programming practice to specify a transaction's isolation level, even when it is SNAPSHOT. It makes an application's source code easier to read and debug because the program's intentions are clearly spelled out.

Starting a Transaction With READ COMMITTED Isolation Level

To start a READ COMMITTED transaction, the isolation level *must* be specified. For example, the following statement starts a transaction for READ WRITE access and sets isolation level to READ COMMITTED:

```
SET TRANSACTION READ WRITE READ COMMITTED;
```

Isolation level always follows access mode. If the access mode is omitted, isolation level is the first parameter.

READ COMMITTED supports mutually exclusive optional parameters, RECORD_VERSION and NO RECORD_VERSION. They determine READ COMMITTED behavior when it encounters a row where the latest version of that row is uncommitted:

- RECORD_VERSION, specifies that the transaction immediately read the latest committed version of a row, even if a more recent uncommitted version also resides on disk.
- NO RECORD_VERSION, the default, specifies that the transaction can only read the latest version of a row. If the WAIT lock resolution option is also specified, then the transaction waits until the latest version of a row is committed or rolled back, and retries its read.

Because NO RECORD_VERSION is the default behavior, it need not be specified with READ COMITTED. For example, the following statements are equivalent. They start a transaction for READ WRITE access and set isolation level to READ COMMITTED NO RECORD_VERSION.

```
SET TRANSACTION READ WRITE READ COMMITTED;

SET TRANSACTION READ WRITE READ COMMITTED
   NO RECORD_VERSION;
```

RECORD_VERSION must always be specified when it is used. For example, the following statement starts a named transaction, *t1*, for READ WRITE access and sets isolation level to READ COMMITTED RECORD_VERSION:

```
SET TRANSACTION READ WRITE READ COMMITTED
   RECORD_VERSION;
```

Starting a Transaction With SNAPSHOT TABLE STABILITY Isolation Level

To start a SNAPSHOT TABLE STABILITY transaction, the isolation level *must* be specified. For example, the following statement starts a transaction for READ WRITE access and sets isolation level to SNAPSHOT TABLE STABILITY:

```
SET TRANSACTION READ WRITE SNAPSHOT TABLE STABILITY;
```

Isolation level always follows the optional access mode and lock resolution parameters, if they are present.

Important Use SNAPSHOT TABLE STABILITY with care. In an environment where multiple transactions share database access, SNAPSHOT TABLE STABILITY greatly increases the likelihood of lock conflicts.

Isolation Level Interactions

To determine the possibility for lock conflicts between two transactions accessing the same database, each transaction's isolation level and access mode must be considered. The following table summarizes possible combinations:

Table 3-6: Isolation Level Interaction with Read (SELECT) and WRITE (UPDATE)

		SNAPSHOT or READ COMMITTED		SNAPSHOT TABLE STABILITY	
		UPDATE	**SELECT**	**UPDATE**	**SELECT**
SNAPSHOT or READ COMMITTED	UPDATE	Some simultaneous updates may conflict.	—	Always conflicts.	Always conflicts.
	SELECT	—	—	—	—
SNAPSHOT TABLE STABILITY	UPDATE	Always conflicts.	—	Always conflicts.	Always conflicts.
	SELECT	Always conflicts.	—	Always conflicts.	—

As this table illustrates, SNAPSHOT and READ COMMITTED transactions offer the least chance for conflicts. For example, if *t1* is a SNAPSHOT transaction with READ WRITE access, and *t2* is a READ COMMITTED transaction with READ WRITE access, *t1* and *t2* only conflict when they attempt to update the same rows. If *t1* and *t2* have READ ONLY access, they never conflict with any other transaction.

A SNAPSHOT TABLE STABILITY transaction with READ WRITE access is guaranteed that it alone can update tables, but it conflicts with all other simultaneous transactions except for SNAPSHOT and READ COMMITTED transactions running in READ ONLY mode. A SNAPSHOT TABLE STABILITY transaction with READ ONLY access is compatible with any other read-only transaction, but conflicts with any transaction that attempts to insert, update, or delete data.

Lock Resolution

The lock resolution parameter determines what happens when a transaction encounters a lock conflict. There are two options:

- WAIT, the default, causes the transaction to wait until locked resources are released. Once the locks are released, the transaction retries its operation.
- NO WAIT immediately returns a lock conflict error without waiting for locks to be released.

Because WAIT is the default lock resolution, it need not be specified in a SET TRANSACTION statement. For example, the following statements are equivalent. They both start a transaction, *t1*, for READ WRITE access, WAIT lock resolution, and READ COMMITTED isolation level:

```
SET TRANSACTION READ WRITE READ COMMITTED;

SET TRANSACTION READ WRITE WAIT READ COMMITTED;
```

To use NO WAIT, the lock resolution parameter must be specified. For example, the following statement starts the named transaction, *t1*, for READ WRITE access, NO WAIT lock resolution, and SNAPSHOT isolation level:

```
SET TRANSACTION READ WRITE NO WAIT READ SNAPSHOT;
```

When lock resolution is specified, it follows the optional access mode, and precedes the optional isolation level parameter.

Tip It is good programming practice to specify a transaction's lock resolution, even when it is WAIT. It makes an application's source code easier to read and debug because the program's intentions are clearly spelled out.

RESERVING Clause

The optional RESERVING clause enables transactions to guarantee themselves specific levels of access to a subset of available tables at the expense of other simultaneous transactions. Reservation takes place at the start of the transaction instead of only when data manipulation statements require a particular level of access. RESERVING is only useful in an environment where simultaneous transactions share database access. It has three main purposes:

- To prevent possible deadlocks and update conflicts that can occur if locks are taken only when actually needed (the default behavior).
- To provide for *dependency locking*, the locking of tables that may be affected by triggers and integrity constraints. While explicit dependency locking is not required, it can assure that update conflicts do not occur because of indirect table conflicts.
- To change the level of shared access for one or more individual tables in a transaction. For example, a READ WRITE SNAPSHOT transaction may need exclusive update rights for a single table, and could use the RESERVING clause to guarantee itself sole write access to the table.

To reserve tables for a transaction, use the following SET TRANSACTION syntax:

```
SET TRANSACTION
```

```
      [READ WRITE| READ ONLY]
      [WAIT | NO WAIT]
      [[ISOLATION LEVEL] {SNAPSHOT [TABLE STABILITY]
         | READ COMMITTED [[NO] RECORD_VERSION]}]
      RESERVING <reserving_clause>;

   <reserving_clause> = table [, table ...]
      [FOR [SHARED | PROTECTED] {READ | WRITE}] [, <reserving_clause>]
```

Each table should only appear once in the RESERVING clause. Each table, or a list of tables separated by commas, must be followed by a clause describing the type of reservation requested. The following table lists these reservation options:

Table 3-7: Table Reservation Options for the RESERVING Clause

Reservation Option	Purpose
PROTECTED READ	Prevents other transactions from updating rows. All transactions can select from the table.
PROTECTED WRITE	Prevents other transactions from updating rows. SNAPSHOT and READ COMMITTED transactions can select from the table, but only this transaction can update rows.
SHARED READ	Any transaction can select from this table. Any READ WRITE transaction can update this table. This is the most liberal reservation mode.
SHARED WRITE	Any SNAPSHOT or READ COMMITTED READ WRITE transaction can update this table. Other SNAPSHOT and READ COMMITTED transactions can also select from this table.

The following statement starts a SNAPSHOT transaction for READ WRITE access, and reserves a single table for PROTECTED WRITE access:

```
   SET TRANSACTION READ WRITE WAIT SNAPSHOT
      RESERVING EMPLOYEE FOR PROTECTED WRITE;
```

The next statement starts a READ COMMITTED transaction for READ WRITE access, and reserves two tables, one for SHARED WRITE, and another for PROTECTED READ:

```
   SET TRANSACTION READ WRITE WAIT READ COMMITTED
      RESERVING EMPLOYEES FOR SHARED WRITE, EMP_PROJ
      FOR PROTECTED READ;
```

SNAPSHOT and READ COMMITTED transactions use RESERVING to implement more restrictive access to tables for other simultaneous transactions. SNAPSHOT TABLE STABILITY transactions use RESERVING to reduce the likelihood of deadlock in critical situations.

Ending a Transaction

When a transaction's tasks are complete, or an error prevents a transaction from completing, the transaction must be ended to set the database to a consistent state. There are two statements that end transactions:

- COMMIT makes a transaction's changes permanent in the database. It signals that a transaction completed all its actions successfully.
- ROLLBACK undoes a transaction's changes, returning the database to its previous state, before the transaction started. ROLLBACK is typically used when one or more errors occur that prevent a transaction from completing successfully.

Both COMMIT and ROLLBACK close the record streams associated with the transaction, reinitialize the transaction name to zero, and release system resources allocated for the transaction. Freed system resources are available for subsequent use by any application or program.

COMMIT and ROLLBACK have additional benefits. They clearly indicate program logic and intention, make a program easier to understand, and most importantly, assure that a transaction's changes are handled as intended by the programmer.

ROLLBACK is frequently used inside error-handling routines to clean up transactions when errors occur. It can also be used to roll back a partially completed transaction prior to retrying it, and it can be used to restore a database to its prior state if a program encounters an unrecoverable error.

Important If the program ends before a transaction ends, a transaction is automatically rolled back, but databases are not closed. If a program ends without closing the database, data loss or corruption is possible. Therefore, open databases should always be closed by issuing explicit DISCONNECT, COMMIT RELEASE, or ROLLBACK RELEASE statements.

Using COMMIT

Use COMMIT to write transaction changes permanently to a database. COMMIT closes the record streams associated with the transaction, resets the transaction name to zero, and frees system resources assigned to the transaction for other uses. The complete syntax for COMMIT is:

```
COMMIT [RETAIN [SNAPSHOT]
```

For example, the following C code fragment contains a complete transaction. It gives all employees who have worked since December 31, 1992, a 4.3% cost-of-living salary increase. If all qualified employee records are successfully updated, the transaction is committed, and the changes are actually applied to the database.

```
. . .
SET TRANSACTION SNAPSHOT TABLE STABILITY;
UPDATE EMPLOYEE
   SET SALARY = SALARY * 1.043
   WHERE HIRE_DATE < "1-JAN-1993";
COMMIT;
. . .
```

Tip Even READ ONLY transactions that do not change a database should be ended with a COMMIT rather than ROLLBACK. The database is not changed, but the overhead required to start subsequent transactions is greatly reduced.

Committing Updates Without Freeing a Transaction

To write transaction changes to the database without establishing a new *transaction context*—the system resources, and current state of cursors used in a transaction—use the RETAIN option with COMMIT. In a busy, multi-user environment, maintaining the transaction context for each user speeds up processing and uses fewer system resources than closing and starting a new transaction for each action. The syntax for the RETAIN option is:

```
COMMIT RETAIN [SNAPSHOT];
```

COMMIT RETAIN writes all pending changes to the database, ends the current transaction *without* closing its record stream and cursors and without freeing its system resources, then starts a new transaction and assigns the existing record streams and system resources to the new transaction.

A ROLLBACK executed after a COMMIT RETAIN can only roll back updates and writes occurring *after* the COMMIT RETAIN.

Using ROLLBACK

Use ROLLBACK to restore the database to its condition prior to the start of the transaction. ROLLBACK also closes the record streams associated with the transaction, resets the transaction name to zero, and frees system resources assigned to the transaction for other uses. The syntax for ROLLBACK is:

```
ROLLBACK;
```

PART 2

Windows ISQL

Part 2 explains Windows ISQL, InterBase’s interactive SQL tool.

Chapter 4: “Using Windows ISQL” describes how to use Windows ISQL. Windows ISQL can be used to define, query, and manipulate data on InterBase servers.

Chapter 5: “Using ISQL Script Files” describes how to run an ISQL script file from Windows ISQL, and provides details on ISQL commands that can be used in scripts.

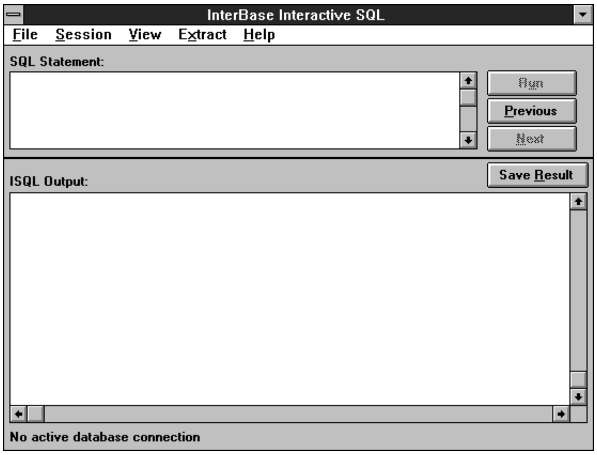
CHAPTER 4

Using Windows ISQL

This chapter describes how to use Windows ISQL, InterBase's interactive SQL tool. Windows ISQL is part of the Local InterBase Server package that can be used to define, query, and manipulate data on InterBase servers.

Starting and Exiting Windows ISQL

To start Windows ISQL, double-click on the Windows ISQL icon in the Delphi program group. The ISQL window will open:


InterBase Interactive SQL
File Session View Extract Help
SQL Statement:
Run
Previous
Next
ISQL Output:
Save Result
No active database connection

The ISQL window can also be opened from the Server Manager by choosing Tasks | Interactive SQL or clicking on the corresponding Speedbar button. Windows ISQL will then be connected to Server Manager's current database (if any).

The ISQL Window

The Interactive SQL window consists of a menu bar with pull-down menus, the SQL Statement area, the ISQL Output area, control buttons, and a status bar at the bottom of the window.

The ISQL menus are:

- File menu—contains commands to connect to, create, drop, and disconnect from a database, execute an SQL script file, save results and the session to a file, commit and roll back work, and exit ISQL.
- Session menu—contains statements to set basic and advanced ISQL settings, and display ISQL settings and version.
- View menu—contains a command to view metadata.
- Extract menu—contains commands to extract metadata for databases, tables, and views.
- Help menu—provides on-line help.

The SQL Statement area is where you type an SQL statement to be executed. It scrolls vertically.

The ISQL Output area is where the results of the SQL statements are displayed. It scrolls both vertically and horizontally.

The three buttons to the right of the SQL Statement area, Run, Previous, and Next, are used to execute SQL statements interactively and select statements in the SQL command history. For more information about using these buttons, see "Executing SQL Interactively," in this chapter. The button above the ISQL Output area labeled Save Result opens a dialog box in which you can enter a file name to which to save the results of the last SQL statement executed.

The status bar at the bottom of the ISQL window shows the name of the database to which Windows ISQL is connected or "No active database connection" if it is not connected to a database.

To use Windows ISQL, you must either create a new database or connect to an existing database.

Getting Help

Windows ISQL provides a full online help system. Choose one of the items on the Help menu or click on a Help button in a dialog box to get help.

Exiting Windows ISQL

To exit Windows ISQL, choose File | Exit. This will close the connection to the current database (if any) and exit Windows ISQL. Any uncommitted changes to the database will be rolled back.

Temporary Files

Windows ISQL creates temporary files used during a session to store information such as the command history, output file names, and so on. These files are named ISQL_AA.*xx*, where *xx* is a pair of sequential generated letters. The files are stored in the directory specified by the TMP environment variable, or if that is not defined, the working directory, or if that is not defined, then the WINDOWS directory.

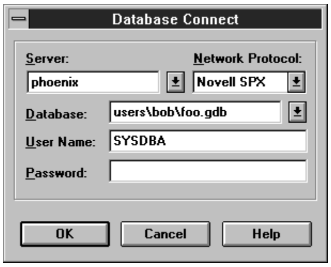
To avoid cluttering the WINDOWS directory with temporary files, specify a directory in which to store them by defining TMP or by defining a working directory for Windows ISQL (by choosing File | Properties in Program Manager).

When you exit, Windows ISQL will delete these temporary files. If Windows ISQL abnormally terminates (for example, due to a power failure), then these files will remain and may be freely deleted without any adverse effects. You should not delete any of these temporary files while Windows ISQL is running, because they may be used in the current session.

Connecting to a Database

Choose File | Connect to Database... to connect to an existing database. If Windows ISQL is currently connected to a database, the connection will be closed; a dialog box will prompt you to commit changes to it (if there are any). If you choose No, then all database changes since the last commit will be rolled back and the connection will be closed. If you choose Yes, then database changes will be committed.

Then the Database Connect dialog box will open:



Server: phoenix
Network Protocol: Novell SPX
Database: users\bob\foo.gdb
User Name: SYSDBA
Password:

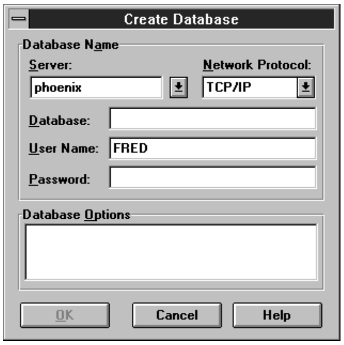
The Server text field contains 'local' and the network protocol contains 'none'. In the Database text field, enter the name of the database to which to connect (including full volume and directory path), or click on the drop-down list and select a database from the list of previously used databases.

The User Name and Password text fields can be left blank. A null User Name with a null Password is considered valid. For development and testing purposes, character strings in the User Name and Password fields are compared to the security database, ISC4.GDB. User Names and Passwords are added and edited by accessing the security database through the Server Manager.

Creating a Database

To create a new database and connect to it, choose File | Create Database.... If currently connected to a database, a dialog box will prompt you to commit changes to it (if any). If you choose No, then all database changes since the last commit will be rolled back. If you choose Yes, then database changes will be committed.

Then the Create Database dialog box will open:



Server: phoenix
Network Protocol: TCP/IP
Database:
User Name: FRED
Password:

The Server text field contains 'local' and the network protocol contains 'none'. In the Database text field, enter the name of the database to which to connect (including full volume and directory path), or click on the drop-down list and select a database from the list of previously used databases.

In the User Name and Password text fields, enter alphanumeric character strings for the InterBase user name and password. The password will not be displayed. Any alphanumeric strings will be accepted and no check will be made upon future connections. The security feature is disabled, but some entry is still required.

In the Database Options area, enter any additional options of the CREATE DATABASE statement, such as PAGE_SIZE, DEFAULT CHARACTER SET, or secondary files. For a complete list of CREATE DATABASE options, see the *Language Reference*. To create a basic database without any options, leave the Database Options area blank.

Note Primary database files must reside on a local drive. Secondary files can reside on either local or on remote drives.

Choose OK to create the database. ISQL will then create the database on the specified server and connect to the database.

For more information about creating databases, see the *Data Definition Guide*.

Dropping a Database

Dropping a database deletes the database to which ISQL is currently connected, removing both data and metadata. To drop the current database, choose File | Drop Database.... A dialog box will ask you to confirm that you want to delete the database. A database can be dropped only by its creator or the SYSDBA user.

A dropped database is removed from the list of databases maintained in INTERBAS.INI.

Caution Dropping a database deletes all data and metadata in the database.

Disconnecting From a Database

To disconnect from the database to which Windows ISQL is connected, choose File | Disconnect from Database.... A dialog box will open to confirm that you want to disconnect. If there are any uncommitted database changes, you will be prompted to commit them before disconnecting.

Executing SQL Statements

In Windows ISQL, you can execute SQL statements:

- Interactively, one statement at a time.
- From a file containing an SQL script.

Executing SQL Interactively

To execute an SQL statement interactively, type it in the SQL Statement area and choose Run or press **Alt+U**. The statement will be echoed, and up to 32K of the results displayed in the ISQL Output area. Any output beyond 32K will be scrolled out of the ISQL Output Area.

Tip You can copy text from other Windows applications (such as the Notepad text editor) and paste it into the SQL Statement area with **Ctrl+V**. You can also copy statements from the ISQL Output area by highlighting them and pressing **Ctrl+C**. You can then paste them into the SQL Statement area with **Ctrl+V**.

When an SQL statement is executed (whether successfully or not), it becomes part of the ISQL *command history,* a sequential list of SQL statements entered in the current session. The *current statement* is the statement displayed in the SQL Statement area.

The three buttons to the right of the SQL Statement area are:

- Run: executes the current statement. The resultant output is displayed in the ISQL Output area. This button is dimmed if there is no active database connection.
- Previous: recalls the previous SQL statement in the command history, making it the current statement. When the current statement is the first statement in the command history, this button is dimmed and you may not choose it.
- Next: recalls the next SQL statement in the command history, making it the current statement. When the current statement is the last statement in the command history, this button is dimmed and you may not choose it.

As an alternative to these buttons, use the hot keys **Alt+R**, **Alt+P**, and **Alt+N**, respectively. The hot key for each button is underlined in its label.

Legal Statements

You can execute interactively any SQL statements identified as "available in ISQL" in the *Language Reference*.

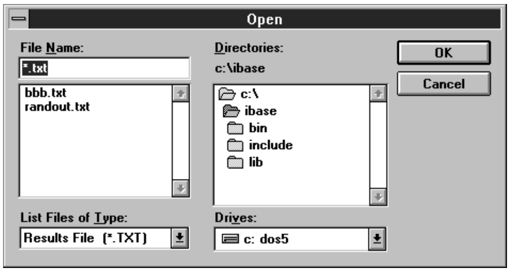
Note The SET NAMES statement cannot be entered in the SQL Statement area. To change the active character set, choose Session | Advanced Settings... and select the desired character set in the Advanced Set Options dialog box.

Transaction names may not be used with SET TRANSACTION statement. Each SQL statement optionally may be terminated by a semicolon (;).

SQL script files can include statements that are not legal to enter interactively. For example, most of the SET statements such as SET LIST or SET TERM can be used in scripts, but cannot be entered interactively. Use the Session menu items to perform the corresponding functions for an interactive session.

Executing an ISQL Script File

To execute a file containing SQL statements, choose File | Run ISQL Script.... The following dialog box will appear:



Enter the path and name of the file and choose OK. If you have made uncommitted changes to the database, you will prompted to commit or roll back the work. Then, a dialog box will appear asking "Save Output to a File?" If you choose Yes, then another dialog box will appear enabling you to specify an output file. If you choose No, then the results will then be displayed in the ISQL Output area. If you choose Cancel, then the operation is canceled.

After Windows ISQL finishes executing a script file, a summary dialog will appear indicating if there were any errors. If there were errors, then an error message will appear in the ISQL Output Area (or output file) after each statement that caused the error.

Every ISQL script file must begin with either a CREATE DATABASE statement or a CONNECT statement (including user name and password) to specify the database on which the script file operates. For more information, see Chapter 5: "Using ISQL Script Files."

Statements executed in a script file do not become part of the command history.

Committing and Rolling Back Work

Changes to the database from data definition (DDL) statements—for example, CREATE and ALTER statements—are automatically committed by default. To turn off automatic commit of DDL, choose Session | Basic ISQL Settings... and click off the Auto Commit DDL check box.

Changes made to the database by data manipulation (DML) statements—for example INSERT and UPDATE—are not permanent until they are committed. Commit changes by choosing File | Commit Work.

To undo all database changes from DML statements since the last commit, choose File | Rollback Work.

Saving Results to a File

Windows ISQL enables you to save to a file:

- The output of the last SQL statement executed.
- SQL statements entered in the current session.

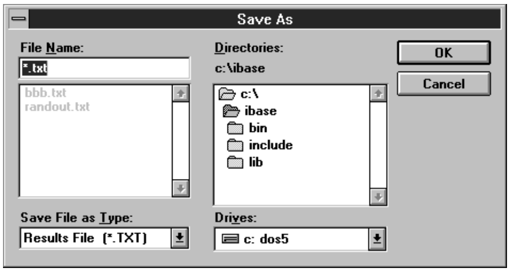
Saving ISQL Output

To save to a file the results of the last SQL statement executed, choose File | Save Result to File... or click on the Save Result button in the ISQL window. You can also use the hot key **Alt+R**.

The following dialog box will appear:

Select the desired directory and file name or type the file name in the text field, and choose OK. The output from the last successful statement and the statement itself will be saved to the named text file.

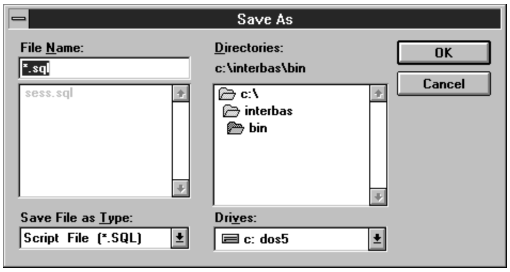
If you run an SQL script, and then choose File | Save Result to File..., then all the commands in the script file and their results will be saved to the output file. If



command display has been turned off in a script with SET ECHO OFF, then SQL statements in the script will not be saved to the file.

Saving the Session

To save the SQL statements entered in the current session to a text file, choose File | Save Session to a File.... The following dialog box will appear:



Select the desired directory and file name or type the file name, and choose OK to save the SQL statements to the file.

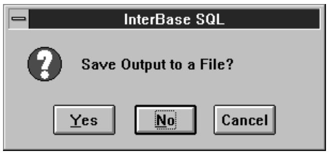
Only the SQL statements entered in the current session, not the output, will be saved to the specified file.

Extracting Metadata

Windows ISQL enables you to extract metadata for the entire database and for a specific table or view.

Extracting Database Metadata

To extract data definition statements (metadata) from a database to a file, choose Extract | SQL Metadata for Database.... The following dialog box will open:



Save Output to a File?

If you choose Yes, then another dialog box will open, enabling you to enter the name of the file to which to extract the metadata. If you choose No, then the metadata will be displayed to the ISQL Output area only. If you choose Cancel, then the operation will be canceled.

This command does not extract:

- Generators.
- Code of external functions or filters, because that code is not part of the database. The declarations to the database (with DECLARE EXTERNAL FUNCTION and DECLARE FILTER) are extracted.
- System tables, system views, and system triggers.

This command extracts metadata in the following order:

Table 4-1: Order of Metadata Extraction

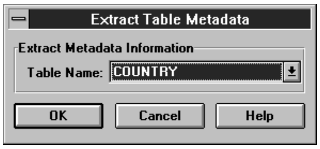
Metadata	**Comments**
Database	Extracts database with default character set and PAGE_SIZE.
Domains	
Tables	
BLOB data types and known subtypes	
NULL and default values	
PRIMARY KEY constraints	
CHECK constraints	
FOREIGN KEY constraints	Must be added after tables by ALTER TABLE to avoid tables referenced before being created.
Indexes	Only for tables extracted, except triggers from referential or unique constraints.
Views WITH CHECK OPTION	
Stored procedures	In the extracted DDL, stored procedures are shown with no body in CREATE PROCEDURE and then ALTER PROCEDURE to add the text of the procedure body.
Triggers	Does not extract triggers from CHECK constraints.

Table 4-1: Order of Metadata Extraction (Continued)

Metadata	Comments
GRANTs	From RDB$USER_PRIVILEGES table.

Extracting Table Metadata

To extract metadata for a single table, choose Extract | SQL Metadata for Table.... The following dialog box will open:



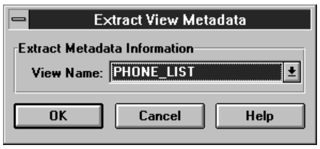
Click on the arrow to the right of the Table Name field to see a drop-down list of tables in the database. Select a table, then choose OK to extract metadata from that table.

Another dialog box will open, asking whether to save output to a file. Choose Yes to save the metadata to a text file, No to display the metadata to the Output area only, or Cancel to cancel the operation.

If there are no tables in the database, then the menu item will be dimmed, and you cannot select it.

Extracting View Metadata

To extract metadata for a single view, choose Extract | SQL Metadata for View.... The following dialog box will open:



Click on the arrow to the right of the View Name field to see a drop-down list of views in the database. Choose a view, then choose OK to extract metadata from that view.

Another dialog box will open, asking whether to save output to a file. Choose Yes to save the metadata to a text file, No to display the metadata to the Output area only, or Cancel to cancel the operation.

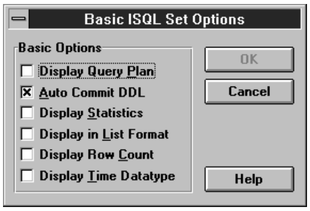
If there are no views defined for the database, then the menu item will be dimmed, and you cannot select it.

Changing Windows ISQL Settings

The Session menu enables you to change ISQL settings for the current session and display information about the database and its metadata.

Basic ISQL Settings

Choose Session | Basic ISQL Settings... to open a dialog box displaying all the basic settings that can be toggled on or off:



- [ ] Display Query Plan
- [✓] Auto Commit DDL
- [ ] Display Statistics
- [ ] Display in List Format
- [ ] Display Row Count
- [ ] Display Time Datatype

Each setting has a corresponding check box. If there is an "X" in the box, then the setting is on. Otherwise, it is off. Click on the check box or the setting name to toggle the setting.

The following table summarizes basic ISQL settings:

Table 4-2: Basic ISQL Settings

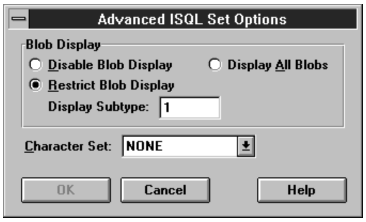
Setting	Behavior when setting is ON
Display Query Plan	Display the query plan chosen by the optimizer when a SELECT is entered. To modify the optimizer plan, use the PLAN option of the SQL SELECT statement.
Auto Commit DDL	Automatically commits DDL (data definition) statements as each statement is entered. This setting is ON by default. If this setting is off, you must explicitly commit DDL statements (with File | Commit Work) to make them permanent.

Table 4-2: Basic ISQL Settings (Continued)

Setting	Behavior when setting is ON
Display Statistics	Displays performance statistics for each statement entered. The following performance statistics appear after the result of each statement: • Number of read or write requests • Number of requests for data or updates which can be serviced in cache • Elapsed time • CPU time • Memory usage • Database page size • Database buffers used
Display in List Format	Displays data in list format, with headings on the left and column values on the right, one row at a time. If this setting is off (default) data is displayed in tabular format, with data in rows and columns, which may wrap longer rows.
Display Row Count	Displays the number of rows returned by each SELECT query entered.
Display Time Data Type	Displays the time portion of DATE values. If this setting is OFF, then only the date portion of DATE values is displayed.

Advanced ISQL Settings

There are two advanced ISQL settings: BLOB display and character set choice. Choose Session | Advanced ISQL Settings... to open the following dialog box:


Advanced ISQL Set Options

Blob Display
( ) Disable Blob Display ( ) Display All Blobs
(●) Restrict Blob Display
Display Subtype: 1

Character Set: NONE

Choose OK to accept all the setting changes, or choose Cancel to cancel setting changes.

BLOB Display

The upper area in the dialog box enables you to determine the display of BLOB data types.

This setting determines the display of BLOB data. SELECT always displays the BLOB ID for columns of BLOB data type. By default, a SELECT will also display actual BLOB data of text subtypes beneath the associated row.

The choices are:

- Disable BLOB Display: Do not display contents of BLOB columns.
- Display ALL BLOBs: Display BLOB data of all subtypes.
- Restrict BLOB Display: Display contents of BLOB columns only for the specified subtype. Use 0 for an unknown subtype; 1 for a text subtype (the default), and other integers for other BLOB subtypes.

Character Set

This setting determines the active character set for strings for subsequent connections to the database. It enables you to override the default character set for a database.

Specify the character set before connecting to the database whose character set you want to specify. For a complete list of character sets recognized by InterBase, see the *Language Reference*.

Choice of character set limits possible collation orders to a subset of all available collation orders. Given a character set, a collation order can be specified when data is selected, inserted, or updated in a column.

You can perform the same function in an SQL script with the SET NAMES command. Use SET NAMES before connecting to the database whose character set you want to specify.

Displaying Settings

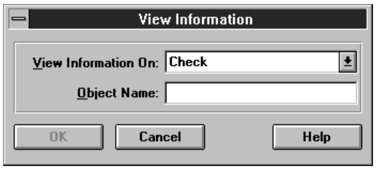
To display all the current ISQL settings, choose Session | Display Settings.... The basic settings and selected advanced settings will be displayed in the ISQL Output area.

Displaying Version Information

To display version information, choose Session | Display Connect Version in the ISQL Output Area. This will display the version of ISQL being used. If connected to a database, this command will also display the versions of the InterBase access method, server, and remote interface.

Displaying Database Information and Metadata

Choose View | Metadata Information... to display database information and metadata. The following dialog box will open:



Select the object type for which to display information, supply any required information in the Object Name text field and choose OK. Generally, if you do not supply an Object Name, then ISQL will display the names of all objects of the selected type in the database. If you do supply an Object Name, then ISQL will display information about that object.

The following table summarizes the items that can be displayed.

Table 4-3: Metadata Information Items

Item	DIsplays
Check...	Check constraints for the specified table. Specify table name in the Object Name field.
Database	Current database's file name, page size and allocation, and sweep interval. Do not specify an Object Name.
Domain	Names of all domains in the database (with no Object Name). Name and data type of the domain given as Object Name.
Exception	Names of all exceptions in the database, their associated messages, and the names of triggers and stored procedures which use them (with no Object Name). Name and message of exception given as Object Name, and names of triggers and stored procedures that use it.
Generator	Names and current values of all generators in the database (with no Object Name). Name and current value of the generator given as Object Name.

Table 4-3: Metadata Information Items (Continued)

Item	DIsplays
Grant	Displays permissions for the table or view given as Object Name.
Index	Names of all indexes in the database, their constituent columns, and uniqueness (with no Object Name). Names of all indexes for the table given as Object Name, their constituent columns, and uniqueness. Constituent columns for the index given as Object Name, and the index's uniqueness.
Procedure	Names and dependencies of all stored procedures in the database (with no Object Name). Procedure body, for the procedure given as Object Name, its input parameters, and output parameters.
System	Displays the names of system tables and system views for the current database. Do not specify an Object Name.
Table	Names of all tables in the database (with no Object Name). Columns, data types, PRIMARY KEY, FOREIGN KEY, and CHECK constraints for the table given as Object Name.
Trigger	Names of all triggers in the database and the tables for which they are defined (with no Object Name). Trigger bodies when a table is given as Object Name. Body of the trigger given as Object Name.
View	Names of all views in the database (with no Object Name). Columns, data types, and view source for the view given as Object Name.

CHAPTER 5

Using ISQL Script Files

This chapter describes how to run an ISQL script file from Windows ISQL, and provides details on ISQL commands that can be used in scripts, but not interactively.

Creating and Executing SQL Files

The basic steps for using script files with Windows ISQL are:

- Create the file using a text editor.
- Execute the file with Windows ISQL.
- View output and confirm database changes with Windows ISQL.

Creating an ISQL Script File

You can use any text editor to create an ISQL script file, as long as the final file format is "plain text" (ASCII).

Every ISQL script file must begin with either a CREATE DATABASE statement or a CONNECT statement (including user name and password) to specify the database on which the script file operates.

The CONNECT or CREATE statement must contain a complete database file name and directory path.

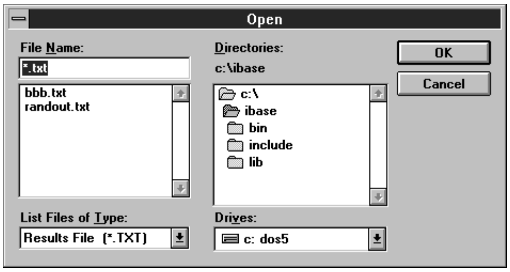
An ISQL script may contain any SQL statements, as described in the *Language Reference,* ISQL SET commands as described in this chapter, and comments. Each SQL statement in a script *must* be terminated by a semicolon (;) or the current terminator if it has been changed with SET TERM.

Each script file should end with either EXIT to commit database changes or QUIT to roll back changes made by the script. If neither is specified, then database changes are committed by default.

For the full syntax of CONNECT and CREATE DATABASE, see the *Language Reference*.

Executing an ISQL Script File

To execute a file containing SQL statements, choose File | Execute ISQL Script.... The following dialog box will appear:



Enter the path and name of the file and click on OK. A dialog box will appear asking "Save output to a file?" If you choose Yes, then another dialog box will open, enabling you to enter a file name to which to save output. If you choose No, then output and any error messages will be displayed in the SQL Output area.

After Windows ISQL finishes executing a script file, a summary dialog will appear indicating if there were any errors. If there were errors, then an error message will appear in the ISQL Output Area (or output file) after each statement that caused the error.

After a script is executed, all ISQL settings prior to executing it will be restored as well as the previous database connection, if any. Any ISQL SET commands in the script only affect the ISQL session while the script is running.

Committing and Rolling Back Work

Changes to the database from data definition (DDL) statements—for example, CREATE and ALTER statements—are automatically committed by default. This means that other users of the database will see changes as soon as each DDL statement is executed. To turn off automatic commit of DDL in a script, use SET AUTODDL OFF.

Note When creating tables and other database objects, it is good practice to put a COMMIT statement in the ISQL script after each CREATE statement (or group of related statements) to make sure the changes are committed before creating other database objects and that other users of the database will see the objects immediately.

Changes made to the database by data manipulation (DML) statements—for example INSERT and UPDATE—are not permanent until they are committed. Commit changes in a script with COMMIT. To undo all database changes since the last COMMIT, use ROLLBACK. For the full syntax of COMMIT and ROLLBACK, see the *Language Reference*.

Adding Comments

ISQL scripts are commented exactly like C programs:

```
/* comment */
```

A comment may occur on the same line as ISQL commands and may be of any length, as long as it is preceded by "/*" and followed by "*/".

ISQL SET Statements

SET Statements are used to configure the ISQL environment from a script file. Changes to the session setting from SET statements in a script affect the session only while the script is running. After a script completes, the session settings prior to running the script will be restored.

You cannot enter ISQL SET statements interactively in the SQL Statement area. When using ISQL interactively, perform these same functions with the Session menu items. SET GENERATOR and SET TRANSACTION (without a transaction name) are SQL statements and so may be entered interactively. The ISQL SET statements are:

Table 5-1: SET Statements

Statement	Description
SET AUTODDL	Toggles the commit feature for DDL statements.
SET BLOBDISPLAY *n*	Turns on the display of BLOB type *n*. The parameter *n* is required to display BLOB types.
SET COUNT	Toggles the count of selected rows on or off.
SET ECHO	Toggles the display of each command on or off.
SET LIST *string*	Displays columns vertically or horizontally.
SET NAMES	Specifies the active character set.
SET PLAN	Specifies whether or not to display the optimizer's query plan.

Table 5-1: SET Statements (Continued)

Statement	Description
SET STATS	Toggles the display of performance statistics on or off.
SET TERM *string*	Allows you to change to an alternate terminator character(s).
SET TIME	Toggles display of time in DATE values.

By default all settings are initially OFF except AUTODDL and TIME, and the terminator is a semicolon (;). Each time you start an ISQL session or execute an ISQL script file, settings begin with their default values.

After an ISQL script completes, the settings return to their values before the script was run. So you can modify the settings for interactive use, then change them as needed in an ISQL script, and after running the script they automatically return to their previous configuration.

The statements SET DATABASE, SET GENERATOR, and SET TRANSACTION are not exclusively ISQL commands, so they are not documented in this chapter. For more information about these commands, see the *Language Reference*.

SET AUTODDL

Specifies whether DDL statements are committed automatically after being executed or committed only after an explicit COMMIT.

Syntax

```
SET AUTODDL [ON | OFF];
```

Argument	Description
ON	Turns on automatic commitment of DDL (default).
OFF	Turns off automatic commitment of DDL.

Description SET AUTODDL is used to turn on or off the automatic commitment of data definition language (DDL) statements. By default, DDL statements are automatically committed immediately after they are executed, in a separate transaction. This is the recommended behavior.

If the OFF keyword is specified, auto-commit of DDL is then turned off. In OFF mode, DDL statements can only be committed explicitly through a user's transaction. This mode is useful for database prototyping, because uncommitted changes are easily undone by rolling them back.

SET AUTODDL has a shorthand equivalent, SET AUTO.

Tip The ON and OFF keywords are optional. If they are omitted, SET AUTO switches from one mode to the other. Although you can save typing by omitting the optional keyword, including the keyword is recommended because it avoids potential confusion.

Examples The following example shows part of an ISQL script which turns off AUTO DDL, creates a table named TEMP, then rolls back the work.

```
...
SET AUTO OFF;
CREATE TABLE TEMP (a INT, b INT);
ROLLBACK;
...
```

This script creates TEMP and then rolls back the statement. If you choose View | Metadata... and select “Tables,” the TEMP table will not appear, because its creation was rolled back.

The next script uses the default AUTO DDL ON. It creates the table TEMP and then performs a rollback:

```
...
CREATE TABLE TEMP (a INT, b INT);
ROLLBACK;
...
```

Because DDL is automatically committed, the rollback does not affect the creation of TEMP. If you choose View | Metadata... and select “Tables,” you will see the TEMP table.

See Also EXIT, QUIT

SET BLOBDISPLAY

Specifies subtype of BLOB data to display.

Syntax

```
SET BLOBDISPLAY [n | ALL | OFF];
```

Argument	Description
n	Integer specifying the BLOB subtype to display. Use 0 for BLOB data of an unknown subtype; use 1 (default) for BLOB data of a text subtype, and other integer values for other subtypes.
ALL	Display BLOB data of all subtypes.
OFF	Turn off display of BLOB data of all subtypes.

Description

SET BLOBDISPLAY has the following uses:

- To display BLOB data of a particular subtype, use SET BLOBDISPLAY *n*. By default, ISQL displays BLOB data of text subtype (*n* = 1).
- To display BLOB data of all subtypes, use SET BLOBDISPLAY ALL.
- To avoid displaying BLOB data, use SET BLOBDISPLAY OFF. Omitting the OFF keyword has the same effect. Turn BLOB display off to make output easier to read.

In any column containing BLOB data, the actual data does not appear in the column. Instead, the column displays a BLOB ID that represents the data. If SET BLOBDISPLAY is on, data associated with a BLOB ID appears under the row containing the BLOB ID. If SET BLOBDISPLAY is off, the BLOB ID still appears even though its associated data does not.

SET BLOBDISPLAY has a shorthand equivalent, SET BLOB.

To determine the subtype of a BLOB column, use SHOW TABLE.

Examples

The following examples show output from the same SELECT statement. Each example uses a different SET BLOB command to affect how output appears. The first example turns off BLOB display.

```
SET BLOB OFF;
SELECT PROJ_NAME, PROJ_DESC FROM PROJECT;
```

With BLOBDISPLAY OFF, the output shows only the BLOB ID:

```
PROJ_NAME                PROJ_DESC
====================     =================
Video Database           24:6
DigiPizza                24:8
AutoMap                  24:a
MapBrowser port          24:c
Translator upgrade       24:3b
Marketing project 3      24:3d
```

The next example restores the default by setting BLOBDISPLAY to subtype 1 (text).

```
SET BLOB 1;
SELECT PROJ_NAME, PROJ_DESC FROM PROJECT;
```

Now the contents of the BLOB appear below each BLOB ID:

```
PROJ_NAME                PROJ_DESC
====================     =================
Video Database           24:6
==============================================================
PROJ_DESC:
Design a video data base management system for
controlling on-demand video distribution.

PROJ_NAME                PROJ_DESC
====================     =================
DigiPizza                24:8
==============================================================
PROJ_DESC:
Develop second generation digital pizza maker
with flash-bake heating element and
digital ingredient measuring system.
. . .
```

See Also BLOBDUMP

SET COUNT

Specifies whether to display number of rows retrieved by queries.

Syntax

```
SET COUNT [ON | OFF];
```

Argument	Description
ON	Turns on display of the “rows returned” message.
OFF	Turns off display of the “rows returned” message (default).

Description By default, when a SELECT statement retrieves rows from a query, no message appears to say how many rows were retrieved.

Use SET COUNT ON to change the default behavior and display the message. To restore the default behavior, use SET COUNT OFF.

Tip The ON and OFF keywords are optional. If they are omitted, SET COUNT switches from one mode to the other. Although you can save typing by omitting the optional keyword, including the keyword is recommended because it avoids potential confusion.

Example The following examples sets COUNT ON to display the number of rows returned by all following queries:

```
SET COUNT ON;
SELECT * FROM COUNTRY
   WHERE CURRENCY LIKE "%FRANC%";
```

The output displayed would then be:

```
   COUNTRY                       CURRENCY
   ===============               ==========
   SWITZERLAND                   SFRANC
   FRANCE                        FFRANC
   BELGIUM                       BFRANC

3 rows returned
```

SET ECHO

Specifies whether commands are displayed to the ISQL Output area before being executed.

Syntax

```
SET ECHO [ON | OFF];
```

Argument	Description
ON	Turns on command echoing (default)
OFF	Turns off command echoing.

Description By default, commands in script files are displayed (echoed) in the ISQL Output area, before being executed. Use SET ECHO OFF to change the default behavior and suppress echoing of commands. This may be useful when sending the output of a script to a file, if you want only the results of the script and not the statements themselves in the output file.

Command echoing is useful if you want to see the commands as well as the results in the ISQL Output area.

Tip The ON and OFF keywords are optional. If they are omitted, SET ECHO switches from one mode to the other. Although you can save typing by omitting the optional keyword, including the keyword is recommended because it avoids potential confusion.

Example Suppose you execute the following script from Windows ISQL:

```
...
SET ECHO OFF;
SELECT * FROM COUNTRY;
SET ECHO ON;
SELECT * FROM COUNTRY;
EXIT;
```

The output (in a file or the ISQL Output area) will look like this:

```
...
SET ECHO OFF;

COUNTRY      CURRENCY
===========  ========
USA          Dollar
England      Pound
...
SELECT * FROM COUNTRY;

COUNTRY      CURRENCY
===========  ========
USA          Dollar
England      Pound
...
```

The first SELECT statement is not displayed, because ECHO is OFF. Notice also that the SET ECHO ON statement itself is not displayed, because when it is executed, ECHO is still OFF. After it is executed, however, the second SELECT statement is displayed.

See Also INPUT, OUTPUT

SET LIST

Specifies whether output appears in tabular format or in list format.

Syntax

```
SET LIST [ON | OFF];
```

Argument	Description
ON	Turns on list format for display of output.
OFF	Turns off list format for display of output (default).

Description By default, when a SELECT statement retrieves rows from a query, the output appears in a tabular format, with data organized in rows and columns.

Use SET LIST ON to change the default behavior and display output in a list format. In list format, data appears one value per line, with column headings appearing as labels. List format is useful when columnar output is too wide to fit nicely on the screen.

Tip The ON and OFF keywords are optional. If they are omitted, SET LIST switches from one mode to the other. Although you can save typing by omitting the optional keyword, including the keyword is recommended because it avoids potential confusion.

Example Suppose you execute the following statement in a script file:

```
SELECT JOB_CODE, JOB_GRADE, JOB_COUNTRY, JOB_TITLE FROM JOB
   WHERE JOB_COUNTRY = "Italy";
```

The output will be:

```
JOB_CODE   JOB_GRADE   JOB_COUNTRY   JOB_TITLE
========   =========   ===========   ====================
SRep       4           Italy         Sales Representative
```

Now suppose, you precede the SELECT with SET LIST ON:

```
SET LIST ON;
SELECT JOB_CODE, JOB_GRADE, JOB_COUNTRY, JOB_TITLE FROM JOB
   WHERE JOB_COUNTRY = "Italy";
```

The output will then be:

```
   JOB_CODE                 SRep
   JOB_GRADE                4
   JOB_COUNTRY              Italy
   JOB_TITLE                Sales Representative
```

SET NAMES

Specifies the active character set to use in database transactions.

Syntax

```
SET NAMES [charset];
```

Argument	Description
charset	Name of the active character set. Default: NONE.

Description SET NAMES specifies the character set to use for subsequent database connections in ISQL. It enables you to override the default character set for a database. To return to using the default character set, use SET NAMES with no argument.

Use SET NAMES before connecting to the database whose character set you want to specify. For a complete list of character sets recognized by InterBase, see the *Language Reference*.

Choice of character set limits possible collation orders to a subset of all available collation orders. Given a specific character set, a specific collation order can be specified when data is selected, inserted, or updated in a column.

Example The following statement at the beginning of a script file indicates to set the active character set to ISO8859_1 for the subsequent database connection:

```
 SET NAMES ISO8859_1;
 CONNECT "EAGLE:\USR\INTERBASE\EXAMPLES\EMPLOYEE.GDB";
...
```

SET PLAN

Specifies whether to display the optimizer's query plan.

Syntax

```
SET PLAN [ON | OFF];
```

Argument	Description
ON	Turns on display of the optimizer's query plan.
OFF	Turns off display of the optimizer's query plan (default).

Description By default, when a SELECT statement retrieves rows from a query, ISQL does not display the query plan used to retrieve the data.

Use SET PLAN ON to change the default behavior and display the query optimizer plan. To restore the default behavior, use SET PLAN OFF.

To change the query optimizer plan, use the PLAN clause in the SELECT statement.

Tip The ON and OFF keywords are optional. If they are omitted, SET PLAN switches from one mode to the other. Although you can save typing by omitting the optional keyword, including the keyword is recommended because it avoids potential confusion.

Example The following example shows part of a script which sets PLAN ON:

```
SET PLAN ON;
SELECT JOB_COUNTRY, MIN_SALARY FROM JOB
   WHERE MIN_SALARY > 50000
      AND JOB_COUNTRY = "France";
```

The output then includes the query optimizer plan used to retrieve the data as well as the results of the query:

```
PLAN (JOB INDEX (RDB$FOREIGN3,MINSALX,MAXSALX))
JOB_COUNTRY                 MIN_SALARY
===============             ======================
France                      118200.00
```

SET STATS

Specifies whether to display performance statistics after the results of a query.

Syntax

```
SET STATS [ON | OFF];
```

Argument	Description
ON	Turns on display of performance statistics.
OFF	Turns off display of performance statistics (default).

Description By default, when a SELECT statement retrieves rows from a query, ISQL does not display performance statistics after the results. Use SET STATS ON to change the default behavior and display performance statistics. To restore the default behavior, use SET STATS OFF. Performance statistics include:

- Current memory available, in bytes
- Change in available memory, in bytes
- Maximum memory available, in bytes

- Elapsed time for the operation
- CPU time for the operation
- Number of cache buffers used
- Number of reads requested
- Number of writes requested
- Number of fetches made

Performance statistics can help determine if changes are needed in system resources, database resources, or query optimization.

Tip The ON and OFF keywords are optional. If they are omitted, SET STATS switches from one mode to the other. Although you can save typing by omitting the optional keyword, including the keyword is recommended because it avoids potential confusion.

Do not confuse SET STATS with the SQL statement SET STATISTICS, which recalculates the selectivity of an index.

Example The following part of a script file turns on display of statistics and then performs a query:

```
SET STATS ON;
SELECT JOB_COUNTRY, MIN_SALARY FROM JOB
   WHERE MIN_SALARY > 50000
      AND JOB_COUNTRY = "France";
```

The output displays the results of the SELECT statement and the performance statistics for the operation:

```
   JOB_COUNTRY                MIN_SALARY
   ===============            ======================
   France                     118200.00

Current memory = 407552
Delta memory = 0
Max memory = 412672
Elapsed time= 0.49 sec
Cpu = 0.06 sec
Buffers = 75
Reads = 3
Writes = 2
Fetches = 441
```

See Also SHOW DATABASE

SET TERM

Specifies which character or characters signal the end of a command.

Syntax

```
SET TERM string;
```

Argument	Description
string	Specifies a character or characters to use in terminating a statement. Default: semicolon (;).

Description

By default, when a line ends with a semicolon, ISQL interprets it as the end of a command. Use SET TERM to change the default behavior and define a new termination character.

SET TERM is typically used with CREATE PROCEDURE or CREATE TRIGGER. Procedures and triggers are defined using a special "procedure and trigger" language in which statements end with a semicolon. If ISQL were to interpret semicolons as statement terminators, then procedures and triggers would execute during their creation, rather than when they are called.

A script file containing CREATE PROCEDURE or CREATE TRIGGER definitions should include one SET TERM command before the definitions and a corresponding SET TERM after the definitions. The beginning SET TERM defines a new termination character; the ending SET TERM restores the semicolon (;) as the default.

Example

The following example shows a text file that uses SET TERM in creating a procedure. The first SET TERM defines "##" as the termination characters. The matching SET TERM restores ";" as the termination character.

```
SET TERM ## ;
CREATE PROCEDURE ADD_EMP_PROJ (EMP_NO SMALLINT, PROJ_ID CHAR(5))
AS
BEGIN
   BEGIN
      INSERT INTO EMPLOYEE_PROJECT (EMP_NO, PROJ_ID)
         VALUES (:emp_no, :proj_id);
   WHEN SQLCODE -530 DO
   EXCEPTION UNKNOWN_EMP_ID;
   END
   RETURN;
END ##
SET TERM ; ##
```

SET TIME

Specifieswhether to display the time portion of a DATE value.

Syntax

```
SET TIME [ON | OFF];
```

Argument	Description
ON	Turns on display of time in DATE value.
OFF	Turns off display of time in DATE value (default)

Description The InterBase DATE data type includes a date portion (including day, month, and year) and a time portion (including hours, minutes, and seconds).

By default, ISQL displays only the date portion of DATE values. SET TIME ON turns on the display of time values. SET TIME OFF turns off the display of time values.

Note The ON and OFF keywords are optional. If they are omitted, the command toggles time display from ON to OFF or OFF to ON.

Example The following example shows the default display of a DATE data type, which is to display day, month, and year:

```
SELECT HIRE_DATE FROM EMPLOYEE WHERE EMP_NO = 145;
HIRE_DATE
-------------------
2-MAY-1994
```

This example shows the effects of SET TIME ON, which causes the hours, minutes and seconds to be displayed as well:

```
SET TIME ON;
SELECT HIRE_DATE FROM EMPLOYEE WHERE EMP_NO = 145;
HIRE_DATE
-------------------
2-MAY-1994 12:25:00
```

PART 3

Tutorial

Part 4 is an SQL tutorial using Windows ISQL.

Chapter 6: “Getting Started With Windows ISQL” introduces some fundamental database concepts, SQL statements and terminology, and the Windows ISQL tool. This chapter introduces the main categories of SQL statements.

Chapter 7: “Basic Data Definition” introduces some more SQL concepts and provides examples of performing SQL data definition. This chapter provides a thorough introduction to data definition language (DDL) statements.

Chapter 8: “Populating the Database” provides a thorough overview of data manipulation language (DML) statements: INSERT, UPDATE, and DELETE.

Chapter 9: “Retrieving Data” explains how the SELECT statement works and provides a thorough overview of its syntax and use.

Chapter 10: “Advanced Data Definition” discusses granting and revoking SQL privileges, creating triggers, and creating stored procedures.

CHAPTER 6

Getting Started With Windows ISQL

This chapter introduces some fundamental database concepts, and illustrates them with simple examples in Windows ISQL. Some of the basic database tasks include:

- Creating a database.
- Creating tables.
- Adding data to tables and modifying the data.
- Retrieving data from tables.

If you are new to SQL, read this chapter for an introduction to SQL database concepts, and the Windows ISQL tool. Then move on to the following chapters that provide detailed SQL tutorials.

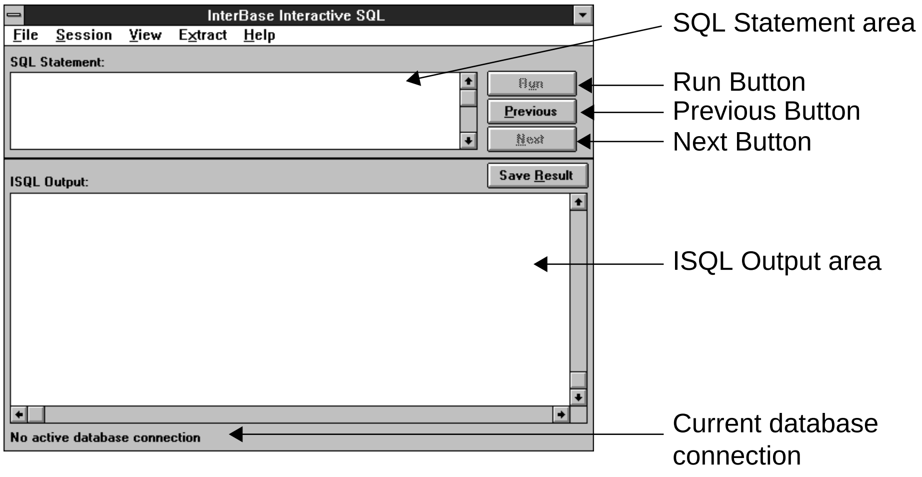
If you are an experienced SQL programmer, skim this chapter for an overview of how Windows ISQL works, then read any of the other chapters that are of interest.

In the tutorial presented in this chapter, you create a very simple personnel database for employee records. In the next chapter, you use the concepts learned in this chapter to build and use a more complex database provided with InterBase.

☞ Throughout the tutorial, a pointing finger in the left margin will identify actions you need to perform. Pay particular attention to these items.

Starting the Windows ISQL Session

☞ Start Windows ISQL by clicking on the Windows ISQL icon in the InterBase Windows Client program group. The InterBase Interactive SQL window will open:



To enter an SQL statement, type the statement in the SQL Statement area at the top of the window and then click on the Run button. The results are displayed in the area labeled "ISQL Output". The Previous and Next buttons enable you to move back and forth through the list of statements previously entered.

Do not try to enter an SQL statement now, because Windows ISQL must first be connected to a database. To do this, keep reading and follow the tutorial instructions.

An Overview of SQL

SQL statements are divided into two major categories:

- Data definition language (DDL) statements.
- Data manipulation language (DML) statements.

DDL statements are used to define, change, and delete the database, tables, and other elements that are part of the database. Collectively, the objects defined with DDL statements are known as *metadata*.

Basic DDL statements begin with the keyword CREATE to create metadata, and corresponding statements to modify metadata begin with the keyword ALTER. Statements to delete metadata begin with the keyword DROP. So, for example, CREATE TABLE is used to define a table, ALTER TABLE to modify an existing table, and DROP TABLE to delete a table.

DML statements are used to manipulate data within the data structures defined with DDL statements. The three basic DDL statements are INSERT, UPDATE, and DELETE. INSERT is used to add data to a table, UPDATE is used to modify existing data, and DELETE is used to delete data.

DML also includes what is probably the most important SQL statement of all: SELECT. The SELECT statement is used to retrieve or *query* information from the database.

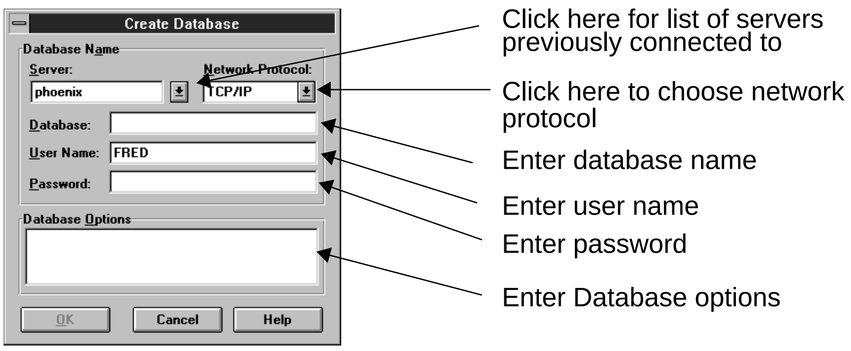
Creating a Database

InterBase is a relational database. A relational database is a collection of tables, which are two-dimensional structures composed of *rows* (also called records) and *columns* (also called fields). InterBase databases are stored in files, customarily given the filename extension .GDB.

To create a database, you must have a valid user name and password in the security database, ISC4.GDB. For instructions on how to access the security database using InterBase's Server Manager, see Chapter 11: "Introduction to Server Manager."

Initially, the information you need to supply to create a database is the pathname of the database.

Create a database now by choosing File | Create Database.... The Create Database dialog box opens:



Server: phoenix
Network Protocol: TCP/IP
Database:
User Name: FRED
Password:

Press **Tab** to move the cursor from one field to the next. Make sure the User Name field shows your user name. Enter your InterBase password in the Password text field.

☞ In the Database field, type the name of the database to create, including the directory path and file specification. For example:

```
C:\IBLOCAL\EXAMPLES\MYDB.GDB
```

Note Be sure to create the database in a directory where you have the necessary file permissions.

If you create the database in your own directory area, then you can give it any name you want. If you create it in a common directory such as IBLOCAL\EXAMPLES, you should give the database a unique name to avoid conflicts with other users. For example, if your name is Fred, you could name the database FRED.GDB. You do not have to use the .GDB file name extension, but it is an InterBase convention. Leave the Database Options area empty, because you are creating a simple database.

☞ Click on OK. Windows ISQL will create a database in the directory specified. There will be a short pause and the cursor will turn into an hourglass while the server is creating the database. Then the CREATE DATABASE statement will be echoed in the SQL Output area and a message will appear at the bottom of the ISQL Window that says you are connected, for example:

```
Connected to: C:\IBLOCAL\EXAMPLES\MYDB.GDB
```

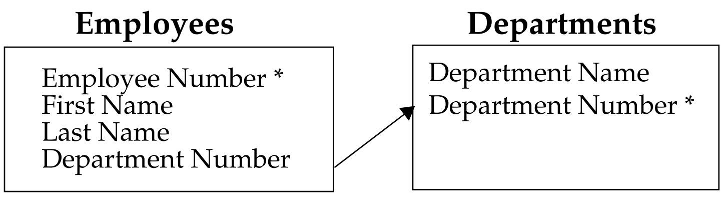
Conceptual Database Design

Before getting into the details of building a database, you should step back and determine exactly what you want to do with the database. In this "conceptual design" phase, you should basically define the objects you want to model with the database, their characteristics, and their relationships. Try to map out the details as much as possible before actually doing any SQL data definition. Sometimes it is useful to create diagrams on paper to help visualize the database.

Because this chapter is intended to introduce basic database concepts, you are going to build a very simple database, containing only two tables. In the real world, databases will rarely be this simple. But imagine that you only need to keep track of employees and the corporate department to which they belong. The best way to do this is to have a table for the employees, and a table for the departments.

The employee table should contain a row for each employee, and a column for each item of information related to the employee. For this simple example, let's assume that we only need to keep track of the employee's name (first and last), employee number, and department. Each department has a unique department number and a department name.

A conceptual diagram of this database might look like this:



The box on the left represents the table for employees, and the box on the right represents the table for departments. The columns of each table are listed inside each box, and an asterisk indicates that the value of the column uniquely identifies a row (this is known as a primary key, and will be explained later). The arrow indicates that each department number entered in the employee table references a department number in the department table (this is known as a foreign key, and will be explained later).

Creating Tables

A table is a data structure consisting of an unordered set of rows, each containing a specific number of columns. Conceptually, a database table is like an ordinary table. Much of the power of relational databases comes from defining the *relationships* among the tables.

For example, in this simple personnel database, the table for employees could be called EMPLOYEE, with columns as defined previously. Each row represents an individual employee. Here is an illustration of what such an EMPLOYEE table might look like this:

Table 6-1: EMPLOYEE Table

EMPNO	LAST_NAME	FIRST_NAME	DEPT_NO
10335	Smith	John	180
21347	Carter	Catherine	620
13314	Jones	Sarah	100
5441	Lewis	Stephen	180

The table containing information on departments could be called DEPARTMENT, and look like this:

Table 6-2: DEPARTMENT Table

DEPTNO	DEPARTMENT
180	Marketing
620	Software Products Div.
100	Sales
600	Engineering

The DEPARTMENT table is simple, so it makes a good starting point. To create a table with Windows ISQL, use the CREATE TABLE statement. The full syntax of this statement, as shown in the *Language Reference* is quite complex, but the basic form is simple: the keywords CREATE TABLE, followed by the name of the table, and then in parentheses a list of the columns in the table, separated by commas. Each column in the list specifies the name of the column, the data type, and attributes of the column such as NOT NULL and UNIQUE.

☞ To create the DEPARTMENT table, type the following in the SQL Statement area:

```
CREATE TABLE DEPARTMENT
   (DEPT_NO CHAR(3) NOT NULL UNIQUE, DEPARTMENT VARCHAR(25) NOT NULL);
```

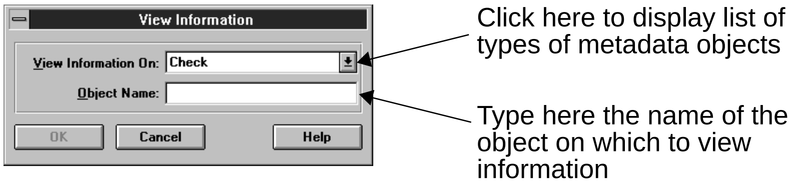
SQL is not case-sensitive, so you can enter statements in uppercase or lowercase. You could enter the statement all on one line, but it is easier to read if spread across several lines. The semicolon at the end of the statement is optional.

Type the above statement and click on Run. If you did not make any typing mistakes, then the statement will be echoed in the ISQL Output area. If you made a mistake, an error message will be displayed.

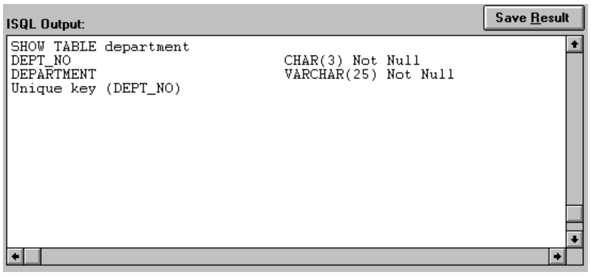
Note From now on in this chapter, it will be assumed that you know how to type SQL statements in the SQL Statement area, and click on the Run button when you are done.

This statement creates a table called "DEPARTMENT" with two columns: DEPT_NO for the department number and DEPARTMENT for the department name. The department number is defined as a three-character string, and department name is defined as a string with up to 25 characters. The keywords NOT NULL signify that each row must contain data in that column. UNIQUE means that the data in the column must be unique. So each department must have a name and department number and each department number must be unique.

☞ To view your new table definition, choose View | Metadata Information.... This dialog box will open:


View Information
View Information On: Check
Object Name:
OK
Cancel
Help
Click here to display list of types of metadata objects
Type here the name of the object on which to view information

☞ Display a drop-down list of types of metadata objects by clicking on the arrow to the right of the top field (as indicated above), then select "Table" and type the name of the table, DEPARTMENT in the Object Name field. Click on OK. The table definition will be displayed in the ISQL Output area:



```
SHOW TABLE department
DEPT_NO                         CHAR(3) Not Null
DEPARTMENT                      VARCHAR(25) Not Null
Unique key (DEPT_NO)
```

At any point during this tutorial, you can view metadata by choosing View | Metadata Information... and selecting the type of metadata. If you do not enter anything in the Object Name field, then ISQL will display the names of all the metadata objects of the selected type. If you enter a name, then ISQL will display all the details about that object.

Next, you will create the EMPLOYEE table. But first, you have to understand some new concepts.

Primary Keys and Foreign Keys

A *primary key* is a column or set of columns that uniquely identifies a row. In practice, every table should have a primary key. In the employee table, EMP_NO should be a primary key for EMPLOYEE because the employee number uniquely identifies an employee and DEPT_NO should be the primary key for DEPARTMENT because it uniquely identifies a department.

A *foreign key* is a column in one table that is the primary key column for another table. Primary key and foreign key constraints are defined with the PRIMARY KEY and FOREIGN KEY keywords in a CREATE TABLE statement.

☞ Now define a new table with a primary key and a foreign key. Type the following in the SQL Statement area:

```
CREATE TABLE EMPLOYEE
   (EMP_NO SMALLINT NOT NULL,
   LAST_NAME VARCHAR(25) NOT NULL,
   FIRST_NAME VARCHAR(20) NOT NULL,
   DEPT_NO CHAR(3) NOT NULL,
   PRIMARY KEY (EMP_NO),
   FOREIGN KEY (DEPT_NO)
      REFERENCES DEPARTMENT (DEPT_NO));
```

This statement creates a table called "EMPLOYEE" with four columns: EMP_NO for each employee's employee number, FIRST_NAME and LAST_NAME, for each employee's first and last names, and DEPT_NO for the employee's department number. NOT NULL after each column name signifies that data is required in the column when a row is added to the database.

After the list of columns, the keywords PRIMARY KEY define the table's primary key to be the EMP_NO column. The keywords FOREIGN KEY indicate that DEPT_NO references a column in another table, and the data in this column must match the data in the other table.

Make sure the table definition is entered in the database by choosing View | Metadata Information..., selecting Tables, and typing EMPLOYEE as the table name. You should see the table definition in the ISQL Output area.

Adding Data to Tables

Creating a table with CREATE TABLE simply defines the data structure. To create a useful database, you must then add data to the table. The easiest way to add data to a table in SQL is with the INSERT statement. The simplest form of the INSERT statement specifies values to insert into all the columns in a single row of a table, as follows:

```
INSERT INTO table_name VALUES (val1, val2, ...);
```

where *table_name* is the name of the table, and *val1*, *val2*, and so on, are the values to insert. For example, to insert the values into the DEPARTMENT table for
☞ the first row shown in the previous section, type the following:

```
INSERT INTO DEPARTMENT VALUES (180, "Marketing");
```

To use this syntax, you must know the default order of the columns. Because you just created the table with the DEPTNO column first and then DEPARTMENT, you know to give the department number first and then the name. If you try to insert values in a different order, you will get an error.

Now type the following:

```
INSERT INTO DEPARTMENT VALUES (100, "Sales");
```

Note Windows ISQL does not require a semicolon at the end of each statement. The semicolon (or another terminator character) is required in statements in ISQL script files. It is a good idea to get in the habit of ending your SQL statements with semicolons, so you will not forget to do so when creating script files.

There is a more general form of the INSERT statement that enables you to enter values for specific columns, even if you do not know the default order:

```
INSERT INTO table_name (col1, col2, ...) VALUES (val1, val2, ...);
```

where *col1* is the name of the column into which to insert value *val1*, *col2* is the name of the column into which to insert *val2*, and so on. To insert the next row of the DEPARTMENT table, type:

```
INSERT INTO DEPARTMENT (DEPARTMENT, DEPT_NO)
   VALUES ("Software Products Div.", 620);
```

This form of the INSERT statement is useful if you want to insert values into a subset of the columns, or you do not remember the default column order. Now, using either form of the INSERT statement, insert one more row into the DEPARTMENT table for a department named "Engineering" with department number 600.

Type the following to insert the values in the EMPLOYEE table. Be sure to enter the statements *one at a time* and click on Run after each.

```
INSERT INTO EMPLOYEE VALUES (10335, "Smith", "John", 180);
INSERT INTO EMPLOYEE VALUES (21347, "Carter", "Catherine", 620);
INSERT INTO EMPLOYEE VALUES (13314,"Jones", "Sarah", 100);
INSERT INTO EMPLOYEE VALUES (5441, "Lewis", "Stephen", 180);
```

Tip After you run the first of these statements, you can save some typing by choosing the Previous button to recall it to the SQL Statement area, highlighting the data following the VALUES keyword, and typing just the new values instead of the entire statement.

Testing Referential Integrity

InterBase databases include a feature called referential integrity. *Referential integrity* in its simplest form are constraints placed upon data by primary and foreign key definitions. When you defined the EMPLOYEE table, you made EMP_NO its primary key and DEPT_NO its foreign key, referencing the DEPARTMENT table. What this means is that each row in the EMPLOYEE table must have a unique value for the EMP_NO column and the value of the DEPT_NO column must match a value in the DEPARTMENT table. These referential integrity constraints are translations of real-world rules: each employee must have a unique employee number and each employee must be assigned to an existing department.

Test out the referential integrity rules for yourself to see how InterBase handles them. First, try to add an employee with the same employee number as another employee. Enter the following:

```
INSERT INTO EMPLOYEE VALUES (21347, "Lesh", "Phil", 620);
```

A small error dialog box will appear stating: “Statement failed, SQLCODE = -803”. Choose the Detail button to get more information.

You will see the error message: “Violation of PRIMARY or UNIQUE KEY constraint INTEG_10”. The constraint name shown may be something other than INTEG_10, because InterBase automatically gives names to integrity constraints if you do not explicitly name them in your CREATE TABLE statement, and the name it gives them depends on other DDL done previously.

Now try to add an employee with a non-existent department number. Enter:

```
INSERT INTO EMPLOYEE VALUES (5441, "West", "August", 999);
```

The error dialog will appear with the message: “Statement failed, SQLCODE = -530”. Choose the Detail button, and you will see “Violation of FORIEGN KEY constraint: INTEG_11”. The referential integrity rules will not let you enter an employee with a department number that is not in the DEPRTMENT table.

Committing Work

By default, data definition statements are automatically committed by Windows ISQL. DML statements, such as INSERT, UPDATE, and DELETE, are not committed unless you explicitly do so by choosing File | Commit Work. This means that you can undo any DML statements since the last time you committed.

Commit your work now by choosing File | Commit Work to make the changes to the database permanent.

Viewing Data

Now that you have put data into the tables, you need a way to view it. This requires one of the most important statements in SQL: SELECT. Because SELECT is so powerful, it has a very complex syntax, allowing a great deal of freedom in retrieving data from tables. The simplest form of SELECT is easy, though:

```
SELECT * FROM table_name;
```

where *table_name* is the name of the table from which to retrieve data, and the asterisk (*) means to select all columns from the table. Enter this statement for the DEPARTMENT table:

```
SELECT * FROM DEPARTMENT;
```

The statement will be echoed to the ISQL Output area, and you should also see the following output:

```
DEPTNO         DEPARTMENT
=========      ======================
180            Marketing
620            Software Products Div.
100            Sales and Marketing
600            Engineering
```

Enter the corresponding statement for the EMPLOYEE table to see the values you inserted.

```
SELECT * FROM EMPLOYEE;
```

Instead of selecting all columns from a table, you can specify certain columns, using this form of SELECT:

```
SELECT col1, co2, ... FROM table_name;
```

where *col1*, *col2*, and so on, are the names of the columns to select from the table. Experiment with this form to view subsets of the columns of the EMPLOYEE table.

The SELECT statement has a wealth of clauses that make it such a powerful statement. One of the most useful is the WHERE clause, that enables you to specify conditions that rows must meet. For example, enter the following:

```
SELECT * FROM EMPLOYEE WHERE DEPT_NO = 180;
```

This query selects rows with DEPT_NO equal to 180, in other words, only employees in department 180.

For the complete syntax of the SELECT statement, see the *Language Reference*.

Modifying Data

Now that you have entered data into tables, and learned how to view it, how do you change the data? The UPDATE statement enables you to modify existing rows, using the following syntax:

```
UPDATE table_name SET col1 = val1, col2 = val2,
   . . . WHERE condition;
```

where *table_name* is the name of the table being updated, *col1*, *col2*, and so on, are the names of the columns being updated, and *val1*, *val2*, and so on, are the new values to assign to the columns. The *condition* determines which rows are updated. Although *condition* in its full form allows a great deal of flexibility in determining rows, its basic form is:

```
column [ = | > | < | >= | <= ] value
```

In other words, a simple condition compares the value of a column with some fixed value.

So, for example, say Sarah Jones (employee number 13314) gets married and changes her last name to Zabrinske. To change her record in the employee table, enter the following:

```
UPDATE EMPLOYEE SET LAST_NAME = "Zabrinske" WHERE EMP_NO = 13314;
```

Because EMP_NO is the primary key of the EMPLOYEE table, the condition is guaranteed to identify exactly one row to update. Check that the record has been updated by entering a SELECT statement.

The update statement can make sweeping changes to the database, so use caution when entering it against a real database.

The other major DML statement in SQL is DELETE. This statement deletes rows from the table, and should be used with caution to avoid losing valuable data.

The basic form of DELETE is:

```
DELETE FROM table_name WHERE condition;
```

where *table_name* is the name of the table from which rows are being deleted, and *condition* is the condition that determines which rows are deleted. As in the UPDATE statement, condition can be quite complex, but in its simplest form it compares the value of a column with a fixed value.

Say Catherine Carpenter (employee number 21347) is leaving the company, and you want to delete her record from the EMPLOYEE table. Then type:

```
DELETE FROM EMPLOYEE WHERE EMP_NO = 21347;
```

Confirm that the record has been deleted by doing a SELECT from EMPLOYEE. You will not get an error message, but there will be no output displayed in the ISQL Output area.

Ending the ISQL Session

☞ Whenever you finish your work with ISQL, you should commit it to make it permanent. Choose File | Commit Work.

If you want to continue the tutorial, do not exit Windows ISQL—continue to the next chapter. If you've had enough for now, you can end your ISQL session by choosing File | Exit to disconnect from the database and exit ISQL. If you want to keep Windows ISQL running, you can choose File | Disconnect from Database to disconnect from the database only.

Now that you have gained some basic experience with SQL, you can move on to the following chapters for more detailed tutorial examples.

CHAPTER 7

Basic Data Definition

This chapter will build on the basic concepts introduced in the previous chapter. Starting with the simple database you defined in the previous chapter, you will go through all the steps to create the full EMPLOYEE database, used throughout the documentation.

More Conceptual Design

In the previous chapter, you defined a database consisting of two tables: EMPLOYEE and DEPARTMENT. Now you are going to move from this basic example to a personnel and sales database that might actually be useful in a "real-world" application. Obviously, you will need more than just two tables. You will also have to add more columns and other attributes to the two existing tables.

Start by defining the goals of the database. Let's say that upper management has determined that your company needs a database to keep track of:

- Personnel records
- Projects and budgets
- Sales
- Customers

Your company does business all over the world, so the database will have to account for many different countries.

Personnel records include each employee's employee number and name (as before), salary, job code, job grade, and country, and other associated details. The database also needs to maintain information on the manager of each department, the department's budget and location, and how it fits in the departmental hierarchy. Records must be maintained on each job type, including job requirements, maximum and minimum salary, and language requirements. Each employee's salary history must also be maintained.

Project records include the name, project ID, team leader, product type, description of each project, and the project to which each employee is assigned. The department containing the project, the project's budget, and quarterly head count are also important.

Sales records include important information from each purchase order, including PO number, customer, salesperson, date shipped, and so on.

Customer records include a unique customer number, contact names, addresses, and phone number, and other related information.

Designing a database means deciding which tables belong in the database, which columns belong in each table, and the relationship between the tables. A database design in a relational database affords flexibility because the logical structure of the database is independent of the physical storage and structure of the database.

Two concepts, *relationship modeling* and *normalization*, are basic to designing a database.

Relationship Modeling

Relationship modeling includes:

- Identifying the major groups of information to store in the database.
- Analyzing the type of information and its properties.
- Identifying relationships among sets of information.

For example, think of the groups of information as tables, with each table describing one thing, such as a company or an employee. The type of information and its properties are columns in the table, describing the employee's salary and the company address. Some questions to ask then are, "Does the information work as a table?" Or "Do the columns need to be moved from one group to another?"

Normalization

Normalization means splitting tables into two or more smaller related tables that can then be joined back together. Initially in a database design, you will probably create tables that contain data that are all related. As your design progresses, however, you will find that you need tables that contain a narrower focus of data.

Normalization also applies to columns within tables. Each column in a row should contain only one value that cannot be broken down into a smaller value. For example, one column should contain an employee first name, another column contains the employee last name, instead of having a single column for first and last name.

After studying the requirements, you determine that you need the following tables:

- EMPLOYEE for employees' records, and SALARY_HISTORY for each employee's salary history.
- DEPARTMENT for records on each department.
- JOB for information about each job type.
- PROJECT, EMP_PROJECT, and PROJ_DEPT_BUDGET for project records.
- CUSTOMER for records on each customer.
- SALES for sales information.
- COUNTRY for maintaining the currency for each country.

For an illustration of the database, see Appendix C: *Example Database*. For more information on database design, see the *Data Definition Guide*.

Defining Domains

A *domain* is a customized column definition used in creating tables. A domain allows you to define a column with complex characteristics that you can incorporate in many tables simply by referencing the domain name. This simplifies data definition. Conceptually, a domain is like a user-defined data type.

For example, you could define a domain to use for all employee names in the database. Then every time you need to define a column to contain a name in a table, you can simply refer to the domain. This is a simple example, but you can attach CHECK constraints and other advanced features to a domain definition. Referring to the domain is then much easier than referring to the complex column definition.

Use the SQL statement CREATE DOMAIN to define a domain, including the name of the domain, its data type, and optional characteristics like default value and CHECK constraints. You can use the ALTER DOMAIN statement to change the domain definition, and it changes in every table in which it is used. This simplifies maintenance and updating of the database.

Defining domains is often one of the first steps in data definition, because you can then use the domains in creating tables. The syntax to define domains consists of the keywords CREATE DOMAIN, followed by the name of the domain, then the keyword AS, followed by the data type of the domain, and finally any of the optional characteristics of the domain.

Not every column needs to be defined as a domain, but if it is something that is likely to be used many times in the database, it is a good candidate. For now, you will define domains for employees' first and last names, employee number, and department number.

☞ First, define domains for employees' first and last names and employee numbers. Type the following statements in the SQL Statement area. Be sure to click on the Run button after typing each statement.

```
CREATE DOMAIN LASTNAME AS VARCHAR(20);
CREATE DOMAIN FIRSTNAME AS VARCHAR(15);
CREATE DOMAIN EMPNO AS SMALLINT;
```

If you typed the statements correctly, then each one will be echoed in the ISQL Output area after it is executed.

☞ Next, define a domain for department number. It is defined as a three-character string. In addition to the data type, this domain includes CHECK constraints to ensure that the department number is either "000", alphabetically between "0" and "999", or NULL. Enter the following and then click on Run.

```
CREATE DOMAIN DEPTNO AS CHAR(3) CHECK
   (VALUE = "000" OR
   (VALUE > "0" AND VALUE <= "999")
   OR VALUE IS NULL);
```

You can enter the statement on one line or on several lines to make it easier to read.

Using Data Definition Files

To define the rest of the domains in the database, you can use a data definition file. A *data definition file* (also referred to as an ISQL *script file*) contains ISQL statements, and is created with an editor (such as Windows Notepad) and run by Windows ISQL. Data definition files can be very useful, because you can enter multiple SQL statements with all the tools that a text editor provides, including cut, copy, and paste. This makes repetitive tasks much easier.

In practice, most data definition is performed using data definition files, because they enable you to maintain a record of the DDL executed and allow you to work in a text editor instead of command by command.

The data definition files you will need are included in the EXAMPLES\TUTORIAL subdirectory of the InterBase directory. They all have file name extensions of .SQL.

☞ The file, DOMAINS.SQL, contains domain definitions. View this file with Windows Notepad. The first line in the file is a CONNECT statement followed by a dummy database name, user name, and password:

```
CONNECT "C:/path/mydb.gdb"
   USER "myusername" PASSWORD "mypassword"
```

Important Every ISQL script file *must* begin with a CONNECT statement (or a CREATE DATABASE statement) to connect to a database.

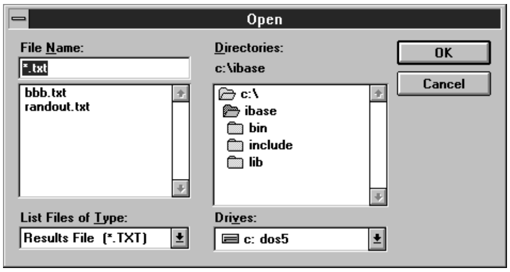
☞ Edit the file and change the database name, user name, and password.

You must make the same changes to the CONNECT statement at the beginning of all the ISQL script files used in this tutorial. To save time, you can cut and paste the information from one file to the others.

Now look at the rest of the file, DOMAINS.SQL. You will see that it contains a number of CREATE DOMAIN statements:

```
CREATE DOMAIN ADDRESSLINE AS VARCHAR(30);
CREATE DOMAIN PROJNO
   AS CHAR(5)
   CHECK (VALUE = UPPER (VALUE));
CREATE DOMAIN CUSTNO
   AS INTEGER
   CHECK (VALUE > 1000);
. . .
```

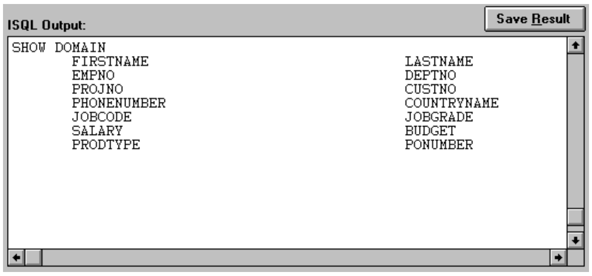
☞ To execute the statements in this file, choose File | Run ISQL Script.... The following dialog box will appear:



This is the standard Windows Open dialog box. In the right side of the dialog box, select the InterBase home directory, and then the EXAMPLES\TUTORIAL directory. ☞ Select the file, DOMAINS.SQL, and choose OK. A dialog box will appear, asking if you want to save the results to a file. Click on No, because you want to see the results in the ISQL window.

As Windows ISQL reads the script file, it will echo the statements to the ISQL Output area.

☞ To confirm the domains have been created, choose View | Metadata information..., select Domain from the drop-down list, and the click on OK. You should see all the domains defined for the database displayed in the SQL Output area, like this:



```
SHOW DOMAIN
       FIRSTNAME                              LASTNAME
       EMPNO                                  DEPTNO
       PROJNO                                 CUSTNO
       PHONENUMBER                            COUNTRYNAME
       JOBCODE                                JOBGRADE
       SALARY                                 BUDGET
       PRODTYPE                               PONUMBER
```

Starting Over

In the previous chapter, you created some simple tables and populated them with data. Now its time to delete those tables and the data they contain so you can create and populate a more complex database.

Before you can remove the tables, though, you have to make sure that ISQL will release them. Depending on what you have been doing with ISQL, there may be an active transaction. Choose File | Commit Work (if it is not dimmed) to end any active transactions. If the menu selection is dimmed, then there is no transaction to commit.

☞ Now you can remove these tables from the database. To do this, you will use the DROP statement, which is used to delete metadata. Enter the following:

```
DROP TABLE EMPLOYEE;
DROP TABLE DEPARTMENT;
```

☞ Because DDL statements are automatically committed by default, you do not need to commit these statements to make them permanent. Confirm that the tables are gone by choosing View | Metadata Information... and selecting Tables. Now that you have deleted these two tables and all their data, you can move on and create the EMPLOYEE sample database.

Creating More Tables

Refresh your memory of CREATE TABLE syntax by entering the following statement:

```
CREATE TABLE COUNTRY
   (COUNTRY COUNTRYNAME NOT NULL PRIMARY KEY,
   CURRENCY VARCHAR(10) NOT NULL);
```

This defines a two-column table to hold the names of countries and their currencies. Notice the declaration of the COUNTRY column uses the COUNTRYNAME domain instead of a standard data type.

Now you will move on to more complex tables using the domains you defined in the previous section. The file, TABLES.SQL, contains statements to create the rest of the tables in the database. Open the file with Notepad to view it.

Note Do not forget to edit the CONNECT statement at the beginning of TABLES.SQL and put in your database name, user name, and password.

The first table defined in the file is a more complex version of DEPARTMENT. The definition looks like this:

```
CREATE TABLE DEPARTMENT
   (DEPT_NO DEPTNO NOT NULL,
   DEPARTMENT VARCHAR(25) NOT NULL UNIQUE,
   HEAD_DEPT DEPTNO,
   MNGR_NO EMPNO,
   BUDGET BUDGET,
   LOCATION VARCHAR(15),
   PHONE_NO PHONENUMBER DEFAULT "555-1234",
   PRIMARY KEY (DEPT_NO),
   FOREIGN KEY (HEAD_DEPT) REFERENCES DEPARTMENT (DEPT_NO));
```

The second table defined in the file is named JOB, and defines job descriptions. The next table is the complete EMPLOYEE table. The definition of this table is central to this database:

```
CREATE TABLE EMPLOYEE
   (EMP_NO EMPNO NOT NULL,
   FIRST_NAME FIRSTNAME NOT NULL,
   LAST_NAME LASTNAME NOT NULL,
   PHONE_EXT VARCHAR(4),
   HIRE_DATE DATE DEFAULT "NOW" NOT NULL,
   DEPT_NO DEPTNO NOT NULL,
   JOB_CODE JOBCODE NOT NULL,
   JOB_GRADE JOBGRADE NOT NULL,
   JOB_COUNTRY COUNTRYNAME NOT NULL,
   SALARY SALARY NOT NULL,
   FULL_NAME COMPUTED BY (LAST_NAME || "," || FIRST_NAME)),
     PRIMARY KEY (EMP_NO),
     FOREIGN KEY (DEPT_NO) REFERENCES
     DEPARTMENT (DEPT_NO),
     FOREIGN KEY (JOB_CODE, JOB_GRADE, JOB_COUNTRY) REFERENCES
     JOB (JOB_CODE, JOB_GRADE, JOB_COUNTRY),

   CHECK (SALARY >= (SELECT MIN_SALARY FROM JOB WHERE
     JOB.JOB_CODE = EMPLOYEE.JOB_CODE AND
     JOB.JOB_GRADE = EMPLOYEE.JOB_GRADE AND
     JOB.JOB_COUNTRY = EMPLOYEE.JOB_COUNTRY) AND
     SALARY <= (SELECT MAX_SALARY FROM JOB WHERE
     JOB.JOB_CODE = EMPLOYEE.JOB_CODE AND
     JOB.JOB_GRADE = EMPLOYEE.JOB_GRADE AND
     JOB.JOB_COUNTRY = EMPLOYEE.JOB_COUNTRY));
```

Notice the complex check constraint on SALARY. It states that the salary entered for an employee has to be greater than the minimum salary for the employee's job (specified by JOB_CODE, JOB_GRADE, and JOB_COUNTRY) and less than the corresponding maximum.

Skim the file, TABLES.SQL, and look at the rest of the table definitions. Make sure you understand them. Notice that there is a CREATE INDEX statement after each table definition. Indexes will be explained later in this chapter.

☞ After editing the CONNECT statement at the beginning of the file, choose File | Run an ISQL Script... and select TABLES.SQL.

☞ Then confirm that the tables have been created by choosing View | Metadata Information..., select Table, and choose OK. You will see a list of all the table names in the ISQL Output area.

Creating Indexes

Indexes are used to improve the speed of data access for a table. An index identifies columns that can be used to efficiently retrieve and sort rows in the table. Because a primary key uniquely identifies a row, it is often also defined as the index of the table. The CREATE INDEX statement is used to define indexes in SQL.

An index is based on one or more columns in a table. Indexes can also enforce uniqueness and referential integrity constraints. A unique index will prevent duplicate values in the columns in the index.

An index is created with the CREATE INDEX statement. Here is the simplified syntax:

```
CREATE INDEX name ON table (columns)
```

For example, TABLES.SQL created an index called NAMEX for the EMPLOYEE table, as follows:

```
CREATE INDEX NAMEX ON EMPLOYEE (LAST_NAME, FIRST_NAME);
```

This statement defines an index called NAMEX for the LAST_NAME and FIRST_NAME columns in the EMPLOYEE table.

Preventing Duplicate Row Entries

To define an index that eliminates duplicate entries, include the UNIQUE keyword in CREATE INDEX. After a unique index is defined, users cannot insert or update values in indexed columns if the same values already exist there.

TABLES.SQL defined a unique index named PRODTYPEX, on the PROJECT table as follows:

```
CREATE UNIQUE INDEX PRODTYPEX ON PROJECT (PRODUCT, PROJ_NAME);
```

Note For unique indexes defined on multiple columns, like PRODTYPEX in the example above, the same value may be entered within individual columns, but the combination of values entered in all columns defined for the index must be unique.

Modifying Indexes

You can modify an index definition to change the columns that are indexed, prevent insertion of duplicate entries, or specify a different sort order.

To change the definition of an index, follow these steps:

1. Use ALTER INDEX to make the current index inactive.
2. Drop the current index.
3. Create a new index and give it the same name as the dropped index.

☞ Choose View | Metadata Information... and select Index from the drop-down list of object types. Enter NAMEX in the Object Name field. The ISQL Output area will display the definition of the index:

```
NAMEX INDEX ON EMPLOYEE (LAST_NAME, FIRST_NAME)
```

For example, suppose you need to prevent duplicate entries in the NAMEX index you defined for the EMPLOYEE table with a UNIQUE keyword. First,
☞ make the current index inactive, then drop it. Enter:

```
ALTER INDEX NAMEX INACTIVE;
DROP INDEX NAMEX;
```

☞ Then redefine NAMEX to include the UNIQUE keyword:

```
CREATE UNIQUE INDEX NAMEX ON EMPLOYEE (LAST_NAME, FIRST_NAME);
```

This index will now prevent entries in the EMPLOYEE table with the same first and last names as an existing row.

For more information about altering indexes, see the *Data Definition Guide*.

Creating Views

A view is a virtual table. Views are not physically stored in the database, but appear exactly like "real" tables. A view can contain data from one or more tables or other views and can store an often-used query or set of queries in the database. The CREATE VIEW statement is used to define views in SQL.

You are now going to create a view called PHONE_LIST that maintains a phone list of employees from the EMPLOYEE and DEPARTMENT tables.

☞ Enter the following statement:

```
CREATE VIEW PHONE_LIST AS
   SELECT EMP_NO, FIRST_NAME, LAST_NAME, PHONE_EXT, LOCATION, PHONE_NO
   FROM EMPLOYEE, DEPARTMENT
   WHERE EMPLOYEE.DEPT_NO = DEPARTMENT.DEPT_NO;
```

This statement creates a view called PHONE_LIST from columns in the EMPLOYEE and DEPARTMENT tables. After you populate these tables with data you will be able to query this view just as you would a table.

Moving On

You have created all the tables for the full EMPLOYEE database. In the next chapter, you will populate the database, that is, add data to it.

CHAPTER 8

Populating the Database

In this chapter, you will *populate* (add data to) the database created in the previous chapter and manipulate the data using the SQL statements:

- INSERT, to add data to the database.
- UPDATE, to modify data in the database.
- DELETE, to eliminate data from the database.

You will also create a simple view and select data from it.

Inserting Data

You previously learned the basic form of the INSERT statement:

```
INSERT INTO table_name (col1, col2, ...) VALUES (val1, val2, ...);
```

Now, you will use this form again to insert data into the EMPLOYEE database.

Inserting Data Using Column Values

☞ Open the file, INSERTS.SQL, with a text editor. It contains a number of INSERT statements to add data to the database. The first group of statements inserts values into the COUNTRY table, for example:

```
INSERT INTO COUNTRY (COUNTRY, CURRENCY) VALUES ("USA", "DOLLAR");
```

The next group inserts values into the DEPARTMENT table. For example:

```
INSERT INTO DEPARTMENT
   (DEPT_NO, DEPARTMENT, HEAD_DEPT, BUDGET, LOCATION, PHONE_NO)
VALUES
   ("000", "CORPORATE HEADQUARTERS", NULL, 1000000, "MONTEREY",
   "(408) 555-1234");
```

There are groups of statements to populate the JOB and EMPLOYEE tables also.

☞ Make sure the CONNECT statement at the beginning of the file contains the correct database name, user name, and password. Choose File | Run an ISQL Script... and then select INSERTS.SQL to execute the script and insert the data into the tables.

☞ To make the changes to the database permanent, you must commit your work by choosing File | Commit Work.

☞ Confirm that the data has been inserted correctly with SELECT, for example:

```
SELECT * FROM DEPARTMENT;
```

Try selecting from the COUNTRY, JOB, and EMPLOYEE tables, too. Notice that all the data in the LANGUAGE_REQ column in the JOB table is NULL. This is because this column is an array, and you cannot insert data into an array using ISQL.

The script file, INSERTS2.SQL, inserts data into the other tables in the database.
☞ View this file and then run INSERTS2.SQL by choosing File | Run an ISQL Script.... Commit the changes to the database, by choosing File | Commit Work.

SELECT from the PROJECT, CUSTOMER, and SALES tables to confirm that the data has been successfully inserted. Notice that all the data in the PROJ_DESC column of the PROJECT table is NULL. This is because this column is a BLOB, and you cannot insert data into a BLOB using ISQL.

Inserting Data From an External File

Note This section covers an optional topic and may be skipped without losing any continuity. However, it is an important topic not covered in detail elsewhere in the documentation.

An *external* table is a special kind of table that stores its data in an ASCII file separate from the database. It may occasionally want to import data from an ASCII file into a database (for example, if the data was originally entered in another application or at a remote location).

You can populate a table with data from a formatted ASCII file by following these steps:

1. Create the table you want to populate. Often this table will already exist in the database.
2. Create an ASCII file *on the server* containing the data, formatted strictly to conform to the column definitions of the table in step one. Depending on how the file originated (for example, from a desktop application), you may have to edit the file manually with a text editor to ensure that it is formatted correctly.

3. Create a temporary external table that has all the columns that will get data from the external file. It is usually easiest to create all the fields as CHAR(*n*), even if they will contain numeric data. The table must also have a CHAR(1) column (usually called EOL) to take the end-of-line character.
4. Insert the data into the destination table using INSERT with a SELECT clause. InterBase's automatic type conversion feature will ensure that the data in each column is automatically converted from CHAR to the appropriate data type.

For example, suppose a salesman on the road has been keeping his sales records on his laptop computer in a spreadsheet application. When he gets back to the office, one way he could enter these records into the SALES table would be to export the information to a text file and then import the data into the database through an external table. So, in this example, you do not need to perform step one, because the SALES table already exists in the database.

The next step is to create the data file. The sales data is in the file, SALES.DAT, in the EXAMPLES\TUTORIAL directory. View this file now with the Notepad editor. It looks something like this:

```
V92E0340        1004    11     shipped    15-OCT-1992    16-OCT-1992    17-OCT-1992 y
V92J1003        1010    61     shipped    26-JUL-1992    4-AUG-1992     15-SEP-1992 y
V93J2004        1010    118    shipped    30-OCT-1993    2-DEC-1993     15-NOV-1993 y
```

The lines are too wide to display above, so only the leftmost portion of each line is shown. You can scroll the Notepad window to the right to see the remainder of each line.

Each line in this file corresponds to a row of data (record) in the SALES table, and each item of text on a line is a value to be inserted into a field in the row. The text is padded with spaces where necessary to make each field have the specified number of characters, even at the end of each line. The first item in each line (for example "V92E0340") is a value for the PONUMBER column, the second (for example "1004") is a value for the CUST_NO column, and so on. It is crucial that the items on each line always are in the same order.

For the server to be able to access this file, you must copy it to the server platform (to a disk to which the server has direct access). Use the standard FTP utility or operating system copy command to copy SALES.DAT to the directory on the server where your database resides. That completes step two of the process.

The next step is to create a temporary external table in the database called SALES_EXT. Look at the file, SALES_XT.SQL. It contains the following CREATE TABLE statement:

```
CREATE TABLE SALES_EXT EXTERNAL "/PATH/SALES.DAT"
```

```
(PO_NUMBER CHAR(10),
   CUST_NO CHAR(12),
   SALES_REP CHAR(10),
   ORDER_STATUS CHAR(13),
   ORDER_DATE CHAR(12),
   SHIP_DATE CHAR(12),
   DATE_NEEDED CHAR(12),
   PAID CHAR(7),
   QTY_ORDERED CHAR(12),
   TOTAL_VALUE CHAR(12),
   DISCOUNT CHAR(16),
   ITEM_TYPE CHAR(8),
   EOL CHAR(1));
```

Notice the keyword EXTERNAL at the top, followed by a file path in quotes. You must edit this path to specify the location on the server to which you copied SALES.DAT in the previous step. All the columns in SALES_EXT are defined as CHAR (character) values. Notice also the EOL column. This is a dummy column to contain the carriage return at the end of each line of data in SALES.DAT.

Input this definition by choosing File | Run an ISQL Script... and selecting SALES_XT.SQL in the EXAMPLES\TUTORIAL directory. At this point, you have an external table which has data stored in a file on the server. You can query data from this table as if it were an ordinary table, but you cannot modify the data, because it does not actually reside in the database, but in the file. Enter the following statement:

```
SELECT * FROM SALES_EXT;
```

You will see the data from the data file in the ISQL Output area. Now you have completed step three of the procedure.

In the final step, you will migrate the data from the external table into the real SALES table. Look at the file, MIGRATE.SQL. It contains the following INSERT statement:

```
INSERT INTO SALES
   (PO_NUMBER, CUST_NO, SALES_REP, ORDER_STATUS, ORDER_DATE, SHIP_DATE,
   DATE_NEEDED, PAID, QTY_ORDERED, TOTAL_VALUE, DISCOUNT, ITEM_TYPE)
SELECT
   PO_NUMBER, CUST_NO, SALES_REP, ORDER_STATUS, ORDER_DATE, SHIP_DATE,
   DATE_NEEDED, PAID, QTY_ORDERED, TOTAL_VALUE, DISCOUNT, ITEM_TYPE
   FROM SALES_EXT;
```

This statement selects values from the SALES_EXT table (excluding the EOL delimiter) and inserts them into rows in the SALES table, migrating the data from the file to the SALES table.

Edit the CONNECT statement at the beginning of this file and specify the server and database you are using. Then input this statement by choosing File | Run

ISQL Script... and choosing MIGRATE.SQL from the EXAMPLES\TUTORIAL directory.

☞ Now enter:

```
SELECT * FROM SALES;
```

and you will see the data that was in the SALES.DAT file has been inserted into the SALES table. Notice that the non-character columns have been converted to the appropriate data type automatically.

Updating Data

To change values for one or more rows of data, use the UPDATE statement. A simple update has the following syntax:

```
UPDATE table
   SET column = value
   WHERE condition
```

The UPDATE statement changes values for columns specified in the SET clause; columns not listed in the SET clause are not changed. To update more than one column, list each column assignment in the SET clause, separated by a comma. The WHERE clause determines which rows to update.

☞ For example, increase the salary of salespeople by $2,000, by updating the EMPLOYEE table as follows:

```
UPDATE EMPLOYEE
   SET SALARY = SALARY + 2000
   WHERE JOB_CODE = "SALES";
```

To make a more specific update, make the WHERE clause more restrictive. For example, instead of increasing the salary for all salespeople, you could increase ☞ the salaries only of salespeople hired before January 1, 1992:

```
UPDATE EMPLOYEE
   SET SALARY = SALARY + 2000
   WHERE JOB_CODE = "SALES" AND HIRE_DATE < "01-Jan-1992";
```

A WHERE clause is not required for an update. If the previous statements did not include a WHERE clause, the update would increase the salary of all employees in the EMPLOYEE table.

☞ Be sure to commit your work to make it permanent by choosing File | Commit Work.

Updating With a Script File

Open the file, UPDATES.SQL, with Notepad. As you can see, it contains a number of UPDATE statements to update the DEPARTMENT, EMPLOYEE, SALARY_HISTORY, and CUSTOMER tables.

Run this file by choosing File | Run ISQL Script.... Confirm that the updates have been made.

Updating Using a Subquery

The search condition of a WHERE clause can be a subquery. Suppose you want to change the manager of all employees in the same department as Katherine Young. One way to do this is to first determine Katherine Young's department number:

```
SELECT DEPT_NO FROM EMPLOYEE
   WHERE FULL_NAME = "Young, Katherine";
```

This query returns "623" as the department. Then, using 623 as the search condition in an UPDATE, you could change the manager number of all the employees in the department with the following statement (do not enter this statement):

```
UPDATE EMPLOYEE
   SET MNGR_NO = 107
   WHERE DEPT_NO = "623";
```

Instead of doing this, a more efficient way is to combine the two statements together using a subquery as follows. Enter this statement:

```
UPDATE EMPLOYEE
   SET MNGR_NO = 107
   WHERE DEPT_NO = (SELECT DEPT_NO FROM EMPLOYEE
      WHERE FULL_NAME = "Young, Katherine");
```

Confirm the result by selecting from the department table, and then choose File | Commit Work to make the update permanent.

Deleting Data

To remove one or more rows of data from a table, use the DELETE statement. A simple DELETE has the following syntax:

```
DELETE FROM table
   WHERE condition
```

As with UPDATE, the WHERE clause specifies a search condition that determines the rows to delete. Search conditions can be combined or can be formed using a subquery.

Caution A WHERE clause is not required in a DELETE statement. If you fail to include a WHERE clause, you will delete *all* rows in the table.

Enter the following statement to delete rows from the EMPLOYEE table for which the JOB_CODE column is “MNGR.” In other words, managers are removed from the table. Enter:

```
DELETE FROM EMPLOYEE
   WHERE JOB_CODE = "Mngr";
```

You can restrict deletions further by combining search conditions. For example, enter the following statement to delete records of all sales reps hired before 10 July 1993:

```
DELETE FROM EMPLOYEE
   WHERE JOB_CODE = "Srep" AND HIRE_DATE < "10-Jul-1993";
```

Confirm that these statements deleted the appropriate records by entering the following query

```
SELECT EMP_NO, JOB_CODE, HIRE_DATE FROM EMPLOYEE;
```

You should not see any records with a JOB_CODE of “Mngr” or any records with a JOB_CODE of “SRep” and a hire date before 10 July 1993.

Because you really did not want to delete those records from the table, roll back the changes to the database by choosing File | Rollback Work. Choose Previous to recall the previous SELECT query and then Run to run it. You should now see the deleted records displayed.

Caution If you do not rollback these deletes, you will not get the correct results when you do the rest of the tutorial.

Deleting Data Using a Subquery

The previous section used a subquery to update data. DELETE statements can also use subqueries.

To remove all employees who are in the same department as Katherine Young, including Katherine Young herself, you could first determine Katherine Young’s department number:

```
SELECT DEPT_NO FROM EMPLOYEE
   WHERE FULL_NAME = "Young, Katherine";
```

☞ This query returns "623" as the department number. Then, using 623 as the search condition in a DELETE, you would enter :

```
DELETE FROM EMPLOYEE
   WHERE DEPT_NO = "623";
```

The other way to remove the desired rows is to combine the two previous statements using a subquery. In this case, the DELETE statement becomes:

```
DELETE FROM EMPLOYEE
   WHERE DEPT_NO = (SELECT DEPT_NO FROM EMPLOYEE
      WHERE FULL_NAME = "Young, Katherine");
```

☞ Try this and confirm that it deletes the appropriate rows. Roll back the deletions by choosing File | Rollback Work.

CHAPTER 9

Retrieving Data

The SELECT statement was introduced in Chapter 4. This chapter provides further practice with this important SQL statement.

Overview of SELECT

Chapter 6: "Getting Started With Windows ISQL"presented the simplest form of the SELECT statement. The full syntax is much more complex; take a minute to look at the *Language Reference* entry for SELECT. Much of SELECT's power comes from the rich syntax it allows.

In this chapter, you will learn a distilled version of SELECT syntax:

```
SELECT [DISTINCT] columns
   FROM tables
   WHERE <search_conditions>
   [GROUP BY column HAVING <search_condition>]
   ORDER BY <sort_order>;
```

This distilled version of SELECT has six main keywords. A keyword and its associated information is called a *clause*.

The clauses are:

Table 9-1: SELECT Keywords

Clause	Description
SELECT *columns*	Lists columns to retrieve.
DISTINCT	Optional keyword that eliminates duplicate rows.
FROM *tables*	Identifies the tables to search for values.
WHERE <*search_conditions*>	Specifies the search conditions used to limit retrieved rows to a subset of all available rows.
GROUP BY *column*	Groups rows retrieved according the value of the specified column.

Table 9-1: SELECT Keywords (Continued)

Clause	Description
HAVING *<search_conditions>*	Specifies search condition to use with GROUP BY clause.
ORDER BY *<sort_order>*	Specifies the sort order of rows returned by a SELECT.

The order of the clauses in the SELECT statement is important, but SELECT and FROM are the only required clauses.

☞ You have already used some basic SELECT statements to retrieve data from single tables. SELECT can also retrieve data from multiple tables, by listing the table names in the FROM clause, separated by commas. For example, enter the following SQL statement:

```
SELECT DEPARTMENT, DEPT_NO, FULL_NAME, EMP_NO
   FROM DEPARTMENT, EMPLOYEE
   WHERE DEPARTMENT = "Engineering" AND MNGR_NO = EMP_NO;
```

This statement retrieves the specified fields for the employee who is the manager of the Engineering department.

Sometimes, a column name occurs in more than one table in the same query. If so, columns must be distinguished from one another by preceding each column name with the table name and a dot (.).

Selecting From a View

☞ Recall the view named PHONE_LIST you created in Chapter 7: “Basic Data Definition”. You can select from this view just like a table. Try this by entering the statement:

```
SELECT * FROM PHONE_LIST;
```

You will see output like this:

```
EMP_NO FIRST_NAME LAST_NAME PHONE_EXT LOCATION      PHONE_NO
====== ========== ========= ========= ===========   ===============
12     Terri      Lee       256       Monterey      (408) 555-1234
105    Oliver H.  Bender    255       Monterey      (408) 555-1234
85     Mary S.    MacDonald 477       San Francisco (415) 555-1234
....
```

As you can see, the output looks just as if there were a table called PHONE_LIST containing the pertinent information.

Removing Duplicate Rows With DISTINCT

☞ Suppose you want to retrieve a list of all the valid job codes in the EMPLOYEE database. Enter this query:

```
SELECT JOB_CODE FROM JOB;
```

As you can see, the results of this query are rather long, and some job codes are repeated a number of times. What you really want is a list of job codes where each value returned is distinct from the others. To eliminate duplicate values, use the DISTINCT keyword.

☞ Revise the previous query by clicking on the Previous button and editing the command as follows:

```
SELECT DISTINCT JOB_CODE FROM JOB;
```

As you can see, each job code is listed once in the results.

☞ What happens if you specify another column when using DISTINCT? Enter the following SELECT statement:

```
SELECT DISTINCT JOB_CODE, JOB_GRADE FROM JOB;
```

This query produces:

```
JOB_CODE JOB_GRADE
======== =========
Accnt            4
Admin            4
Admin            5
CEO              1
CFO              1
Dir              2
Doc              3
Doc              5
Eng              2
Eng              3
Eng              4
Eng              5
. . .
```

DISTINCT applies to all columns listed in a SELECT statement. In this case, duplicate job codes are retrieved. However, DISTINCT treats the job code and job grade together, so the *combination* of values is distinct.

Using the WHERE Clause

The WHERE clause of the SELECT statement follows the SELECT and FROM clauses. If an ORDER BY clause is used, the WHERE clause must precede it. The WHERE clause tests data to see whether it meets certain conditions, and the SELECT statement only returns the rows that meet the condition. For example, the statement:

```
SELECT LAST_NAME, FIRST_NAME, PHONE_EXT
   FROM EMPLOYEE
   WHERE LAST_NAME = "Green";
```

returns only rows for which LAST_NAME is "Green". The text following the WHERE keyword, in this case:

```
LAST_NAME = "Green"
```

is called a *search condition*, because a SELECT statement searches for rows that meet the condition. Search conditions have the following general form:

```
WHERE condition;
```

In this clause:

```
condition = column operator value [log_operator condition]
value = value arith_operator value
```

column is the column name in the table being queried, *operator* is a comparison operator (described in the following table), *value* is a value or a range of values compared against the column, described in the next table. A condition can be composed of two or more conditions as operands of logical operators. A value can be composed of two or more values as operands of arithmetic operators.

Search conditions use the following types of operators:

Table 9-2: Search Condition Operators

Operator	Description
Comparison operators	Used to compare data in a column to a value in the search condition. Examples include <, >, <=, >=, =, and <>. Other operators include BETWEEN, CONTAINING, IN, IS NULL, LIKE, and STARTING WITH.
Arithmetic operators	Used to calculate and evaluate search condition values. The operators are +, -, *, and /.
Logical operators	Used to combine search conditions or negate a condition. The keywords NOT, AND, and OR.

Search conditions can use the following types of values:

Table 9-3: Search Condition Values

Types of Values	Description
Literal values	Numbers and text strings whose value you want to test literally (for example the number 1138 or the string "Smith").
Derived values	Functions and arithmetic expressions, for example: SALARY * 2 or LAST_NAME || FIRST_NAME.
Subqueries	A nested SELECT statement that returns one or more values. The returned values are used in testing the search condition.

When a row is compared to a search condition, one of three values is returned:

- *True*: A row meets the conditions specified in the WHERE clause.
- *False*: A row does not meet the conditions specified in the WHERE clause.
- *Unknown*: A field in the WHERE clause contains an unknown value that could not be evaluated because of a NULL value.

Comparison Operators

InterBase uses all the standard comparison operators: greater than (>), less than (<), equal to (=), and so on. These operators can be used to compare numeric or alphabetic (text) values. Text literals must be quoted. Numeric literals must not be quoted.

A previous example had a WHERE clause that compared a column to a literal value:

```
SELECT LAST_NAME, FIRST_NAME, PHONE_EXT
   FROM EMPLOYEE
   WHERE LAST_NAME = "Green";
```

This query will retrieve records from the EMPLOYEE table for which the last name is "Green". If you change the equal sign to a greater than (>) sign, it will retrieve rows for which the last name is alphabetically greater than (after) "Green". Likewise, if you change it to less than (<). Try these different queries to see how the results change.

You can negate any expression with the negation operators !, ^, and ~. These operators are all synonyms for NOT. For example, to retrieve all rows except those for which the last name is "Green", change the search condition to:

```
WHERE NOT (LAST_NAME = "Green"
```

Try negating some of the previous queries to see how the results change.

Pattern Matching

Besides comparing values, search conditions can also test character strings for a particular pattern. If data is found that matches a given pattern, the row is retrieved.

There are a great many pattern matching operators. This section will only discuss some of the most commonly used ones: LIKE, STARTING WITH, IS NULL, and BETWEEN.

LIKE Operator

The LIKE operator lets you use wildcard characters in matching text. *Wildcard characters* are characters that have special meanings when used in a search condition. A percent sign (%) will match zero or more characters. An underscore (_) will match any single character.

☞ For example, enter this statement in the SQL Statement area:

```
SELECT LAST_NAME, FIRST_NAME, EMP_NO FROM EMPLOYEE
   WHERE LAST_NAME LIKE "%an";
```

You should see the following results:

```
LAST_NAME            FIRST_NAME      EMP_NO
==================== =============== ======
Ramanathan           Ashok           45
Steadman             Walter          46
```

As you can see from the results, this statement retrieves rows for employees whose last names end with “an”, because the percent sign will match any characters. LIKE distinguishes between uppercase and lowercase.

☞ Now enter the following statement:

```
SELECT LAST_NAME, FIRST_NAME, EMP_NO FROM EMPLOYEE
   WHERE LAST_NAME LIKE "_e%";
```

This statement retrieves rows for employees whose last name has “e” as the second letter. The underscore will match any one character in the last name.

STARTING WITH Operator

The STARTING WITH operator tests whether a value starts with a particular character or sequence of characters. As with the LIKE operator, STARTING

WITH distinguishes between uppercase and lowercase. STARTING WITH does not support wildcard characters.

☞ The following statement retrieves employee last names that start with “Ke”:

```
SELECT LAST_NAME, FIRST_NAME
   FROM EMPLOYEE
   WHERE FIRST_NAME STARTING WITH "Ke";
```

The CONTAINING operator is similar to STARTING WITH, except it matches strings containing the specified string, *anywhere,* within the string.

Testing for an Unknown Value

Another type of comparison tests for the absence or presence of a value. Use the IS NULL operator to test whether a value is unknown (that is, absent). To test for the presence of any value, use IS NOT NULL.

☞ For example, to retrieve the names of employees who do not have phone extensions, enter:

```
SELECT LAST_NAME, FIRST_NAME
   FROM EMPLOYEE
   WHERE PHONE_EXT IS NULL;
```

You should see the following results:

```
LAST_NAME            FIRST_NAME
==================== ===========
Sutherland           Claudia
Glon                 Jacques
Osborne              Pierre
```

☞ To retrieve the names of employees who *do* have phone extensions, enter:

```
SELECT LAST_NAME, FIRST_NAME, PHONE_EXT
   FROM EMPLOYEE
   WHERE PHONE_EXT IS NOT NULL;
```

The results should be all the employee records *except* the three retrieved by the previous query.

Comparing Against a Range or List of Values

The previous sections described operators to compare columns to a single value. The BETWEEN and IN operators enable comparison against multiple values.

BETWEEN tests whether a value falls within a range. For example, to retrieve names of employees whose salaries are between $100,000 and $250,000, inclusive, enter:

```
SELECT LAST_NAME, FIRST_NAME
   FROM EMPLOYEE
   WHERE SALARY BETWEEN 100000 AND 250000;
```

The IN operator searches for values matching one of the values in a list. For example, to retrieve the names of all employees in departments 120, 600, and 623, enter:

```
SELECT DEPT_NO, LAST_NAME, FIRST_NAME FROM EMPLOYEE
   WHERE DEPT_NO IN (120, 600, 623);
```

The values in the list must be separated by commas, and the list must be enclosed in parentheses. Use NOT IN to search for values that do not occur in a set.

Logical Operators

Up until now, the examples presented have included only one search condition. However, you can include any number of search conditions in a WHERE clause by combining them with the logical operators AND or OR.

When AND appears between search conditions, both conditions must be true for a row to be retrieved. For example, enter this query:

```
SELECT DEPT_NO, LAST_NAME, FIRST_NAME, HIRE_DATE
   FROM EMPLOYEE
   WHERE DEPT_NO = 623 AND HIRE_DATE > "01-Jan-1992";
```

The query returns information on employees in department 623 who were hired after 1 January 1992.

When OR appears between search conditions, either search condition can be true for a row to be retrieved. Choose Previous to recall the previous query and change AND to OR. As you can see, the results are quite different, because the query retrieves rows for employees who are in department 623 *or* who were hired before 1 January 1992.

As another example of using OR in a search condition, enter this query:

```
SELECT CUSTOMER, CUST_NO
   FROM CUSTOMER
   WHERE COUNTRY = "USA" OR COUNTRY = "Canada";
```

This query retrieves customer records for customers in the US or Canada.

Controlling the Order of Evaluation

When entering compound search conditions, you must be aware of the order of evaluation of the conditions. Suppose you want to retrieve employees in department 623 or department 600 who have a hire date later than 1 January 1992. Try entering this query:

```
SELECT LAST_NAME, FIRST_NAME, HIRE_DATE, DEPT_NO
   FROM EMPLOYEE
   WHERE DEPT_NO = 623 OR DEPT_NO = 600
   AND HIRE_DATE > "01-JAN-1992";
```

As you can see, the results include employees hired earlier than you want:

```
LAST_NAME            FIRST_NAME      HIRE_DATE   DEPT_NO
==================== =============== =========== =======
Young                Katherine       14-JUN-1990 623
De Souza             Roger           18-FEB-1991 623
Phong                Leslie           3-JUN-1991 623
Brown                Kelly            4-FEB-1993 600
Parker               Bill             1-JUN-1993 623
Johnson              Scott           13-SEP-1993 623
```

The WHERE clause was not interpreted the way you meant it because AND has *higher precedence* than OR. This means that the expressions on either side of AND are tested before those associated with OR. In the example as written, the search conditions are interpreted as follows:

```
(WHERE DEPT_NO = 623)
   OR
(WHERE DEPT_NO = 600 AND HIRE_DATE > "01-JAN-1992")
```

The restriction on the hire date applies only to the second department. Employees in department 623 are listed regardless of hire date.

Use parentheses to override normal precedence. In the example, place parentheses around the two departments so they are tested against the AND operator as a unit:

```
SELECT LAST_NAME, FIRST_NAME, HIRE_DATE, DEPT_NO
   FROM EMPLOYEE
   WHERE (DEPT_NO = 623 OR DEPT_NO = 600)
   AND HIRE_DATE > "01-JAN-1992";
```

This displays the results you want:

```
LAST_NAME            FIRST_NAME      HIRE_DATE   DEPT_NO
==================== =============== =========== =======
Brown                Kelly            4-FEB-1993 600
Parker               Bill             1-JUN-1993 623
Johnson              Scott           13-SEP-1993 623
```

Order of precedence is not just an issue for AND and OR. All operators are defined with a precedence level that determines their order of interpretation. For detailed information about operator precedence, see the *Programmer's Guide*.

Tip To avoid confusion with operator precedence, always use parentheses to group operations in complex search conditions.

Using Subqueries

Suppose you want to retrieve a list of employees who work in the same country as a particular employee whose ID is 144. You would first need to find out what country this employee works in. Enter this query:

```
SELECT JOB_COUNTRY FROM EMPLOYEE
   WHERE EMP_NO = 144;
```

This query returns "USA." With this information, you can form your next query:

```
SELECT EMP_NO, LAST_NAME FROM EMPLOYEE
   WHERE JOB_COUNTRY = "USA";
```

This query returns a list of employees in the USA, the same country as employee number 144. You can obtain the same result by combining the two queries:

```
SELECT EMP_NO, LAST_NAME FROM EMPLOYEE
   WHERE JOB_COUNTRY =
      (SELECT JOB_COUNTRY FROM EMPLOYEE
      WHERE EMP_NO = 144);
```

This statement uses a *subquery*, a SELECT statement inside the WHERE clause of another SELECT statement. A subquery works like a search condition to restrict the number of rows returned by the outer, or *parent*, query.

In this case, the subquery retrieves a single value, "USA." The main query interprets "USA" as a value to be tested by the WHERE clause. Because the WHERE clause is testing for a single value, the subquery must return a single value; otherwise, the statement produces an error. As long as a subquery retrieves a single value, you can use it in any search condition that tests for a single value.

If a subquery returns more than one value, you must use an operator that tests against more than one value. IN is such an operator. The following example retrieves all management-level employees. It uses a subquery that returns any job grade lower than or equal to 2:

```
SELECT FIRST_NAME, LAST_NAME
   FROM EMPLOYEE
   WHERE JOB_GRADE IN
      (SELECT JOB_GRADE FROM JOB WHERE JOB_GRADE <= 2);
```

Conditions for Subqueries

The following table summarizes the operators that compare a value on the left of the operator to the results of a subquery to the right of the operator:

Table 9-4: InterBase Comparison Operators Requiring Subqueries

Operator	Purpose
ALL	Returns true if a comparison is true for all values returned by a subquery.
ANY or SOME	Returns true if a comparison is true for at least one value returned by a subquery.
EXISTS	Determines if a value exists in *at least one* value returned by a subquery.
SINGULAR	Determines if a value exists in *exactly one* value returned by a subquery.

Suppose you want to see how salaries compare to the salaries of employees in department 623. First you would need an expression that returns employee salaries for department 623. The following query returns that information:

```
SELECT SALARY FROM EMPLOYEE
   WHERE DEPT_NO = 623;
```

and produces this output:

```
    SALARY
 =========
 67241.25
 69482.62
 56034.38
 35000.00
 60000.00
```

The previous query can now be used as a subquery in the next several examples. To see which employees have the same salary as those in department 623, enter:

```
SELECT LAST_NAME, DEPT_NO FROM EMPLOYEE
   WHERE SALARY IN
   (SELECT SALARY FROM EMPLOYEE WHERE DEPT_NO = 623);
```

The IN operator tests whether a value equals one of the values in a list. In this case, the value being tested is SALARY, and the list comes from a subquery. The statement yields this output:

```
LAST_NAME            DEPT_NO
==================== =======
Hall                     900
```

```
Young                    623
De Souza                 623
Phong                    623
Parker                   623
Johnson                  623
Montgomery               672
```

The output shows that two employees, Hall and Montgomery, earn the same as someone in department 623.

Using ALL

The IN operator tests only against the *equality* of a list of values. What if you want to test some relationship other than equality? For example, suppose you want to find out who earns more than the people in department 623. Enter the following query:

```
SELECT LAST_NAME, SALARY FROM EMPLOYEE
   WHERE SALARY > ALL
   (SELECT SALARY FROM EMPLOYEE WHERE DEPT_NO = 623);
```

to yield this output:

```
LAST_NAME              SALARY
=================== =======
Nelson              105900.00
Young                97500.00
Lambert             102750.00
Forest               75060.00
. . .
```

This example uses the ALL operator. The statement tests against *all* values in the subquery. If the salary is greater, the row is retrieved. The manager of department 623 can use this output to see which company employees earn more than his or her employees.

Using ANY, EXISTS, and SINGULAR

Instead of testing against all values returned by a subquery, you can rewrite the example to test for at least one value. Enter this query:

```
SELECT LAST_NAME, SALARY FROM EMPLOYEE
   WHERE SALARY > ANY
   (SELECT SALARY FROM EMPLOYEE WHERE DEPT_NO = 623);
```

This statement retrieves rows for which SALARY is greater than any of the values from the subquery, so this statement retrieves records of employees whose salary is greater than *any* salary in department 623. The ANY keyword has a synonym, SOME. The two are interchangeable.

Two other subquery operators are EXISTS and SINGULAR. For a given value, EXISTS tests whether *at least one* qualifying row meets the search condition specified in a subquery. EXISTS returns either true or false, even when handling NULL values. For a given value, SINGULAR tests whether *exactly one* qualifying row meets the search condition specified in a subquery.

Using Aggregate Functions

SQL provides *aggregate functions* that calculate a single value from a group of values. A group of values is all data in a particular column for a given set of rows, such as the job code listed in all rows of the JOB table. Aggregate functions may be used in a SELECT clause, or anywhere a value is used in a SELECT statement.

The following table lists the aggregate functions supported by InterBase:

Table 9-5: Aggregate Functions

Function	What It Does
AVG(*value*)	Returns the average value for a group of rows.
COUNT(*value*)	Counts the number of rows that satisfy the WHERE clause.
MIN(*value*)	Returns the minimum value in a group of rows.
MAX(*value*)	Returns the maximum value in a group of rows.
SUM(*value*)	Adds numeric values in a group of rows.

☞ For example, suppose you want to know how many different job codes are in the JOB table. Enter the following statement:

```
SELECT COUNT(JOB_CODE) FROM JOB;
```

The result is:

```
      COUNT
===========
         31
```

☞ However, this is not what you want, because the query included duplicate job codes in the count. To count only the unique job codes, use the DISTINCT keyword as follows:

```
SELECT COUNT(DISTINCT JOB_CODE) FROM JOB;
```

This produces the correct result:

```
      COUNT
===========
         14
```

☞ Enter the following query to retrieve the average salary of employees from the EMPLOYEE table:

```
SELECT AVG(SALARY) FROM EMPLOYEE;
```

☞ A single SELECT can retrieve multiple aggregate functions. Enter this statement to retrieve the number of employees, the earliest hire date, and the total salary paid to all employees:

```
SELECT COUNT(EMP_NO), MIN(HIRE_DATE), SUM(SALARY)
   FROM EMPLOYEE;
```

The result is:

```
      COUNT         MIN                    SUM
=========== =========== ======================
         42 28-DEC-1988           115530468.00
```

Sometimes, a value involved in an aggregate calculation is NULL or unknown. In this case, the function ignores the entire row to prevent wrong results. For example, when calculating an average over fifty rows, if ten rows contain a NULL value, then the average is taken over forty values, not fifty.

Grouping Query Results

You can use the optional GROUP BY clause to organize data retrieved from aggregate functions. Each column name that appears in a GROUP BY clause must also appear in the SELECT clause. And each SELECT clause in a query can have only one GROUP BY clause.

☞ Suppose you want to display the maximum allowable salary for each job code and job grade in the United States. Enter this query:

```
SELECT JOB_CODE, JOB_GRADE, MAX_SALARY
   FROM JOB WHERE JOB_COUNTRY = "USA";
```

You should see these results (shown in part):

```
JOB_CODE JOB_GRADE             MAX_SALARY
======== ========= ======================
CEO              1              250000.00
CFO              1              140000.00
VP               2              130000.00
```

```
Dir              2              120000.00
Mngr             3              100000.00
Mngr             4               60000.00
Admin            4               55000.00
Admin            5               40000.00
. . .
```

Now suppose you want to total the salaries for each group of job codes. In other words, find the maximum total possible salary for all job codes, regardless of job grade. To do so, use the SUM() function and group the results by job code. Enter the following query:

```
SELECT JOB_CODE, SUM(MAX_SALARY)
   FROM JOB WHERE JOB_COUNTRY = "USA"
   GROUP BY JOB_CODE;
```

to produce the desired output (shown in part):

```
JOB_CODE                    SUM
======== ======================
Accnt                  55000.00
Admin                  95000.00
CEO                   250000.00
CFO                   140000.00
Dir                   120000.00
Doc                   100000.00
Eng                   300000.00
. . .
```

Note the difference in the results. The first query produces four entries for engineers (Eng). The second query totals the salaries for these four entries and displays a single row as the result.

As another example, the DEPARTMENT table lists budgets for each department in the company. Each department also has a head department to which it reports. Suppose you want to find out the total budget for each head department. To do so, you would need to add the budgets for individual departments and group the results by each head department. Enter the following query:

```
SELECT HEAD_DEPT, SUM(BUDGET)
   FROM DEPARTMENT
   GROUP BY HEAD_DEPT;
```

to produce these results:

```
HEAD_DEPT                    SUM
========= ======================
000                   3500000.00
100                   3800000.00
110                    800000.00
120                   1300000.00
600                   2350000.00
```

```
620                   1350000.00
670                   1310000.00
<null>                1000000.00
```

Using the HAVING Clause

Just as a WHERE clause reduces the number of rows returned by a SELECT clause, the HAVING clause can be used to reduce the number of rows returned by a GROUP BY clause. Like the WHERE clause, a HAVING clause has a search condition. In a HAVING clause, the search condition typically corresponds to an aggregate function used in the SELECT clause.

☞ For example, you can modify the previous query to display only the head departments whose total budgets are greater than 2,000,000. Change the query as follows:

```
SELECT HEAD_DEPT, SUM(BUDGET)
   FROM DEPARTMENT
   GROUP BY HEAD_DEPT
   HAVING SUM(BUDGET) > 2000000;
```

This query produces the following results:

```
HEAD_DEPT         SUM
========= ===========
000        3500000.00
100        3850000.00
600        2350000.00
```

Using the ORDER BY Clause

By default, a query retrieves rows in "natural order," the order it finds them in a table. Because internal table storage is typically unordered, retrieval is unordered as well. The ORDER BY clause sorts results according to a column you specify. Every column in the ORDER BY clause must also appear in the SELECT clause of the statement.

☞ For example, enter the statement:

```
SELECT LAST_NAME, FIRST_NAME, PHONE_EXT
   FROM EMPLOYEE
   ORDER BY LAST_NAME;
```

As you can see, this query sorts results by employee's last name.

☞ By default, ORDER BY sorts in ascending order, in this case from A to Z. To sort in descending order instead, use the DESC keyword. Enter:

```
SELECT LAST_NAME, FIRST_NAME, PHONE_EXT
   FROM EMPLOYEE
   ORDER BY LAST_NAME DESC;
```

In the previous two examples, the sort column contains characters, so ORDER BY performs an alphanumeric sort. If a sort column contains numbers, results are sorted numerically.

☞ ORDER BY can also sort results by more than one column. For example, if several employees have the same last name, you can sort by both first name and last name using the following SELECT statement:

```
SELECT LAST_NAME, FIRST_NAME, PHONE_EXT
   FROM EMPLOYEE
   ORDER BY LAST_NAME DESC, FIRST_NAME;
```

In this case, the results are initially sorted by last name, in descending order. For employees with the same last name, data is further sorted by first name. The first name is also sorted in descending order because once you specify a column's sort order, it applies to all subsequent columns until you specify another sort order. To explicitly sort in ascending order, use the ASC keyword.

Joining Tables

Joins enable a SELECT statement to retrieve data from two or more tables in a database. The tables are listed in the FROM clause. The optional ON clause can reduce the number of rows returned, and the WHERE clause can further reduce the number of rows returned.

From the information in a SELECT that describes a join, InterBase builds a table that contains the results of the join operation, the *result table*, sometimes also called a *dynamic* or *virtual table*.

InterBase supports two basic types of joins: inner joins and outer joins.

Inner joins link rows in tables based on specified join conditions and return only those rows that match the join conditions. If a joined column contains a NULL value for a given row, that row is not included in the result table. Inner joins are the more common type because they restrict the data returned and show a clear relationship between two or more tables.

Outer joins link rows in tables based on specified join conditions but return rows whether they match the join conditions or not. Outer joins are useful for viewing joined rows against a background of rows that do not meet the join conditions.

Inner Joins

There are three types of inner joins:

- *Equi-joins* link rows based on common values or equality relationships in the join columns.
- Joins that link rows based on comparisons other than equality in the join columns. There is not an officially recognized name for these types of joins, but for simplicity's sake they may be categorized as *comparative joins*, or *non-equi-joins*.
- *Reflexive* or *self-joins*, compare values within a column of a single table.

To specify a SELECT statement as an inner join, list the tables to join in the FROM clause, and list the columns to compare in the WHERE clause. The simplified syntax is:

```
SELECT <columns>
   FROM <left_table> [INNER] JOIN <right_table>
      [ON <searchcondition>]
   [WHERE <searchcondition>];
```

Search conditions based on a column in the right table can be specified in an optional ON clause following the right table reference.

For example, consider the following query including an inner join:

```
 SELECT D.DEPARTMENT, D.MNGR_NO, E.SALARY
   FROM DEPARTMENT D JOIN EMPLOYEE E
   ON D.MNGR_NO = E.EMP_NO
      AND E.SALARY*2 > (SELECT SUM(S.SALARY) FROM EMPLOYEE S
      WHERE D.DEPT_NO = S.DEPT_NO)
   ORDER BY D.DEPARTMENT;
```

Examine this statement in detail. The SELECT clause uses correlation names D for DEPARTMENT and E for EMPLOYEE (as specified in the FROM clause) to select the department name and manager number from DEPARTMENT and the manager's salary from the EMPLOYEE table.

The ON clause states a compound join condition:

- The MNGR_NO column in the DEPARTMENT table must match the EMP_NO column in EMPLOYEE.
- The manager's salary times two (E.SALARY*2) must be greater than the sum of all employees' salaries in the department. In other words, the manager's salary must be greater than half the sum of all salaries in the department.

☞ Enter the above statement. You should see the following results:

```
DEPARTMENT                MNGR_NO                SALARY
========================= ======= ======================
Consumer Electronics Div.     107             111262.50
Corporate Headquarters        105             212850.00
Customer Services              94              56295.00
Engineering                     2             105900.00
Field Office: Canada           72             100914.00
Field Office: France          134             390500.00
Field Office: Italy           121           99000000.00
Field Office: Japan           118            7480000.00
Field Office: Switzerland     141             110000.00
Finance                        46             116100.00
Sales and Marketing            85             111262.50
```

Outer Joins

Outer joins produce a result table containing columns from every row in one table and a subset of rows from another table. Outer join syntax is very similar to that of inner joins:

```
SELECT col [, col ...] | *
   FROM <left_table> {LEFT | RIGHT | FULL} [OUTER] JOIN
      <right_table> [ON <searchcondition>]
   [WHERE <searchcondition>];
```

However, with outer joins, you need to specify the type of join to perform. There are three possibilities:

- A *left outer join* retrieves all rows from the left table in a join, and retrieves any rows from the right table that match the search condition specified in the ON clause.
- A *right outer join* retrieves all rows from the right table in a join, and retrieves any rows from the left table that match the search condition specified in the ON clause.
- A *full outer join* retrieves all rows from both the left and right tables in a join regardless of the search condition specified in the ON clause.

Outer joins are useful for comparing a subset of data to the background of all data from which it is retrieved. For example, when listing the employees that are assigned to projects, it may be interesting to see the employees that are not assigned to projects, too.

The following outer join retrieves employee names from the EMPLOYEE table and project IDs from the EMPLOYEE_PROJECT table, for employees that are assigned to projects.

```
SELECT PROJ_ID, FULL_NAME
   FROM EMPLOYEE LEFT OUTER JOIN EMPLOYEE_PROJECT
   ON EMPLOYEE.EMP_NO = EMPLOYEE_PROJECT.EMP_NO;
```

All employee names in the EMPLOYEE table are retrieved, regardless of whether they are assigned to a project, because EMPLOYEE is the left table in the join. Enter it to see what the results look like.

Notice that some employees are not assigned to a project; the PROJ_ID column is empty for them. Reverse the outer join, by changing the FROM clause to:

```
FROM EMPLOYEE_PROJECT LEFT OUTER JOIN EMPLOYEE
```

The results look different. Why?

Formatting Data

This section describes three ways to change data formats:

- Converting data types
- Concatenating strings
- Converting characters to uppercase

Using CAST( ) to Convert Data Types

Normally, only similar data types can be compared in search conditions, but you can work around this by using CAST(). Use the CAST function in search conditions to translate one data type into another. The syntax for CAST() is:

```
CAST (<value> | NULL AS datatype)
```

For example, the following WHERE clause uses CAST() to translate a CHAR data type, INTERVIEW_DATE, to a DATE data type. This conversion lets you compare INTERVIEW_DATE to another DATE column, HIRE_DATE:

```
. . . WHERE HIRE_DATE = CAST(INTERVIEW_DATE AS DATE);
```

You can use CAST() to compare columns in the same table or across tables. CAST() allows the conversions listed in the following table:

Table 9-6: Compatible Data Types for CAST()

From Data Type	To Data Type
NUMERIC	CHARACTER, DATE
CHARACTER	NUMERIC, DATE

Table 9-6: Compatible Data Types for CAST() (Continued)

From Data Type	To Data Type
DATE	CHARACTER, NUMERIC

Using the String Operator in Search Conditions

The string operator, also referred to as a *concatenation operator*, `||`, joins two or more character strings into a single string. Character strings can be constants or values retrieved from a column. For example, enter the following:

```
SELECT DEPARTMENT, LAST_NAME || " is the manager"
   FROM DEPARTMENT, EMPLOYEE
   WHERE MNGR_NO = EMP_NO;
```

to produce this result:

```
DEPARTMENT
========================= ===================================
Corporate Headquarters    Bender is the manager
Sales and Marketing       MacDonald is the manager
Engineering               Nelson is the manager
Finance                   Steadman is the manager
Quality Assurance         Forest is the manager
Customer Support          Young is the manager
Consumer Electronics Div. Cook is the manager
Research and Development  Papadopoulos is the manager
Customer Services         Williams is the manager
Field Office: East Coast  Weston is the manager
. . .
```

Converting to Uppercase

The UPPER() function converts character values to uppercase. For example, when defining a column in a table, you can use a CHECK constraint that ensures that all column values are entered in uppercase. The following CREATE DOMAIN statement uses the UPPER() function in defining the PROJNO domain:

```
CREATE DOMAIN PROJNO
 AS CHAR(5)
 CHECK (VALUE = UPPER (VALUE));
```

CHAPTER 10

Advanced Data Definition

This chapter provides examples of some advanced DDL features, including:

- Creating and using triggers.
- Creating and using stored procedures.

Triggers and Stored Procedures

A *trigger* is a self-contained routine associated with a table, that automatically performs an action when a row in the table is inserted, updated, or deleted. A *stored procedure* is a program that can be called by applications or from ISQL.

Both stored procedures and triggers are part of a database's metadata and are written in *stored procedure and trigger language*, an InterBase extension of SQL. Procedure and trigger language includes SQL data manipulation statements and some powerful extensions, including IF . . . THEN . . . ELSE, WHILE . . . DO, FOR SELECT . . . DO, exceptions, and error handling.

Stored procedures can be invoked directly from applications, or can be substituted for a table or view in a SELECT statement. They can receive input parameters from and return values to the calling application.

A trigger is never called directly. Instead, when an application or user attempts to INSERT, UPDATE, or DELETE a row in a table, any triggers associated with that table and operation are automatically executed, or *fired*.

For a full explanation of stored procedures and triggers, see the *Data Definition Guide*.

Triggers

Triggers have a wide variety of uses, but in general, they enable you to automate tasks that would otherwise be done manually. They enable you to define actions that occur automatically whenever data is inserted, updated or deleted in a particular table. Triggers are a versatile tool, and their uses are virtually unlimited.

The triggers defined in the EMPLOYEE database:

- Generate and insert unique employee numbers in the EMPLOYEE table and customer numbers in the CUSTOMER table.
- Maintain a record of employees' salary changes.
- Post an event when a new sale is made.

Generating Unique Column Values With Triggers

Recall the EMPLOYEE table in the example database. This table has a primary key column named EMP_NO for each employee's employee number. Because it is a primary key, each employee number must be unique. And, generally, employee numbers are sequential. So, each time you insert a new employee record in this table, you would have to remember what the last employee number issued was, and then give the new employee the next number. This would be cumbersome and error-prone.

Triggers provide a simple way to automate this process, by using a handy database object called a *generator*. A generator is a named variable that is called and incremented through the GEN_ID() function. Each time GEN_ID() is called, it generates the next incremental value of the generator. The value of the generator is initialized with SET GENERATOR.

☞ Look at the SQL file, TRIGGERS.SQL. The beginning of the file has the following statements:

```
CREATE GENERATOR EMP_NO_GEN;
SET GENERATOR EMP_NO_GEN TO 145;
```

The first statement creates a generator named EMP_NO_GEN. The second statement initializes the generator to 145 (recall that in the script file, INSERTS.SQL, records were inserted into EMPLOYEE for employee numbers up to 145).

The next statements define a trigger named SET_EMP_NO that uses EMP_NO_GEN to generate unique sequential employee numbers, and inserts them into the EMPLOYEE table.

```
/* Create trigger to add unique customer number */

SET TERM !! ;
CREATE TRIGGER SET_EMP_NO FOR EMPLOYEE
BEFORE INSERT
AS
BEGIN
```

```
      NEW.EMP_NO = GEN_ID(EMP_NO_GEN, 1);
   END !!
   SET TERM ; !!
```

The statements above define the trigger. Because each statement in a trigger body must be terminated by a semicolon, SET TERM is first used to define a different symbol to terminate the CREATE TRIGGER statement as a whole.

The CREATE TRIGGER statement above specifies:

- The name of the trigger, SET_EMP_NO
- The table with which the trigger is associated, EMPLOYEE
- When and how the trigger is fired, in this case *before* every INSERT operation
- Following the AS keyword, the *body* of the trigger—what the trigger does when it fires, bracketed by BEGIN and END. In this case, it uses a context variable, NEW.EMP_NO to insert the next employee number into the EMP_NO column.

Context variables are unique to triggers. They allow you to specify NEW and OLD to reference the values of columns being updated. For more information on context variables, see the *Data Definition Guide*.

There are several other triggers defined in TRIGGERS.SQL, which you will examine later. But first, you are going to see how the SET_EMP_NO trigger works. Read the file into ISQL by choosing File | Run an ISQL Script.... Now, refresh your memory of the EMPLOYEE table by typing the statement:

```
SELECT * from EMPLOYEE;
```

Notice that the last employee listed has employee number 145. Now enter a new employee record, for instance:

```
INSERT INTO EMPLOYEE (FIRST_NAME, LAST_NAME, DEPT_NO, JOB_CODE,
JOB_GRADE, JOB_COUNTRY, HIRE_DATE, SALARY, PHONE_EXT) VALUES
("Reed", "Richards", "671", "Eng", 5, "USA", "07/27/95", 34000, "444");
```

Retrieve the new record by entering

```
SELECT * from EMPLOYEE WHERE LAST_NAME = "Richards";
```

Notice that the employee number is 146. The trigger has automatically assigned the new employee the next employee number.

TRIGGERS.SQL defines a similar trigger named SET_CUST_NO to assign unique customer numbers. It also defines two other triggers: SAVE_SALARY_CHANGE and POST_NEW_ORDER.

Maintaining Change Records With a Trigger

☞ SAVE_SALARY_CHANGE maintains a record of changes to employees' salaries in the SALARY_HISTORY table. Choose View | Metadata Information..., select Trigger, and then type "SAVE_SALARY_CHANGE" to view the trigger. This will be displayed in the Output area:

```
SHOW TRIGGER SAVE_SALARY_CHANGE
Triggers on Table EMPLOYEE:
SAVE_SALARY_CHANGE, Sequence: 0, Type: AFTER UPDATE, Active
AS
BEGIN
   IF (OLD.SALARY <> NEW.SALARY) THEN
   INSERT INTO SALARY_HISTORY
   (EMP_NO, CHANGE_DATE, UPDATER_ID, OLD_SALARY, PERCENT_CHANGE)
   VALUES (OLD.EMP_NO,
   "NOW",
   USER,
   OLD.SALARY,
   (NEW.SALARY - OLD.SALARY) * 100 / OLD.SALARY);
END
```

This trigger fires AFTER UPDATE of the EMPLOYEE table. It then compares the value of the SALARY column before the update to SALARY after the update, and if they are different, it enters a record in SALARY_HISTORY consisting of the employee number, date, previous salary, and percentage change in the salary. Update an employee record and change the salary to see how this trigger works.

Posting an Event With a Trigger

The trigger, POST_NEW_ORDER, posts an event named "new_order" whenever a record is inserted into the SALES table.

```
CREATE TRIGGER POST_NEW_ORDER FOR SALES
AFTER INSERT AS
BEGIN
   POST_EVENT "new_order";
END !!
```

An *event* is a message passed by a trigger or stored procedure to the InterBase event manager to notify interested applications of the occurrence of a particular condition. Applications which have registered interest in an event can pause execution and wait for the specified event to occur. For more information on events, see the *Programmer's Guide*.

The POST_NEW_ORDER trigger is fired *after* a new record is inserted into the SALES table, in other words when a new sale is made. When this event occurs, interested applications may take appropriate action, such as printing an invoice or notifying the shipping department.

Stored Procedures

Stored procedures are programs stored with a database's metadata. Applications can call stored procedures and you can also use stored procedures in ISQL. For more information on calling stored procedures from applications, see the *Programmer's Guide*.

There are two types of stored procedures:

- *Select procedures* that an application can use in place of a table or view in a SELECT statement. A select procedure must be defined to return one or more values (output parameters), or an error results.
- *Executable procedures* that an application can call directly with the EXECUTE PROCEDURE statement. An executable procedure may or may not return values to the calling program.

Both kinds of procedures are defined with CREATE PROCEDURE and have essentially the same syntax. The difference is in how the procedure is written and how it is intended to be used. Select procedures can return more than one row, so that to the calling program they appear as a table or view. Executable procedures are simply routines invoked by the calling program which may or may not return values.

A CREATE PROCEDURE statement is composed of a *header* and a *body*. The header contains:

- The *name* of the stored procedure, which must be unique among procedure, view, and table names in the database.
- An optional list of *input parameters* and their data types that a procedure receives from the calling program.
- If the procedure returns values to the calling program, the RETURNS keyword followed by a list of *output parameters* and their data types.

The procedure body contains:

- An optional list of *local variables* and their data types.
- A *block* of statements in InterBase procedure and trigger language, bracketed by BEGIN and END. A block can itself include other blocks, so that there may be many levels of nesting.

The stored procedures for the EMPLOYEE database are defined in the script file named PROCS.SQL. Open up this file with a text editor to view them. Input this file by choosing File | Include. You are going to experiment with these procedures one at a time to learn about them.

A Simple Select Procedure

The first procedure defined in PROCS.SQL is named GET_EMP_PROJ:

```
CREATE PROCEDURE GET_EMP_PROJ (EMP_NO SMALLINT)
RETURNS (PROJ_ID CHAR(5))
AS
BEGIN
   FOR SELECT PROJ_ID
   FROM EMPLOYEE_PROJECT
   WHERE EMP_NO = :EMP_NO
   INTO :PROJ_ID
   DO
      SUSPEND;
END ^
```

This is a select procedure that takes an employee number as its input parameter (EMP_NO, specified in parentheses after the procedure name) and returns all the projects to which the employee is assigned (PROJ_ID, specified after RETURNS).

It uses a FOR SELECT . . . DO statement to retrieve multiple rows from the EMPLOYEE_PROJECT table. This statement retrieves values just like a normal select statement, but retrieves them one at a time into the variable listed after INTO, and then performs the statements following DO. In this case, the only statement is SUSPEND, which suspends execution of the procedure and sends values back to the calling application (in this case, ISQL).

☞ See how it works by entering the following query:

```
SELECT * FROM GET_EMP_PROJ(71);
```

As you can see, this query looks as if there is a table named GET_EMP_PROJ, except that you provide the input parameter in parentheses following the procedure name. The results are:

```
PROJ_ID
=======
VBASE
MAPDB
```

These are the projects to which employee number 71 is assigned. Try it with some other employee numbers.

A Simple Executable Procedure

The next procedure defined in PROCS.SQL is an executable procedure named ADD_EMP_PROJ. It is a simple example of an executable procedure and makes use of an *exception*, a named error message, defined with CREATE EXCEPTION:

```
CREATE EXCEPTION UNKNOWN_EMP_ID
   "Invalid employee number or project id.";
```

Once defined, this exception can be *raised* in a trigger or stored procedure with the statement EXCEPTION UNKNOWN_EMP_ID. The associated error message is then returned to the calling application.

The stored procedure, ADD_EMP_PROJ, is shown below:

```
CREATE PROCEDURE ADD_EMP_PROJ (EMP_NO SMALLINT, PROJ_ID CHAR(5))
AS
BEGIN
   BEGIN
      INSERT INTO EMPLOYEE_PROJECT (EMP_NO, PROJ_ID)
      VALUES (:emp_no, :proj_id);
      WHEN SQLCODE -530 DO
         EXCEPTION UNKNOWN_EMP_ID;
   END
   SUSPEND;
END ^
```

This procedure takes an employee number and project ID as input parameters and adds the employee to the specified project using a simple INSERT statement. The error-handling WHEN statement checks for SQLCODE -530, violation of FOREIGN KEY constraint, and then raises the previously-defined exception when this occurs.

☞ Use this procedure through the EXECUTE PROCEDURE statement, for example:

```
EXECUTE PROCEDURE ADD_EMP_PROJ(20, "DGPII");
```

☞ Now try adding a non-existent employee to a project, for example:

```
EXECUTE PROCEDURE ADD_EMP_PROJ(999, "DGPII");
```

The statement fails and the exception message is displayed on the screen.

A Recursive Procedure

Stored procedures support *recursion*, that is, they can call themselves. This is a powerful programming technique that is useful in performing repetitive tasks across hierarchical structures such as corporate organizations or mechanical parts. Look at the stored procedure, DEPT_BUDGET:

```
SHOW PROCEDURE DEPT_BUDGET;

Procedure text:
=======================================================================
DECLARE VARIABLE sumb DECIMAL(12, 2);
DECLARE VARIABLE rdno CHAR(3);
DECLARE VARIABLE cnt INTEGER;
BEGIN
   tot = 0;

SELECT BUDGET FROM DEPARTMENT WHERE DEPT_NO = :dno INTO :tot;

SELECT COUNT(BUDGET) FROM DEPARTMENT WHERE HEAD_DEPT = :dno INTO :cnt;

IF (cnt = 0) THEN
SUSPEND;

FOR SELECT DEPT_NO
FROM DEPARTMENT
WHERE HEAD_DEPT = :dno
INTO :rdno
DO
BEGIN
EXECUTE PROCEDURE DEPT_BUDGET :rdno RETURNING_VALUES :sumb;
   tot = tot + sumb;
END

SUSPEND;
END

=======================================================================
Parameters:
DNO INPUT CHAR(3)
TOT OUTPUT NUMERIC(15, 2)
```

This procedure takes as its input parameter a department number and returns the budget of the department and all departments under it in the corporate hierarchy. It uses *local variables* declared with DECLARE VARIABLE statements. These variables are only used within the context of the procedure.

First, the procedure retrieves from the DEPARTMENT table the budget of the department given as the input parameter and stores it in the variable, *tot*. Then it retrieves the number of departments reporting to that department using the COUNT() aggregate function. If there are no reporting departments, then it returns the value of *tot* with SUSPEND.

Using a FOR SELECT . . . DO loop, the procedure then retrieves the department number of each reporting department into the local variable, *rdno*, and then recursively calls itself with:

```
 EXECUTE PROCEDURE DEPT_BUDGET :rdno RETURNING_VALUES :sumb;
```

This statement executes DEPT_BUDGET with input parameter, *rdno*, and puts the output value in *sumb*. Notice that when using EXECUTE PROCEDURE within a procedure, the input parameters are not put in parentheses, and the variable into which to put the resultant output value is specified after the RETURNING_VALUES keyword. The value of *sumb* is then added to *tot*, to keep a running total of the budget. The result is that the procedure returns the total of the budgets of all the reporting departments given as the input parameter plus the budget of the department itself. Try it:

```
EXECUTE PROCEDURE DEPT_BUDGET(620);
```

The result is:

```
                  TOT
======================
           2550000.00
```

Notice that the procedure is defined to take a CHAR(3) as its input parameter, but that you can get away with giving it an integer (without quotes). This is because of automatic type conversion, a handy feature that will convert data types, where possible to the required data type. So the integer 620 is automatically converted to the character string “620”.

The automatic type conversion will not work for department number 000 because it will convert it to the string “0”, which is not a department number. Execute the procedure again with:

```
EXECUTE PROCEDURE DEPT_BUDGET("000");
```

This should give the same answer as the query:

```
SELECT TOTAL(BUDGET) FROM DEPARTMENT;
```

Can you figure out why?

There are a number of other procedures, some quite complex, defined in PROCS.SQL for the EMPLOYEE database. Now that you have a basic understanding of procedures, see if you can understand and use them.

PART 4

Server Manager

Part 4 describes the Local InterBase Server Manager, the graphical tool for InterBase database administration and monitoring.

Chapter 11: "Introduction to Server Manager" provides an overview of the Server Manager, describing what it can do, and its primary windows, menus, and dialog boxes.

Chapter 12: "Accessing a Database" describes how to log in to an InterBase server, connect to a database, add new users, and modify user information.

Chapter 13: "Maintaining a Database" describes how to perform database maintenance with the Server Manager, including shutting down and restarting a database, configuring database sweeping, managing transaction recovery, and validating a database.

Chapter 14: "Backing Up and Restoring a Database" describes how to do database backup and restoration with the Server Manager.

CHAPTER 11

Introduction to Server Manager

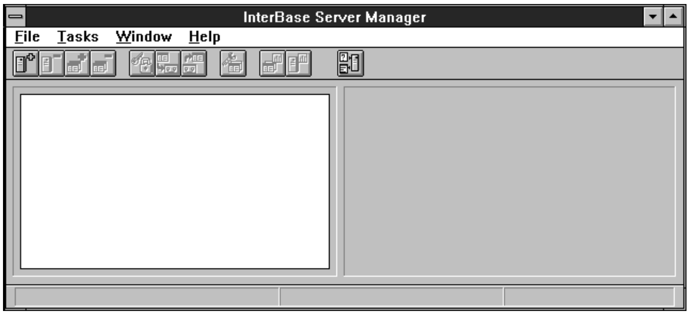
This chapter introduces the InterBase Server Manager, a Windows application for monitoring and administering InterBase 4.0 databases and servers. Server Manager runs on a Windows Client, but can manage databases on any server on the local network.

Server Manager enables you to:

- Manage server security.
- Back up and restore a database.
- Perform database maintenance, including:
  - Validating the integrity of a database.
  - Sweeping a database.
  - Recovering transactions that are “in limbo.”

The Server Manager Window

Start Server Manager by clicking on the Server Manager icon in the InterBase PC Client program group. The Server Manager window will then open:



This window consists of the:

- Menu bar, across the top of the window, containing commands you can choose to perform DBA tasks with Server Manager.
- SpeedBar, a row of shortcut buttons for menu commands, just below the menu bar.
- Server/database tree, displayed in the left side of the window below the SpeedBar, showing the local server's name and the databases to which Server Manager is currently connected.
- Summary information area, displayed in the right side of the window below the SpeedBar. This area displays information about the server or database, depending on which is selected in the server/database tree.
- Status line, that shows the current server and user login and flyover help for menus and the SpeedBar.

Server Manager Menus

The Server Manager menus are the basic way to perform tasks with Server Manager. There are four pull-down menus:

- File menu: enables you to log in to a server and log out, connect to a database, disconnect from a database, and exit Server Manager.
- Tasks menu: enables you to manage database security, perform backup and restoration, validate a database, open the database maintenance window, and start Windows ISQL.

- Window menu: enables you to close or minimize Server Manager windows.
- Help menu: provides online help.

SpeedBar

The SpeedBar is a row of buttons that are shortcuts for menu commands. The SpeedBar buttons are:

Server login: opens the login dialog box, enabling you to log in to a remote InterBase server. The local server is already connected.

Server logout: logout from the local server, and disconnect from any databases on that server to which you are currently connected.

Database connect: opens a dialog box, enabling you to connect to a database on the current server.

Database disconnect: disconnects Server Manager from the current database.

Configure users: opens the User Configuration dialog box for administering server security.

Database backup: opens the Database Backup dialog box.

Database restore: opens the Database Restore dialog box.

Database maintenance: opens the Database Maintenance window, which enables you to perform database maintenance tasks.

Start ISQL: opens the Interactive SQL Window, and automatically connects to the current database.

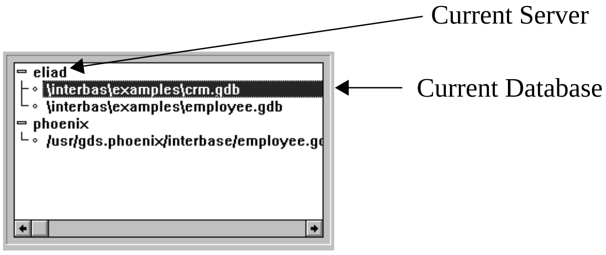
Server/Database Tree

When the Server Manager window initially opens, the only menu or SpeedBar commands available are Server Login, Windows ISQL, and Help. Once connected to a database, all other commands are enabled.

You can connect to a database by clicking on the Database Connect SpeedBar button or choosing File | Database Connect.... A dialog box will open enabling you to enter the file and directory path of a database.

Once connected to a server, the server name is displayed on the left side of the Server Manager window. This area is called the server/database tree.

If Server Manager is not connected to any database on a server, a small dot will be displayed to the left of the server name. After connecting to a database, a "-" will be displayed instead. Each database to which Server Manager is connected is displayed beneath the server on which it resides in an expandable and collapsible tree.


Current Server
Current Database
eliad
\interbas\examples\crm.gdb
\interbas\examples\employee.gdb
phoenix
/usr/gds.phoenix/interbase/employee.gd

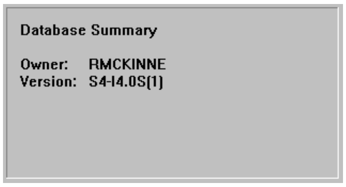
Click on the "-" next to a server name (or double-click on the server name) to collapse the database tree for the server, and then a "+" will be displayed instead.

Click on the "+" next to a server name (or double-click on the server name) to expand the tree and display the names of all databases on that server to which Server Manager is currently connected. The "+" will become a "-".

In an expanded tree, click on a database name to highlight it. The highlighted database will be the one upon which Server Manager operates, referred to as the *current database*. When a database is highlighted, the server on which the database resides becomes the *current server.* Any actions of Server Manager then affect that server.

Summary Information Area

The summary information area in the right side of the server manger window displays information about the server or database currently selected in the server/database tree.



Database Summary

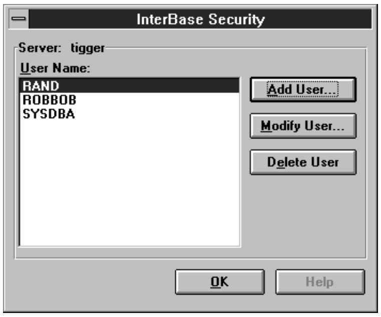
Owner: RMCKINNE
Version: S4-I4.0S(1)

Administering Security

Server Manager enables you to:

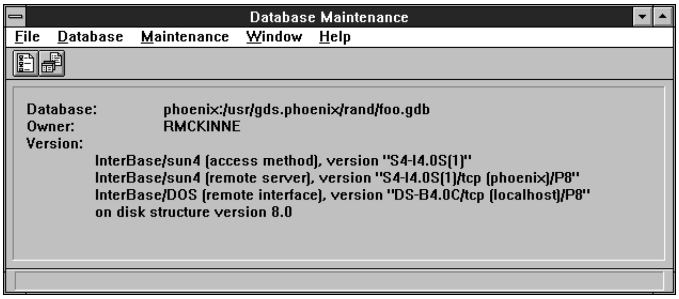
- View the list of authorized users for the server.
- Authorize new users.
- Modify user information (user name, password).
- Remove users' authorization.

To perform any of these tasks, you must log in to the server as SYSDBA with password masterkey and choose Tasks | Security.... The InterBase Security dialog box will then open:



The Database Maintenance Window

The other major window in the InterBase Server Manager is the Database Maintenance window. Open the Database Maintenance window by choosing Tasks | Database Maintenance... or by clicking on the Database Maintenance SpeedBar button.



```
Database:        phoenix:/usr/gds.phoenix/rand/foo.gdb
Owner:           RMCKINNE
Version:
           InterBase/sun4 (access method), version "S4-I4.0S(1)"
           InterBase/sun4 (remote server), version "S4-I4.0S(1)/tcp (phoenix)/P8"
           InterBase/DOS (remote interface), version "DS-B4.0C/tcp (localhost)/P8"
           on disk structure version 8.0
```

If a Database Maintenance window is open, and you choose Tasks | Database Maintenance... again, Server Manager will switch focus to the existing window rather than open a new one. This prevents conflicting changes to the database.

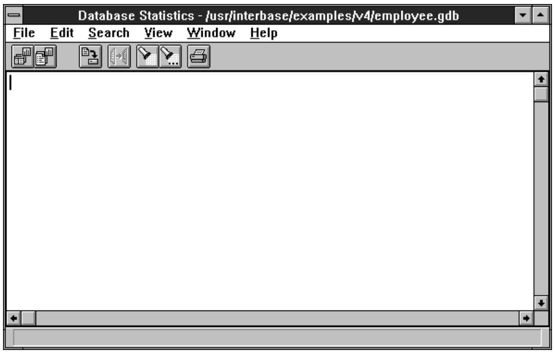
The Database Maintenance window has five pull-down menus:

- File menu: enables you to close the Database Maintenance window.
- Database menu: enables you to modify database properties.
- Maintenance menu: enables you to perform transaction recovery and an immediate database sweep.
- Window menu: enables you to switch focus to the main window.
- Help menu: provides online help.

Standard Text Display Window

The standard text display window is used to monitor database backup and restoration and to display database and lock manager statistics. Although these operations all display output in a standard text display window, each will have menu commands specific to the particular operation.

The standard text display window contains a menu bar, a SpeedBar with icons for often-used menu commands, and a scrolling text display area. Here is an example of a standard text display window:


Database Statistics - /usr/interbase/examples/v4/employee.gdb
File Edit Search View Window Help

The scrolling text area displays the information of interest: messages from database backup and restore.

The standard menus in this window are:

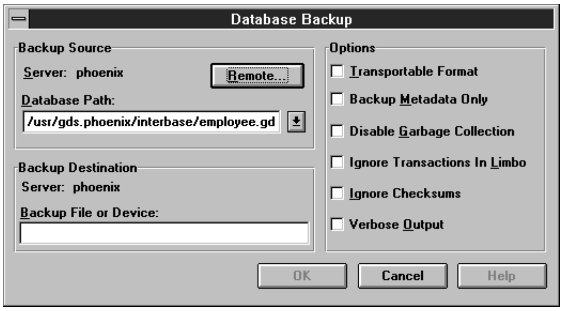
- File menu: enables you to save the contents of the scrolling text area to a file, or send it to a printer, and to close the window.

- Edit menu: enables you to copy selected text into the clipboard.
- Search menu: enables you find patterns in the scrolling text area.
- Window menu: enables you to switch back to the main Server Manager window.
- Help menu: provides online help.

The SpeedBar buttons are shortcuts for often-used menu commands. The function of each button is shown at the bottom of the window when the mouse cursor is over the button.

Database Backup and Restoration

Server Manager enables you to back up a database to a file or storage device and restore a database from a file or storage device. To perform a backup, choose Tasks | Backup in the Server Manager window. The Database Backup dialog box will appear:



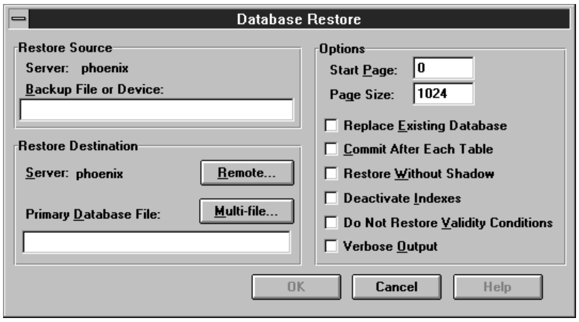
Server: phoenix
Database Path: /usr/gds.phoenix/interbase/employee.gd

Server: phoenix
Backup File or Device:

☐ Transportable Format
☐ Backup Metadata Only
☐ Disable Garbage Collection
☐ Ignore Transactions In Limbo
☐ Ignore Checksums
☐ Verbose Output

After entering the necessary information, choosing the desired options, and clicking on OK, a standard text display window will appear, displaying information about the backup process as it occurs.

To restore a database, choose Tasks | Restore... in the Server Manager window. The Database Restore dialog box will then appear:

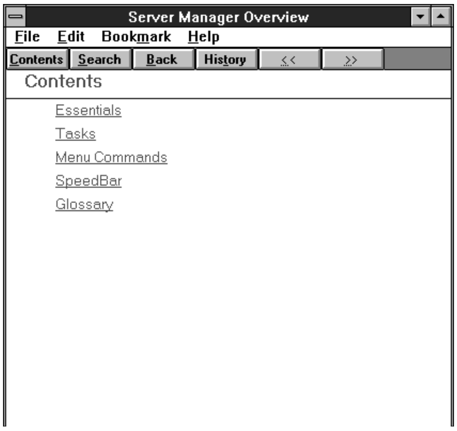


After entering the necessary information, choosing the desired options, and clicking on OK, a standard text display window will appear, displaying information about the restore process as it occurs.

For more information on database backup and restoration, see Chapter 14: “Backing Up and Restoring a Database.”

Using Online Help

Invoke the online help system by choosing a topic from the Help menu or clicking on a Help button in a dialog box. The help topic appropriate for the current context will appear. All help topics are accessible through the Help Contents:



For instructions on using the online help system, choose Help | Using Help.

CHAPTER 12

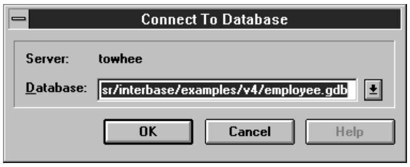
Accessing a Database

Before performing any database administration tasks, you must first connect to a database. You may switch context from one connected database to another by choosing the desired database in the database/server tree.

Connecting to a Database

Connect to a database by clicking on the Database Connect SpeedBar button or choosing File | Database Connect....

The Connect to Database dialog box will then appear:



Server: towhee

Database: sr/interbase/examples/v4/employee.gdb

The last database connected to will be shown in the Database text field. Click on the arrow to the right of the text field for a drop down list and select a database from the list, or enter the full pathname for a different database name. Choose OK to connect to that database.

If you enter a different name, Server Manager saves the last ten databases to which it connected in the WINDOWS\INTERBAS.INI file. The database file name and path must be appropriate; for example, C:\INTERBAS\MYDB.GDB.

After connecting to a database, the Server Manager SpeedBar and menus will be active, and any actions you take will apply to the selected database.

CHAPTER 13

Maintaining a Database

Database maintenance tasks include:

- Configuring database properties.
- Managing transaction recovery.
- Performing a database sweep.
- Validating and repairing a database.

Server Manager must be logged in to a server and connected to a database before performing any of these operations. All of these tasks are performed from the Database Maintenance Window except for validation, which is peformed from the Server Manager window.

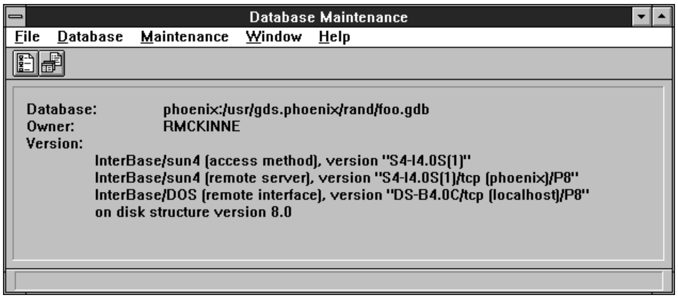
The Database Maintenance Window

To perform database maintenance, first choose a database by:

- Clicking the "+" to the left of a server name in the server/database tree, if necessary, to display all databases to which Server Manager is connected on that server.
- Clicking on the name of the desired database in the server/database tree, leaving it highlighted in reverse video.

This database is then the *current database*, and all Server Manager actions apply to it.

You can then click the Database Maintenance SpeedBar button or choose Tasks | Database Maintenance... to open the Database Maintenance window:



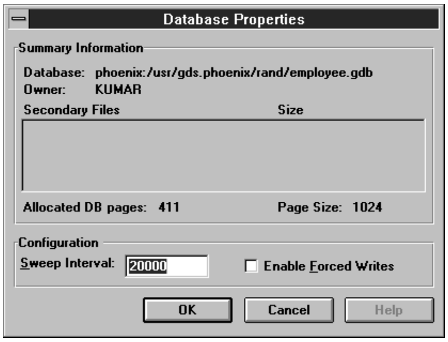
```
Database:       phoenix:/usr/gds.phoenix/rand/foo.gdb
Owner:          RMCKINNE
Version:
        InterBase/sun4 (access method), version "S4-I4.0S(1)"
        InterBase/sun4 (remote server), version "S4-I4.0S(1)/tcp (phoenix)/P8"
        InterBase/DOS (remote interface), version "DS-B4.0C/tcp (localhost)/P8"
        on disk structure version 8.0
```

The name of the current database and its owner are displayed at the top of the window, along with the versions of the InterBase server, client, and access method.

You can open a Database Maintenance window for each database to which Server Manager is connected. You can copy text from one Database Maintenance window and paste it into another to duplicate values between databases.

Configuring Database Properties

To view and configure database properties, choose Database | Properties... from the menu bar in the Database Maintenance window or click on the Database Properties SpeedBar button. The Database Properties dialog box will then appear:



Database: phoenix:/usr/gds.phoenix/rand/employee.gdb
Owner: KUMAR
Secondary Files   Size
Allocated DB pages: 411   Page Size: 1024

Sweep Interval: 20000   ☐ Enable Forced Writes

This dialog box contains a Summary Information area that displays properties but does not allow modification of them and a Configuration area that does allow modification of the parameters.

The Summary Information area displays:

- Database name.
- User name of the database owner.
- Database Page Size.
- Number of allocated pages.
- Secondary file names and sizes.

The configuration area displays and allows modification of:

- Sweep interval.
- Enabling of forced writes.

Adjusting Database Sweeping

Sweeping a database is a systematic way of removing outdated records from the database. Periodic sweeping prevents a database from growing too large. However, sweeping can also slow system performance.

Overview of Sweeping

InterBase uses a multi-generational architecture. This means that multiple versions of data records are stored directly on the data pages. When a record is updated or deleted, InterBase keeps a copy of the old state of the record and creates a new version. This can increase the size of a database.

To limit the growth of the database, InterBase performs *garbage collection*, which frees up space allocated to outdated versions of a record. Whenever a transaction accesses a record, outdated versions are garbage collected. Records that were rolled back are ignored by typical transactions and will not be garbage collected. To guarantee that all records are garbage collected, including those that were rolled back, InterBase periodically "sweeps" the database.

Sweeping in the Local InterBase Server is done through a dialog box which pops up at a preconfigured interval. The dialog will ask if you want to perform a sweep immediately. If you answer yes, the sweep will start. If you answer no, the server will wait for the preconfigured interval again.

Note Periodic sweeping is necessary and recommended. If sweeps are not made, old record versions will take up space and system memory.

When sweeping a database, InterBase reads every record in the database. This forces garbage collection of outdated record versions as well as rolled back records.

Tip Sweeping a database is not the only way to perform systematic garbage collection. Backing up a database achieves the same result because InterBase must read every record, an action that forces garbage collection throughout the database. As a result, regularly backing up and restoring a database can reduce the need to sweep. This enables you to maintain better application performance. For more information about the advantages of backing up and restoring, see Chapter 14: "Backing Up and Restoring a Database."

You can sweep a database immediately by using the Maintenance | Database Sweep menu command.

Controlling Performance of Forced Writes

When InterBase performs *forced writes* (also referred to as synchronous writes), it physically writes data to disk whenever the database performs an (internal) write operation.

If forced writes are not enabled, then even though InterBase performs a write, the data may not be physically written to disk, because operating systems buffer disk writes. If there is a system failure before the data is written to disk, then information can be lost.

Performing forced writes ensures data integrity and safety, but will slow performance. In particular, operations which involve data modification will be slower.

When forced writes are enabled an "X" appears in the box labeled "Enable Forced Writes" in the Database Properties dialog box. To disable forced writes, click on the check box to remove the "X".

Caution If forced writes are enabled for a database, then the database will be subject to data loss if there is a hardware or other system failure. In general, it is best to have this feature active.

Two-phase Commit and Transaction Recovery

When committing a transaction that spans multiple databases, InterBase automatically performs a two-phase commit. A *two-phase commit* guarantees that the transaction updates either all of the databases involved or none of them—data is never partially updated.

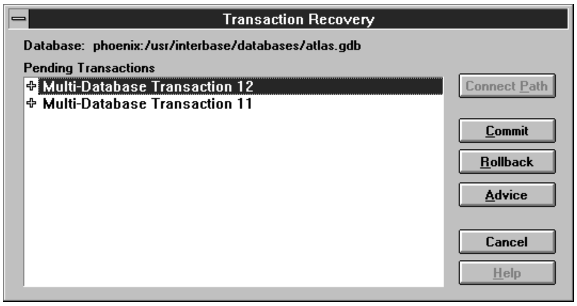
In the first phase of a two-phase commit, InterBase prepares each database for the commit by writing the changes from each *subtransaction* to the database. A subtransaction is the part of a multi-database transaction that involves only one database. In the second phase, InterBase marks each subtransaction as committed in the order that it was prepared.

If a two-phase commit fails during the second phase, some subtransactions will be committed and others will not be. A two-phase commit can fail if a network interruption or disk crash makes one or more databases unavailable. Failure of a two-phase commit causes *limbo transactions*, transactions that the server does not know whether to commit or roll back.

It is possible that a limbo transaction will make some records in a database inaccessible. To correct this, you must recover the transaction using Server Manager. *Recovering* a limbo transaction means committing it or rolling it back.

Recovering Transactions

To recover limbo transactions, choose Maintenance | Transaction Recovery... in the Database Maintenance window. A dialog box will then display a list of limbo transactions that can then be operated upon to recover—that is, to commit or roll back:


Transaction Recovery

Database: phoenix:/usr/interbase/databases/atlas.gdb

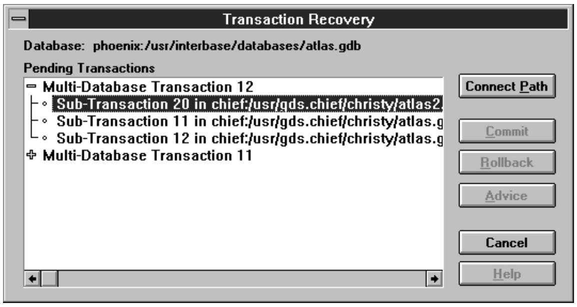
Pending Transactions

+ Multi-Database Transaction 12

+ Multi-Database Transaction 11

All the pending transactions in the database are listed in the scrolling area on the left side of the dialog box. Click on the “+” to display all the subtransactions of a transaction.

It is also possible to have a single database transaction that has been prepared and not committed. These transactions are displayed with a bullet to the left of the transaction. You can roll back or commit such transactions.

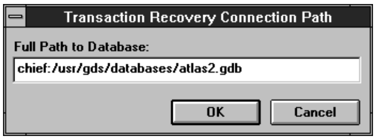


Database: phoenix:/usr/interbase/databases/atlas.gdb

Pending Transactions

```
⊟ Multi-Database Transaction 12
├∘ Sub-Transaction 20 in chief:/usr/gds.chief/christy/atlas2.
├∘ Sub-Transaction 11 in chief:/usr/gds.chief/christy/atlas.g
└∘ Sub-Transaction 12 in chief:/usr/gds.chief/christy/atlas.g
⊞ Multi-Database Transaction 11
```

You can change the path of the database specified by each subtransaction by choosing Connect Path. The following dialog box will appear:



Full Path to Database: chief:/usr/gds/databases/atlas2.gdb

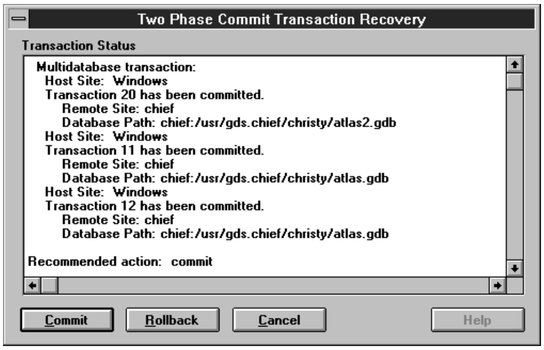
Enter the directory path of the other database involved in the subtransaction, then choose OK.

The information on the path to the database was stored when the client application attempted the commit. Before attempting to roll back or commit any transaction, confirm the path of all involved databases is correct.

You can choose to either commit or roll back each transaction. To commit or roll back, select the desired transaction ID from the list and choose either Commit or Rollback.

Note Only entire transactions can be recovered, so the commit and rollback buttons will only be enabled when the main transaction is selected. They will be disabled when a subtransaction is selected.

You can also seek advice by choosing the Advice button. This dialog box will open:



```
Multidatabase transaction:
  Host Site:  Windows
  Transaction 20 has been committed.
      Remote Site: chief
      Database Path: chief:/usr/gds.chief/christy/atlas2.gdb
  Host Site:  Windows
  Transaction 11 has been committed.
      Remote Site: chief
      Database Path: chief:/usr/gds.chief/christy/atlas.gdb
  Host Site:  Windows
  Transaction 12 has been committed.
      Remote Site: chief
      Database Path: chief:/usr/gds.chief/christy/atlas.gdb

Recommended action:  commit
```

This dialog box will display information on each subtransaction: whether it has been committed, the remote server name, and database name. At the bottom, an action will be recommended: either commit or roll back.

Server Manager analyzes the state of subtransactions by determining when the two-phase commit failed. If the first transactions are in limbo but later transactions are not, Server Manager assumes that the prepare phase did not complete. In this case, you are prompted to do a rollback.

Performing an Immediate Database Sweep

To perform a database sweep, choose Maintenance | Database Sweep from the menu bar in the Database Maintenance window.

This operation runs an immediate sweep of the database, releasing space held by records which were rolled back and by out-of-date record versions. Sweeps are also done automatically at a specified interval; see "Adjusting Database Sweeping," in this chapter.

Important Sweeping a database does not require it to be shut down. You can perform sweeping at any time, but it can impact system performance and should be done when it will least affect users.

Validating and Repairing a Database

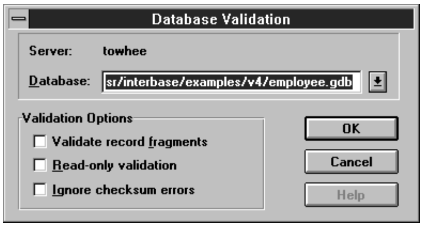
In day-to-day operation, a database is sometimes subjected to events that pose minor problems to database structures. These events include:

- Abnormal termination of a database application. This does not affect the integrity of the database. When an application is canceled, committed data is preserved, and uncommitted changes are rolled back. If InterBase has already assigned a data page for the uncommitted changes, the page might be considered an *orphan page*. Orphan pages are unassigned disk space that should be returned to free space.
- Write errors in the operating system or hardware. These usually create a problem with database integrity. Write errors can result in "broken" or "lost" data structures, such as a database page or index. These corrupt data structures can make committed data unrecoverable.

You should validate a database:

- Whenever a database backup is unsuccessful.
- Whenever an application receives a "corrupt database" error.
- Periodically, to monitor for corrupt data structures or misallocated space.
- Any time you suspect data corruption.

To validate a database, choose Tasks | Database Validation... in the Server Manager window. The following dialog box will open:


Database Validation

Server: towhee

Database: sr/interbase/examples/v4/employee.gdb

Validation Options
- ☐ Validate record fragments
- ☐ Read-only validation
- ☐ Ignore checksum errors

The name of the current database is displayed in the Database text field. Because there are some conditions such as a checksum error that will make it impossible to connect to a database, it is not necessary to connect to the database before performing a validation. If Server Manager is not connected to the database, you can enter the desired database name in the Database text field or select it from the drop down list by clicking on the arrow to the right of the field.

When Server Manager validates a database it verifies the integrity of data structures. Specifically, it will:

- Report corrupt data structures.
- Report misallocated data pages.
- Return orphan pages to free space.

Validation Options

You can select three options with Database Validation:

- Validate record fragments
- Read-only validation
- Ignore checksum errors

By default, database validation reports and releases only page structures. When you select the Validate record fragments option, validation reports and releases record structures as well as page structures.

By default, validating a database updates it, if necessary. To prevent updating, select the Read-only validation option.

Handling Checksum Errors

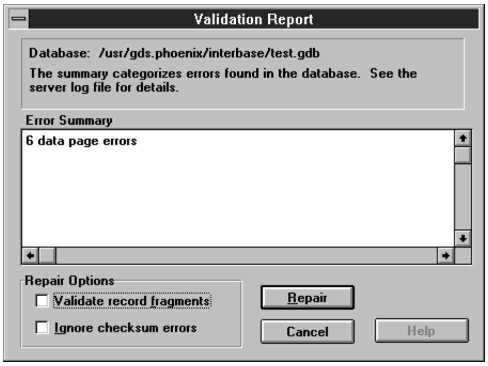
A checksum is a page-by-page analysis of data to verify its integrity. A bad checksum means that a database page has been randomly overwritten (for example, due to a system crash).

Checksum errors indicate data corruption. To repair a database that reports checksum errors, select the Ignore checksum errors option. This option enables Server Manager to ignore checksums when validating a database. Ignoring checksums allows successful validation of a corrupt database, but the affected data may be lost.

Caution Even if you can restore a mended database that reported checksum errors, the extent of data loss may be difficult to determine. If this is a concern, you may want to locate an earlier backup copy and restore the database from it.

Repairing a Corrupt Database

If a database contains errors, the following dialog box will open:



Database: /usr/gds.phoenix/interbase/test.gdb

The summary categorizes errors found in the database. See the server log file for details.

6 data page errors

The errors encountered are summarized in the Error Summary area. The repair options you selected in the Database Validation dialog box will be selected in this dialog box also.

To repair the database, choose Repair. This will fix problems that cause records to be corrupt and mark corrupt structures. In subsequent operations (such as backing up), InterBase ignores the marked records.

Note Some corruptions are too serious for Server Manager to correct. These include corruptions to certain strategic structures, such as space allocation pages. In addition, Server Manager cannot fix certain checksum errors that are random by nature and not specifically associated with InterBase.

If you suspect you have a corrupt database, perform the following steps:

1. Make a copy of the database using an operating-system command. Do not use the InterBase Backup utility, because it cannot back up a database containing corrupt data.
2. Repair the copy database to mark corrupt structures. If Server Manager reports any checksum errors, validate and repair the database again, choosing the Ignore checksum errors option. It may be necessary to validate a database multiple times to correct all the errors.
3. Validate the database again, with the Read-only validation option selected. Note that free pages are no longer reported, and broken records are marked as damaged. Any records marked during repair are ignored when the database is backed up.
4. Back up the mended database with Server Manager. At this point, any damaged records are lost, because they were not included during the

back up. For more information about database backup, see Chapter 14: “Backing Up and Restoring a Database.”

5. Restore the database to rebuild indexes and other database structures. The restored database should now be free of corruption.

6. Verify that restoring the database fixed the problem by validating the restored database with the Read-only validation option.

CHAPTER 14

Backing Up and Restoring a Database

A database *backup* saves a database to a file on a hard disk or other storage medium. To protect a database from power failure, disk crashes, or other potential data loss, you should regularly back up the database. For additional safety, it is recommended to store the backup medium in a different physical location from the database server.

A database *restore* re-creates a database from a backup file.

Using the Backup and Restore Utilities

Operating systems usually include facilities to archive database files. Server Manager offers several advantages over such facilities, including:

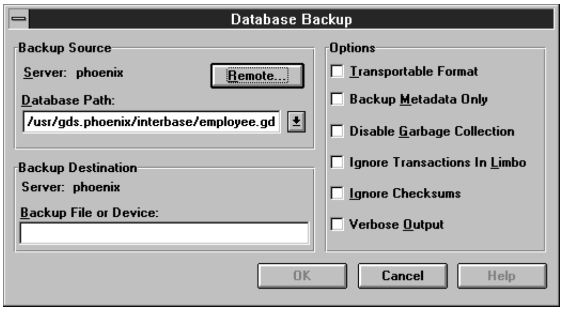
- Database performance can be improved. Backing up and restoring a database garbage-collects outdated records and balances indexes. The process also frees space occupied by deleted records and packs the remaining data, reducing database size. When you restore, you have the option of changing the database page size or distributing the database among multiple files or disks.
- Backups can run concurrently with other users. You need not shut down the database to run a back up. However, any data changes that occur after the back up begins are not recorded in the backup file. After you create a database backup, you can include it as part of a regular system backup.
- Multi-file databases are never partially backed up. If a database spans multiple files, Server Manager backs up either all the files or none.
- Data can be transferred to another operating system. Different computers have their own database file formats and therefore databases cannot simply be copied to a platform with a different operating system. If

desired, you can also make a backup in a generic format called a *transportable* backup that allows restoration to a server on a different operating system. Making transportable backups is highly recommended in heterogeneous environments.

Backing Up a Database

The database being backed up is referred to as the *source.* The file or device to which the database is being backed up is called the *destination* or *target*.

To back up a database, choose Tasks | Backup... from the Server Manager window. The Database Backup dialog box appears:



Backup Source
Server: phoenix
Database Path: /usr/gds.phoenix/interbase/employee.gd

Backup Destination
Server: phoenix
Backup File or Device:

Options
☐ Transportable Format
☐ Backup Metadata Only
☐ Disable Garbage Collection
☐ Ignore Transactions In Limbo
☐ Ignore Checksums
☐ Verbose Output

This dialog box enables you to back up a database to a file or device. To perform a backup:

- Type the name of the source database (including path) in the Database Path text field in the Backup Source area. By default, the database to which Server Manager is currently connected is displayed. Other databases previously connected to can be displayed by clicking on the dropdown button to the right of the text field. To choose another database, select it from the list or type it in the text field.
- Type the name of the destination file or device in the text field in the lower left of the dialog box.
- Select the desired backup options, then choose OK to start the backup timer.

Server Manager will open a standard text display window to display status and any messages during the backup process.

Note Database files and backup files can have any name that is legal on the operating system; the .GDB and .GBK file extensions are InterBase conventions only.

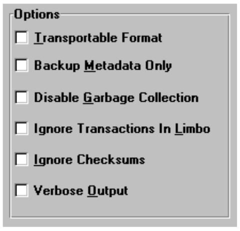
When creating a backup file, Server Manager stores the database as one file. You cannot split a large database among multiple backup files. A backup file will typically occupy less space than the database because it includes only the current version of data and incurs less overhead for data storage.

If you specify a backup file that already exists, Server Manager overwrites it. To avoid overwriting, specify a unique name for the backup file.

If a database spans multiple files, specify only the first file (the *primary* file) as the source. Server Manager uses the header page of each file to locate additional files, so the entire database can be backed up based on the primary file.

Backup Options

The backup options are indicated by check boxes on the right side of the Database Backup dialog box. If a check box has an "X" inside, then the option is selected. If the box is empty, the option is not selected.



Transportable Format

To move a database to a machine with a different operating system from the machine on which the backup was performed, check the Transportable Format option. This option writes data in a generic format, enabling you to restore to any machine that supports InterBase.

To make a transportable backup:

1. Back up the database using transportable format by selecting the Transportable Format option in the Database Backup dialog box.
2. If you backed up to a removable medium, proceed to Step 3. If you created a backup file, use operating-system commands to copy the file to

tape, then load the contents of the tape onto another machine. Or copy it across a network to the other machine.

3. On the destination machine, restore the backup file. If restoring from a removable medium, such as tape, specify the device name instead of the backup file.

Back Up Metadata Only

When backing up a database, you can exclude its data, saving only its metadata. You might want to do this to:

- Retain a record of the metadata before it is modified.
- Create an empty copy of the database. The copy will have the same metadata but can be populated with different data.

To back up metadata only, select the Back Up Metadata Only option.

You can also extract a database's metadata using Windows ISQL. ISQL produces an SQL data definition (text) file containing SQL commands. Server Manager creates a backup file containing metadata only.

Disable Garbage Collection

By default, Server Manager performs garbage collection during backup. To prevent garbage collection during a backup, select the Disable Garbage Collection option.

Garbage collection physically erases old versions of records from disk. Generally, you will want Server Manager to perform garbage collection during backup.

You might not want to perform garbage collection during backup if there is data corruption in old record versions and you want to prevent InterBase from visiting those records during a backup.

Ignore Transactions in Limbo

To ignore limbo transactions during backup, select the Ignore Transactions in Limbo option.

When Server Manager ignores limbo transactions during backup, it ignores all record versions created by any limbo transaction, finds the most recently committed version of a record, and backs up that version.

Limbo transactions are usually caused by the failure of a two-phase commit. They can also exist due to system failure or when a single-database transaction is prepared.

Before backing up a database that contains limbo transactions, it is a good idea to perform transaction recovery, by choosing Maintenance | Transaction Recovery... in the Database Maintenance window.

Ignore Checksums

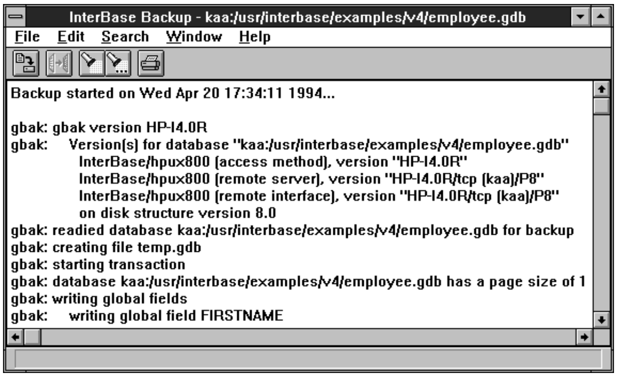
To ignore checksums during backup, select the Ignore Checksums option.

A checksum is a page-by-page analysis of data to verify its integrity. A bad checksum means that a data page has been randomly overwritten; for example, due to a system crash.

Checksum errors indicate data corruption, and InterBase normally prevents you from backing up a database if bad checksums are detected. Examine the data the next time you restore the database.

Verbose Output

To monitor the backup process as it runs, select the Verbose Output option. This option opens a standard text display window to display status messages on the screen. For example:


InterBase Backup - kaa:/usr/interbase/examples/v4/employee.gdb
File Edit Search Window Help

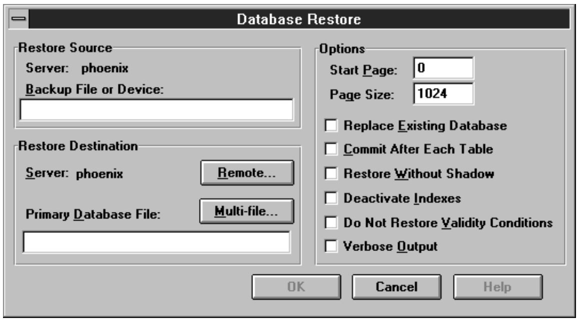
```
Backup started on Wed Apr 20 17:34:11 1994...

gbak: gbak version HP-I4.0R
gbak:    Version(s) for database "kaa:/usr/interbase/examples/v4/employee.gdb"
            InterBase/hpux800 (access method), version "HP-I4.0R"
            InterBase/hpux800 (remote server), version "HP-I4.0R/tcp (kaa)/P8"
            InterBase/hpux800 (remote interface), version "HP-I4.0R/tcp (kaa)/P8"
            on disk structure version 8.0
gbak: readied database kaa:/usr/interbase/examples/v4/employee.gdb for backup
gbak: creating file temp.gdb
gbak: starting transaction
gbak: database kaa:/usr/interbase/examples/v4/employee.gdb has a page size of 1
gbak: writing global fields
gbak:    writing global field FIRSTNAME
```

By default, the backup window displays the time that the backup process starts, the time it ends, and any error messages.

The standard text display window enables you to search for specific text, save the text to a file, and print the text. For an explanation of how to use the standard text display window, see Chapter 11: “Introduction to Server Manager.”

Restoring a Database

To restore a database, choose Tasks | Restore... in the Server Manager window. The Database Restore dialog box will then appear:



Restore Source
Server: phoenix
Backup File or Device:

Restore Destination
Server: phoenix
Primary Database File:

Options
Start Page: 0
Page Size: 1024
☐ Replace Existing Database
☐ Commit After Each Table
☐ Restore Without Shadow
☐ Deactivate Indexes
☐ Do Not Restore Validity Conditions
☐ Verbose Output

This dialog box enables you to restore a database from a previously created backup file on the current server.

The backup file from which the database is being restored is called the *source*. The database being restored is called the *destination* or *target*.

To restore a database:

- Type the name of the source file or device on the current server in the Backup File or Device text field.

  To restore a database to more than one database file, click on the Multi-file button.... For more information about restoring to multiple database files, see "Restoring to Multiple Files," in this chapter.

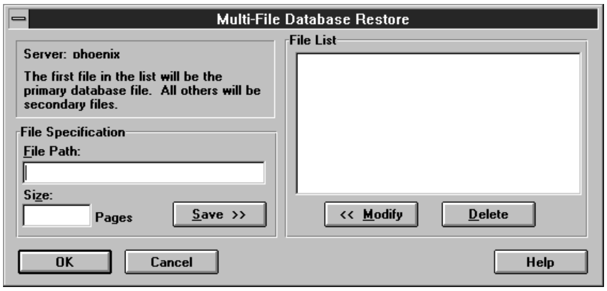
- Type the name (including directory path) of the database to restore to in the Primary Database File text field.
- Type the page on which to start the restore in the Start Page field, and the page size, in bytes, in the Page Size text field. Typically, the starting page will be zero (0).
- Select the desired restore options, and choose OK to begin the restore.

Typically, a restored database occupies less disk space than it did before being backed up, but disk space requirements could change if the on-disk structure version changes. For information about the ODS, see "Upgrading to a New On-disk Structure," in this chapter.

Restoring to Multiple Files

You might want to restore a database to multiple files to distribute it among different disks, which provides more flexibility in allocating system resources.

To restore a database to multiple database files, click on the Multi-file button in the Database Restore dialog box. The following dialog box opens:


Multi-File Database Restore
Server: phoenix
The first file in the list will be the primary database file. All others will be secondary files.
File Specification
File Path:
Size:
Pages
Save >>
File List
<< Modify
Delete
OK
Cancel
Help

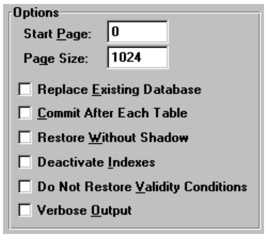
To specify the database files to restore to, type the file name in the File Path text field and then type the number of pages for that file in the text field below it. The minimum number of pages in a file is 200. Choose Save, and the file name will appear in the File List on the right side of the dialog box.

To modify one of the files in the list, select it and choose Modify. The selected file name will appear in the File Path text field, where you can edit it, and the associated number of pages will appear in the Pages text field. To delete a file, select it in the File List and choose the Delete button.

After entering all the names of the database files to restore to, choose OK to return to the Database Restore dialog box.

Restore Options

The restore options are shown in check boxes on the right side of the Database Restore dialog box. If a check box has an “X” inside, then the option is selected. If the box is empty, the option is not selected.



Options
Start Page: 0
Page Size: 1024
☐ Replace Existing Database
☐ Commit After Each Table
☐ Restore Without Shadow
☐ Deactivate Indexes
☐ Do Not Restore Validity Conditions
☐ Verbose Output

Start Page

The Start Page is the page on which to start the restore. In most cases, this should be left as the default, zero.

Page Size

InterBase supports database page sizes of 1024, 2048, 4096, and 8192 bytes. The default is 1024 bytes. To change page size, back up the database and then restore it, modifying the Page Size field in the Database Restore dialog box.

Changing the page size can improve performance for the following reasons:

- Storing and retrieving BLOB data is most efficient when the entire BLOB fits on a single database page. If an application stores many BLOBs exceeding 1K, using a larger page size reduces the time for accessing BLOB data.
- InterBase performs better if rows do not span pages. If a database contains long rows of data, consider increasing the page size.
- If a database has a large index, increasing the database page size reduces the number of levels in the index hierarchy. Indexes work faster if their depth is kept to a minimum. Choose Tasks | Database Statistics to display index statistics, and consider increasing the page size if index depth is greater than two on any frequently used index.
- If most transactions involve only a few rows of data, a smaller page size may be appropriate, because less data needs to be passed back and forth and less memory is used by the disk cache.

Replace Existing Database

Server Manager will not overwrite an existing database file unless the Replace Existing Database option is selected. If you attempt to restore to an existing database name, and this option is not selected, the restore will fail.

Caution Replacing an existing database is discouraged. When restoring to an existing file name, a safer approach is to rename the existing database file, restore the database, then drop or archive the old database as needed.

Commit After Each Table

Normally, Server Manager restores all metadata before restoring any data. If you select the Commit After Each Table option, Server Manager restores the metadata and data for each table together, committing one table at a time.

This option is useful when you are having trouble restoring a backup file; for example, if the data is corrupt or invalid according to integrity constraints.

If you have a problem backup file, restoring the database one table at a time lets you recover some of the data intact. You can restore only the tables that precede the bad data; restoration fails the moment it encounters bad data.

Deactivate Indexes

Normally, InterBase rebuilds indexes when a database is restored. If the database contained duplicate values in a unique index when it was backed up, restoration will fail. Duplicate values can be introduced into a database if indexes were temporarily made inactive (for example, to allow insertion of many records or to rebalance an index).

To enable restoration to succeed in this case, select the Deactivate Indexes option. This makes indexes inactive and prevents them from rebuilding. Then eliminate the duplicate index values, and re-activate indexes through ALTER INDEX in Windows ISQL.

A unique index cannot be activated using the ALTER INDEX statement; a unique index must be dropped and then created again. For more information about activating indexes, see the *Language Reference*.

Note The Deactivate Indexes option is also useful for bringing a database online more quickly. Data access will be slower until indexes are rebuilt, but the database is available. After the database is restored, users can access it while indexes are reactivated.

Do Not Restore Validity Conditions

If you redefine validity constraints in a database where data is already entered, your data might no longer satisfy the validity constraints. You might not discover this until you try to restore the database, at which time an error message about invalid data appears.

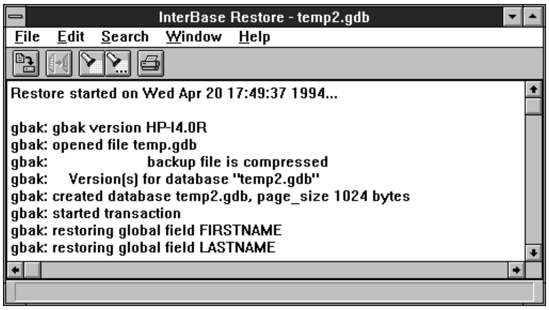
Caution Always make a copy of metadata before redefining it; for example, by extracting it using Windows ISQL.

To restore a database that contains invalid data, select the Do Not Restore Validity Conditions option. This option deletes validity constraints from the metadata. After the database is restored, change the data to make it valid according to the new integrity constraints. Then add back the constraints that were deleted.

This option is also useful if you plan to redefine the validity conditions after restoring the database. If you do so, thoroughly test the data after redefining any validity constraints.

Verbose Output

To monitor the restore process as it runs, select the Verbose Output option. This option will open a standard text display window to display status messages on the screen. For example:



```
Restore started on Wed Apr 20 17:49:37 1994...

gbak: gbak version HP-I4.0R
gbak: opened file temp.gdb
gbak:                  backup file is compressed
gbak:    Version(s) for database "temp2.gdb"
gbak: created database temp2.gdb, page_size 1024 bytes
gbak: started transaction
gbak: restoring global field FIRSTNAME
gbak: restoring global field LASTNAME
```

The standard text display window enables you to search for specific text, save the text to a file, and print the text. For an explanation of how to use the standard text display window, see Chapter 11: “Introduction to Server Manager.”

Upgrading to a New On-disk Structure

New major releases of the InterBase server often contain changes to the on-disk structure (ODS). If the ODS has changed, and you want to take advantage of any new InterBase features, upgrade your databases to the new ODS.

You need not upgrade databases to use a new version of InterBase. The new versions can still access databases created with a previous version, but cannot take advantage of any new InterBase features.

To upgrade existing databases to a new ODS, perform the following steps:

1. Before installing the new version of InterBase, back up databases using the old version.
2. Install the new version of the InterBase server as described in *Installing and Running InterBase* for the platform.
3. Once the new version is installed, restore the databases with the new version of InterBase.

The restored databases will be able to use any new InterBase server features.

Appendix A

Error Messages

This appendix lists the error messages generated by the Server Manager during database backup and restoration. Along with the text of each error message is a suggested action to correct the problem.

Table A-1: Server Manager Error Messages

Error Message	**Causes and Suggested Actions to Take**
Array dimension for column <*string*> is invalid	Fix the array definition before backing up.
Bad attribute for RDB$CHARACTER_SETS	An incompatible character set is in use.
Bad attribute for RDB$COLLATIONS	Fix the attribute in the named system table.
Bad attribute for table constraint	Check integrity constraints; if restoring, consider using the “no validity” option to delete validity constraints.
Blocking factor parameter missing	Supply a numeric argument for “factor” option.
Cannot commit files	Database may contain corruption, or metadata may violate integrity constraints. Try restoring tables using “one at a time” option, or delete validity constraints using “no validity” option.
Cannot commit index <*string*>	Data may conflict with defined indexes. Try restoring using “inactive” option to prevent rebuilding indexes.
Cannot find column for BLOB	
Cannot find table <*string*>	
Cannot open backup file <*string*>	Correct the file name you supplied and try again.
Cannot open status and error output file <*string*>	Messages are being redirected to invalid file name. Check format of file or access permissions on the directory of output file.
Column <*string*> used in index <*string*> seems to have vanished	An index references a non-existent column. Check either the index definition or column definition.
Commit failed on table <*string*>	Data corruption or violation of integrity constraint in the specified table. Check metadata or restore “one table at a time.”

Table A-1: Server Manager Error Messages (Continued)

Error Message	Causes and Suggested Actions to Take
Could not drop database *<string>* (database might be in use)	You used the Replace Existing Database option in restoring a file to an existing database, but the database is in use. Either rename the target database or wait until it is not in use.
Could not open file name *<string>*	Fix the file name and re-execute command.
Could not read from file *<string>*	Fix the file name and re-execute command.
Could not write to file *<string>*	Fix the file name and re-execute command.
Data type *n* not understood	An illegal data type is being specified.
Database format *n* is too old to restore to	The server version is incompatible with the version of the database.
Database *<string>* already exists. To replace it, use the -R switch	The target database for restoration already exists. Either rename the target database or use the Replace Existing Database option.
Do not recognize record type *n*	
Do not recognize *<string>* attribute *n* -- continuing	
Do not understand BLOB INFO item *n*	
Error accessing BLOB column *<string>* -- continuing	
ERROR: Backup incomplete	The backup cannot be written to the target device or file system. Either there is insufficient space, a hardware write problem, or data corruption.
Error committing metadata for table *<string>*	A table within the database may be corrupt. If restoring a database, try using the "Commit After Each Table" option to isolate the table.
Exiting before completion due to errors	This message accompanies other error messages and indicates that back up or restore could not execute. Check other error messages for the cause.
Expected array dimension *m* but instead found *n*	The problem array may need to be redefined.
Expected array version number *m* but found *n*	The problem array may need to be redefined.
Expected backup database *<string>*, found *<string>*	Check the name of the backup file being restored.
Expected backup description record	
Expected backup start time *<string>*, found *<string>*	
Expected backup version 1, 2, or 3. Found *n*	
Expected data attribute	
Expected database description record	
Expected number of bytes to be skipped, encountered *<string>*	

Table A-1: Server Manager Error Messages (Continued)

Error Message	**Causes and Suggested Actions to Take**
Expected record length	
Expected volume number *m*, found volume *n*	When backing up or restoring with multiple tapes, be sure to specify the correct volume number.
Expected XDR record length	
Failed in put_blr_gen_id	
Failed in store_blr_gen_id	
Failed to create database *<string>*	The target database specified is invalid. It may already exist.
Index *<string>* omitted because *m* of the expected *n* keys were found	
Input and output have the same name. Disallowed.	A backup file and database must have unique names. Correct the names and try again.
Length given for initial file (*m*) is less than minimum (*n*)	In restoring a database into multiple files, the primary file was not allocated sufficient space. InterBase automatically increases the page length to the minimum value. No action necessary.
Missing parameter for the number of bytes to be skipped	
Multiple sources or destinations specified	Only one device name can be specified as a source or target.
No table name for data	The database contains data that is unassigned to a table. Use Server Manager to validate or mend the database.
Page size specified (*n* bytes) rounded up to *n* bytes	Invalid page sizes are rounded up to 1024, 2048, 4096, or 8192, whichever is closest.
Page size specified (*n*) greater than limit (8192 bytes)	Specify a page size of 1024, 2048, 4096, or 8192.
Protection is not there yet	
Requires both input and output file names	Specify both a source and target when backing up or restoring.
Restore failed for record in table *<string>*	Possible data corruption in the named table.
Skipped *n* bytes after reading a bad attribute *n*	
Skipped *n* bytes looking for next valid attribute, encountered attribute *n*	
Trigger *<string>* is invalid	

Table A-1: Server Manager Error Messages (Continued)

Error Message	**Causes and Suggested Actions to Take**
Unexpected end of file on backup file	Restoration of the backup file failed. The backup procedure that created the backup file may have terminated abnormally. If possible, create a new backup file and use it to restore the database.
Unexpected I/O error while *<string>* backup file	A disk error or other hardware error may have occurred during a backup or restore.
User name parameter missing	The backup or restore is accessing a remote machine. Supply a user name.
Validation error on column in table *<string>*	The database cannot be restored because it contains data that violates integrity constraints. It may be necessary to delete constraints from the metadata by specifying the "Do Not Restore Validity Conditions" during restore.
Warning -- record could not be restored	Possible corruption of the named data.
Wrong length record, expected *m* encountered *n*	

Appendix B
Connecting to InterBase

This appendix describes how to troubleshoot common InterBase SQL Link connection problems, and discusses various topics about using Borland SQL Links® that are unique to InterBase.

InterBase Server Requirements

Table B-1 lists software that should already be installed and running at the InterBase server before you install Borland SQL Links for Windows.

Table B-1: Server Software Requirements

Category	Description
Database server software	InterBase version 3.3 or higher.
Network protocol software	Network protocol software compatible with both the database server and the client workstation network protocol.

For information on network protocol software and network access rights, see your system administrator.

Client Workstation Requirements

Table B-2 lists software that should already be installed and running at the client workstation. It also lists related files and parameters.

Table B-2: Client Workstation

Category	Description
BDE application(s)	Supported BDE application, installed as required by the product documentation.

Table B-2: Client Workstation (Continued)

Category	Description
Hardware and operating system requirements	1.5 MB of free disk space. Hardware and operating system that meets the requirements of your Borland desktop product.
Access rights (for desktop products installed on the network server *only*)	If your Borland desktop product is installed on a network file server, make sure your network user account has Read and Write access rights to the product's BDE files (including IDAPICFG.EXE and the BDE configuration file). This directory is modified during SQL Link installation.
Network protocol software	Network protocol software compatible with both the server network protocol and the client workstation client database communication driver.
HOSTS file	A HOSTS file containing the name and IP address of each server that you plan to attach. This file must contain the name and IP address of at least one host. For example: 128.127.50.12 mis_server
SERVICES file	A SERVICES file containing the protocol for InterBase server access. During SQL Links installation, this file is updated to include the line: gds_db 3050/tcp **Note:** If you prefer, you can add the line to your SERVICES file manually, after SQL Links installation.

Installation Changes

When you install the InterBase SQL Link driver, the following items are installed in your workstation system:

Table B-3: Installation Changes for the InterBase SQL Link Driver

Item Added	Description
SQLD_IB.DLL	Dynamic Link Library comprising the new InterBase driver and its supporting files.
INTRBASE driver type	Added to Configuration Utility Driver Manager to enable basic configuration of Borland InterBase SQL Link driver.
INTRBASE alias type	Added to Configuration Utility Alias Manager to enable creation of an alias that can connect to an SQL Server database.
SQLD_IB.HLP	Help file for configuring InterBase driver.

Table B-3: Installation Changes for the InterBase SQL Link Driver (Continued)

Item Added	Description
READLINK.TXT	Borland SQL Links for Windows README file.
INTERBAS.MSG	InterBase message files, usually installed in C:\INTERBAS.
CONNECT.EXE	Utility to test connection between the workstation and the InterBase server; see "TCP/IP Interface."
REMOTE.DLL GDS.DLL	InterBase-supplied.DLLs.
InterBase server specification, to InterBase SERVICES file	The installation updates the workstation SERVICES file to add the correct protocol specification for InterBase server access. The line should be similar to: gds_db 3050/tcp For further information, see your database administrator.

TCP/IP Interface

The following files provide InterBase client applications their interface to Winsock 1.1 compliant TCP/IP products.

Table B-4: Winsock 1.1 Client Files

File Name	Description
MVWASYNC.EXE	Asynchronous communication module
VSL.INI	TCP/IP transport initialization file
WINSOCK.DLL	Windows Socket DLL
MSOCKLIB.DLL	Maps Windows socket calls to VSL driver

For TCP/IP products that are not Winsock 1.1 compliant, InterBase client applications will require one of the following files.

You can choose not to have the Installation program add a TCP/IP file by specifying "Use existing TCP file" during SQL Links for Windows installation.

Table B-5: Non-Winsock Compliant TCP Support Files

File Name	TCP/IP Product
M3OPEN.EXE	3Com 3+Open TCP Digital PATHWORKS Microsoft LAN Manager TCP/IP
M3OPEN.DLL	3Com 3+Open TCP Version 2.0
MBW.EXE	Beame & Whiteside TCP/IP

Table B-5: Non-Winsock Compliant TCP Support Files (Continued)

File Name	TCP/IP Product
MFTP.EXE	FTP PC/TCP
MHPARPA.DLL	HP ARPA Service for DOS
MNETONE.EXE	Ungermann-Bass Net/One
MNOVLWP.DLL	Novell LAN WorkPlace for DOS
MPATHWAY.DLL	Wollongong Pathway Access for DOS
MPCNFS.EXE	Sun PC NFS
MPCNFS2.EXE	Sun PC NFS v3.5
MPCNFS4.DLL	Sun PC NFS v4.0
MWINTCP.EXE	Wollongong WIN TCP\IP for DOS

Other Communication Protocols

The InterBase Workgroup Server for NetWare supports Novell SPX/IPX protocol. Two client files are required: NWIPXSPX.DLL, and NWCALLS.DLL.

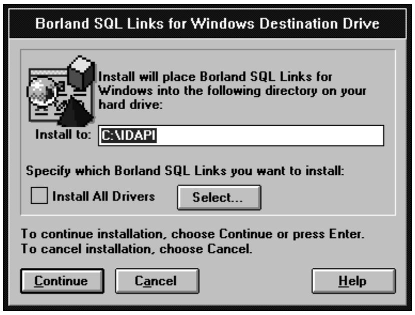
The InterBase Workgroup Server for Windows NT supports Microsoft Named Pipes protocol. No additional client files are required to support Named Pipes, but the client machine must have Microsoft LAN Manager or Windows for Workgroups 3.1.1 installed.

Testing the InterBase Connection

To test whether you can connect to InterBase successfully, use the InterBase Connection Utility (CONNECT.EXE). This utility is stored in the same directory as the BDE files.

1. Choose File | Run from the Program Manager menu bar. The Run dialog box appears.
2. In the Command Line text box, enter the command to run CONNECT. (If you installed BDE files in C:\BDE, the command is C:\BDE\CONNECT.EXE.)
3. Choose OK. The InterBase Connect Utility dialog box appears.

Figure B-1: InterBase Connect Utility Dialog Box


Borland SQL Links for Windows Destination Drive

Install will place Borland SQL Links for Windows into the following directory on your hard drive:

Install to: C:\IDAPI

Specify which Borland SQL Links you want to install:

To continue installation, choose Continue or press Enter.
To cancel installation, choose Cancel.

4. Enter information in each text box:

Text Box	Information Required
Database Path	The path to an InterBase database, in the format: servername/usr/databaseDirectory/databaseName.gdb Be sure to use Unix-style forward-slash characters, and recall that Unix path names are case-sensitive.
User Name	A valid user name for the database you specified.
Password	A valid password for the user name you specified.

5. Choose Connect to test your network connection.

If the connection succeeds, a status message appears.

If the connection does not succeed, an error message appears.

Troubleshooting Common Connection Problems

If you have problems establishing an InterBase connection with SQL Link, try to isolate the problem the following way:

1. Run the Connection Utility (CONNECT.EXE) to determine if you can connect to the InterBase server from your client workstation.

   If CONNECT does not work—Consult your database administrator.

   If CONNECT works—Continue with step 2.

2. Verify that your InterBase SQL Link driver is correctly installed.

   Reinstall SQL Link by following the procedures in *Getting Started*.

Also, check the SERVICES file for the correct protocol for InterBase server access. The line should be similar to:

```
gds_db                   3050/tcp
```

If you are unable to install the driver correctly—Consult your database administrator.

If the driver is correctly installed—Continue with step 3.

Note The following steps require a TELNET program and a PING program. These DOS programs are not included in the SQL Link product package, but they are available from your TCP/IP network software vendor. (Your TCP/IP network software package may use different names for these programs.)

If you do not have these programs on your client workstation, ask your network administrator to perform these tests for you.

3. Test the lower-level protocols.

   - Enter the TELNET command to ensure that the TCP libraries are correctly installed.

     If the TCP libraries are correctly installed, the `login:` prompt is displayed. Login to the network and check for the presence of the database you are trying to attach.

     If the message `can't resolve hostname` is displayed, check your workstation HOSTS file to ensure that you have an entry for your host name and IP address. The entry looks similar to:

     ```
     128.127.50.12          mis_server
     ```

     If TELNET is successful and CONNECT is not, you may have a problem with your InterBase installation. See your database administrator for assistance.

   - PING the server to check that the InterBase server itself is running and visible to your desktop application. (If PING is successful, the message `servername is alive` is displayed.)

     If PING is successful but the TELNET command is not, there may be a problem with the **inet** daemon.

     If you cannot PING the server, you may have a routing problem. Report the problem to your network administrator.

Note If you don't have PING on your DOS client, you can PING the DOS client from the server node (if you have access to the server node). Ask your network administrator for instructions.

If the lower-level protocols do not seem to be running—Consult your database administrator.

If the lower-level protocols are running—Continue with step 4.

4. Confirm that you have a login set in the InterBase security database, ISC4.GDB.

   If so—Continue with step 5.

5. Check whether your BDE application InterBase alias is set up properly.

If you can connect directly from your workstation but not from within your BDE application, there is probably a problem with your IDAPI.CFG alias setup. Run the Configuration Utility and examine your InterBase alias.

Borland Language Drivers for InterBase

The following table lists language drivers available for use with InterBase and their corresponding InterBase subtypes. The language driver you choose must use the same collation sequence as your server, and the same character set as the one your server uses to pass data to your BDE application. The default can be set at either a database or a table level.

InterBase supports subtypes for different fields in the same relation. However, rules of a language driver you specify will apply to a relation as a whole. The result of a query on a relation containing fields of different subtypes may vary according to where it was processed. In such a case, set SQLQRYMODE to SERVER to produce consistent query results.

Table B-6: Borland Language Drivers for InterBase

Long Driver Name	Short Driver Name	InterBase Subtype
Paradox “ascii”	ascii	0 (default), 1, 100, 101
Borland DAN Latin-1	BLLT1DA0	139
DEU LATIN1	BLLT1DE0	144
ENG LATIN1	BLLT1UK0	152
ENU LATIN1	BLLT1US0	153
ESP LATIN1	BLLT1ES0	149
FIN LATIN1	BLLT1FI0	141
FRA LATIN1	BLLT1FR0	142
FRC LATIN1	BLLT1CA0	143
ISL LATIN1	BLLT1IS0	145

Table B-6: Borland Language Drivers for InterBase (Continued)

Long Driver Name	Short Driver Name	InterBase Subtype
ITA LATIN1	BLLT1IT0	146
NLD LATIN1	BLLT1NL0	140
NOR LATIN1	BLLT1NO0	105
PTG LATIN1	BLLT1PT0	154
Paradox INTL	INTL	102
Pdox NORDAN4	NORDAN40	105
Pdox SWEDFIN	SWEDFIN	106
SVE LATIN1	BLLT1SV0	151

Note For information on InterBase subtypes that correspond to dBASE® language drivers, contact Borland Technical Support.

Working With InterBase Servers

This section provides information about InterBase servers and their implementation of SQL. The topics discussed in this section cover aspects of InterBase that differ from other SQL database products.

Table B-7 lists the general items that you might find helpful in working with InterBase.

Table B-7: General information About InterBase Servers

Item	Description
Dynamic Link Library (DLL) name	SQLD_IB.DLL
Case-sensitive for data?	Yes (including pattern matching)
Case-sensitive for objects (such as tables, columns, indexes)?	No
Does the server require an explicit request to begin a transaction for multistatement transaction processing?	Yes
Does the server require that you explicitly start a transaction for multi-statement transaction processing in pass-through SQL?	No
Implicit row IDs	No

Table B-7: General information About InterBase Servers (Continued)

Item	Description
BLOB handles	InterBase BLOBs have handles. However, InterBase CHAR and VARCHAR columns that are more than 255 characters long are treated as non-handle BLOBs.
Maximum size of single BLOBs read (if BLOB handles are not supported)	32K

InterBase Data Type Translations

Certain database operations cause SQL Link to convert data from Paradox® or dBASE format to InterBase format. For example, a BDE application that copies or appends data from a local table to an InterBase table causes SQL Link to convert the local data to InterBase format before performing the copy or append operation.

Other database operations cause a conversion in the opposite direction, from InterBase format to Paradox or dBASE format. For example, suppose you run a local query against one or more SQL tables. During the query, SQL Link converts any data originating in an SQL database to Paradox or dBASE format (depending on the answer format requested) before placing the data in the local answer table.

Tables B-8 through B-13 list InterBase, Paradox, and dBASE data types and show how SQL Link translates them in append, copy, and local query operations.

Table B-8: InterBase to Paradox and dBASE Data Type Translations

FROM: InterBase	TO: Paradox	TO: dBASE
SHORT	Short	Number {6.0}
LONG	Number	Number {11.0}
FLOAT	Number	Float {20.4}
DOUBLE	Number	Float {20.4}
DATE[a]	DateTime	Date
BLOB	Binary	Memo
BLOB/1	Memo	Memo
CHAR(1-255)	Alphanumeric(*n*)	Character(*n*)[2]
CHAR(greater than 255)	Memo	Memo

Table B-8: InterBase to Paradox and dBASE Data Type Translations (Continued)

FROM: InterBase	TO: Paradox	TO: dBASE
VARYING(1-255)	Alphanumeric(*n*)	Character(*n*)[b]
VARYING(greater than 255)	Memo	Memo
ARRAY[b]	Binary	Memo

a. From InterBase, QBE maps InterBase DATE to Paradox Date. Copy table maps InterBase DATE to Paradox Char(n).

b. Although an InterBase ARRAY is mapped to Paradox and dBASE data types, the resulting fields appear to be empty when displayed within your client product.

Table B-9: Paradox to InterBase and dBASE Data Type Translations

FROM: Paradox	TO: InterBase	TO: dBASE
Alphanumeric(*n*)	VARYING(*n*)	Character(*n*)
Number	DOUBLE	Float {20.4}
Money	DOUBLE	Float {20.4}
Date	DATE	Date
Short	SHORT	Number {6.0}
Memo	BLOB/1 (Text)	Memo
Formatted memo	BLOB (Binary)	Memo
Binary	BLOB (Binary)	Memo
Graphic	BLOB (Binary)	Memo
OLE	BLOB (Binary)	Memo
Long	Long	Number {11.0}
Time	Character {>8}	Character {>8}
DateTime	Date	Character {>8}
Bool	Character {1}	Bool
AutoInc	Long	Number {11.0}
Bytes	BLOB	Bytes
BCD	N/A	N/A

Table B-10: dBASE to InterBase and Paradox Data Type Translations

FROM: dBASE	TO: InterBase	TO: Paradox
Character(*n*)	VARYING(*n*)	Alphanumeric(*n*)
Number	SHORT, DOUBLE	Short number, Number
Float[a]	DOUBLE	Number

Table B-10: dBASE to InterBase and Paradox Data Type Translations (Continued)

FROM: dBASE	TO: InterBase	TO: Paradox
Date	DATE	Date
Lock	Character {24}	Alpha {24}
Bytes	BLOB	Bytes
Bool	Character {1}	Bool
Memo	BLOB/1	Memo

a. dBASE data types Number and Float translate to different InterBase and Paradox data types depending on the WIDTH and DEC specification. dBASE Number and Float values with a WIDTH less than 5 and a DEC equal to 0 translate to InterBase SHORT or Paradox Short Number data types.

Table B-11: Paradox to BDE Logical to dBASE Data Type Translations

Paradox Physical	BDE Logical	dBASE
fldPDXCHAR	fldZSTRING	fldDBCHAR
fldPDXNUM	fldFLOAT	fldDBFLOAT {20.4}
fldPDXMONEY	fldFLOAT/fldstMONEY	fldDBFLOAT {20.4}
fldPDXDATE	fldDATE	fldDATE
fldPDXSHORT	fldINT16	fldDBNUM {6.0}
fldPDXMEMO	fldBLOB/fldstMEMO	fldDBMEMO
fldPDXBINARYBLOB	fldBLOB/fldstBINARY	fldDBMEMO
fldPDXFMTMEMO	fldBLOB/fldstFMTMEMO	fldDBMEMO
fldPDXOLEBLOB	fldBLOB/fldstOLEOBJ	fldDBMEMO
fldPDXGRAPHIC	fldBLOB/fldstGRAPHIC	fldDBMEMO
fldPDXBLOB	fldPDXMEMO	fldDBMEMO
fldPDXLONG	fldINT32	fldDBNUM {11.0}
fldPDXTIME	fldTIME	fldDBCHAR {>8}
fldPDXDATETIME	fldTIMESTAMP	fldDBCHAR {30}
fldPDXBOOL	fldBOOL	fldDBBOOL
fldPDXAUTOINC	fldINT32	fldDBNUM {11.0}
fldPDXBYTES	fldBYTES	fldDBBYTES
fldPDXBCD	fldBCD	fldDBCHAR

Table B-12: dBASE to BDE Logical to Paradox Data Type Translations

dBASE Physical	BDE Logical	Paradox
fldDBCHAR	fldZSTRING	fldPDXCHAR
fldDBNUM	if(iUnits2=0 && iUnits1<5)	
	fldINT16	fldPDXSHORT
	else fldFLOAT	fldPDXNUM
fldDBMEMO	fldBLOB	fldPDXMEMO
fldDBBOOL	fldBOOL	fldPDXBOOL
fldDBDATE	fldDATE	fldPDXDATE
fldDBFLOAT	fldFLOAT	fldPDXNUM
fldDBLOCK	fldLOCKINFO	fldPDXCHAR {24}
fldDBBINARY	fldBLOB/fldstTYPEDBI-NARY	fldPDXBINARYBLOB
fldDBOLEBLOB	fldBLOB/fldstDBSOLEOBJ	fldPDXOLEBLOB

Table B-13: InterBase to BDE Logical to Paradox and dBASE Data Type Translations

InterBase Physical	BDE Logical	Paradox Physical	dBASE Physical
fldIBSHORT	fldINT16	fldPDXSHORT	fldDBNUM {6.0}
fldIBLONG	fldINT32	fldPDXLONG	fldDBNUM {11.0}
fldIBFLOAT	fldFLOAT	fldPDXNUM	fldDBFLOAT {20.4}
fldIBDOUBLE	fldFLOAT	fldPDXNUM	fldDBFLOAT {20.4}
fldIBCHAR ≤ 255	fldZSTRING	fldPDXCHAR	fldDBCHAR
fldIBCHAR > 255	fldBLOB	fldSTMEMO	fldDBCHAR
fldIBVARYING ≤ 255	fldZSTRING	fldPDXCHAR	fldDBCHAR
fldIBVARYING > 255	fldBLOB	fldSTMEMO	fldDBCHAR
fldIBDATE	fldTIMESTAMP	fldPDXDATETIME	fldDBDATE
fldIBBLOB	fldBLOB	fldPDXBINARYBLOB	fldDBMEMO
fldIBTEXTBLOB	fldBLOB/fldstMEMO	fldPDXMEMO	fldDBMEMO

InterBase Equivalents to Standard SQL Data Types

When you use pass-through SQL commands to create or alter an InterBase table, you must use standard SQL data types. Table B-14 lists standard SQL data types and their corresponding InterBase data types.

Table B-14: SQL to InterBase Data Type Translations

FROM: SQL	**TO: InterBase**
SMALLINT	SHORT
INTEGER	LONG
DATE	DATE
CHAR(*n*)	CHAR(*n*)
VARCHAR(*n*)	VARYING
DECIMAL	LONG
FLOAT	FLOAT
LONG FLOAT	DOUBLE
BLOB	BLOB

Note SQL does not support InterBase arrays of data types.

InterBase System Relations/Tables

InterBase includes a special set of tables called *system relations*. System relations describe privileges, indexes, SQL table structures, and other items that define relationships within a database. You can access system relations with pass-through SQL from your desktop product through the SQL Editor (see your desktop application documentation).

Table B-15 lists InterBase system relations you can access through SQL Link.

Table B-15: Selected InterBase System Relations

Name	**Use**
RDB$RELATIONS	Lists all tables and views
RDB$RELATION_FIELDS	Lists columns of tables and views
RDB$INDICES	Lists indexes

InterBase Field-naming Rules

Table B-16 lists field-naming rules for Paradox, dBASE, and InterBase.

Table B-16: InterBase Field-naming Rules

Rule	Paradox	dBASE	InterBase
Max length (characters)	25	10	31
Valid characters[a]	All	All alphanumeric except punctuation marks, blank spaces, and other special characters	Letters (A-Z, a-z), digits, $, or _
Must begin with . . .	Any valid character except space	A letter	Letters only (A-Z, a-z)

a. Paradox field names should not contain square brackets [], curly braces {}, pipes |, parentheses (), or the combination ->, or the symbol # alone.

Note You cannot use InterBase reserved words for table names. See the *InterBase Language Reference* for a list of reserved words.

Appendix C

Example Database

This appendix summarizes and describes the example database provided with InterBase. The database, source code, and executables for these examples are contained in the EXAMPLES subdirectory of the InterBase directory (INTERBAS, by default).

The Example Database

The database (EMPLOYEE.GDB) is created with the data definition file, CREATEDB.SQL. It is a personnel management and sales database for a fictional company corresponding to the database that is built in the tutorial. It is designed to include such InterBase features as FOREIGN KEY and CHECK constraints. Triggers are also defined for some of the tables.

The database is made up of ten tables. Those tables are:

Table C-1 Tables in the Example Database

EMPLOYEE	DEPARTMENT
JOB	SALES
PROJECT	CUSTOMER
EMPLOYEE_PROJECT	PROJ_DEPT_BUDGET
COUNTRY	SALARY_HISTORY

Each of the database tables is described in a separate table in this appendix. The structure of the Employee database is shown in Figure C-1, "EMPLOYEE Database". Each box in Figure C-1 represents a table. The arrows connecting boxes represent the FOREIGN KEY references among the tables.

Domains

Fifteen domains are defined for EMPLOYEE.GDB. Domains make table definition easier, because they predefine data types, CHECK constraints, and defaults.

Six domains are defined as simple data types without CHECK constraints or DEFAULT values.

Table C-2 Simple Example Domains

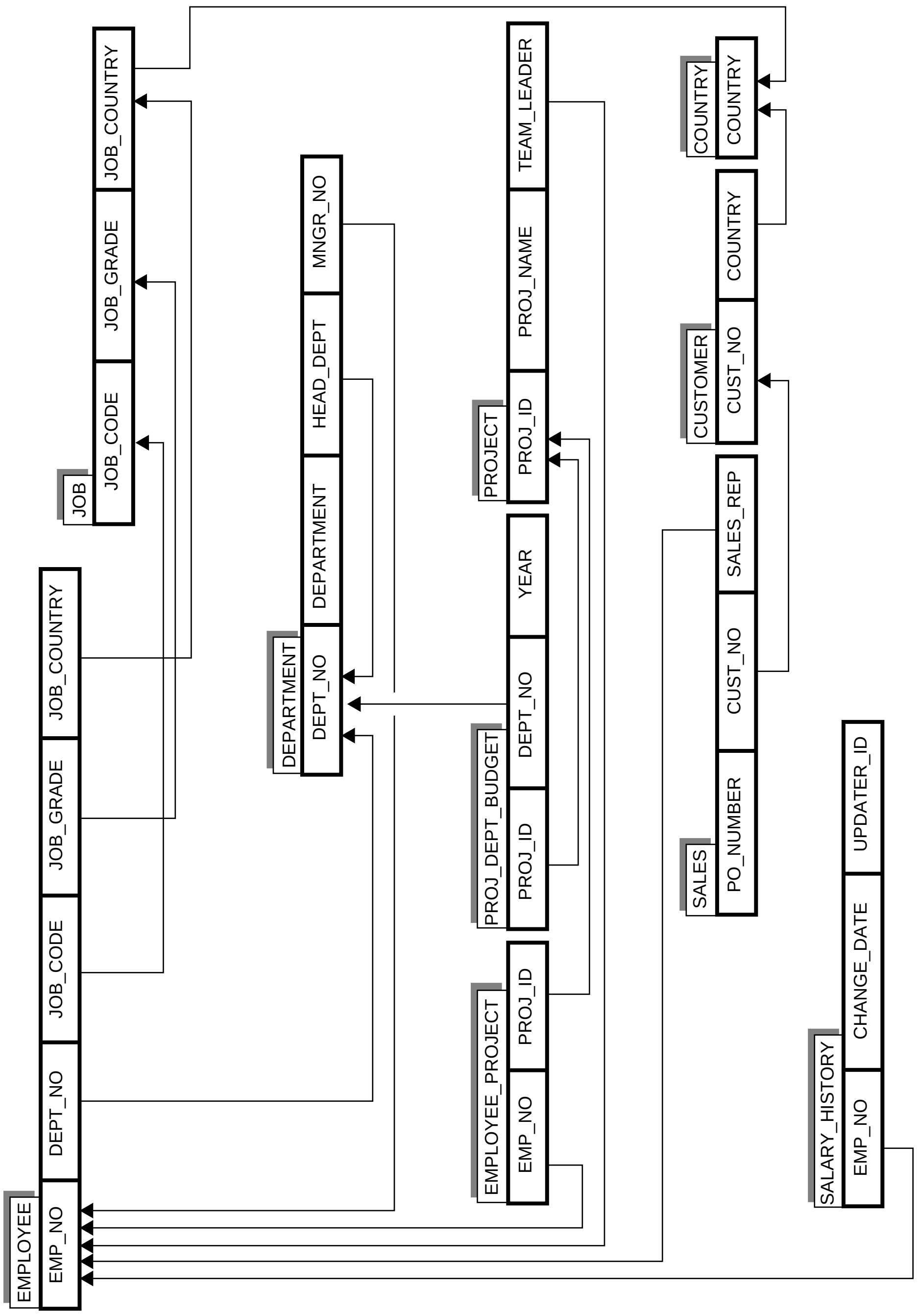
Domain Name	Data Type
FIRSTNAME	(VARCHAR)
LASTNAME	(VARCHAR)
PHONENUMBER	(VARCHAR)
COUNTRYNAME	(VARCHAR)
ADDRESSLINE	(VARCHAR)
EMPNO	(SMALLINT)

Nine domains are defined with CHECK constraints and/or default values.

Table C-3 Complex Example Domains

Domain Name	Data Type	CHECK Constraint	Default
DEPTNO	CHAR(3)	CHECK (VALUE = ‘000’ OR (VALUE > ‘0’ AND VALUE <= ‘999’) OR VALUE IS NULL)	None
PROJNO	CHAR(5)	CHECK (VALUE = UPPER (VALUE))	None
CUSTNO	INTEGER	CHECK (VALUE > 1000)	None
JOBCODE	VARCHAR(5)	CHECK (VALUE > ‘99999’)	None
JOBGRADE	SMALLINT	CHECK (VALUE BETWEEN 0 AND 6)	None
SALARY	NUMERIC(10,2)	CHECK (VALUE > 0)	0
BUDGET	DECIMAL(12,2)	CHECK (VALUE > 10000 AND VALUE <= 2000000)	50000
PRODTYPE	VARCHAR(12)	CHECK (VALUE IN (‘software’, ‘hardware’, ‘other’, ‘N/A’))	‘software’
PONUMBER	CHAR(8)	CHECK (VALUE STARTING WITH ‘V’)	None

Figure C-1 EMPLOYEE Database



Triggers

The database contains the following triggers:

- SET_EMP_NO creates a unique employee number when a new employee record is inserted.
- SAVE_SALARY_CHANGE inserts a new record in the SALARY_HISTORY table when an employee's salary changes.
- SET_CUST_NO creates a unique customer number when a new customer record is inserted.
- POST_NEW_ORDER posts an event named "new_order" when a new record is inserted in the SALES table.

Stored Procedures

The database contains the following stored procedures:

- ADD_EMP_PROJ adds an employee to a project, returning an error message if the employee is not in the EMPLOYEE table.
- DELETE_EMPLOYEE removes an employee's records in the EMPLOYEE, DEPARTMENT, and EMPLOYEE_PROJECT tables, unless the employee has any sales records in the SALES table.
- GET_EMP_PROJ is a select procedure that returns all the projects to which an employee is assigned.
- MAIL_LABEL creates a six-line customer mailing label, when given the customer number as input.
- ORG_CHART returns an organization chart, showing department names and numbers, manager name and title, and number of employees in each department.
- SHIP_ORDER takes a purchase order number (PO_NUMBER) as input, and updates the SALES table to indicate that an order has been shipped, unless it has already been shipped, the customer is on hold, or the customer has on overdue balance.
- SUB_TOT_BUDGET returns the average, smallest, and largest department budgets for all departments in the department given as the input parameter.
- DEPT_BUDGET takes a department number as input and returns the total budget of all departments under that department, inclusive.

- SHOW_LANGS returns the language requirements for a job (stored in an array in the JOB table), when given the job code, grade, and country. This procedure illustrates how to display the contents of an array for a specific row and column.
- ALL_LANGS uses SHOW_LANGS to return the language requirements for all jobs in the JOB table. This procedure illustrates how to display the contents of an array using a stored procedure for all rows in a table.

Example Database Tables

Conceptually, the EMPLOYEE table is the central table in the database. There is one record in this table for each employee, with the employee number (EMP_NO column) as the primary key, because each employee is uniquely identified by an employee number. The DEPT_NO column is a foreign key that references the DEPARTMENT table. The columns JOB_CODE, JOB_GRADE, and JOB_COUNTRY reference the JOB table. The table also contains other information on each employee, such as salary and hire date. The salary is given in the currency in which the employee works.

Table C-4, "EMPLOYEE Table" shows the contents of the EMPLOYEE table, the definition of each column in the table and any relations to other tables (such as foreign keys.

Table C-4 EMPLOYEE Table

Column Name	Data Type, Default Value, and CHECK Constraints
EMP_NO (EMPNO) *PRIMARY KEY*	SMALLINT NOT NULL
FIRST_NAME (FIRSTNAME)	VARCHAR(15) NOT NULL
LAST_NAME (LASTNAME)	VARCHAR(20) NOT NULL
PHONE_EXT	VARCHAR(4) Nullable
HIRE_DATE DATE	NOT NULL DEFAULT 'NOW'
DEPT_NO (DEPTNO) *FOREIGN KEY - references* DEPARTMENT (DEPT_NO)	CHAR(3) NOT NULL CHECK (VALUE = '000' OR (VALUE > '0' AND VALUE <= '999') OR VALUE IS NULL)
JOB_CODE (JOBCODE) *FOREIGN KEY - references JOB*	VARCHAR(5) NOT NULL CHECK (VALUE > '99999')
JOB_GRADE (JOBGRADE) *FOREIGN KEY - references JOB*	SMALLINT NOT NULL CHECK (VALUE BETWEEN 0 AND 6)

Table C-4 EMPLOYEE Table (Continued)

Column Name	Data Type, Default Value, and CHECK Constraints
JOB_COUNTRY (COUNTRYNAME) *FOREIGN KEY - references JOB*	VARCHAR(15) NOT NULL
SALARY (SALARY)	DOUBLE PRECISION NOT NULL DEFAULT 0 CHECK (VALUE > 0)
FULL_NAME	Computed by: (last_name || ', ' || first_name)

There is also a complex CHECK constraint on SALARY:

```
CHECK (SALARY >= (SELECT MIN_SALARY FROM JOB WHERE
      JOB.JOB_CODE = EMPLOYEE.JOB_CODE AND
      JOB.JOB_GRADE = EMPLOYEE.JOB_GRADE AND
      JOB.JOB_COUNTRY = EMPLOYEE.JOB_COUNTRY)
   AND
   SALARY <= (SELECT MAX_SALARY FROM JOB WHERE
      JOB.JOB_CODE = EMPLOYEE.JOB_CODE AND
      JOB.JOB_GRADE = EMPLOYEE.JOB_GRADE AND
      JOB.JOB_COUNTRY = EMPLOYEE.JOB_COUNTRY))
```

The DEPARTMENT table contains a record for each department in the company, with the DEPT_NO as the primary key. DEPARTMENT, the department name, is also a unique (or alternate) key. The HEAD_DEPT column is a foreign key referencing the parent department. So, in effect, the table defines a tree, in which each department can contain other departments. The "root" of the tree is the Corporate Headquarters department, for which HEAD_DEPT is NULL. The table also contains columns for each department's location, budget, and other information.

Table C-5, "DEPARTMENT Table" shows the contents of the DEPARTMENT table.

Table C-5 DEPARTMENT Table

Column Name	Data Type, Default Value, and CHECK Constraints
DEPT_NO (DEPTNO) *PRIMARY KEY*	CHAR(3) NOT NULL CHECK (VALUE = '000' OR (VALUE > '0' AND VALUE <= '999') OR VALUE IS NULL)
DEPARTMENT *UNIQUE key*	VARCHAR(25) NOT NULL
HEAD_DEPT (DEPTNO) *FOREIGN KEY - references* DEPARTMENT (DEPT_NO)	CHAR(3) NOT NULL CHECK (VALUE = '000' OR (VALUE > '0' AND VALUE <= '999') OR VALUE IS NULL)

Table C-5 DEPARTMENT Table (Continued)

Column Name	Data Type, Default Value, and CHECK Constraints
MNGR_NO (EMPNO) *FOREIGN KEY - references* EMPLOYEE (EMP_NO)	SMALLINT Nullable
BUDGET (BUDGET)	DOUBLE PRECISION Nullable DEFAULT 50000 CHECK (VALUE > 10000 AND VALUE <= 2000000)
LOCATION	VARCHAR(15) Nullable
PHONE_NO (PHONENUMBER)	VARCHAR(20) Nullable DEFAULT '555-1234'

The JOB table contains a record for each job in the company. The three columns JOB_CODE, JOB_GRADE, and JOB_COUNTRY are the primary key that uniquely identifies a job. JOB_COUNTRY references the COUNTRY table, which identifies the currency of each country.

Table C-6, "JOB Table" shows the contents of the JOB table.

Table C-6 JOB Table

Column Name	Data Type, Default Value, and CHECK Constraints
JOB_CODE (JOBCODE) *PRIMARY KEY*	VARCHAR(5) NOT NULL CHECK (VALUE > '99999')
JOB_GRADE (JOBGRADE) *PRIMARY KEY*	SMALLINT NOT NULL CHECK (VALUE BETWEEN 0 AND 6)
JOB_COUNTRY (COUNTRYNAME) *PRIMARY KEY* *FOREIGN KEY - references* COUNTRY (COUNTRY)	VARCHAR(15) NOT NULL
JOB_TITLE	VARCHAR(25) NOT NULL
MIN_SALARY (SALARY)	DOUBLE PRECISION NOT NULL DEFAULT 0 CHECK (VALUE > 0) CHECK (min_salary < max_salary)
MAX_SALARY (SALARY)	DOUBLE PRECISION NOT NULL DEFAULT 0 CHECK (VALUE > 0) CHECK (min_salary < max_salary)
JOB_REQUIREMENT	BLOB segment 400, subtype TEXT Nullable
LANGUAGE_REQ	ARRAY OF [1:5] VARCHAR(15) Nullable

The SALES table contains a record for each sale closed, with PO_NUMBER as the primary key. Foreign keys are CUST_NO referencing the CUSTOMER table and SALES_REP referencing the EMPLOYEE table.

Table C-7, "SALES Table" shows the contents of the SALES table.

Table C-7 SALES Table

Column Name	Data Type, Default Value, and CHECK Constraints
PO_NUMBER (PONUMBER) *PRIMARY KEY*	CHAR(8) NOT NULL CHECK (VALUE STARTING WITH 'V')
CUST_NO (CUSTNO) *FOREIGN KEY - references* CUSTOMER (CUST_NO)	INTEGER NOT NULL CHECK (VALUE > 1000)
SALES_REP (EMPNO) *FOREIGN KEY - references* EMPLOYEE (EMP_NO)	SMALLINT Nullable
ORDER_STATUS	VARCHAR(7) NOT NULL DEFAULT 'new'
ORDER_DATE	DATE NOT NULL DEFAULT 'now'
SHIP_DATE	DATE Nullable
DATE_NEEDED	DATE Nullable
PAID	CHAR(1) Nullable DEFAULT 'n'
QTY_ORDERED	INTEGER NOT NULL DEFAULT 1
TOTAL_VALUE	INTEGER NOT NULL
DISCOUNT	FLOAT NOT NULL DEFAULT 0
ITEM_TYPE	(PRODTYPE) VARCHAR(12) NOT NULL DEFAULT 'software' CHECK (VALUE IN ('software', 'hardware', 'other', 'N/A'))
AGED	Computed by: (ship_date - order_date)

Several checks are performed on the SALES table, among them:

- A sale order must have a status: open, shipped, waiting.
- The ship date must be entered, if order status is "shipped".
- New orders cannot be shipped to customers with "on_hold" status.

The CHECK constraints for this table are:

```
CHECK (order_status in ("new", "open", "shipped", "waiting"))
CHECK (ship_date >= order_date OR ship_date IS NULL)
CHECK (date_needed > order_date OR date_needed IS NULL)
CHECK (paid in ("y", "n"))
CHECK (qty_ordered >= 1)
CHECK (total_value >= 0)
CHECK (discount >= 0 AND discount <= 1)
CHECK (NOT (order_status = "shipped" AND ship_date IS NULL))
CHECK (NOT (order_status = "shipped" AND
   EXISTS (SELECT on_hold FROM customer
      WHERE customer.cust_no = sales.cust_no
      AND customer.on_hold = "*")))
```

The PROJECT table contains a record for each project, with PROJ_ID as the primary key, and TEAM_LEADER referencing the EMP_NO in the EMPLOYEE table. The PROJ_DEPT_BUDGET column shows the budget for each project and year.

Table C-8, "PROJECT Table" shows the contents of the PROJECT table.

Table C-8 PROJECT Table

Column Name	Data Type, Default Value, and CHECK Constraints
PROJ_ID (PROJNO) *PRIMARY KEY*	CHAR(5) NOT NULL CHECK (VALUE = UPPER (VALUE))
PROJ_NAME *UNIQUE key*	VARCHAR(20) NOT NULL
PROJ_DESC	BLOB segment 800, subtype TEXT Nullable
TEAM_LEADER (EMPNO) *FOREIGN KEY - references* EMPLOYEE (EMP_NO)	SMALLINT Nullable
PRODUCT (PRODTYPE)	VARCHAR(12) NOT NULL DEFAULT 'software' CHECK (VALUE IN ('software', 'hardware', 'other', 'N/A'))

The CUSTOMER table contains a record for each customer, with CUST_NO as the primary key, and columns for other information such as address, contact name and phone number.

Table C-9, "CUSTOMER Table"shows the contents of the CUSTOMER table.

Table C-9 CUSTOMER Table

Column Name	Data Type, Default Value, and CHECK Constraints
CUST_NO (CUSTNO) *PRIMARY KEY*	INTEGER NOT NULL CHECK (VALUE > 1000)
CUSTOMER	VARCHAR(25) NOT NULL

Table C-9 CUSTOMER Table (Continued)

Column Name	Data Type, Default Value, and CHECK Constraints
CONTACT_FIRST (FIRST-NAME)	VARCHAR(15) Nullable
CONTACT_LAST (LASTNAME)	VARCHAR(20) Nullable
PHONE_NO (PHONENUMBER)	VARCHAR(20) Nullable
ADDRESS_LINE1 (ADDRESSLINE)	VARCHAR(30) Nullable
ADDRESS_LINE2 (ADDRESSLINE)	VARCHAR(30) Nullable
CITY	VARCHAR(25) Nullable
STATE_PROVINCE	VARCHAR(15) Nullable
COUNTRY (COUNTRYNAME) *FOREIGN KEY - references* COUNTRY (COUNTRY)	VARCHAR(15) Nullable
POSTAL_CODE	VARCHAR(12) Nullable
ON_HOLD	CHAR(1) Nullable DEFAULT NULL CHECK (on_hold IS NULL OR on_hold = '*')

Table C-10, "EMPLOYEE_PROJECT Table" shows the contents of the EMPLOYEE_PROJECT table.

Table C-10 EMPLOYEE_PROJECT Table

Column Name	Data Type, Default Value, and CHECK Constraints
EMP_NO (EMPNO) *PRIMARY KEY* *FOREIGN KEY - references* EMPLOYEE (EMP_NO)	SMALLINT NOT NULL
PROJ_ID (PROJNO) *PRIMARY KEY* *FOREIGN KEY - references* PROJECT (PROJ_ID)	CHAR(5) NOT NULL CHECK (VALUE = UPPER (VALUE))

Table C-11, "PROJ_DEPT_BUDGET Table" shows the contents of the PROJ_DEPT_BUDGET table.

Table C-11 PROJ_DEPT_BUDGET Table

Column Name	Data Type, Default Value, and CHECK Constraints
YEAR *PRIMARY KEY*	INTEGER NOT NULL CHECK (YEAR >= 1993)

Table C-11 PROJ_DEPT_BUDGET Table (Continued)

Column Name	Data Type, Default Value, and CHECK Constraints
PROJ_ID (PROJNO) *PRIMARY KEY* *FOREIGN KEY - references* PROJECT (PROJ_ID)	CHAR(5) NOT NULL CHECK (VALUE = UPPER (VALUE))
DEPT_NO (DEPTNO) *PRIMARY KEY* *FOREIGN KEY - references* DEPARTMENT (DEPT_NO)	CHAR(3) NOT NULL CHECK (VALUE = ‘000’ OR (VALUE > ‘0’ AND VALUE <= ‘999’) OR VALUE IS NULL)
QUART_HEAD_CNT	ARRAY OF [1:4] INTEGER Nullable
PROJECTED_BUDGET (BUDGET)	DOUBLE PRECISION Nullable DEFAULT 50000 CHECK (VALUE > 10000 AND VALUE <= 2000000)

Table C-12, “COUNTRY Table” shows the contents of the COUNTRY table.

Table C-12 COUNTRY Table

Column Name	Data Type, Default Value, and CHECK Constraints
COUNTRY (COUNTRYNAME *PRIMARY KEY*	VARCHAR(15) NOT NULL
CURRENCY	VARCHAR(10) NOT NULL

The SALARY_HISTORY table contains a record for each time an employee’s salary changes. It is automatically maintained by the SAVE_SALARY_CHANGE trigger.

Table C-13, “SALARY_HISTORY Table” shows the contents of the SALARY_HISTORY table.

Table C-13 SALARY_HISTORY Table

Column Name	Data Type, Default Value, and CHECK Constraints
EMP_NO (EMPNO) *PRIMARY KEY* *FOREIGN KEY - references* EMPLOYEE (EMP_NO)	SMALLINT NOT NULL
CHANGE_DATE *PRIMARY KEY*	DATE NOT NULL DEFAULT ‘NOW’
UPDATER_ID *PRIMARY KEY*	VARCHAR(20) NOT NULL
OLD_SALARY (SALARY)	DOUBLE PRECISION NOT NULL DEFAULT 0 CHECK (VALUE > 0)

Table C-13 SALARY_HISTORY Table (Continued)

Column Name	Data Type, Default Value, and CHECK Constraints
PERCENT_CHANGE	DOUBLE PRECISION NOT NULL DEFAULT 0 CHECK (VALUE between -50 and 50)
NEW_SALARY	Computed by: (OLD_SALARY + OLD_SALARY * PERCENT_CHANGE / 100)

Appendix D

ODBC Driver

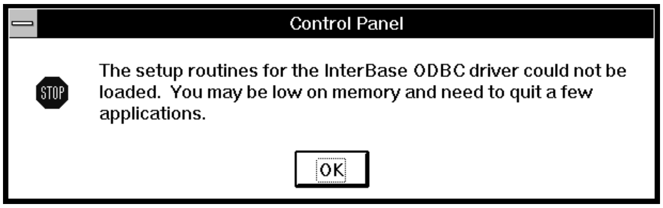
The Local InterBase Server includes an ODBC driver. The driver is implemented through Windows DLLs.

Important For more information on the InterBase ODBC driver, refer to the IBODBC.TXT "readme" file in the InterBase home directory.

System Requirements

The Local InterBase Server installation program asks if you want to install the InterBase ODBC driver. If you choose to install the InterBase ODBC driver, the installation program copies all necessary DLLs to the WINDOWS\SYSTEM directory, and set up Borland InterBase as the driver name and InterBase as the database source.

If you attempt to configure a data source and you do not have the INTERBASE directory on your path or the driver DLLs in your WINDOWS\SYSTEM directory, the following message appears:



Control Panel

The setup routines for the InterBase ODBC driver could not be loaded. You may be low on memory and need to quit a few applications.

ODBC Files

If you choose to install the InterBase ODBC driver, the following files are installed to the WINDOWS\SYSTEM directory (or WINNT\SYSTEM on Windows NT):

- ODBCADM.EXE - InterBase ODBC Administrator executable.

- ODBC.DLL, ODBCCURS.DLL, ODBCINST.DLL, BLBAS04.DLL, BLINT04.DLL, BLMDS04.DLL, BLUTIL04.DLL - InterBase ODBC dynamic link libraries.
- BLODBC.LIC - InterBase ODBC license file.
- BLINT04.HLP, ODBCINST.HLP - Online help files.

These files are installed in the WINDOWS directory (or WINNT on Windows NT):

- ODBC.INI, ODBCINST.INI

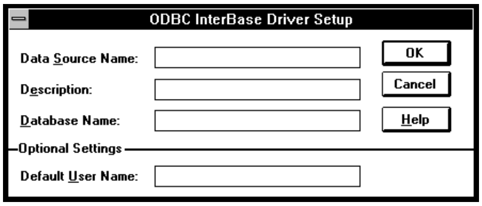
The IBODBC.TXT "Read Me" file is installed to the InterBase home directory.

These files require a total of approximately 560K.

Configuring Data Sources

If you have an ODBC administrator installed on your system, you can configure an InterBase data source as follows:

1. Start the ODBC Administrator by double-clicking on the ODBC icon in the Control Panel application in the Main program group. A dialog box with a list of data sources appears.
2. If you are configuring a new data source, click Add. A list of installed drivers appears. Select Borland InterBase, and click OK. If you are configuring an existing data source, select the data source name and click Setup. The Setup dialog box appears.



3. Specify values as follows:

   Data Source Name: identifies a single connection to an InterBase database system. This can be any string. Examples include "InterBase", "Accounting", or "InterBase-Serv1."

   Description: an optional long description of a data source name. For example, "My Accounting Database" or "InterBase on Server #1."

Database Name: the name of the database to which you want to connect, including server name, separator indicating network protocol, and full directory path. For TCP/IP, the separator is a colon (:). For Novell SPX, the separator is an at-sign (@). For NetBEUI, the separator is a backslash (\) and the server name must be preceded by a double backslash (\\).

For example, to connect to a database, EMPLOYEE.GDB, in the directory, \USERS\FRED, on a server named APTOS with TCP/IP, enter:

```
APTOS:\USERS\FRED\EMPLOYEE.GDB
```

To connect using Novell SPX, enter:

```
APTOS@\USERS\FRED\EMPLOYEE.GDB
```

To connect using NetBEUI/Named Pipes, enter:

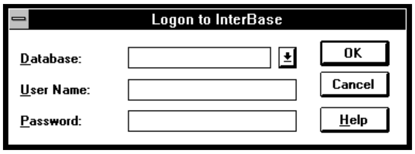
```
\\APTOS\C:\\USERS\FRED\EMPLOYEE.GDB
```

Default User Name: the default user name used to connect to your InterBase database system, for example, SYSDBA or GUEST. Your ODBC application may override this value or you may override this value in the Logon dialog box.

Note Users must be authorized with user names and passwords through Server Manager.

Connecting to a Data Source Using a Logon Dialog Box

Some ODBC applications display a Logon dialog box when you are connecting to a data source. For InterBase, the dialog box is as follows:



In this dialog box, do the following:

1. Enter the name of the server and database you want to access (case-sensitive) or click the arrow to the right of the box to select a server name you specified in the Setup dialog box. This must be a full connection string including the server name, the network protocol separator, directory path and database file name, as described in the previous section. For example, APTOS:\USERS\FRED\MYDB.GDB.
2. Enter your user name.

3. Enter your password for the system. It is case-sensitive.
4. Click OK to log on to the InterBase database system installed on the server you specified and to update the values in ODBC.INI.

Connecting to a Data Source Using a Connection String

If your application requires a connection string to connect to a data source, you must specify the data source name that tells the driver which section of ODBC.INI to use for the default connection information. Optionally, you may specify *attribute=value* pairs in the connection string to override the default values stored in ODBC.INI.

You can specify either long or short names in the connection string. The connection string has the form:

```
"DSN=data source name[;attribute=value[;attribute=value]...]"
```

An example of a connection string for InterBase is:

```
"DSN=ACCOUNTING;DB=APTOS:\USERS\FRED\PAYRLL;UID=JOHN;PWD=XYZZY"
```

The following table gives the long and short names for each attribute, as well as a description.

Table D-1: Connection String Attributes

Attribute	Description
DataSourceName (DSN)	A string that identifies a single Name connection to an InterBase database system. Examples include "Accounting" or "InterBase-Serv1." Setup label: Data Source Name.
Database (DB)	The name of the database system to which you want to connect. Setup label: Database Name.
LogonID (UID)	The case-sensitive user name used to connect to your InterBase database system. Setup label: Default User Name.
BinarySegmentSize (BSS)	Segment size used to create a binary BLOB. The size of the segment determines how many bytes the segment can hold. This value does not reflect the maximum size of the BLOB. Setup label: none.
CharSegmentSize (CSS)	Segment size used to create a text BLOB. BLOB data are stored in segments. The size of the segment determines how many bytes the segment can hold. This value does not reflect the maximum size of the BLOB. Setup label: none.

Table D-1: Connection String Attributes (Continued)

Attribute	Description
Password (PWD)	InterBase password for the specified server.

Data Types

The following table shows how the InterBase data types are mapped to the standard ODBC data types:

Table D-2: InterBase and ODBC Data Types

InterBase Data Type	ODBC Data Type
BLOB (SEGMENTSIZE , 0)	SQL_LONGVARBINARY
BLOB (SEGMENTSIZE , 1)	SQL_LONGVARCHAR
CHAR (LENGTH)	SQL_CHAR
DATE	SQL_DATE
DOUBLE PRECISION	SQL_DOUBLE
FLOAT	SQL_FLOAT
INTEGER	SQL_INTEGER
SMALLINT	SQL_SMALLINT
VARCHAR (MAX_LENGTH)	SQL_VARCHAR

The BLOB data types cannot be used in a WHERE clause and cannot be inserted into a column as a string. Arrays do not have an equivalent data type in ODBC and therefore are not supported.

Isolation and Lock Levels Supported

InterBase supports the following transaction isolation levels: READ COMMITTED, SNAPSHOT, and SNAPSHOT TABLE STABILITY. The default is SNAPSHOT. ODBC applications can use this isolation level by calling SQLSetConnectOption(1040,1).

The InterBase ODBC driver supports three transaction types. The default is SNAPSHOT isolation level. SNAPSHOT allows repeatable reads of database records.

Table D-3: ODBC and InterBase Transaction Levels

ODBC Model	InterBase Model
SQL_TXN_READ_UNCOMMITTED	READ UNCOMMITED isolation level. Not supported. InterBase does not provide any way of doing dirty reads.
SQL_TXN_READ_COMMITTED No dirty reads, phantom reads, non-repeatable reads allowed.	READ COMMITTED isolation level. Both types of Read Committed (NO RECORD_VERSION and RECORD_VERSION) provide the properties required of SQL_TXN_READ_COMMITTED.
SQL_TXN_SERIALIZABLE Serializable transactions. Dirty reads, non-repeatable reads, and phantoms not possible.	SNAPSHOT TABLE STABILITY isolation level. Transactions that reserve table-level locks at start of transaction are serializable. SNAPSHOT TABLE STABILITY does not have dirty reads, non-repeatable reads, or phantoms.
SQL_TXN_VERSIONING Transactions are serializable. More concurrency than with SQL_TXN_SERIALIZABLE	SNAPSHOT isolation level (default). Transactions reserve tables (placing shared read/write locks) on the required tables. This does not allow serializability, but provides benefits of versioning, and no dirty reads.

ODBC Conformance Level

The InterBase driver supports the Core, Level 1, and Level 2 API functions listed below.

Table D-4: ODBC Functions Supported

Core Functions	Level One Functions	Level Two Functions
SQLAllocConnect	SQLColumns	SQLDataSources
SQLAllocEnv	SQLDriverConnect	SQLDrivers
SQLAllocStatement	SQLGetConnectOption	SQLExtendedFetch
SQLBindCol	SQLGetData	SQLMoreResults
SQLCancel	SQLGetFunctions	SQLNativeSQL
SQLColAttributes	SQLGetInfo	SQLNumParams

Table D-4: ODBC Functions Supported (Continued)

Core Functions	Level One Functions	Level Two Functions
SQLConnect	SQLGetStmtOption	SQLProcedures
SQLDescribeCol	SQLGetTypeInfo	SQLPrimaryKeys
SQLDisconnect	SQLParamData	SQLSetScrollOptions
SQLError	SQLPutData	SQLTablePrivileges
SQLExecDirect	SQLSetConnectOption	
SQLExecute	SQLSetStmtOption	
SQLFetch	SQLSpecialColumns	
SQLFreeConnect	SQLStatistics	
SQLFreeEnv	SQLTables	
SQLFreeStmt		
SQLGetCursorName		
SQLNumResultCols		
SQLPrepare		
SQLRowCount		
SQLSetCursorName		
SQLSetParam		
SQLTransact		

The following table lists the connection options supported by the ODBC driver.

Table D-5: ODBC Connection Options

Supported	Not Supported
SQL_CURRENT_QUALIFIER	SQL_ACCESS_MODE
SQL_LOGIN_TIEMOUT	SQL_AUTOCOMMIT
SQL_PACKET_SIZE	SQL_ODBC_CURSORS
	SQL_OPT_TRACE
	SQL_OPT_TRACEFILE
	SQL_QUIET_MODE
	SQL_TRANSLATE_OPTION
	SQL_TXN_ISOLATION

The following table lists statement options supported by the ODBC driver.

Table D-6: ODBC Statement Options

Supported	Not Supported
SQL_ASYNC_ENABLE	SQL_BIND
SQL_CONCURRENCY	SQL_CURSOR_TYPE
SQL_KEYSET_SIZE	SQL_MAX_LENGTH
SQL_QUERY_TIMEOUT	SQL_MAX_ROWS
	SQL_NOSCAN
	SQL_RETRIEVE_DATA
	SQL_ROWSET_SIZE
	SQL_SIMULATE_CURSOR

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User’s Guide

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