InterBase® 15

Operations Guide

embarcadero®

© 2025 Embarcadero Technologies, Inc. Embarcadero, the Embarcadero Technologies logos, and all other Embarcadero Technologies product or service names are trademarks or registered trademarks of Embarcadero Technologies, Inc. All other trademarks are property of their respective owners.

Embarcadero tools are built for elite developers who build and maintain the world's most critical applications. Our customers choose Embarcadero because we are the champion of developers, and we help them build more secure and scalable enterprise applications faster than any other tools on the market. In fact, ninety of the Fortune 100 and an active community of more than three million users worldwide have relied on Embarcadero's award-winning products for over 30 years.

September, 2025

TABLE OF CONTENTS

INTRODUCTION TO OPERATIONS

Who Should Use this Guide 7
Topics Covered in this Guide 7
System Requirements and Server Sizing 7
Primary InterBase Features 8
About InterBase SuperServer Architecture 13
Overview of Command-line Tools 14

LICENSING (OPERATIONS GUIDE)

InterBase License Options 17
Using the License Manager 19

SERVER CONFIGURATION

Configuring Server Properties 22
Multi-Instance 24
SMP Support 29
Hyper-threading Support on Intel Processors 31
Using InterBase Manager to Start and Stop InterBase 31
Starting and Stopping the InterBase Server on UNIX 32
The Attachment Governor 37
Server Configuration Using Environment Variables 38
Managing Temporary Files 39
Configuring Parameters in ibconfig 41
Viewing the Server Log File 49

NETWORK CONFIGURATION

Network Protocols 51
Connecting to Servers and Databases 52
Encrypting Network Communication 65
Connection Troubleshooting 77
Communication Diagnostics 82

DATABASE USER MANAGEMENT

Security Model 88
The InterBase Security Database 90
Implementing Stronger Password Protection 92
Enabling Embedded User Authentication 94

System Table Security 96
SQL Privileges 98
Groups of Users 98
Other Security Measures 100
User Administration with IBConsole 101
User Administration With the InterBase API 105
Using gsec to Manage Security 105
Using gsec to Manage Database Alias 110
gsec Error Messages 111

DATABASE CONFIGURATION AND MAINTENANCE

Database Files 114
On-disk Structure (ODS) 120
Read-write and Read-only Databases 121
Creating Databases 123
Dropping Databases 126
Backup File Properties 126
Removing Database Backup Files 127
Shadowing 128
Setting Database Properties 135
Sweep Interval and Automated Housekeeping 137
Configuring the Database Cache 141
Forced Writes vs. Buffered Writes 143
Validation and Repair 144
Shutting Down and Restarting Databases 148
Limbo Transactions 151
Viewing the Administration Log 154
gfix Command-line Tool 155
gfix Error Messages 159
gfix Fixing a database 160

DATABASE BACKUP AND RESTORE

About InterBase backup and restore options 161
Performing backups and restores using the gbak command 163
Performing backups and restores using IBConsole 188

JOURNALING AND DISASTER RECOVERY

About Journals, Journal Files, and Journal Archives 203
Enabling Journaling and Creating Journal Files 207
Using Journal Archiving 213
Using a Journal Archive to Recover a Database 215
Managing Archive Size 215

Journaling Tips and Best Practices 217

DATABASE STATISTICS AND CONNECTION MONITORING

Monitoring with System Temporary Tables 223
Viewing Statistics using IBConsole 228
Monitoring Client Connections with IBConsole 235
The gstat Command-line Tool 236
Viewing Lock Statistics 240
Retrieving Statistics with isc database info() 242

INTERACTIVE QUERY

Managing isql Temporary Files 244
Executing SQL Statements 244
Using Batch Updates to Submit Multiple Statements 246
Inspecting Database Objects 250
Command-line isql Tool 254
isql Command Reference 264
Using SQL Scripts 299

DATABASE AND SERVER PERFORMANCE

Introduction to Database and Server Performance 305
Hardware Configuration 305
Operating System Configuration 310
Performance Considerations for a Network Configuration 311
Database Properties 312
Database Design Principles 316
Database Tuning Tasks 318
Application Design Techniques 321
Application Development Tools 324

MIGRATING TO INTERBASE

Migration Process 328
Migration Issues 329
Setting SQL Dialects 331
Features and Dialects 334
Migrating Servers and Databases 352
Migrating Databases to Dialect 3 355
Migrating Clients 362
Migrating Data from Other DBMS Products 364

INTERBASE LIMITS

Various InterBase Limits 365

INTRODUCTION TO OPERATIONS

The InterBase *Operations Guide* is a task-oriented reference of procedures to install, configure, and maintain an InterBase database server or Local InterBase workstation.

This chapter describes who should read this book, and provides a brief overview of the capabilities and tools available in the InterBase product line.

1. Who Should Use this Guide

The InterBase *Operations Guide* is for database administrators or system administrators who are responsible for operating and maintaining InterBase database servers. The material is also useful for application developers who wish to understand more about InterBase technology. The guide assumes knowledge of:

- Server operating systems for Windows, Linux, and UNIX
- Networks and network protocols
- Application programming

2. Topics Covered in this Guide

- Introduction to InterBase features
- Server configuration, startup and shutdown
- Network configuration and troubleshooting guidelines
- Security configuration for InterBase servers, databases, and data; reference for the security configuration tools
- Implementing stronger password protection
- Database configuration and maintenance options; reference for the maintenance tools
- Licensing: license registration tools, available certificates, the contents of the InterBase license file
- Backing up and restoring databases; reference for the backup tools
- Tracking database statistics and connection monitoring
- Interactive query profiling; reference for the interactive query tools
- Performance troubleshooting and tuning guidelines.
- Two appendices covering migration and the limits of a number of InterBase characteristics

3. System Requirements and Server Sizing

InterBase server runs on a variety of platforms, including Microsoft Windows server platforms, Linux, and several UNIX operating systems.

The InterBase server software makes efficient use of system resources on the server node. The server process uses little more than 1.9MB of memory. Typically, each client connection to the

server adds approximately 115KB of memory. This varies based on the nature of the client applications and the database design, so the figure is only a baseline for comparison.

The minimal software installation requires disk space ranging from 9MB to 12MB, depending on platform. During operation, InterBase sorting routine requires additional disk space as scratch space. The amount of space depends on the volume and type of data the server is requested to sort.

The InterBase client also runs on any of these operating systems. In addition, InterBase provides the InterClient Java client interface using the JDBC standard for database connectivity. Client applications written in Java can run on any client platform that supports Java, even if InterBase does not explicitly list it among its supported platforms. Examples include Internet appliances with embedded Java capabilities.

Terminology: Throughout this document set, "Windows server platforms" refers to the supported Windows Server versions. "Windows non-server platforms" refers to the supported Windows versions designed for personal computers.

For a list of supported Windows versions refer to System Requirements/Prerequisites.

4. Primary InterBase Features

InterBase offers all the benefits of a full-featured RDBMS. The following table lists some of the key InterBase features:

Feature	Description
Network protocol support	• All platforms of InterBase support TCP/IP • InterBase servers and clients for Windows support NetBEUI/named pipes
SQL-92 entry-level conformance	ANSI standard SQL, available through an Interactive SQL tool and Embarcadero desktop applications.
Simultaneous access to multiple databases	One application can access many databases at the same time.
multigenerational architecture	Server maintains older versions of records (as needed) so that transactions can see a consistent view of data.
Optimistic row-level locking	Server locks only the individual records that a client updates, instead of locking an entire database page.

Feature	Description
Query optimization	Server optimizes queries automatically, or you can manually specify a query plan.
Blob data type and Blob filters	Dynamically sizeable data types that can contain unformatted data such as graphics and text.
Declarative referential integrity	Automatic enforcement of cross-table relationships (between `FOREIGN` and `PRIMARY KEY` constraints).
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.
Event alerters	Messages passed from the database to an application; enables applications to receive asynchronous notification of database changes.
Updatable views	Views can reflect data changes as they occur.
User-defined functions (UDFs)	Program modules that run on the server.
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 client reading a table does not block others from it.
multidimensional arrays	Column data types arranged in an indexed list of elements.
Automatic two-phase commit	Multi-database transactions check that changes to all databases happen before committing (InterBase Server only).

Feature	Description
InterBase API	Functions that enable applications to construct SQL/DSQL statements directly to the InterBase engine and receive results back.
`gpre`	Preprocessor for converting embedded SQL/DSQL statements and variables into a format that can be read by a host-language compiler; included with the InterBase server license.
IBConsole	Windows tool for data definition, query, database backup, restoration, maintenance, and security.
`isql`	Command-line version of the InterBase interactive SQL tool; can be used instead of IBConsole for interactive queries.
Command-line database administrator utilities	Command-line version of the InterBase database administration tools; can be used instead of IBConsole.
Header files	Files included at the beginning of application programs that define InterBase data types and function calls.
Example make files	Files that demonstrate how to invoke the makefiles to compile and link InterBase applications.
Example programs	C programs, ready to compile and link, which you can use to query standard InterBase example databases on the server.
Message file	`interbase.msg`, containing messages presented to the user.

4.1. SQL SUPPORT

InterBase conforms to entry-level SQL-92 requirements. It supports declarative referential integrity with cascading operations, updatable views, and outer joins. InterBase Server provides libraries that support development of embedded SQL and DSQL client applications. On all InterBase platforms, client applications can be written to the InterBase API, a library of functions with which to send requests for database operations to the server.

InterBase also supports extended SQL features, some of which anticipate SQL99 extensions to the SQL standard. These include stored procedures, triggers, SQL roles, and segmented Blob support.

For information on SQL, see the Language Reference Guide.

4.2. Multiuser Database Access

InterBase enables many client applications to access a single database simultaneously. A client applications can also access the multiple databases simultaneously. SQL triggers can notify client applications when specific database events occur, such as insertions or deletions.

You can write user-defined functions (UDFs) and store them in an InterBase database, where they are accessible to all client applications accessing the database.

4.3. 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 appears to be unchanged except for the changes made by the transaction. Records deleted by another transaction exist, newly stored records do not appear to exist, and updated records remain in the original state.

For information on transaction management, see the Embedded SQL Guide.

4.4. Multigenerational 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 multigenerational architecture, which creates and stores multiple versions of each data record. By creating a new version of a record, InterBase allows all clients 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.

4.5. Optimistic Row-level Locking

Optimistic locks are applied only when a client actually updates data, instead of at the beginning of a transaction. InterBase uses optimistic locking technology to provide greater throughput of database operations for clients.

InterBase implements true row-level locks, to restrict changes only to the records of the database that a client changes; this is distinct from page-level locks, which restrict any arbitrary data that is stored physically nearby in the database. Row-level locks permit multiple clients to update data that is in the same table without coming into conflict. This results in greater throughput and less serialization of database operations.

InterBase also provides options for pessimistic table-level locking. See the Embedded SQL Guide for details.

4.6. Database Administration

InterBase provides both GUI and command-line tools for managing databases and servers. You can perform database administration on databases residing on Local InterBase or InterBase Server with IBConsole, a Windows application running on a client PC. You can also use command-line database administration utilities on the server.

IBConsole and command-line tools enable the database administrator to:

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

You can find more information on server security later in this chapter, and later chapters describe individual tasks you can accomplish with IBConsole and the command-line tools.

4.6.1. 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 InterBase security database (`admin.ib` by default), on the server.

Note:
Starting with version XE7 InterBase implements stronger password protection on InterBase databases. See Implementing Stronger Password Protection.

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

For information about managing server security, see Database User Management.

4.6.2. Backing Up and Restoring Databases

You can backup and restore a database using IBConsole or command-line `gbak`. A backup can run concurrently with other processes accessing the database 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 multifile
- Transferring a database from one operating system to another
- Backing up only a database's metadata to recreate an empty database

For information about database backup and recovery, see About InterBase backup and restore options.

4.6.3. Maintaining a Database

You can prepare a database for shutdown and perform database maintenance using either IBConsole or the command-line utilities. 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 off-line.

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

For information about database maintenance, see Database Configuration and Maintenance.

4.6.4. Viewing Statistics

You can monitor the status of a database by viewing statistics from the database header page, and an analysis of tables and indexes. For more information, see Database Statistics and Connection Monitoring.

5. About InterBase SuperServer Architecture

InterBase uses SuperServer architecture: a multi-client, multi-threaded implementation of the InterBase server process. SuperServer replaces the Classic implementation used for previous versions of InterBase. SuperServer serves many clients at the same time, using threads instead of separate server processes for each client. Multiple threads share access to a single server process.

6. Overview of Command-line Tools

For each task that you can perform in IBConsole, there is a command-line tool that you can run in a command window or console to perform the same task.

The UNIX versions of InterBase include all of the following command-line tools. The graphical Windows tools do not run on a UNIX workstation, though you can run most of the tools on Windows to connect to and operate on InterBase databases that reside on UNIX servers.

An advantage of noninteractive, command-line tools is that you can use them in batch files or scripts to perform common database operations. You can automate execution of scripts through the scheduling facility of your operating system(`cron` on UNIX, `AT` on Windows). It is more difficult to automate execution of graphical tools.

6.1. isql

The `isql` tool is a shell-type interactive program that enables you to quickly and easily enter SQL statements to execute with respect to a database. This tool uses InterBase Dynamic SQL mechanism to submit a statement to the server, prepare it, execute it, and retrieve any data from statements with output (for example, from a `SELECT` or `EXECUTE PROCEDURE`). `isql` manages transactions, displays metadata information, and can produce and execute scripts containing SQL statements.

See Interactive Query for full documentation and reference on `isql` and using `isql` from IBConsole.

6.2. gbak

The `gbak` tool provides options for backing up and restoring databases. `gbak` now backs up to multiple files and restores from multiple files, making it unnecessary to use the older `gsplit` command. Only `SYSDBA` and the owner of a database can back up a database. Any InterBase user defined on the server can restore a database, although the user must be `SYSDBA` or the database owner in order to restore it *over* an existing database.

Note:
When you back up and restore databases from IBConsole on Windows platforms, you are accessing this same tool through the IBConsole interface.

See About InterBase backup and restore options for full documentation and reference on using `gbak`.

6.3. gfix

`gfix` configures several properties of a database, including:

- Database active/shutdown status
- Default cache allocation for clients
- Sweep interval and manual sweep
- Synchronous or asynchronous writes
- Detection of some types of database corruption
- Recovery of unresolved distributed transactions

You can also access all the functionality of `gfix` through the IBConsole graphical interface. Only SYSDBA and the owner of a database can run `gfix` against that database.

See Database Configuration and Maintenance for descriptions of these properties, and a reference of the `gfix` tool.

6.4. gsec

You can configure authorized users to access InterBase servers and databases with `gsec`. You can also perform the same manipulations on the security database with IBConsole.

See Database User Management for full details and reference.

6.5. gstat

`gstat` displays some database statistics related to transaction inventory, data distribution within a database, and index efficiency. You can also view these statistics from IBConsole. You must be `SYSDBA` or the owner of a database to view its statistics.

See Database Statistics and Connection Monitoring for more information on retrieving and interpreting database statistics.

6.6. iblockpr (gds_lock_print)

Note:
The gds_lock_print utility is deprecated and is not included with some versions of InterBase.

You can view statistics from the InterBase server lock manager to monitor lock request throughput and identify the cause of deadlocks in the rare case that there is a problem with the InterBase lock manager. The utility is called `gds_lock_print` on the UNIX platforms, and `iblockpr` on the Windows platforms.

See Database Statistics and Connection Monitoring for more information on retrieving and interpreting lock statistics.

6.7. ibmgr

On UNIX servers, use the `ibmgr` utility to start and stop the InterBase server process. See the section Using ibmgr to Start and Stop the Server for details on using this utility.

LICENSING (OPERATIONS GUIDE)

This chapter summarizes the licensing provisions and add-ons available for InterBase products. The licensing information in this chapter is not meant to replace or supplant the information in the much more detailed license agreement you receive at the time of purchase. Instead, this chapter summarizes general licensing terms and options.

To activate and use an InterBase product, you must register it when you install it or soon after. For detailed instructions on how to install InterBase products, see the **IBsetup.html** file that you receive upon purchase.

This chapter also provides basic instructions on how to use the **InterBase License Manager** to view existing license information for the products you have purchased, to register those products if you have not already, and to view additional add-ons licenses.

1. InterBase License Options

This section summarizes the license provisions and add-on options available for each InterBase product. For the purposes of this chapter, an "add-on" refers to an InterBase feature or option you can purchase to "add-on" to the InterBase product(s) you have already purchased. Each add-on comes with its own license agreement. To purchase an InterBase add-on, see your sales or Value-Added Reseller () representative, or go to the Embarcadero.com website.

To view available InterBase add-ons and licenses, you can use the InterBase License Manager, which installs with your product. For more information, see Using the License Manager.

Note:
To distribute the InterBase software to third parties as bundled with your own software application or installed on your hardware, you must contact Embarcadero Technologies and enter into an Original Equipment Manager (OEM) license agreement.

1.1. Server Edition

InterBase Server Edition software provides strong, symmetric multiple processing support, and robust database and server monitoring facilities.

The InterBase Server Edition License allows you to:

- Install Server Edition software on a single computer.
- Make up to four (4) connections per user to the machine on which the server software is running.

- The provisions for each server license are specific to the single computer for which the server software is licensed. For example, if you purchase two server licenses for 20 users each, you cannot increase the number of licensed users to 40 on a single instance of the server. Please use "Add-on" licenses to increase the user capacity per instance of InterBase server.

> **Note:**
> You can use the same serial number to install and register Server Edition software on a second computer for backup purposes as long as the second computer is not used concurrently with the primary installation.

Add-ons available for the Server Edition

The following add-ons are available for the Server Edition:

- **InterBase Simultaneous User License**

To connect users to Server Edition software, you must purchase as many Simultaneous User Licenses as you have simultaneous users wanting to connect to that server instance. For example, if 10 different end users connect to the database server, you must first purchase 10-User Simultaneous User licenses. Each user count in this Simultaneous User License allows a single user up to four (4) connections to the Server software.

- **InterBase Unlimited Users License**

Use this license to allow an unlimited number of users to access the software. To enable your users to connect to the Server Edition software via an unrestricted-access Internet application, you must purchase an Unlimited User License.

- **InterBase Additional CPUs License**

Every license certificate you purchase allows you to install and execute the software on one computer with up to eight (8) CPUs for each license. The Additional CPUs license enables an additional 8 CPU cores per license up to a limit of 32 on the system.

1.2. Developer Edition

The Developer Edition License is limited to use of the Server Edition for development purposes only, using solely client applications executing on the same, single computer as the server. This license grants no rights for use in a production environment.

There are no add-ons available for the Developer Server Edition.

1.3. Desktop Edition

The InterBase Desktop Edition is an InterBase database server designed to run in a stand-alone environment for use by a single end user. You can deploy the Desktop Edition on a desktop, laptop, or other mobile computer.

The InterBase Desktop Edition license enables you to:

- Install a single copy of the Desktop Edition on a single computer for your internal data processing needs only
- Log into the same computer on which the software is running and make up to eight (8) connections to the InterBase Desktop Edition software.

There are no add-ons available for the Desktop Server Edition.

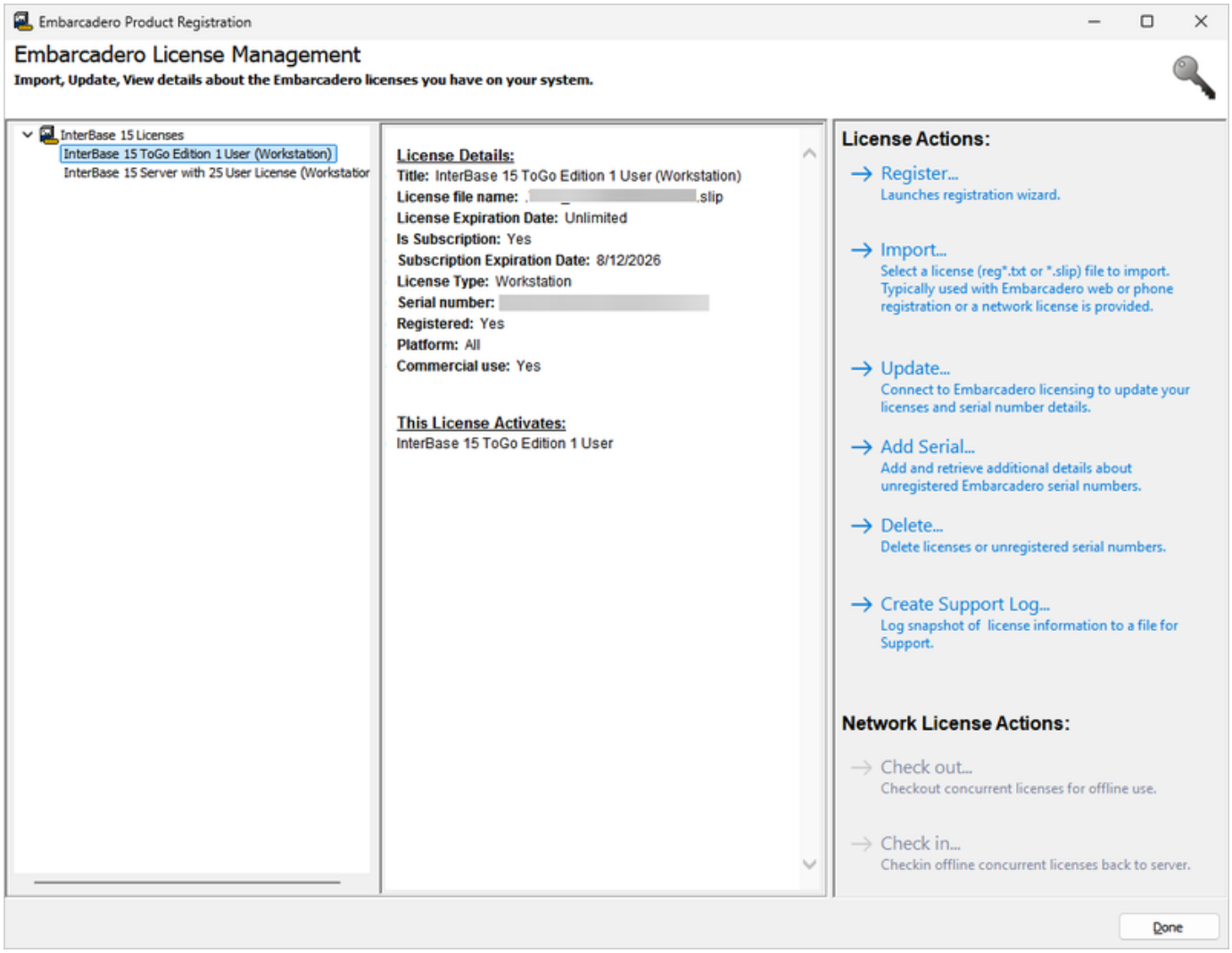
1.4. ToGo Edition

The InterBase ToGo Edition is a small, portable version of the Desktop Edition, and is designed to run in a stand-alone environment. Refer to System Requirements/Prerequisites for a list of supported platforms.

The InterBase ToGo license enables the purchaser to:

- Deploy applications that are embedded with the InterBase ToGo engine (available in a shared library).
- Deploy ToGo Edition software on a standalone computer for use by a single end user.

2. Using the License Manager



A separate **License Manager** tool installs with the Desktop, ToGo, and Server Editions. to view existing license information for the products you have purchased, to register those products if you have not already, and to view additional licenses for add-ons.

If your Linux or Solaris environment does not support the GUI installer, you can use the command-line tool to register additional options and licenses. For information on how to do so, see the **IBsetup.html** file.

Important:
In versions of InterBase prior to 2007, you could access an older version of the License Manager from IBConsole. Because the IBConsole version of License Manager does not contain up-to-date licensing information and options, including add-ons, we recommend that you use only the separate InterBase License Manager tool to purchase new licenses. For more information on licenses refer to Installation, Registration, and Licensing Information.

2.1. Accessing the License Manager

To access the separate InterBase License Manager tool, do the following:

1. From the Start menu, select **Programs > Embarcadero InterBase 15 > License Manager**. The License Manager window opens.
2. To view and select the add-ons available for the InterBase product you are using, click on the Serial menu and select Add.
3. When the Add Serial Number dialog opens, type in your serial number and click OK. The License Manager displays licensing information and allows you to register the product you purchased if you have not done so already.

SERVER CONFIGURATION

This chapter describes the operation and configuration of the InterBase server process, including the following topics:

1. Configuring Server Properties

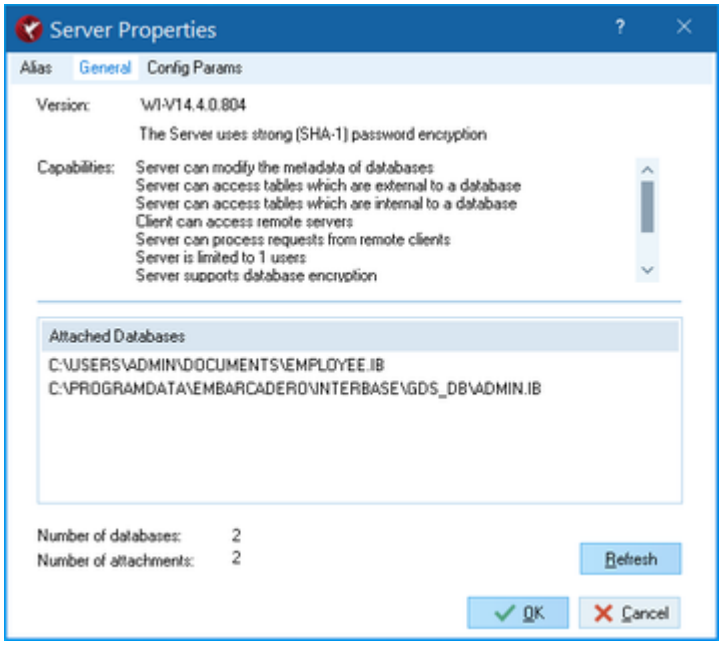
You can use InterBase Manager to change database cache size of client map size. The InterBase Guardian Server Properties dialog enables you to display and configure these server settings. To access InterBase Guardian, right-click the InterBase Guardian icon in the System Tray. You can access the Server Properties dialog by any of the following methods:

- Select a server (or any branch under the server hierarchy) in the Tree pane and choose Server|Server Properties.
- Select a server in the Tree pane and click Server Properties in the Work pane.
- Right-click a server in the Tree pane and choose Server Properties from the context menu.

The Server Properties dialog contains two tabs, Alias and General.

1.1. The General Tab

The General tab of the Server Properties dialog is where you can view such server settings as the version, capabilities, number of databases, and number of attachments. You cannot edit the information displayed on this tab.



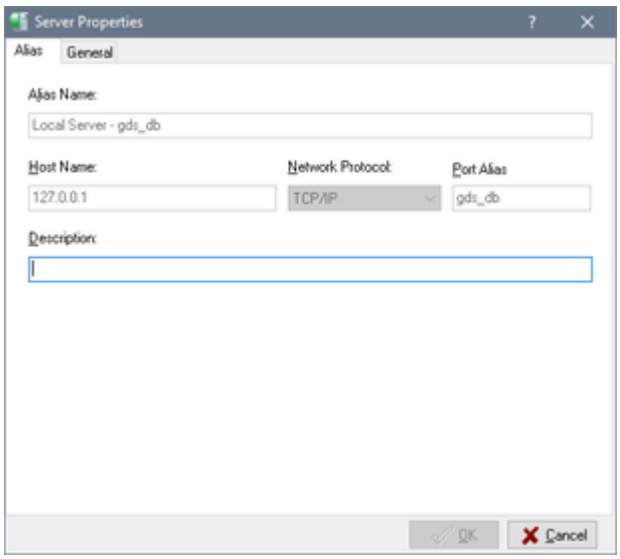
The server properties displayed are:

- **Version**: displays the version number for the InterBase Server.
- **Capabilities**: displays support capabilities for the InterBase Server.
- **Attached databases**: displays the path and filename for each attached database
- **Number of databases**: displays the total number of databases in the InterBase Server.
- **Number of attachments**: displays the total number attachments to the InterBase Server.

You cannot update the information displayed on the General tab; however, you can click Refresh at any time to retrieve the current server property information. If you need to view or configure server settings, click the IB Settings tab.

1.2. The Alias Tab

On the Alias tab, you can inspect the host name and network protocol for the server. You can inspect and change the Alias name and description.



- **Alias Name**: the name of the server as it appears in the Tree pane. This setting is editable.
- **Host Name**: the name of the host server. This is determined at the time you create the server connection and cannot be changed in this dialog.
- **Network Protocol**: the protocol that the server is using to communicate. This is determined at the time you create the server connection and cannot be changed in this dialog.
- **Description**: any additional information you wish to add about the server. This field is optional and editable.

See Also

- Using InterBase Manager to Start and Stop InterBase
- Using Environment Variables
- Managing Temporary Files

2. Multi-Instance

InterBase allows multiple instances of InterBase servers to run simultaneously, you can run one previous version along side a newer version simultaneously.

multi-instance in general terms set IB_PROTOCOL environment variables so their application can target the proper InterBase instance

> **Note:**
> Make sure to select the proper Multi-instance option during install and select a unique TCP/IP port for the InterBase instance.

2.1. Windows Server Setup

Start the server as an application with the following switches on a Windows machine.

```
ibserver -a -p service_name -i interbase_env_variable
```

The service_name is the entry contained in the services file pointing to the port number which the InterBase server should bind to. Below is an example of a part of the file from the <system directory>\drivers\etc\services file.

```
gds_db 3050/tcp #default interbase port number
ib__a 3051/tcp # A's interbase port number
```

The InterBase environment variable or the -i switch is used for local connections. These values determines which InterBase server a client on the same machine will connect to. The InterBase environment variable for a client and server's -i switch must match to have a successful connection. So if InterBase server is started with the setting:

```
ibserver -a -p ib__a -i C:\Embarcadero\InterBase
```

The InterBase server will accept remote connections on the TCP/IP port number 3051 as the service ib__a is set to port 3051. The local connections will be accepted from client on the same machine who have their InterBase environment variable set to C:\Program Files\interbase.

Older versions of InterBase servers (pre-7.5) can still run using the default setting. These pre-7.5 InterBase servers will accept remote connections on TCP/IP port number 3050. The local connections will be accepted when the client uses a pre-7.5 interbase client library.

We recommend using the -i switch to set the local InterBase variable for the server. The order in which InterBase server looks for the InterBase environment variable is as follow; Command line

argument '-i', InterBase environment variable setting, InterBase Registry key setting, Server's current directory.

2.2. Accessing Remote Databases

2.2.1. Client Side Settings to Access Remote Databases

In order to connect to a specific InterBase server on a machine you need to identify the server you want to connect to.

2.2.2. Remote Servers

In order to access the database database_name.ib located in the directory database_dir. On a remote machine remote_host accepting connections on a port number specified by a service_name on the client machine. The database name specified in isql, the client API or any InterBase driver should be remote_host/service_name:/database_dir/database_name.ib

Assume that a remote client application wants to access windows server running on a machine called remote_host running 2 servers with the example configuration specified above. The client machine will need to have the same service name set as the server, so the services file will need to have these entries:

```
gds_db 3050/tcp #default interbase port number
ib__a 3051/tcp # A's interbase port number
```

In order to access an InterBase server running on the 3051 port number, use the following database connection string (through isql or through the API) `remote_host/3051:c:\database_dir\ib80test.ib.`

For older clients specify the service name which is bound to the port number on which the older server is listening e.g. `remote_host/gds_db:c:\database_dir\ib71test.ib`

2.3. Accessing Local Databases

Note:
Windows platform only.

In order to access a database on a local InterBase server, InterBase depends on the InterBase Environment variable to identify the server to be connected to. A pre-7.5 InterBase server running will be connected to if no server with the InterBase environment variable setting is running.

In order to access an older server make sure that your application uses the older gds32.dll. To access a older server using a 7.5 InterBase client library make sure your InterBase environment variable is set to a empty string "".

Applications can also pass in the information regarding the InterBase server they want to attach to as part of the InterBase database parameter block (isc_dpb parameter). Setting the isc_dpb_client_interbase_var followed by the length and the location of the InterBase server will allow the user to specify the InterBase server to be used. The following code demonstrates how a client should set the dpb parameter to attach to a InterBase server running with the InterBase environment variable set to "c:/interbase"

```
#include <ibase.h>
…
char dpb_buffer[256], dpb;
short dpb_length;
char *ib_server = "c:/interbase";
char *str = "employee.ib";
isc_db_handle db1;
ISC_STATUS status_vector[20];
/* construct the dpb, specifing the IB server to attach to */
dpb = dpb_buffer;
*dpb++ = isc_dbp_version;
*dpb++ = isc_dpb_client_interbase_var;
*dpb++ = strlen(ib_server);
strcpy (dpb, ib_server);
/* set other dpb parameters */
…
/* set the dpb_length as usual */
dpb_length = dpb - dpb_buffer;
/* finally call isc_attach or create with the dpb parameters */
isc_attach_database(status_vector, strlen(str), str, &db1, dpb_length,
dpb_buffer);
```

2.4. Automatic Rerouting of Databases

Once multiple instance of InterBase servers are running on a machine simultaneously, this feature will allow setups where some database connections can be re-routed to a different InterBase server. The user will have to manually start the different instance of InterBase as an application or service.

2.4.1. Server Side Setup

In order to setup simultaneous InterBase servers on a machine follow the instructions specified above. Once these machines are set up, and running, follow the instructions below to setup and use the DB_ROUTE database table in the ADMIN.IB.

The structure of the DB_ROUTE table is as follows:

Column Name	Data type	Length	Description
DB_NAME	CHAR	1024	Complete name of the database to be rerouted, including the path of the database on the server. e.g. Server_Name:DATABASE_DIR\EMPLOYEE.Ib
SERVICE_NAME	CHAR	30	Service name to look up in the services file for the port number to be re-routed to. The look up takes place at the server side, the client is only aware of the port number and not the service name. e.g. ib__a
ACTIVATE_ROUTE	BOOLEAN		Set to true if this re-routing is active, flase it this re-routing is disabled.

The service name that is entered in the set DB_ROUTE table must exist in the services file:

```
gds_db 3050/tcp #default interbase port number
ib__a 3051/tcp # A's interbase port number
```

2.4.2. Client Side Settings for Automatic Rerouting of Databases

No client side settings are required. In order to access the database database_name.ib located in the directory database_dir. On a remote machine remote_host accepting connections on a default port number. The database name specified in the client API or any InterBase driver would be REMOTE_HOST:DATABASE_DIR\DATABASE_NAME.IB.

In order to setup the database server AGNI so that it can re-route in coming connections, for the database c:\smistry\employee.ib to an older server running on port number specified by the service ib__a. The ADMIN.IB database on server AGNI will need the following row of information in DB_ROUTE table.

DB_ROUTE Column Name	Value
DB_NAME	Server_Name:DATABASE_DIR/EMPLOYEE.IB
SERVICE_NAME	ib__a
ACTIVATE_ROUTE	TRUE

Since the DB_ROUTE is a regular InterBase table in the ADMIN.IB database, you can use regular SQL to enter, modify or remove database re-routing from information.

2.5. Startup Parameters

To accommodate multiple instances of InterBase running on the same machine the InterBase Guardian and Server now have label names as part of their Service names.

- InterBase %Service Name% Guardian, i.e. InterBase 2020 server1 Guardian
- InterBase (%Service Name%) Server, i.e. InterBase 2020 server1 Server

The InterBase Server and Guardian have two new command line arguments:

```
-i %interbase_INSTALL_DIR% -p %SERVICE NAME%
```

Command line arguments are called start parameters as far as starting the applications are concerned.

If you write to the Microsoft auto run registry key entry you will need to do the same to the `/SOFTWARE/MICROSOFT/WINDOWS/CURRENTVERSION/RUN` registry key setting too.

Currently the registry key is:

`InterBaseGuardian`.

Change this to:

`InterBaseGuardian%SERVICE NAME%`

The value of this registry key is currently:

`%interbase_INSTALL_DIR%/bin/ibguard -a`.

Change this to:

```
%interbase_INSTALL_DIR%/bin/ibguard -a -i %interbase_INSTALL_DIR% -
p %SERVICE NAME%
```

3. SMP Support

InterBase provides symmetric multiprocessor (SMP) support for both clients and servers. Older versions of InterBase ran on SMP systems safely by allowing only a single processor at a time to execute within the InterBase components. Current versions of InterBase exploit SMP hardware by running InterBase threads on all processors simultaneously for increased throughput and performance.

> **Important:**
> When you purchase a single server license, you acquire the right to use a single processor. You must purchase one additional license for each additional processor that you wish to use.

On Windows platforms, the `CPU_AFFINITY` setting in the `ibconfig` configuration file specifies which processors of a multiprocessor system InterBase should use. The default setting, in effect when `CPU_AFFINITY` is commented out, is to use as many processors as licensing permits. See Expanded Processor Control: CPU_AFFINITY below for how to specify a subset of processors to use.

3.1. Expanded Processor Control: CPU_AFFINITY

On Windows multiprocessor platforms, you can specify which processors InterBase should use by adding the `CPU_AFFINITY` parameter to the `ibconfig` file. This setting is useful whenever the number of licensed processors is less than the number of actual processors present.

> **Important:**
> Note that when you purchase a single server license, you acquire the right to use a single processor. You must purchase one additional license for each additional processor that you wish to use.

The `CPU_AFFINITY` parameter populates a bit vector in which each bit represents a processor on the system on which the threads are allowed to run. The maximum number of processors depends on the operating system. To specify which processors should be used, give `CPU_AFFINITY` a decimal value that corresponds to the binary value that results from setting a bit for each desired machine. For example, to use processors 2 and 3, set `CPU_AFFINITY` to 6:

```
CPU_AFFINITY 6
```

To use these processors	CPU_AFFINITY value	Array setting
1	1	0 0 1
2	2	0 1 0
1 and 2	3	0 1 1
3	4	1 0 0
2 and 3	6	1 1 0
1, 2, and 3	7	1 1 1

3.2. ibconfig Parameter: MAX_THREADS

Setting the `MAX_THREADS` parameter in `ibconfig` controls the maximum number of threads that can be active at one time within the InterBase engine. The default setting is 100:

```
MAX_THREADS 100
```

This configuration parameter controls the number of active threads in the engine. The ideal setting for this number depends partly on the nature of the work being performed by your clients. If you have many clients performing very similar tasks, you may want to lower the `MAX_THREADS` setting to reduce contention. On the other hand, if simultaneous activity is highly diverse, setting this to a higher value may increase throughput.

Note that this setting does not affect the maximum possible threads that can be created by the InterBase server but only the number that can be active in the engine at one time.

3.3. ibconfig Parameter: THREAD_STACK_SIZE_MB 2

This parameter controls the stack size of various threads in InterBase. The value is in multiple of MBs per thread. The valid range is 2MB to 32MB. If it is set beyond the range, the value defaults to 2MB.

You should not have to change this parameter for normal use of InterBase. In extremely rare cases of abnormal termination of the process, the reason might be thread stack space constraints

due to high levels of recursive calls (of stored procedures and such). Feel free to increase this value then.

- The default setting on 32-bit Editions is 2 (2 MB).
- The default setting on 64-bit Editions is 4 (4 MB).

4. Hyper-threading Support on Intel Processors

InterBase can support hyper-threading on Intel processors that support logical processors using Intel hyperthreading technology. To enable this support in the InterBase server, you must make a setting in the InterBase configuration file, `ibconfig`. If you are running the InterBase server on a machine with hyper-threaded processors, edit the `ENABLE_HYPERTHREADING` parameter in the configuration file. By default, this parameter is set to zero. Set the value to 1 to allow the InterBase server to use hyperthreaded processors.

5. Using InterBase Manager to Start and Stop InterBase

The InterBase Server and InterBase Guardian must be started before you enable database connections. On Windows platforms, you can use the InterBase Manager to start and stop the InterBase Server and Guardian. In previous versions of InterBase the InterBase Manager is a Windows Control Panel applet. Now the InterBase Manager is an application installed for each instance of the InterBase Server installed. To start the InterBase Manager, choose **Start| Programs|<InterBase install directory>**. You can use InterBase Manager to do the following:

- Choose the server startup mode: whether to start the InterBase server manually, or have it start automatically at system boot time.
- Change the path to the server: if you click the Change option, you can browse and select a different directory.
- Change how InterBase Server operates. By default, InterBase runs automatically as a service on Windows platforms, though it is possible (but not recommended) to run it as an application.

Note:
To start InterBase Server as an application from a command prompt or in a batch file, invoke InterBase Guardian with the following options:

```
ibguard -a -p service_name -i interbase_env_variable
```

Options: Start and Stop InterBase Commands are:

Command/option	Description
-a	Start as application.

Command/option	Description
-i	Environment variable; identifies the Server location for clients that want to connect locally to the Server.
-p	Port number; where the **<service_name>** is the entry in the services file pointing to the port number where InterBase Server listens for connection requests from clients.

InterBase Guardian starts the server, and places an icon in the System Tray.

- Start InterBase Server and InterBase Guardian, via a Start/Stop button. Click Start in the InterBase Manager Status area to start InterBase Server (and InterBase Guardian). The server status changes, and an InterBase Guardian icon appears in the system tray. Once you have started the InterBase Server, you can exit InterBase Manager, and both InterBase Server and InterBase Guardian will continue to run. The InterBase Guardian icon remains in the System Tray until you stop the server.
- Stop InterBase Server and InterBase Guardian, via a Start/Stop button. Click Stop in the InterBase Manager Status area to stop InterBase Server (and InterBase Guardian). Or, right-click the InterBase Guardian icon in the System Tray and choose Shutdown.

6. Starting and Stopping the InterBase Server on UNIX

The following sections describe how to start and stop the InterBase server on UNIX.

6.1. Using ibmgr to Start and Stop the Server

The InterBase Server and InterBase Guardian must be started before you enable database connections. On Windows platforms, you can use the InterBase Manager to start and stop the InterBase Server and Guardian. In previous versions of InterBase, the InterBase Manager is a Windows Control Panel applet. Now the InterBase Manager is an application installed for each instance of the InterBase Server installed. To start the InterBase Manager, choose **Start > Programs > InterBase install directory**. You can use InterBase Manager to do the following:

- Choose the server startup mode: whether to start the InterBase server manually, or have it start automatically at system boot time.
- Change the path to the server: if you click the Change option, you can browse and select a different directory.
- Change how InterBase Server operates. By default, InterBase runs automatically as a service on Windows platforms, though it is possible (but not recommended) to run it as an application.

Note:
To start InterBase Server as an application from a command prompt or in a batch file, invoke InterBase Guardian with the following options:

```
ibguard -a -p service_name -i interbase_env_variable
```

Options: Start and Stop InterBase Commands are:

Command/option	Description
-a	Start as application
-i	Environment variable; identifies the Server location for clients that want to connect locally to the Server.
-p	Port number; where the **<service_name>** is the entry in the services file pointing to the port number where InterBase Server listens for connection requests from clients.

InterBase Guardian starts the server and places an icon in the System Tray.

- Start InterBase Server and InterBase Guardian, via a Start/Stop button. Click Start in the InterBase Manager Status area to start InterBase Server (and InterBase Guardian). The server status changes, and an InterBase Guardian icon appears in the system tray. Once you have started the InterBase Server, you can exit InterBase Manager, and both InterBase Server and InterBase Guardian will continue to run. The InterBase Guardian icon remains in the System Tray until you stop the server.
- Stop InterBase Server and InterBase Guardian, via a Start/Stop button. Click Stop in the InterBase Manager Status area to stop InterBase Server (and InterBase Guardian). Alternatively, right-click the InterBase Guardian icon in the System Tray and choose Shutdown.

6.2. Starting the Server

To start the InterBase server, log in as the "root" or "interbase" user. ("interbase" is a synonym for "InterBase," to accommodate operating systems that do not support nine-character account names.) For example, start InterBase with the following command:

```
ibmgr -start -p service_name
```

Note:
Once you have started `ibserver` using one login, such as "root," be aware that all objects created belong to that login. They are not accessible to you if you later start `ibserver` as one of the other two ("interbas" or "InterBase"). It is highly recommended to run the InterBase Server as "InterBase." If the -p option is not specified, the default of gds_db is used.

6.3. Stopping the Server

Note:
For safety, make sure all databases have been disconnected before you stop the server.

The command switches `-user` and `-password` can be used as option switches for commands like `-start` or `-shut`. For example, you can shut down a server in any of the following ways:

```
ibmgr -shut -password password
```

or

```
ibmgr u
IBMGR> shut -password password
```

or

```
imbgr u
IBMGR> password password
IBMGR> shut
```

Note:
The `-shut` option rolls back all current transactions and shuts down the server immediately. If you need to allow clients a grace period to complete work and detach gracefully, use shutdown methods for individual databases. See Shutting Down and Restarting Databases.

6.4. Starting the Server Automatically

To configure a UNIX server to start the InterBase Server automatically at server host boot-time, you must install a script that the `rc` initialization scripts can run. Refer to `/etc/init.d/README` for more details on how UNIX runs scripts at boot-time.

Example initialization script:

```
#!/bin/sh
# ibserver.sh script - Start/stop the InterBase daemon
# Set these environment variables if and only if they are not set.
: ${InterBase:=/usr/interbase}
# WARNING: in a real-world installation, you should not put the
# SYSDBA password in a publicly-readable file. To protect it:
# chmod 700 ibserver.sh; chown root ibserver.sh
export InterBase

ibserver_start() {
 # This example assumes the InterBase server is
# being started as UNIX user 'InterBase'.
echo '$InterBase/bin/ibmgr -start -forever' |su InterBase
}

ibserver_stop() {
 # No need to su.
$InterBase/bin/ibmgr -shut -user SYSDBA -password password
}

case $1 in
'start') ibserver_start ;;
'start_msg') echo 'InterBase Server starting...\c' ;;

'stop') ibserver_stop ;;
'stop_msg') echo 'InterBase Server stopping...\c' ;;

*) echo 'Usage: $0 { start | stop }' ; exit 1 ;;
esac

exit 0
```

Example initialization script installation on Solaris:

1. Log in as root.

   ```
   $ su
   ```

2. Enter the example script above into the initialization script directory.

   ```
   # vi /etc/init.d/ibserver.sh
   ```

3. Enter text.
4. Link the initialization script into the `rc` directories for the appropriate run levels for starting and stopping the InterBase server.

   ```
   # ln /etc/init.d/ibserver.sh /etc/rc0.d/K30ibserver
   # ln /etc/init.d/ibserver.sh /etc/rc2.d/S85ibserver
   ```

Example initialization script installation on Linux:

1. Log in as root.

```
$ su
```

2. Enter the Linux example script (given below) into the initialization script directory.

```
# cp ibserver.sh /etc/rc.d/init.d/ibserver.sh
# chmod 700 /etc/rc.d/init.d/ibserver.sh
```

3. Link the initialization script into the `rc` directories for the appropriate run levels for starting the InterBase server.

```
# ln -s /etc/rc.d/init.d/ibserver.sh /etc/rc.d/rc0.d/S85ibserver
```

4. Link the initialization script into the `rc` directories for the appropriate run levels for stopping the InterBase server.

```
# ln -s /etc/rc.d/init.d/ibserver.sh /etc/rc.d/rc0.d/K30ibserver
```

5. Make sure you have host equivalence.

```
# touch /etc/gds_hosts.equiv
# echo “+” >> /etc/gds_hosts.equiv
```

6. Make sure you do not have an inetd entry for InterBase Classic.

```
# echo -e “/gds_db/s/^/#/\nwq” | ed /etc/inetd.conf
# killall -HUP inetd
```

Example Linux initialization script:

```
#!/bin/sh
# ibserver.sh script - Start/stop the InterBase daemon
# Set these environment variables if and only if they are not set.
: ${InterBase:=/usr/interbase}
# WARNING: in a real-world installation, you should not put the
# SYSDBA password in a publicly-readable file. To protect it:
# chmod 700 ibserver.sh; chown root ibserver.sh
export InterBase

ibserver_start() {
 # This example assumes the InterBase server is
# being started as user “InterBase”.
su - InterBase -c “$InterBase/bin/ibmgr -start -forever”
RETVAL=$?
[ $RETVAL -eq 0 ] && touch //lock/subsys/ibserver
```

```
}

ibserver_stop() {
 # No need to su.
$InterBase/bin/ibmgr -shut -user SYSDBA -password password
RETVAL=$?
[ $RETVAL -eq 0 ] && rm -f //lock/subsys/ibserver
}

if [ ! -d “$InterBase” ] ; then
echo “$0: cannot find InterBase installed at $InterBase” >&2
exit 1
fi
if [ ! -x “$InterBase/bin/ibmgr” ] ; then
echo “$0: cannot find the InterBase SuperServer manager as
$InterBase/bin/ibmgr” >&2
if [ ! -x “$InterBase/bin/gds_inet_server” ] ; then
echo “$0: this is InterBase Classic; use inetd instead of
ibserver daemon” >&2
fi
exit1
fi

case $1 in
’start’)
ibserver_start ;
echo “InterBase started” ;;
’start_msg’)
echo 'InterBase Server starting...\c' ;;

’stop’)
ibserver_stop ;
echo “InterBase stopped” ;;
’stop_msg’)
echo 'InterBase Server stopping...\c' ;;

’restart’)
ibserver_stop ; ibserver_start
echo “InterBase restarted” ;;
’restart_msg’)
echo 'InterBase Server restarting...\c' ;;

*) echo “Usage: $0 { start | stop | restart }” ; exit 1 ;;
esac

exit 0
```

7. The Attachment Governor

The InterBase server has an attachment governor that regulates the number of attachments to the server. Multiply the value of the `USERS` field in the license file by four to determine the total number of permitted concurrent attachments.

All successful attempts to create or connect to a database increment the number of current attachments. Both local and remote connections count toward the connection limit. Connections

are permitted by the governor until the maximum number of concurrent attachments is reached. All successful attempts to drop or disconnect from a database decrement the number of current attachments.

Once the maximum number of attachments is reached, the server returns the error constant `isc_max_att_exceeded` (defined in `ibase.h`), which corresponds to the message:

```
Maximum user count exceeded. Contact your database administrator.
```

8. Server Configuration Using Environment Variables

This section describes the environment variables that InterBase recognizes. When defining environment variables, keep these rules in mind:

- Environment variables must be in the scope of the `ibserver` process.
- On Windows, define environment variables as system variables in the Windows **Control Panel|System** dialog.
- On UNIX, the easiest way to define environment variables is to add their definitions to the system-wide default shell profile.

8.1. ISC_USER and ISC_PASSWORD

If you do not provide a user name and password when you connect to a database or when you run utilities such as `gbak`, `gstat`, and `gfix`, InterBase looks to see if the `ISC_USER` and `ISC_PASSWORD` environment variables are set; if they are, InterBase uses that user and password as the InterBase user.

Although setting these environment variables is convenient, do not do so if security is at all an issue.

8.2. The INTERBASE Environment Variables

8.2.1. INTERBASE

The `INTERBASE` variable is used both during installation and during runtime. During installation, it defines the path where the InterBase product is installed. If this path is different from `/usr/interbase`, all users must have the correct path set at runtime. During runtime, use the `INTERBASE` variable to set the InterBase install directory. The `INTERBASE` environment variable is used on Windows for local connections. The `INTERBASE` environment variable is used by the client to identify the local instance of InterBase Server to attach to.

8.2.2. INTERBASE_TMP

The `INTERBASE_TMP` variable can be used to set the location of InterBase sort files on the server. There are other options for defining the location of these files. See Configuring Sort Files.

8.2.3. INTERBASE_LOCK and INTERBASE_MSG

`INTERBASE_LOCK` sets the location of the InterBase lock file and `INTERBASE_MSG` sets the location of the InterBase message file. These two variables are independent of each other and can be set to different locations.

8.2.4. IB_PROTOCOL

The `IB_PROTOCOL` is used to specify which port you want the InterBase Server to use during runtime. It is also used by the InterBase Manager to identify which InterBase Server to manage. It is used by the InterBase clients to identify the instance of InterBase server to connect to.

8.3. The TMP Environment Variable

The `TMP` environment variable defines where InterBase stores temporary files, if the `INTERBASE_TMP` variable is not defined.

8.4. UNIX and Linux Host Equivalence

On UNIX and Linux machines, you must provide a host equivalence for localhost, since even local connections go through TCP/IP. To do this, place a line in the `/etc/hosts` file:

```
127.0.0.1  localhost
```

If your local machine has additional names, include them in the line:

```
127.0.0.1  localhost  mymachine_name
```

See Also

- Configuring Sort Files

9. Managing Temporary Files

InterBase creates two types of temporary files: sort files and history list files.

The InterBase server creates sort files when the size of the internal sort buffer is not big enough to perform the sort. Each request (for example, `CONNECT` or `CREATE DATABASE`) gets and shares the same list of temporary file directories. Each request creates its own temporary files (each has its own I/O file handle). Sort files are released when sort is finished or the request is released. If space runs out in a particular directory, InterBase creates a new temporary file in the next directory from the directory list. If there are no more entries in the directory list, it prints an error message and stops processing the current request.

The InterBase `isql` client creates the history list files to keep track of the input commands. Each instance creates its own temporary files, which can increase in size until they run out of disk space. Temporary file management is not synchronized between clients. When a client quits, it releases its temporary files.

9.1. Configuring History Files

To set the location for history files, define the `TMP` environment variable on your client machine. This is the *only* way to define the location of history files. If you do not set the location for the history files by defining the `TMP` environment variable, an InterBase client uses whatever temporary directory it finds defined for the local system. If no temporary directory is defined, it uses `/tmp` on a UNIX system or `C:\temp` on a Windows system.

9.2. Configuring Sort Files

You should make sure to have plenty of free space available for temporary sorting operations. The maximum amount of temporary space InterBase needs might be larger than the database itself in some cases.

Temporary sort files are always located on the server where the database is hosted; you should specify temporary directories on disk drives that are physically local to the server (not on mapped drives or network mounted file systems).

There are two ways to specify directories for sort files:

- You can add an entry to the `$InterBase/ ibconfig` file to enable directory and space definition for sort files. The syntax is:

```
TMP_DIRECTORY size “pathname”
```

Important:
The pathname must be in double quotes, or the config file will fail.

This defines the maximum size in bytes of each sort directory. You can list several directories, each on its own line with its own size specification and can specify a directory more than once

with different size configurations. InterBase exhausts the space in each specification before proceeding to the next one.
For example, if you specify `dir1` with a size of 5,000,000 bytes, then specify `dir2` with 10,000,000 bytes, followed by `dir1` with 2,000,000 bytes, InterBase uses `dir1` until it reaches the 5,000,000 limit, then uses `dir2` until it has filled the 10,000,000 bytes allocated there, and then returns to `dir1` where it has another 2,000,000 bytes available. Below are the `ibconfig` entries that describe this configuration:

```
TMP_DIRECTORY 5000000 “C:\dir1”
TMP_DIRECTORY 10000000 “D:\dir2”
TMP_DIRECTORY 2000000 “C:\dir1”
```

- You can use the `INTERBASE_TMP` and `TMP` environment variables to define the location.

If you specify temporary directories in `ibconfig`, the server uses those values for the sort files and ignores the server environment variable values. If you do not specify configuration of temporary directories in `ibconfig`, then the server picks a location for a sort file based on the following algorithm:

1. Use the directory defined in `INTERBASE_TMP` environment variable.
2. If `INTERBASE_TMP` is not defined, use directory defined in `TMP` environment variable.
3. If `TMP` is not defined, default to the `/tmp` directory (UNIX) or `C:\temp` (Windows).

10. Configuring Parameters in ibconfig

You specify configuration parameters for InterBase Server by entering their names and values in the configuration file, `ibconfig`. Entries are in the form:

```
parameter <whitespace> value
```

- **<parameter>** is a string that contains no white space and names a property of the server being configured.
- **<value>** is a number or string that is the configuration of the specified property.

Each line in `ibconfig` is limited to 80 characters, including the parameter name and any whitespace.

If you specify a value of zero or less for a parameter, the server ignores the setting and uses the default value for that parameter. However, there is no upper limit applied to these parameters.

The server reports the values for each of these parameters in the `interbase.log` file on startup.

When a parameter is commented out in the `ibconfig` file, the server uses the default value.

The following is a summary of allowable entries in `ibconfig`:

Parameter	Description
`ADMIN_DB`	• Platforms: All • Specifies the name of the InterBase security database. • Needed only if the security database is not named. `admin.ib` • The security database must always be in the InterBase home directory.
`APPDATA_DIRECTORY`	• The directory path MUST be enclosed in double quotes. • The choice entered may vary based on the underlying OS platform version. • It is an application for all platforms. • It specifies a directory where InterBase data files (requiring read-write) access are located. This includes database files admin.ib, examples/ sub-folder, ext/ sub-folder, secure/ sub-folder to support SSL/OTW configuration, license/ sub-folder to deliver licenses required for InterBase runtime, and, other temporary files InterBase creates to support its runtime engine (.lck and .env files, interbase.log etc.). • This has been introduced to support Windows UAC driven requirements when installing under "Program Files" area, but can also be applied to isolate InterBase "writable" files into a separate location on other supported Editions and/or OS platforms.
`CPU_AFFINITY`	• Platform: Windows only. • 32-bit values only allowed. Only the first 32 processors can be set. • On a SMP system, sets which processors can be used by the InterBase server. The value is taken from a bit vector in which each bit represents a processor. Thus, to use only the first processor, the value is 1. To use both the first and second processors, the value is 3. To use the second and third, the value is 6. • The default is to use all processors (when entry is commented out).
`CONNECTION_TIMEOUT`	• Platforms: All • Seconds to wait before concluding an attempt to connect has failed. • Default: 180
`DATABASE_CACHE_PAGES`	• Platforms: All • Server-wide default for the number of database pages to allocate in memory per database. • Can be overridden by clients. • See Configuring the Database Cache for more information. • Default: 2048
`DATABASE_ODS_VERSION`	• Platforms: All • Version: starting in InterBase XE7 • The database server/engine will automatically create/restore databases to this major ODS version number, if specified. • Valid ODS major versions are in the range of 17 to 18. • Default major ODS version is the latest version supported by the product. • Default: 19

Parameter	Description
DEADLOCK_TIMEOUT	• Platforms: All • Seconds before an ungranted lock causes a scan to check for deadlocks. • Default: 10
DUMMY_PACKET_INTERVAL	• Platforms: All • Seconds to wait on a silent client connection before the server sends dummy packets to request acknowledgment. • The default value of 0 will not send any dummy keepalive packets to the client from the server. • Versions of InterBase before 7.1 used to have this set at 60 seconds, by default. This has now been modified to have a default of 0 (zero) seconds due to a memory leak bug in one of the Windows system drivers for socket connections. • Alternatively, you can set the interval value for a specific client by using the isc_dpb_dummy_packet_interval DPB parameter while doing a connection.
ENABLE_HYPERTHREADING	• Platforms: Windows, for InterBase 32-bit Edition(s) only • Specifies whether Intel Hyper-threading technology enabled logical processors should be enabled. • Valid values are: 1 (enable), 0 (disable). • Default: 0 (disable)
ENABLE_PARTIAL_INDEX_SELECTIVITY	• Platforms: All • Starting with InterBase XE7 and ODS 16, multi-segment index definitions track per segment selectivity statistics. • Specifies whether the SQL Optimizer should use this selectivity data to optimize retrieval. • This setting is engine-wide, so it applies to all queries submitted to an active engine. • When disabled, the SQL optimizer will treat the index with a single selectivity value that is not segment specific, as per InterBase versions prior. • Valid values are: 1 (enable), 0 (disable) • Default: 1 (enable) • This parameter should be left on its default status and changed only for testing purposes when it is suspected to produce performance issues. *For:* **2017 Update 2** *and above only*.
EXTERNAL_FILE_DIRECTORY	• Platforms: All • The default directory for an external table's file is <interbase_home>/ext. • Using this parameter, you can list additional directories where external files can reside. • For security reasons, do not put other files in this directory. • Directory path MUST be enclosed in double quotes. For e.g. EXTERNAL_FILE_DIRECTORY "C:\Temp" EXTERNAL_FILE_DIRECTORY "/tmpdir" • List multiple entries one per line; directories are used in the order specified.

Parameter	Description
EXTERNAL_FUNCTION_DIRECTORY	• Platforms: All • The default directory for UDF libraries is <interbase_home>/UDF. • Using this parameter, you can list additional directories where UDF libraries should be loaded from. • For security reasons, do not put other files in this directory. • Directory path MUST be enclosed in double quotes. For e.g. EXTERNAL_FUNCTION_DIRECTORY "C:\Temp" EXTERNAL_FUNCTION_DIRECTORY "/tmpdir" • List multiple entries one per line; directories are used in the order specified.
LOCK_ACQUIRE_SPINS	• Platforms: All • Number of spins during a busy wait on the lock table mutex • Relevant only on SMP machines • Default: 0
LOCK_HASH_SLOTS	• Platforms: All • Tune lock hash list; more hash slots means shorter hash chains. • Not necessary except under very high load • Prime number values are recommended. • Default: 101
LOOPBACK_CONNECTION	• Platforms: All • Local database pathnames connect using a TCP/IP loopback connection depending on the value of the parameter; the parameter value is case-senstive. • A value of "all" makes all connections loopback. • A value of "tss" is Windows-specific and causes connections originating from a Terminal Services session to loopback. • Any other value disables loopback connection for local paths. • Default: none
MAX_DB_VIRMEM_USE	• Platforms: Windows • Define an upper percentage limit of how much of the available virtual memory InterBase can use for its large memory allocations like those of database cache etc. This is set as a percentage of total virtual memory available to the process. • This can be used to set the limit to a lower level if you observe that other critical memory allocations such as file I/O buffers, file handles, socket buffers etc. need the user space. • Valid range that can be set is between 50 and 100. • Please note that setting this to 100 indicates that InterBase can use up all available virtual memory for its database cache etc. This is not recommended. For e.g. setting this to 90 (the default), indicates that on a 2GB virtual address space, InterBase process will only use up 1.8GB of the available virtual memory for database cache allocations; the rest will be available for other critical memory allocations.

Parameter	Description
MAX_THREADS	• Platforms: All • Controls the maximum number of threads that can be active at one time within the InterBase engine. The listed value applies to a system with multiple licensed CPUs. For a single CPU system, the value defaults to 1 which eliminates the synchronization overhead required by multiple CPUs. • Default: 1000000
MAX_ASSISTANTS	• Platforms: All • Controls the maximum number of threads that can be active assisting other threads with their tasks. This number should be less than the number of CPUs on which InterBase can run. • Default: 1
MEMORY_RECLAMATION	• Platforms: All • Number of seconds between attempts to return unused memory to OS. • This parameter enables better co-existence with neighboring processes by not monopolizing memory. It cannot guarantee that other processes will behave in kind. • 0 = disable memory reclamation • 1 = memory reclamation on attach of first database • 2 = memory reclamation on detach of last database • 3 = 1 + 2 above • > 15 = number of seconds between memory reclamations • Default: 300
PAGE_CACHE_EXPANSION	• Platforms: All • Number of MB of memory to expand page buffer cache until upper limit is reached. The upper limit can be a database-specific setting or the DATABASE_CACHE_PAGES parameter. The page buffer cache is expanded when there are no more free buffers, which occurs when all buffers have been loaded with a database page. • This parameter is used to smooth the memory allocation of page buffers to match demand generated by client load. • 0 = allocate all page buffers on first database attach. • > 0 = expand this many MBs at a time until all page buffers allocated. • Default: 256

Parameter	Description

PREDICTIVE_IO_PAGES	• Platforms: All
	• Starting with InterBase XE7, InterBase introduced predictive I/O mechanism to populate in-memory database cache with interesting pages that can be fetched instead of read from disk by request worker threads.
	• This setting allows you to manipulate the number of pages to be prefetched in one shot, between the values 0 and 64.
	• As a special case, a setting of 0 pages will disable the predictive I/O mechanism
	• Valid values include:
	`Default: 64`
	`Valid range for predictive I/O: 1-64`
	`Disable feature: 0`
	• This parameter should be left on its default status and changed only for testing purposes when it is suspected to produce performance issues.
	For: **2017 Update 2** *and above only*.

SERVER_CLIENT_MAPPING	• Platform: Windows • Size in bytes of one client's portion of the memory mapped file used for interprocess communication. • Valid values are 1024, 2048, 4096, 8192, 16384 • If set beyond this range, value resets to default value of 8192. • Default: 8192
SERVER_PRIORITY_CLASS	• Platforms: Windows • Priority of the InterBase service on Windows • The value 1 is low priority, 2 is high priority • Default is 1
SERVER_WORKING_SIZE_MAX	• Platforms: Windows • Threshold above which the OS is requested to swap out all memory. • Default is 0 (system-determined)
SERVER_WORKING_SIZE_MIN	• Platforms: Windows • Threshold below which the OS is requested to swap out no memory. • Default is 0 (system-determined)
SOLARIS_BOUND_THREADS	• Platform: Solaris • When set to 1 each user-level thread is bound to a LWP thread. • The default of 0 creates user-level threads unbound and causes a user-level scheduler to map them to available LWPs. • Default: 0
SOLARIS_SYNC_SCOPE	• Platform: Solaris • When set to 1 threads use process-level synchronization variables. • The default of 0 causes thread-level synchronization variables to be used. • Default: 0

Parameter	Description
SORTMEM_BUFFER_SIZE	• Platforms: All • Specifies the size of a sort buffer in memory. • Versions of InterBase before 7.1 used to have a static value of approx. 128 KB. This is now configurable per server using this parameter. The default value is just about 1 MB. • Setting this to a higher value will enable better performance in large sort-merge queries. • Default: 1048500
SQL_COMPILER_RECURSION	• Platforms: All • Specifies the call depth that the recursive descent parsing algorithm will try during SQL compilation phase of statement preparation. If the call depth would exceed this limit than a stack overflow is declared and returned as an error. Note that this is an artificial stack overflow detection and not a hardware detected stack overflow. • Default: 2000
STARTING_TRANSACTION_ID	• Platforms: All • Version: starting in InterBase XE7 • ODS version: 16+ • The database server/engine will automatically create/restore databases with this transaction ID as the starting number. • If you want to restore your database(s) to test with very high transaction ID numbers, to evaluate 48-bit transaction ID support, set this value and restart InterBase. • Valid values include any value >= 0, that can be represented in a 48-bit Integer data type. • Default starting transaction ID on database create/restore is 0 • Default: 0
SWEEP_QUANTUM	• Platform: All • Specifies the maximum number of records that a garbage collector thread or a sweeper thread is allowed to work before yielding control back to the worker threads. • Default:10
SWEEP_YIELD_TIME	• Platforms: All • Specifies the time, in milliseconds, the sweeper or garbage collector thread sleeps. • Default:1 millisecond
TCP_REMOTE_BUFFER	• Platforms: All • TCP/IP buffer size for send and receive buffers. This applies to both client and server programs. • Valid range is 1448 to 32768 • Default: 8192 bytes

Parameter	Description
THREAD_STACK_SIZE_MB	• Platforms: ALL • This parameter controls the user configurable value for thread stack size • The value is in multiple of MBs per thread. • Valid range is 1MB to 32MB. If set beyond this range, value resets to default value • You should not have to change this parameter for normal use of InterBase. • In extremely rare cases of abnormal termination of the process, the reason might be thread stack space constraints due to high levels of recursive calls (of stored procedures and such). Feel free to increase this value then. • Default: 2 (2 MB) on 32 bit Editions • Default: 6 (6 MB) on 64 bit Editions
TMP_DIRECTORY	• Platforms: All • Directory to use for storing temporary files (such as sort files). • Default is the value of environment variables INTERBASE_TMP or TMP, in that order; otherwise /tmp on UNIX or C:\temp on Windows NT/2000/XP. • If you have lots of space in your default temporary folders as above, then there is no need to mention any further directory listings here. • Specify directory path and number of bytes available in the directory. • Directory path MUST be enclosed in double quotes. • Format for entry is as follows. TMP_DIRECTORY <MaxBytes> <AbsoluteDirectoryPath> MaxBytes should be a number indicating maximum space in bytes to be used in the directory, of type 32-bit unsigned integer. Valid range: 1MB - 4GB (in bytes) • For e.g. TMP_DIRECTORY 500400300 "C:\Temp" TMP_DIRECTORY 1500400300 "/tmpdir" • List multiple entries, one per line; directories are used in the order specified.
USER_QUANTUM	• Platforms: All • Specifies the maximum number of records that a worker thread (thread running an user query) is allowed to work before yielding control back to other threads. • Default: 1000
V4_EVENT_MEMSIZE	• Platforms: All • Bytes of shared memory allocated for event manager. • Default: 32768
V4_LOCK_GRANT_ORDER	• Platforms: All • 1 means locks are granted first come, first served. • 0 means emulate InterBase V3.3 behavior, where locks are granted as soon as they are available; can result in lock request starvation. • Default: 1
V4_LOCK_MEM_SIZE	• Platforms: All • Bytes of shared memory allocated for lock manager. • Default is 98304 on Linux and Solaris, 256K on Windows.

Parameter	Description
V4_LOCK_SEM_COUNT	• Platforms: All • Number of semaphores for interprocess communication (Classic architecture only). • Default: 32
V4_LOCK_SIGNAL	• Platforms: All • UNIX signal to use for interprocess communication • (Classic architecture only). • Default: 16
V4_SOLARIS_STALL_VALUE	• Platform: Solaris • Number of seconds a server process waits before retrying for the lock table mutex. • Default is 60
WINDOWS_LOCAL_CONNECT_RETRIES	• Platforms: Windows • Number of retries a client attempts to connect to local • InterBase server process. There is a 1 millisecond wait before each retry. Terminal Services clients sometimes fail to connect on first attempt during heavy contention. • Default: 0

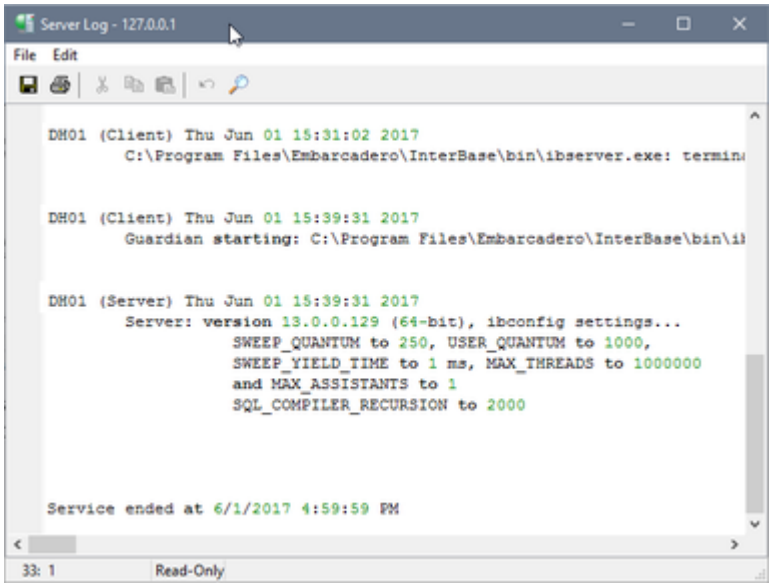
11. Viewing the Server Log File

InterBase Server logs diagnostic messages in the file `interbase.log` in the InterBase install directory. Any messages generated by `ibserver` are sent to this file. This can be an important source of diagnostic information if your server is having configuration problems.

Refer to the *Language Reference* for a list of error messages that can appear in this file.

IBConsole displays this log file in a standard text display window. To display the Server Log dialog:

- Select a server and expand it if it is not already expanded, click Server Log and then double-click View Logfile in the Work pane.
- Right-click a server in the Tree pane and choose View Logfile from the context menu.
- Select a server and then choose View Logfile from the Server menu.



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 Text Viewer Window.

NETWORK CONFIGURATION

This chapter details issues with configuring InterBase in a networked client/server environment. Topics include network protocols supported by InterBase, remote connection specifiers, encrypting the data that passes between servers, and network troubleshooting tips.

1. Network Protocols

InterBase supports TCP/IP for all combinations of client and server platforms. Additionally, InterBase supports NetBEUI on Windows server platforms and for all Windows clients, and a local connection mode (involving inter-process communication but no network interface) for Windows clients.

InterBase is designed to allow clients running one operating system to access an InterBase server that is running on a different platform and operating system than the client.

"Windows server platforms" refers to the supported Windows Server versions. "Windows non-server platforms" refers to the supported Windows versions designed for personal computers.

For a list of supported Windows and Linux versions refer to System Requirements/Prerequisites.

	InterBase server platform		
Client platform	**Windows non-server**	**Windows server**	**UNIX**
Windows non-server	TCP/IP , Local	TCP/IP, NetBEUI	TCP/IP
Windows server	TCP/IP	TCP/IP, NetBEUI, Local	TCP/IP
UNIX/Linux	TCP/IP	TCP/IP	TCP/IP

See Also

- Connecting to Servers and Databases
- Connection Troubleshooting

2. Connecting to Servers and Databases

Before performing any database administration tasks, you must first register and log in to a server. Once you log in, you can register and connect to databases residing on the server. You can switch context from one connected database to another by selecting the desired database from the IBConsole Tree pane. The selected database in the Tree pane is referred to as the *current database*. The selected server or the server where the current database resides is referred to as the *current server*.

See Also

- Network Protocols
- Encrypting Network Communication
- Connection Troubleshooting
- Communication Diagnostics

2.1. Adding a Server

You can access the Add Server Wizard in IBConsole by one of the following methods:

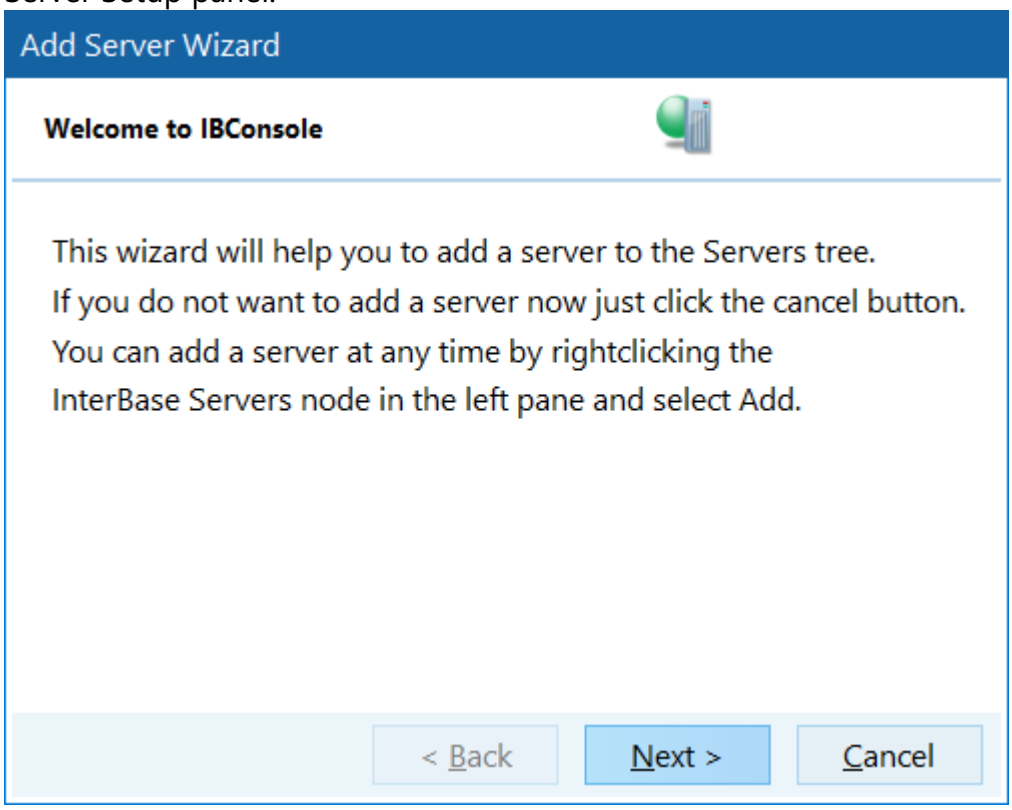
- Choose Server|Add or click the Add a New InterBase Server toolbar button.
- Double-click InterBase Servers in the Tree pane.
- Right-click InterBase Servers and choose Add from the context menu.

When you add a server, and there is no local server yet added, the Local Server dialogue opens.

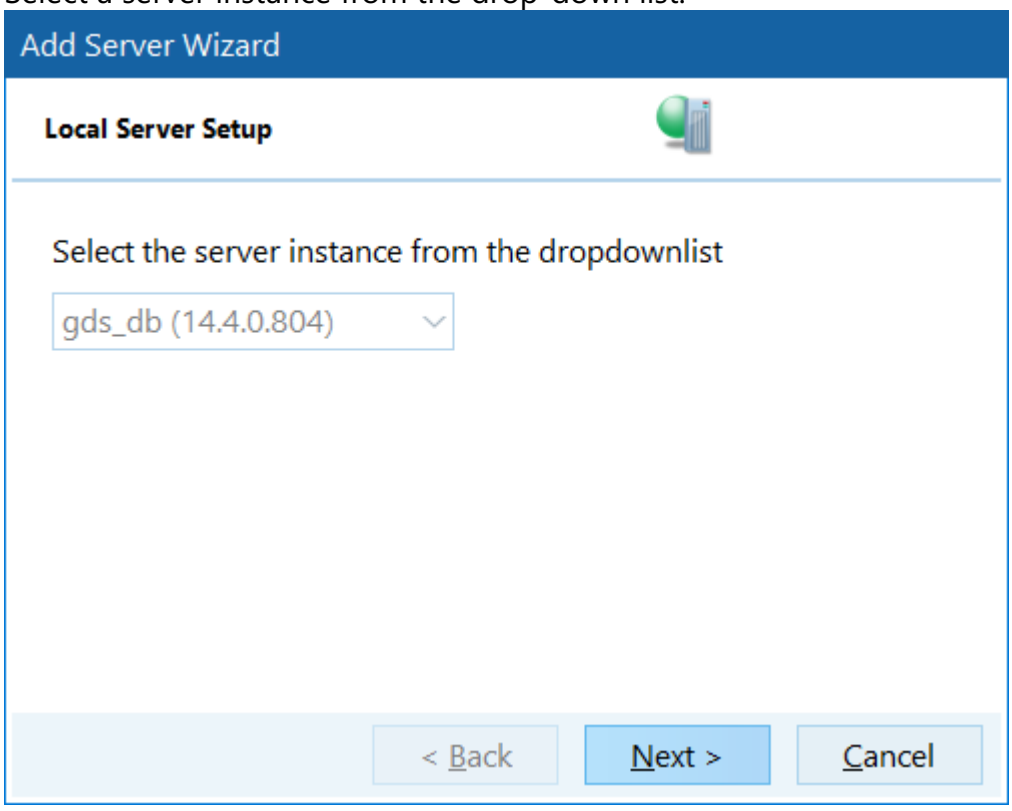
If a local server already exists, the Remote Server Setup dialog opens.

To add a local server:

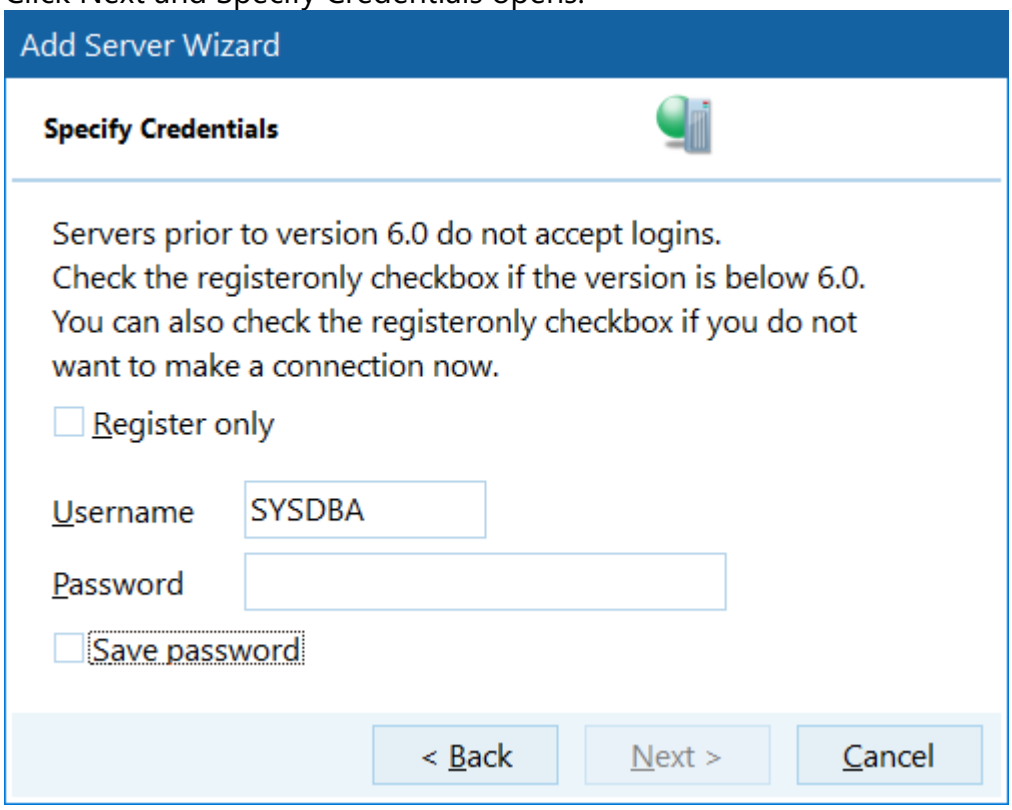
1. Once you have clicked Server|Add, click Next in the Welcome dialog to advance to the Local Server Setup panel.



2. Select a server instance from the drop-down list.



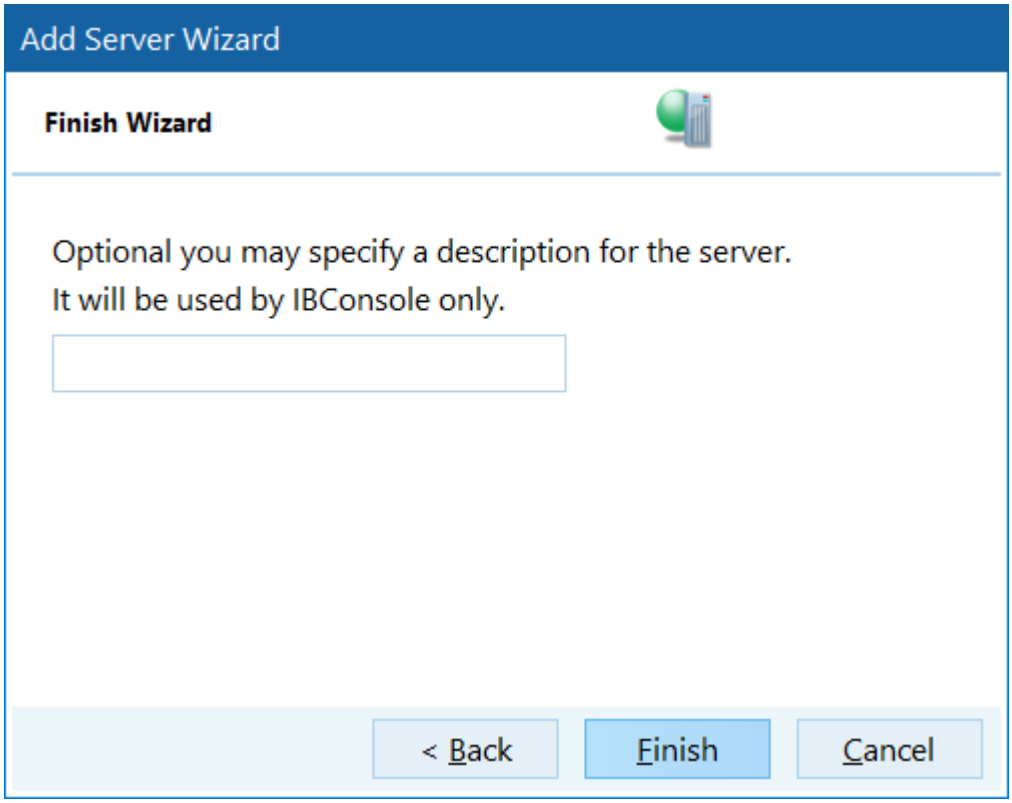
3. Click Next and Specify Credentials opens.



4. You can choose to just add the server (without logging in) or you can choose to add and connect to the server simultaneously.
   If you want to just add the server you can ignore the Login Information and click Next.
   If you want to add and connect to the server simultaneously, enter a username and password in the corresponding text fields and click Next.

> **Note:**
> The usernames and passwords must be the InterBase usernames and passwords stored in the InterBase security database (admin.ib by default) on the server.

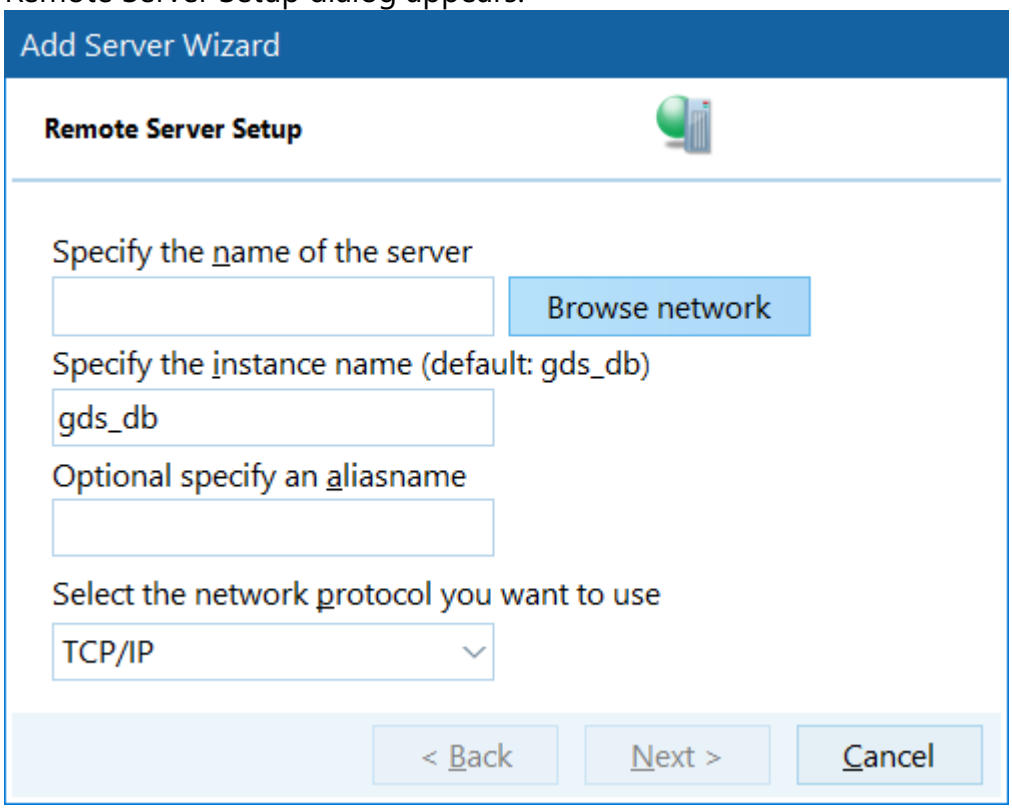
5. Click Next to advance to the Finish Wizard. Here you have the option to enter a description name for the server.



6. Click Finish and once a server is added, IBConsole displays it in the Tree pane.

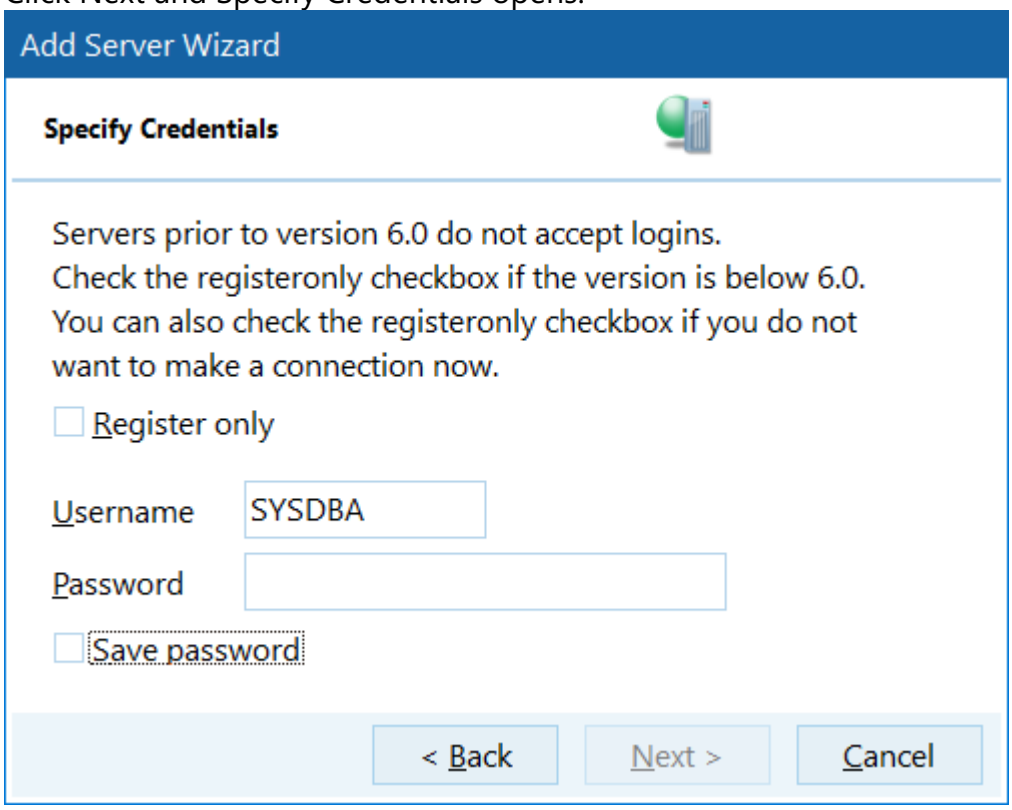
To add a remote server:

1. Choose Server > Add or click the Add a New InterBase Server toolbar button and the Remote Server Setup dialog appears.



2. Browse the name of the server.
3. Specify the instance name (the default is gds_db)
   The InterBase server name is the name of the database server machine. There is not a specific name for the InterBase server process itself. For example, if the server is running on the NT server “venus”, you enter this name in the Server Name text field.
4. Enter an alias name in the Optional: Specify an Aliasname text field.
5. The network protocol you select can be TCP/IP on any platform. On Windows, it can also be NetBEUI or local. Protocols are valid only when they are supported by both the client and the server.

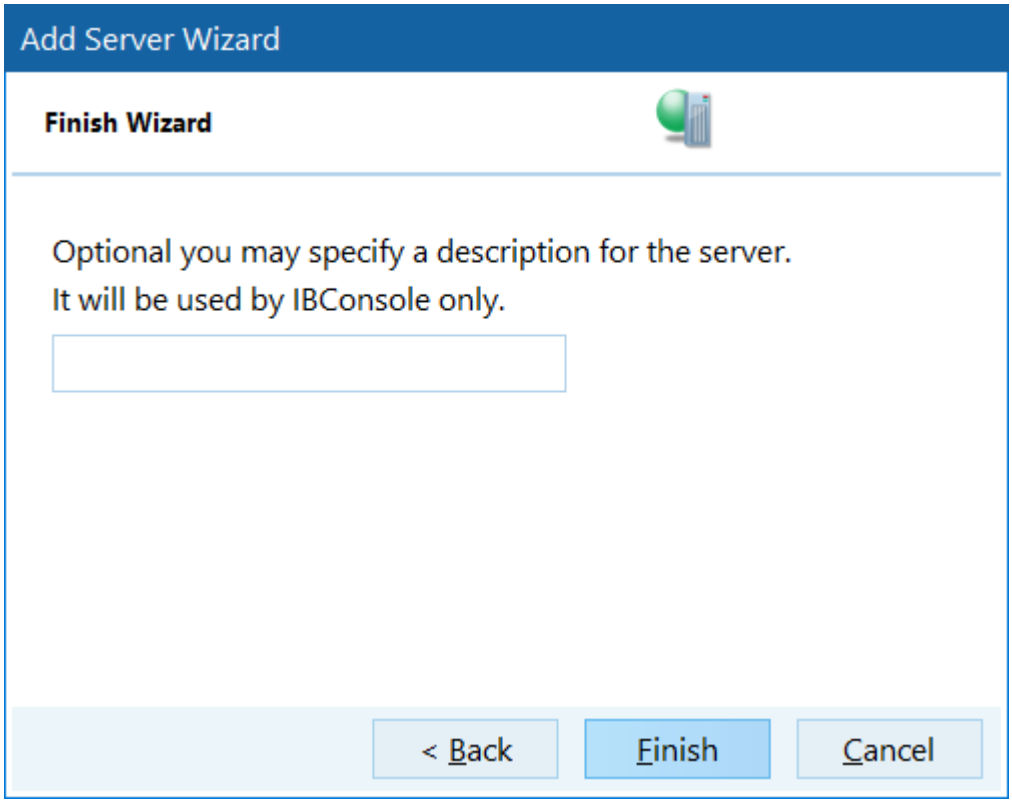
6. Click Next and Specify Credentials opens.



7. You can choose to just add the server (without logging in) or you can choose to add and connect to the server simultaneously.
   If you want to just add the server you can ignore the Login Information and click Next.
   If you want to add and connect to the server simultaneously, enter a username and password in the corresponding text fields and click Next.

> **Note:**
> The usernames and passwords must be the InterBase usernames and passwords stored in the InterBase security database (admin.ib by default) on the server.

8. Click Next to the Finish Wizard dialog. Here you have the option to enter a description name for the server.



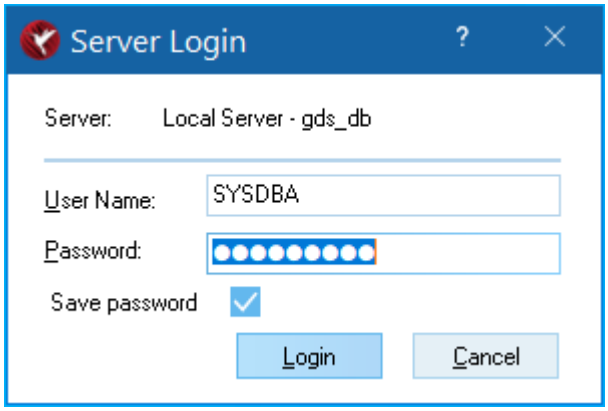
9. Click Finish and once a server is added, IBConsole displays it in the Tree pane.

2.2. Logging in to a Server

You can access the Server Login dialog in IBConsole by one of the following methods:

- In the Tree pane, select a registered server that is not already logged in. Choose Server| Login, or double-click Login in the Work pane.
- In the Tree pane, double-click a registered server that is not already logged in.
- In the Tree pane, right-click a registered server that is not already logged in and choose Login from the context menu.

The Server Login dialog appears:



To log in to a server:

1. Verify that the server displayed in the Server field is correct.
2. Enter a username and password in the corresponding text fields. For convenience, IBConsole defaults the UserName text field to the last username that was used to log in (successfully or unsuccessfully).
   - The usernames and passwords must be the InterBase usernames and passwords that are stored in the InterBase security database (`admin.ib` by default) on the server.
   - The username is significant to 31 bytes and is not case-sensitive. The password is significant to eight characters and is case-sensitive.
   - All users must enter their username and password to log in to a server. The username and password are verified against records in the security database. If a matching record is found, the login succeeds.
3. Click Login to log in to the server.

Important:
Initially, every server has only one authorized user with username SYSDBA. The SYSDBA must log on and add other authorized users. For more information about how to add new users, see User Administration with IBConsole.

2.3. Logging Out from a Server

Logging out from a server automatically disconnects all databases but does not un-register any databases on the server.

You can log out from a server in IBConsole by one of the following methods:

- Select a connected server in the Tree pane (you can also select any branch under the desired server hierarchy) and choose Server|Logout.
- Select a connected server in the Tree pane and double-click Logout in the Work pane.
- Right-click a connected server in the Tree pane and choose Logout from the context menu.

A confirmation dialog asks you to confirm that you wish to close the connection to the selected server. Click Yes if you want to log out from the server, otherwise click No.

2.4. Removing a Server

To remove a server in IBConsole by one of the following methods:

- Select **Menu |Server > Remove** from the toolbar menu.
- Click the **Remove InterBase Server** toolbar button.

A confirmation dialog asks you to confirm that you wish to remove the selected server. Click Yes if you want to remove the server, otherwise click No.

> **Note:**
> Removing a server removes that server from the Tree pane and automatically logs you out of the current server as well as disconnects any databases on the server.

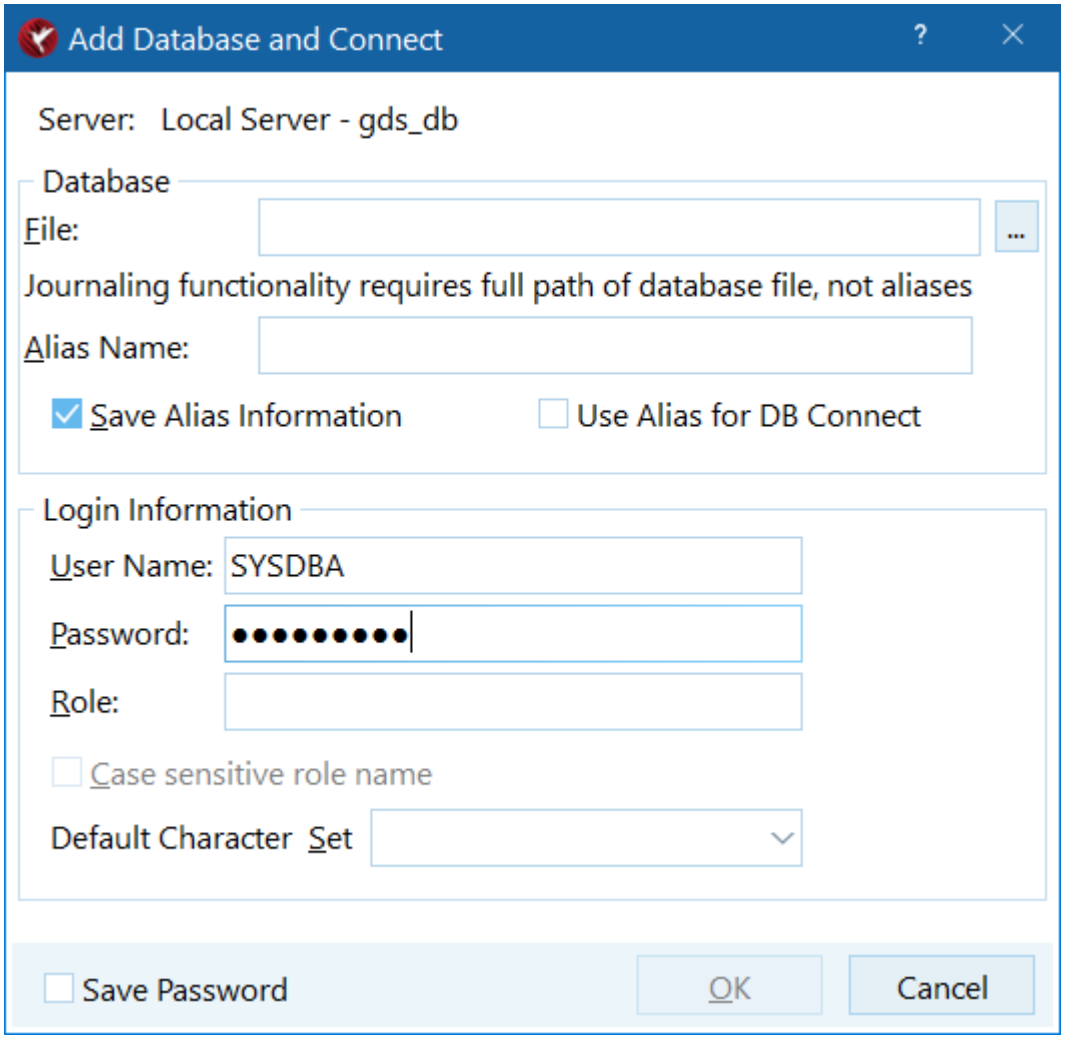
See Also

- Adding a Server
- Logging in to a Server
- Logging Out from a Server

2.5. Adding a Database

You can access the Add Database and Connect dialog in IBConsole by one of the following methods:

- Expand a connected server branch. Right-click Databases in the Tree pane and choose Add from the context menu.
- Select a disconnected database in the Tree pane and double-click Add in the work pane, or right-click the database and choose Add from the context menu.



To Add a Database:

1. Make sure the server displayed in the Server field is correct.
2. Enter the database filename, including the path where the file is located, in the File text field. For databases that reside on the local server, you also have the option of clicking the Browse button to locate the file you want. The Browse button is disabled for all remote servers.
3. Type an alias name for the database in the Alias Name text field. This is the name that will appear in the IBConsole window. If you omit this step, the alias defaults to the filename that you select in step 2.
4. Check the Save Alias Information check box if you wish to permanently register the database. This saves the database alias name in the Windows registry.
5. Check the Use alias DB Connect check if you have specified an Alias Name and you want to connect using it instead of using the File entry.
6. You also have the option to save your password so it is automatically supplied each time you log in.
7. At this point you can choose to just add the database without connecting, or you can choose to add and connect to the database simultaneously. If you only want to add the database, ignore the Login Information and click OK.

8. If you want to add and connect a database simultaneously, type the username, password and optional role and default character set for the database in the corresponding text fields and click OK. If you want to connect using a role, specify the role in the Role text field. This is optional. Connecting using a role gives you all privileges that have been assigned to that role, assuming that you have previously been granted that role with the GRANT statement. For more information on roles, refer to SQL Roles.

Once you add a database, it appears in the Tree pane.

See Also

- Connecting to a New Database
- Disconnecting a Database
- Un-registering a Database

2.6. Connecting to a New Database

IBConsole provides two methods for connecting to a database. The first method is a quick connect using the username and password that were supplied with the login to the server to instantaneously connect the database. The second method allows you to connect to the database using a different username and password by accessing the Database Connect dialog.

2.6.1. Connecting to a Database Using Connect

If you want to perform an automatic connect, using the username and password supplied for the server login to instantaneously connect the database, you can do so by one of the following methods:

- Select a disconnected database in the Tree pane. Choose Database|Connect, choose Connect in the Work pane, or click on the Database Connect toolbar button.
- Right-click a disconnected database in the Tree pane and choose Connect from the context menu.
- Double-click a disconnected database in the Tree pane.

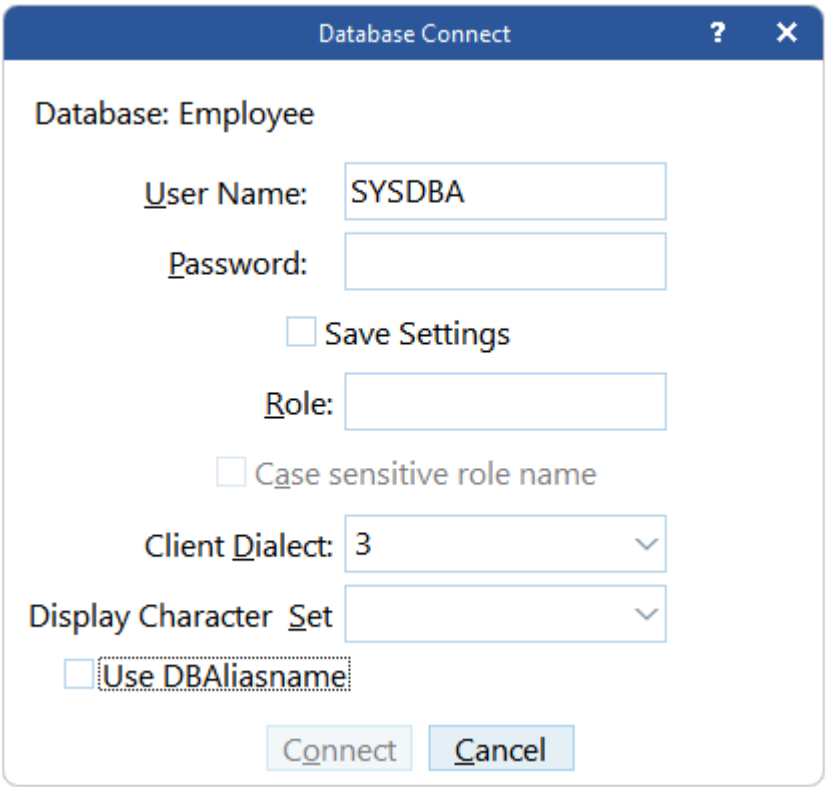
Once you connect to a database, the database tree expands to display the database hierarchy.

2.6.2. Connecting to a Database Using Connect As

If you want to access the Connect Database dialog in IBConsole to connect to the database using a different username and password from that which was supplied in the server login, you can do so by one of the following methods:

- Select a disconnected database in the Tree pane. Choose Database|Connect As or choose Connect As in the Work pane.

- Right-click a disconnected database in the Tree pane and choose Connect As from the context menu. This displays the Database Connect dialog box:



To Connect to a Database:

1. Verify that the database displayed in the Database field is correct.
2. Type the username and password for the database in the corresponding User Name and Password text fields.
3. If you want to connect as a role, specify the role in the Role text field. This is optional. Connecting as a role gives you all privileges that have been assigned to that role, assuming that you have previously been granted that role with the `GRANT` statement. Once you have typed a character in the Role field, the Case Sensitive Role Name field becomes active. Check this box if you want the server to consider case in the role name. Role names are case insensitive by default. For more information on roles, refer to SQL Roles.
4. Select the SQL Client dialect. The dialect for the database connection will default to the lower value of the client or server. For more information on SQL dialects, refer to "Understanding SQL Dialects" in the migration appendix of the InterBase *Operations Guide*.
5. Optionally, you can choose a character set to use. If you do not specify one here, the server uses the default set that was specified at creation time.
6. Click Connect.

Once you connect to a database, the database tree expands to display the database hierarchy.

2.7. Disconnecting a Database

You can disconnect a database in IBConsole by one of the following methods:

- Select a connected database in the Tree Pane (you can also select any branch under the desired database hierarchy) and choose **Database|Disconnect** or click the Disconnect Database toolbar button
- Select a connected database in the Tree pane and double-click Disconnect in the Work pane.
- Right-click a connected database in the Tree pane and choose Disconnect from the context menu.

A confirmation dialog asks you to confirm that you wish to close the connection to the selected database. Click OK if you want to disconnect the database, otherwise click Cancel.

See Also

- Adding a Database
- Connecting to a New Database
- Un-registering a Database

2.8. Un-registering a Database

Un-registering a database automatically disconnects the current database and removes it from the Tree pane.

You can un-register a disconnected database in IBConsole by one of the following methods:

- Select a database in the Tree pane (you can also select any branch under the desired database hierarchy) and choose **Database|Un-register**.
- Select a database in the Tree pane and double-click Un-register in the Work pane.
- Right-click a database in the Tree pane and choose Un-register from the context menu.

A confirmation dialog asks you to confirm that you wish to un-register the database. Click Yes if you want to un-register the database, otherwise click No.

See Also

- Adding a Database
- Connecting to a New Database
- Disconnecting a Database

2.9. Connection-specific Examples

Here are some examples of connecting to databases on various types of servers.

- For a Windows server, the database path name must contain the appropriate drive letter designation. For example, to connect to a local database:

```
D:\users\accting\fin\accred.ib
```

- To connect to a database on a remote server using the TCP/IP protocol:

```
ntserver:D:\users\accting\fin\accred.ib
```

- To connect via NetBEUI (Windows server platforms only), use UNC notation:

```
\\ntserver\D:\users\accting\fin\accred.ib
```

- For a UNIX or Linux server, you must enter the complete and absolute directory path for the database. For example:

```
server:/usr/accting/fin/accred.ib
```

See Also

- Logging in to a Server
- Logging Out from a Server
- Adding a Database
- Connecting to a New Database
- Disconnecting a Database

3. Encrypting Network Communication

Information sent to an InterBase remote client from a database server is unencrypted during the transmission process, even when the data was encrypted prior to transmission. This creates an opportunity for a security breach. To protect against this, you can use the Over-the-Wire (OTW) encryption feature of InterBase to encrypt data during the transmission process.

In the XE3 release, a Strong Encryption license was incorporated into the server license that allows AES encryption which applies to OTW. This is no longer an add-on license, but is automatically part of Server/Desktop.ToGo Edition.

You can also use InterBase to encrypt a database and/or individual columns in a database table. For information on how to do so, see the Data Definition Guide.

Note:
The OTW functionality is designed to be used in conjunction with the InterBase database user name and password. It is not meant to replace it.

See Also

- Network Protocols
- Connecting to Servers and Databases
- Connection Troubleshooting
- Communication Diagnostics

3.1. Requirements and Constraints for Encrypted Network Communications

InterBase OTW encryption is provided using SSL v3 and TLS v1 security protocols. SSL uses the X.509 standard for its public key infrastructure. Both the InterBase client and server must have the X.509 files installed to use OTW encryption.

InterBase uses the following conventions on both the client and server sides:

- All the X.509 PKI (public key infrastructure) files, which include the certificate file and the CA files, **must be in the Privacy Enhanced Mail (PEM) format**.
- The clientCertFile and IBSSL_SERVER_CERTFILE parameters always refer to the PEM formatted file that contains the CA signed certificate and the private key. These files should not be distributed.
- The serverPublicPath and serverPublicFile parameters on the client, and IBSSL_SERVER_CAFILE and IBSSL_SERVER_CAPTH on the server, always refer to the public key certificate.
- InterBase supports both stronger (AES) and weak (DES) encryptions out of the box. InterBase XE and earlier supports the use of weak encryption (DES) out of the box, but to use stronger encryption (AES), you must, due to U.S. export regulations, obtain a strong encryption license from InterBase and install it on the server machine.

Note:
The InterBase JDBC driver now supports the OTW functionality.

3.2. Setting up OTW Encryption

InterBase OTW encryption consists of two parts: one resides on the server side and the other resides on the client side and works to secure the server. The sections below explain how to set up OTW on both the server and client sides. Sample OTW configurations follow the instructions.

Note:
For information on specifying JDBC properties for OTW, see SSL File Properties. Also in the Developer's Guide, refer to the new extended properties.

Before setting up OTW encryption on the server or client side, you must first obtain the necessary security certificates, provided by your Certificate Authority (CA) vendor. InterBase uses these certificates to verify identity information.

3.2.1. Generating Security Certificates

OTW requires the generation and use of the following certificates:

- **A public key certificate for the server.** For example, ibserverCAfile.pem
- **The server's private key and server certificate**. For example, ibserver.pem

You can use any SSL tool to generate these certificates, or contact your IT department or CA vendor. To learn how to create SSL certificates using OpenSSL, see the following website:

- http://www.openssl.org/docs/apps/openssl.html

3.2.2. Setting up the Client Side

The client application indicates to the InterBase client library that it needs to perform OTW encryption via the connection string. The connection string takes the OTW parameters before the database path/name, as specified in the syntax below.

Note:
The existing OTW properties have been changed to the new JDBC OTW properties.

Important:
It is strongly recommended that the old native OTW properties no longer be used. However, the new native client and server supports both the old and new names.

It is likely that this will be the last release of InterBase Client which supports the old parameters. It is important that you start using the new parameters:

Old OTW Client Properties:	New OTW Properties Starting with InterBase XE:

OTWENABLE	ssl=true
PASSPHRASE	clientPassPhrase
PASSPHRASEFILE	clientPassPhraseFile
CERTFILE	clientCertFile
CAFILE	serverPublicFile
CAPATH	serverPublicPath

Syntax: To enable OTW on the client side, use the following syntax for your database connection string:

```
<secure server host name>[/secure server port name | secure server port number]?
ssl=true[?serverPublicFile=complete location of the CA file | ?
serverPublicPath=name
 of directory containing the CA certificates |?clientCertFile=name of the client
certificate file][?clientPassPhraseFile=pass phrase filename |?
clientPassPhrase=pass phrase]??:<database path>/<database name>
```

The starting '?ssl=true' and the ending '??' are mandatory, and work as demarcations for the OTW encryption parameters. The following table lists the descriptions of the options used in the syntax sample.

Client-side OTW Options

Options	Description
secure server host name	The hostname, Fully Qualified Domain name, or IP address of the machine that is hosting the secure InterBase server. If the machine has multiple network interface cards, define the hostname/IP of the interface that is used by the InterBase server.
secure server port name	If you have a local service name associated with the socket port of the remote server, mention that name here; this is typically defined in the /etc/services file on Unix or on the <windows system directory>/drivers/etc/services file on Windows. The client library will automatically translate this to the socket port number at connection time.

Options	Description
secure server port number	The socket port number where the remote server is listening for secure connection requests. You provide this OR the port name above; not both.
ssl	This must be set for any of the other OTW parameters to be accepted and for the connection to be secure. **Note:** This option replaces the "OTWENABLE" option. It is strongly recommended that the OTWENABLE option no longer be used.
serverPublicFile	Location of the certificate file. By default, InterBase searches for ibserverCAfile.pem in the user's home directory. Both the serverPublicFile and serverPublicPath (defined below) must follow the PEM format as per standard SSL requirements. The client will not be expected to create this file. This file will be created by the database administrator of the server you are connecting to. If you are the person generating this file, please ensure that the public certificate file has been created binding the certificate to the DNS of the server. This DNS must match the <secure host name> used by the client. **Note:** This option replaces the "CAFILE" option. It is strongly recommended that the CAFILE option no longer be used.
serverPublicPath	If you use and mention the serverPublicPath, then each file in the directory must contain only a single CA certificate and the files must be named by the hash of the subject name and extension of ".0". There are no default for this option. It is recommended that you use the serverPublicFile as opposed to serverPublicPath; if you specify both, serverPublicFile will be used. The organization hosting the server will provide the CA file. This file is used to verify that the connection is being made to a legitimate and verified server. Care must be taken to ensure that you are referencing the CA you want to use. Please see About the "c_rehash" command for more information. **Note:** This option replaces the "CAPATH" option. It is strongly recommended that the CAPATH option no longer be used.

In addition, if you need **to enable server verification of the client**, you can use the parameters described in the table below. An example follows the table:

Parameter name	Description
clientCertFile	Location and name of the client certification file. This certificate will be presented to the server during the SSL connection phase. The clientCertFile must be in the PEM format and must contain both the client certificate and the private key. **Note:** This option replaces the "CERTFILE" option. It is strongly recommended that the CERTFILE option no longer be used.
clientPassPhraseFile	Name and location of the text file containing the client private key passphrase. You can use either the clientPassPhrase File parameter, or the clientPassPhrase parameter. **Note:** This option replaces the "PASSPHRASEFILE" option. It is strongly recommended that the PASSPHRASEFILE option no longer be used.
clientPassPhrase	Specify a private key PassPhrase. You can use either the clientPassPhrase parameter or the clientPassPhraseFile parameter. **Note:** This option replaces the "PASSPHRASEFILE" option. It is strongly recommended that the PASSPHRASEFILE option no longer be used.

Following is a sample of how to use these parameters in an isql command:

```
isql> connect 'localhost/gds_ssl?ssl=true?clientPassPhrase=clientkey?
clientCertFile=c:\ib_builds\InterBase\secureserver\client\client.pem?
serverPublicFile=c:\ib_builds\InterBase\secureserver\client\
serverCAfile.pem??:c:/foo.ib'
```

3.2.3. About the "c_rehash" command

Use this command if you want to use the serverPublicPath parameter instead of the serverPublicFile on the client or the IBSSL_SERVER_CAPATH instead of the IBSSL_SERVER_CAFILE parameter on the server. For more information on how to set up this directory please go to the OpenSSL website and look for the c_rehash command.

"c_rehash" is a command provided by OpenSSL. This script automatically creates symbolic links to a directory of certificates. For example, suppose that you have a directory called some/where/certs, which contains several CA certificates, and that you want to prepare this directory for use as a serverPublicPath directory. In this case, you can use the following commands:

```
cd /some/where/certs
c_rehash .
```

3.3. Setting up the Server Side

After you have enabled the client side for OTW, you must change the configuration parameters in the SSL configuration file called "ibss_config." This file is located in "<install_directory>\secure\server" directory. The configuration file contains information required by the server. Instructions on how to set up this file are provided below.

In addition, the InterBase server requires two DH (Diffie-Hellman) parameter files to operate. For more information about the dhparameter files, see Generating the dhparameter files.

3.3.1. Changing the ibss_config file

Following is sample ibss_config file:

```
IBSSL_SERVER_HOST_NAME=localhost
IBSSL_SERVER_PORT_NO=3065
IBSSL_SERVER_PHASSPHRASE=serverkey
IBSSL_SERVER_clientCertFile=<install_directory>/secure/server/ibserver.pem
#IBSSL_SERVER_PASSPHRASEFILE=c:/secure/pass.txt
#example comment line
#only needed for client verification
#IBSSL_SERVER_VERIFY_CLIENT
#IBSSL_SERVER_CAFILE=<install_directory>/secure/server/root.pem
```

The following table provides a description of each parameter in the sample above.

Parameter	Description
IBSSL_SERVER_PORT_NO and IBSSL_SERVER_HOST_NAME	Port number and the hostname of the SSL port number and SSL machine name (can be localhost) of the InterBase server the InterBase Server is running on. The defaults are machine name or host name and '3065.' In most cases, the IBSSL_SERVER_HOST_NAME need not be set.
IBSSL_SERVER_CERTFILE	Location of the private key stored in a file.This will be used by the server for encryption. (Default location and filename: will the <install_directory>/secure/server/ibserver.pem. The IBSSL_SERVER_CERTFILE must be in PEM format and must contain both the private key and the certificate.
IBSSL_SERVER_PASSPHRASEFILE	Location of the file containing the passphrase. This must be secure. Make sure you have the correct permissions for this file; the server only needs read access to the file during start up time. The log file will indicate via a message that the passphrase is not loaded. This means you can have the pass phrase on a removable media and once the server has started the media (and hence the passphrase) maybe safely removed.

Parameter	Description
IBSSL_SERVER_PASSPHRASE	Contains the server pass phrase to be used in conjunction with the server certificate file. Use this instead of the IBSSL_SERVER_PASSPHRASEFILE. If both are set the IBSSL_SERVER_PASSPHRASE is used instead of IBSSL_SERVER_PASSPHRASEFILE. If both are not set, InterBase assumes that the private key does not contain a pass phrase.
IBSSL_SERVER_VERIFY_CLIENT	If this parameter is set, then the server will ensure that the client has sent us a certificate. This certificate will be verified against the file specified in the IBSSL_SERVER_CAFILE (or the directory specified in the IBSSL_SERVER_CAPTH).
IBSSL_SERVER_CAFILE	Location of the file containing the CA file, which can be used to verify the client certificate.There is no default for this file. However, it is recommended that you locate the file in <install_directory>/secure/server/ and call it ibrootcert.pem. The file must be in PEM format and is needed only if the IBSSL_SERVER_VERIFY_CLIENT flag is set.
IBSSL_SERVER_CAPATH	Used for the same purpose as the IBSSL_SERVER_CAFILE. However, in this case, the parameter points to a directory containing the CA certificates in PEM format. The files each contain one CA certificate and are only needed if the IBSSL_SERVER_VERIFY_CLIENT flag is set. The files are looked up by the CA subject name hash value, which must be available. See About the "c_rehash" command for information about this command, which can be used to convert multiple PEM files into a IBSSL_SERVER_CAPATH-accessible directory.

In addition, InterBase following information is assumed about the **ibss_config** file:

- General format of the file is <parameter_name>=value.
- Lines starting with "#" are assumed to be comments.
- Lines greater than 1023 characters are truncated to 1023 characters.
- Spaces at the end of the line are considered part of the name or number, so do not put spaces at the end of a line. In case of a filename, enclose the filename in straight quotation marks to avoid problems with unseen space characters at the end of the line.

3.3.2. Generating the dhparameter files

As mentioned above, to use OTW, the server also requires two DH (Diffie-Hellman) parameter files. These are located at <install_directory>/secure/server and are called dh512.pem and dh1024.pem, respectively. InterBase uses the DH key exchange protocol to establish a SSL connection, be it DSA- or RSA-based. InterBase also uses ephemeral mode to ensure forward secrecy.

You are encouraged to generate your own DH parameter files, if you want these files to be unique to your installation. Otherwise, the default ones provided by InterBase will be used. In order for the InterBase server to make successful SSL connections, these files are required.

To create the dhparameter files, use the following commands:

```
openssl dhparam -check -text -5 512 -out dh512.pem
openssl dhparam -check -text -5 1024 -out dh1024.pem
```

After generating the files, copy them to the <install_directory>/secure/server directory.

3.4. Sample OTW Configurations

The following sample configurations were designed to help you effectively enable and implement OTW across your network.

3.4.1. Sample 1: Setting up the Client and Server Without Client Verification by the Server

This is the setup that most InterBase customers will use. In this setup, the server's identity is provided by the server's certificate and the client verifies that the server matches what the client wanted to connect to. The client also authenticates the server certificate based on a CA file located on the client.

Setting up the server

To set up the sample server for OTW, take the following steps:

1. Create the ibserverCAfile.pem and the ibserver.pem files.
2. Copy the ibserver.pem file to <install_directory>/secure/server/ibserver.pem.
3. Create or copy the ibss_config in the <install_directory>/secure/server/ directory from the ibss_config default file.
4. Setup and create the 2 dhparam files in the <install_directory>/secure/server directory, if you want unique ones for your location.
5. Start the server, which should be set up for receiving SSL connections on port 3065 (default).

Setting up the client

To set up the sample client for OTW:

1. Copy the ibserverCAfile.pem provided by the server DBA to the user's home directory.

2. Using isql, make a connection using the following as your URL. Assume your server and client are on the same machine then the hostname is “localhost”.

```
isql> connect “localhost/3065?ssl=true??:c:/foo.ib”;
```

You are now set up to use OTW. This example used default locations for all the certificate and CA files used. If you do not use the defaults and decide to change the location of the server files, you must change the IBSSL_SERVER_CERTFILE parameter in the ibss_config file to point to your PEM formatted Certificate (plus private key) file.

If you locate the CA file (on the client machine) in a directory other than your home directory use the following command on connect:

```
isql> connect “localhost/3065?ssl=true?serverPublicFile=<your CA file location
and name>??:c:/foo.ib”;
```

3.4.2. Sample 2: Setting up the Client and Server for Verifying the Client

To setup InterBase with client side verification, you must first perform all the steps in Sample 1 for both server and client setup. For this example, we will assume that InterBase is installed in C:\InterBase.

Setting up the server

To set up the sample server:

1. Copy the ibrootcert.pem file to the <install_directory>/secure/server directory. This is the public key certificate used by the server to identify the client.
2. The ibss_config file must be modified to indicate to the server that client verification has been enabled, and that the public key certificate location. This is done by adding the following to the <install_directory>/secure/server/ibss_config file:

```
IBSSL_SERVER_VERIFY_CLIENT
IBSSL_SERVER_CAFILE=c:\InterBase\secure\server\ibrootcert.pem
```

Setting up the client

To set up the sample client:

1. Copy the ibclient.pem file, which is a PEM formatted file that contains the client certificate and private key, to your HOME directory on the client. Assume that your HOME directory is C:\smistry, then the complete path for the file will be c:\smistry\ibclient.pem.
2. Specify the location of your client certificate and private key on the connection URL. For example, if you are connecting to c:/foo.ib using isql, the command would be:

```
isql> connect “localhost/3065?ssl=true?clientCertFile=C:
\smistry\ibclient.pem??:c:/foo.ib”;
```

3.4.3. Sample 3: Setting up a JDBC Client and InterBase Server for Verifying the Client

These instructions are only needed if you need your JDBC client connection verified by the server. Use the Sun provided keytool.

You can use the "keytool -genkey" to generate a new self signed private key and public key pair. This password is to be used when making a connection via JDBC (clientPassPhrase).

Examples:

[C:/ib_svn_build/certificates] keytool -genkey -keystore smclient.jks
Enter keystore password: client
What is your first and last name?
  [Unknown]: Shaunak Mistry
What is the name of your organizational unit?
  [Unknown]: InterBase
What is the name of your organization?
  [Unknown]: Embarcadero
What is the name of your City or Locality?
  [Unknown]: Scotts Valley
What is the name of your State or Province?
  [Unknown]: CA
What is the two-letter country code for this unit?
  [Unknown]: US
Is CN=Shaunak Mistry, OU=InterBase, O=Embarcadero, L=Scotts Valley, ST=CA, C=US
correct?
  [no]: yes

Enter key password for <mykey>

```
RETURN if same as keystore password):
```

These commands created a new keystore called smclient.jks. It contains your private and public key and a self signed certificate.

If you follow this example then the following values need to be appended to your JDBC connection URL to make a JDBC connection using client side verification.

```
?clientPrivateFile=c:/smistry/smclient.jks?clientPassPhrase=client
```

Next you can use the keytool -export -rfc to export you public key. This public key must be added to the server, and pointed to by the server using the IBSSL_SERVER_CAFILE option in the ibss_config file.

```
[C:/ib_svn_build/certificates] keytool -export -rfc -keystore smclient.jks
```

Enter keystore password: client

```
-----BEGIN CERTIFICATE-----
MIIDHzCCAtwCBEpt7k4wCwYHKoZIzjgEAwUAMHUxCzAJBgNVBAYTAlVTMQswCQYDVQQIEwJDQTEW
MBQGA1UEBxMNU2NvdHRzIFZhbGxleTEUMBIGA1UEChMLRW1iYXJjYWRlcm8xEjAQBgNVBAsTCUlu
dGVyQmFzZTEXMBUGA1UEAxMOU2hhdW5hayBNaXN0cnkwHhcNMDkwNzI3MTgxMzM0WhcNMDkxMDI1 .....
utRZT+ZxBxCBgLRJFnEj6EwoFhO3zwkyjMim4TwWeotUfI0o4KOuHiuzpnWRbqN/C/ohNWLx+2J6
ASQ7zKTxvqhRkImog9/hWuWfBpKLZl6Ae1UlZAFMO/7PSSoDgYQAAoGAOOavhpQAOLHr/Yw59LrA
SOflcsA15BaAy1NUEl65cqb1/TO/jWroKjlG8dv1uNdsc2kZ4ptmM0L2RjksLxcrqUBm9qjedan9
X8cjEnTeU2hOrmARoZeFhlvtw4CfiuXwnFeagF2IxrETyVLEXMV1A5ATRzrdTqQcfnwPCua0F3Ew-----
END CERTIFICATE----- CwYHKoZIzjgEAwUAAzAAMC0CFQCJtK/
qpIw0ahuIYqYP5d1D90UbdAIUEeU4nXvZAUxZv5SPcFFP uowm7bI= -----END CERTIFICATE-----
```

or use the command

```
[C:/ib_svn_build/certificates] keytool -export -rfc -keystore smclient.jks -file
mycert.pem
```

Enter keystore password: client

Certificate stored in file <mycert.pem>

Now the file mycert.pem contains your public certificate. Move this to the server and make sure this is included in the file pointed to by the IBSSL_SERVER_CAFILE.

If you want to get your private key validated by a certification authority, the client need to use the "keytool -certreq" command to generate a certificate signing request for a Certificate signing authority. Once this request is validated you would add this certificate reply to your keystore via a

"keytool -import" command. This is followed by a "keytool -export" command to get the certificate to authenticate your public key. This exported certificate will then be moved to the InterBase server, so the InterBase server can "trust" and verify the client private key.

4. Connection Troubleshooting

This section describes some troubleshooting guidelines for issues related to network configuration and client/server connections. If you are having trouble connecting client to server over a network, use the steps listed below to diagnose the cause. On Windows, you can perform some of these tests using the Communications Diagnostic dialog. See Communication Diagnostics for more information.

4.1. Connection Refused Errors

If the client fails to reach the server host at all, or the `gds_db` service fails to answer, you might get a "connection refused" error. Below is a checklist that you can use to diagnose the source of this error:

- Is there low-level network access between the client and server?
- Can the client resolve the server's hostname?
- Is the server behind a firewall?
- Are the client and server on different subnets?
- Can you connect to a database locally?
- Can you connect to a database loopback?
- Is the server listening on the InterBase port?
- Is the services file configured on client and server?

4.1.1. Is there low-level network access between the client and server?

You can quickly test whether the client cannot reach the server because of a physically disconnected network or improper network software configuration, by using the `ping` command. Usage is:

```
ping servername
```

Error messages from `ping` indicate that there is a network problem. Check that the network is plugged in, that the network wires are not damaged, and that the client and server software is properly configured.

Test connectivity from the client in question to another server; if it succeeds, this could rule out improper network configuration on the client.

Test connectivity from another client to the InterBase server host; if it succeeds, this could rule out improper network configuration on the server.

4.1.2. Can the client resolve the server's hostname?

InterBase clients must specify the server by name, not by IP address, except in some Linux distributions. Therefore, the client must be able to resolve the server's hostname. For TCP/IP, this is done either by maintaining a `hosts` file on the client with the mappings of hostnames to IP addresses, or by the client querying a DNS server or WINS server to resolve this mapping. Make sure the name server has a correct entry for the server host in question.

4.1.3. Is the server behind a firewall?

If the database server is behind a software or hardware firewall, all network traffic could be restricted and the client might not be able to reach the server at all. Some firewalls permit or restrict traffic based on the port to which the client attempts to connect. Because of this, it is not conclusive whether a given service can reach the server. Neither is it an indication of connectivity if the client can resolve the IP address; that merely indicates that the client can reach a name server that resolves the InterBase server hostname.

If the client is separated from the server by a firewall, the client cannot connect.

4.1.4. Are the client and server on different subnets?

NetBEUI cannot route network traffic between subnets. Other protocols can also be configured to restrict traffic between subnets. If the client and server are on a complex network with multiple subnets, ask your network administrator if the network configuration allows you to route network traffic between the client and server in question using a given protocol.

4.1.5. Can you connect to a database locally?

To confirm that the `ibserver` process is running on the server and able to attach to your database, try a local database connection:

1. Log in to the console of the database server host, and run an application such as command-line `isql`.
2. Attempt to connect to a database without specifying a hostname: list just the path.

The Communications Diagnostic dialog also has a local database attachment test. See DB Connection Tab for details.

Note:
Local connection mode is not available on UNIX servers.

4.1.6. Can you connect to a database loopback?

You can simulate a client/server connection and test the configuration of the server without the additional variable of the client configuration and intervening network by connecting in a *loopback* mode.

1. Log in to the console of the database server host and run an application such as command-line `isql` or InterBase IBConsole isql.
2. Attempt to connect to the database using a remote connection specification, even though the server named is also the client host.

Whether this test fails or succeeds, it helps to narrow the focus of further diagnostic tests. If it fails, you can infer that the configuration of the server is at fault. If it succeeds, you can infer that the server is not at fault and you can concentrate further tests on the client.

4.1.7. Is the server listening on the InterBase port?

If the `ibserver` process on the server has not started, there is no answer to attempts to connect to the `gds_db` service (port 3050).

Start the `ibserver` process on the server. Use `ibmgr -start` on UNIX, or the InterBase Manager on Windows. See Server Configuration.

4.1.8. Is the services file configured on client and server?

The `services` file must have correct entries to indicate the port number associated with the named service `gds_db` . This configuration must be accessible on the client as well as the server.

```
gds_db 3050/tcp # InterBase Server
```

This file is found in the following locations:

Windows server platforms: `C:\system32\drivers\etc\services` or `C:\Windows\system32\drivers\etc\services` on new Windows platforms

On Windows non-server platforms: `C:\windows\services` .

On UNIX: `/etc/services` .

In a UNIX environment with NIS, the NIS server can be configured to supply the `services` file to all NIS clients on UNIX workstations.

See Also

- Connection Rejected Errors
- Other Errors

4.2. Connection Rejected Errors

If the client reaches the server host and the `gds_db` service answers but you still cannot attach to a database, it can result in a "connection rejected" error. Below is a checklist that you can use to diagnose the source of this error.

- Did you get the correct path to the database?
- Is UNIX host equivalence established?
- Is the database on a networked file system?
- Are the user and password valid?
- Does the server have permissions on the database file?
- Does the server have permissions to create files in the InterBase install directory?

4.2.1. Did you get the correct path to the database?

Verify that you supplied the correct path to the database file. Keep in mind:

- On Windows, you must supply the drive letter with the path.
- On UNIX, paths are case-sensitive.
- Slash ("/") vs. backslash ("\") does not matter, unless you need to use double-backslashes in string literals in C or C++ code.

4.2.2. Is UNIX host equivalence established?

To use the UNIX user-equivalence feature, there must be a *trusted host* relationship between the client and the server. See Users on UNIX.

4.2.3. Is the database on a networked file system?

A database file must not reside on an NFS file system or a mapped drive. When the `ibserver` process finds such a case, it either denies the connection or passes the connection request on to the InterBase service running on the file server. See Networked File Systems for more details.

To correct this situation, move your database to a file system on a hard disk that is physically local to the database server.

4.2.4. Are the user and password valid?

The client application must use a valid user and password combination that matches an entry in the InterBase security database (`admin.ib` by default).

4.2.5. Does the server have permissions on the database file?

The `ibserver` process must have permission to read and write the database file at the operating system level. Check the permissions on the database file, and the uid of the `ibserver` process. (On UNIX, you have the option of running `ibserver` as user *InterBase*, a non-superuser uid.)

The InterBase security database (`admin.ib` by default) that contains users and passwords must also be writable by the `ibserver` process.

4.2.6. Does the server have permissions to create files in the InterBase install directory?

The `ibserver` process must have write permission in the InterBase directory (by default, `/usr/InterBase` on UNIX, `C:\Program Files\Embarcadero\InterBase` on Windows). The server process must be able to write to, and perhaps create, the `interbase.log` file and other temporary files.

See Also

- Connection Refused Errors
- Other Errors

4.3. Other Errors

4.3.1. Unknown Win32 error 10061

This error is often associated with a missing server-access license for the InterBase software on the server host. Make sure you have licensed InterBase server to allow clients to connect from the network.

4.3.2. Unable to complete network request to host

This error occurs in cases when the InterBase client cannot establish a network connection to the server host. This can occur for a variety of reasons. Below is a list of common causes:

- The BDE Administrator requires that you specify the InterBase connect string in the `SERVER NAME` alias property. You must use this property and must not use the `PATH` alias property, or else you receive the network error message.
- The InterBase client attempts to translate the server portion of your connect string to an IP address, by calling `gethostbyname()`. If you supplied an IP address, `gethostbyname()` is likely to fail to resolve it. Some modern TCP/IP drivers – including Winsock 2 and Linux TCP/IP – do resolve strings that look like IP addresses. If you are on Windows, specify hosts by name, or else upgrade your TCP/IP driver to Winsock 2.

- The InterBase client must look up the InterBase network *service* by name. If the client doesn't find the entry for `gds_db` in the `services` file, it might fail to connect to the server, and give the network error. You can create the entry in the `services` file manually, or reinstall InterBase to perform this task.
- The server you specify must be running on the network that you use. If the hostname corresponds to a host that is inaccessible because of network interruption, or the host is not running, then the connection request fails with the network error.
- The syntax of the InterBase connect string determines the network protocol the client uses to connect to the server host (see Connection-specific Examples). Different server platforms support different subsets of network protocols. If your server does not support the protocol indicated by your connect string, the connection attempt fails with the network error. For example, the NetBEUI connection syntax (`\\server\C:\path\database.ib`) works only if your server is running Windows. The syntax does not work if your server is running UNIX or Linux.
- A network connection request succeeds only if the InterBase server is installed and active on the server host, and that the InterBase server is licensed to receive remote connection requests. If there is no process listening for connection requests, the client's connection requests with the network error. You should check that the InterBase server is installed on the server, that it is running, and that the license includes the Server capability.

5. Communication Diagnostics

Network configuration of a client/server system involves several different software and hardware layers and proper configuration of each of these layers. When one or more layers are mis-configured, it is not always evident where the problem lies. InterBase Communication diagnostics helps to identify the source of the problem by testing each layer progressively for existing or potential network problems.

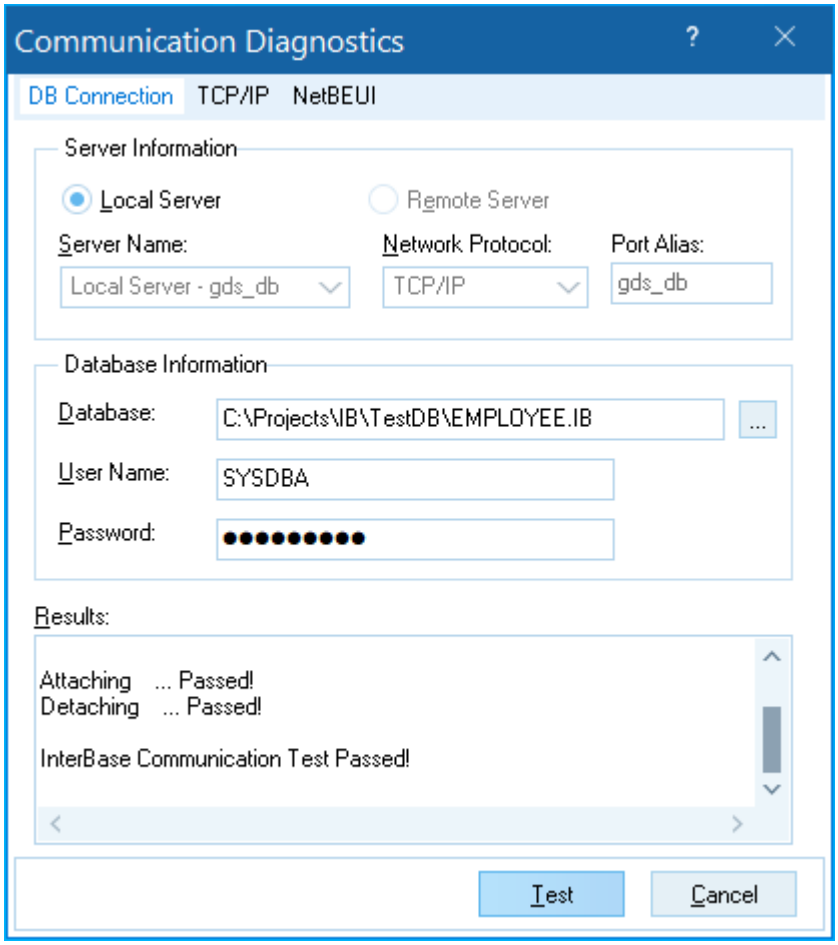
You can access the Communication Diagnostics dialog by one of the following methods:

- Select a disconnected server in the Tree pane. Choose Server|Diagnose Connection .
- Right-click InterBase Servers or any disconnected server in the Tree pane and choose Diagnose Connection from the context menu.
- Select a disconnected server from the Tree pane and double-click Diagnose Connection in the Work pane.

There are four types of diagnostics that you can perform. The Communications Diagnostics dialog has separate tabs for each diagnostic type.

5.1. DB Connection Tab

This test lets you connect to an InterBase database using the InterBase client libraries. It is the most basic test of InterBase operation and is generally used only after confirmation that the underlying network is working correctly.



5.1.1. To Run a DB Connection Test

1. Select either the Local Server option or the Remote Server option.

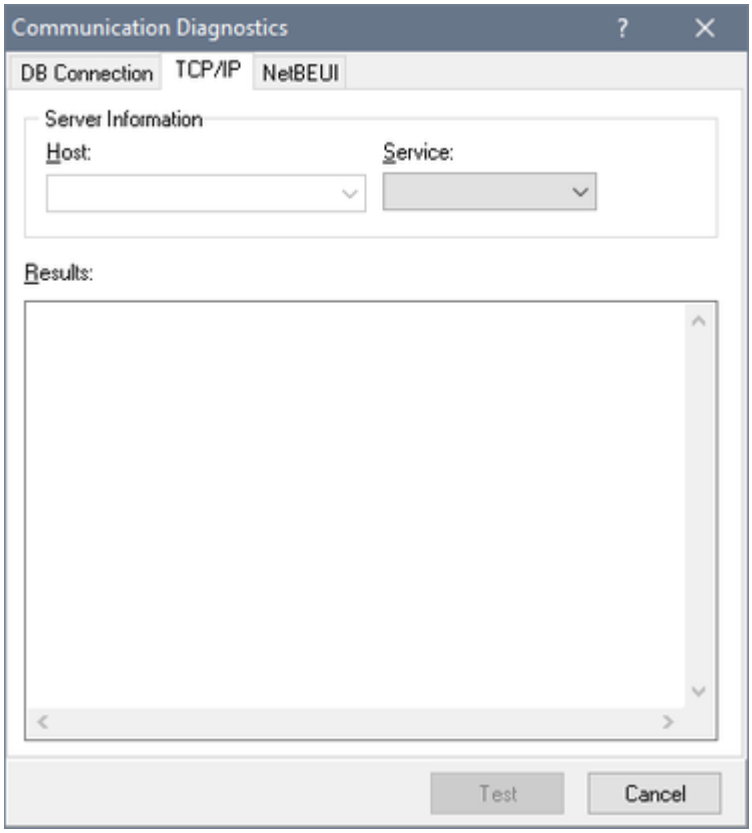
2. If you choose Local Server, the Server Name and Network Protocol information is not required. These text fields are disabled. You can proceed to step 5.
3. If you choose Remote Server, type the name of the server in the Server Name text field.
4. The InterBase server name is the name of the database server machine. There is not a specific name for the InterBase server process itself. For example, if the server is running on the NT server " venus ", you enter this name in the Server Name text field.
5. If you choose Remote Server, select a network protocol from the drop-down list: either TCP/IP, NetBEUI, named pipe, or local. Protocols are valid only when they are supported by both the client and the server.
6. Enter the database filename, including the path where file is located, in the Database text field. If you selected the Local Server option in step 1 you can also click the browse button to locate the file you want. If you selected the Remote Server option, however the browse button is disabled.
7. Type the username and password for the database in the corresponding User Name and Password text fields.
8. Click Test to display the results of the connectivity test in the Results text area.

5.1.2. Sample output (local connection)

```
Attempting to attach to:
C:\Program Files\Embarcadero\InterBase\examples\Database\employee.ib
Attaching ...Passed!
Detaching ...Passed!
InterBase Communication Test Passed!
```

5.2. TCP/IP Tab

Use this property sheet to test Winsock TCP/IP connectivity.



To run a winsock TCP/IP connectivity test:

1. Enter either a network host name or IP address in the Host text field.
2. Select a service name or number from the drop-down Service list. Possible service selections are: 21, Ping, 3050, ftp, `gds_db` .
   Select Ping from the Service drop-down list to display a summary of round-trip times and packet loss statistics.
3. Click Test to display the results of the connectivity test in the Results text area.

Sample results (ftp):

```
Initialized Winsock.
Attempting connection to DBSERVE.
Socket for connection obtained.
Found service ‘FTP’ at port ‘21’.
Connection established to host ‘DBSERVE’ on port 21.
TCP/IP Communication Test Passed!
```

Sample results (ping):

```
Pinging DBSERVE [200.34.4.5] with 32 bytes of data.
Reply from 200.34.4.5: bytes=32 time=1ms TTL=128
Reply from 200.34.4.5: bytes=32 time=1ms TTL=128
Reply from 200.34.4.5: bytes=32 time=1ms TTL=128
Reply from 200.34.4.5: bytes=32 time=0ms TTL=128
```

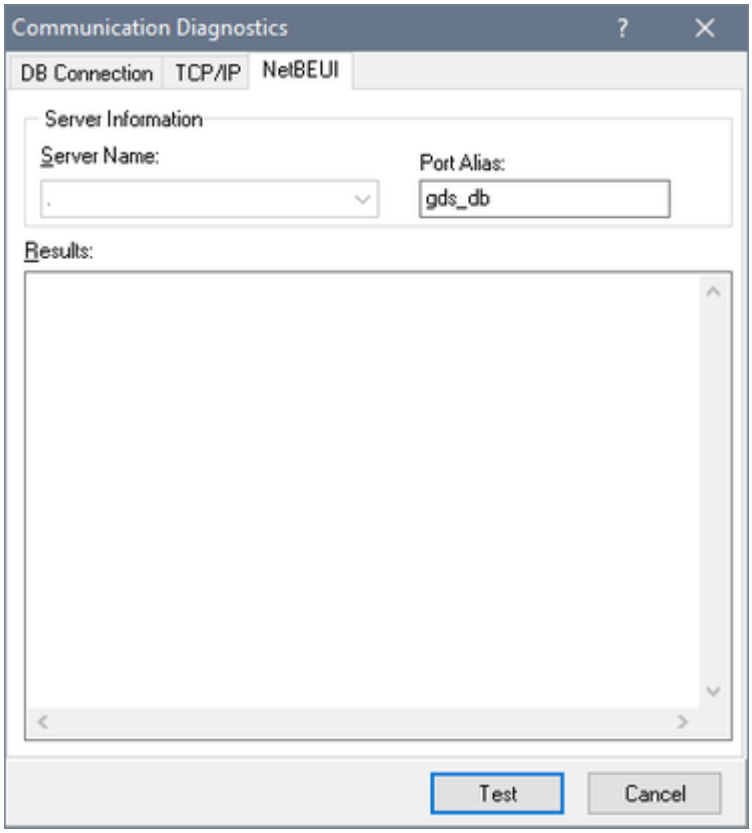
```
Ping statistics for 200.34.4.5:
Packets: Send = 4, Received = 4, Lost = 0 (0%),
Approximate round trip times in milli-seconds:
Minimum = 0ms, Maximum = 1ms, Average = 0ms
```

If the error message is	Then check
Failed to find named port	Your `services` file to be sure there is an entry for `gds_db` in the form: `gds_db 3050/tcp` .
Failed to connect to host	• Hostname, port 3050 • The InterBase Server to make sure it is installed properly, is running, and is configured for TCP/IP.
Failed to resolve hostname	• Hostname • Your `hosts` file or DNS to be sure it has an entry for the server. • That you used a hostname and not an IP address.
Unavailable database	Whether the InterBase server is running; the server must be running before attempting a database connection.

5.3. NetBEUI Tab

NetBEUI is supported on all Windows clients, but only Windows server platforms support NetBEUI as a server.

Use this property sheet to test NetBEUI connectivity between the client and the server.



To run a NetBEUI connectivity test:

1. Select a Windows server on which InterBase has been installed from the Server Name drop-down list. If the desired server does not exist in this list, you can type the server name in the edit portion of the drop-down list.
2. Click Test to display the results of the connectivity test in the Results text area.

Sample output (NetBEUI connection):

```
Attempting to attach to DBSERVE using
the following named pipe:
\\dbserve\pipe\interbas\server'ds.db.
NetBEUI Communication Test Passed!
```

The connection may fail if a Microsoft Windows network is not the default network for the client. You should also be logged into the Windows network with a valid user name and password.

DATABASE USER MANAGEMENT

InterBase provides several methods for configuring and enforcing security by controlling how a database is accessed and used. Server security enables you to:

- Add a user to the security database
- Delete a user from the security database
- Modify user information in the security database
- Display a list of users in the security database
- Enable embedded user authentication
- Create database alias
- Delete a database alias
- Display a list of all database alias

This chapter gives an overview of these options. The user administration tools are covered here, but SQL statements for configuring privileges are in other InterBase books; these passages are referenced where appropriate.

1. Security Model

Security for InterBase relies on a central security database for each server host. This database, `admin.ib` by default, contains a record for each legitimate user who has permission to connect to databases and InterBase services on that host. Each record includes the user login name and the associated encrypted password. The entries in this security database apply to all databases on that server host.

The username is significant to 31 bytes and is not case sensitive. When a stronger password protection is implemented, the password is now significant to 32 bytes instead of 8 and is case sensitive.

Before performing any database administration tasks, you must first log in to a server. Once you log in to a server, you can then connect to databases residing on the server.

All users must enter their username and password to log in to a server. The password is encrypted for transmission over the network. The username and password are verified against records in the security database. If a matching record is found, the login succeeds.

1.1. The SYSDBA User

Every InterBase server has a `SYSDBA` user, with default password masterkey. `SYSDBA` is a special user account that can bypass normal SQL security and perform tasks such as database backups and shutdowns.

Initially, SYSDBA is the only authorized user on a server; the SYSDBA must authorize all other users on the server. Only the SYSDBA user can update the security database to add, delete, or modify user configurations. SYSDBA can use either gsec or IBConsole to authorize a new user by assigning a username and password in the security database.

Important:
We *strongly* recommend you change the password for SYSDBA as soon as possible after installing InterBase. If you do not alter the SYSDBA password, unauthorized users have easy access and none of your databases are secure.

1.2. Other Users

The SYSDBA account can create other users on a per-server basis. Use gsec or IBConsole to create, modify, or remove users from the InterBase security database. These users are authorized to connect to any database on that database server host. It is a common design strategy to create a distinct InterBase user for each person who uses the databases on your server. However, other strategies are also legitimate. For example:

- Create one InterBase user for an entire group of people to use, in order to simplify password administration. For example, a user FINANCE could satisfy the access needs for any and all staff in a financial analysis team. This team only needs to remember one password between them.
- Create one InterBase user for a group of people to use, as warranted by requirements of distinct privilege configurations. For example, if Erin and Manuel have identical access to the data within a database, they could use the same InterBase user account.

1.3. Users on UNIX

If both the client and the server are running UNIX, you can allow UNIX usernames access to databases by configuring the server host to treat the client host as a *trusted host*.

To establish a trusted host relationship between two hosts, add an entry in /etc/hosts.equiv or /etc/gds_hosts.equiv on the server. The former file establishes trusted host status for any service (for example, rlogin, rsh, and rcp); the latter file establishes trusted host status for InterBase client/server connections only. The format of entries in both files is identical; see your operating system documentation on hosts.equiv for details.

The login of the client user must exist on the server. In addition to the hosts.equiv method of establishing a trusted host, the you can also use the .rhosts file in the home directory of the account on the server that matches the account on the client.

The InterBase client library defaults to using the current client's UNIX login as the InterBase login only when the client specifies no username through any of the following methods:

- Database parameter buffer (`dpb`) parameters – see the API Guide.
- Command-line options – for example, `-user` options of `isql` or another utility
- Environment variables – see ISC_USER and ISC_PASSWORD.

Notes

- This feature is not implemented on Windows servers, because Windows does not implement a trusted host mechanism as UNIX does.
- Windows clients cannot be treated as trusted hosts by UNIX servers.

See Also

- The InterBase Security Database
- Implementing Stronger Password Protection
- Enabling Embedded User Authentication
- System Table Security
- SQL Privileges
- Groups of Users
- Other Security Measures
- User Administration with IBConsole
- User Administration With the InterBase API
- Using gsec to Manage Security
- Using gsec to Manage Database Alias
- gsec Error Messages

2. The InterBase Security Database

The InterBase server stores the names and passwords of its authorized users in a special security database that resides in the InterBase home directory. By default, it is named `admin.ib` .

> **Note:**
> For information on stronger password protection on InterBase databases. See Implementing Stronger Password Protection.

You can use another name for the security database if you wish. If you change this name, you must add an entry to the `ibconfig` file, setting `ADMIN_DB` to the new name.

```
ADMIN_DB newname.ib
```

Note:
You can use any file extension for database files, but InterBase recommends using `.ib`.

Every user of an InterBase server requires an entry in the InterBase security database. The `gsec` security utility lets you display, add, modify, or delete information in the security database. IBConsole provides a graphical interface for the same functionality. The following table describes the contents of the security database:

Column	Required	Description
User name	Yes	The name that the user supplies when logging in; maximum length is 31 bytes.
Password	Yes	The user's password • Case sensitive • Only the first eight bytes are significant • Maximum length: 32 bytes.
UID	No	An integer that specifies a user ID.
GID	No	An integer that specifies a group ID.
Full name	No	User's real name (as opposed to login name)

See Also

- Security Model
- Implementing Stronger Password Protection
- Enabling Embedded User Authentication
- System Table Security
- SQL Privileges
- Groups of Users
- Other Security Measures
- User Administration with IBConsole
- User Administration With the InterBase API
- Using gsec to Manage Security
- Using gsec to Manage Database Alias
- gsec Error Messages

3. Implementing Stronger Password Protection

Stronger password protection on InterBase databases can be implemented since InterBase XE. This additional functionality supports a longer effective password length, resulting in stronger password protection.

3.1. Requirements/Constraints

- This design supports server-wide user authentication as manifested by the USERS table of the security database, configured with the IBCONFIG.ADMIN_IB property parameter, which defaults to the admin.ib file.
- The design also supports EUA (Embedded User Authentication) databases. As with the non-EUA databases, it also has to be explicitly enabled by the owner/administrator. Please note that the USERS table in admin.ib has RDB$USERS as the counterpart in EUA databases; so the earlier references have to be compatible with EUA database references.
- A user account in the USERS table can only accommodate a single password hash value. This restriction means that once the user account password is changed to use SHA-1, the user has to use the new IB client to log into the new IB server.
- A plaintext password length of 32 bytes is supported in this release, up from 8 bytes in earlier versions of InterBase.
- An updated version of IBConsole is present in the kit. This version does not show the “Default” buttons in the database/server login screens.
- A batch script (changepassword.bat) is now provided in the <interbase>/bin directory to update the SYSDBA account password post-install.

3.2. Getting Started with Implementing Stronger Password Protection

The DES-CRYPT password algorithm has been replaced with a modern cryptographic hash function that is more widely accepted by organizations in private industry and government. The design uses SHA-1, which generates a fixed length 160-bit hash.

1. Before starting, it is strongly recommended that you back up your old admin.ib from the current installation before installing the new InterBase. This allows you to restore it, if needed.
2. After new IB has been installed on the server, run the following against admin.ib:

```
isql admin.ib -user SYSDBA -pass xxxxxxx
sql> ALTER DATABASE SET PASSWORD DIGEST 'SHA-1';
sql> CREATE DOMAIN PASSWORD_DIGEST AS CHAR(16) CHARACTER SET ASCII;
sql> ALTER TABLE USERS ADD PASSWORD_DIGEST PASSWORD_DIGEST;
sql> UPDATE USERS SET PASSWORD_DIGEST = 'DES-CRYPT';
sql> COMMIT;
```

> **Note:**
> The ALTER DATABASE command can only be run by the database owner or SYSDBA. This command modifies RDB$DATABASE.RDB$PASSWORD_DIGEST to the string value "SHA-1". This means that all new password hash generation for new or existing user accounts in the USERS table will use the SHA-1 hash function.

The password hash function can be reset to DES-CRYPT using the same DDL:

```
ALTER DATABASE SET PASSWORD DIGEST 'DES-CRYPT';
```

The admin database is now prepared so that new user accounts or modifying the password of existing accounts will generate SHA-1 password hashes against plaintext passwords up to an untruncated length of 32 significant bytes.

GSEC [add | modify], IBConsole, and the IB Services API support the SHA-1 password hash algorithm. Any of these tools can be used to maintain the passwords of server-wide user accounts. If an existing user account has had its password changed, then that user must log in to the server using the new IB client library.

> **Important:**
> There will be backward compatibility problems if the converted admin.ib database is backed up and restored by an older IB engine after the password hashes have been converted to SHA-1. Older IB engines will not understand the different password hashes and will cause unrecoverable login errors.

See Also

- Security Model
- The InterBase Security Database
- Enabling Embedded User Authentication
- System Table Security
- SQL Privileges
- Groups of Users
- Other Security Measures
- User Administration with IBConsole
- User Administration With the InterBase API
- Using gsec to Manage Security
- Using gsec to Manage Database Alias
- gsec Error Messages

4. Enabling Embedded User Authentication

Embedded user authentication (EUA) stores database user name and password information directly in the database. When user authentication is embedded in a database, database metadata IP is better protected from outside inspection. EUA also makes transportable databases more secure.

Only the database owner is allowed to administer embedded user authentication. A regular user may alter the password for their own user account.

Having a SYSDBA user account under embedded user authentication is optional. If there is a SYSDBA account, it has most of the same privileges for the database in which it is embedded that any admin.ib would have. The sole exception is that the SYSDBA cannot maintain admin control for EUA if it has been implemented by another user.

Important: EUA must be enabled to use the InterBase encryption feature, which facilitates the encryption of database pages and columns. Access to encrypted databases and columns can be given to specified users when EUA has been enabled. For more information about the InterBase encryption feature, see the Data Definition Guide.

4.1. Check if EUA is Active with isc_database Info API

If `isc_databaseinfo()` is invoked with info item `isc_info_db_eua_active` it returns:

- 1 if EUA is active for the database.
- 0 if EUA is not active.

Only the owner or SYSDBA can query for this information, once connected to the database. For all other users, the info request is ignored.

4.2. Enabling EUA Using iSQL

You can enable EUA using the following commands:

- When creating a new database, use:

```
CREATE DATABASE <database name> [WITH ADMIN OPTION]
```

The admin clause automatically inserts name and password information for the user creating the database into the RDB$USERSsystem table.

- When altering an existing database, use:

```
ALTER DATABASE [ADD ADMIN OPTION]
```

Alternatively, the **gsec** command-line utility has a new option, `-user_database` [database_name], which allows that tool to maintain user accounts for embedded user authentication enabled databases.

To disable EUA, use the following syntax:

```
ALTER DATABASE [DROP ADMIN OPTION]
```

Once EUA is disabled, access to the database will be authenticated via the centralized user authentication database of the server `ADMIN.IB`.

4.3. Enabling EUA Using IBConsole

You can enable EUA using the IBConsole when you use the IBConsole interface to create a new database.

To enable EUA from IB Console:

1. Right-click on Databases and choose Create Database from the context menu.
2. On Create Database, in the **Embedded User Authentication** field, change the default, No, to **Yes**.
3. Change the other settings as needed, and choose **OK** to create the database. EUA is now enabled.

4.4. Adding and Modifying Users in a EUA-enabled Database

To add users to a EUA-enabled database, use the `isc_spb_user_dbname` service parameter block (SPB) with the `isc_action_svc_add_user` service action. The allowed service actions are `isc_action_svc_xxx_user`, where you replace `xxx` with add/modify/delete/display for each respective action.

The following code sample illustrates how to use this SPB to add a user to EUA-enabled database:

```
#ifdef EUA_DATABASE
*thd++ = isc_spb_user_dbname;
ADD_SPB_LENGTH (thd, strlen(target_db));
for (x = target_db; *x;)
*thd++ = *x++;
#endif
```

For more information about using this and other service parameter blocks and service actions, see the InterBase API Guide.

See Also

- Security Model
- The InterBase Security Database
- Implementing Stronger Password Protection
- System Table Security
- SQL Privileges
- Groups of Users
- Other Security Measures
- User Administration with IBConsole
- User Administration With the InterBase API
- Using gsec to Manage Security
- Using gsec to Manage Database Alias
- gsec Error Messages

5. System Table Security

InterBase stores the database metadata in its system tables. These tables have an intricate set of dependencies between them, and writing to one without sufficient knowledge can corrupt the database. For this reason, the system tables have the following *default* security access applied to them:

- By default, `PUBLIC` users have only `SELECT` privileges on the system tables.
- The database owner, the SYSDBA user, and the operating system administrator (root on UNIX and Administrator on Windows server platforms) have full access to the system tables, including write permission. These users can, if desired, assign write privileges to individual users or to `PUBLIC`, using the `GRANT` statement.

5.1. Older Databases

InterBase applies this default security (no write access for `PUBLIC`) to older databases whenever possible:

- The `gbak` backup/restore utility applies the default security to any database when it is restored to ODS 10.1 (InterBase 6.5) or later.
- When an InterBase server that is version 6.5 or later attaches an older database, it applies the default privileges to that database if they are not already present, even if the database is ODS 10.0 or earlier.

5.2. Scripts for Changing Database Security

Three SQL scripts are included in `<ib_install>/examples/security` directory: `readmeta.sql`, `writemeta.sql` and `blindmeta.sql`. These scripts can be run against

databases with isql to make wholesale changes to system tables access privileges of a database, except or rdb$users for security purposes.

- `readmeta.sql` applies the default `PUBLIC` access privileges: PUBLIC can only select from the system tables, but the database owner, system administrator, and SYSDBA user have full access. This script can be used to return a database that has customized system table privileges back to this default.
- `writemeta.sql` grants all system table privileges to `PUBLIC`. This is the behavior that existed in InterBase 6.0 and earlier.
- `blindmeta.sql` revokes all system table privileges from `PUBLIC`. This prevents any `PUBLIC` user from querying the system tables, including InterBase and third-party utilities run by `PUBLIC` users. For example, `gstat`, `gbak`, QLI and IBConsole would not be able to query system metadata. This script allows developers to protect their intellectual property by hiding the database design of tables, stored procedures and triggers from the general public and competitors. Blind access makes it difficult, if not impossible, for a general user to generate ad hoc queries against a database.

A database with blind access does not prevent any user from using InterBase Data Definition Language (DDL) to define new database objects. It just prevents a user from querying or writing to the system tables directly.

isc_blob_lookup_desc() and isc_array_lookup_bounds() Two client-side APIs, `isc_blob_lookup_desc()` and `isc_array_lookup_bounds()`, cannot execute without `SELECT` metadata privileges, because the APIs directly query some InterBase system tables. Thus databases that have had `blindmeta.sql` run against them are not able to execute these APIs for any users except the owner, the system administrator, and `SYSDBA`.

Older InterBase clients InterBase 6.0 and previous InterBase kits cannot access a database on behalf of a user if that user has no privileges to the system tables. Thus an InterBase developer who runs `blindmeta.sql` on an InterBase database cannot ship that database to customers with InterBase 6.0 or older runtime kits and expect those users to be able to access the database. The developer would have to run `readmeta.sql` against a copy of the database and ship that to customers who have older InterBase runtimes.

5.3. System Table Security Migration Issues

The InterBase engine automatically installs the default (`SELECT`-only) SQL privileges for `PUBLIC` on the system tables when attaching ODS 10.0 or older databases. Thus if all users must be able to write to database metadata, `writemeta.sql` will have to be run against each database to restore that behavior.

See Also

- Security Model
- The InterBase Security Database
- Implementing Stronger Password Protection

- Enabling Embedded User Authentication
- SQL Privileges
- Groups of Users
- Other Security Measures
- User Administration with IBConsole
- User Administration With the InterBase API
- Using gsec to Manage Security
- Using gsec to Manage Database Alias
- gsec Error Messages

6. SQL Privileges

Connecting to a database does not automatically include privileges to modify or even view data stored within that database. Privileges must be granted explicitly; users cannot access any database objects until they have been granted privileges. Privileges granted to `PUBLIC` apply to all users.

For full description of syntax of SQL privileges, see entries for `GRANT` and `ROLE` in the *Language Reference* and Data Definition Guide.

7. Groups of Users

InterBase implements features for assigning SQL privileges to groups of users. SQL roles are implemented on a per-database basis. UNIX groups are implemented on a server-wide basis, using the UNIX `group` mechanism.

7.1. SQL Roles

InterBase supports SQL group-level security as described in the *ISO-ANSI Working Draft for Database Language*. For syntax of SQL `ROLE`, see Language Reference Guide and Data Definition Guide.

Implementing roles is a four-step process:

1. Declare the role with `CREATE ROLE`.

```
CREATE ROLE sales;
```

2. Assign privileges on specific tables and columns to the role using the `GRANT` statement.

```
GRANT UPDATE ON table1 TO sales;
```

3. Grant the role to users, again with the `GRANT` statement.

```
GRANT sales TO user1, user2, user3;
```

4. Finally, to acquire the privileges assigned to a role, users must specify the role when connecting to a database.

```
CONNECT 'foo.ib' USER 'user1' PASSWORD 'peanuts' ROLE sales;
```

User1 now has update privileges on `TABLE1` for the duration of the connection.

A user can belong to only one role per connection to the database and cannot change role while connected. To change role, the user must disconnect and reconnect, specifying a different role name.

You can adopt a role when connecting to a database by any one of the following means:

- **To specify a role when attaching to a database through IBConsole isql**, display the Database Connect dialog and type a rolename in the Role field.
- **To specify a role programmatically upon connection using the InterBase API**, use the dpb parameter `isc_dpb_sql_role_name` . See the API Guide.
- **To specify a role for a connection made by an embedded SQL application or isql session**, use the `ROLE` **<rolename>** clause of the `CONNECT` statement. See the statement reference for `CONNECT` in the Language Reference Guide.

> **Note:**
> Applications using BDE version 5.02 or later, including Delphi, JBuilder, and C++Builder, have a property by which they can specify a role name. Also, the ODBC driver that currently ships with InterBase also recognizes roles.

7.2. UNIX Groups

Operating system-level groups are implicit in InterBase security on UNIX, similarly to the way UNIX users automatically supplement the users in the InterBase security database. For full description of usage and syntax of using UNIX groups with InterBase security, see Language Reference Guide and Data Definition Guide.

> **Note:**
> Integration of UNIX groups with database security is not a SQL standard feature.

See Also

- Security Model
- The InterBase Security Database
- Implementing Stronger Password Protection
- Enabling Embedded User Authentication
- System Table Security

- SQL Privileges
- Other Security Measures
- User Administration with IBConsole
- User Administration With the InterBase API
- Using gsec to Manage Security
- Using gsec to Manage Database Alias
- gsec Error Messages

8. Other Security Measures

InterBase provides some restrictions on the use of InterBase tools in order to increase security. In addition, there are things that you can do to protect your databases from security breaches. This section describes these options.

8.1. Restriction on Using InterBase Tools

As a security measure, InterBase requires that only the owner of a database or `SYSDBA` can execute `gbak`, `gstat`, and `gfix`.

- Only the database owner or `SYSDBA` can use `gbak` to back up a database. Anyone can restore a database, because there is no concept of an InterBase user for a backup file. However, only the owner or `SYSDBA` can restore a database over an existing database. For security purposes, make sure that your backup files are stored in a secure location. This prevents unauthorized persons from restoring databases and gaining access to them.
- On UNIX platforms, there is a further constraint on `gstat`: to run `gstat`, you must have system-level read access to the database file. To access the database with `gstat`, you must either be logged into the account running the InterBase server ("InterBase" or "root") or someone must change the permissions on the database file to include read permission for your Group.

8.2. Protecting your Databases

You can take several steps to increase the security of your databases and other files on your system:

- UNIX and Linux systems: Before starting the InterBase server, log in as user "InterBase" (or "interbas", if user names longer than eight characters are not allowed), rather than "root" (only these users can start the server). This restricts the ability of other users to accidentally or intentionally access or overwrite sensitive files such as the password file. Start the InterBase server while you are logged on as user "InterBase".
- Windows server platforms: When the InterBase server is run as a service, you can protect a database against unauthorized access from outside InterBase (such as by a copy command), by making the database files readable only by the system account, under which services run.

However, if you make the database readable only by the system account, remote access to the database must be by TCP/IP, not by NetBEUI.

- Because anyone can restore a backed up database, it is wise to keep your backup files in a directory with restricted access. On UNIX, only the backup file itself, not the directory in which it resides, needs to have permissions restricted to prevent reading by unauthorized persons.

For example, if all of the following are true:

- the backup file has permission 600 (`rw-------`) or 640 (`rw-r-----`)
- only trusted persons belong to the groups
- the directory has permission `rwxr-xr-x`

then persons other than the responsible owner and group can see that the backup file is there, but they cannot get at it. If the user or backup script issues the command `umask 077` (or 027, as appropriate) before running `gbak`, unauthorized persons will not be able to access the backup file, no matter what the permissions on the directory. The directory should not be writable by "other", since this permits other persons to delete the backup file.

See Also

- Security Model
- The InterBase Security Database
- Implementing Stronger Password Protection
- Enabling Embedded User Authentication
- System Table Security
- SQL Privileges
- Groups of Users
- User Administration with IBConsole
- User Administration With the InterBase API
- Using gsec to Manage Security
- Using gsec to Manage Database Alias
- gsec Error Messages

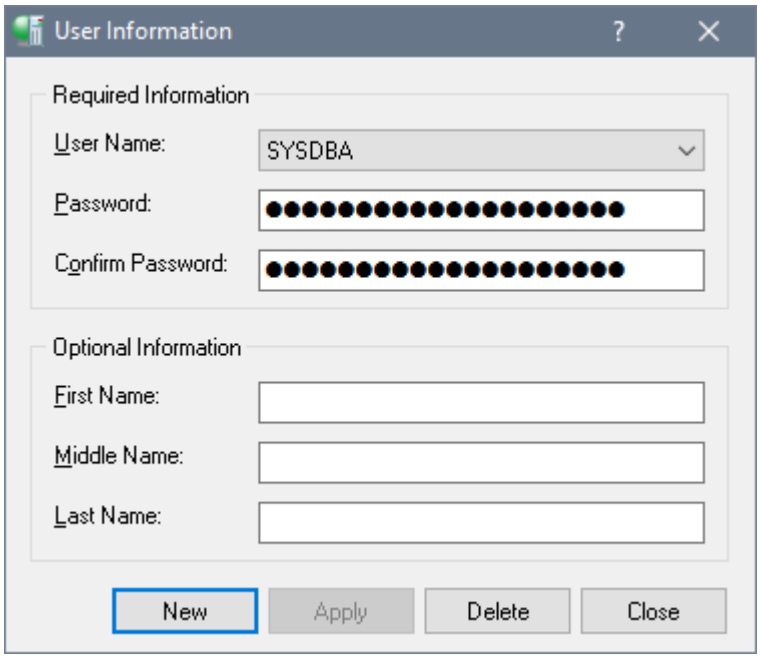
9. User Administration with IBConsole

User administration is accomplished through the User Information dialog where you are able to add, modify, view and delete users. User administration can only be performed after logging in to the server.

9.1. Displaying the User Information Dialog

You can use any of the following methods to access the User Information dialog:

- Select a logged in server or any branch under the server hierarchy from the list of registered servers in the Tree pane; choose Server|User Security.
- Select a logged in server from the list of registered servers in the Tree pane. Double-click User Security in the Work pane or right-click the selected server and choose User Security from the context menu.
- Select Users under the desired server in the Tree pane to display a list of valid users in the Work pane. Double-click a user name to display the User Information dialog.



9.2. Adding a User

Use the User Information dialog to add new users. To access this dialog follow one of the methods described in Displaying the User Information Dialog.

To add a new user:

1. Display the User Information dialog in one of the following ways:
   - Select a logged in server or any branch under the server hierarchy from the list of registered servers in the Tree pane; choose Server|User Security.
   - Select a logged in server from the list of registered servers in the Tree pane. Double-click User Security in the Work pane or right-click the selected server and choose User Security from the context menu.
   - Select Users under the desired server in the Tree pane to display a list of valid users in the Work pane. Double-click a user name to display the User Information dialog.

2. Click New. The New and Delete buttons are disabled and the Close button changes to a Cancel button.
3. Type the new username in the User Name text field.
4. Type the user's password in both the Password and the Confirm Password text fields.
5. Add any desired optional information in the corresponding text fields. Each of the optional text fields can be up to 32 bytes.
6. Click Apply to add the new user to the security database or click Cancel to abandon your changes.

Note:
Usernames can be up to 31 bytes long and are *not* case sensitive. Passwords *are* case-sensitive and only the first eight characters are significant. InterBase does not allow you to create usernames or passwords containing spaces.

9.3. Modifying User Configurations

Use the User Information dialog to modify user configurations. To access this dialog follow one of the methods described in Displaying the User Information Dialog.

To modify user's details:

1. Display the User Information dialog in one of the following two ways:
   - Select a logged in server or any branch under the server hierarchy from the list of registered servers in the Tree pane; choose Server|User Security to display the User Information dialog.
   - Select a logged in server from the list of registered servers in the Tree pane. Double-click User Security in the Work pane or right-click the selected server and choose User Security from the context menu.
   - Select Users under the desired server in the Tree pane to display a list of valid users in the Work pane. Double-click a user name to display the User Information dialog.
2. From the User Name drop-down list, select the user whose configuration you wish to modify. The user's details display. You can also type the first letter of the desired username in the User Name drop-down list to quickly scroll to usernames beginning with that letter. By repeatedly typing that same letter, you can scroll through all usernames that begin with that letter.
3. Change any of the text fields except the User Name. If you change the password, you must enter the same password in the Password text field and the Confirm Password text field.
4. Click the Apply button to save your changes.

You cannot modify a username. The only way to change a username is to delete the user and then add a user with the new name.

9.4. Deleting a User

Use the User Information dialog to removed users from the security database. To access this dialog follow one of the methods described in Displaying the User Information Dialog.

1. Display the User Information dialog in one of the following two ways:
   - Select a logged in server or any branch under the server hierarchy from the list of registered servers in the Tree pane; choose Server|User Security.
   - Select a logged in server from the list of registered servers in the Tree pane. Double-click User Security in the Work pane or right-click the selected server and choose User Security from the context menu.
2. Select the user you wish to delete from the User Name drop-down list. You can also type the first letter of the desired username in the User Name drop-down list to quickly scroll to usernames beginning with that letter. By repeatedly typing that same letter, you can scroll through all usernames that begin with that letter.
3. Click Delete. A confirmation dialog inquires, "Do you wish to delete user *username*?" If you choose OK, the user is removed and is no longer authorized to access databases on the current server.

Important:
Although it is possible for the `SYSDBA` to delete the `SYSDBA` user, it is strongly not recommended because it will no longer be possible to add new users or modify existing user configurations. If you do delete the `SYSDBA` user, you must reinstall InterBase to restore the InterBase security database (`admin.ib` by default).

See Also

- Security Model
- The InterBase Security Database
- Implementing Stronger Password Protection
- Enabling Embedded User Authentication
- System Table Security
- SQL Privileges
- Groups of Users
- Other Security Measures
- User Administration With the InterBase API
- Using gsec to Manage Security
- Using gsec to Manage Database Alias
- gsec Error Messages

10. User Administration With the InterBase API

The InterBase API includes three functions that permit authors of InterBase applications to add, delete, and modify users programmatically using three API functions: `isc_add_user( )`, `isc_delete_user( )`, and `isc_modifiy_user( )`. These functions are deprecated in InterBase 6 and later, however, because they are replaced by functions in the InterBase Services API.

The InterBase Services API provides a much broader and more robust set of tools for programmatically managing users in the security database. See "Working with Services" in the API Guide for details and examples of using the Services API functions.

For programmers using Delphi and C++Builder, the IBX components include components for managing users. For more information on using the IBX components, refer to the Developer's Guide.

See Also

- Security Model
- The InterBase Security Database
- Implementing Stronger Password Protection
- Enabling Embedded User Authentication
- System Table Security
- SQL Privileges
- Groups of Users
- Other Security Measures
- User Administration with IBConsole
- Using gsec to Manage Security
- Using gsec to Manage Database Alias
- gsec Error Messages

11. Using gsec to Manage Security

The InterBase command-line security utility is `gsec`. This utility is used in conjunction with the InterBase security database (`admin.ib` by default) to specify user names and passwords for an InterBase server. This tool duplicates the functionality of Server|User Security in IBConsole for Windows.

The security database resides in the InterBase install directory. To connect to a database on the server, users must specify a user name and password, which are verified against information stored in the security database. If a matching row is found, the connection succeeds.

Important:
Only the SYSDBA can run `gsec`. To do this, use one of the following methods:

- Invoke the command as:

```
gsec -user sysdba -password masterkey
```

- Define the `ISC_USER` and `ISC_PASSWORD` environment variables for `SYSDBA` before you invoke the command.
- Run `gsec` when you are logged in as root on UNIX or Administrator on Windows.

To use `gsec` interactively, type `gsec` at the command prompt. The prompt changes to `GSEC>`, indicating that you are in interactive mode. To quit an interactive session, type `QUIT`.

11.1. Running gsec Remotely

You can use `gsec` on a client host to administer users in a security database on a remote server. Use the `-database` option with a remote database specification to connect to a remote InterBase security database. For example:

```
gsec -database jupiter:/usr/InterBase/admin.ib
```

11.2. Running gsec with Embedded Database User Authentication

You can gsec to database which enabled embedded user authentication. Use the `-user_database` option with embedded user authentication database specification to connect to a database which enabled embedded user authentication.

For example:

gsec -user_database jupiter:/usr/InterBase/employee.ib

11.3. Using gsec Commands

The following table summarizes `gsec` commands. The initial part of each command is required. The part in brackets is optional.

Command	Description
`di[splay]`	Displays all rows of the InterBase security database (`admin.ib` by default)

Command	Description
`di[splay] name`	Displays information only for user **<name>**
`a[dd] name -pw password [option argument] [option argument ...]`	Adds user **<name>** to the security database with password **<string>**. Each option and corresponding argument specify other data associated with the user, as shown in Adding Entries to the Security Database
`mo[dify] name [options]`	Like `add`, except that **<name>** already exists in the security database
`de[lete] name`	Deletes user **<name>** from the security database
alias_add path name	Adds a database alias. The path is the location of the database, and **<name>** is the name given for the alias
alias_del name	Deletes database alias **<name>** from the security database
alias_dis	Displays all database alias
alias_dis name	Displays information only for alias **<name>**
`h[elp]` or `?`	Displays `gsec` commands and syntax
`q[uit]`	Quits the interactive session

11.3.1. Displaying the Security

To see the contents of the InterBase security database, enter the `DISPLAY` command at the `GSEC>` prompt. All the rows in the security database are displayed:

```
GSEC> display
user name uid gid full name
------------------------------------------
JOHN 123 345 John Doe
JANE 124 345 Jane Doe
RICH 125 345 Richard Roe
```

Note that passwords are never displayed.

11.3.2. Adding Entries to the Security Database

To add users to the security database, use the `add` command:

```
a[dd] name -pw password [options]
```

followed by a user name, the `-pw` option followed by a password, and any other options, as shown in the following table. The password is case sensitive. None of the other parameters are case sensitive.

For each option, the initial letter or letters are required, and optional parts are enclosed in brackets. Each option must be followed by a corresponding argument, a string that specifies the data to be entered into the specified column in the InterBase security database (`admin.ib` by default).

Option	Meaning
- `password` or `-pa string`	Password of user who is performing the change
- `user string`	User who is performing the change
- `pw string`	Target user password
- `uid integer`	Target user ID
- `gid integer`	Group ID for target user
- `fname string`	First Name for target user
- `mname string`	Middle Name for target user
- `lname string`	Last Name for target user
`-user_database string`	Name of user database

Option	Meaning
`-database string`	Name of remote security database

Note:
The `-pa` switch specifies the root or the `SYSDBA` account password; `-pw` specifies the password for the user being added or modified.

For example, to add user "jones" and assign the password "welcome", enter:

```
GSEC> add jones -pw welcome
```

Use `display` to verify the entry. An unassigned UID or GID defaults to 0:

```
GSEC> display
user name     uid     gid     full name
-----------------------------------------------
JONES         0       0
```

For example, to add authorization for a user named Cindi Brown with user name "cbrown" and password "coffee2go", use the following `gsec` command:

```
GSEC> add cbrown -pw coffee2go -fname cindi -lname brown
```

To verify the new entry, display the contents of the security database:

```
GSEC> display
user name     uid     gid     full name
-----------------------------------------------
JONES         0       0
CBROWN        0       0       CINDI BROWN
```

`gsec` stores the user name in uppercase regardless of how it is entered.

11.3.3. Modifying the Security Database

To change existing entries in the security database, use the `modify` command. Supply the user name for the entry to change, followed by the option indicating the items to change and the corresponding values to which to change them.

For example, to set the user ID of user "cbrown" to 8 and change the first name to "Cindy", enter the following commands:

```
GSEC> modify cbrown -uid 8 -fname cindy
```

To verify the changed line, use `display` followed by the user name:

```
GSEC> display cbrown
user name    uid    gid    full name
-----------------------------------------------
CBROWN       8      0      CINDY BROWN
```

Note:
To modify a user name, first delete the entry in the security database, then enter the new user name and re-enter the other information.

11.3.4. Deleting Entries from the Security Database

To delete a user's entry from the security database, use `delete` and specify the user name:

```
GSEC> delete cbrown
```

You can confirm that the entry has been deleted with the `display` command.

11.4. Using gsec from a Windows Command Prompt

To use `gsec` from the Windows command prompt, precede each command with `gsec` and prefix each `gsec` command with a hyphen (-). For example, to add user "aladdin" and assign the password, "sesame", enter the following at the command line:

```
C:> gsec -add aladdin -pw sesame
```

To display the contents of the InterBase security database, enter:

```
C:> gsec -display
```

12. Using gsec to Manage Database Alias

Database Alias eliminates the need of knowing the exact location of the database file by the client application as long as the client application refers to the database by its alias.

To add database alias to the security database, use the `alias_add` command:

```
alias_add alias name
```

and alias_dbpath path name

where path is the location of the database.

For example, to add the database alias "emp" with the path "C:\Embarcadero\InterBase\examples\database\employee.ib", enter:

```
GSEC> alias_add emp -alias_dbpath "C:
\Embarcadero\InterBase\examples\database\employee.ib"
```

Note:
Quotes are necessary for paths that contain spaces.

Use `alias_dis` to verify the entry:

```
GSEC> alias_dis emp C:\Embarcadero\InterBase\examples\database\employee.ib
```

To delete a database alias from the security database, use the `alias_del` command:

```
alias_del name
```

For example, to delete the database alias “emp”, enter:

```
GSEC> alias_del emp
```

See Also

- Security Model
- The InterBase Security Database
- Implementing Stronger Password Protection
- Enabling Embedded User Authentication
- System Table Security
- SQL Privileges
- Groups of Users
- Other Security Measures
- User Administration with IBConsole
- User Administration With the InterBase API
- Using gsec to Manage Security
- gsec Error Messages

13. gsec Error Messages

The following table desribes gsec Security Error Messages

Error Message	Causes and Suggested Actions to Take
Add record error	The `add` command either specified an existing user, used invalid syntax, or was issued without appropriate privilege to run `gsec`. Change the user name or use `modify` on the existing user.
<string> already specified	During an `add` or `modify`, you specified data for the same column more than once. Retype the command.
Ambiguous switch specified	A command did not uniquely specify a valid operation.
Delete record error	The `delete` command was not allowed. Check that you have appropriate privilege to use `gsec`.
Error in switch specifications	This message accompanies other error messages and indicates that invalid syntax was used. Check other error messages for the cause.
Find/delete record error	Either the `delete` command could not find a specified user, or you do not have appropriate privilege to use `gsec`.
Find/display record error	Either the `display` command could not find a specified user, or you do not have appropriate privilege to use `gsec`.
Find/modify record error	Either the `modify` command could not find a specified user, or you do not have appropriate privilege to use `gsec`.
Incompatible switches specified	Correct the syntax and try again.
Invalid parameter, no switch defined	You specified a value without a preceding argument.
Invalid switch specified	You specified an unrecognized option. Fix it and try again.

Error Message	Causes and Suggested Actions to Take
Modify record error	Invalid syntax for `modify` command. Fix it and try again. Also check that you have appropriate privilege to run `gsec`.
No user name specified	Specify a user name after `add`, `modify`, or `delete`.
Record not found for user: <string>	An entry for the specified user could not be found. Use `display` to list all users, then try again.
Unable to open database	The InterBase security database does not exist or cannot be located by the operating system.

See Also

- Security Model
- The InterBase Security Database
- Implementing Stronger Password Protection
- Enabling Embedded User Authentication
- System Table Security
- SQL Privileges
- Groups of Users
- Other Security Measures
- User Administration with IBConsole
- User Administration With the InterBase API
- Using gsec to Manage Security
- Using gsec to Manage Database Alias

DATABASE CONFIGURATION AND MAINTENANCE

This chapter describes configuration and maintenance issues for individual databases, including the following topics:

1. Database Files

InterBase database files are in many cases self-contained. All the data and indexes are maintained as data structures within one type of file. The transaction log is also kept within this file.

You can extend the functions available in InterBase database metadata by creating libraries of functions compiled in your language of choice. You can compile functions into a dynamic library (called a DLL on Windows, and a shared library on UNIX) and use them in queries, stored procedures, triggers, views, and so on.

1.1. Database File Size

InterBase database file size is the product of the number of database pages times the page size. The minimum page size is 1 KB, the default page size is 4KB, and the maximum page size is 16KB. Each page can store records only from a single table. You set the database page size when you create a database by using the `PAGE SIZE` clause of the `CREATE DATABASE` statement, or its equivalent in IBConsole. You can change the page size when you restore a database using `gbak` or IBConsole.

InterBase supports 64-bit file IO, so the size of a database file is effectively limited only by the operating system.

Note:
Using `gbak` is the only way to reduce the size of the primary database file. When you restore a database, you can specify multiple files without reference to the original file sizes.

1.1.1. Dynamic File Sizing

InterBase dynamically expands the last file in a database as needed. This applies to single-file databases as well as to the last file of multifile databases. Specifying a `LENGTH` for the last or only file in a database has no effect.

1.1.2. Database File Preallocations

The InterBase SQL statement CREATE DATABASE includes a preallocation clause to specify extra database space for the new database. The space is actually allocated when the user detaches from the connection that was established by the CREATE DATABASE statement. The database preallocation feature supports secondary database files in that the preallocation will be spread across all secondary files in accordance with their file size specifications.

To specify preallocation, use the following syntax:

Example:

```
... [[NO] PREALLOCATE [=] int [PAGES]]
```

By default, creating a database does not preallocate additional database pages, so it is as if NO PREALLOCATE had been specified. IB provides this syntax so that a DDL script can explicitly state and document that preallocation has not been specified. Database preallocation is always specified in units of database pages to be consistent with other related features (i.e., length of secondary database files or shadow sets).

Important:
If a preallocation exceeds available disk space, the IB thread making the write request when the device fills will timeout after 1 minute of waiting for the I/O to complete. It makes 4 additional I/O attempts, waiting 1 minute each time, to complete the write (results written to the InterBase log). If space is not freed to allow the preallocation operation to continue, the space requested will not be allocated.

1.1.3. isql -extract PREALLOCATE

The CREATE DATABASE command now includes the isql -extract PREALLOCATE clause to the formatted CREATE DATABASE statement if there is a non-zero preallocation value for the database. The isql extract operation can be invoked with the -a|-x options.

1.1.4. GSTAT (Database File Size)|GSTAT

GSTAT displays the database preallocation information, which is stored on the database header page. Following is a sample from a GSTAT -H command:

Example:

```
variable header data:
Preallocate pages: 5000
```

```
Sweep interval: 25000
*END*
```

1.1.5. API DPB Parameter

At the InterBase API-level, there is a DPB parameter, isc_dpb_preallocate, that takes a 4-byte integer to specify database preallocation. It is only recognized and processed by isc_create_database(). isc_attach_database() silently ignores isc_dpb_preallocate. You can use the isc_info_db_preallocate database info parameter to request database preallocate information stored on the database header page.

With the InterBase service API, actions isc_action_svc_backup (isc_action_svc_restore) take new parameters, isc_spb_bkp_preallocate (isc_spb_res_preallocate), respectively. Both parameters take a 4-byte argument to specify the database preallocation in units of database pages. The service parameters have the same numeric value but two symbolic constants are provided for source code clarity to show the proper intent.

Note:
See “Working with Databases” in the API Guide for more information about DPB parameters.

See Also

- External Files
- Temporary Files
- File Naming Conventions
- Multifile Databases
- Networked File Systems

1.2. External Files

InterBase permits external files to be used as *external tables*. These tables are limited in their functionality:

- From a database that is in read-write mode, you can execute only `SELECT` and `INSERT` statements on external tables. From a read-only database, you can execute only `SELECT` statement on external tables.
- You cannot define indexes on external tables; they are outside of the control of the multigenerational architecture.
- The 2GB external file size limit has been removed from InterBase XE onward.

The default location for external files is `<InterBase_home>/ext`. InterBase can always find external files that you place here. If you want to place them elsewhere, you must specify the location in the `ibconfig` configuration file using the `EXTERNAL_FILE_DIRECTORY` entry.

Important:
For security reasons, it is extremely important that you not place files with sensitive content in the same directory with external tables.

Migration note: If you are migrating from InterBase 6.x or older to InterBase 7.x or newer, and your database includes external table files, you must either move these files to `<InterBase_home>/ext` or note their locations in `ibconfig` using the `EXTERNAL_FILE_DIRECTORY` entry

1.3. Temporary Files

InterBase dynamically creates files in the temporary file space for scratch space during sorting operations involving large amounts of data. See Managing Temporary Files for details on temporary file use.

1.4. File Naming Conventions

You can use any file extension for database files, but InterBase recommends using `.ib` for database files and `.ibk` for backup files.

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

Generally, InterBase fully supports each file naming conventions of a platform, 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 statements, file specification is denoted as '**<filespec>**'

1.4.1. 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.

1.4.2. Secondary File Specifications

For InterBase syntax that supports multiple file specification, such as `CREATE DATABASE`, all file specifications after the first one are *secondary*. Secondary file specifications cannot include a node name, but can specify a full path name.

See Also

- Database File Size
- External Files
- Temporary Files
- Multifile Databases
- Networked File Systems

1.5. Multifile Databases

InterBase supports databases that span multiple files and multiple file systems. You can add additional files to the database without having to take it off line.

The Database Restore task in IBConsole and in the `gbak` command-line utility permit you to create a multifile database. The only way to alter the file size allocation of an existing database is to back up and restore the database file.

1.5.1. Adding Database Files

You have the option of specifying the size of secondary files in either of two ways: specify the page on which each secondary file starts, or specify the length in database pages of each file. When you specify the size using the `LENGTH` keyword, do not specify the length of the final file. InterBase sizes the final file dynamically, as needed.

The following `isql` example adds files using `STARTING AT` syntax:

```
CONNECT ‘first.ib’;
ALTER DATABASE
 ADD FILE 'second.ib' STARTING AT 50000;
```

1.5.2. Altering Database File Sizes

You cannot use `ALTER DATABASE` to split an existing database file. For example, if your existing database is 80,000 pages long and you issue the command above, InterBase starts the new database file at page 80,001. The only way to split an existing database file into smaller files is to back it up and restore it. When you restore a database, you are free to specify secondary file sizes at will, without reference to the original file sizes.

The following `isql` example adds a file using `LENGTH` syntax. `second.ib` will begin on the page following the final page of `first.ib` and will grow to 50,000 database pages. Then InterBase begins writing to `third.ib` and dynamically increases the size as necessary.

```
CONNECT 'first.ib';
ALTER DATABASE ADD FILE 'second.ib' LENGTH 50000
 ADD FILE 'third.ib';
```

InterBase starts writing data to `third.ib` only after `second.ib` file fills up. In the example above, `second.ib` is 50,000 pages long, and begins following the original file. InterBase will begin filling the `third.ib` file after `second.ib` reaches 50,000 pages. Database pages are 4KB each by default and have a maximum size of 8KB.

There is no guarantee that a given table resides entirely in one file or another. InterBase stores records based on available space within database files. Over time, records from a given table tend to spread over all the files in a multifile database.

1.5.3. Maximum Number of Files

InterBase allows up to 131,000 database files, including shadow files. Note that your operating system might have a lower limit on the number of simultaneous open files than the `ibserver` process can have.

1.5.4. Application Considerations

A multifile database is not the same thing as multiple single-file databases. The tables are all part of the same database they used to be in, but they can be stored across the multiple files. From the standpoint of your application, they are all part of the same database and are accessed exactly the same way they would be in a single-file database.

Your application does not need to know about any files except the first one. Any time your database operations access/write data in the secondary files, the InterBase software takes care of it without requiring any special programming from your application. The application attaches to the database by specifying the path of the first file of the database; applications do not change.

1.5.5. Reorganizing File Allocation

You can change the sizes of the files of a multifile database when using `gbak` to restore a database. If you need to move a multi-file database to a different disk or directory, use gbak to back up the database, then specify the new locations of all secondary files as you restore the database. See Performing backups and restores using the gbak command.

Tip:
Any database in a production environment should include a definition for at least one secondary file, even if the current size of the database does not warrant a multifile database. Data tends to accumulate without bounds, and some day in the future your database might exceed your file system size, or the maximum file size of the operating system. By defining a secondary file, you specify what action InterBase takes when the database grows beyond these limits. This means that the database administrator is freed from monitoring the database as it approaches the file size limit.

See Also

- Database File Size
- External Files
- Temporary Files
- File Naming Conventions
- Networked File Systems

1.6. Networked File Systems

An InterBase database must reside on a disk local to the server software that accesses it. The database file (including any secondary files and shadow files) cannot reside on networked or remote file systems (called *mapped drives* on Windows and *NFS file systems* on UNIX). External tables and UDF libraries can reside on networked file systems, but this practice is not recommended because networked file systems can suffer from intermittent availability.

On UNIX, the InterBase software detects that a database file is located on an NFS file system. In this case, it invokes the remote access method to contact an InterBase server process running on the host that exported the file system. If there is no InterBase server software running on that node, any connection to the database fails.

2. On-disk Structure (ODS)

Each release of InterBase has characteristic features in its internal file format. To distinguish between the file formats, InterBase records an on-disk structure (ODS) number in the database file. In general, major ODS versions (those incrementing the number to the left of the decimal point) introduce features that are not backward compatible with earlier ODS versions.

The InterBase 15 format is ODS 19, but still supports existing databases with ODS 18 through 17. Older ODS version are not supported and can not be connected to. It is strongly recommended to back up and restore your database so it can be upgraded to ODS 19 and benefit from the newer features.

When you create a new database or restore a backup file in the current version of InterBase, the resulting database file has the current ODS version.

> **Important:**
> To upgrade the ODS of an older database, you must back it up using the backup utility for the version of the existing database and then restore it using the current version of InterBase.

3. Read-write and Read-only Databases

InterBase databases have two modes: read-only and read-write. At creation, all databases are both readable and writable: they are in *read-write mode*.

3.1. Read-write Databases

To function in read-write mode, databases must exist on writable media and the `ibserver` process must have write access to the database file. For databases that are in read-write mode, this is true even when they are used only for reading because the transaction states are kept in an internal inventory data structure within the database file. Therefore any transaction against the database requires the ability to write to the transaction inventory.

Under both Windows and UNIX, read-write database files must be writable by the user ID for the `ibserver` process. However, the operating environment or file system can be configured to create files that have limited file privileges by default. If you attempt to attach to a database and get an error of "unavailable database," first check to see if the permissions of the database file are such that the user ID of the `ibserver` process does not have write privilege on the database file.

3.2. Read-only Databases

You can change InterBase databases to *read-only mode*. This provides enhanced security for databases by protecting them from accidental or malicious updates and enables distribution on read-only media. Databases are always in read-write mode at creation time. This feature is independent of dialect. Any ODS 10 or higher database can be set to read-only mode.

You can use `gbak`, `gfix`, or IBConsole to change a database to read-only mode. (See Making a Database Read-only below.)

3.2.1. Properties of Read-only Databases

- In read-only mode, databases can be placed on CD-ROMs or in read-only file systems as well as on read-write file systems.
- Attempted `INSERT`, `UPDATE`, and `DELETE` operations on a read-only database generate an error. See the "Error Codes and Messages" chapter of the Language Reference Guide.
- No metadata changes are allowed in read-only databases.
- Generators in a read-only database do not increment and are allowed only to return the current value. For example, in a read-only database, the following statement succeeds:

```
SELECT GEN_ID(generator_name, 0) FROM table_name;
```

The following statement fails with the error "attempted update on read-only database."

```
SELECT GEN_ID(generator_name, 1) FROM table_name;
```

- External files accessed through a read-only database open in read-only mode, regardless of the file's permissions at the file system level.

3.2.2. Making a Database Read-only

To change the mode of a database between read-write and read-only, you must be either its owner or `SYSDBA` and you must have exclusive access to a database.

From within InterBase, you can change a read-write database to read-only mode in any of three ways:

- In IBConsole, select the database, display its properties, and edit the mode. For more information, refer to Setting Database Properties.
- Use `gbak` to back up the database and restore it in read-only mode:

```
gbak -create -mode read_only foo.ibk foo.ib
```

- Use `gfix` to change the mode to read-only:

```
gfix -mode read_only foo.ib
```

Important:
To set a database to read-only mode from any application that uses BDE, ODBC, or JDBC, use the `isc_action_svc_properties` () function in the InterBase Services API.

Tip:
To distribute a read-write database on a CD-ROM, back it up and put the `database.ibk` file on the CD-ROM. As part of the installation, restore the database to the user's hard disk.

3.2.3. Read-only with Older InterBase Versions

- A pre-6 InterBase client can access a read-only database to perform `SELECT` operations. No other operation succeeds.
- If a current InterBase client tries to set a pre-6 database to read-only mode, the server silently ignores the request. There is no way to make older databases read-only. You must upgrade them.

See Also

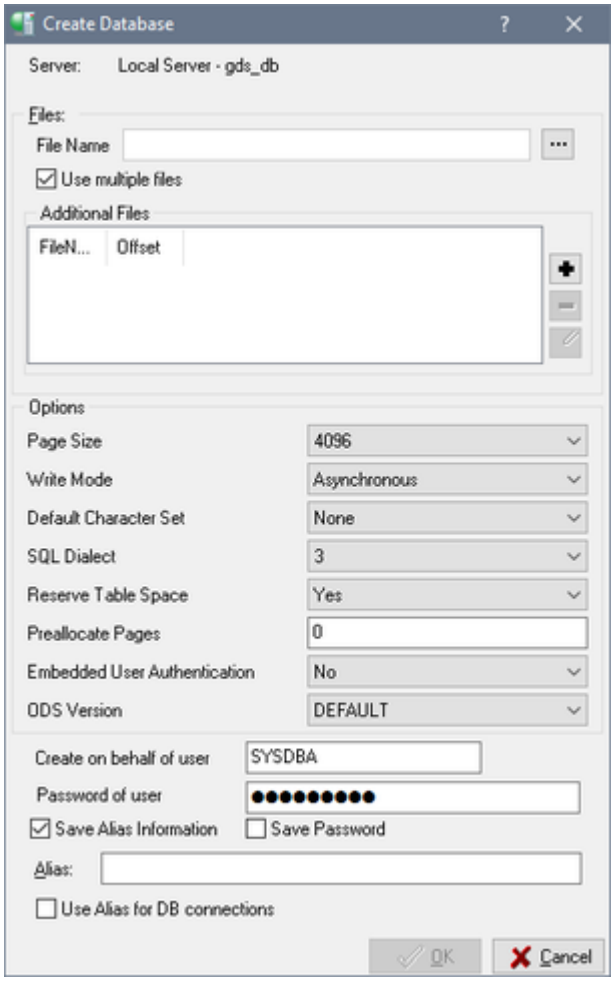
- Database Files
- Creating Databases
- Dropping Databases

4. Creating Databases

You can create databases on local and remote servers using IBConsole with the Create Database dialog.

You can use any of the following methods to access the Create Database dialog:

- In the Tree pane, select a server or anywhere in the branch under the desired server and choose **Database|Create Database**.
- In the Tree pane, right click the Databases branch under the desired server, and select **Create Database** from the context menu.



To Create a Database:

1. Ensure that the server indicated is correct. If it is not, cancel this dialog and re-initiate it under the correct server.
2. Type an Alias name for the new database in the Alias text field.
3. On the **Files** section, click ... to set the name and destination folder of your backup.

   To use multiple files, select **Use Multiple Files** and click ✚ to add files.

   > **Note:**
   > Database files must reside on a local drive.

4. You can specify create options by entering a valid value, by clicking the option value and choosing a new value from a drop-down list of values or by double-clicking the option value to rotate its value to the next in the list of values. For more information, see Database Options below.

   To create a basic database without any options, leave all options blank.
5. Click **OK** to create the specified database.

Important:
The alias name that you specify when creating a database references the necessary database file information associated with the database. When performing database configuration and maintenance, you need to specify only the alias name, not the actual database filename. If the database spans multiple files, the server uses the header page of each file to locate additional files.

4.1. Database Options

The database options that you can set are Page Size, Default Character Set, and SQL dialect.

4.1.1. Page Size (Database Options)

InterBase supports database page sizes of 1024, 2048, 4096, 8192, and 16384 bytes. The default is 4096 bytes.

4.1.2. Default Character Set

See **Character Set** setting on the page Options Tab for a detailed explanation of character sets.

For more information about creating databases, see the Language Reference Guide. See the Data Definition Guide for an explanation of character sets.

4.1.3. SQL Dialect

An InterBase database SQL dialect determines how double quotes, large exact numerics, and certain data types such as `SQL DATE`, `TIME`, and `TIMESTAMP` are interpreted. In most cases you should create databases in dialect 3 in order to have access to all current InterBase features.

Changing a database dialect from 1 to 3 may require some preparation if it contains `DATE` data types, `DECIMAL` or `NUMERIC` data types with precision greater than 9, or has strings that are in double quotes rather than single quotes. For more information about dialects, refer to Understanding SQL Dialects in the migration appendix of the *Operations Guide*.

To Change the Database Dialect:

1. Highlight the database in the Tree pane and perform one of the following actions:
   - Choose Database|Properties.
   - Right-click and choose Properties from the context menu.
   - Double-click Properties in the Work pane.
2. Click the General tab and change the SQL dialect in the Options field.

Tip:
To suppress the display of system tables in IBConsole, deselect System Data from the View menu.

See Also

- Database Files
- Read-write and Read-only Databases
- Dropping Databases
- Removing Database Backup Files
- Setting Database Properties

5. Dropping Databases

You can drop databases using IBConsole. Dropping a database deletes the current database and database alias, removing both data and metadata.

A database can be dropped only by its creator or SYSDBA.

To Drop a Database:

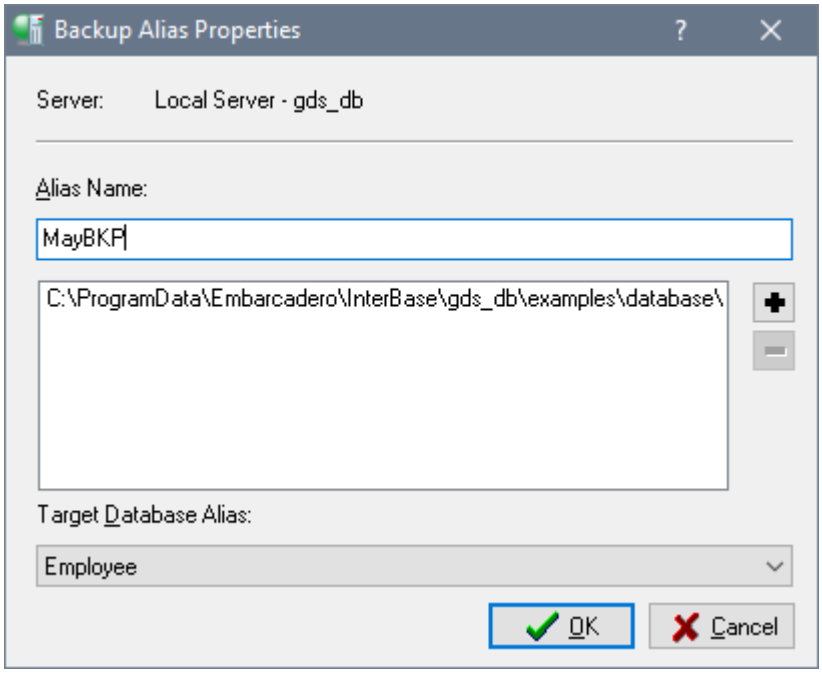
1. Select the database you wish to drop in the Tree pane.
2. Choose Database|Drop Database or select Drop Database from the Work pane.
3. A dialog asks you to confirm that you wish to delete the database. Click Yes if you want to drop the selected database, otherwise click No.

Important:
Dropping a database deletes all data and metadata in the database.

6. Backup File Properties

You can view and modify backup file information in IBConsole with the Backup Alias Properties dialog. You can access this dialog with either of the following methods:

- Expand **Backup** in the Tree pane, select a backup alias, and double-click **Modify Backup Alias** from the Work pane.
- Right-click a backup alias in the Tree pane and choose **Modify Backup Alias** from the context menu.



To Edit Backup File Properties:

1. Enter a new backup alias name in the Alias Name text field.
2. Add, remove, or modify the backup filenames and corresponding file sizes associated with the backup in the backup files table. When specifying filenames, be sure to include the file path where the file is located.
3. add a new row to the backup files table, move to the last row and column of the table and type `W - Z` . To remove a file from the backup file list, delete the values from the table.
4. Select a server from the Target Database Server drop-down list. You can also type the server name in the edit portion of the drop-down list.
5. Select a database alias from the Target Database Alias drop-down list. You can also type the alias name in the edit portion of the drop-down list.
6. Click **Apply** to save your changes.

See Also

- Removing Database Backup Files
- Setting Database Properties

7. Removing Database Backup Files

You can remove database backup files in IBConsole with either of the following methods:

- Expand Backup in the Tree pane and select a backup alias and double-click Delete Alias from the Work pane.
- Right-click a backup alias in the Tree pane and choose Delete Alias from the context menu.

A dialog asks you to confirm that you wish to remove the selected backup file. Click Yes if you want to delete the backup file, otherwise click No.

See Also

- Backup File Properties
- Database Files

8. Shadowing

InterBase lets you recover a database in case of disk failure, network failure, or accidental deletion of the database. The recovery method is called *disk shadowing*, or sometimes just *shadowing*. This chapter describes how to set up and use shadowing.This section describes the various tasks involved in shadowing, as well as the advantages and limitations of shadowing.

8.1. Tasks for Shadowing

The main tasks in setting up and maintaining shadowing are as follows:

1. Creating a shadow.
   Shadowing begins with the creation of a shadow. A shadow is an identical, physical copy of a database. When a shadow is defined for a database, changes to the database are written simultaneously to its shadow. In this way, the shadow always reflects the current state of the database. For information about the different ways to define a shadow, see Creating a Shadow.
2. Activating a shadow.
   If something happens to make a database unavailable, the shadow can be activated. *Activating* a shadow means it takes over for the database; the shadow becomes accessible to users as the main database. Activating a shadow happens either automatically or through the intervention of a database administrator, depending on how the shadow was defined. For more information about activating a shadow, see Activating a Shadow.
3. Deleting a shadow.
   If shadowing is no longer desired, it can be stopped by deleting the shadow. For more information about deleting a shadow, see Dropping a Shadow.
4. Adding files to a shadow.
   A shadow can consist of more than one file. As shadows grow in size, files can be added to accommodate the increased space requirements. For more information about adding shadow files, see Adding a Shadow File.

8.2. Advantages of Shadowing

Shadowing offers several advantages:

- Recovery is quick. Activating a shadow makes it available immediately.
- Creating a shadow does not require exclusive access to the database.

- Shadow files use the same amount of disk space as the database. Log files, on the other hand, can grow well beyond the size of the database.
- You can control the allocation of disk space. A shadow can span multiple files on multiple disks.
- Shadowing does not use a separate process. The database process handles writing to the shadow.
- Shadowing can run behind the scenes and needs little or no maintenance.

8.3. Limitations of Shadowing

Shadowing has the following limitations:

- Shadowing is not an implementation of *replication*. Shadowing is one-way writing, duplicating every write operation on the master database. Client applications cannot access the shadow file directly.
- Shadowing is useful only for recovery from hardware failures or accidental deletion of the database. User errors or software failures that corrupt the database are duplicated in the shadow.
- Recovery to a specific point in time is not possible. When a shadow is activated, it takes over as a duplicate of the database. Shadowing is an "all or nothing" recovery method.
- Shadowing can occur only to a local disk. Shadowing to a NFS file system or mapped drive is not supported. Shadowing to tape or other media is unsupported.

8.4. Creating a Shadow

A shadow is created with the `CREATE SHADOW` statement in SQL. Because this does not require exclusive access, it can be done without affecting users. For detailed information about `CREATE SHADOW`, see the *Language Reference*.

Before creating a shadow, consider the following topics:

- The location of the shadow

A shadow should be created on a different disk from where the main database resides. Because shadowing is intended as a recovery mechanism in case of disk failure, maintaining a database and its shadow on the same disk defeats the purpose of shadowing.

- Distributing the shadow

A shadow can be created as a single disk file called a shadow file or as multiple files called a shadow set. To improve space allocation and disk I/O, each file in a shadow set can be placed on a different disk.

- User access to the database

If a shadow becomes unavailable, InterBase can either deny user access to the database until shadowing is resumed, or allow access even though database changes are not being shadowed. Depending on which database behavior is desired, the database administrator creates a shadow either in auto mode or in manual mode. For more information about these modes, see Auto Mode and Manual Mode.

- Automatic shadow creation

To ensure that a new shadow is automatically created, create a conditional shadow. For more information, see Conditional Shadows, in this chapter.

The next sections describe how to create shadows with various options:

- Single-file or multifile shadows
- Auto or manual shadows
- Conditional shadows

These choices are not mutually exclusive. For example, you can create a single-file, conditional shadow in manual mode.

8.4.1. Creating a Single-file Shadow

To create a single-file shadow for database `employee.ib`, enter:

```
SQL> CREATE SHADOW 1 '/usr/InterBase/examples/employee.shd';
```

The name of the shadow file is `employee.shd`, and it is identified by the number 1. Verify that the shadow has been created by using the `isql` command `SHOW DATABASE`:

```
SQL> SHOW DATABASE;
Database: employee.ib
Shadow 1: '/usr/InterBase/examples/employee.shd' auto
PAGE_SIZE 4096
Number of DB pages allocated = 392
Sweep interval = 20000
```

The page size of the shadow is the same as that of the database.

See Also

- Creating a Multifile Shadow
- Auto Mode and Manual Mode
- Conditional Shadows

8.4.2. Creating a Multifile Shadow

If your database is large, you can shadow it to a multifile shadow, spreading the shadow files over several disks. To create a multifile shadow, specify the name and size of each file in the shadow set. As with multifile databases, you have the option of specifying the size of secondary files in either of two ways: specify the page on which each secondary file starts, or specify the length in database pages of each file. When you specify the size using the `LENGTH` keyword, do not specify the length of the final file. InterBase sizes the final file dynamically, as needed.

For example, the following example creates a shadow set consisting of three files. The primary file, `employee.shd`, is 10,000 database pages in length. The second file is 20,000 database pages long, and the final file grows as needed.

```
SQL> CREATE SHADOW 1 'employee.shd' LENGTH 10000
CON> FILE 'emp2.shd' LENGTH 20000
CON> FILE 'emp3.shd';
```

Instead of specifying the page length of secondary files, you can specify their starting page. The following example creates the same shadows as the previous example:

```
SQL> CREATE SHADOW 1 'employee.shd'
CON> FILE 'emp1.shd' STARTING AT 10000
CON> FILE 'emp2.shd' STARTING AT 30000;
```

In either case, you can use `SHOW DATABASE` to verify the file names, page lengths, and starting pages for the shadow just created:

```
SQL> SHOW DATABASE;
Database: employee.ib
Shadow 1: '/usr/InterBase/examples/employee.shd' auto length 10000
file /usr/InterBase/examples/emp1.shd length 2000 starting 10000
file /usr/InterBase/examples/emp2.shd length 2000 starting 30000
PAGE_SIZE 4096
Number of DB pages allocated = 392
Sweep interval = 20000
```

The page length you allocate for secondary shadow files need not correspond to the page length of the secondary files of the database. As the database grows and its first shadow file becomes full, updates to the database automatically overflow into the next shadow file.

See Also

- Creating a Single-file Shadow
- Auto Mode and Manual Mode
- Conditional Shadows

8.4.3. Auto Mode and Manual Mode

A shadow can become unavailable for the same reasons a database becomes unavailable (disk failure, network failure, or accidental deletion). If a shadow becomes unavailable, and it was created in *auto mode*, database operations continue automatically without shadowing. If a shadow becomes unavailable, and it was created in *manual mode*, further access to the database is denied until the database administrator intervenes. The benefits of auto mode and manual mode are compared in the following table:

Mode	Advantage	Disadvantage
Auto	Database operation is uninterrupted	Creates a temporary period when the database is not shadowed The database administrator might be unaware that the database is operating without a shadow
Manual	Prevents the database from running unintentionally without a shadow	Database operation is halted until the problem is fixed Needs intervention of the database administrator

Auto mode

The `AUTO` keyword directs the `CREATE SHADOW` statement to create a shadow in auto mode:

```
SQL> CREATE SHADOW 1 AUTO 'employee.shd';
```

Auto mode is the default, so omitting the `AUTO` keyword achieves the same result.

In `AUTO` mode, database operation is uninterrupted even though there is no shadow. To resume shadowing, it might be necessary to create a new shadow. If the original shadow was created as a conditional shadow, a new shadow is automatically created. For more information about conditional shadows, see Conditional Shadows.

Manual mode

The `MANUAL` keyword directs the `CREATE SHADOW` statement to create a shadow in manual mode:

```
SQL> CREATE SHADOW 1 MANUAL 'employee.shd';
```

Manual mode is useful when continuous shadowing is more important than continuous operation of the database. When a manual-mode shadow becomes unavailable, further attachments to the database are prevented. To allow database attachments again, the database owner or `SYSDBA` must enter the following command:

```
gfix -kill database
```

This command deletes metadata references to the unavailable shadow corresponding to **<database>**. After deleting the references, a new shadow can be created if shadowing needs to resume.

See Also

- Creating a Single-file Shadow
- Creating a Multifile Shadow
- Conditional Shadows

8.4.4. Conditional Shadows

You can define a shadow in a way that if that shadow replaces a database, the server creates a new shadow file. This allows shadowing to continue uninterrupted. A shadow defined with this behavior is called a **conditional shadow**.

To create a conditional shadow, specify the `CONDITIONAL` keyword with the `CREATE SHADOW` statement. For example,

```
CREATE SHADOW 3 CONDITIONAL 'atlas.shd';
```

Creating a conditional file directs InterBase to automatically create a new shadow. This happens in either of two cases:

- The database or one of its shadow files becomes unavailable.
- The shadow takes over for the database due to hardware failure.

8.5. Activating a Shadow

When a database becomes unavailable, database operations are resumed by activating the shadow. To do so, log in as SYSDBA or the database owner and use `gfix` with the `-activate` option.

Important:
Before activating a shadow, check that the main database is unavailable. If a shadow is activated while the main database is available, the shadow can be corrupted by existing attachments to the main database.

To activate a shadow, specify the path name of its primary file. For example, if database `employee.ib` has a shadow named `employee.shd`, enter:

```
gfix -activate employee.shd
```

After a shadow is activated, you should change its name to the name of your original database. Then, create a new shadow if shadowing needs to continue and if another disk drive is available.

8.6. Dropping a Shadow

To stop shadowing, use the shadow number as an argument to the `DROP SHADOW` statement. For example,

```
SQL> DROP SHADOW 1
```

If you need to look up the shadow number, use the `isql` command `SHOW DATABASE`.

Important:
`DROP SHADOW` deletes shadow references from a database's metadata, as well as the physical files on disk. Once the files have been removed from disk, there is no opportunity to recover them. However, a shadow is merely a copy of an existing database, so the new shadow is identical to the dropped shadow.

8.7. Adding a Shadow File

If a database is expected to increase in size, consider adding files to its shadow. To add a shadow file, first use `DROP SHADOW` to delete the existing shadow, then use `CREATE SHADOW` to create a multifile shadow.

The page length you allocate for secondary shadow files need not correspond to the page length of the database's secondary files. As the database grows and its first shadow file becomes full, updates to the database automatically overflow into the next shadow file.

9. Setting Database Properties

The Database Properties dialog enables you to display and configure certain database settings. You can access the Database Properties dialog by any of the following methods:

- Select a connected database (or any branch under the database hierarchy) in the Tree pane and choose Database|Properties.
- Select a connected database in the Tree pane and double-click Properties in the Work pane.
- Right-click a connected database in the Tree pane and choose Properties from the context menu.

The Database Properties dialog contains two tabs, Alias and General.

9.1. Alias Tab

The Alias tab of the Database Properties dialog is where you can specify an alias name for a database as well as the file path and file name of the selected database.

Error creating thumbnail: Unable to save thumbnail to destination

To edit database alias settings:

1. Enter the alias name of the database in the Alias Name text field.
2. Enter database file name, including the path where the file is located, in the File text field. If you prefer, you can also click the browse button to locate the file you want.
   If you want to change the database file name, the database must be disconnected before you access the Database Properties dialog.
3. If you need to view or configure the general database settings, click the General tab and see General Tab below for further information.
4. Once you are finished making changes to the database properties click **OK** to save your changes, otherwise click **Cancel**.

9.2. General Tab

The General tab of the Database Properties dialog is where you can view such database settings as the database owner, secondary files and their start pages, the number of allocated database pages and the page size. You can also set such options as Forced Writes, Sweep Interval, SQL Dialect and Read Only.

Error creating thumbnail: Unable to save thumbnail to destination

To edit database general options:

1. Choose option values in the Options table. You can specify options by clicking the option value and entering a new value, by choosing a new value from a drop-down list of values or by double-clicking the option value to rotate its value to the next in the list of values.
2. If you need to view or configure the database alias settings, click the Alias tab and see Alias Tab above for further information.
3. Once you are finished making changes to the database properties click **OK** to save your changes, otherwise click **Cancel**.

Option	Value
Read Only	Option values are **True** and **False**. To make the database read only set the Read Only option to True. This prevents users from performing any DML or updates to the database. The default setting for this option is False. See Making a Database Read-only for more information.
Write Mode	Sets the database write mode. Available options are Asynchronous, Synchronous and Direct I/O
Sweep Interval	he sweep interval is the number of transactions that will occur before an automatic database sweep takes place. You can enter any positive number for the sweep interval, or zero to disable the automatic sweep. See Sweep Interval and Automated Housekeeping for further information on setting the sweep interval.
Database Dialect	An InterBase database SQL dialect determines how double quotes, large exact numerics, and certain data types such as SQLDATE, TIME, and TIMESTAMP are interpreted. In most cases you should choose dialect 3 in order to have access to all current InterBase features. For more information refer to Features and Dialects.
Page Buffers	Enter a numeric value. It lets you set the number of database page buffers.
Linger Interval	Set a value in seconds. It allows a database to remain in memory after the last user detaches.
Flush Interval	Enables database flush. The interval <number> is interpreted in units of seconds.

Option	Value
Reclaim Interval	Set a value in seconds. Determines how often the garbage collector thread will run to release memory from unused procedures, triggers, and internal system queries back to InterBase memory heap.
Group Commit	Available options are **Yes** and **No** when enabled allows transactions to be committed by a background cache writer thread.
Reserve Table Space	Available options are **Yes** and **No**. When set to No it disables space reservation on the database.
Embedded User Authentication	Option Values are **Disabled** and **Enabled**. Stores database user name and password information directly in the database.

See Also

- Database Files
- Read-write and Read-only Databases
- Creating Databases
- Dropping Databases

10. Sweep Interval and Automated Housekeeping

Sweeping a database is a systematic way of removing outdated records. Periodic sweeping prevents a database from growing too large. In the past, sweeping slowed system performance and users disabled the automatic database sweep function because of the impact on product operations.

InterBase databases periodically need to be swept. Otherwise, the main memory allocated for the bitmap of each translation increases to the point where performance becomes unacceptable. The longer sweep takes to complete, the more main memory requirements increase for starting new transactions.

10.1. Fast Sweep

With the implementation of the fast sweep optimization starting with InterBase XE, the memory allocation issue has been mitigated. The user has the option to configure their databases for automatic sweep. In cases where large databases have large archival or infrequently modified tables, a database sweep will have minimal impact on the performance of running transactional operations.

Only ODS 15 and later databases can perform fast database sweeps. The effectiveness of a fast sweep is directly proportional to the fraction of database data pages that have been modified since the last sweep. If every data page has been changed, fast sweep is no faster than the

former methodology. If very few pages are changed, fast sweep is nearly instantaneous. If half the pages were updated, fast sweep is then half the former sweep time.

Starting with InterBase XE7, any database that you restore is immediately marked as swept, therefore the first sweep of that database is a fast sweep. This feature is available starting with InterBase XE7 and onwards.

There is no new user interface or action required by the user to enable fast sweep functionality. Manual sweep initiated by the GFIX command line tool, IBConsole, or programmatically, as well as automatic sweep configuration on a database, use the fast sweep mechanism.

As a database administrator, you can tune database sweeping, balancing its advantages and disadvantages to best satisfy the needs of the users.

10.2. Overview of Sweeping

InterBase uses a multigenerational 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.

10.2.1. Garbage Collection

To limit the growth of the database, InterBase performs garbage collection by sweeping the database. This process frees up space allocated to outdated record versions. Whenever a transaction accesses a record, outdated versions of that record are collected. Records that were rolled back are not collected. To guarantee that all outdated records are collected, including those that were rolled back, InterBase periodically sweeps the database.

10.2.2. Automatic Housekeeping

If a transaction is left in an active (unresolved) state, this is an “interesting” transaction. In a given transaction inventory of a database, the first transaction with a state other than committed is known as the Oldest Interesting Transaction (OIT). Automatic housekeeping occurs when the difference between the OIT and the oldest active transaction (OAT) is greater than the sweep interval. By default, this sweep interval is 20,000, but it is configurable (see Setting the Sweep Interval).

Note:
It is a subtle but important distinction that the automatic sweep does *not* necessarily occur every 20,000 transactions. It is only when the *difference* between the OIT and OAT reaches the threshold. If every transaction to the database is committed promptly, then this difference it is not likely to be great enough to trigger the automatic sweep.

The InterBase server process initiates a special thread to perform this sweep asynchronously, so that the client process can continue functioning, unaffected by the amount of work done by the sweep.

Tip:
Sweeping a database is not the only way to perform systematic garbage collection. Backing up a database achieves the same result, because the InterBase server must read every record, an action that forces garbage collection throughout the database. As a result, regularly backing up 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 About InterBase backup and restore options.

10.2.3. Configuring Sweeping

You are able to control several aspects of database sweeping. You can:

- Change the automatic sweep interval.
- Disable automatic sweeping.
- Sweep a database immediately.

The first two functions are performed in the Database Properties dialog. The last is performed with a sweep menu command and is explained in Performing an Immediate Database Sweep.

10.3. Setting the Sweep Interval

To set the automatic sweep threshold to n transactions:

```
gfix -h n
```

Sweeping a database can affect transaction start-up if rolled back transactions exist in the database. As the time since the last sweep increases, the time for transaction start-up can also increase. Lowering the sweep interval can help reduce the time for transaction start-up.

On the other hand, frequent database sweeps can reduce application performance. Raising the sweep interval could help improve overall performance. The database administrator should weigh the issues for the affected applications and decide whether the sweep interval provides the desired database performance.

To set the sweep interval with IBConsole, refer to Setting Database Properties.

Tip:
Unless the database contains many rolled back transactions, changing the sweep interval has little effect on database size. As a result, it is more common for a database

administrator to tune the database by disabling sweeping and performing it at specific times. These activities are described in the next two sections.

10.4. Disabling Automatic Sweeping

To disable automatic sweeping, set the sweep threshold to zero (0). Disabling automatic sweeping is useful if:

- Maximum throughput is important. Transactions are never delayed by sweeping.
- You want to schedule sweeping at specific times. You can manually sweep the database at any time. It is common to schedule sweeps at a time of least activity on the database server, to avoid competing for resources with clients.

To disable automatic sweeping with IBConsole, refer to Setting Database Properties.

10.5. Performing an Immediate Database Sweep

You can perform an immediate database sweep with any of the following methods:

- Right click a connected database in the Tree pane and choose Maintenance|Sweep from the context menu.
- Select a connected database in the Tree pane and double-click Sweep in the Work pane.
- enter the following command:

```
gfix -sweep
```

This operation runs an immediate sweep of the database, releasing space held by records that were rolled back and by out-of-date record versions. Sweeps are also done automatically at a specified interval.

Sweeping a database does not strictly 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 inconveniences users the least.

If a sweep is performed as an exclusive operation on the database, there is additional tuning that the procedure performs. As long as there are no outstanding active transactions, the sweep updates the state of data records and the state of the inventory of past transactions. Non-committed transactions are finally rendered obsolete, and internal data structures need not track them in order to maintain snapshots of database versions. The benefit of this is a reduction of memory use, and a noticeable performance improvement.

11. Configuring the Database Cache

The database cache consists of all database pages (also called buffers) held in memory at one time. Database cache size is the number of database pages. You can set the default size of the database cache at three levels:

- Server level: applies to all databases
- Database level: applies only to a single database (using `gfix` or `ALTER DATABASE SET PAGE CACHE` to set the size for a specific database)
- Connection level: applies only to a specific `isql` connection

We recommend setting cache size at the database level rather than at the server level. This reduces the likelihood of inappropriate database cache sizes.

Every database on a server requires RAM equal to the cache size (number of database pages) times the page size. By default, the cache size is 2048 pages per database and the page size is 4KB. Thus, a single database running at the default setting requires 8MB of memory, but three such databases require 24MB of memory.

11.1. Default Cache Size Per Database

The `buffers` parameter of the `gfix` utility sets the default number of cache pages for a specific database:

```
gfix -buffers n database_name
```

This sets the number of cache pages for the specified database to **<n>**, overriding the server value, which by default is 2048 pages.

The default size for a database can also be set using the ALTER DATABASE statement:

```
ALTER DATABASE SET PAGE CACHE n
```

To run `gfix` or `ALTER DATABASE`, you must be either `SYSDBA` or the owner of the database.

Both gfix and ALTER DATABASE immediately attempt to expand the cache buffers to the number of pages requested.

11.2. Default Cache Size Per isql Connection

To configure the number of cache pages for the duration of one `isql` connection, invoke `isql` with the following option:

```
isql -c n database_name
```

<n> is the number of cache pages to be used as the default for the session; **<n>** is trimmed to the database-specific cache setting if it is greater than that value.

A `CONNECT` statement entered in an `isql` query accepts the argument `CACHE n`. (Refer to the discussion of `CONNECT` in the *Language Reference* manual for a full description of the `CONNECT` function). For example:

```
isql> CONNECT database_name CACHE n;
```

The value **<n>** can be any positive integer number of database pages. If a database cache already exists in the server because of another attachment to the database, the cache size is increased only if **<n>** is greater than current cache size.

11.3. Setting Cache Size in Applications

InterBase API: use the `isc_dpb_num_buffers` parameter to set cache size in a database parameter buffer (DPB).

IBX: use the num_buffers parameter to set cache size in the TIBDatabase parameter list. For example: num_buffers=250. For the parameter to be parsed correctly, there must be no spaces around the = sign.

The number of buffers passed by the InterBase API or IBX is trimmed to the database-specific cache setting if it is greater than that value.

11.4. Default Cache Size Per Server

For SuperServer installations, you can configure the default number of pages used for the database caches. By default, the database cache size is 2048 pages per database. You can modify this default by changing the value of `DATABASE_CACHE_PAGES` in the `ibconfig` configuration file. When you change this setting, it applies to every active database on the server **.**

You can also set the default cache size for each database using the `gfix` or **SET PAGE CACHE** utilities. This approach permits greater flexibility, and reduces the risk that memory is overused, or that database caches are too small.

We strongly recommend that you use `gfix` or `SET PAGE CACHE` to set cache size rather than `DATABASE_CACHE_PAGES`.

11.5. Verifying Cache Size

To verify the size of the database cache currently in use, execute the following commands in isql:

```
isql> CONNECT database_name;
isql> SET STATS ON;
isql> COMMIT;
Current memory = 415768
Delta memory = -2048
Max memory = 419840
Elapsed time = 0.03 sec
Buffers = 2048
Reads = 0
Writes 2
Fetches = 2
isql> QUIT;
```

The empty `COMMIT` command prompts `isql` to display information about memory and buffer usage. The “Buffers” line specifies the size of the cache for that database.

Note:
The example command listing shows "**Buffers=2048**" for user to verify that cache setting has been changed. This is no longer strictly true. For very large cache buffer settings (>256MB), InterBase incrementally allocates additional cache buffers on-demand. So it is possible that the listed command will show a **Buffers** value that is a lower number. The actual value can always be determined by running **gstat -h** and examining the **Page buffers** entry or querying column RDB$PAGE_CACHE from system table RDB$DATABASE.

12. Forced Writes vs. Buffered Writes

When an InterBase Server 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, since 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 slow performance. In particular, operations that involve data modification are slower.

Forced writes are enabled or disabled in the Database Properties dialog. For more information, refer to Setting Database Properties.

13. Validation and Repair

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 cause data structures such as database pages and indexes to become broken or lost. These corrupt data structures can make committed data unrecoverable.

13.1. Validating a Database

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.

Database validation requires exclusive access to the database. Shut down a database to acquire exclusive access. If you do not have exclusive access to the database, you get the error message:

```
bad parameters on attach or create database - secondary server attachments cannot
validate databases
```

To shut down a database, refer to the directions in Shutting Down a Database.

13.1.1. Validating a Database Using gfix

To validate a database using gfix, follow these steps:

1. Enter the following command:

   ```
   gfix -v
   ```

2. If you suspect you have a corrupt database, make a copy of your database using an OS command (`gbak` will not back up corrupt data).
3. Use the `gfix` command to mark corrupt structures in the copied database:

```
gfix -mend
```

4. If `gfix` reports any checksum errors, validate and repair the database again, ignoring any checksum errors:

```
gfix -validate -ignore
```

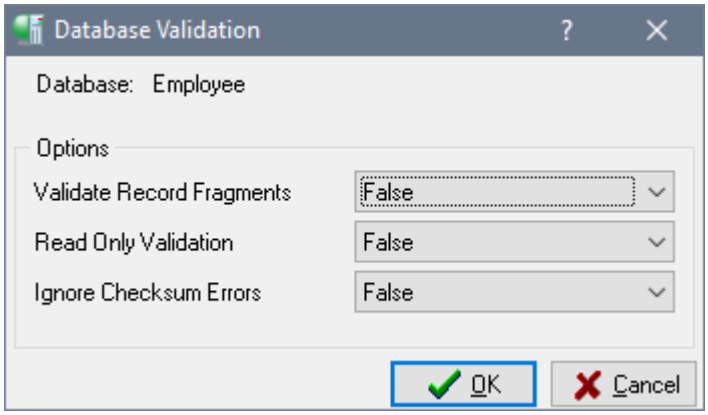
> **Note:**
> InterBase supports true checksums only for ODS 8 and earlier.

It may be necessary to validate a database multiple times to correct all the errors.

13.1.2. Validating a Database using IBConsole

To validate a database using IBConsole, access the Database Validation dialog by any of the following methods:

- Select a disconnected database in the Tree pane and double-click Validation in the Work pane.
- Right-click a disconnected database in the Tree pane and choose Validation from the context menu.
- Select Database|Maintenance|Validation.



To validate database:

1. Check that the database indicated is correct. If it is not, cancel this dialog and re-initiate the Database Validation dialog under the correct database.
2. Specify which validation options you want by clicking in the right column and choosing True or False from the drop-down list. See the table below for a description of each option.
3. Click OK if you want to proceed with the validation, otherwise click Cancel.

When IBConsole validates a database, it verifies the integrity of data structures. Specifically, it does the following:

- Reports corrupt data structures.
- Reports misallocated data pages.
- Returns orphan pages to free space.

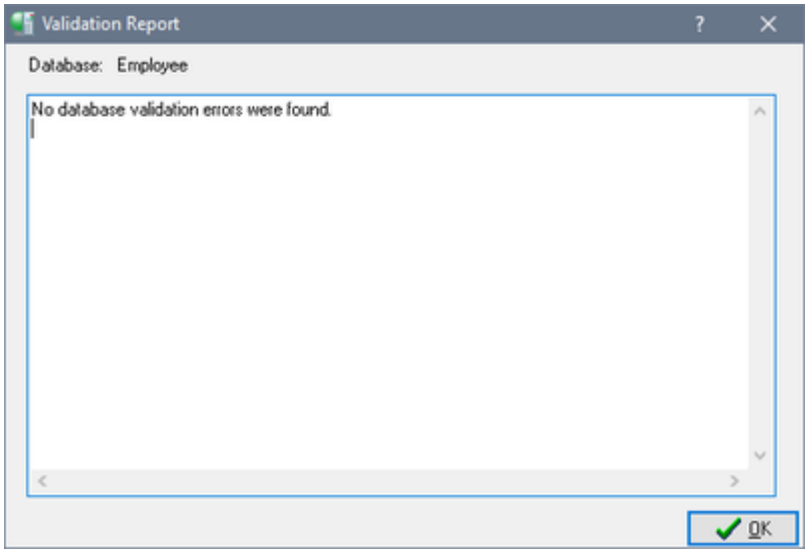
Option	Value
Validate Record Fragments	Option values are True and False. By default, database validation reports and releases only page structures. If the Validate Record Fragments option is set to True, validation reports and releases record structures as well as page structures.
Read Only Validation	Option values are True and False. By default, validating a database updates it, if necessary. To prevent updating, set the Read Only Validation option to True.
Ignore Checksum Errors	Option values are True and False. 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, set the Ignore Checksum Errors option to True. This enables IBConsole to ignore checksums when validating a database. Ignoring checksums allows successful validation of a corrupt database, but the affected data may be lost. **Note**: InterBase supports true checksums only for ODS 8 and earlier.

See Also

- Repairing a Corrupt Database
- Shutting Down and Restarting Databases

13.2. Repairing a Corrupt Database

If a database contains errors, they are displayed in the following dialog:



The errors encountered are summarized in the text display area. The repair options you selected in the Database Validation dialog are selected in this dialog also.

To repair the database, choose Repair. This fixes problems that cause records to be corrupt and marks corrupt structures. In subsequent operations (such as backing up), InterBase ignores the marked records.

Some corruptions are too serious for IBConsole to correct. These include corruptions to certain strategic structures, such as space allocation pages. In addition, IBConsole cannot fix certain checksum errors that are random by nature and not specifically associated with InterBase.

Note:
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.

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 IBConsole Backup utility or the gbak command, because they cannot back up a database containing corrupt data. If IBConsole reports any checksum errors, validate and repair the database again, setting the Ignore Checksum Error option to True. *Note*: InterBase supports true checksums only for ODS 8 and earlier.
2. It may be necessary to validate a database multiple times to correct all the errors. Validate the database again, with the Read Only Validation option set to True.
3. Back up the mended database with IBConsole or `gbak`. At this point, any damaged records are lost, since they were not included during the back up. For more information about database backup, see About InterBase backup and restore options.
4. Restore the database to rebuild indexes and other database structures. The restored database should now be free of corruption.

5. To verify that restoring the database fixed the problem, validate the restored database with the Read Only Validation option set to True.

14. Shutting Down and Restarting Databases

Maintaining a database often involves shutting it down. Only the `SYSDBA` or the owner of a database (the user who created it) can shut it down. The user who shuts down the database then has exclusive access to the database.

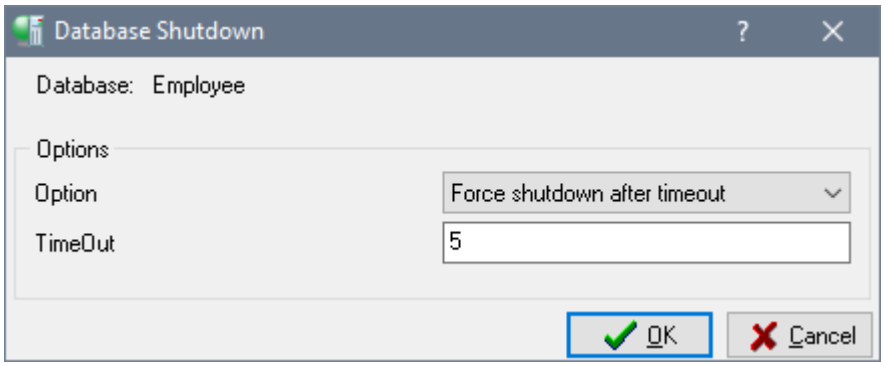
Exclusive access to a database is required to:

- Validate and repair the database.
- Add or drop a foreign key on a table in the database.
- Add a secondary database file.

After a database is shut down, the database owner and SYSDBA are still able to connect to it, but any other user attempting to connect gets an error message stating that the database is shut down.

14.1. Shutting Down a Database

To shut down a database, select a connected database from the Tree pane and double-click Shutdown in the Work pane or choose Database|Maintenance|Shutdown to display the Database Shutdown dialog:



14.1.1. Shutdown Timeout Options

You can specify a timeout value by selecting a new value from the drop-down list of values or by typing the value in the edit portion of the drop-down list. Timeout values can range from 1 minute to 500 minutes.

14.1.2. Shutdown Options

You can specify shutdown options by selecting a new value from the drop-down list of values. Shutdown option values include: Deny New Connections While Waiting, Deny New Transactions While Waiting, and Force Shutdown After Timeout.

Deny new connections while waiting

This option allows all existing database connections to complete their operations unaffected. IBConsole shuts down the database after all processes disconnect from the database. At the end of the time-out period, if there are still active connections, then the database is not shut down.

This prevents any new processes from connecting to the database during the timeout period. This enables current users to complete their work, while preventing others from beginning new work.

Suppose the SYSDBA needs to shut down database `orders.ib` at the end of the day (five hours from now) to perform routine maintenance. The Marketing department is currently using the database to generate important sales reports.

In this case, the SYSDBA would shut down `orders.ib` with the following parameters:

- Deny New Connections.
- Timeout of 300 minutes (five hours).

These parameters specify to deny any new database connections and to shut down the database any time during the next five hours when there are no more active connections.

Any users who are already connected to the database are able to finish processing their sales reports, but new connections are denied. During the timeout period, the SYSDBA sends out periodic broadcast messages asking users to finish their work by 6 p.m.

When all users have disconnected, the database is shut down. If all users have not disconnected after five hours, then the database is not shut down. Because the shutdown is not critical, it is not forced.

It would be inappropriate to deny new transactions, since generating a report could require several transactions, and a user might be disconnected from the database before completing all necessary transactions. It would also be inappropriate to force shutdown, since it might cause users to lose work.

Deny new transactions while waiting

This option allows existing transactions to run to normal completion. Once transaction processing is complete, IBConsole shuts down the database. Denying new transactions also denies new database connections. At the end of the time-out period, if there are still active transactions, then the database is not shut down.

This is the most restrictive shutdown option, since it prevents any new transactions from starting against the database. This option also prevents any new connections to the database.

Suppose the SYSDBA needs to perform critical operations that require shutdown of the database `orders.ib`. This is a database used by dozens of customer service representatives throughout the day to enter new orders and query existing orders.

At 5 p.m., the SYSDBA initiates a database shutdown of `orders.ib` with the following parameters:

- Deny New Transactions.
- Timeout of 60 minutes.

These parameters deny new transactions for the next hour. During that time, users can complete their current transactions before losing access to the database. Simply denying new connections would not be sufficient, since the shutdown cannot afford to wait for users to disconnect from the database.

During this hour, the `SYSDBA` sends out periodic broadcast messages warning users that shutdown is happening at 6 p.m and instructs them to complete their work. When all transactions have been completed, the database is shut down.

After an hour, if there are still any active transactions, IBConsole cancels the shutdown. Since the `SYSDBA` needs to perform database maintenance, and has sent out numerous warnings that a shutdown is about to occur, there is no choice but to force a shutdown.

Force Shutdown After Timeout

With this option, there are no restrictions on database transactions or connections. As soon as there are no processes or connections to the database, IBConsole shuts down the database. At the end of the time-out period, if there are still active connections, IBConsole rolls back any uncommitted transactions, disconnects any users, and shuts down the database.

If critical database maintenance requires a database to be shut down while there are still active transactions, the SYSDBA can force shut down. This step should be taken only if broadcast

messages have been sent out to users that shutdown is about to occur. If users have not heeded repeated warnings and remain active, then their work is rolled back.

This option does not deny new transactions or connections during the time-out period. If, at any time during the time-out period, there are no connections to the database, IBConsole shuts down the database.

Important:
Forcing database shutdown interferes with normal database operations, and should only be used after users have been given appropriate broadcast notification well in advance.

See Also

- Restarting a Database
- Database Files

14.2. Restarting a Database

After a database is shut down, it must be restarted (brought back online) before users can access it.

To restart a database, select a previously shut down database from the Tree pane and choose Database|Maintenance|Database Restart or double-click Database Restart in the Work pane. The currently selected database is brought back online immediately.

15. Limbo Transactions

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.

Note:
The Borland Database Engine (BDE), as of version 4.5, does not exercise the two-phase commit or distributed transactions capabilities of InterBase, therefore applications using the BDE never create limbo transactions.

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 are committed and others are not. 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 some records in a database are inaccessible due to their association with a transaction that is in a limbo state. To correct this, you must recover the transaction using IBConsole. *Recovering* a limbo transaction means committing it or rolling it back. Use gfix to recover transactions.

15.1. Recovering Transactions

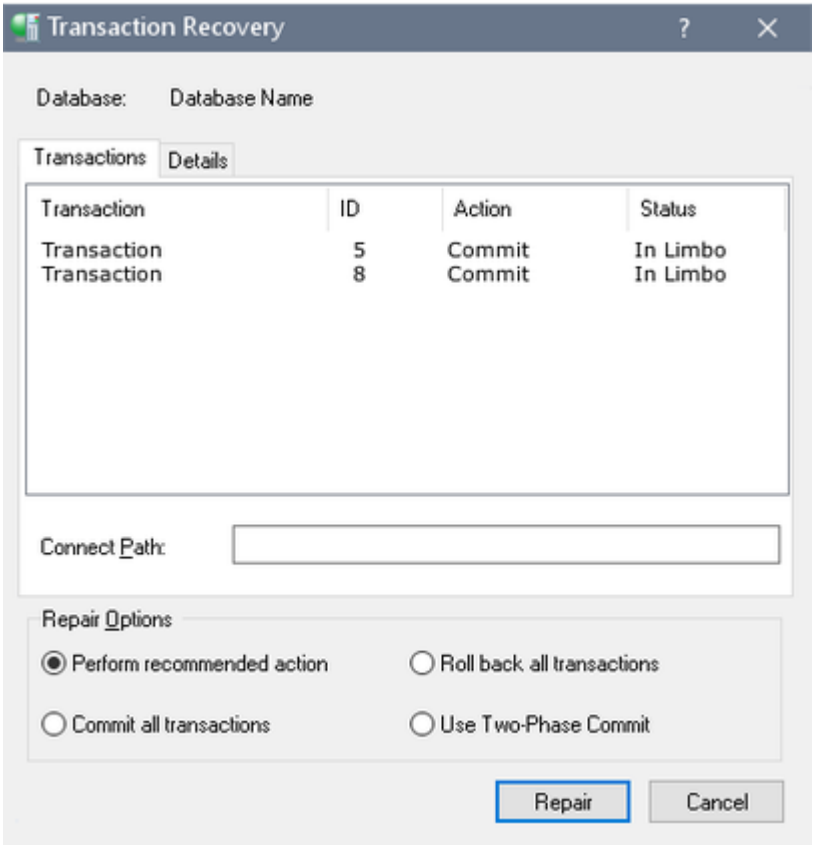
You can recover transactions by any of the following methods:

- Select a connected database in the Tree pane and double-click Transaction Recovery in the Work pane or choose Database|Maintenance|Transaction Recovery.
- Right-click a connected database in the Tree pane and choose Maintenance|Transaction Recovery from the context menu.

The Transaction Recovery dialog contains two tabs, Transactions and Details. The Transactions tab displays a list of limbo transactions that can then be recovered—that is, to committed or rolled back. You can also seek suggested recovery actions and set current actions to perform on the selected limbo transactions. The Details tab displays detailed information about a selected transaction.

15.1.1. Transaction Tab

All the pending transactions in the database are listed in the text area of the Transactions tab. You can roll back, commit, or perform a two-phase commit on such transactions.

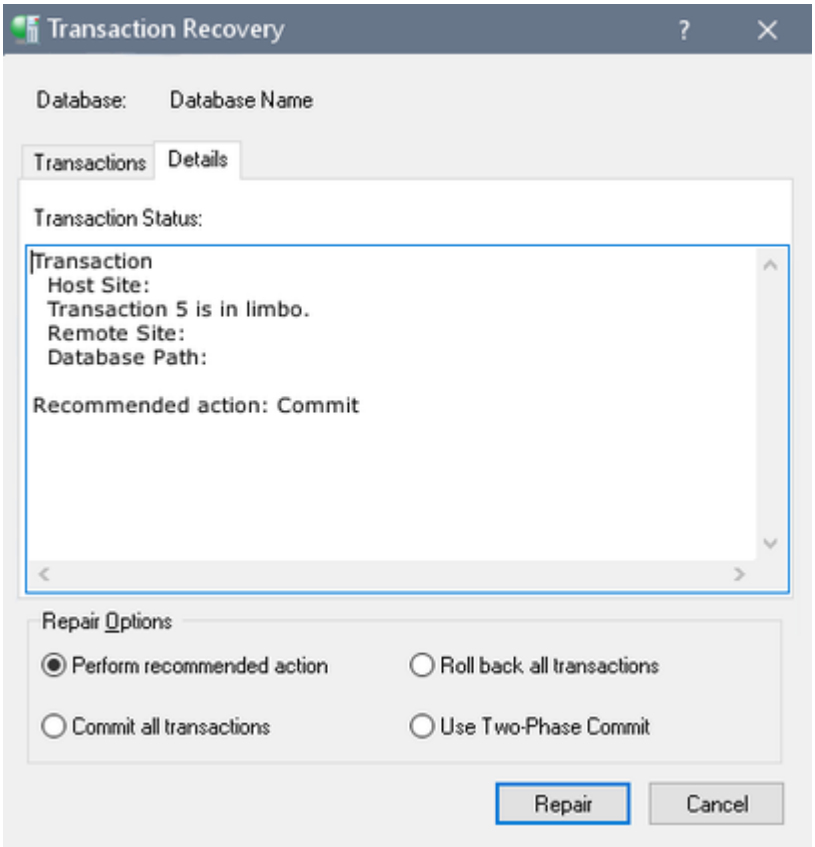


To recover Limbo Transactions:

1. Select a limbo transaction in the table.
2. The Connect Path text field displays the current path of the database file for the selected transaction, if it is a multi-database transaction. You can change the target database path, if necessary, by overwriting the current path.</br> The information on the path to the database was stored when the client application attempted the commit. It is possible that the path and network protocol from that machine does not work from the client which is now running IBConsole. Before attempting to roll back or commit any transaction, confirm the path of all involved databases is correct.</br> When entering the current path, be sure to include the server name and separator indicating communication protocol. To use TCP/IP, separate the server and directory path with a colon (:). To use NetBEUI, precede the server name with either a double backslash (\\) or a double slash (//), and then separate the server name and directory path with either a backslash or a slash.
3. If you want to continue with the transaction recovery process select a repair option and click Repair, otherwise click Cancel. To determine the recommended action, click on the transaction and select the Details tab. For further information about transaction recovery suggestions, see Details Tab below.

15.1.2. Details Tab

The Details tab displays the host server, the remote server, database path, and recommended action: either commit or rollback. If you want to continue with the transaction recovery process select a repair option and click Repair, otherwise click Cancel.



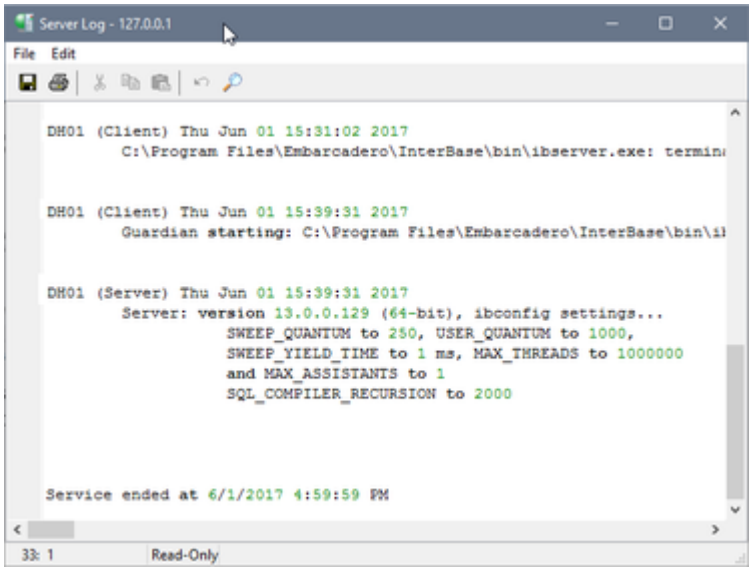
See Also

- Database Files
- Shadowing

16. Viewing the Administration Log

IBConsole displays the administration log file in a standard text display window, the Administration Log dialog, which can be accessed by any of the following methods:

- Select a server (or any branch under the server hierarchy) in the Tree pane and choose Server|View Logfile.
- Right-click the desired server in the Tree pane and choose View Logfile from the context menu.
- Under the desired server, select Server Log in the Tree pane and then double-click View Logfile in the Work pane.



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 Text Viewer Window.

17. gfix Command-line Tool

The `gfix` tool performs a number of maintenance activities on a database, including the following:

- Database shutdown
- Changing database mode to read-only or read-write
- Changing the dialect of a database
- Setting cache size at the database level
- Committing limbo transactions
- Mending databases and making minor data repairs
- Sweeping databases
- Displaying, committing, or recovering limbo transactions

To run `gfix`, you must attach as either `SYSDBA` or the owner of the database. Most of these actions can also be performed through IBConsole.

```
gfix [options] db_name
```

Options: In the `OPTION` column of the following table, only the characters outside the brackets ([ ]) are required. You can specify additional characters up to and including the full option name. To help identify options that perform similar functions, the `TASK` column indicates the type of activity associated with an option.

gfix Options

Option	Task	Description
`-ac[tivate]`	Activate shadows	Activate shadows when the database dies. NOTE: syntax is gfix -ac (no database name).
`-at[tach] n`	Shutdown	Used with `-shut` to prevent new database connections during timeout period of **<n>** seconds; shutdown is canceled if there are still processes connected after **<n>** seconds.
`-b[uffers] n`	Cache buffers	Sets default cache buffers for the database to **<n>** pages.
`-c[ommit] {ID| all}`	Transaction recovery	Commits limbo transaction specified by `ID` or commit all limbo transactions.
`-force n`	Shutdown	Used with `-shut` to force shutdown of a database after **<n>** seconds; this is a drastic solution that should be used with caution.
`-fu[ll]`	Data repair	Used with `-v` to check record and page structures, releasing unassigned record fragments.
`-h[ousekeeping] n`	Sweeping	Changes automatic sweep threshold to **<n>** transactions. • Setting **<n>** to 0 disables sweeping. • Default threshold is 20,000 transactions (see Overview of Sweeping). • Exclusive access not needed
`-i[gnore]`	Data repair	Ignores checksum errors when validating or sweeping; InterBase supports true checksums only for ODS 8 and earlier.
`-k[ill]`	Drop shadows	• Drops unavailable shadows. • Syntax is `gfix -k` (no database name).

Option	Task	Description
`-l [ist]`	Transaction recovery	Displays IDs of each limbo transaction and indicates what would occur if `-t` were used for automated two-phase recovery.
`-m [end]`	Data repair	Marks corrupt records as unavailable, so they are skipped (for example, during a subsequent backup).
`-mo[de] [read_write| read_only}`	Set access mode	• Sets mode of database to either read-only or read-write. • Default table mode is read_write. • Requires exclusive access to the database.
`-n [o_update]`	Data repair	Used with `-v` to validate corrupt or misallocated structures; structures are reported but not fixed.
`-o [nline]`	Shutdown	Cancels a `-shut` operation that is scheduled to take effect or rescinds a shutdown that is currently in effect.
`-pa [ssword] text`	Remote access	Checks for password **<text>** before accessing a database.
`-pr[ompt]`	Transaction recovery	Used with `-l` to prompt for action during transaction recovery.
`-r [ollback] {ID| all}`	Transaction recovery	Rolls back limbo transaction specified by `ID` or roll back all limbo transactions.
`-sh [ut]`	Shutdown	• Shuts down the database. • Must be used in conjunction with `-attach`, `-force`, or `-tran`.
`-sq[l_dialect] n`	Database dialect	Changes database dialect to **<n>**. • Dialect 1 = InterBase 5.x compatibility • Dialect 3 = Current InterBase with SQL92 features

Option	Task	Description
`-sw[eep]`	Sweeping	Forces an immediate sweep of the database. • Useful if automatic sweeping is disabled. • Exclusive access is not necessary.
`-tr[an] n`	Shutdown	Used with `-shut` to prevent new transactions from starting during timeout period of **<n>** seconds; cancels shutdown if there are still active transactions after **<n>** seconds.
`-tw[o_phase] {ID | all}`	Transaction recovery	Performs automated two-phase recovery, either for a limbo transaction specified by `ID` or for all limbo transactions.
`-user name`	Remote access	Checks for user **<name>** before accessing a remote database.
`-v[alidate]`	Data repair	Locates and releases pages that are allocated but unassigned to any data structures; also reports corrupt structures.
`-w[rite] {sync | async | direct}`	Database writes	Database writes Enables or disables forced (synchronous) writes. `sync` enables forced writes; `async` enables buffered writes; **direct** enables direct I/O.
`-z`		Shows version of `gfix` and of the InterBase engine.

Examples: The following example changes the dialect of the `customer.ib` database to 3:

```
gfix -sql 3 customer.ib
```

The following example changes the customer.ib database to read-only mode:

```
gfix -mo read_only customer.ib
```

18. gfix Error Messages

The following table describes gfix Database Maintenance Error Messages:

Error Message	Causes and Suggested Actions to Take
Database file name <string> already given	A command-line option was interpreted as a database file because the option was not preceded by a hyphen (-) or slash (/). Correct the syntax.
Invalid switch	A command-line option was not recognized.
Incompatible switch combinations	You specified at least two options that do not work together, or you specified an option that has no meaning without another option (for example, `-full` by itself).
More limbo transactions than fit. Try again.	The database contains more limbo transactions than `gfix` can print in a single session. Commit or roll back some of the limbo transactions, then try again.
Numeric value required	The `-housekeeping` option requires a single, non-negative argument specifying number of transactions per sweep.
Please retry, specifying <string>	Both a file name and at least one option must be specified.
Transaction number or “all” required	You specified `-commit`, `-rollback`, or `-two_phase` without supplying the required argument.
-mode read_only or read_write	The `-mode` option takes either read_only or read_write as an option.
“read_only” or “read_write” required	The `-mode` option must be accompanied by one of these two arguments.

See Also

- gfix Command-line Tool

19. gfix Fixing a database

This section guides you on how to attempt fixing a corrupt database, during this process it's possible to lose some data.

Follow these steps to start the process:

1. Make sure you work with a copy of the database, this can prevent further damage and provides exclusive access to the database, which is necessary for performing the required actions.
2. Type `gfix -v -f databasename.gdb` on the command line console.
3. If the previous step reports corruption, type `gfix -m -i databasename.gdb`
4. Repeat step 2 to see if corruption was fixed.

To know more about `gfix` parameters refer to Gfix Command-line Tool

DATABASE BACKUP AND RESTORE

The purpose of a **database backup** is to protect and preserve data in case of database or machine failure. A **database restore** uses the backup file to recreate the database.

A database backup saves a database to a file on a hard disk or other storage medium. InterBase provides full and incremental backup capability, as well a number of options that allow you to tailor your backups to suit a iety of scenarios.

To most effectively protect your database from power failure, disk crashes, or other potential data loss, perform backups on a regular basis. For additional safety, store the backup file in a different physical location from the database server.

This chapter explains how to perform full and incremental backups on InterBase machines. It also explains how to restore InterBase databases.

1. About InterBase backup and restore options

You can use InterBase to backup data to the following locations:

- To a second drive on the InterBase server.
- To another machine on the local network.
- To a machine at a remote location using a VPN or WAN.

InterBase backups can **run concurrently** while other users are using the database. You do not have to shut down the database to run a backup. However, any data changes that clients commit to the database after the backup begins are not recorded in the backup file.

1.1. InterBase backup and restore tools

You can use either of the following InterBase tools to backup and restore InterBase databases:

- The **gbak** command-line tool

Use the InterBase `gbak` command to specify and execute backup and restore operations from a Windows or Unix command line. Familiarity with isql, InterBase version of SQL is recommended. isql provides a number of options to help tailor your backup and restore to suit different circumstances and environments.

- The **IBConsole**

The IBConsole intuitive user interface allows you to use your mouse, context menus, and dialog boxes to specify the type of backup and restore you want to perform. The same backup and restore options that are available using `gbak` are available through the IBConsole user interface.

You do not need to be familiar with command-line operations or with SQL or isql to use IBConsole.

This chapter explains how to use both tools to perform backups and restores.

1.2. The difference between logical and physical backups

InterBase uses the gbak command to perform backups. The gbak command makes the following distinctions between backup types.

- **Logical:**

The full backup typically performed by gbak is a "logical" backup. It extracts every record in the database and stores it in a different format. Thus, it is not an exact replica of the database file. Logical backups **reclaim space** occupied by deleted records, thereby reducing database size.
A logical backup, performed by a gbak client, can save the target backup file anywhere on the network; you do not have to have an InterBase server on the client machine. If the backup is performed using the Services API, then the backup file can only be written to file systems that are accessible to the server (since the server is performing the backup operation).
When executing a logical backup with gbak, use the following syntax:
gbak [-b] [options] **<database> <target>**
If you choose the **Backup** option using IBConsole, this is the type of backup InterBase executes.
Restoring from logical backups gives you the option of changing the database page size and distributing the database among multiple files or disks.

- **Physical:**

InterBase physical backup, also referred to as an online dump, copies the database at the page level and saves it in its original format. Thus, a physical backup creates an exact replica of the database during backup process. You can convert the replica to a read-write database, though if you do so, you will no longer be able to dump to the replica from the original database.
To perform a physical backup, use the following syntax:
gbak [-d] [options] **<database> <target>**
Notice that the physical backup uses the -d switch rather than the -b switch that is specified in the logical backup.
An **incremental backup** copies all of the changes that have been committed to the database since the last full backup. An incremental backup is a physical backup and uses the -d switch. The first time you use the gbak -d switch, InterBase performs a full physical backup (an online dump). After the initial full dump, each subsequent backup using the -d switch performs an incremental backup, saving and copying all of the transactions committed since the last full backup.
If you choose the **Incremental Backup** option using IBConsole, IBConsole performs an initial full online dump using the -d switch. All subsequent backups using the -d switch are incremental.

Important:
To add an additional level of database protection, use journal files and journal archiving.

Journal files record each database transaction as it occurs, even those that occur when a backup is running. A journal archive stores current journal files. You can use a journal archive to recover data to a specific point in time. For more information about journaling and journal archives, see Journaling and Disaster Recovery.

1.3. Database ownership

Although backing up a database can be performed only by the owner or SYSDBA, any user can restore a database as long as they are not restoring it over an existing database. A database file restored from a logical backup belongs to the user ID of the person who performed the restore. This means that backing up and restoring a database is a mechanism for changing the ownership of a database. It also means that an unauthorized user can steal a database by restoring a backup file to a machine where he knows the SYSDBA password. It is important to ensure that your backup files are secured from unauthorized access.

To restore a database over an existing database, you must be SYSDBA or the owner of the existing database.

1.3.1. Restoring the ODS

InterBase automatically restores the database to the latest on-disk structure (ODS). If the database uses an earlier ODS, errors may occur. To avoid this, keep your databases updated by using the latest version of the ODS.

To upgrade existing databases to a new ODS, perform the following steps:

1. Before installing a new version of InterBase, back up databases using the old version.
2. Install the InterBase server.
3. Once the new server is installed, restore the databases.

For more information about migrating to a later version of InterBase, see Migrating to InterBase.

2. Performing backups and restores using the gbak command

You can use the `gbak` command-line tool to perform database backups and restores, using different options to specify different outcomes. For instruction on how to use IBConsole for backups and restores, see Performing backups and restores using IBConsole, later in this chapter.

Note:
For information on how to use the gbak command to encrypt backup files and to restore encrypted backup files, see Encrypting Your Data.

2.1. General guidelines for using gbak

When backing up a database, keep the following information in mind:

- Unless the `-service` option is specified, `gbak` writes the backup files to the current directory of the machine on which it is running, not on the server where the database resides. If you specify a location for the backup file, it is relative to the machine where `gbak` is executing. You can write the backup files only to this local machine or to drives that are mapped to it. Note that the `-service` switch changes this behavior. (See Using gbak with InterBase Service Manager.)
- When you are backing up a multifile database, specify *only* the first file in the backup command. You must not name the subsequent database files: they will be interpreted as backup file names.
- The default unit for backup files is bytes. You can choose to specify kilobytes, megabytes, or gigabytes (`k`, `m`, or `g`) instead. Restored database files can be specified only in database pages.
- Use the `-transportable` switch if you operate in a multiplatform environment. This switch permits the database to be restored to a platform other than the one on which it originally resided. Using this option routinely is a good idea when you are operating in a multiplatform environment.
- Use the `-service` switch if you are backing up to the same server that holds the original database. This option invokes the InterBase Service Manager on the server host and saves both time and network traffic.

Tip:
It is good security practice to change your backup files to read-only at the system level after creating them. This prevents them from being accidentally overwritten. In addition, you can protect your databases from being "kidnapped" on UNIX and Windows systems by placing the backup files in directories with restricted access.

2.2. Initiating multi- and single-file backups

When backing up a multifile database, specify only the first file name of the database.

For backing up to a single file

```
gbak [-b] [options] database target
```

For backing up to multiple files

```
gbak [-b] [options] database target1 size1[k|m|g] target2 [size2[k|m|g] target3
```

Arguments for gbak

Argument	Description
<database>	• Name of a database to back up • For a multifile database, the name of the first database file
<target>	Name of a storage device or backup file to which to back up • On UNIX, can also be `stdout`, in which case `gbak` writes its output to the standard output (usually a pipe). • No size need be specified when restoring to a single file, since the database always expands as needed to fill all available space.
<size>	Length of a backup file or restored database file • The only permissible unit for a restored database file is database pages; minimum value is 200. • Default unit for a backup file is bytes. • Size of backup files can also be specified in kilobytes, megabytes, or gigabytes. • Do not specify a size for the final backup file or database file; the last file always expands as needed to fill all available space.

Options: In the `OPTION` column of the following tables, only the characters outside the square brackets ([ ]) are required.

The following table lists the options to `gbak` that are available for creating backups.

Backup Options for gbak

Option	Description
`-b [ ackup_database ]`	Backs up database to file or device.
`-co [ nvert ]`	Converts external files as internal tables.
`-d[ump]`	The first time you use the -d switch, it executes a full physical backup. Subsequent uses execute an incremental backup.
`-e [ xpand ]`	Creates a noncompressed back up.
`-fa [ ctor ] n`	Uses blocking factor **<n>** for tape device.

Option	Description
-g [arbage_collect]	This option instructs the server not to perform garbage collection on every record it visits. This enables the server to retrieve records faster, and to send them to the gbak client for archiving.
-ig [nore]	Ignores checksums during backup; *Note*: InterBase supports true checksums only for ODS 8 and earlier.
-l [imbo]	Ignores limbo transactions during backup.
-m [etadata]	Backs up metadata only, no data.
-nt	Creates the backup in nontransportable format.
-ol [d_descriptions]	Backs up metadata in old-style format.
-ov [erwrite_dump]	This switch causes the current set of online dump files to be deleted, and initiates a full database dump
-pas [sword] text	Checks for password **<text>** before accessing a database.
-role name	Connects as role **<name>**.

Option	Description
-se[rvice] servicename	• Creates the backup files on the host where the original database files are located, using InterBase Service Manager. • **<servicename>** invokes the Service Manager on the server host; syntax varies with the network protocol in use: **IMPORTANT NOTE**: If you are providing file path names with embedded spaces in them and using the InterBase service manager (-service switch in GBAK), you will need to multi-quote the file names: <double_quote><single_quote>filepath<single_quote><double_quote> The above is required because the command shell strips away the external double_quotes and only leaves the internal single_quotes for InterBase to know that it is a single string value. For example: # gbak –service service_mgr –r "'/path/with space/foo.ibk'" "'/path/with space/foo.ib'" –user sysdba –password masterkey
-t[ransportable]	Creates a transportable backup [default].
-user name	Checks for user **<name>** before accessing remote database.
-v[erbose]	Shows what gbak is doing.
-y [file | suppress_output]	Direct status messages to **<file>**; **<file>** must not already exist; suppress_output suppress output messages.
-z	Show version of gbak and of InterBase engine.

2.3. Creating incremental backups

An incremental backup copies all of the changes to the database that have occurred since the last full or incremental backup. The first time you use the gbak -d switch, InterBase performs a full physical backup (an online dump). After the initial full dump, the -d switch performs an incremental backup, saving and copying all of the transactions committed since the last full backup.

2.3.1. Incremental backup guidelines

When specifying an incremental backup, keep the following information in mind:

- Performing an incremental online dump still requires a full scan of the source database.
- The performance improvement accrues from limiting the number of page writes to the online dump files, especially if those files are located on a remote file server.
- Multiple online dumps of the same or distinct databases can be run concurrently though this would not be recommended for performance reasons.
- An active online dump can be cancelled by the InterBase Performance Monitor or killing the GBAK process.
- External tables are not backed up by an online dump.
- External tables may not be accessible if the online dump is attached as a read-only database. If the external file pathnames cannot be accessed from the online dump location, there is no way to modify the metadata of the dump without making the dump a read-write database. If it is made a read-write database, it can no longer be a target for online dump again.
- Since an online dump is a physical backup, the online dump files are not transportable to other hardware platforms. To make the backup transportable, use traditional logical backup of gbak using the -t switch.
- When a `CREATE JOURNAL ARCHIVE` statement is executed, InterBase uses the online dump feature to copy the database to a journal archive directory. For more information about journal files and journal archiving, see Journaling and Disaster Recovery.

2.3.2. Executing an incremental backup

To execute an incremental backup, use the following syntax:

```
GBAK {-D} dbname file [size] add_file1 [size1] add_file2 [size2] ...
```

The first dump file in the list is similar to the first database file in a multi-file database. It is the file that is used as a reference to an existing online dump. If there are additional dump files listed on the GBAK command line, those files are added to the set of files in the online dump.

Example: The following example can assist you in creating an initial incremental online dump.

```
[E:/EMPLOYEE] gbak -d EMPLOYEE.gdb EMPLOYEE.gdmp EMPLOYEE.gdmp.1
gbak: WARNING: Dumped 46270 pages of a total 46270 database pages
gbak: WARNING: Dumped 1 pages to page appendix file

[E:/EMPLOYEE] gbak -d EMPLOYEE.gdb EMPLOYEE.gdmp EMPLOYEE.gdmp.1
gbak: ERROR: I/O error for file "E:\EMPLOYEE\EMPLOYEE.GDMP.1"
gbak: ERROR: Error while trying to create file
gbak: ERROR: The file exists.
```

```
gbak: Exiting before completion due to errors

[E:/EMPLOYEE] gbak -d EMPLOYEE.gdb EMPLOYEE.gdmp EMPLOYEE.gdmp.2
gbak: WARNING: Dumped 2 pages of a total 46270 database pages
gbak: WARNING: Dumped 0 pages to page appendix file
```

In the example above, `EMPLOYEE.gdmp` .1 was added in the course of a full database dump.

Re-executing the command gives an error because it tries to add `EMPLOYEE.gdmp.1` again causing a file creation error. The last command adds a new file `EMPLOYEE.gdmp.2` successfully.

The online dump files can be on either a local or a remote file system that is writable by the InterBase server. An online dump is a server-side operation only. While the online dump files can be located on any mounted file system, the page appendix file is always on the local file system. This file is written to by concurrent server threads handling client requests when it is necessary to preserve the state of an image of a page for the online dump. This is analogous to InterBase multigenerational architecture (MGA) where a previous version of a row is stored when updating a row to preserve a snapshot of a transaction. The page appendix file helps to maintain the physical page snapshot of the online dump. It is a temporary file and is deleted when the online dump completes.

The [size] parameter is optional and denotes the size of the file in units of pages, using the page size of the database. If the [size] parameter is not provided then that dump file's size will be determined by its file-sequenced counterpart in the database. If the sequence of the dump file is higher than the sequence of any database file, then it takes the size of its predecessor dump file.

If you run `GBAK -D` against an existing online dump, an incremental dump will be created.

```
[E:/EMPLOYEE] gbak -d EMPLOYEE.gdb EMPLOYEE.gdmp
gbak: WARNING: Dumped 46270 pages of a total 46270 database pages
gbak: WARNING: Dumped 23 pages to page appendix file

[E:/EMPLOYEE] gbak -d EMPLOYEE.gdb EMPLOYEE.gdmp
gbak: WARNING: Dumped 2 pages of a total 46270 database pages

gbak: WARNING: Dumped 0 pages to page appendix file
```

This updates the online dump with only those pages that have changed since the last dump. An incremental dump can always be retried if it fails. If a full online dump fails, InterBase will delete the online dump files that were written prior to the failure. If InterBase cannot access those files because of the failure, those online dump files will have to be deleted manually.

Distinguished Dump: "Incremental Dump" before and in InterBase XE3 required the database server to read all pages from the database file, but only write the pages that had been modified to the target database dump file. With the implementation of a tracking system in XE7, only those pages that need updating since the last dump would be fetched. This provides

instantaneous updates to the target. There can only be 1 "Distinguished Dump" per source database. The choice of a "distinguished dump" is as follows:

- The first "dump" on the source database file will be a "distinguished dump"; all further dump targets are "normal dump" targets.
- Should the "first" dump be made online and thus sever its link to the source database, the next "dump" to be incrementally updated will now become the "disinguished dump".

2.3.3. Over-writing Incremental backups

The `-OV` overwrite switch causes the current set of online dump files to be deleted, and initiates a full database dump.

```
[E:/EMPLOYEE] gbak -d EMPLOYEE.gdb EMPLOYEE.gdmp
gbak: WARNING: Dumped 2 pages of a total 46270 database pages
gbak: WARNING: Dumped 1 pages to page appendix file

[E:/EMPLOYEE] gbak -d -ov EMPLOYEE.gdb EMPLOYEE.gdmp
gbak: WARNING: Dumped 46270 pages of a total 46270 database pages
gbak: WARNING: Dumped 7 pages to page appendix file
```

The online dump files are marked as a read-only InterBase database. This means that it can be accessed by read-only database applications. It is undefined how such database applications will behave if they access the online dump “database” while the dump files are being incrementally updated. If an online dump is converted to read-write, it ceases to be an online dump and becomes a standalone database. Attempting to perform an online dump against it will fail.

```
[E:/EMPLOYEE] gfix EMPLOYEE.gdmp -mode read_write

[E:/EMPLOYEE] gbak -d EMPLOYEE.gdb EMPLOYEE.gdmp
gbak: ERROR: online dump failure: dump file has no dump timestamp
gbak: Exiting before completion due to errors

[E:/EMPLOYEE] gfix EMPLOYEE.gdmp -mode read_only

[E:/EMPLOYEE] gbak -d EMPLOYEE.gdb EMPLOYEE.gdmp
gbak: ERROR: online dump failure: dump file has no dump timestamp
gbak: Exiting before completion due to errors
```

The online dump can be converted to a read-write database by using the `gfix -mode read_write` command and used in place. If the current location is not convenient for database processing, then online dump can be run against these dump files to copy them somewhere else local or remote. This provides a general copy mechanism that allows multifile databases to be copied and have their internal secondary file name links automatically updated for the copy destination.

Database validation (`gfix -v`) can be run against an online dump because it is a database. An additional validation check is performed against an online dump, which checks that no database page has a write timestamp greater than that of the online dump timestamp. The online dump timestamp represents that last time a full or incremental dump succeeded.

```
[E:/EMPLOYEE] gfix -v -n EMPLOYEE.gdmp
Summary of validation errors

Number of database page errors : 1
and in the InterBase log file:.
IBSMP (Server) Sat Jun 24 14:41:36 2006
Database: E:\EMPLOYEE\EMPLOYEE.GDMP
Page 155 has timestamp 1151170444 greater than dump timestamp 1151170438
```

2.3.4. Timestamp Changes

`GSTAT -H` has been modified to list the online dump timestamp after the database creation date entry. Note that the database creation date is that of the source database and not the online dump.

```
[E:/EMPLOYEE] gstat -h EMPLOYEE.gdmp
Database "EMPLOYEE.gdmp"
Database header page information:
Flags 0
Checksum 12345
Write timestamp Jun 28, 2025 19:57:41
Page size 4096
ODS version 19.0
Oldest transaction 72
Oldest active 73
Oldest snapshot 73
Next transaction 74
Sequence number 0
Next attachment ID 0
Implementation ID 16
Shadow count 0
Page buffers 0
Next header page 0
Clumplet End 102
Database dialect 3
Creation date Jun 25, 2025 13:22:10
Online dump timestamp Jun 28, 2025 19:59:16
Attributes read only

Variable header data:

Dump file length: 20000
*END*
```

You can request an online dump by passing a string of database parameter blocks to the `isc_attach_database()` API.

2.3.5. Database parameter blocks used by an incremental backup

Incremental backup support has been added to the `gbak` utility using database parameter blocks (DPB). All general requirements and restrictions for DPB construction are documented in the API Guide in the Working with Databases chapter. Refer to DPB Parameters Groups by Purpose and the Alphabetical List of DPB Parameters.

A successful online dump returns a warning status vector to pass back dump information status:

```
status [0] = isc_arg_gds
status [1] = isc_arg_success
status [2] = isc_arg_warning
status [3] = isc_old_dump_stats
status [4] = isc_arg_number
status [5] = <no. of dumped pages>
status [6] = isc_arg_number
status [7] = <total no. of DB pages>
status [8] = isc_arg_gds
status [9] = isc_old_appendix_stats
status [10] = isc_arg_number
status [11] = <no. pages written to appendix>
status [12] = isc_arg_end
```

2.3.6. Page Appendix File

When an online dump is running, client worker threads never write to the online dump files. Thus, their performance is not degraded by writing over the network to a remote file system. However, to maintain physical and time consistency of the dump, client worker threads may write pages to a local temporary file with a prefix of `ib_dump_` . Any database page is guaranteed to be written at most one time to this temporary file. This temporary file is known as the dump or page appendix file.

For very large databases with intensive update activity, the page appendix file could also grow to a very large size. There must be adequate space in the temp directories to handle this storage demand or the online dump will fail. The dump information returned to GBAK about the number of pages written to the appendix file can aid configuration of the temp file space.

2.3.7. Preallocating database space with gbak

GBAK backs up and restores database preallocation information. This preallocation information will be silently ignored by earlier versions of the product that are not aware of the feature. A switch has been added to -gbak to alter the stored preallocation in a database or backup file.

Example:

```
/D/testbed>isql
 Use CONNECT or CREATE DATABASE to specify a database
 SQL> create database 'pr.ib' preallocate 500;
 SQL> commit;
 SQL> quit;
 /D/testbed>ls -l pr.ib
-rwxrwxrwx 1 Administrators None 2048000 Jul 2 18:09
pr.ib /* It is 2MB size because each of the 500 database pages is
4KB in size */
 /D/testbed>isql -a pr.ib
SET SQL DIALECT 3;
/* CREATE DATABASE 'pr.ib' PREALLOCATE 500
PAGE_SIZE 4096
 */
/* Grant permissions for this database */
 /D/testbed>isql -x pr.ib
SET SQL DIALECT 3;
/* CREATE DATABASE 'pr.ib' PREALLOCATE 500 PAGE_SIZE 4096
 */
/* Grant permissions for this database */
 /D/testbed>
```

2.3.8. Using the switch -PR(EALLOCATE) argument

The switch `-PR(EALLOCATE)` uses an integer argument, which consists of the number of preallocation pages. This switch is legal for both backup and restore command-line options. For backup, the preallocation switch stores its argument in the backup file instead of the value specified in the database that is being backed up. For restore, the preallocation switch argument is used at the preallocation value in the restore database, instead of the value stored in the backup file.

A GBAK preallocate switch value of 0 (zero) effectively disables database preallocation in the backup file or restored database. In GBAK verbose mode, database preallocation is logged to the console. The example below shows a sample database backup in verbose mode. A similar message is logged for database restore.

Example:

```
gbak -v foo.gdb foo.gbk -pr 5000
...
gbak: readied database foo.gdb for backup
gbak: creating file foo.gbk
gbak: starting transaction
gbak: database foo.gdb has a page size of 4096 bytes.
gbak: database preallocation 5000 pages
```

If a database restore reduces the page size, the number of pages for database preallocation is automatically scaled upward to maintain a constant database preallocation size in bytes. If the restored page size is increased, database preallocation is reduced accordingly with a similar "Reducing" message written to the console. If the `GBAK -PREALLOCATE` switch was given, then the automatic scaling of the database preallocation does not occur with changing page size. In other words, the `-PREALLOCATE` switch takes precedence.

Example:

```
gbak -v foo.gdb foo.gbk -page_size 2048
...
Reducing the database page size from 4096 bytes to 2048 bytes
Increasing database preallocation from 5000 pages to 10000 pages
created database foo1.gdb, page_size 2048 bytes
database preallocation 10000 pages
```

2.4. Restoring a database with gbak

Note:
For information on restoring tablespaces refer to Tablespace Backup/Restore and Recovery

Use the following syntax to restore a database:

For restoring:

```
gbak {-c|-r} [options] source dbfile
```

For restoring to multiple files:

```
gbak {-c|-r} [options] source dbfile1 size1 dbfile2 [size2 dbfile3 …]
```

For restoring from multiple files:

```
gbak {-c|-r} [options] source1 source2 [source3 …] dbfile
```

By extension, you can restore *from* multiple files *to* multiple files using the following syntax:

```
gbak {-c|-r} [options] source1 source2 [source3 …] dbfile1 size1
 dbfile2 [size2 dbfile3 …]
```

For restoring from Embedded User Authentication backup files:

The USER and PASSWORD server credentials are required to create a database on the server and execute the restore service. The **-eua_u[ser] name** and **-eua_p[assword] text** database credentials are required to ensure that only the database owner can restore an EUA database.

Argument	Description
<source>	Name of a storage device or backup file from which to restore. On UNIX, this can also be `stdin`, in which case `gbak` reads input from the standard input (usually a pipe).
<dbfile>	The name of a restored database file.
<size>	Length of a backup file or restored database file • The only permissible unit for a restored database file is database pages; minimum value is 200. • Default unit for a backup file is bytes. • Size of backup files can also be specified in kilobytes, megabytes, or gigabytes. • Do not specify a size for the final backup file or database file; the last file always expands as needed to fill all available space.

The following table lists `gbak` options that are available when restoring databases.

Option	Description
-c[reate_database]	Restores database to a new file.
-bu[ffers]	Sets cache size for restored database.
-i[nactive]	Makes indexes inactive upon restore.

Option	Description
-eua_u[ser] name	Checks for user name before accessing EUA (embedded user authentication) database. The -user and -password options still need to be provided, in addition to your -eua equivalents when restoring an EUA database. Either EUA switch can be omitted if it has an identical value to its counterpart. However it is recommended that the PASSWORD and EUA_PASSWORD should not be the same.
-eua_p[assword] text	Checks for password text before accessing EUA (embedded user authentication) database. The -user and -password options still need to be provided, in addition to your -eua equivalents when restoring an EUA database. Either EUA switch can be omitted if it has an identical value to its counterpart. However it is recommended that the PASSWORD and EUA_PASSWORD should not be the same.
-k[ill]	Does not create any shadows that were previously defined.
-mo[de] {read_write | read_only}	Specifies whether the restored database is writable • Possible values are `read_only` and `read_write`. • Default is `read_write`.
-n[o_validity]	Deletes validity constraints from restored metadata; allows restoration of data that would otherwise not meet validity constraints.

<table>
<tr><th>Option</th><th>Description</th></tr>
<tr><td>-ods[_version] n</td><td>Restores the database to specific major ODS version number. where <n> is a supported major ODS version. The target database engine will have its own allowed major ODS version list. When this option is specified at restore time, it overrides the server-side IBConfig setting DATABASE_ODS_VERSION.
gbak -r employee.gbk emp15.ib -ods_version 15 -user sysdba -pass masterkey
gbak -c employee.gbk emp17.ib -ods_version 17 -user sysdba -pass masterkey
gbak -service localhost:service_mgr -r <path>/employee.gbk <path>/emp17.ib -ods_version 17 -user sysdba -pass masterkey</td></tr>
<tr><td>-o[ne_at_a_time]</td><td>Restores one table at a time; useful for partial recovery if database contains corrupt data.</td></tr>
<tr><td>-p[age_size] n</td><td>Resets page size to <n> bytes (1024, 2048, 4096, 8192, or 16384); default is 4096.</td></tr>
<tr><td>-pas[sword] text</td><td>Checks for password <text> before accessing a database.</td></tr>
<tr><td>-r[eplace_database]</td><td>Restores database to new file or replaces existing file.</td></tr>
<tr><td>-se[rvice] servicename</td><td>Creates the restored database on the host where the backup files are located, using InterBase Service Manager.
<servicename> invokes the Service Manager on the server host; syntax varies with the network protocol in use:
<table><tr><td>TCP/IP</td><td><code>hostname:service_mgr</code></td></tr><tr><td>Named pipes</td><td><code>\\hostname\service_mgr</code></td></tr><tr><td>Local</td><td><code>service_mgr</code></td></tr></table></td></tr>
<tr><td>-user name</td><td>Checks for user <name> before accessing database.</td></tr>
</table>

Option	Description
-use_[all_space]	Restores database with 100% fill ratio on every data page. By default, space is reserved for each row on a data page to accommodate a back version of an UPDATE or DELETE. Depending on the size of the compressed rows, that could translate e to any percentage.
-v[erbose]	Shows what `gbak` is doing.
-va[lidate]	Use to validate the database when restoring it.
-w[rite] {async | sync | direct}	Overrides a database write mode. The "write" mode is preserved during a backup/restore lifecycle. `sync` enables forced writes; `async` enables buffered writes; **direct** enables direct I/O.
-y [file | suppress_output]	If used with `-v`, directs status messages to **<file>**; if used without `-v` and **<file>** is omitted, suppresses output messages.
-z	Show version of `gbak` and of InterBase engine.

When restoring a database, keep the following information in mind:

- Anyone can restore a database. However, only the database owner or `SYSDBA` can restore a database over an existing database.
- Do not restore a backup over a database that is currently in use; it is likely to corrupt the database.
- When restoring from a multifile backup, name all the backup files, in any order.
- Do not provide a file size for the last (or only) file of the restored database. InterBase does not return an error, but it always "grows" the last file as needed until all available space is used. This dynamic sizing is a feature of InterBase.
- You specify the size of a restored database in database pages. The default size for database files is 200 pages. The default database page size is 4K, so if the page size has not been changed, the default database size is 800K. This is sufficient for only a very small database. To change the size of the database pages, use the `-p[age_size]` option when restoring.

Tip:
Use the `-service` switch if you are restoring to the same server that holds the backup

file. This option invokes the InterBase Service Manager on the server host and saves both time and network traffic.

Note:
If you specify several target database files but have only a small amount of data, the target files are quite small (around 800K for the first one and 4K for subsequent ones) when they are first created. They grow in sequence to the specified sizes as you populate the database.

2.5. Using gbak with InterBase Service Manager

When you run `gbak` with the `-service` switch, `gbak` invokes the backup and restore functions of InterBase's Service Manager on the server where the database resides. When run without the `-service` switch, `gbak` executes on the machine where it is invoked – typically a client – and writes the backup file on (or relative to) that machine. Using the `-service` switch to invoke the Service Manager saves a significant amount of time and network traffic when you want to create the backup on the same host on which the database resides. When the Service API is used, both the database and the backup file must be accessible to the server.

When you use the `-service` switch, you specify the host name followed by the string "service_mgr". The syntax you use for this ies with the network protocol you are using. Together, these components are referred to as "host_service" in the syntax statements that follow in this section:

Network protocol	Syntax
TCP/IP	`hostname:service_mgr`
NetBEUI	`\\hostname\service_mgr`
Local	`service_mgr`
OTW (Over-the-wire)	`hostname/port number?ssl=true?...<other OTW parameters>...??:service_mgr`

The syntax in the right column appears in the `gbak` syntax below as "host_service".

The local case is trivial on NT. If you are backing up a local database, the results in terms of time and network traffic are the same whether you use the `-service` switch or not, even though the actual implementation would be slightly different. On UNIX systems, the local case is equivalent to specifying (for TCP/IP) `localhost:service_mgr` and saves both time and network traffic.

Syntax: Backing up with Service Manager

```
gbak -b [options] -se[rvice] host_service database filename
```

Syntax: Restoring with Service Manager

```
gbak {-c|-r} [options] -se[rvice] host_service filename database
```

You can back up to multiple files and restore from multiple files using Service Manager.

Important:
On UNIX systems, in order to restore a database that has been backed up using the Service Manager, you must either use the Service Manager for the restore or you must be logged onto the system as the user that InterBase was running as when the backup was created (either `root` or `InterBase`). This is because the InterBase user (`root` or `InterBase`) is the owner of the backup file at the system level when the Service Manager is invoked, and the backup file is readable to only that user. When `gbak` is used to back up a database without the `-service` option, the owner of the backup file at the system level is the login of the person who ran `gbak`. On Windows platforms, the system-level constraints do not apply.

2.6. The user name and password

When InterBase checks to see whether the user running `gbak` is authorized to do so, it determines the user according to the following hierarchy:

- The -`user` that is specified, with a correct password, as part of the `gbak` command.
- The user and password specified in the `ISC_USER` and `ISC_PASSWORD` environment variables, provided they also exist in the InterBase security database. (Setting these environment variables is strongly *not* recommended, since it is extremely insecure.)
- UNIX only: If no user is specified at any of the previous levels, InterBase uses the UNIX login if the user is running on the server or on a trusted host.

2.7. Some backup and restore examples

Note:
The following examples use forward slashes exclusively. InterBase accepts either forward or backward slashes for paths on Wintel platforms.

2.7.1. Database backup examples

The following example backs up `foo.ib`, which resides on the server `jupiter` and writes the backup file to the current directory of the client machine where `gbak` is running. `foo.ib` can be either a single-file database or the name of the first file in a multifile database. Using this syntax (without the `-se` switch) copies a lot of data over the net.

```
gbak -b -user joe -password blurf@ jupiter:/foo.ib foo.ibk
```

The next example backs up `foo.ib`, which resides on the server `jupiter` and writes the backup file to the `C:/archive` directory on the client machine where `gbak` is running. As before, `foo.ib` can be a single file database or the name of the first file in a multifile database. This syntax causes the same amount of network traffic as the first example.

```
gbak -b -user joe -password blurf@ jupiter:/foo.ib C:\archive\foo.ibk
```

The next example backs up the same database on `jupiter`, but uses the `-se[rvice]` switch to invoke the Service Manager on `jupiter`, which writes the backup to the `\backup` directory on `jupiter`. This command causes very little network traffic and is therefore faster than performing the same task without the `-se (-service)` switch. Note that the syntax (`jupiter:service_mgr`) indicates a TCP/IP connection.

```
gbak -b -user joe -password blurf@ -se jupiter:service_mgr /foo.ib /backup/
foo.ibk
```

The next example again backs up `foo1.ib` on server `jupiter` to multiple files in the `/backup` directory on `jupiter` using the Service Manager. This syntax backs up a single file or multifile database and uses a minimum of time and network traffic. It converts external files as internal tables and creates a backup in a transportable format that can be restored on any InterBase-supported platform. To back up a multifile database, name only the first file in the backup command. In this example, the first two backup files are limited to 500K. The last one expands as necessary.

```
gbak -b -user joe -pass blurf@ -co -t -se jupiter:service_mgr
 /foo1.ib/backup/backup1.ibk 500k /backup/backup2.ibk 500k
 /backup/lastBackup.ibk
```

2.7.2. Database restore examples

The first example restores a database that resides in the `/archive` directory on the machine where `gbak` is running and restores it to `jupiter`, overwriting an existing (but inactive) database.

```
gbak -r -user joe -pass blurf@ C:\archive\foo.ibk jupiter:/foo.ib
```

The next example restores a multifile database from the `/backup` directory of jupiter to the `/companydb` directory of `jupiter`. This command runs on the server by invoking Service Manager, thus saving time and network traffic. In this example, the first two files of the restored database are 500 pages long and the last file grows as needed.

```
gbak -r user -joe -pass blurf@ -se jupiter:service_mgr /backup/foo1.ibk
 /backup/foo2.ibk /backup/fooLast.ibk /companydb/foo1.ib 500
 /companydb/foo2.ib 500 /companydb/fooLast.ib
```

The next example executes on server Jupiter using Service Manager and restores a backup that is on Jupiter to another server called Pluto.

```
gbak -r user -joe -pass blurf@ -se jupiter:service_mgr

 /backup/foo.ibk pluto:/companydb/foo.ib
```

2.7.3. Database restore examples

The first example restores a database that resides in the `/archive` directory on the machine where `gbak` is running and restores it to `jupiter`, overwriting an existing (but inactive) database.

```
gbak -r -user joe -pass blurf@ C:\archive\foo.ibk jupiter:/foo.ib
```

The next example restores a multifile database from the `/backup` directory of jupiter to the `/companydb` directory of `jupiter`. This command runs on the server by invoking Service Manager, thus saving time and network traffic. In this example, the first two files of the restored database are 500 pages long and the last file grows as needed.

```
gbak -r user -joe -pass blurf@ -se jupiter:service_mgr /backup/foo1.ibk
 /backup/foo2.ibk /backup/fooLast.ibk /companydb/foo1.ib 500
 /companydb/foo2.ib 500 /companydb/fooLast.ib
```

The next example executes on server Jupiter using Service Manager and restores a backup that is on Jupiter to another server called Pluto.

```
gbak -r user -joe -pass blurf@ -se jupiter:service_mgr

 /backup/foo.ibk pluto:/companydb/foo.ib
```

2.8. gbak 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 contains corruption or metadata violates integrity constraints. • Try restoring tables using `-one_at_a_time` option, or delete validity constraints using `-no_validity` option.
Cannot commit index <string>	• Data might 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.

Error Message	Causes and Suggested Actions to Take
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"
Conflicting switches for backup/restore	A backup-only option and restore-only option were used in the same operation; fix the command and execute again.
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
Datatype n not understood	An illegal data type is being specified
Database format n is too old to restore to	• The `gbak` version used is incompatible with the InterBase version of the database • Try backing up the database using the `-expand` or `-old` options and then restoring it.
Database <string> already exists. To replace it, use the -R switch	• You used `-create` in restoring a back up file, but the target database already exists. • Either rename the target database or use `-replace`.
Could not drop database <string> (database might be in use).	• You used `-replace` 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.
Device type not specified	The `-device` option (Apollo only) must be followed by `ct` or `mt`; obsolete as of InterBase V3.3
Device type <string> not known	The `-device` option (Apollo only) was used incorrectly; obsolete as of InterBase V3.3
Do not recognize record type n	
Do not recognize <string> attribute n -- continuing	
Do not understand BLOB INFO item n	

Error Message	Causes and Suggested Actions to Take
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 could be corrupt. • If restoring a database, try using `-one_at_a_time` 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 n but instead found m.	Try redefining the problem array.
Expected array version number n but instead found m.	Try redefining the problem array.
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 blocking factor, encountered <string>	The `-factor` option requires a numeric argument.
Expected data attribute	
Expected database description record	
Expected number of bytes to be skipped, encountered <string>	
Expected page size, encountered <string>	The `-page_size` option requires a numeric argument.

Error Message	Causes and Suggested Actions to Take
Expected record length	
Expected volume number n, 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 might already exist.
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.
Found unknown switch	An unrecognized `gbak` option was specified.
Index <string> omitted because n of the expected m 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 (n) is less than minimum (m).	• 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 not assigned to any table. • Use `gfix` to validate or mend the database.

Error Message	Causes and Suggested Actions to Take
Page size is allowed only on restore or create.	The `-page_size` option was used during a back up instead of a restore.
Page size parameter missing	The `-page_size` option requires a numeric argument.
Page size specified (n bytes) rounded up to m bytes.	Invalid page sizes are rounded up to 1024, 2048, 4096, 8192, or 16384, whichever is closest.
Page size specified (n) greater than limit	Specify a page size of 1024, 2048, 8192, or 16384. The default is 4096 bytes.
Password parameter missing	• The back up or restore is accessing a remote machine. • Use `-password` and specify a password.
Protection is not there yet	Unimplemented option `-unprotected` used
Redirect location for output is not specified.	You specified an option reserved for future use by InterBase.
REPLACE specified, but the first file <string> is a database.	Check that the file name following the `-replace` option is a backup file rather than a database.
Requires both input and output file names.	Specify both a source and target when backing up or restoring.
RESTORE: decompression length error	• Possible incompatibility in the `gbak` version used for backing up and the `gbak` version used for restoring. • Check whether `-expand` should be specified during back up.
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 m.	
Trigger <string> is invalid	

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 might 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 might have occurred during a backup or restore.
Unknown switch <string>	An unrecognized `gbak` option was specified.
User name parameter missing	• The backup or restore is accessing a remote machine. • Supply a user name with the `-user` option.
Validation error on column in table <string>	• The database cannot be restored because it contains data that violates integrity constraints. • Try deleting constraints from the metadata by specifying `-no_validity` during restore.
Warning -- record could not be restored	Possible corruption of the named data
Wrong length record, expected *n* encountered n	

3. Performing backups and restores using IBConsole

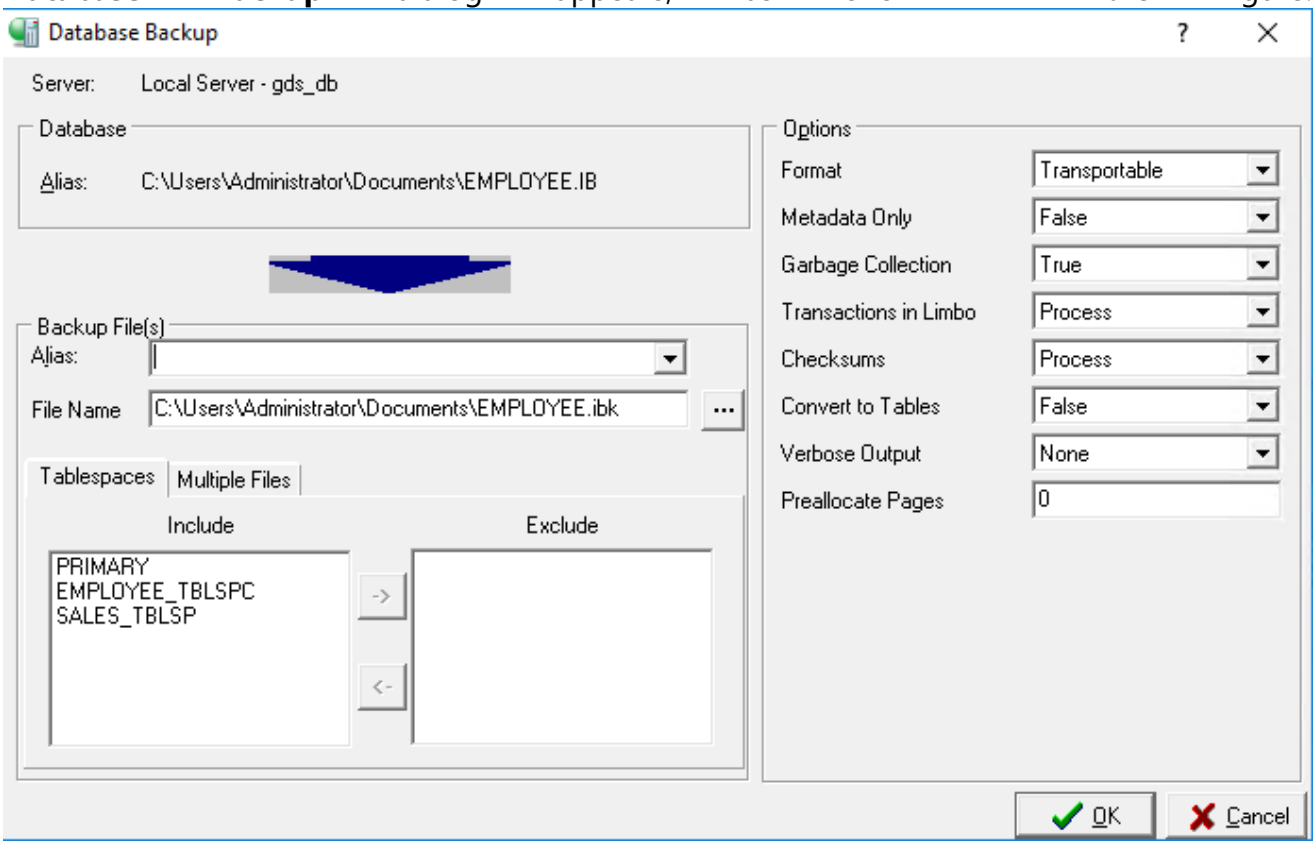
This section provides instruction on how to use IBConsole to backup and restore a database. You can use IBConsole to specify both full and incremental backups. For an overview of each type, see the About InterBase backup and restore options section at the beginning of this chapter.

3.1. Performing a full backup using IBConsole

To initiate a full, logical backup using IBConsole, take the following steps:

1. Right-click on a database in the tree pane, and select **Backup/Restore** from the context menu.

2. When the context menu expands to display backup and restore options, select **Backup**. The **Database Backup** dialog appears, as shown in the figure:



3. Check the database server to make sure the indicated server is correct. If it is not, cancel this dialog and re-initiate the Database Backup dialog under the correct server.
4. If you accessed the Database Backup dialog from a database alias, the Alias field is automatically assigned. If you accessed the Database Backup dialog from the Databases menu, then you must select an alias from the list of database aliases.
5. The database alias references the associated database file name, so you need to specify only the alias name, not the actual database filename, when indicating the database to back up. If the database spans multiple files, the server uses the header page of each file to locate additional files, so the entire database can be backed up based on the alias filename.
6. Select a destination server from a list of registered servers in the Backup Files Server drop-down list.
7. Once a destination server has been selected, a list of backup file aliases is available from the Backup Files Alias drop-down list. If you want to overwrite an existing backup file, select the appropriate file from the drop-down list. If you want to create a new backup file, you can type a new alias name in the Backup File(s) Alias field.
8. On the **File Name** section, click ... to set the name and destination folder of your backup.

9. On the **Tablespaces** the **Include** field lists all the tablespaces included in the backup. If you want to exclude a tablespace from the backup process, select it and click the right arrow -> to add it to the **Excluded** list.
   - To use multiple files, go to the **Multiple Files** tab and select **Use Multiple Files** then click ✚ to add files.
10. You can specify backup options by entering a valid value, by clicking the option value and choosing a new value from a drop-down list of values, or by double-clicking the option value to rotate its value to the next in the list of values. See About IBConsole backup options below for descriptions of these options.
11. Click **OK** to start the backup.

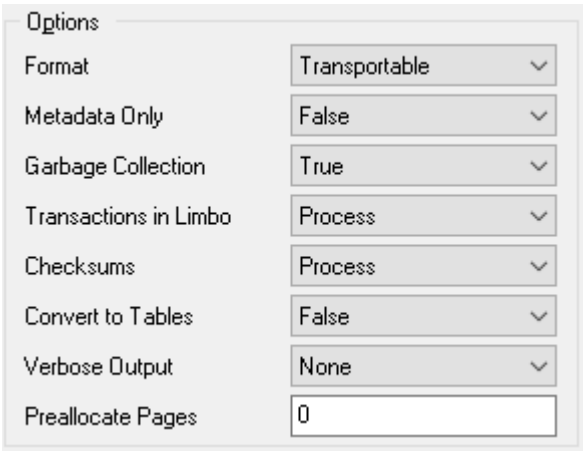
> **Note:**
> Database files and backup files can have any name that is legal on the operating system; the `ib` and `ibk` file extensions are InterBase conventions only.

A backup file typically occupies less space than the source database because it includes only the current version of data and incurs less overhead for data storage. A backup file also contains only the index definition, not the index data structures.

If you specify a backup file that already exists, IBConsole overwrites it. To avoid overwriting, specify a unique name for the backup file.

3.1.1. About IBConsole backup options

The backup options are shown on the right side of the Database Backup dialog. You can specify options by entering a value, by clicking the option value and choosing a new value from a drop-down list of values, or by double-clicking the option value to rotate its value to the next in the list of values.



3.1.2. Format

To move a database to a machine with an operating system different from the one under which the backup was performed, make sure the Format option is set to Transportable. This option writes data in a generic format, enabling you to move to any machine that supports InterBase.

Important:
Never copy a database from one location to another. Back it up and then restore it to the new location.

3.1.3. Metadata Only

Option values are True and False.

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 has the same metadata but can be populated with different data.

To back up metadata only, select True for the Metadata Only option.

Tip:
You can also extract a database's metadata using `isql`. `isql` produces a SQL data definition text file that contains the SQL code used to create it. IBConsole backup Metadata Only creates a binary backup file containing only metadata.

This function corresponds to the `-metadata` option of `gbak`.

3.1.4. Garbage Collection

Option values are `True` and `False`.

By default, IBConsole performs garbage collection during backup. To prevent garbage collection during a backup, set the **Garbage Collection** option value to `False`.

Garbage Collection marks space used by old versions of data records as free for reuse. Generally, you want IBConsole to perform garbage collection during backup.

Tip:
Disabling garbage collection during the backup process improves backup performance. If garbage collection is necessary, you can run a separate sweep operation using gfix. In addition, you do not want to perform garbage collection if there is data corruption in old record versions and you want to prevent InterBase from visiting those records during a backup.

This function corresponds to the `-garbage_collect` option of `gbak`.

3.1.5. Transactions in limbo

Option values are Process and Ignore.

To ignore limbo transactions during backup, set the **Transactions in Limbo** option value to Ignore.

When IBConsole 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 **Database>Maintenance>Transaction Recovery** in the Database Maintenance window. Refer to Recovering Transactions for more information.

This function corresponds to the `-limbo` option of `gbak`.

3.1.6. Checksums

Note:
For performance reasons, InterBase supports true checksums only for ODS 8 and earlier. For ODS 9 and later, InterBase always generates the string "12345" as the checksum. This maintains compatibility with older versions.

Option values are Process and Ignore.

To ignore checksums during backup, set the **Checksums** option value to Ignore.

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.

This function corresponds to the `-ignore` option of `gbak`.

3.1.7. Convert to Tables

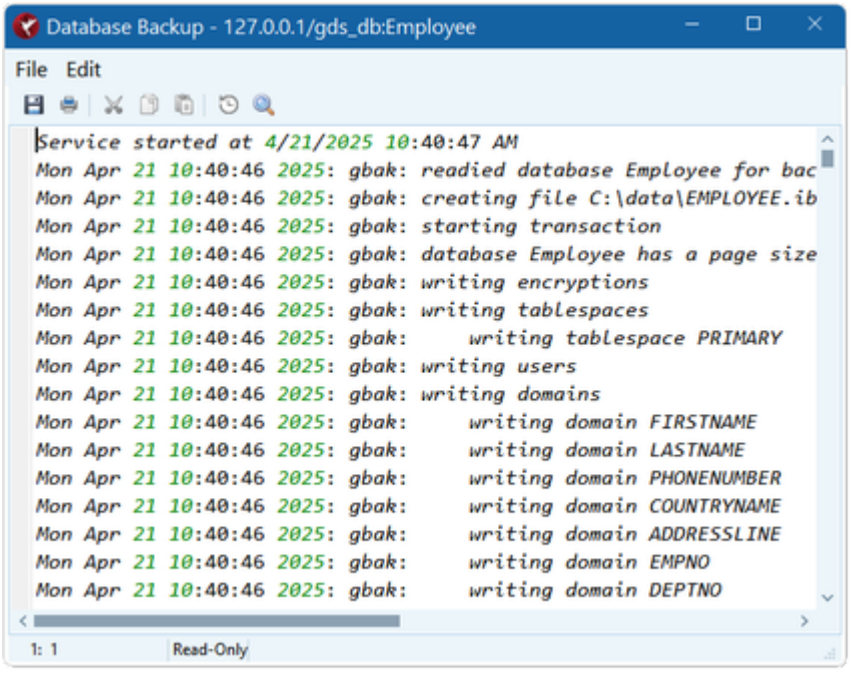
To convert external files to internal tables, set the **Convert to Tables** option value to `True`.

This function corresponds to the `-convert` option of `gbak`.

3.1.8. Performing a Full Backup with Verbose Output

Option values are *None*, *To Screen* and *To File*.

To monitor the backup process as it runs, set the Verbose Output option value to *To Screen*. This option opens a standard text display window to display status messages during the backup. For example:



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 Text Viewer Window.

This function corresponds to the `-verbose` option of `gbak`.

3.1.9. Transferring databases to servers running different operating systems

1. Set the Format option to Transportable in the Database Backup dialog.
2. Back up the database.
3. If you backed up to a removable medium, proceed to Step 4. If you created a backup file on disk, use operating-system commands to copy the file to a removable medium, such as a tape. Then load the contents of the medium onto another machine, or copy it across a network to another machine.
4. 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.

3.2. Performing an incremental backup using IBConsole

An **incremental backup** copies all of the changes that have been committed to the database since the last full backup. The first time you choose Incremental Backup from IBConsole, InterBase performs a full physical backup (an online dump). After the initial full dump, each subsequent incremental backup saves and copies all of the transactions committed since the last full backup.

To initiate an incremental backup using IBConsole, take the following steps:

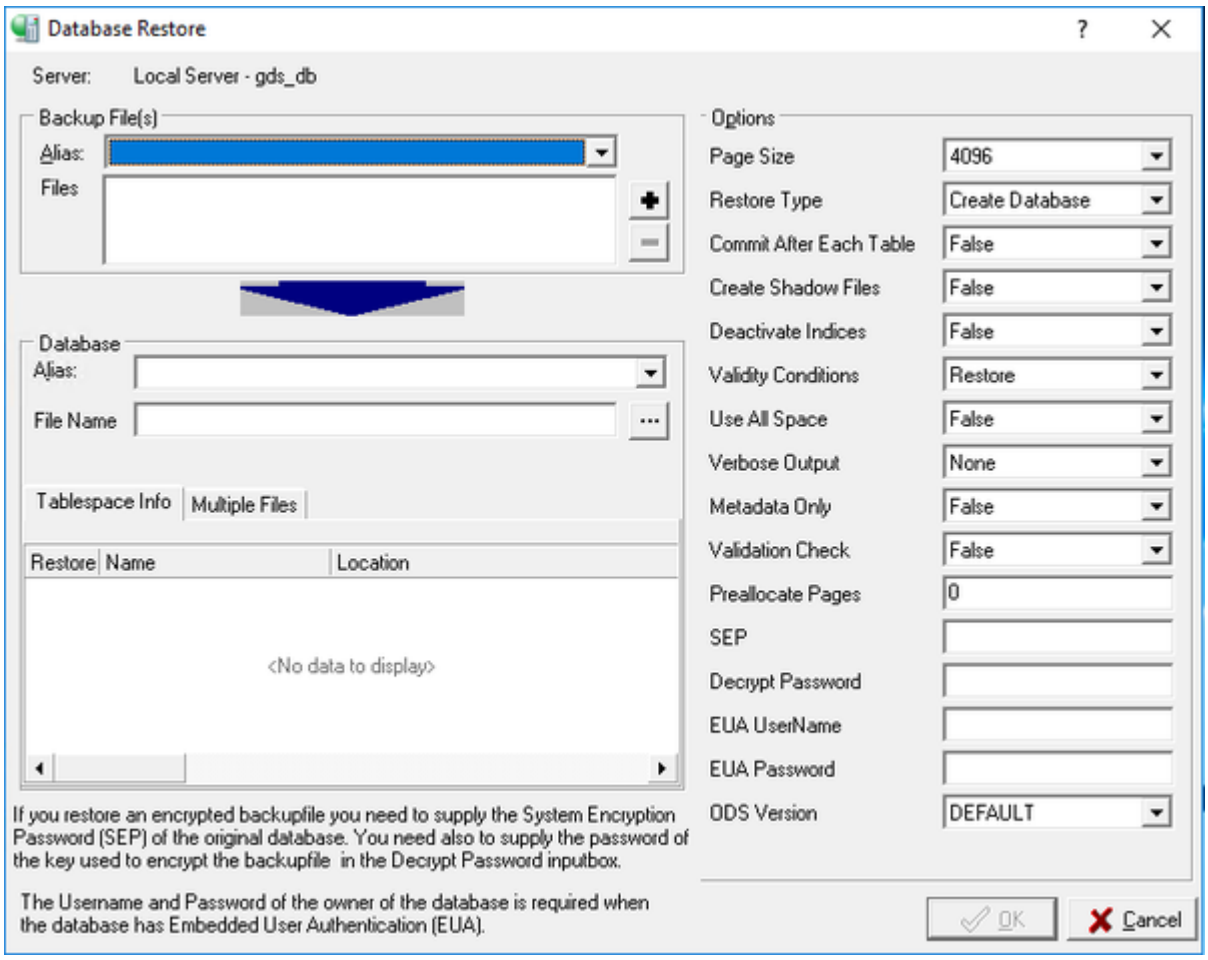
1. In the tree pane, right-click the database on which to perform an incremental backup, and select **Backup/Restore** from the context menu.
2. When the context menu expands to display backup and restore options, select **Incremental Backup**. The Incremental Backup dialog appears, as shown in the figure:
   Error creating thumbnail: Unable to save thumbnail to destination
3. On **Incremental Backup**, specify the following:
   - To add a dump file click on the **Files** section, on the **New Dump File** dialog click to set the name and destination folder of your backup, .
   - Once you add a file, the **Tablespaces** tab shows a list of tablespaces on the database.
   - To change a file location, select a file and click
4. To use multiple files go the **Multiple Files** tab, select **Use Multiple Files** and click to add files.
5. To overwrite the previous incremental backup, change the **Overwrite** value to True. For detailed information about what occurs when you overwrite an incremental backup, see Over-writing Incremental backups.
6. Choose **OK** to start the backup.

3.3. Restoring a database using IBConsole

Use the Database Restore dialog to restore databases. To access this dialog, select a server from the list of available servers displayed in the Tree pane and continue with one of these possible methods:

- Select anything under the databases hierarchy and choose **Database|Maintenance|Backup/Restore|Restore**.
- Double-click any backup alias name under the Backup hierarchy.
- Right-click **Backup** or any backup alias name under the Backup hierarchy and choose **Restore** from the context menu.
- Select any backup alias name under Backup and click **Restore** in the Work pane.

The Database Restore dialog appears:



Important:
When restoring a database, do not replace a database that is currently in use.

To restore a database:

1. Check the source Backup File(s) Server to make sure the indicated server is correct. If it is not, cancel this dialog and re-initiate the Database Restore dialog under the correct server.
2. If you accessed the Database Restore dialog from a backup alias, then the Alias field is automatically assigned.
3. If you accessed the Database Restore dialog from **Backup**, then you must select an alias from the list of backup aliases or click to add backup files. It is important that you include all filenames associated with the restore.

   > **Note:**
   > The backup alias references the associated backup file names, so you need only to specify the alias name, not the actual backup file name, when indicating the backup to restore. If the backup spans multiple files, the server uses the header page of each file to locate additional files, so the entire backup can be restored based on the alias filename.

4. Once you select your backup file(s) the table on the **Tablespace Info** tab populates with all the tablespaces present on the backup. On this section you can choose which tablespaces include in the restore process.
5. Select a destination server from a list of registered servers in the Database Server drop-down list.
6. If you want to restore to an existing database, select its alias from the Database Alias drop-down list. If you want to restore to a new database, type a new alias name in the Database Alias field and click to set a filename and destination.
7. To use multiple files, select **Use Multiple Files** and click to add files.

   > **Note:**
   > You cannot restore a database to a network file system (mapped drive).

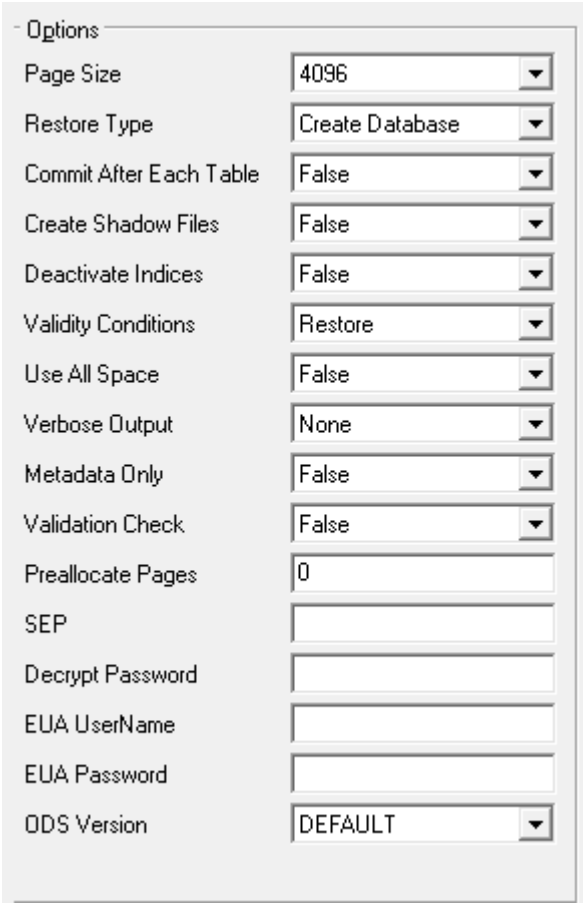
8. You can specify options for the restore by entering a valid value, by clicking the option value and choosing a new value from a drop-down list of values or by double-clicking the option value to rotate its value to the next in the list of values. See Restore options below for a description of these options.
9. Click **OK** to start 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 ODS version changes. For information about the ODS, see Restoring the ODS.

> **Note:**
> The InterBase restore utility allows you to restore a database successfully even if for some reason the restore process could not rebuild indexes for the database. For example, this can occur if there is not enough temporary disk space to perform the sorting necessary to build an index. If this occurs, the database is restored and available, but indexes are inactive. After the restore completes, use `ALTER INDEX` to make the indexes active.

3.3.1. Restore options

The restore options are shown on the right side of the **Database Restore** dialog. You can specify options by entering a value, by clicking the option value and choosing a new value from a drop-down list of values, or by double-clicking the option value to rotate its value to the next in the list of values.



3.3.2. Restoring Page Size Options

InterBase supports database page sizes of 1024, 2048, 4096, 8192, and 16384 bytes. The default is 4096 bytes. To change the page size, back up the database and then restore it, modifying the Page Size option in the Database Restore dialog.

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 4KB, 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 tree. Indexes work faster if their depth is kept to a minimum. Choose Database|Maintenance|Database Statistics to display index statistics, and consider increasing the page size if index depth is greater than three 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.

This function corresponds to the - `page_size` option of `gbak`.

3.3.3. Overwrite

Option values are `True` and `False`.

IBConsole cannot overwrite an existing database file unless the **Overwrite** option value is set to `True`. If you attempt to restore to an existing database name and this option is set to `False`, the restore does not proceed.

To restore a database over an existing database, you must be the owner of the existing database or SYSDBA.

Important:
Do not replace an existing database while clients are operating on it. 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.

This function corresponds to the - `replace` option of `gbak`.

3.3.4. Restore Type

Option values are:

`Create Database | Replace Database | Create Tablespace | Replace Tablespace.`

Create Database Fully restore to a target database, if it does not exist already.

Replace Database Overwrite a potentially existing target database.

Create Tablespace Truncate table(s) in target tablespace before restoring from backup.

Replace Tablespace Delete target tablespace file(s) and recreate from backup.

To restore a database over an existing database, you must be the owner of the existing database or SYSDBA.

Important:
Do not replace an existing database while clients are operating on it. 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.

This function corresponds to the - `replace` option of `gbak`.

3.3.5. Commit After Each Table

Option values are True and False.

Normally, IBConsole restores all metadata before restoring any data. If you set the Commit After Each Table option value to True, IBConsole 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. This can happen if the data is corrupt or is 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.

This function corresponds to the - `one_at_a_time` option of `gbak`.

3.3.6. Create Shadow Files

Shadow files are identical, physical copies of database files in a database. To recreate shadow files that were saved during the backup process set the Create Shadow Files option to True. For further information on shadowing see Shadowing.

3.3.7. Deactivate Indexes

Option values are True and False.

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 fails. 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, set the Deactivate Indexes option to True. This makes indexes inactive and prevents them from rebuilding. Then eliminate the duplicate index values, and re-activate indexes through `ALTER INDEX` in `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*.

Tip:
The Deactivate Indexes option is also useful for bringing a database online more quickly. Data access is slower until indexes are rebuilt, but the database is available. After the database is restored, users can access it while indexes are reactivated.

This function corresponds to the - `inactive` option of `gbak`.

3.3.8. Validity Conditions

Option values are Restore and Ignore.

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.

Important:
Always make a copy of metadata before redefining it; for example, by extracting it using `isql`.

To restore a database that contains invalid data, set the Validity Conditions option to Ignore. 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.

This function corresponds to the - `no_validity` option of `gbak` .

3.3.9. Use All Space

Option values are True and False.

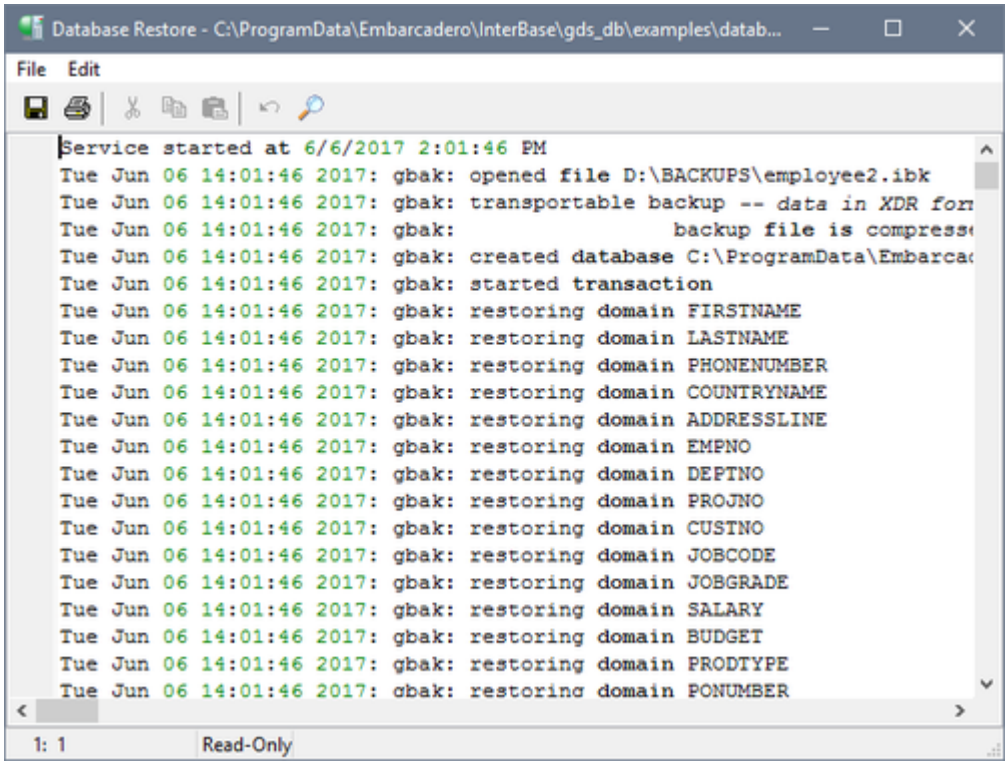
To restore a database with 100% fill ratio on every data page, set the Use All Space option to True. By default, space is reserved for each row on a data page to accommodate a back version of an UPDATE or DELETE. Depending on the size of the compressed rows, that could translate to any percentage.

This function corresponds to the `-use_all_space` option of `gbak` .

3.3.10. Restoring a Backup Using Verbose Output

Option values are None, To Screen, and To File.

To monitor the restore process as it runs, set the Verbose Output option to To Screen. This option opens a standard text display window to display status messages during the restore. For example:



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 Text Viewer Window.

This function corresponds to the - `verbose` option of `gbak` .

JOURNALING AND DISASTER RECOVERY

Journaling combines the protection of forced writes (also known as synchronous writes) with better performance, and also supports the improved disaster recovery provided by journal archiving.

When enabled, journal archiving allows databases to recover from a complete loss of an InterBase server machine to within a few minutes of when the disaster occurred, or to a specific point in time.

This chapter defines key terms such as journal, journal file, and journal archive, and explains how to implement and use them with your database.

Note:
Journaling is available in the Server Edition of InterBase, starting from version 2007. It is not available in the Desktop Edition.

1. About Journals, Journal Files, and Journal Archives

A **journal** consists of one or more journal files. A journal file records each database transaction as it occurs. This makes a journal an always-up-to-date record of database transactions. **Journaling** is sometimes referred to as **write-ahead logging (WAL)**.

A journal archive is a directory that contains a full database dump and all the journal files completed since that dump. You can use the journal archive to recover to the last transaction recorded in the most recently archived journal file. You can also use an archived journal file to perform point-in-time recovery. Point-in-time recovery uses the internal timestamp that is recorded on each transaction in the file, which allows you to, if desired, recover to a specific date and time.

1.1. How Journaling Works

Journaling turns off forced writes to the hard drive, and synchronously writes the updates to the journal file instead. Because journal file writes are sequential rather than random, there is no disk head movement, which improves database performance.

To save changed pages in the database cache to the hard disk, you set up **journaling checkpoints** to occur automatically. A checkpoint specifies the time at which InterBase must save all the changed pages in the database cache to the database file. After the checkpoint has been reached, the data in the journal file is no longer needed, so the file can be reused. For best performance, place the journal files on a dedicated hard drive. The journal files must be on the database server machine.

Journaling guarantees that all changes are on disk before a transaction is marked committed as long as O/S and hardware caching are disabled.

You do not need to use journal archiving to use journaling and journal files. However, journal archiving lets you recover from a disaster that completely destroys the database server.

When a database is configured for direct I/O, adding journaling does not automatically convert the database to asynchronous buffered I/O as it does when the database is configured for synchronous buffer I/O. This is to avoid buffered I/O at all costs when the database is set to direct I/O.

InterBase uses buffered file I/O on all platforms to perform I/O on database pages for the file on disk. The pages are delivered via the System File Cache, which acts as a duplicate store of the pages on RAM. Subsequent loads of the same page(s) are quickly served by the OS kernel if the page exists in the System File Cache. On systems where there is high contention with other files for the System File Cache (a shared pool used by all processes for buffered file I/O) the performance of InterBase may not be optimal. If available System File Cache is limited due to RAM resource limitations, the kernel must spend time cleaning up unused blocks of memory from other processes as well as provide for servicing a new block I/O request.

The performance problem is alleviated by using "direct I/O" (also known as non-buffered I/O) so blocks of pages are directly read from the disk into the process space and do not need to use the System File Cache.

This is supported on Windows OS only. This setting is not supported on non-Windows platform databases; you will see the following error.

```
feature is not supported
-direct I/O operation
```

If a database enabled with "direct" I/O is then copied to an older version of InterBase, the setting will not be used by the older InterBase server. The older server will employ the "sync" write mode in this case.

The fixes are as follows:

- The gfix command line tool has been modified to allow setting a database to be in "direct" I/O write mode.

```
# gfix [-write {async, sync, direct}] . . .
```

For example:

```
#gfix -write direct foo.ib -user sysdba -password masterkey
```

- The gbak command line tool now has a new restore option (optional) setting to override a database write mode. The "write" mode will be preserved during a backup/restore lifecycle.

```
# gbak [-write {async, sync, direct}] . . .
```

For example:

```
# gbak -write direct -r foo.ibk foo.ib -user sysdba -password masterkey
```

- Services API support for the new and updated `gfix` and `gbak` options. You can find the various new arguments and respective values in ibase.h

Service API database restore arguments

Argument	Purpose	Argument length	Argument value

isc_spb_res_write_mode	Set the write mode of the database. The next byte must be one of:
	`isc_spb_res_wm_async`
	`isc_spb_res_wm_sync`
	`isc_spb_res_wm_direct`
	Corresponds to `gbak -write`
		1 byte	byte

Service API database properties arguments

Add `isc_spb_prp_wm_direct` to the following argument: `isc_spb_prp_write_mode >`

- `gstat` command line tool will exhibit the following setting,direct, in its "Attributes" header line output.

```
# gstat -h foo.ib -user sysdba -password masterkey
. . .
Database header page information:
Flags 0
Checksum 12345
Write timestamp Sep 3, 2025 13:36:31
Page size 8192
ODS version 19.0
. . .
Creation date May 23, 2025 14:58:27
Attributes force write, direct, no reserve
Variable header data:
Sweep interval: 20000
*END*
. . .
```

It is important to note that a database needs to be set with "gfix -write direct" option and reloaded by the database engine for this to take effect.

Also, since the System File Cache will not be used when "direct" I/O is set, it is recommended that the database cache setting and database linger interval be set suitably. This allows the most frequently used pages to be in memory, the InterBase database cache, when new connections are serviced.

This "direct" I/O setting on a database is only possible if the database page size is an exact multiple of the underlying disk sector size of the file. The standard for so many decades has been 512 bytes per sector on hard disks. Newer hard disks however are trying to adopt the more Advanced Format of 4096 bytes per sector. InterBase supports the following database page sizes: 1024, 2048, 4096, 8192 and 16384 bytes per page. Databases that have a page size of 1024 or 2048 bytes cannot be set to "direct" I/O on hard disks that only support the 4096 bytes per sector standard; you need to restore your database to a larger page size on such disks before enabling "direct" I/O on them.

If you try to enable "direct" I/O on an incompatible device, the following error message is returned stating the minimum required database page size. The following example shows an error message where the disk sector size is 4096 bytes.

```
Error: must backup and restore to DB page size
>= 4096 bytes to support direct I/O on this device.
```

1.1.1. How Journal Archiving Works

The purpose of journal archiving is to provide effective and efficient disaster recovery. As mentioned above, a journal archive is a directory that contains a full database dump and all of the completed journal files that have been archived since that dump. As such, a journal archive enables you to recover to the last committed transaction in the most recently archived and completed journal file.

Important:
For disaster recovery purposes, a journal archive should always be located on a different machine — ideally, in a remote location — than the one that houses the database server.

Only completed journal files are archived to the archive directory. This means that up to the moment recovery is possible when the hard drive that contains the current, active, unarchived journal file remains intact. However, if disaster wipes out the hard drive that contains the active, incomplete journal file, the data on that file will also be lost.

> **Note:**
> Before you can activate journal archiving, you must first enable journaling. For instructions on how to do so, see Enabling Journaling and Creating Journal Files. For instructions on how to activate journal archiving, see Using Journal Archiving.

1.2. Configuring your System to Use Journaling and Journal Archiving

Use the following criteria to determine the optimal journaling configuration of your system:

- The I/O speed of the device on which the journal files are created.
- The speed of concurrent creation of new journal files.
- Hardware requirements and ease of setup.

It is not necessary for InterBase to be installed and running on the machine used for journal archive storage.

1.2.1. Additional Considerations

- A journal archive is platform-specific. For example, an archive created with InterBase for Windows cannot be directly used to recover an InterBase database on another platform. Instead, an archived database dump could be logically backed up in transportable format and then logically restored on the other platform.
- Only full dumps are archived. You cannot archive incremental database dumps. The gbak `-archive_database` command initiates a full, physical backup. For more information about InterBase backup options, see About InterBase backup and restore options.
- The journal and journal archive are restricted to a single directory. The number of items allowed to be archived will be limited by the number of files that are allowed in a directory for a given file system.

2. Enabling Journaling and Creating Journal Files

To create a journal file and activate journaling, use the following DDL syntax:

```
CREATE JOURNAL [<journal-file-specification>] [LENGTH <number-of-pages> [PAGES]]
```

```
[CHECKPOINT LENGTH <number-of-pages> [PAGES]]
[CHECKPOINT INTERVAL <number-of-seconds> [SECONDS]]
[PAGE SIZE <number-of-bytes> [BYTES]]
[PAGE CACHE <number-of-buffers> [BUFFERS]]
[[NO] TIMESTAMP NAME]
[[NO] PREALLOCATE <number-of-pages> [PAGES]];
```

> **Note:**
> InterBase currently requires that all journal files be stored in the same directory.

All `CREATE JOURNAL` clauses are optional. The following table describes the function of each option and its default value.

Option	Description	Default values
<Journal_file_spec>	Specifies a quoted string containing the full path and base file name of the journal file. The base journal file name is used as a template for the actual journal file names as they are created.	The full database path and file name
LENGTH	This clause specifies the number of pages that can be written to the journal file before rolling over to a new journal file. For tips on calculating this number, see Tips for Determining Journal Rollover Frequency.	Maximum: 2GB or 4000 pages
`CHECKPOINT LENGTH`	This clause specifies the number of pages that can be written to the journal file before checkpoint occurs. For tips on calculating checkpoint length, see Tips for Determining Journal Rollover Frequency.	500
`CHECKPOINT INTERVAL`	Determines the number of seconds between database checkpoints. The checkpoint interval determines how long it will take to recover after a server crash. Note: If both `CHECKPOINT LENGTH` and `CHECKPOINT INTERVAL` are specified, whichever event occurs first will initiate a database checkpoint. For tips on calculating the checkpoint interval, see Tips for Determining Checkpoint Intervals.	0

Option	Description	Default values
`PAGE SIZE`	Determines the size of a journal page in bytes. A journal page size must be at least twice the size of a database page size. If a journal page size of less is specified, it will be rounded up to twice the database page size and a warning will be returned. The journal page size need not be a power of 2.	Twice the database page size
`PAGE CACHE`	Determines the number of journal pages that are cached to memory. This number must be large enough to provide buffers for worker threads to write to when the cache writer is writing other buffers. If the number is too small, the worker threads wait and performance suffers.	100 buffers
`[NO] TIMESTAMP NAME`	Determines whether or not to append the file creation timestamp to the base journal file name. If used, the base journal file name will be appended with a timestamp in the following format: `YYYY_MM_DDTHH_MM_SSZ.sequence_number.journal`	Enabled
`[NO] PREALLOCATE`	Specifies the amount of disk space preallocated for journal files. For more information about using the preallocate clause, see About Preallocating Journal Space.	No default value.

The `CREATE JOURNAL` statement causes all subsequent write operations on a database to be done asynchronously. The journal file I/O is always synchronous and cannot be altered. All transaction changes are safely recorded on durable storage before the transaction is committed. This guarantees the ACID properties of a transaction (the database industry standards for Atomicity, Consistency, Isolation, and Durability).

Using asynchronous I/O for database writes allows the operating system to optimize file I/O, such as by writing consecutive pages together, or by using scatter/gather techniques that write consecutive pages in discontiguous page buffers. Journal file I/O is performed using InterBase

careful write strategy. This implies that database pages can be written back to the database in any order after their changes have been journaled.

During a database checkpoint, any database page writes that were buffered asynchronously are flushed to disc before checkpoint completion is signaled. You can re-enable synchronous writes for the database, which removes the requirement for a flush operation before a database checkpoint can be considered complete. Doing so, however, can degrade performance.

2.1. About Preallocating Journal Space

As suggested earlier, for best performance journal files should be placed on a dedicated hard drive. If they are not, access to other files on the drive causes the disk heads to move away from the journal files, which forces a seek-back to the journal file before a new page is written. In addition, each time the journal file size increases, even when the journal files are on a dedicated drive, the disk heads seek away from the journal file so the operating system can update the directory information. To allow the disk heads to remain on the current journal file at all times, you can use the PREALLOCATE clause. The PREALLOCATE clause enables you to allocate space equal to the maximum number of journal files that will exist during normal operation, multiplied by the length of the journal files specified in the LENGTH clause of the CREATE JOURNAL statement.

If the journal is not on a dedicated drive, you can use the PREALLOCATE clause to allocate space equal to the size of the maximum number of journal files that might exist. This guarantees that other files cannot consume the space that may be needed for the journal. If journal archiving is enabled, and you are archiving to a remote machine, allocate enough space to accommodate the journal files that will accumulate if the connection to the remove machine is lost and the journal files cannot be archived for a period of time.

2.2. Tips for Determining Journal Rollover Frequency

Journal file rollover is a time-consuming operation. If rollover happens too frequently, performance will degrade. However, if you are using journal archiving, you want the journal file to rollover as often as possible so the completed journal file can be archived frequently, which minimizes the number of transactions that will be lost if disaster destroys the database server. Determining the most effective rollover frequency is a balancing act and the best answer will be different for each InterBase installation.

You can use the following equations to help you determine the most efficacious rollover frequency for your journal files. You can enter the resulting number in the `LENGTH` clause of the `CREATE JOURNAL` statement, which specifies when the end of a journal file is reached. When the end of the file is reached, journaling resumes on a new file. When a journal file is complete (i.e. its end has been reached), it can be saved to the archive directory.

To determine frequency in bytes, use the following equation:

```
(journal file length * journal page size) = # of bytes before rollover occurs
```

To determine a rollover interval, you can use either of the following equations:

```
(journal file length * journal page size) / (database page size * writes per
minute) = # of minutes between rollovers
```

The equation above lets you see how often a rollover will occur for a given journal file length. The equation below calculates the journal length that will give the rollover interval you specify:

```
(rollover interval * database page size * writes per minute) / journal page size
= journal file length
```

2.3. Tips for Determining Checkpoint Intervals

InterBase uses the checkpoint interval to determine how long it takes InterBase to recover after a server crash. If the server crashes, all of the changes in the cache will be lost. This is okay because the changes were written synchronously to the journal, which stores them on disk, but not in the database. When the server restarts, it must read all of the journal files and copy the changes in the journal to the database to bring the database file up-to-date. The more journal files there are, the longer this will take. Performing frequent checkpoints means that the changes in the cache are written to the database frequently, so fewer changes are kept in the journal. This in turn means that fewer journal files are required and recovery will take less time.

You can use the following equations to help you determine the most effective checkpoint interval for your system:

```
(checkpoint length * journal page size) / (database page size * writes/minutes) =
# of minutes between checkpoints
```

To help determine the time your system needs to recover, use this equation:

```
(checkpoint length * journal page size) / 1,048,576 = maximum time to recover
after a crash in seconds
```

Note:
This equation assumes that the journal file is processed at a rate of one megabyte per second during crash recovery. Typically, a journal file is processed at one to two megabytes per second.

To determine checkpoint length for a given recovery time, use this equation:

```
(recovery time in seconds * 1,048,576) / journal page size = checkpoint length
```

2.4. Displaying Journal Information

To display journaling information for a database, use the following command:

```
gstat <a_database> -l
```

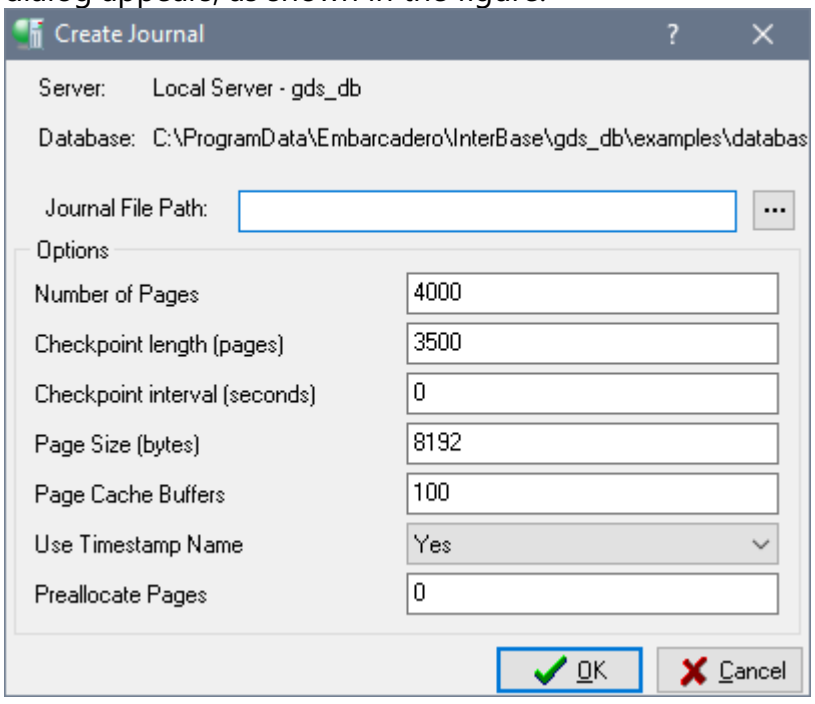
The switch is a lower case L, rather than the numeral one.

2.5. Using IBConsole to Initiate Journaling

IBConsole offers the same journaling options in a dialog box as those described in **Enabling Journaling and Creating Journal Files**. You cannot use IBConsole to create journal archives.

To initiate journaling from IBConsole, take the following steps:

1. In the tree pane, right-click the database for which to initiate journaling, and select **Backup/Restore** from the context menu.
2. When the Backup/Restore menu options appear, select **Create Journal**. The Create Journal dialog appears, as shown in the figure:



3. On Create Journal, specify the options to use, then choose **OK** to begin journaling. For descriptions of each option, see **Enabling Journaling and Creating Journal Files**.

2.6. Disabling Journal Files

The `DROP JOURNAL` statement discontinues the use of write-ahead logging and deletes all journal files. This operation does not delete any journal files in the journal archive but does discontinue maintenance of the journal archive. Dropping journal files requires exclusive access to the database.

To disable journaling, use the following syntax:

```
DROP JOURNAL
```

3. Using Journal Archiving

As mentioned on the previous section, a **journal archive** is a directory that contains a full database dump, and the completed journal files that have been archived since that dump. InterBase requires that you create and update archive content (the dump and journal files) in two steps:

1. Archive the database.
2. Archive the journal files.

The commands used to perform each task are explained below.

Note:
Creating a journal archive does not require exclusive database access.

3.1. The command that Activates Journal Archiving

The CREATE JOURNAL ARCHIVE command activates journal archiving in an InterBase database. A journal archive file (IB_JOURNAL_ARCHIVE) is placed in the journal archive directory.

Note:
To perform an initial (and subsequent) dumps, gbak -archive_database must be performed.

The following command is used to **activate** journaling:

```
CREATE JOURNAL ARCHIVE <journal archive directory>
```

where <journal archive directory> is the location in which InterBase stores the journal archive. If the directory does not exist or is not accessible, InterBase returns an error message. The directory path can be a local drive, a mapped drive, or an UNC path (as long as the underlying file APIs can open the file using that specification). If you do not specify a journal archive directory in the

`CREATE JOURNAL ARCHIVE` statement, InterBase uses the journal directory created with the `CREATE JOURNAL` statement.

When you do not activate journal archiving, the current journal files are reused after a checkpoint writes the records of a jounal file to the hard drive.

Important:
You only use the CREATE JOURNAL ARCHIVE command to initiate journal archiving on a database. Once you initiate archiving and InterBase performs the first dump, you use the gbak `-archive_database` command, discussed below, to perform subsequent dumps. If you disable journal archiving and want to resume it, use CREATE JOURNAL ARCHIVE.

3.2. The Command that Archives Journal Files

The gbak -archive_journals command instructs InterBase to copy the completed journal files to the journal archive directory. To ensure that the archive always contains the most recently completed journal files, you should issue this command on a regular basis.

To copy completed journal files to the archive directory, use the following syntax:

```
gbak -archive_journals <dbname>
```

where `<dbname>` specifies the database that is being archived. The journal archive will grow in storage size as the most recently completed journal files are continually archived. For instructions on how to manage archive size, see Managing Archive Size.

3.3. The Command that Performs Subsequent Archive Dumps

After the initial dump, performed by the CREATE JOURNAL ARCHIVE command, you use the following syntax to perform subsequent dumps:

```
gbak -archive_database <dbname>
```

This command performs a full, physical dump to the archive directory, which helps to reduce the number of journal files that must be stored. The older a dump is, the more journal files InterBase needs to keep the archive up-to-date.

3.4. How Often Should you Archive Journal Files?

Use the following statements and questions to help determine how often to archive journal files:

- How much data can you afford to lose if the IB server is destroyed?

- What is the journal rollover frequency? There is no reason to archive journal files more often that the journal rollover interval.
- Frequent journal rollover + frequent journal archiving means minimum data loss. However, too frequent journal rollover + too frequent journal archiving means poor performance. What is the best balance for your system?

3.5. Disabling a Journal Archive

The DROP JOURNAL ARCHIVE statement disables journal archiving for the database. It causes all journal files and database file dumps to be deleted in all journal archive directories. The file system directories themselves are not deleted.

Disabling journal archiving does not disable database journaling (the creation of journal files). The database will continue to use the write-ahead protocol to commit database changes to the journals. If the intent is to also disable journaling, then you must execute a separate `DROP JOURNAL` statement, shown in Disabling Journal Files.

To disable journal archiving, use the following syntax:

```
DROP JOURNAL ARCHIVE
```

4. Using a Journal Archive to Recover a Database

To recover a database from a journal archive, use the following syntax:

```
gbak -archive_recover [-until <timestamp>] <archive_dbname> <local_dbname>
```

If you do not use the `-UNTIL` switch, InterBase recovers the database to the last committed transaction in the most recently archived journal file or to the last committed transaction in the current, active journal file if the current, active journal file is accessible. The `-until <timestamp>` instructs InterBase to recover transactions until the date and time you specify.

It is recommended that you start building a new archive soon after a successful recovery event. You can create a new archive by issuing the gbak `-archive_database` and the gbak -archive_journals commands.

5. Managing Archive Size

As the number of archived journal files grows, recovery time increases. To keep the archive from becoming too large, you can use any of the following options:

- Run the `gbak -archive_database` command to create a new dump, thereby reducing the number of journal files InterBase needs to keep the archive up-to-date.
- Run the `gfix` command to set a maximum number of dumps to allow in the archive:

```
gfix -archive_dumps <number> db_name
```

When the number of database dumps in the archive exceeds the <number> given, older dumps and journals will be deleted.

- Run the gfix -archive_sweep command to manually control archive size (described below).

5.1. About Archive Sequence Numbers and Archive Sweeping

All archived items are denoted by an archive sequence number that corresponds to the order in which the items were created in the archive.

To remove all files in an archive with a sequence number lower than a number you specify, use the following syntax:

```
gfix -archive_sweep <archive_sequence_no> [-force] db_name
```

If an archived item cannot be swept (garbage-collected), the sweep will stop and return an error status. Sometimes all lower sequenced items cannot be deleted. For example, a database dump may depend on a lower sequenced journal file with which to start recovery. In that case, InterBase will automatically adjust the given sequence number to a lower number, so that this dependency is not lost.

5.2. Tracking the Archive State

To track the state of the archive, use the `RDB$JOURNAL_ARCHIVES` system table. The gbak and gfix commands use this system table to decide which archive items are targets for the command.

The following table describes column and data type information for `RDB$JOURNAL_ARCHIVES`.

Column Name	Data Type	Length	Description
RDB$ARCHIVE_NAME	CHAR	1024	The name of the archived item.
RDB$ARCHIVE_TYPE	CHAR	1	The type of the archived item. 'D' indicates a database dump. 'S' indicates a secondary database file of a database dump. 'J' indicates a journal file.
RDB$ARCHIVE_LENGTH	INT64	8	Length of the archived item as stored in bytes.

Column Name	Data Type	Length	Description
RDB$ARCHIVE_SEQUENCE	INTEGER	4	Sequence number of archived item.
RDB$ARCHIVE_TIMESTAMP	TIMESTAMP	8	Timestamp when item was stored in the archive.
RDB$DEPENDED_ON_SEQUENCE	INTEGER	4	Sequence of archived item that this item depends on. For 'S' archive types, it would be the sequence no. of the 'D' primary database dump file. For 'D' archive types, it is the sequence no. of the starting journal file for recovering from the archive.
RDB$DEPENDED_ON_TIMESTAMP	TIMESTAMP	8	As above, but the archive timestamp for the archived item that this item depends on.

6. Journaling Tips and Best Practices

The following example uses the `EMPLOYEE` sample database that is shipped with InterBase, and is intended as a “best practice” for creating and managing journal files and archives. Its settings are designed to minimize journal file rollover and to reduce the probability of journal buffer wait states. The default property values for the sample journal subsystem are for a low-end machine with minimal configuration. This is very similar to InterBase default page buffer cache of 2048.

6.1. Designing a Minimal Configuration

To begin, set the following parameters:

```
CREATE JOURNAL 'e:\database\test'
LENGTH 65000
CHECKPOINT LENGTH 10000
PAGE CACHE 2500;
```

Given a database that has an `8KB` page size, the journal `PAGE SIZE` will default to `16KB (2 x 8KB)`. Therefore, the `LENGTH parameter (65000)` will cause rollover to a new journal file every `1GB (65000 x 16KB)`. If you instead set the `LENGTH` at 500, the system would roll over to a new journal file every 8MB, which is extremely frequent. A performance drop

may occur during this process. Using a larger `LENGTH` value will make this occur (65000/500 or 130 times) less often.

The CHECKPOINT LENGTH parameter of 10000 means the database checkpoint will occur every 160MB (10000 x 16KB). Assume the built-in CHECKPOINT LENGTH is 500, which means your system will checkpoint the database every 8MB (500 x 16KB). CHECKPOINT LENGTH is a matter of individual taste. It represents the maximum number of bytes that will have to be applied to a database from the journal files after a system crash. You can expect to average between 1MB to 2MB/sec. applying the journal files during the recovery process. So the 160MB checkpoint length suggested here would take a maximum of about 2 minutes to recover depending on your machine. If your organization can tolerate a longer recovery time in return for minimizing the online frequency of database checkpoints, then raise the CHECKPOINT LENGTH accordingly.

The `PAGE CACHE` parameter can be raised to reduce the probability of incurring journal buffer wait states. At any moment, the journal cache writer thread will be syncing some number of journal buffers to the journal file on disk. During this period, we want to insure that the worker threads have enough spare journal buffers to write to when a database page's journal changes need to be moved to a journal buffer.

For example, imagine that the journal cache writer is syncing 500 journal buffers to disk. The 2500 journal buffer configuration will leave 2000 spare buffers for the worker threads to dump their journal changes. At the built-in `PAGE CACHE` default of 100, the worker threads can stall due to a high rate of journal buffer wait states.

Lastly, the use of a SAN mirrored cache will always make InterBase journaling sub-system result in lower performance than a non-journaled InterBase database. This is because twice the amount of data is being written with the journaling subsystem: once to the journal files and once to the database files, plus the additional CPU cost of journal cache management in the InterBase server.

Even for direct-attached storage, it is necessary to pay attention to on-disk write cache enablement. New computers sometimes arrive with on-disk write cache enabled. This means that synchronous writes to a database or journal are not really synchronized to disk oxide. Unless the write cache (SAN or direct) has been disabled or has battery backup, it cannot offer durability for database commits.

InterBase journaling should only result in a performance gain when disk I/O is write-through, where every database write goes to disk oxide and not an on-disk cache.

Hopefully, the `CREATE JOURNAL` statement above will minimize this cost. Remember that the end goal is to provide point-in-time disaster recovery using the `CREATE JOURNAL` ARCHIVE statement to archive time-consistent database dumps and journal files.

6.2. Creating a Sample Journal Archive

To get started, issue:

`CREATE JOURNAL ARCHIVE` <journal archive directory>

This activates journal archiving and performs the initial database dump.

Then copy the completed journal files to the archive directory, using the following syntax:

```
gbak -archive_journals <dbname>
```

Now, in the archive directory listing below, the database dump, EMPLOYEE.2006-08-21T15-48-17Z.1.DATABASE, has no database changes made after 2006-08-21 15:48:17. It does not care what updates are going to the main database while it is being dumped or after it is finished dumping. This includes the checkpoint process.

```
24 Aug 21 15:45 IB_JOURNAL
 24 Aug 21 15:45 IB_JOURNAL_ARCHIVE
 130399832 Aug 21 16:00 EMPLOYEE.2006-08-21T15-45-11Z.1.JOURNAL
 979562496 Aug 21 16:00 EMPLOYEE.2006-08-21T15-48-17Z.1.DATABASE
 130397262 Aug 21 16:00 EMPLOYEE.2006-08-21T15-51-51Z.2.JOURNAL
 130399932 Aug 22 18:13 EMPLOYEE.2006-08-21T15-57-03Z.3.JOURNAL
 130398336 Aug 22 18:13 EMPLOYEE.2006-08-22T18-06-19Z.4.JOURNAL
 130397418 Aug 22 18:14 EMPLOYEE.2006-08-22T18-10-52Z.5.JOURNAL
 35392721 Aug 23 00:27 EMPLOYEE.2006-08-22T18-14-47Z.6.JOURNAL
```

Use the `gstat -L EMPLOYEE.2006-08-21T15-48-17Z.1.DATABASE` command to generate the following summary:

```
Database log page information:
 Creation date Aug 21, 2006 15:45:11
 Log flags: 1
 Recovery required
 Next log page: 0
 Variable log data:
 Control Point 1:
 File name: E:\EMPLOYEE_JOURNALS_AND_ARCHIVES\ EMPLOYEE.2006-08-21T15-45-11Z.
1.JOURNAL

 Partition offset: 0 Seqno: 1 Offset: 5694
```

This is what the log page of the main database looked like at precisely `2006-08-21 15:48:17`. If you attempt to recover using this database dump, it will start with journal file, `EMPLOYEE.2006-08-21T15-45-11Z.1.JOURNAL`, at offset 5694 and continue through the last journal file or whatever timestamp was specified with an optional `-UNTIL` clause:

```
GBAK -ARCHIVE_R E:\EMPLOYEE_JOURNALS_AND_ARCHIVES\EMPLOYEE.2006-08-21T15-48-17Z.
1.DATABASE E:\EMPLOYEE_RECOVER\EMPLOYEE.GDB -UNTIL "2006-08-21 18:08:15"
```

and in the `interbase.log`:

```
IBSMP (Server) Tue Aug 22 22:49:08 2006
 Database: E:\EMPLOYEE_RECOVER\EMPLOYEE.GDB
 Long term recovery until "2006-08-21 18:08:15" begin

 IBSMP (Server) Tue Aug 22 22:49:09 2006
 Database: E:\EMPLOYEE_RECOVER\EMPLOYEE.GDB
 Applying journal file: E:\EMPLOYEE_JOURNALS_AND_ARCHIVES\EMPLOYEE.
2006-08-21T15-45-11Z.1.JOURNAL

 IBSMP (Server) Tue Aug 22 22:51:38 2006
 Database: E:\EMPLOYEE_RECOVER\EMPLOYEE.GDB
 Applying journal file: E:\EMPLOYEE_JOURNALS_AND_ARCHIVES\EMPLOYEE.
2006-08-21T15-51-51Z.2.JOURNAL
```

```
IBSMP (Server) Tue Aug 22 22:53:24 2006
Database: E:\EMPLOYEE_RECOVER\EMPLOYEE.GDB
Applying journal file: E:\EMPLOYEE_JOURNALS_AND_ARCHIVES\EMPLOYEE.
2006-08-21T15-57-03Z.3.JOURNAL

IBSMP (Server) Tue Aug 22 22:55:44 2006
Database: E:\EMPLOYEE_RECOVER\EMPLOYEE.GDB
Applying journal file:
E:\EMPLOYEE_JOURNALS_AND_ARCHIVES\EMPLOYEE.2006-08-22T18-06-19Z.4.JOURNAL

IBSMP (Server) Tue Aug 22 22:55:57 2006
Database: E:\EMPLOYEE_RECOVER\EMPLOYEE.GDB
Long term recovery end
```

`GBAK -ARCHIVE_DATABASE` (creating archive db dump) never locks anything. The only archive management restriction is that archive operations are serialized. You cannot do multiple `GBAK/GFIX` operations against it at the same time. The important point here is that the main database is fully accessible at all times.

`GBAK -ARCHIVE_JOURNALS <my_database>` causes non-archived journal files to be copied to the archive (or marked as archived as above) when you do not want to dump the whole database. Again, a row is entered into `RDB$JOURNAL_ARCHIVES` for each archived journal file.

`GFIX -ARCHIVE_SWEEP <sequence no.> <my_database>` deletes all files in `RDB$JOURNAL_ARCHIVES` with `RDB$ARCHIVE_SEQUENCE` less than the requested sequence.

`GFIX -ARCHIVE_DUMPS <number> <my_database>` configures the maximum number of database dumps allowed in the archive. After issuing `GBAK -ARCHIVE_DATABASE`, archive management will automatically delete the oldest archive database dump and all earlier journal files if the dump limit has been exceeded by the addition of the new database dump.

`GBAK -ARCHIVE_RECOVER <archive_directory/archive_database> <new_database> [-UNTIL <timestamp>]`, will recover a database from the archived journal files. Remember that <archive_directory> has to be mounted for read access on the machine performing the recovery.

Archive directories can be located on InterBase servers or passive file servers and appliances. The archived files are opened directly by clients and not through an InterBase server. Archive database dumps are sealed so you can simultaneously run database validation (usually requires exclusive), logical GBAK, and have multiple, same-platform machines on the network attach the database for read-only queries, which implies high levels of page I/O over the network.

If the most current, non-archived journal files are accessible from the machine where the recover is being executed, then the recovery process will "jump" to those journal files to recover the most recently committed transactions, notwithstanding the optional `-UNTIL` clause. The recovered database is divorced of any journal or journal archive so it is necessary to define them again if desired.

However, it is more useful to leave the recovered database in a perpetual state of long term recovery. That is, every time after the first `GBAK -ARCHIVE_RECOVER`, subsequent `GBAK -ARCHIVE_RECOVER` statements apply the incremental journal changes. This provides perfect symmetry with the online dump feature:

```
rem Full online dump
gbak -dump employee.gdb dump.ib
rem Incremental dump
gbak -dump employee.gdb dump.ib
rem Incremental dump
gbak -dump employee.gdb dump.ib
rem Divorce from main DB, and make the dump database online for read-write
operations
gfix -mode read_write dump.ib

rem Archive Database
gbak -archive_database employee.gdb
rem Archive Journals
gbak -archive_journal employee.gdb
rem To recover, find the lastest employee.gdb.*.database file in the archive
folder, and recover from that. For example, if the latest full database archive
file is employee.gdb.5.database, execute the following archive recover command:
gbak -archive_recover employee.gdb.5.database recover.ib
rem  Make the recovered database online for read-write operations. Note: the
recovered database does not have any journal archive setup at this point. You
will need to set this up again.
gfix -mode read_write recover.ib
```

Note: The sample above is a Windows batch script.

This functional modification is much more efficient. Full, archival recovery can take hours depending on the volume of journal changes.

If you divorce from the database, you save 1 second in not having to type `GFIX -MODE READ_WRITE` at the cost of having to create another full recovery if you want a more recent copy (hour(s)). Now you have to run `GFIX -MODE READ_WRITE` to divorce, but you gain hours of efficiency by being able to get the incremental journal changes since the last `GBAK -ARCHIVE_RECOVER`. This also means that the recovered database can be deployed more quickly if the main database is lost. It also can function as a more up-to-date `READ_ONLY` database for queries and reporting purposes.

Lastly, the journal archive is never implicitly dropped as a side-effect of `DROP DATABASE` or `DROP JOURNAL`. It is necessary to explicitly issue a `DROP JOURNAL ARCHIVE` statement before `DROP DATABASE`. The journal archive potentially represents the last known source of the contents of a dropped database so it is intentionally difficult to delete.

DATABASE STATISTICS AND CONNECTION MONITORING

InterBase provides a number of ways to view statistics about database behavior and to exert control over that behavior.

1. Monitoring with System Temporary Tables

The InterBase Server has always kept a lot of statistics about what was going on, but it has not been easy, or in some cases possible, to surface that information. Now, InterBase captures that information and makes it available in a set of global system temporary tables. These tables describe the runtime behavior of a database. They also provide a level of control.

Although it has always been possible to see a list of users who were currently attached to a database, you can now find out much more. For example, you can see how long each user has been connected, what application each user is running, or the total amount of data I/O used by each attachment. A glance at the temporary table metadata listed in the Language Reference Guide will suggest the vast possibilities that are available here.

It is also possible to exercise a certain amount of control over the state of a database by performing updates to these tables. See Updating System Temporary Tables.

These system temporary tables are specific to each database attachment and are visible only to the sysdba user and the database owner. There is therefore no need for unique names and no danger of collisions by separate attachments. Each table is populated only at the point when a client queries it.

The following system temporary tables are available. Their structure is documented in the Language Reference Guide.

Table name	Description
TMP$ATTACHMENTS	One row for each connection to a database.
TMP$DATABASE	One row for each database you are attached to.
TMP$HEAPS	One row for each entry in the InterBase Random and Block heap.
TMP$INDICES	One row for each index loaded in to database cache.

Table name	Description
TMP$POOL_BLOCKS	One row for each block of memory in each pool.
TMP$POOLS	One row for each current memory pool.
TMP$PROCEDURES	One row for each procedure executed since the current connection began.
TMP$RELATIONS	One row for each relation referenced since the current connection began.
TMP$STATEMENTS	One row for each statement currently executing for any current connection.
TMP$TRANSACTIONS	One row for each transaction that is active or in limbo.
TMP$TRIGGERS	One row for each trigger loaded in to the database cache.

1.1. Querying System Temporary Tables

Clients can query these tables using `SELECT` statements, just as they would query any other table. By querying these tables, a rich collection of data about server performance and user behavior is available.

You cannot create or redefine temporary tables yourself.

Tip:
For frequent monitoring, the best transaction control is to start the transaction as `READ_COMMITTED, READ_ONLY`. Then commit it with `COMMIT_RETAINING`. This has the least impact on the system.

1.1.1. Refreshing the Temporary Tables

To refresh the rows in the temporary tables, commit your transaction and perform the `SELECT` from the temporary tables again. InterBase automatically deletes the rows stored in temporary tables on a commit.

1.1.2. Listing the Temporary Tables

To display a list of these temporary tables, issue the following command in **isql**:

```
SHOW SYSTEM
```

The temporary tables are listed at the end of the system tables. To see the metadata for a particular table, issue:

```
SHOW TABLE tablename
```

Note:
The `SHOW SYSTEM` command is available only in command-line **isql**, not in InterBase Windows `isql`.

1.1.3. Security

Unlike system tables, which have a default access privilege of `SELECT` for `PUBLIC` users, the temporary tables have no default access by `PUBLIC`. The display and manipulation of this runtime information is restricted to `SYSDBA` and the database owner. These two users have the option of using the `GRANT` statement to allow access to other users. The statement can grant only `SELECT` privileges.

1.1.4. Examples of Querying System Temporary Tables

To illustrate the richness of the possibilities afforded by these temporary tables, here are some examples how you might query them.

Top ten SQL statements by execution :

```
SELECT a.tmp$user, s.tmp$timestamp, s.tmp$sql, s.tmp$quantum
FROM TMP$STATEMENTS s, TMP$ATTACHMENTS a
WHERE a.TMP$ATTACHMENT_ID = s.TMP$ATTACHMENT_ID
ORDER BY s.TMP$QUANTUM DESC ROWS 10;
```

Top ten oldest transaction snapshots:

```
SELECT a.TMP$USER, t.TMP$TIMESTAMP, t.TMP$TRANSACTION_ID, t.TMP$SNAPSHOT
FROM TMP$ATTACHMENTS a, TMP$TRANSACTIONS t
WHERE a.TMP$ATTACHMENT_ID = t.TMP$ATTACHMENT_ID
ORDER BY t.TMP$SNAPSHOT ROWS 10;
```

Top ten tables with the most garbage to clean up:

```
SELECT TMP$RELATION_NAME, TMP$GARBAGE_COLLECT_PAGES
FROM TMP$RELATIONS
ORDER BY TMP$GARBAGE_COLLECT_PAGES DESC ROWS 10;
```

Top ten most executed stored procedures:

```
SELECT TMP$PROCEDURE_NAME, TMP$INVOCATIONS
FROM TMP$PROCEDURES
ORDER BY TMP$INVOCATIONS DESC ROWS 10;
```

Is database sweep active and what's its progress?:

```
SELECT TMP$SWEEP_RELATION, TMP$SWEEP_RECORDS
FROM TMP$DATABASE
WHERE TMP$SWEEP_ACTIVE = 'Y';
```

Pool memory allocations grouped by pool type:

```
SELECT TMP$TYPE, SUM(TMP$POOL_MEMORY) TMP$TOTAL_MEMORY,
SUM(TMP$FREE_MEMORY) TMP$TOTAL_FREE
FROM TMP$POOLS
GROUP BY TMP$TYPE
ORDER BY 2 DESC;
```

1.2. Updating System Temporary Tables

There are cases where, having acquired information about the state of the database, you need to take appropriate action. You might, for example, detect a transaction that had unexpectedly been open for many hours, or one that was consuming resources that were needed by others. By updating the `TMP$STATE` column of certain temporary tables, you can perform the following updates:

- Roll back an active or limbo transaction
- Commit a limbo transaction
- Cancel an attachment’s executing operation
- Shut down the current attachment
- Ping database attachments to check if they are alive
- Make an executing statement stop running

1.2.1. Making single changes

The following examples operate on a single attachment or transaction.

Action	Statement
To roll back an active transaction	`UPDATE TMP$TRANSACTIONS SET TMP$STATE = 'ROLLBACK' WHERE TMP$TRANSACTION_ID=123;`
To roll back a limbo transaction	`UPDATE TMP$TRANSACTIONS SET TMP$STATE = 'ROLLBACK' WHERE TMP$TRANSACTION_ID=123;`
To commit a limbo transaction	`UPDATE TMP$TRANSACTIONS SET TMP$STATE = 'COMMIT' WHERE TMP$TRANSACTION_ID=123;`
To cancel the attachment's currently executing operation	`UPDATE TMP$ATTACHMENTS SET TMP$STATE = 'CANCEL' WHERE TMP$ATTACHMENT_ID=123;`
To shut down the current attachment	`UPDATE TMP$ATTACHMENTS SET TMP$STATE = 'SHUTDOWN' WHERE TMP$ATTACHMENT_ID=123;`
To ping an attachment by sending a keepalive request. If the connection/attachment is defunct, the server will automatically cleanup the port	`UPDATE TMP$ATTACHMENTS SET TMP$STATE = 'KEEPALIVE' WHERE TMP$ATTACHMENT_ID=123;`
To make an executing statement stop running	`UPDATE TMP$STATEMENTS SET TMP$STATE = 'CANCEL' WHERE TMP$STATEMENT_ID=123;`

Note:
Shutting down an attachment detaches the user from the database and terminates the local or network attachment to the server.</blockquote>

1.2.2. Making global changes

You can make more global changes, as listed below.

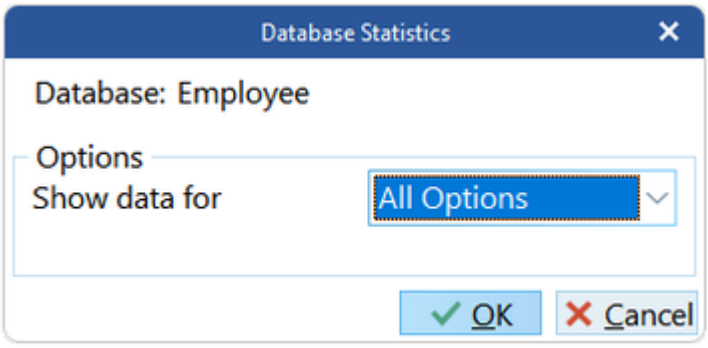
Action	Statement
To roll back all active transactions	`UPDATE TMP$TRANSACTIONS SET TMP$STATE = 'ROLLBACK' WHERE TMP$STATE ='ACTIVE';`
To roll back all limbo transactions	`UPDATE TMP$TRANSACTIONS SET TMP$STATE = 'ROLLBACK' WHERE TMP$STATE ='LIMBO';`
To commit all limbo transactions	`UPDATE TMP$TRANSACTIONS SET TMP$STATE = 'COMMIT' WHERE TMP$STATE ='LIMBO';`

2. Viewing Statistics using IBConsole

To view database statistics, use one of the following methods to access the Database Statistics dialog:

- Select a connected database in the Tree pane and choose Database|Maintenance|Database Statistics.
- Select a connected database in the Tree pane and double-click Database Statistics in the Work pane.
- Right-click a connected database in the Tree pane and choose Maintenance|Database Statistics from the context menu.

A Database Statistics dialog appears where you can select which statistics you want to display.

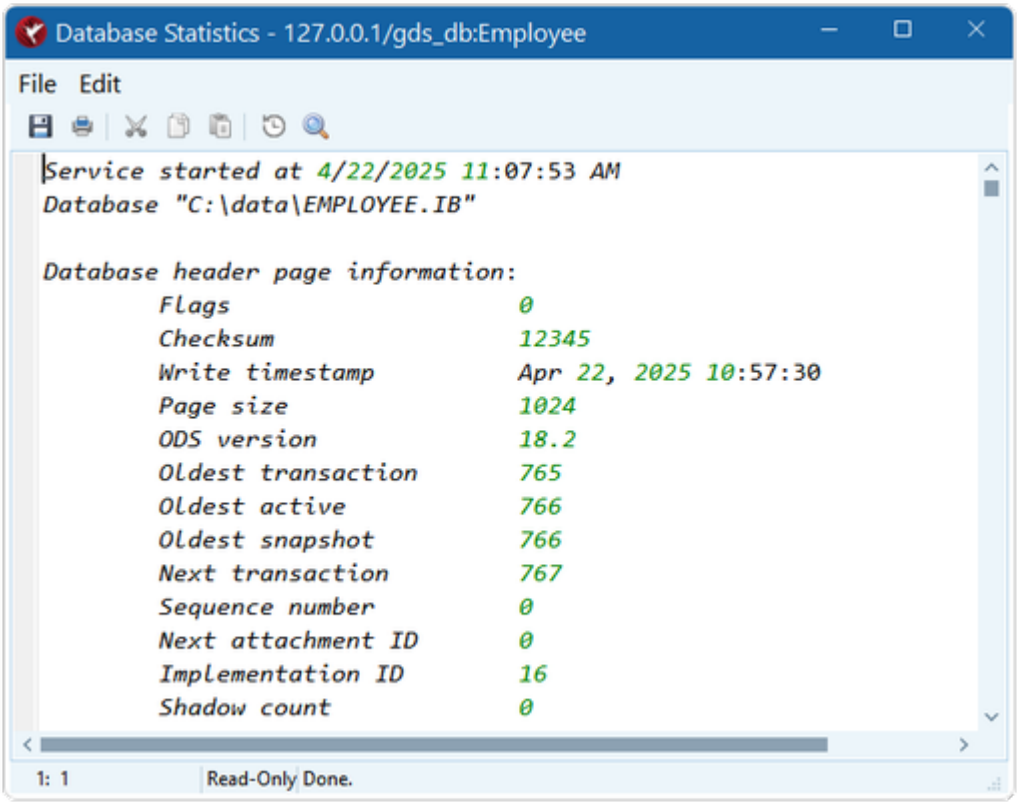


To view database statistics:

1. Select the statistical data you wish to generate from the Options list. You can specify options by entering a value, by clicking the option value and choosing a new value from a drop-down list of values or by double-clicking the option value to rotate its value to the next in the list of values.

2. Click OK to generate database statistics.

> **Note:**
> In some cases, it can take a long time to display the statistics for large databases because, depending on what information has been selected to report, generating these statistics may analyze all the tables and indexes in a database.



The Database Statistics report dialog is a standard text display window that exhibits database summary and database analysis information statistics. For an explanation of how to use the standard text display window, see Text Viewer Window.

2.1. Database Statistics Options

When you request a statistic option, InterBase generates and displays information for that database statistic. Possible statistic option values include: All Options, Data Pages, Database Log, Header Pages, Index Pages, and System Relations.

> **Note:**
> In addition to the selected statistic, header page information is displayed, regardless which statistic has been selected to report. If Header Pages is the selected option value, then only header page information will be displayed.

2.1.1. All Options

Displays statistic information for all options including Data Pages, Database Log, Header Pages, Index Pages, and System Relations.

This function corresponds to the `-all` option of `gstat`.

2.1.2. Data Pages

Displays data page information in the database summary. Below is an example of data page information, followed by an explanation of each item.

```
COUNTRY (31)
Primary pointer page: 246, Index root page: 247
Data pages: 1, data page slots: 1, average fill: 59%
Fill distribution:
0 - 19% = 0
20 - 39% = 0
40 - 59% = 1
60 - 79% = 0
80 - 99% = 0
```

The first line displays a database table name while the remaining lines contain item information pertaining to the table. These items include:

Item	Description
Primary pointer page	The page that is the first pointer page for the table.
Index root page	The page number that is the first pointer page for indexes.
Data pages	The total number of data pages.
Data page slots	The number of pointers to database pages, whether the pages are still in the database or not.
Average fill	The average percentage to which the data pages are filled.
Fill distribution	A histogram that shows the number of data pages that are filled to the percentages.

2.1.3. Database Log

Displays the database log in the database summary. Below is an example of database log information.

This function corresponds to the `-log` option of `gstat`.

```
Database log page information:
Creation date Dec 20, 1998 11:38:19
Log flags: 2
No write ahead log
Next log page: 0
Variable log data:
Control Point 1:
File name:
Partition offset: 0 Seqno: 0 Offset: 0
Control Point 2:
File name:
Partition offset: 0 Seqno: 0 Offset: 0
Current File:
File name:
Partition offset: 0 Seqno: 0 Offset: 0
```

2.1.4. Header Pages

Displays header page information in the database summary. Below is an example of database summary header page information, followed by an explanation of each item.

This function corresponds to the `-header` option of `gstat`.

```
Database "C:\Embarcadero\InterBase\examples\Database\employee.ib"

Database header page information:
Flags 0
Checksum 12345
Generation 41
Page size 4096
ODS version 12.0
Oldest transaction 29
Oldest active 30
Oldest snapshot 30
Next transaction 34
Bumped transaction 1
Sequence number 0
Next attachment ID 0
Implementation ID 16
Shadow count 0
Page buffers 0
Next header page 0
Database dialect 1
```

```
Creation date Aug 26, 2006 17:05:03

Variable header data:
Sweep interval: 20000
*END*

Service ended at 9/3/2006 4:59:05 PM
```

The first line displays the name and location of the primary database file while the remaining lines contain information on the database header page. These items include:

Item	Description
Checksum	InterBase supports true checksums only for ODS 8 and earlier. For ODS 9 and later, the checksum value is always "12345".
Generation	Counter incremented each time header page is written.
Page size	The current database page size, in bytes.
ODS version	The version of the database's on-disk structure.
Oldest transaction	The transaction ID number of the oldest "interesting" transaction (those that are active, in limbo, or rolled back, but not committed).
Oldest active	The transaction ID number of the oldest active transaction.
Next transaction	The transaction ID number that InterBase assigns to the next transaction. The difference between the oldest transaction and the next transaction determines when database sweeping occurs. For example, if the difference is greater than this difference (set to 20,000 by default), then InterBase initiates a database sweep. See Overview of Sweeping.
Sequence number	The sequence number of the header page (zero is used for the first page, one for second page, and so on).
Next connection ID	ID number of the next database connection.

Item	Description
Implementation ID	The architecture of the system on which the database was created. These ID definitions are platform-dependent #define directives for a macro class named CLASS: • 1 HP Apollo Domain OS • 2 Sun Solaris SPARC, HP9000 s300, Xenix, Motorola IMP UNIX, UnixWare, NCR UNIX, NeXT, Data General DG-UX Intel • 3 Sun Solaris x86 • 4 VMS • 5 VAX Ultrix • 6 MIPS Ultrix • 7 HP9000 s700/s800 • 8 Novell NetWare • 9 Apple Macintosh 680x0 • 10 IBM AIX POWER series, IBM AIX PowerPC • 11 Data General DG-UX 88K • 12 HP MPE/xl • 13 SGI IRIX • 14 Cray • 15 SF/1 • 16 Microsoft Windows 7 (32-bit and 64-bit) • 17 OS/2 • 18 Windows 16 bit • 19 LINUX on Intel series • 20 LINUX on Sparc systems • 21 DARWIN on Intel • 22 DARWIN on PowerPC • 23 DARWIN on iOS ARM architecture • 24 Android on x86 architecture (emulator) • 25 Android on ARM architecture (device
Shadow count	The number of shadow files defined for the database.
Number of cache buffers	The number of page buffers in the database cache.
Next header page	The ID of the next header page.
Database dialect	The SQL dialect of the database
Creation date	The date when the database was created.
Attributes	• force write—indicates that forced database writes are enabled. • no_reserve—indicates that space is not reserved on each page for old generations of data. This enables data to be packed more closely on each page and therefore makes the database occupy less disk space. • shutdown—indicates database is shut down.

Item	Description
Variable header data	• sweep interval • secondary file information

2.1.5. Index Pages

Displays index information in the database summary. Below is an example of index page information, followed by an explanation of each item.

```
Index CUSTNAMEX (2)
Depth: 2, leaf buckets: 2, nodes: 27
Average data length: 45.00, total dup: 0, max dup: 0
Fill distribution:
0 - 19% = 0
20 - 39% = 0
40 - 59% = 1
60 - 79% = 0
80 - 99% = 1
```

Item	Description
Index	The name of the index.
Depth	The number of levels in the index page tree. If the depth of the index page tree is greater than three, then sorting may not be as efficient as possible. To reduce the depth of the index page tree, increase the page size. If increasing the page size does not reduce the depth, then return it to its previous size.
Leaf buckets	The number of leaf (bottom level) pages in the index page tree.
Nodes	The total number of index pages in the tree.
Average data length	The average length of each key, in bytes.
Total dup	The total number of rows that have duplicate indexes.
Max dup	The number of duplicates of the index with the most duplicates
Fill distribution	A histogram that shows the number of index pages filled to the specified percentages.

2.1.6. System Relations

Displays information for system tables in the database.

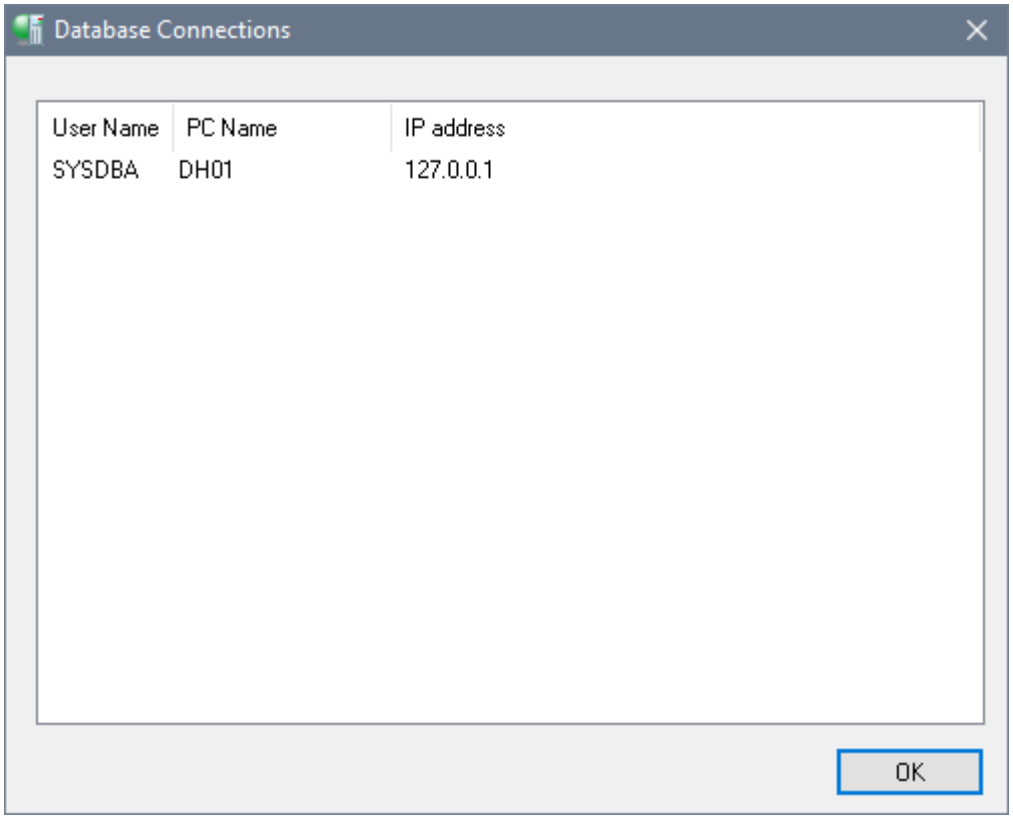
```
RDB$CHECK_CONSTRAINTS (24)
Primary pointer page: 54, Index root page: 55
Data pages: 5, data page slots: 5, average fill: 59%
Fill distribution:
0 - 19% = 0
20 - 39% = 1
40 - 59% = 0
60 - 79% = 4
80 - 99% = 0

Index RDB$INDEX_14 (0)
Depth: 1, leaf buckets: 1, nodes: 68
Average data length: 0.00, total dup: 14, max dup: 1
Fill distribution:
0 - 19% = 0
20 - 39% = 0
40 - 59% = 1
60 - 79% = 0
80 - 99% = 0
```

The statistics contained here are similar to that of data pages and index pages. For information on the items see Data Pages and Index Pages above.

3. Monitoring Client Connections with IBConsole

You can view a list of users currently connected to a particular database in IBConsole using the Database Connections dialog. You can access this dialog by one of the following methods:

- Select a database (or any branch under the database hierarchy) in the Tree pane and choose Database|Connected Users.
- Select a database in the Tree pane and double-click `Connected Users` in the Actions column of the Work pane.
- Right-click a database in the Tree pane and choose `Connected Users` from the context menu.



Note:
InterBase temporary system tables provide resources for more extensive monitoring of database activity. See Monitoring with System Temporary Tables.

4. The gstat Command-line Tool

```
gstat [<options>] <database>
```

Description: The `gstat` program is a command-line tool for retrieving and reporting database statistics. Its function is the same as that described for IBConsole earlier in this chapter.

You must be `SYSDBA` or the owner of a database to run `gstat`. On UNIX platforms, there is a further constraint on `gstat`: in order to run `gstat`, you must have system-level read access to the database files. You can gain this by logging in as the same account that the InterBase server is running as (InterBase or root) or by setting the system-level permissions on the database file to include read permission for your Group. These restrictions exist on UNIX platforms because `gstat` accesses the database file at the system level rather than through the InterBase server.

Note:
You can run `gstat` only against local databases: run `gstat` on the server host.

Options: The following table lists the valid options for gstat:

Option	Description
-all	Equivalent to supplying -index and -data; this is the default if you supply none of -index, -data, or -all.
-data	Retrieves and displays statistics on data tables in the database.
-header	Stops reporting statistics after reporting the information on the header page.
-index	Retrieves and displays statistics on indexes in the database.
-log	Stops reporting statistics after reporting the information on the log pages.
-pa[ssword] text	Checks for password **<text>** before accessing a database.
-r[ecord]	Adds lines for average record length and average version length to the table statistics.
-system	Retrieves statistics on system tables and indexes in addition to user tables and indexes.
-t[able]	Outputs index and fill information for the requested table, in addition to database header, file, and log statistics; table name is case sensitive.
-user name	Checks for user **<name>** before accessing database.
-z	Prints product version of gstat.

Example: The following command requests table statistics, including record and version length for the JOB table in employee.ib:

```
gstat -user SYSDBA -pa masterkey employee.ib -t JOB -r
```

The command produces the following output:

```
Database "employee.ib"

Database header page information:
Flags 0
Checksum 12345
Write timestamp         Jul 9, 2025 19:58:59
Generation 26
Page size 4096
ODS version 19.0
Oldest transaction 19
Oldest active 20
Oldest snapshot 20
Next transaction 21
Sequence number 0
Next attachment ID 0
Implementation ID 16
Shadow count 0
Page buffers 0
Next header page 0
Database dialect 1
Creation date           Jul 9, 2025 19:58:59
Attributes              force write

variable header data:
Sweep interval: 20000
*END*

Database file sequence:
File employee.ib is the only file

Database log page information:
Creation date
Log flags: 2
No write ahead log

Next log page: 0

variable log data:
Control Point 1:
File name:
Partition offset: 0 Seqno: 0
 Offset: 0
Control Point 2:
File name:
Partition offset: 0 Seqno: 0
 Offset: 0
Current File:
File name:
Partition offset: 0 Seqno: 0
 Offset: 0
```

```
*END*

Analyzing database pages ...

JOB (129)
Primary pointer page: 178, Index root page: 179
Average record length: 64.87, total records: 31, max record length: 77
Average version length: 0.00, total versions: 0, max versions: 0
Data pages: 3, data page slots: 3, average fill: 72%
Fill distribution:
0 - 19% = 0
20 - 39% = 1
40 - 59% = 0
60 - 79% = 0
80 - 99% = 2

Blob pointer page: 253
Average blob length: 535.27, total blobs: 11, max blob length: 4598
Average segment length: 33.83, total segments: 175, max segment       length:85
Blob pages: 1, blob page slots: 1, average fill: 41%
Fill distribution:
0 - 19% = 0       20 - 39% = 0
40 - 59% = 1
60 - 79% = 0
80 - 99% = 0

Index MAXSALX (2)
Depth: 1, leaf buckets: 1, nodes: 31
Average data length: 4.00, total dup: 5, max dup: 1
Fill distribution:
0 - 19% = 1
20 - 39% = 0
40 - 59% = 0
60 - 79% = 0
80 - 99% = 0

Index MINSALX (1)
Depth: 1, leaf buckets: 1, nodes: 31
Average data length: 4.00, total dup: 7, max dup: 2
Fill distribution:
0 - 19% = 1
20 - 39% = 0
40 - 59% = 0
60 - 79% = 0
80 - 99% = 0

Index RDB$FOREIGN3 (3)
Depth: 1, leaf buckets: 1, nodes: 31
Average data length: 1.00, total dup: 24, max dup: 20
Fill distribution:
0 - 19% = 1
20 - 39% = 0
40 - 59% = 0
60 - 79% = 0
80 - 99% = 0

Index RDB$PRIMARY2 (0)
```

```
Depth: 1, leaf buckets: 1, nodes: 31
Average data length: 10.00, total dup: 0, max dup: 0
Fill distribution:
0 - 19% = 1
20 - 39% = 0
40 - 59% = 0
60 - 79% = 0
80 - 99% = 0
```

5. Viewing Lock Statistics

> **Note:**
> The `gds_lock_print` utility is deprecated and is not included with some versions of InterBase.

Locking is a mechanism that InterBase uses to maintain the consistency of the database when it is accessed by multiple users. The lock manager is a thread in the `ibserver` process that coordinates locking.

The lock manager uses a lock table to coordinate resource sharing among client threads in the `ibserver` process connected to the database. The lock table contains information on all the locks in the system and their states. The global header information contains useful aggregate information such as the size of the lock table, the number of free locks, the number of deadlocks, and so on. There is also process information such as whether the lock has been granted or is waiting. This information is useful when trying to correct deadlock situations.

```
iblockpr [a,o,w] (Windows) or gds_lock_print [a,o,w] (UNIX)
```

```
iblockpr [-i{a,o,w}] [t n]
```

Description: `iblockpr` monitors performance by checking lock requests.

The first form of syntax given above retrieves a report of lock statistics at one instant in time. The second form monitors performance by collecting samples at fixed intervals.

The options display interactive information on current activity in the lock table. The utility prints out the events per second for each sampling and gives the average of the values in each column at the end.

Option	Description
[none]	Same as -o

Option	Description
`-a`	Prints a static view of the contents of the lock table.
`-o`	Prints a static lock table summary and a list of all entities that own blocks.
`-w`	Prints out all the information provided by the `-o` flag plus wait statistics for each owner; this option helps to discover which owner's request is blocking others in the lock table.
The following options supply interactive statistics (events/second) for the requested items, which are sampled `<n>` times every `<t>` seconds, with one line printed for each sample. The average of the sample values is printed at the end of each column. If you do not supply values for `<n>` and `<t>`, the default is `<n>=1`.	
`-i`	Prints all statistics; the output is easier to read if you issue `-ia`, `-io`, and `-iw` separately.
`-ia`	Prints how many threads are trying to acquire access to the lock table per second.
`-io`	Prints operation statistics such lock requests, conversions, downgrades, and releases per second.
`-iw`	Prints number of lock acquisitions and requests waiting per second, wait percent, and retries.
`t`	Specifies the time in seconds between samplings.
`n`	Specifies the number of samples to be taken.

Example: The following statement prints "acquire" statistics (access to lock table: acquire/s, acqwait/s, %acqwait, acqrtry/s, and rtrysuc/s) every three seconds until ten samples have been taken:

```
gds_lock_print -ia 3 10
```

6. Retrieving Statistics with isc database info()

InterBase includes programming facilities to gather performance timings and database operation statistics.

You can use the API function `isc_database_info( )` to retrieve statistics, by specifying one or more of the following request buffer items:

Request Buffer Item	Result Buffer Contents
`isc_info_fetches`	Number of reads from the memory buffer cache; calculated since the InterBase server started.
`isc_info_marks`	Number of writes to the memory buffer cache; calculated since the InterBase server started.
`isc_info_reads`	Number of page reads; calculated since the InterBase server started.
`isc_info_writes`	Number of page writes; calculated since the InterBase server started.
`isc_info_backout_count`	Number of removals of record versions per table since the current database attachment started.
`isc_info_delete_count`	Number of row deletions • Reported per table. • Calculated since the current database attachment started.
`isc_info_expunge_count`	Number of removals of a record and all of its ancestors, for records whose deletions have been committed • Reported per table. • Calculated since the current database attachment started.
`isc_info_insert_count`	Number of inserts into the database • Reported per table. • Calculated since the current database attachment started.

Request Buffer Item	Result Buffer Contents
`isc_info_purge_count`	Number of removals of old versions of fully mature records (records committed, resulting in older-ancestor-versions no longer being needed) • Reported per table. • Calculated since the current database attachment started.
`isc_info_read_idx_count`	Number of reads done via an index • Reported per table. • Calculated since the current database attachment started.
`isc_info_read_seq_count`	Number of sequential database reads, that is, the number of sequential table scans (row reads) • Reported per table. • Calculated since the current database attachment started.
`isc_info_read_update_count`	Number of row updates • Reported per table. • Calculated since the current database attachment started.

See the API Guide for information on request buffers, and details of using this API call.

INTERACTIVE QUERY

This chapter documents the IBConsole interactive SQL (isql) and command-line `isql` utilities for InterBase. These tools provide an interface to InterBase Dynamic SQL interpreter. You can use these query tools to perform data definition, prototype queries before implementing them in your application, or to perform ad hoc examination of data in your database. Refer to interactive SQL Window documentation for an over view of this tool.

1. Managing isql Temporary Files

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 in the form `isql_aa.xx`. 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, they are stored in the `Windows` directory.

To avoid cluttering the `Windows` directory with InterBase temporary files, specify a different directory for them by defining the `TMP` environment variable.

When you exit, isql deletes these temporary files. If isql terminates abnormally, then these files remain and may be freely deleted without any adverse effects. You should not delete any of these temporary files while isql is running, because they may be used in the current session.

2. Executing SQL Statements

Within isql, you can execute SQL statements in either of two ways:

- Interactively, one statement at a time
- From a script containing multiple statements

2.1. Executing SQL Interactively

To execute a SQL statement interactively:

1. Type a single SQL statement in the SQL input area. Make sure any other existing statements are *commented*. A statement is commented if it is preceded by "/*" and followed by "*/". If the statement already exists in the SQL input area make sure all statements except the one you wish to execute are commented. Commented statements in the SQL input area are ignored during execution.
2. Choose **Query|Execute**, enter `W` +E, or click the **Execute** toolbar button. If more than one statement is uncommented, **Execute** executes each statement, one after the other.

Tip:
You can copy text from other Windows applications such as the Notepad and Wordpad text editors and paste it into the SQL input area. You can also copy statements from the isql output area and paste them into the SQL input area. This cut-and-paste method is also a convenient way to use the online SQL tutorial provided in the online Help.

When SQL statements are executed, whether successfully or not, they become part of the isql *command history*, a sequential list of SQL statements entered in the current session.

2.2. Preparing SQL Statements

Use the Prepare toolbar button, or select Query|Prepare, to prepare SQL statements for execution and to view the query plan. Prepare compiles the query plan on the server, and displays it in the Plan tab of the SQL output area. Use Prepare to determine if your SQL script is well-constructed, without having to wait for the SQL script to execute.

2.2.1. Valid SQL Statements

- You can execute interactively any SQL statement identified as "available in DSQL" in the *Language Reference*. You cannot use any statements that are specifically identified in the Language Reference as `isql` statements; all these have functionally equivalent menu items in isql.

For example, the `SET NAMES` statement cannot be executed from the SQL input area. To change the active character set, choose Edit|Options and select the desired character set option value in the SQL Options dialog.

- SQL script files can include statements that are not valid to enter interactively. For example, you can use the `SET` statements such as `SET LIST` in scripts.
- Transaction names may not be used with `SET TRANSACTION` statement.
- The SQL input area accepts multiple statements, although only one can be executed at a time. Each statement entered in the SQL input area must be terminated by a semicolon (**;**). The SQL input area accepts multiple statements, although only one can be executed at a time. An uncommented statement that holds the mouse cursor is called the *current statement*.

2.2.2. Executing a SQL Script File

To execute a SQL script file containing SQL statements:

1. Choose Query|Load Script or click the Load Script toolbar button.

2. Locate the desired script file in the Open dialog, and click Open to display the statements of the script file in the SQL input area.
3. Ensure that you are connected to the desired database.
4. If you are connected to the database, comment out any `CONNECT` or `CREATE DATABASE` statements.
5. Choose Query|Execute or click Execute on the toolbar to begin executing the entire script statement by statement.

Note:
Statements executed from a loaded script file do not become part of the command history.

3. Using Batch Updates to Submit Multiple Statements

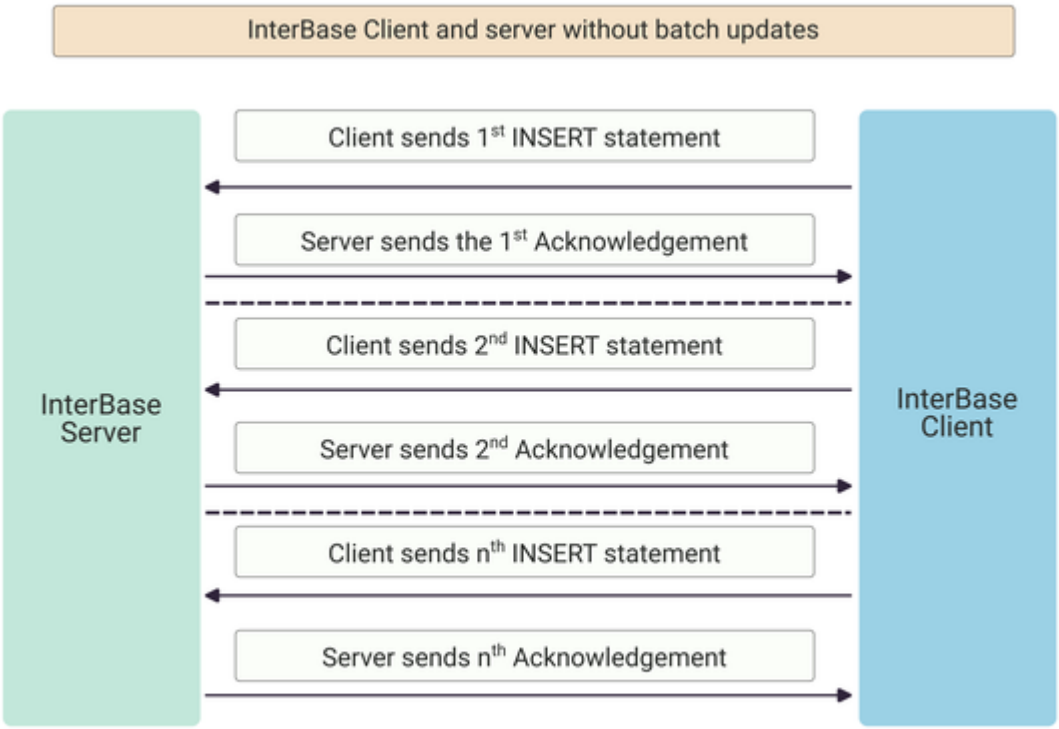
Batch updates allow you to send a group of SQL statements to a server in a single unit. Grouping SQL statements into batches reduces the amount of network traffic between the client and the database server. This results in improved performance, especially in LAN and WAN environments.

Note:
Batch updates only work using the InterBase 2007 client library and an InterClient JDBC driver.

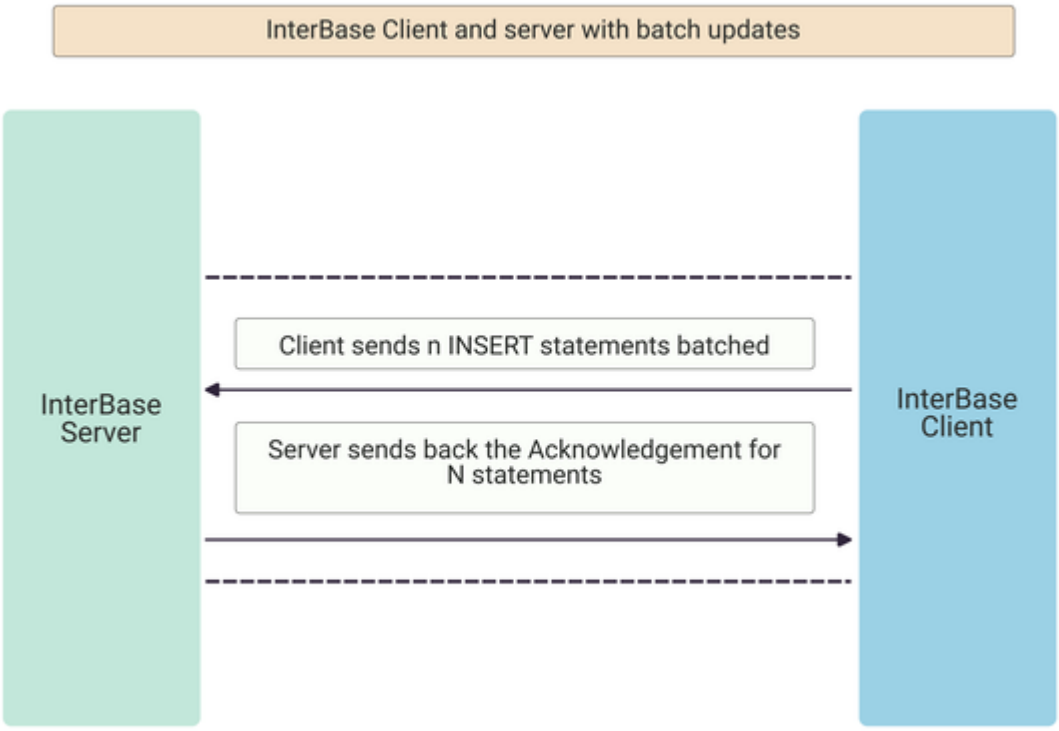
You can send multiple `INSERT`, `UPDATE`, and `DELETE` statements to the server using batch updates. In response, the server returns an array of `ULONG` values that reflect the number of affected rows per statement.

SQL statements such as SELECT and CREATE DATABASE are not supported in batch updates. SQL DDL is supported.

The following diagram shows the flow of communication between client and server when completing a number of `INSERT` statements using traditional InterBase client APIs. Note the flow of communication shown in the figure also applies to `UPDATE` and `DELETE` statements.



The following diagram shows the flow of communication when using batch updates. Note the reduction in network traffic, resulting in better performance.



3.1. Using the Batch Functions in isql

In isql, SQL statements to be executed in batch mode must be surrounded by the new `BATCH START` and `BATCH EXEXCUTE` commands. For example:

```
BATCH START;
...
(allowed DDL/DML statements)
...
BATCH EXECUTE;
```

The `BATCH EXECUTE` command sends the statements between `BATCH START` and `BATCH EXECUTE` to the server. To begin another batch operation, you must issue another `BATCH START` command.

The following demonstrates a specific example of using batch mode with isql.

```
BATCH START;
INSERT INTO t1(f1, f2) VALUES (0,1);
UPDATE t1 SET f1=1 WHERE f2=1;
BATCH EXECUTE;
```

The first SQL statement in the example inserts a new row into table `t1`. The second statement updates the newly inserted row with a new value. Both of these statements are executed in one API call.

For details on how to use the batch_excute and batch_execute_immed functions, see Chapter 15 of the InterBase API Guide.

Note:
The AUTOCOMMITDDL mode of isql must be turned off in order to use batch updates.

3.2. Committing and Rolling Back Transactions

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 Edit|Options and set the Auto Commit DDL option to false in the SQL Options dialog.

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 Transactions|Commit or by clicking Commit on the toolbar.

To undo all database changes from DML statements since the last commit, choose Transactions|Rollback or click Rollback on the toolbar.

3.3. Saving isql Input and Output

You can save the following to a file:

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

3.3.1. Saving SQL Input

To save the SQL statements entered in the SQL input area of the current session to a text file:

1. In the SQL Editor, choose **Menu|Query>Save** Script or click the Save Script toolbar button.
2. Enter a file name, including the location for the new file, in the Save As dialog and click Save. To include the location for the file, type the file path and file name in the Filename text area, or browse to the folder where you would like the file to reside and type only the file name.

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

3.3.2. Saving SQL Output

To save the results of the last executed SQL statement to a file:

1. In the SQL Editor, choose **Menu|Query>Save Output**.
2. Enter a file name, including the location for the new file, in the Export To dialog and click Save. To include the location for the file, either type the file path and file name in the Filename text area, or browse to the folder where you would like the file to reside and type only the file name.

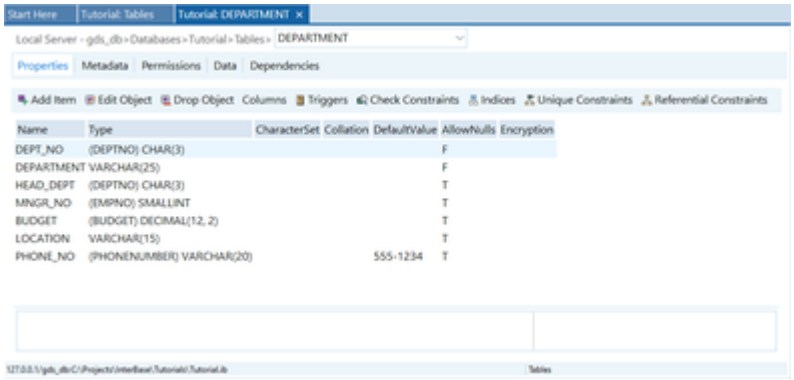
The output in the Data tab from the last successful statement is saved to the named text file.

If you run a SQL script, and then choose to save the output, all the commands in the script file and their results are 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 are not saved to the file.

4. Inspecting Database Objects

Use the object inspector to view properties, metadata, permissions, data, and dependencies for the entire database or for a specific table, view, function, procedure, or any other database attribute displayed in the Tree pane.

To open the object inspector, double-click a database object in the Work pane. The object inspector appears:



Depending on the database object selected, the object inspector has some or all of the following tabs: Properties, Metadata, Permissions, Data, and Dependencies. These are discussed in the following sections.

4.1. Viewing Object Properties

The Properties tab is available when viewing Table and View database objects. Use the Properties tab of the object inspector to display properties for database objects, including columns, triggers,

check constraints, indexes, unique constraints, and referential constraints. The Properties tab has five toolbar buttons for displaying the various object properties:

Button	Description
	Show columns: displays the name, type, collation, character set, default value, and whether or not null values are acceptable for every row in the column. The accelerator key is `W + Y +C`. For more information on columns, refer to "Defining columns" in the Data Definition Guide.
	Show triggers: displays the name and type of each trigger, as well as whether or not it is active. In addition, it displays the SQL trigger statement. The accelerator key is `W + Y +T`. For more information on triggers, refer to "Working with Triggers" in the Data Definition Guide.
	Show check constraints: displays the names of the constraints, whether or not they can be deferred, and if they were initially deferred. In addition, it displays the SQL check constraint statements. The accelerator key is `W + Y +H`. For more information, refer to "Defining a CHECK constraint" in the Data Definition Guide.
	Show indexes: displays the name of the index keys, and whether or not they are unique, descending, or active. The accelerator key is `W + Y +R`. For more information, refer to "Working with Indexes" in the Data Definition Guide.
	Show unique constraints: displays the names of the constraints, whether or not they can be deferred, if they were initially deferred, and the index keys. The accelerator key is `W + Y +U`.
	Show referential constraints: displays the names of the constraints, whether or not they can be deferred, if they were initially deferred, the match options, the update rules, the delete rules, the index, and the reference table. The accelerator key is `W + Y +R`.

4.2. Viewing Metadata

The metadata which the Metadata tab of the object inspector displays depends on the database that is selected in the Tree pane, or the item that is selected in the Work pane.

To view metadata for an entire database Select a connected database in the Tree pane, and then double-click View Metadata in the Work pane. The metadata is displayed in a text window.

To view metadata for a specific database object perform one of the following actions:

- Select a database element from the hierarchy displayed in the Tree pane, and then in the Work pane double-click an object to display its Properties dialog. Click the Metadata tab to see the object's metadata.
- Select a database element from the hierarchy displayed in the Tree pane, and then in the Work pane right-click a database object associated with that element and select Extract from the context menu.

For example, if you want metadata for domains only, expand the desired database hierarchy (if it is not already expanded), select Domains, double-click on a domain in the Work pane, and select the Metadata tab of the Properties dialog.

Use the drop-down list at the top of the dialog to select other objects associated with the database element.

The following table lists the items for which you can view metadata for associated objects with the object inspector.

Item	Displays
Blob Filters	Blob filters definition
Domains	Metadata script, dependencies, data type, description, check constraints, and default values
Exceptions	Description, exception number, exception message, metadata script, and dependencies
External Functions	UDFs definition
Generators	Generator ID, current value, metadata script, and dependencies
Stored Procedures	Metadata script, procedure body, input parameters, output parameters, permissions, data, and dependencies
Roles	Role definition

Item	Displays
Tables	Columns, data types, triggers, indexes, unique constraints, referential constraints, check constraints, metadata script, permissions, data, and dependencies
Views	Metadata script, permissions, data, and dependencies

4.3. Extracting Metadata

You can extract a metadata script to a file by displaying the desired metadata in the Metadata tab and clicking the Save Script toolbar button.

Extracting an entire database exports metadata in a specific order, to allow the resulting script to be used as input to recreate the database.

Metadata	Comments
1. Database	Extracts database with default character set and `PAGE_SIZE`.
2. Domains	Must be before tables that reference domains.
3. Tables	Must be after domains.
4. Indexes	Must be after tables.
5. `FOREIGN KEY` constraints	Must be added after tables to avoid tables being referenced before they have been created.
6. Views	Must be after tables.
7. `CHECK` constraints	Must be after tables.
8. Exceptions	Must be extracted before stored procedures and triggers that contain code to raise exceptions.

Metadata	Comments
9. Stored procedures	Stored procedures are shown with no body in `CREATE PROCEDURE` and then `ALTER PROCEDURE` to add the text of the procedure body; this is to allow circular or recursive procedure references.
10. Triggers	Must be after tables. Must be after stored procedures, to allow trigger code to reference procedures. Does not extract triggers from `CHECK` constraints.
11. Roles	Must be before `GRANT` privileges.
12. `GRANT` privileges	Must be after tables, views, stored procedures, triggers, and roles.

Items that are not extracted include:

- 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.
- Because DDL statements do not contain references to object ownership, the extracted file does not show ownership. The output file includes the name of the object and the owner if one is defined. There is no way to assign an object to its original owner.

5. Command-line isql Tool

Command-line `isql` is a utility for processing SQL data definition (DDL) and data manipulation (DML) statements from interactive input or from a source file. It enables you to create and view metadata, add and modify data, grant user permissions, test queries, and perform database administration tasks.

For a description of the standard SQL commands available in `isql`, see the Language Reference Guide. For a description of special `isql` commands, see isql Command Reference.

You can use `isql` in the following ways:

- Interactively to process SQL statements, by entering statements at the `isql` prompt
- Noninteractively to process SQL statements in a file

5.1. Invoking isql

To start the isql utility, type the following at a UNIX shell prompt or Windows console prompt:

```
isql [options] [database_name]
```

where `options` are command-line options and **<database_name>** is the name of the database to connect to, including disk and directory path.

If no options are specified, `isql` starts an interactive session. If no database is specified, you must connect to an existing database or create a new one. If a database was specified, `isql` starts the interactive session by connecting to the named database.

If options are specified, `isql` starts interactively or noninteractively, depending on the options. For example, reading an input file and writing to an output file are noninteractive tasks, so the `-input` or `-output` options do not start an interactive session. Additional noninteractive options include `-a`, `-database`, `-extract`, and `-x`, which are used when extracting DDL statements.

When you start an interactive `isql` session, the following prompt appears:

```
SQL>
```

You must then end each command with a terminator character. The default terminator is a semicolon (**;**). You can change the terminator to any character or group of characters with the `SET TERMINATOR` command or with the `-terminator` command-line option. If you omit the terminator, a continuation prompt appears (`CON>`).

Note:
For clarity, all of the commands and examples in this chapter end with the default semicolon terminator.

5.1.1. Command-line Options

Only the initial characters in an option are required. You can also type any portion of the text enclosed in brackets, including the full option name. For example, specifying `-n`, `-no`, or `-noauto` has the same effect.

The table below lists the availabel `isql` command-line options:

Option	Description
-a	Extracts all DDL for the named database.
-c[ache]	Set number of cache buffers for this connection to the database; see Default Cache Size Per isql.
-d[atabase] <name>	Used with -x ; changes the CREATE DATABASE statement that is extracted to a file. • Without -d , CREATE DATABASE appears as a C-style comment and uses the database name specified on the isql command line. • With -d , isql extracts an uncommented CREATE DATABASE and substitutes **<name>** as its database argument.
-e[cho]	Displays (echoes) each statement before executing it.
-ex[tract]	Same as -x
-i[nput] <file>	Reads commands from an input file such as a SQL script file instead of from standard input. • input files can contain -input commands that call other files, enabling execution to branch and then return. • isql exits (with a commit) when it reaches the end of the first file. • In interactive sessions, use -input to read commands from a file.
-m[erge_stderr]	• Merges stderr output with stdout. • Useful for capturing output and errors to a single file when running isql in a shell script or batch file.
-names <character set name>	Specifies the character set to use for current database attachment. Default is NONE . **Note:** Any SET NAMES call in isql or inside an SQL script overrides the character set that you provide in the command-line.
-n[oauto]	Turns off automatic commit of DDL statements; by default, DDL statements are committed automatically in a separate transaction.

Option	Description
`-nowarnings`	Displays warning messages if, and only if, an error occurs (be default, isql displays any message returned in a status vector, even if no error occurred).
`-o[utput] file`	Writes results to an output file instead of to standard output; in interactive sessions, use `-output` to write results to a file.
`-pas[sword] password`	Used with `-user` • Specifies a password when connecting to a remote server. • For access, both **<password>** and **<user>** must represent a valid entry in the security database.
`-page[length] <n>`	Prints column headers every **<n>** lines instead of the default 20.
`-q[uiet]`	
`-r[ole] <rolename>`	Grants privileges of role **<rolename>** to **<user>** on connection to the database.
`-s[qldialect] <n>`	Interprets subsequent commands as dialect **<n>** until end of session or until dialect is changed by a `SET SQL DIALECT` statement. • For **<n>** = 1, commands are processed as in InterBase 5 or earlier. • For **<n>** = 2, elements that have different interpretations in dialect 1 and 3 are all flagged with warnings or errors to assist in migrating databases to dialect 3. • For **<n>** = 3, all statements are parsed as current InterBase SQL semantics: double quotes are delimited identifiers, `DATE` data type is `SQL DATE`, and exact numerics with precision greater than 9 are stored as `INT64`.
`-t[erminator] <x>`	Changes the end-of-statement symbol from the default semicolon (**;**) to **<x>**, where **<x>** is a single character or any sequence of characters; deprecated in InterBase 7.

Option	Description
`-u[ser] <user>`	Used with `-password`; specifies a user name when connecting to a remote server. • For access, both **<password>** and **<user>** must represent a valid entry in the security database.
`-x`	Extracts DDL for the named database; displays DDL to the screen unless redirected to a file.
`-z`	Displays the software version of `isql`.

5.1.2. Using Warnings

Warnings can be issued for the following conditions:

- SQL statements with no effect
- SQL expressions that produce different results in InterBase 5 versus InterBase 6 or later
- API calls that will be replaced in future versions of the product
- Pending database shutdown

5.1.3. Examples of Invoking isql

- Suppose `createdb.sql` contains DDL statements to create a database. To execute the statements, enter:

```
isql -input createdb.sql
```

- The following example starts an interactive connection to a remote database. The remote server, jupiter, accepts the specified user and password combination with the privileges assigned to the `STAFF` role:

```
isql -user sales -password mycode -role 'staff''jupiter:/usr/customer.ib'
```

- The next example starts an interactive session but does not attach to a database. `isql` commands are displayed, and query results print column headers every 30 lines:

```
isql -echo -page 30
```

5.1.4. Exiting isql after invoking isql

To exit `isql` and roll back all uncommitted work, enter:

```
QUIT;
```

To exit `isql` and commit all work, enter:

```
EXIT;
```

5.1.5. Connecting to a Database Using isql

If you do not specify a database on the command-line when invoking `isql`, you must either connect to an existing database or create a new one. Use the `CONNECT` command to connect to a database and `CREATE DATABASE` to create a database. For the full syntax of `CONNECT` and `CREATE DATABASE`, see the *Language Reference*.

You can connect to either local or remote databases. The syntax is slightly different for the two:

To connect to a local database on a Windows platform, use the `CONNECT` command with the full path of the database as the argument. For example:

```
SQL> CONNECT 'C:/Embarcadero/InterBase/Database/examples/employee.ib' role
'staff';
```

To connect to a remote database on a Windows or UNIX server using TCP/IP, use the `CONNECT` command with the full node name and path of the database as the argument. Separate the node name from the database path with a colon.

Examples of connecting to remote databases:

To connect to a database on a UNIX platform named *jupiter*:

```
SQL> CONNECT 'jupiter:/usr/InterBase/examples/employee.ib';
```

To connect to a database on a Windows platform named venus:

```
SQL> CONNECT 'venus:c:/Embarcadero/InterBase/examples/database/employee.ib';
```

Note:
Be careful not to confuse node names and shared disks, since both are specified with a

colon separator. If you specify a single letter that maps to a disk drive, it is assumed to be a drive, not a node name.

Tip:
You can use either forward slashes (/) or backslashes (\ ) as directory separators. InterBase automatically converts either type of slash to the appropriate type for the server operating system.

5.2. Setting isql Client Dialect

To use `isql` to create a database in a particular dialect, first set `isql` to the desired dialect and then create the database. You can set `isql` dialect the following ways:

- On the command line, start `isql` with option `-sql_dialect` n, where n is 1, 2, or 3:

```
isql -sql_dialect n
```

- Within an `isql` session or in a SQL script, include the following statement:

```
SET SQL DIALECT n;
```

`isql` dialect precedence is as follows:

- Lowest: Dialect of an attached version 6 or later database
- Next lowest: Dialect specified on the command line
- Next highest: Dialect specified during the session
- Highest: Dialect of an attached Version 5 database (=1)

In InterBase, `isql` has the following behavior with respect to dialects:

- If you start `isql` and attach to a database without specifying a dialect, `isql` takes on the dialect of the database.
- If you specify a dialect on the command line when you invoke `isql`, it retains that dialect after connection unless explicitly changed.
- When you change the dialect during a session using SET SQL DIALECT n, `isql` continues to operate in that dialect until it is explicitly changed.
- When you create a database using `isql`, the database is created with the dialect of the `isql` client; for example, if `isql` has been set to dialect 1, when you create a database, it is a dialect 1 database.
- If you create a database without first specifying a dialect for the `isql` client or attaching to a database, `isql` creates the database in dialect 3.

The statements above are true whether you are running `isql` as a command-line utility or accessing it through IBConsole.

Important:
Any InterBase `isql` client that attaches to a Version 5 database resets to dialect 1.

5.3. Transaction Behavior in isql

When you start `isql`, InterBase begins a transaction. That transaction remains in effect until you issue a `COMMIT` or `ROLLBACK` statement. You must issue a `COMMIT` or `ROLLBACK` statement to end a transaction. Issuing one of these statements automatically starts a new transaction. You can also start a transaction with the `SET TRANSACTION` statement.

`isql` uses a separate transaction for DDL statements. When these statements are issued at the `SQL>` prompt, they are committed automatically as soon as they are completed. DDL scripts should issue a `COMMIT` after every `CREATE` statement to ensure that new database objects are available to all subsequent statements that depend on them. For more information on DDL statements, see the Data Definition Guide.

5.4. Extracting Metadata Using isql

You can extract the DDL statements that define the metadata for a database to an output file with the `-extract` option. Adding the optional `-output` flag reroutes output to a named file. Use this syntax:

```
isql [[-extract | -x][-a] [[-output | -o] outputfile]] database;
```

The `-x` option is an abbreviation for `-extract`. The `-a` flag directs `isql` to extract all database objects. Note that the output file specification, **<outputfile>**, must follow the `-output` flag, while you can place the name of the database being extracted at the end of the command.

Option	Description
<database>	File specification of the database from which metadata is being extracted
<outputfile>	File specification of the text file to receive the extracted statements; if omitted, `isql` writes the information to the screen

You can use the resulting text file to:

- Examine the current state of a database's system tables before you plan alterations to it, or when a database has changed significantly since its creation.
- Use your text editor to make changes to the database definition or create a new database source file.

The `-extract` option does not extract UDF code and Blob filters, because they are not part of the database. It *does* extract the declarations to the database (with `DECLARE EXTERNAL FUNCTION` and `DECLARE FILTER`).

The `-extract` option also does not extract system tables, system views, or system triggers.

Because DDL statements do not contain references to object ownership, the extracted file does not show ownership. The output file includes the name of the object and the owner if one is defined. There is no way to assign an object to its original owner.

For a list of the order of extraction of metadata objects, see Extracting Metadata.For example, the following statement extracts the system catalogs from the database `employee.ib` to a file called `employee.sql`:

```
isql -extract -output employee.sql employee.ib;
```

The resulting output script is created with `-commit` following each set of commands, so that tables can be referenced in subsequent definitions. This command extracts all keywords and object names in uppercase when possible (some international metadata has no uppercase).

To extract DDL statements from database `employee.ib` and store in the file `employee.sql`, enter:

```
isql -a employee.ib -output employee.sql
```

The following example extracts the DDL statements from the database `dev.ib`:

```
isql -x dev.ib
```

This example combines the `-extract` and `-output` options to extract the DDL statements from the database `dev.ib` into a file called `dev.out`. The output database name must follow the `-output` flag.

```
isql -extract -output dev.out dev.ib
```

5.5. isql Commands

At the `SQL>` prompt, you can enter any of three kinds of commands:

- SQL data definition (DDL) statements, such as `CREATE`, `ALTER`, `DROP`, `GRANT`, and `REVOKE`. These statements create, modify, or remove metadata and objects, and control user access (via privileges) to the database. For more information about DDL, see the Data Definition Guide.
- SQL data manipulation (DML) statements such as `SELECT`, `INSERT`, `UPDATE`, and `DELETE`. These four data manipulation operations affect the data in a database. They retrieve, modify, add, or delete data. For more information about DML statements, see the *Language Reference*.
- `isql` commands that fall into three main categories:

- `SHOW` commands (to display metadata or other database information)
- `SET` commands (to modify the `isql` environment)
- Other commands (for example, commands to read an input file, write to an output file, or end an `isql` session)

Some `isql` commands have many options. See isql Command Reference

5.5.1. SHOW Commands

`SHOW` commands are used to display metadata, including tables, indexes, procedures, and triggers.

`SHOW` commands list all of the specified objects or give information about a particular object when used with **<name.>**

`SHOW` commands operate on a separate transaction from user statements. They run as `READ COMMITTED` background statements and acknowledge all metadata changes immediately.

5.5.2. SET Commands

`SET` commands enable you to view and change the `isql` environment.

5.5.3. Other isql Commands

The remaining `isql` commands perform a variety of useful tasks, including reading a SQL file, executing shell commands, and exiting `isql`. The other `isql` commands are: `BLOBDUMP`, `EDIT`, `EXIT`, `HELP`, `INPUT`, `OUTPUT`, `QUIT`, `SHELL`.

5.5.4. QUIT and EXIT Commands

To exit the `isql` utility and roll back all uncommitted work, enter:

```
SQL> QUIT;
```

To exit the `isql` utility and commit all work, enter:

```
SQL> EXIT;
```

5.6. Error Handling in isql

InterBase handles errors in `isql` and DSQL in the same way. To indicate the causes of an error, `isql` uses the `SQLCODE` variable and the InterBase status array.

The following table lists values that are returned to `SQLCODE`:

SQLCODE	Message	Meaning
< 0	`SQLERROR`	Error occurred; statement did not execute
0	`SUCCESS`	Successful execution
+1–99	`SQLWARNING`	System warning or informational message
+100	`NOT FOUND`	No qualifying rows found, or end of current active set of rows reached

For a detailed discussion of error handling, see the Embedded SQL Guide. For a complete listing of `SQLCODE` and InterBase status array codes, see the *Language Reference* Guide.

6. isql Command Reference

This page lists the special commands available in InterBase `isql`. These commands are also available in SQL scripts. Each command has a corresponding topic page, which contains the syntax and a detailed description of the command.

For a list of the standard DSQL commands available in `isql`, see Statement and Function Reference in the Language Reference Guide.

`isql` supports the following special commands:

Command	Topic
BLOBDUMP	BLOBDUMP
EDIT	EDIT
EXIT	EXIT
HELP	HELP
INPUT	INPUT
OUTPUT	OUTPUT
QUIT	QUIT
RECONNECT	RECONNECT
SET	SET
SET AUTODDL	SET AUTODDL
SET BLOBDISPLAY	SET BLOBDISPLAY
SET COUNT	SET COUNT
SET ECHO	SET ECHO
SET LIST	SET LIST
SET NAMES	SET NAMES

Command	Topic
SET PLAN	SET PLAN
SET STATS	SET STATS
SET TERM	SET TERM
SET TIME	SET TIME
SET SUBSCRIPTION	SET SUBSCRIPTION
SHELL	SHELL
SHOW CHECK	SHOW CHECK
SHOW DATABASE	SHOW DATABASE
SHOW DOMAINS	SHOW DOMAINS
SHOW EXCEPTIONS	SHOW EXCEPTIONS
SHOW FILTERS	SHOW FILTERS
SHOW FUNCTIONS	SHOW FUNCTIONS
SHOW GENERATORS	SHOW GENERATORS
SHOW GRANT	SHOW GRANT
SHOW INDEX	SHOW INDEX
SHOW INDICES	SHOW INDEX

Command	Topic
SHOW PROCEDURES	SHOW PROCEDURES
SHOW ROLES	SHOW ROLES
SHOW SUBSCRIPTION SHOW SUBSCRIPTIONS	SHOW SUBSCRIPTION
SHOW SYSTEM	SHOW SYSTEM
SHOW TABLES	SHOW TABLES
SHOW TRIGGERS	SHOW TRIGGERS
SHOW VERSION	SHOW VERSION
SHOW VIEWS	SHOW VIEWS

See Also

- Statement and Function Reference

6.1. BLOBDUMP

Places the contents of a `BLOB` column in a named file for reading or editing.

```
BLOBDUMP blob_id filename;
```

Argument	Description
<blob_id>	System-assigned hexadecimal identifier, made up of two hexadecimal numbers separated by a colon (:) • First number is the ID of the table containing the `BLOB` column • Second number is a sequential number identifying a particular instance of Blob data
<filename>	Name of the file into which to place Blob contents

Description: `BLOBDUMP` stores Blob data identified by **<blob_id>** in the file specified by **<filename>**. Because binary files cannot be displayed, `BLOBDUMP` is useful for viewing or editing binary data. `BLOBDUMP` is also useful for saving blocks of text (Blob data) to a file.

To determine the blob_id to supply in the `BLOBDUMP` statement, issue any `SELECT` statement that selects a column of Blob data. When the table's columns appear, any Blob columns contain hexadecimal Blob IDs. The display of Blob output can be controlled using `SET BLOBDISPLAY`.

Example: Suppose that Blob ID 58:c59 refers to graphical data in JPEG format. To place this Blob data into a graphics file named `picture.jpg`, enter:

```
BLOBDUMP 58:c59 picture.jpg;
```

See Also

- SET BLOBDISPLAY

6.2. EDIT

Allows editing and re-execution of `isql` commands.

```
EDIT [filename];
```

Argument	Description
<filename>	Name of the file to edit

Description: The `EDIT` command enables you to edit commands in:

- A source file and then execute the commands upon exiting the editor.
- The current `isql` session, then re-execute them.

On Windows platforms, `EDIT` calls the text editor specified by the `EDITOR` environment variable. If this environment variable is not defined, then `EDIT` uses the Microsoft Notepad editor.

On UNIX, `EDIT` calls the text editor specified by either the `VISUAL` environment variable or `EDITOR`, in that order. If neither variable is defined, then `EDIT` uses the `vi` editor.

If given filename as an argument, `EDIT` places the contents of filename in an edit buffer. If no file name is given, `EDIT` places the commands in the current isql session in the edit buffer.

After exiting the editor, isql automatically executes the commands in the edit buffer.

Filenames with spaces You can optionally delimit the filename with double or single quotes. This allows you to use filenames with spaces in `EDIT` statements.

Examples: To edit the commands in a file called `start.sql` and execute the commands when done, enter:

```
EDIT START.SQL;
```

In the next example, a user wants to enter `SELECT DISTINCT JOB_CODE, JOB_TITLE FROM JOB;` interactively: Instead, the user mistakenly omits the `DISTINCT` keyword. Issuing the `EDIT` command opens the statement in an editor and then executes the edited statement when the editor exits.

```
SELECT JOB_CODE, JOB_TITLE FROM JOB;
EDIT;
```

See Also

- INPUT
- OUTPUT
- SHELL

6.3. EXIT

Commits the current transaction, closes the database, and ends the `isql` session.

```
EXIT;
```

Description: Both `EXIT` and `QUIT` close the database and end an `isql` session. `EXIT` commits any changes made since the last `COMMIT` or `ROLLBACK`, whereas `QUIT` rolls them back.

`EXIT` is equivalent to the end-of-file character, which differs across systems.

Important:
`EXIT` commits changes without prompting for confirmation. Before using `EXIT`, be sure that no transactions need to be rolled back.

See Also

- QUIT
- SET AUTODDL

6.4. HELP

Displays a list of isql commands and short descriptions.

```
HELP;
```

Description: `HELP` lists the built-in `isql` commands, with a brief description of each.

Example: To save the `HELP` screen to a file named `isqlhelp.lst`, enter:

```
OUTPUT isqlhelp.lst;
HELP;
OUTPUT;
```

After issuing the `HELP` command, use `OUTPUT` to redirect output back to the screen.

6.5. INPUT

Read and execute commands from the named file.

```
INPUT filename;
```

Argument	Description
<filename>	Name of the file containing SQL statements and SQL commands

Description: `INPUT` reads commands from **<filename>** and executes them as a block. In this way, `INPUT` enables execution of commands without prompting. **<filename>** must contain SQL statements or `isql` commands.

Input files can contain their own `INPUT` commands. Nesting `INPUT` commands enables `isql` to process multiple files. When `isql` reaches the end of one file, processing returns to the previous file until all commands are executed.

The `INPUT` command is intended for noninteractive use. Therefore, the `EDIT` command does not work in input files.

Using `INPUT` **<filename>** from within an `isql` session has the same effect as using `-input filename` from the command line.

Unless output is redirected using `OUTPUT`, any results returned by executing filename appear on the screen.

You can optionally delimit the filename with double or single quotes. This allows you to use filenames with spaces in `INPUT` statements.

Examples: For this example, suppose that file `add.lst` contains the following `INSERT` statement:

```
INSERT INTO COUNTRY (COUNTRY, CURRENCY)
VALUES ('Mexico', 'Peso');
```

To execute the command stored in `add.lst`, enter:

```
INPUT add.lst;
```

For the next example, suppose that the file, `table.lst`, contains the following `SHOW` commands:

```
SHOW TABLE COUNTRY;
SHOW TABLE CUSTOMER;
SHOW TABLE DEPARTMENT;
SHOW TABLE EMPLOYEE;
SHOW TABLE EMPLOYEE_PROJECT;
SHOW TABLE JOB;
```

To execute these commands, enter:

```
INPUT table.lst;
```

To record each command and store its results in a file named `table.out`, enter

```
SET ECHO ON;
OUTPUT table.out;
INPUT table.lst;
OUTPUT;
```

See Also

- OUTPUT

6.6. OUTPUT

Redirects output to the named file or to standard output.

```
OUTPUT [filename];
```

Argument	Description
<filename>	Name of the file in which to save output; if no file name is given, results appear on the standard output

Description: `OUTPUT` determines where the results of `isql` commands are displayed. By default, results are displayed on standard output (usually a screen). To store results in a file, supply a **<filename>** argument. To return to the default mode, again displaying results on the standard output, use `OUTPUT` without specifying a file name.

By default, only data is redirected. Interactive commands are not redirected unless `SET ECHO` is in effect. If `SET ECHO` is in effect, `isql` displays each command before it is executed. In this way, `isql` captures both the results and the command that produced them. `SET ECHO` is useful for displaying the text of a query immediately before the results.

Note:
Error messages cannot be redirected to an output file.

Using `OUTPUT` **<filename>** from within an `isql` session has the same effect as using the option - `output filename` from the command line.

You can optionally delimit the filename with double or single quotes. This allows you to use filenames with spaces in `OUTPUT` statements.

Example: The following example stores the results of one `SELECT` statement in the file, `sales.out`. Normal output processing resumes after the `SELECT` statement.

```
OUTPUT sales.out;
SELECT * FROM SALES;
OUTPUT;
```

See Also

- INPUT
- SET ECHO

6.7. QUIT

Rolls back the current transaction, closes the database, and ends the `isql` session.

```
QUIT;
```

Description: Both `EXIT` and `QUIT` close the database and end an `isql` session. `QUIT` rolls back any changes made since the last `COMMIT` or `ROLLBACK`, whereas `EXIT` commits the changes.

Important:
`QUIT` rolls back uncommitted changes without prompting for confirmation. Before using `QUIT`, be sure that any changes that need to be committed are committed. For example, if `SET AUTODDL` is off, DDL statements must be committed explicitly.

See Also

- EXIT
- SET AUTODDL

6.8. SET

Lists the status of the features that control an `isql` session.

```
SET;
```

Description: `isql` provides several `SET` commands for specifying how data is displayed or how other commands are processed.

The SET command, by itself, verifies which features are currently set. Some `SET` commands turn a feature on or off. Other `SET` commands assign values.

Many `isql` `SET` commands have corresponding SQL statements that provide similar or identical functionality. In addition, some of the `isql` features controlled by `SET` commands can also be controlled using `isql` command-line options. `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 are restored.

The `isql` `SET` statements are:

Statement	Description	Default
`SET AUTODDL`	Toggles the commit feature for DDL statements.	ON

Statement	Description	Default
`SET BLOBDISPLAY <n>`	Turns on the display of Blob type <n>; the parameter <n> is required to display Blob types.	OFF
`SET COUNT`	Toggles the count of selected rows on or off.	OFF
`SET ECHO`	Toggles the display of each command on or off.	OFF
`SET LIST <string>`	Displays columns vertically or horizontally.	OFF
`SET NAMES`	Specifies the active character set.	OFF
`SET PLAN`	Specifies whether or not to display the query plan of the optimizer.	OFF
`SET STATS`	Toggles the display of performance statistics on or off.	OFF
`SET TERM <string>`	Allows you to change to an alternate terminator character (deprecated in InterBase 7 and later).	;
`SET TIME`	Toggles display of time in `DATE` values.	ON

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.

`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 are restored 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.

Notes:

- You cannot enter `isql` `SET` statements interactively in the SQL Statement area of IBConsole isql. You can perform the same functions with menu items.
- `SET GENERATOR` and `SET TRANSACTION` (without a transaction name) are DSQL statements and so you can enter them interactively in IBConsole isql or `isql`. These statements are not exclusively `isql` statements, so they are not documented in this chapter. See the Language Reference Guide for details.
- `SET DATABASE` is exclusively an embedded SQL statement. See the Language Reference Guide and the Embedded SQL Guide for details.

Example: To display the `isql` features currently in effect, enter:

```
SET;
Print statistics: OFF
Echo commands: OFF
List format: OFF
Row count: OFF
Autocommit DDL: OFF
Access plan: OFF
Display BLOB type: 1
Terminator: ;
Time: OFF
```

The output shows that `isql` is set to not echo commands, to display Blob data if they are of subtype 1 (text), to automatically commit DDL statements, and to recognize a semicolon (**;**) as the statement termination character.

See Also

- SET AUTODDL
- SET BLOBDISPLAY
- SET COUNT
- SET ECHO
- SET LIST
- SET NAMES
- SET PLAN
- SET STATS
- SET TIME

6.9. SET AUTODDL

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

```
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 that turns off AUTODDL , 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. No table is created. because its creation was rolled back.

The next script uses the default AUTODDL 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.

See Also

- EXIT
- QUIT

6.10. SET BLOBDISPLAY

Specifies subtype of Blob data to display.

```
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 for Blob data of a text subtype [default] • Use other integer values for other subtypes
ALL	Displays Blob data of all subtypes
OFF	Turns 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

6.11. SET COUNT

Specifies whether to display number of rows retrieved by queries.

```
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 example 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
```

6.12. SET ECHO

Specifies whether commands are displayed to the `isql` output area before being executed.

```
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 can 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 IBConsole isql:

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

The output (in a file or the `isql` output area) looks 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

6.13. SET LIST

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

```
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 is:

```
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 is:

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

6.14. SET NAMES

Specifies the active character set to use in database transactions.

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

Argument	Description
<charset>	Name of the active character set; default is 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 'jupiter:/usr/InterBase/examples/employee.ib';
. . .
```

See Also

- Command-line Options

6.15. SET PLAN

Specifies whether to display the optimizer's query plan.

```
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 that 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
```

6.16. SET STATS

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

```
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

6.17. SET TIME

Specifies whether to display the time portion of a DATE value.

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

Argument	Description
`ON`	Turns on display of time in `DATE` value.

Argument	Description
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.

Tip:
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
```

6.18. SHELL

Allows execution of an operating system command or temporary access to an operating system shell.

```
SHELL [os_command];
```

Argument	Description
<os_command>	An operating system command; if no command is specified, isql provides interactive access to the operating system

Description: The `SHELL` command provides temporary access to operating system commands in an `isql` session. Use `SHELL` to execute an operating-system command without ending the current `isql` session.

If **<os_command>** is specified, the operating system executes the command and then returns to `isql` when complete.

If no command is specified, an operating system shell prompt appears, enabling you to execute a sequence of commands. To return to `isql`, type `exit`. For example, `SHELL` can be used to edit an input file and run it at a later time. By contrast, if an input file is edited using the `EDIT` command, the input file is executed as soon as the editing session ends.

Using `SHELL` does not commit transactions before it calls the shell.

This `isql` statement has no equivalent function in IBConsole isql.

Example: The following example uses `SHELL` to display the contents of the current directory:

```
SHELL DIR;
```

See Also

- EDIT

6.19. SHOW CHECK

Displays all `CHECK` constraints defined for a specified table.

```
SHOW CHECK table;
```

Argument	Description
<table>	Name of an existing table in the current database

Description: `SHOW CHECK` displays `CHECK` constraints for a named table in the current database. Only user-defined metadata is displayed. To see a list of existing tables, use `SHOW TABLE`.

Example: The following example shows `CHECK` constraints defined for the `JOB` table. The `SHOW TABLES` command is used first to display a list of available tables.

```
SHOW TABLES;
COUNTRY CUSTOMER
```

```
DEPARTMENT EMPLOYEE
EMPLOYEE_PROJECT JOB
PHONE_LIST PROJECT
PROJ_DEPT_BUDGET SALARY_HISTORY
SALES

SHOW CHECK JOB;
CHECK (min_salary < max_salary)
```

See Also

- SHOW TABLES

6.20. SHOW DATABASE

Displays information about the current database.

```
SHOW [DATABASE | DB];
```

Description: `SHOW DATABASE` displays the current database's file name, page size and allocation, and sweep interval.

The output of `SHOW DATABASE` is used to verify data definition or to administer the database. For example, use the backup and restore utilities to change page size or reallocate pages among multiple files, and use the database maintenance utility to change the sweep interval.

`SHOW DATABASE` has a shorthand equivalent, `SHOW DB`.

Example: The following example connects to a database and displays information about it:

```
CONNECT 'employee.ib';
Database: employee.ib

SHOW DB;
Database: employee.ib
Owner: SYSDBA
PAGE_SIZE 4096
Number of DB pages allocated = 422
Sweep interval = 20000
```

6.21. SHOW DOMAINS

Lists all domains or displays information about a specified domain.

```
SHOW {DOMAINS | DOMAIN name};
```

Argument	Description
<name>	Name of an existing domain in the current database

Options: To see a list of existing domains, use `SHOW DOMAINS` without specifying a domain name. `SHOW DOMAIN` name displays information about the named domain in the current database. Output includes a domain's data type, default value, and any `CHECK` constraints defined. Only user-defined metadata is displayed.

Example: The following example lists all domains and then shows the definition of the domain, `SALARY`:

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

SHOW DOMAIN SALARY;
SALARY NUMERIC(15, 2) Nullable
DEFAULT 0
CHECK (VALUE > 0)
```

6.22. SHOW EXCEPTIONS

Lists all exceptions or displays the text of a specified exception.

```
SHOW {EXCEPTIONS | EXCEPTION name};
```

Argument	Description
<name>	Name of an existing exception in the current database

Description: `SHOW EXCEPTIONS` displays an alphabetical list of exceptions. `SHOW EXCEPTION` name displays the text of the named exception.

Examples: To list all exceptions defined for the current database, enter:

```
SHOW EXCEPTIONS;
Exception Name Used by, Type
```

```
================= ======================================
UNKNOWN_EMP_ID ADD_EMP_PROJ, Stored procedure
Invalid employee number or project ID.
. . .
```

To list the message for a specific exception and the procedures or triggers that use it, enter the exception name:

```
SHOW EXCEPTION CUSTOMER_CHECK;
Exception Name                  Used by, Type
==========================  ======================================
CUSTOMER_CHECK               SHIP_ORDER, Stored procedure
Overdue balance -- can't ship.
```

6.23. SHOW FILTERS

Lists all Blob filters or displays information about a specified filter.

```
SHOW {FILTERS | FILTER name};
```

Argument	Description
<name>	Name of an existing Blob filter in the current database

Options: To see a list of existing filters, use `SHOW FILTERS`. `SHOW FILTER` name displays information about the named filter in the current database. Output includes information previously defined by the `DECLARE FILTER` statement, the input subtype, output subtype, module (or library) name, and entry point name.

Example: The following example lists all filters and then shows the definition of the filter, `DESC_FILTER`:

```
SHOW FILTERS;
DESC_FILTER

SHOW FILTER DESC_FILTER;
BLOB Filter: DESC_FILTER
Input subtype: 1 Output subtype -4
Filter library is: desc_filter
Entry point is: FILTERLIB
```

6.24. SHOW FUNCTIONS

Lists all user-defined functions (UDFs) defined in the database or displays information about a specified UDF.

```
SHOW {FUNCTIONS | FUNCTION name};
```

Argument	Description
<name>	Name of an existing UDF in the current database

Options: To see a list of existing functions defined in the database, use `SHOW FUNCTIONS`. To display information about a specific function in the current database, use `SHOW FUNCTION` **<function_name>**. Output includes information previously defined by the `DECLARE EXTERNAL FUNCTION` statement: the name of the function and function library, the name of the entry point, and the data types of return values and input arguments.

Example: The following `UNIX` example lists all UDFs and then shows the definition of the `MAXNUM()` function:

```
SHOW FUNCTIONS;
ABS MAXNUM
TIME UPPER_NON_C
UPPER

SHOW FUNCTION maxnum;
Function MAXNUM:
Function library is /usr/InterBase/lib/gdsfunc.so
Entry point is FN_MAX
Returns BY VALUE DOUBLE PRECISION
Argument 1: DOUBLE PRECISION
Argument 2: DOUBLE PRECISION
```

6.25. SHOW GENERATORS

Lists all generators or displays information about a specified generator.

```
SHOW {GENERATORS | GENERATOR name};
```

Argument	Description
<name>	Name of an existing generator in the current database

Description: To see a list of existing generators, use `SHOW GENERATORS`. `SHOW GENERATOR` name displays information about the named generator in the current database. Output includes the name of the generator and its next value.

`SHOW GENERATOR` has a shorthand equivalent, `SHOW GEN`.

Example: The following example lists all generators and then shows information about `EMP_NO_GEN`:

```
SHOW GENERATORS;
Generator EMP_NO_GEN, Next value: 146
Generator CUST_NO_GEN, Next value: 1016

SHOW GENERATOR EMP_NO_GEN;
Generator EMP_NO_GEN, Next value: 146
```

6.26. SHOW GRANT

Displays privileges for a database object.

```
SHOW GRANT object;
```

Argument	Description
<object>	Name of an existing table, view, or procedure in the current database

Description: `SHOW GRANT` displays the privileges defined for a specified table, view, or procedure. Allowed privileges are `DELETE`, `EXECUTE`, `INSERT`, `SELECT`, `UPDATE`, or `ALL`. To change privileges, use the SQL statements `GRANT` or `REVOKE`.

Before using `SHOW GRANT`, you might want to list the available database objects. Use `SHOW PROCEDURES` to list existing procedures; use `SHOW TABLES` to list existing tables; use `SHOW VIEWS` to list existing views.

Example: To display `GRANT` privileges on the JOB table, enter:

```
SHOW GRANT JOB;
GRANT SELECT ON JOB TO ALL
GRANT DELETE, INSERT, SELECT, UPDATE ON JOB TO MANAGER
```

`SHOW GRANT` can also show role membership:

```
SHOW GRANT DOITALL;
GRANT DOITALL TO SOCKS
```

See Also

- SHOW PROCEDURES
- SHOW TABLES
- SHOW VIEWS

6.27. SHOW INDEX

Displays index information for a specified index, for a specified table, or for all tables in the current database.

```
SHOW {INDICES | INDEX {index | table} };
```

Argument	Description
<index>	Name of an existing index in the current database
<table>	Name of an existing table in the current database

Description: `SHOW INDEX` displays the index name, the index type (for example, `UNIQUE` or `DESC`), and the columns on which an index is defined.

If the index argument is specified, `SHOW INDEX` displays information only for that index. If table is specified, `SHOW INDEX` displays information for all indexes in the named table; to display existing tables, use `SHOW TABLES`. If no argument is specified, `SHOW INDEX` displays information for all indexes in the current database.

`SHOW INDEX` has a shorthand equivalent, `SHOW IND`. `SHOW INDICES` is also a synonym for `SHOW INDEX`. `SHOW INDEXES` is not supported.

Examples: To display indexes for database `employee.ib`, enter:

```
SHOW INDEX;
RDB$PRIMARY1 UNIQUE INDEX ON COUNTRY(COUNTRY)
CUSTNAMEX INDEX ON CUSTOMER(CUSTOMER)
CUSTREGION INDEX ON CUSTOMER(COUNTRY, CITY)
RDB$FOREIGN23 INDEX ON CUSTOMER(COUNTRY)
. . .
```

To display index information for the `SALES` table, enter:

```
SHOW IND SALES;
NEEDX INDEX ON SALES(DATE_NEEDED)
QTYX DESCENDING INDEX ON SALES(ITEM_TYPE, QTY_ORDERED)
RDB$FOREIGN25 INDEX ON SALES(CUST_NO)
RDB$FOREIGN26 INDEX ON SALES(SALES_REP)
RDB$PRIMARY24 UNIQUE INDEX ON SALES(PO_NUMBER)
SALESTATX INDEX ON SALES(ORDER_STATUS, PAID)
```

See Also

- SHOW TABLES

6.28. SHOW PROCEDURES

Lists all procedures or displays the text of a specified procedure.

```
SHOW {PROCEDURES | PROCEDURE name};
```

Argument	Description
<name>	Name of an existing procedure in the current database

Description: `SHOW PROCEDURES` displays an alphabetical list of procedures, along with the database objects they depend on. Deleting a database object that has a dependent procedure is not allowed. To avoid an `isql` error, delete the procedure (using `DROP PROCEDURE`) before deleting the database object.

`SHOW PROCEDURE` name displays the text and parameters of the named procedure.

`SHOW PROCEDURE` has a shorthand equivalent, `SHOW PROC`.

Examples: To list all procedures defined for the current database, enter:

```
SHOW PROCEDURES;
Procedure Name    Dependency             Type
================= ====================== =======
ADD_EMP_PROJ      EMPLOYEE_PROJECT     Table
                  UNKNOWN_EMP_ID       Exception
DELETE_EMPLOYEE   DEPARTMENT           Table
                  EMPLOYEE             Table
                  EMPLOYEE_PROJECT     Table
                  PROJECT              Table
                  REASSIGN_SALES       Exception
                  SALARY_HISTORY       Table
                  SALES                Table
DEPT_BUDGET       DEPARTMENT           Table
                  DEPT_BUDGET          Procedure
. . .
```

To display the text of the procedure, `ADD_EMP_PROJ`, enter:

```
SHOW PROC ADD_EMP_PROJ;
Procedure text:
============================================================
```

```
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
==============================================================
Parameters:
EMP_NO INPUT SMALLINT
PROJ_ID INPUT CHAR(5)
```

6.29. SHOW ROLES

Displays the names of SQL roles for the current database.

```
SHOW {ROLES | ROLE}
```

Description: `SHOW ROLES` displays the names of all roles defined for the current database. To show user membership in roles, use `SHOW GRANT` **<rolename>**.

Example:

```
SHOW ROLES;

DOITALL DONOTHING
DOONETHING DOSOMETHING
```

See Also

- SHOW GRANT

6.30. SHOW SYSTEM

Displays the names of system tables and system views for the current database.

```
SHOW SYSTEM [TABLES];
```

Description: `SHOW SYSTEM` lists system tables and system views in the current database. `SHOW SYSTEM` accepts an optional keyword, `TABLES`, which does not affect the behavior of the command.

`SHOW SYSTEM` has a shorthand equivalent, `SHOW SYS`.

Example: To list system tables and system views for the current database, enter:

```
SHOW SYS;
RDB$CHARACTER_SETS RDB$CHECK_CONSTRAINTS
RDB$COLLATIONS RDB$DATABASE
RDB$DEPENDENCIES RDB$EXCEPTIONS
RDB$FIELDS RDB$FIELD_DIMENSIONS
RDB$FILES RDB$FILTERS
RDB$FORMATS RDB$FUNCTIONS
RDB$FUNCTION_ARGUMENTS RDB$GENERATORS
RDB$INDEX_SEGMENTS RDB$INDICES
RDB$LOG_FILES RDB$PAGES
RDB$PROCEDURES RDB$PROCEDURE_PARAMETERS
RDB$REF_CONSTRAINTS RDB$RELATIONS
RDB$RELATION_CONSTRAINTS RDB$RELATION_FIELDS
RDB$ROLES RDB$SECURITY_CLASSES
RDB$TRANSACTIONS RDB$TRIGGERS
RDB$TRIGGER_MESSAGES RDB$TYPES
RDB$USER_PRIVILEGES RDB$VIEW_RELATIONS
```

See Also

For more information about system tables, see the *Language Reference*.

6.31. SHOW TABLES

Lists all tables or views, or displays information about a specified table or view.

```
SHOW {TABLES | TABLE name};
```

Argument	Description
<name>	Name of an existing table or view in the current database

Description: `SHOW TABLES` displays an alphabetical list of tables and views in the current database. To determine which listed objects are views rather than tables, use `SHOW VIEWS`.

`SHOW TABLE` name displays information about the named object. If the object is a table, command output lists column names and definitions, `PRIMARY KEY`, `FOREIGN KEY`, and `CHECK` constraints, and triggers. If the object is a view, command output lists column names and definitions, as well as the `SELECT` statement that the view is based on.

Examples: To list all tables or views defined for the current database, enter:

```
SHOW TABLES;
COUNTRY CUSTOMER
DEPARTMENT EMPLOYEE
EMPLOYEE_PROJECT JOB
PHONE_LIST PROJECT
```

```
PROJ_DEPT_BUDGET SALARY_HISTORY
SALES
```

To show the definition for the `COUNTRY` table, enter:

```
SHOW TABLE COUNTRY;
COUNTRY (COUNTRYNAME) CHAR(15) NOT NULL
CURRENCY CHAR(10) NOT NULL
PRIMARY KEY (COUNTRY)
```

See Also

- SHOW VIEWS

6.32. SHOW TRIGGERS

Lists all triggers or displays information about a specified trigger.

```
SHOW {TRIGGERS | TRIGGER name};
```

Argument	Description
<name>	Name of an existing trigger in the current database

Description: `SHOW TRIGGERS` displays all triggers defined in the database, along with the table they depend on. `SHOW TRIGGER` name displays the name, sequence, type, activation status, and definition of the named trigger.

`SHOW TRIGGER` has a shorthand equivalent, `SHOW TRIG` .

Deleting a table that has a dependent trigger is not allowed. To avoid an `isql` error, delete the trigger (using `DROP TRIGGER`) before deleting the table.

Examples: To list all triggers defined for the current database, enter:

```
SHOW TRIGGERS;
Table name  Trigger name
=========== ============
EMPLOYEE    SET_EMP_NO
EMPLOYEE    SAVE_SALARY_CHANGE
CUSTOMER    SET_CUST_NO
SALES       POST_NEW_ORDER
```

To display information about the `SET_CUST_NO` trigger, enter:

```
SHOW TRIG SET_CUST_NO;
Triggers:
SET_CUST_NO, Sequence: 0, Type: BEFORE INSERT, Active
AS
BEGIN
new.cust_no = gen_id(cust_no_gen, 1);
END
```

6.33. SHOW VERSION

Displays information about software versions.

```
SHOW VERSION;
```

Description: `SHOW VERSION` displays the software version of `isql`, the InterBase engine, and the on-disk structure (ODS) of the database to which the session is attached.

Certain tasks might not work as expected if performed on databases that were created using older versions of InterBase. To check the versions of software that are running, use `SHOW VERSION`.

`SHOW VERSION` has a shorthand equivalent, `SHOW VER`.

Example: To display software versions, enter:

```
SQL> SHOW VERSION;
isql Version: WI-V7.0.0.168
InterBase/x86/Windows NT (access method), version "WI-V10.0.0.247"
on disk structure version 11.0
```

See Also

- SHOW DATABASE

6.34. SHOW VIEWS

Lists all views or displays information about a specified view.

```
SHOW
```

{VIEWS | VIEW name};

Argument	Description
<name>	Name of an existing view in the current database

Description: `SHOW VIEWS` displays an alphabetical list of all views in the current database. `SHOW VIEW` name displays information about the named view.

Example: To list all views defined for the current database, enter:

```
SHOW VIEWS;
PHONE_LIST
```

See Also

- SHOW TABLES

7. Using SQL Scripts

The basic steps for using script files are:

1. Create the script file using a text editor.
2. Run the file with `isql` or IBConsole.
3. View output and confirm database changes.

7.1. Creating an isql Script

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

Every SQL script file must begin with either a `CREATE DATABASE` statement or a `CONNECT` statement (including username and password) that specifies the database on which the script file is to operate. The `CONNECT` or `CREATE` statement must contain a complete database file name and directory path.

Note:
You cannot set dialect in a CREATE DATABASE statement. To create a dialect 3 database, specify `isql` option -r 3.

A SQL script can contain any of the following elements:

- SQL statements, as described in the *Language Reference*
- `isql SET` commands as described in this chapter
- Comments.

Each SQL statement in a script must end with a terminator.

Note:
The SQL statement silently fails if significant text follows the terminator character on the same line. Whitespace and comments can safely follow the terminator, but other statements cannot.

Each SQL script file should end with either `EXIT` to commit database changes made since the last `COMMIT`, 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*.

7.2. Running a SQL Script

The following steps execute all the SQL statements in the specified script file. The contents of the script are not displayed in the SQL input area.

7.2.1. To Run a SQL Script Using IBConsole

1. If you are not already in the SQL window, click the Launch SQL toolbar button or choose Tools|Interactive SQL.
2. If you are not running the SQL script on the database to which you are currently connected, then check that the file begins with a valid, uncommented, `CONNECT` or `CREATE DATABASE` statement.
3. Choose Query|Load Script.
4. Enter or locate the desired script filename in the Open dialog, and click Open to load the script into the SQL input area.
5. Click the Execute toolbar button, or choose Query|Execute.

If IBConsole encounters an error, an information dialog appears indicating the error. Once IBConsole finishes executing the script, the script results are displayed in the SQL output window.

After a script executes, all `isql` session settings prior to executing the script are restored as well as the previous database connection, if any. In other words, any `isql SET` commands in the script affect only the `isql` session while the script is running.

7.2.2. To Run a SQL Script Using the Command-line isql Tool

You can run a script from any console prompt using the `-input` option to isql. Specify the full path and filename. In the following example, the script does not contain a `CREATE DATABASE` statement; it runs against an existing database:

```
isql database_name -input filename
```

The following example runs a script that creates a database:

```
isql -input filename
```

During an active `isql` session in which you are already connected to a database, you use the `INPUT` command to read and execute a SQL script against that database:

```
SQL> INPUT filename
```

See Invoking isql for more about running `isql`.

7.3. Committing Work in a SQL Script

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 see changes as soon as each DDL statement is executed. To turn off automatic commit of DDL in a script, use `SET AUTODDL OFF`, or set it in the Query Options dialog. See Using InterBase Manager to Start and Stop InterBase for more information.

Note:
When creating tables and other database objects with `AUTODDL OFF`, it is good practice to put a `COMMIT` statement in the SQL script after each `CREATE` statement or group of related statements. This ensures that other users of the database 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* book.

7.4. Adding Comments in an isql Script

There are two different types of comments that you can use:

1. The **simple comment**: A comment that starts with a special symbol and ends with a new line.

> **Note:**
> The **simple comment** syntax is only available starting with database engine version InterBase 2017.

```
-- comment text
```

2. The **bracketed comment**: A comment that starts and ends with a special symbol. It may be multi-line.

```
/* comment text
more comment text
another line of comment text
*/
```

Regardless of the type of comment that you use, you may start a comment anywhere in a line, but with a simple comment you need to keep in mind that the comment area stops after new line. In order to use the simple comment syntax for a multi-line comment, you need to start each line with the special symbol. For example:

- A multi-line bracketed comment:

```
/* my multi-line
comment is this
text */
```

- A multi-line simple comment:

```
-- my multi-line
-- comment is this
-- text
```

You can place comments on the same line as code, which makes them inline comments.

It is good programming practice to state the input and output parameters of a procedure in a comment preceding the procedure. It is also often useful to comment local variable declarations to indicate what each variable is used for.

Examples The following `isql` samples illustrate some ways to use comments:

```
/*
* Procedure DELETE_EMPLOYEE : Delete an employee.
*
* Parameters:
* employee number
* Returns:
* --
```

```
*/
CREATE PROCEDURE DELETE_EMPLOYEE (EMP_NUM INTEGER)
AS
DECLARE VARIABLE ANY_SALES INTEGER; -- Number of sales for emp.
BEGIN
. . .
```

```
/* This script sets up Change Views Subscriptions
   on the EMPLOYEE table.
*/
CONNECT "emp.ib" user 'SYSDBA' password 'masterkey';
COMMIT;

CREATE SUBSCRIPTION sub ON EMPLOYEE FOR ROW (INSERT, UPDATE, DELETE);
COMMIT;
```

```

-- Create a subscription on Employee table
CREATE SUBSCRIPTION sub1 ON EMPLOYEE FOR ROW (INSERT, UPDATE);
COMMIT;
```

- Simple comment followed by another SLC

```
-- One more comment
CREATE SUBSCRIPTION sub2 ON EMPLOYEE FOR ROW (INSERT);
COMMIT;
```

- Simple comment followed by another SLC with leading whitespace

```

    -- One more comment followed by leading whitespace before CREATE below
CREATE SUBSCRIPTION sub3 ON EMPLOYEE FOR ROW (INSERT, UPDATE, DELETE);
COMMIT;

SHOW SUBSCRIPTIONS;

SELECT COUNT(*)
    -- inline comment 1
    FROM RDB$DATABASE;

SELECT COUNT(*) -- inline comment 2
    FROM RDB$DATABASE;

COMMIT;

SET TERM ^;
```

- Create a stored procedure with inline comments

```
CREATE PROCEDURE test_proc (
  p1 INTEGER, -- Param 1
```

INTERACTIVE QUERY

```
  p2 VARCHAR(68)  -- Param 2
)
RETURNS (op1 INTEGER)   -- Output param
AS
declare variable v1 INTEGER;
declare variable v2 varchar(150); -- Variable 2
BEGIN
  -- sample comment 1
  -- sample comment 2
  -- return input value multiplied by 10
  v1 = p1 * 10;
  op1 = v1;
  SUSPEND;
END^
SET TERM ;^

COMMIT;
SHOW PROCEDURE test_proc;
SELECT op1 from test_proc (2, NULL);
```

DATABASE AND SERVER PERFORMANCE

This chapter describes techniques for designing and operating an InterBase client/server system for best speed and efficiency.

The guidelines in this chapter are organized into the following categories:

- Hardware configuration
- Operating system configuration
- Network configuration
- Database properties
- Database design principles
- Database tuning tasks
- Application design techniques
- Application development tools

1. Introduction to Database and Server Performance

One of the most important requirements for a database as part of your application is to store and retrieve data as quickly as possible. Like any software development technique, there is always more than one method to implement a given specified software solution, and it takes knowledge and experience to choose the design that results in the most efficient operation and the highest performance.

Each project offers unique challenges and requires specific solutions. The suggestions in this chapter augment your own software engineering discipline, which should include careful analysis, testing, and experimentation to implement the best design for your specific project.

2. Hardware Configuration

This section gives guidelines for platform hardware sizing. The suggestions focus on requirements for a server platform.

2.1. Choosing a Processor Speed

The performance of database systems tends by nature to be bound by I/O bandwidth or network bandwidth. An application often waits for I/O or network operations, instead of being computationally intensive. A fast CPU clock speed gives definite performance advantage, but a 10% increase in CPU clock speed is less important for server performance than some other hardware factors, such as RAM configuration, I/O system, or network hardware.

CPU clock speed is often more important on client platforms, because applications that use data might perform CPU-intensive computational analysis on data, or might render sophisticated visualization of data in a computationally costly manner.

It's not appropriate for this document to recommend a specific CPU clock speed for your server, because it is likely that such a recommendation would be obsolete as you read it. You should evaluate the benefit of spending more money on a faster CPU, because the price/performance curve becomes steep for the latest CPU hardware.

2.2. Sizing Memory

It is important to equip your server with a sufficient amount of physical memory to ensure good performance.

While InterBase can function in a low-profile hardware configuration, with as little as 32MB of RAM on most operating systems, it is recommended to have at least 64MB of RAM on a server system. Database servers that experience a high load can benefit from more RAM.

The base RAM requirement of the `ibserver` executable and for each connected user is low: approximately 1500KB, plus 28KB for each client connection. `ibserver` caches metadata and data for each database to which it connects. User operations such as sorting temporarily consume additional memory. A heavily loaded server with dozens of clients performing concurrent queries requires up to 256MB of RAM.

On Windows, you can use the Task Manager, Performance Monitor, and other tools to monitor the resource use of `ibserver`. UNIX and Linux servers have similar resource consumption reporting tools. Add RAM to a system that shows too many page faults.

2.3. Using High-performance I/O Subsystems

A multiuser database server's hard drives are no place to be thrifty, especially in today's market of inexpensive storage. Configuring a relatively high-end I/O system is a cost-effective way to increase performance.

Slow disk subsystems are often the weak link in an otherwise high-performance server machine. The top-rated CPU and maximum memory helps. But if a cheap disk I/O interface limits the data transfer rate, then the money spent on the expensive components is wasted.

It's not appropriate for this document to recommend a particular configuration. The technology changes so quickly that any recommendation here would be outdated. When you specify the machine for a server platform, research the best hardware solution available.

Read the following guidelines for principles:

- Advanced SCSI technology offers superior I/O throughput. The following graph illustrates the relative maximum throughput of different disk interfaces.
- The external interface capacity usually exceeds the internal or sustained transfer rate of any individual device. Only systems that use multiple disk devices make full use of a high-capacity I/O interface.
- Bus-mastering I/O controllers use less CPU resources. This is particularly important on I/O-intensive server machines. SCSI is generally bus-mastering, and newer PCI EIDE interfaces are bus-mastering. IDE is not.
- Use a disk controller with built in cache memory. The controller cache reduces the need for the operating system to use system RAM for disk cache.
- Don't assume all disks of a given size perform equally; research performance ratings made by independent testing labs.

2.4. Distributing I/O

Disk device I/O is orders of magnitude slower than physical memory accesses or CPU cycles. There is a delay while the disk device seeks the data requested. While an application is waiting for data it has requested from a disk device, it is advantageous for the application to spend the time executing other tasks. One appropriate way to do this is to spread multiple data requests over multiple devices. While one disk is preparing to return data, the application requests another disk to start seeking another set of data. This is called *distributed I/O* or *parallel I/O*.

This section describes ways you can persuade InterBase to distribute I/O over multiple disk devices.

2.4.1. Using RAID

You can achieve up to a ten times performance improvement by using RAID.

RAID (redundant array of inexpensive disks) is a hardware design that is intended to give benefits to performance and reliability by storing data on multiple physical disk devices. It is transparent for software applications to use RAID, because it is implemented in the operating system or at the hardware level. InterBase uses operating system I/O interfaces, so InterBase supports RAID as would any other application software.

Disk striping (included in RAID levels 0, 3, or 5) provides performance benefits by distributing I/O across multiple disks.

Hardware RAID is faster than software RAID or software disk mirroring. RAID implemented with software provides only protection from hard disk failure; it is actually slower than operating without RAID.

2.4.2. Using Multiple Disks for Database Files

Similarly to RAID, you can distribute files of a multifile InterBase database among multiple physical disk drives.

For example, if you have a server with four physical disks, `C:`, `D:`, `E:`, and `F:`, and a 10GB database, you can create your database to take advantage of parallel I/O with the following database creation statement:

```
CREATE DATABASE 'C:\data\bigdata1.ib' PAGE_SIZE 4096
FILE 'D:\data\bigdata2.ib' STARTING AT PAGE 1000000
FILE 'E:\data\bigdata3.ib' STARTING AT PAGE 2000000
FILE 'F:\data\bigdata4.ib' STARTING AT PAGE 3000000;
```

2.4.3. Using Multiple Disk Controllers

If you have so much disk activity on multiple disks that you saturate the I/O bus, you should equip the server with multiple disk controllers, and connect the multiple drivers to the controllers as evenly as possible.

For example, if you have sixteen disk devices hosting database files, you might benefit from using four disk controllers, and attaching four disks to each controller.

2.4.4. Making Drives Specialized

A database server makes heavy use of both the virtual memory page file and of temporary disk space of the operating system. If possible, equip the server with multiple disks and configure the virtual memory file, temporary directory, and database files on separate physical disk devices. This can use parallel I/O to the fullest advantage.

For example, on Windows, you could locate the operating system files and `pagefile.sys` on `C:`, the temporary directory and infrequently-used files on `D:`, and database files on drives `E:` and higher.

Change the location of the virtual memory file with:

Control Panel|System|Performance|Virtual Memory.

Change the location of the InterBase temporary directory by either specifying a system environment variable `INTERBASE_TMP`, or editing the `ibconfig` file and specifying the path of the appropriate directory as a value for the `TMP_DIRECTORY` entry.

See Also

- Configuring Sort Files

2.5. Using High-bandwidth Network Systems

For client/server systems, hardware that supports high network bandwidth is as important as I/O capacity. The speed of the network often becomes a bottleneck for performance when many users are making demands on the network simultaneously.

Inexpensive 1000 BASE-T ethernet equipment is common today, but this technology is bare minimum for LAN configuration. It is recommended to use at least 100 Base-T for a high-performance network. The following graph illustrates relative bandwidth rates for various network interface technology.

The maximum bandwidth of gigabit ethernet extends beyond the scale of the graph above.

At the time of this writing, most gigabit ethernet network interface cards (NICs) provide only 600 to 700Mbps bandwidth. Switches, routers, and repeaters also have constrained capacity. It is expected that the state of this technology will continue to improve.

It is recommended that you research reviews and experiment to learn the true throughput of all network hardware in your environment. The slowest component ultimately determines the true throughput.

Tip:
Network cables develop flaws surprisingly frequently. The result can be sporadic lost packets, for which operating systems compensate by automatically resending packets. This translates into mysterious network performance degradation. You should test network cables regularly. Replacing flawed cables is a low-cost way to keep your network running at peak efficiency.

2.6. Using high-performance Bus

Bus is important for both I/O controllers and network interface hardware.

While 32-bit full-duplex PCI bus is capable of up to 264Mbps, PCI cards actually range from 40Mbps to 130Mbps.

Tip:
Use controllers on an integrated local PCI bus, it's faster than peripheral cards that plug into the motherboard.

3. Operating System Configuration

After you have equipped your server hardware appropriately, you should spend time tuning your operating system for server performance.

3.1. Sizing a Temporary Directory

When you configure a temporary directory (see Managing Temporary Files), choose a location that has plenty of free disk space. For some operations such as building an index, InterBase can use a great deal of space for sorting. InterBase can even use an amount of space up to twice the size of your database.

The effects of insufficient temporary space include rapid virtual memory page faults, called *thrashing*, which causes a dramatic performance penalty. Another possible effect is a series of "I/O error" related messages printed to the `interbase.log` file on the server.

3.2. Use a Dedicated Server

Using a server for both workgroup file and print services and as a database server is like letting another user play a video game on your workstation. It detracts from the performance of the workstation, and it is not the intended use for the machine.

Use a secondary server as the file and print server, and a new machine for the database server. Alternately, use the secondary server for InterBase, depending on the relative priority of these tasks – the database server benefits from having a dedicated machine, even if it is not the fastest model available. Whatever is the most important service should be given the best machine as dedicated hardware.

If performance is a high priority, you can spend money more effectively by buying a dedicated machine instead of trying to increase resources such as RAM on a machine that is providing another competing service. Compare the cost of the hardware with the cost of having less than maximum performance.

Similarly, it is best to put a database on a dedicated drive, so that the database I/O does not compete with the operating system virtual memory paging file or other operating system I/O. See Making Drives Specialized.

3.3. Optimizing Windows for Network Applications

It is recommended to set the Windows server to optimize for network applications. Without this setting, you might see the CPU usage of InterBase peak for a few seconds every InterBase server is configured by default to give priority to filesharing services. You can change this configuration on the server: **Control Panel>Network>Services>Server**. In the Optimization panel, choose Optimize Throughput For Network Applications.

This change can result in a dramatic improvement of performance for InterBase, as well as other services.

4. Performance Considerations for a Network Configuration

This section describes performance considerations you should know when configuring a network configuration.

4.1. Choosing a Network Protocol

InterBase supports two protocols: TCP/IP when connecting to any server, and NetBEUI when connecting to a Windows server. See Network Protocols for more details.

4.1.1. NetBEUI

You can use NetBEUI on a network with fewer than 20 users without significant performance costs. Use TCP/IP if you have more active users on your network simultaneously.

NetBEUI is a network protocol designed for use on small local area networks. It is commonly used for filesharing services. It is a connectionless protocol, which means that it broadcasts packets to the entire network. This causes a growing amount of "noise" on a LAN. Noise, from the point of view of any given host, can be defined as network traffic that is not intended for that host. On a LAN with many hosts, enabling NetBEUI can overwhelm the network and reduce the available bandwidth for everyone to use. On most enterprise networks, IT experts discourage the use of NetBEUI.

4.1.2. TCP/IP

TCP/IP is a connection-based protocol, which means packets are routed to the intended recipient. This reduces the saturation of the network and the load on individual hosts. There is effectively more bandwidth available to all hosts, and a large number of hosts can share the same network with less performance penalty.

4.2. Configuring Hostname Lookups

Each host on a TCP/IP network has a designated IP address, and TCP/IP traffic is routed to hosts by address. TCP/IP requires a mechanism for clients to translate hostnames to their numeric addresses. Each client host can store the hostname/address associations in a file called `hosts`. You can alternately store this information on a central server, and the clients then retrieve the information on demand using a protocol called DNS. The client requests that the DNS server resolve a hostname, and the server returns the IP address. Then the client can use the IP address to communicate directly with the intended destination. In this configuration, the client must keep only one IP address locally: that of the DNS server host.

Depending on the load on the network and the DNS server itself, hostname resolution can take several seconds. This translates directly into delays when making a network connection. This is related to the message you might see in a web browser, "Looking up host name..." followed by, "Connecting to host name...". This indicates the delay while querying a DNS server to resolve a hostname.

You can speed up hostname resolution by adding the hostname/address mapping of the database server to the `hosts` file on the client computer. The client can resolve the hostname to its address much faster and more reliably by looking it up in a local file than by querying a service running on another host over the network. This reduces the hostname resolution delay when initiating connections to hosts listed in the local `hosts` file.

Note:
If you use this technique and later change the address of your database server, you must manually update the hosts files on each client workstation. Depending on the number of workstations in your enterprise, this can be tedious and time consuming. That is why DNS was invented, to centralize TCP/IP address administration. The suggestion to keep the database server address in a local file is intended to provide improved connection performance, but you should be aware of the administrative workload that it requires.

Tip:
If you object to the general IP address administration tasks required by using TCP/IP (independently from the DNS issue), consider using DHCP to simplify the task of assigning and tracking IP addresses of each host on the network. InterBase works in a DHCP environment as long as the client host has some means to resolve the IP address of the server correctly at the time a client application requests an InterBase connection.

5. Database Properties

Changing database properties can give an improvement in performance without changing anything in the design of your database. Applications require no change in their coding or design. Property changes are transparent to the client and database design.

5.1. Choosing a Database Page Size

InterBase pages are 4KB by default. A typical production InterBase database gains 25 to 30 percent performance benefit by using this page size, relative to smaller page sizes. This page size results in better performance for the following reasons:

- Fewer record fragments are split across pages

It is common for records to be larger than a single page. This means that InterBase fragments records and stores them on multiple pages. Querying a given record requires multiple page reads from the database.
By increasing the size of a page, InterBase can reduce the number of multiple page reads and can store record fragments more contiguously.

- Index B-trees are more shallow

Indexes are B-trees of pointers to data pages containing instances of specific indexed values. If the index B-tree is larger than one page, InterBase allocates additional database pages for the index tree. If the index pages are larger, InterBase needs fewer additional pages to store the pointers. It is easier for the database cache to store the entire B-tree in memory, and indexed lookups are much faster.

- I/O is more contiguous

It is fairly likely for a query to request successive records in a table. For example, this is done during a table scan, or query that returns or aggregates all records in a table. InterBase stores records on the first page that is unused, rather than ensuring that they are stored near each other in the file. Doing a table scan can potentially require retrieval of data by seeking all over the database. Seeks take time just as reading data takes time.
Any given page can store records from only one table. This indicates that a larger page is certain to contain more data from the same table, and therefore reading that page returns more relevant data.

- Default number of cache buffers is a larger amount of memory

InterBase allocates the database cache in number of pages, rather than a fixed number of bytes. Therefore defining a larger page size increases the cache size. A larger cache is more likely to have a better hit rate than a smaller cache.

- Most operating systems perform low-level I/O in 4096 byte blocks

InterBase performs a page read or write at the OS level by reading in 4096 byte increments regardless of the size of the database page. Therefore, by defining the database with a page size of 4096, the database I/O matches the low-level I/O and this results in greater efficiency when reading and writing pages.

Although 4KB seems to be the best page size for most databases, the optimal size depends on the structure of the specific metadata and the way in which applications access the data. For this reason, you should not consider the 4KB page size guideline to be a magic value. Instead, you should perform testing with your application and database under several different page sizes to analyze which configuration gives the best performance.

5.2. Setting the Database Page Fill Ratio

Data pages store multiple versions of data records, as applications update data. When a database is restored, the `gbak` utility fills pages with data only up to 80 percent of the capacity of each page, to leave space for new record version deltas to be stored, hopefully on the same page with the original record. But in a database that is used mostly for reading data rather than updating it, applications never benefit from this 80 percent fill ratio. In this case, it makes sense to restore data using the full capacity of each page. By storing 25 percent more data on each page, it reduces the amount of record fragmentation and increases the amount of data returned in each page read. You can specify the option to use all the space of every page for storing data during a database restore using the command:

```
gbak -c -use_all_space backup_file.ibk database_file.ib
```

5.3. Sizing Database Cache Buffers

InterBase maintains a cache in the server's RAM of database pages currently in use. If you have a highly active database, you can gain some performance benefit by raising the default cache from its default of 2048 database pages. As with any cache system, at some point you find diminishing returns. Some experimentation with your particular application and database reveals that point.

See Configuring the Database Cache for details about server cache settings.

The `ibserver` process running on an InterBase server maintains a cache in memory of recently used data and index pages. Like any cache, it depends on repeated use of data on a given page to help speed up subsequent access. In InterBase SuperServer implementations, the cache is shared by all clients connected to the database.

By default, InterBase allocates enough memory for 2048 pages per database. If the page size of the current database is 4KB, then `ibserver` uses 8MB of memory. If the page size is 8KB, then `ibserver` uses 16MB of RAM for cache. The InterBase API provides a method for any individual client to request that the size of the cache be higher. You can set a property on an individual database that establishes a different default cache size when any client connects to that database:

```
gfix -buffers 5000 database.ib
```

The default of 2048 assumes that the server has a sufficient memory configuration to allocate for 8MB of RAM per database. If memory is less plentiful on your server, or you have many databases that require simultaneous access, you might need to reduce the default number of cache buffers.

It is highly recommended to increase the cache size for a database if you have enough memory to accommodate it. Consider the following points:

- It is not useful to raise the cache size so high that the memory used by `ibserver` starts to page into virtual memory. That defeats the benefit of caching data from disk in memory.
- It is not useful to raise the cache size higher than the number of pages in the database (which you can view with View Database Statistics in IBConsole, or with the `gstat` command-line program). There is no benefit to this, since any given page from disk occupies only one page in the cache, and is not duplicated.
- One block of memory is allocated for cache per database. If a client connects to two separate databases on one server, the `ibserver` process maintains two separate cache areas of memory. For example, if `database1.ib` has a default cache size of 8000 pages of 4KB each, and `database2.ib` has a default cache size of 10,000 pages of 2KB each, then while both databases have at least one connection, `ibserver` allocates a total of 32MB + 20MB of RAM.

You should experiment with larger cache sizes and analyze the performance improvements. At some point, you will observe diminishing returns. A typical application can achieve up to 30% performance increase from proper cache sizing.

See Also

- Various InterBase Limits

5.4. Buffering Database Writes

InterBase on Windows platforms implements a *write-through* cache by default. Every write operation to a page in cache is immediately written out to the disk I/O of the operating system, which itself might have a cache.

By contrast, a *write-back* cache defers flushing of the contents of a given cache page until a later time. InterBase performs multiple writes to a cache page in RAM before it writes the page out to disk. This results in better response time for the majority of write operations. Write-back cache consolidates I/O efficiently, and therefore it is much faster than write-through cache.

InterBase offers write-back cache as the default on UNIX and Linux, and as an option on Windows platforms. You can configure this at the database level using `gfix -write async` or by disabling forced writes for the database in IBConsole (Database Properties|General tab|Options).

The real benefit of using asynchronous writes (write-back cache) is about four times performance in the typical case. Some users have reported up to 20 times performance improvement from configuring asynchronous writes, in applications that make heavy use of write operations

(`INSERT`, `UPDATE`, `DELETE`). The more writing an application does to the database—including write operations spawned by triggers—the more benefit the application gains.

The risk of asynchronous writes is that data in cache might be lost if the server has a power loss, or if `ibserver` exits abnormally for any reason. Write-through cache protects against data loss, at some performance cost. If you test your server host and client/server application thoroughly and they are not susceptible to crashes, then it is highly recommended to use asynchronous writes.

Tip:
Use an uninterruptible power supply (UPS) to help protect your server against sudden power loss. A modest UPS is inexpensive relative to the cost of losing your data, and easy to install. This can allow you to gain the benefits of the asynchronous I/O mode in safety.

6. Database Design Principles

This section presents guidelines for database design techniques that benefit performance.

6.1. Defining Indexes

Proper use of indexes is an important factor in database performance. Effective policies for defining and maintaining indexes can be the key to a very high performance client/server system. The self-tuning nature of indexes in InterBase greatly benefits performance, but you can gain some additional benefit by periodic maintenance tasks.

6.1.1. What is an Index?

An index in InterBase is a Balanced-Tree data structure stored inside the database file that provides a quick lookup mechanism for the location of specific values in a table. Queries make use of appropriate indexes automatically by means of the cost-based optimizer, which analyzes the tables and columns used in a given query and chooses indexes that speed up the searching, sorting, or joining operations.

Defining indexes for some columns is part of designing a production database. Indexes dramatically improve performance of `SELECT` queries. The greater the number of rows in the table, the greater the benefit of using an index. Intelligently analyzing your database and defining indexes appropriately always improves performance.

Indexes incur a small cost to maintain the index B-tree data structure during `INSERT` and `UPDATE` operations. Because of this cost, it is not recommended to be overly liberal with index definitions. Do not create redundant indexes, and do not make an index on every column as a substitute for database usage analysis.

You should not define an index for columns that have few distinct data values. For example, a column `FISCAL_QUARTER` might have only four distinct values over a potentially very large data set. An index does not provide much benefit for retrieval of data with this kind of distribution of values, and the work required to maintain the index tree might outweigh the benefits.

6.1.2. What Queries Use an Index?

InterBase uses indexes to speed up data fetching for the following query elements:

- Primary and foreign keys
- Join keys
- Sort keys, including `DISTINCT` and `GROUP BY`
- Search criteria (`WHERE`)

In general, you should define indexes on all columns that you use in `JOIN` criteria or as sorting keys in an `ORDER BY` clause. You do not have to define indexes on primary or foreign key columns, because these table constraints implicitly create indexes.

6.1.3. What Queries Don't Use Indexes?

InterBase does not employ an index in the following operations, even if an index exists for the specified columns:

- Search criteria for `CONTAINING` , `LIKE` , and < > inequality operations
- Columns used in aggregate functions, like `COUNT()`
- Other expressions, like `UPPER()`

6.1.4. Directional Indexes

Indexes are defined as either `ASCENDING` or `DESCENDING` . To sort in both directions, you need one index of each type. This is also very important if you are using a scrolling list in a Delphi form, or when using the `TTable.Last` method.

6.2. Normalizing Databases

Design your database with proper normalization of data. Records that have lots of repeating groups of fields are larger than they need to be. Large records can increase the cost of sorting, and also cause records to span more pages than is necessary, resulting in more page fragmentation and needlessly large databases.

Denormalized table design can be more convenient for some types of client applications. You can use InterBase *views* and *stored procedures* to in effect store a denormalized query on the server,

for convenient access from client applications. Meanwhile, the physical storage of the data is kept in a more efficient, normalized form.

See the Data Definition Guide for details on views and stored procedures.

6.3. Choosing Blob Segment Size

A Blob is a data type with an unbounded size. It can be many megabytes in size, much larger than any database interface can handle in a single I/O transfer. Therefore, Blobs are defined as a series of segments of uniform size, and the I/O interface transfers Blobs one segment at a time.

Blobs are a special case because there is a special Blob page type, on which other data types cannot be stored. The data page for a record containing a Blob stores a Blob ID, which indicates which Blob page the Blob is stored on. A Blob is stored on the same page as the primary record version, if it fits. If it does not fit on that page, special pages are allocated for the Blob–as many as are required–and an index is stored on the primary page. Blob pages are never shared; either a Blob is on a normal data page, or it has a page to itself.

It is advantageous to define a Blob with a segment size equal to the page size. If both the page size and the Blob segment size are 4096 bytes, queries of large Blobs can achieve a data transfer rate of up to 20MB per second. InterBase ceases to be any kind of bottleneck in this situation; it is more likely that the hardware I/O bus, the network bandwidth, or the middleware are the limiting factors for throughput.

7. Database Tuning Tasks

This section describes ways you can perform periodic maintenance on your database to keep it running with the best performance.

7.1. Tuning Indexes

Periodic maintenance of indexes can improve their performance benefit. You can write SQL scripts to automate these tasks. See Using SQL Scripts.

7.1.1. Rebuilding Indexes

Periodically, a B-tree data structure might become imbalanced, or it might have some values in the tree that have been deleted from the database (this should not happen in InterBase versions later than 5, due to index garbage collection).

You should periodically rebuild indexes by turning them off and on:

```
ALTER INDEX name INACTIVE;
ALTER INDEX name ACTIVE;
```

7.1.2. Recalculating Index Selectivity

The selectivity of an index is an indicator of its uniqueness. The optimizer uses selectivity in its cost-based analysis algorithm when deciding whether to use a given index in a query execution plan. If the selectivity is out of date and does not accurately represent the state of the index, the optimizer might use or discount the index inappropriately. This does usually not have a great performance penalty unless the selectivity is highly out of date.

You should recalculate the index selectivity if a change to the table affects the average distribution of data values. InterBase calculates index selectivity automatically only when an index is created or activated, or under user request using `SET STATISTICS INDEX <index_name>`. Bulk data updates on the underlying table can put an index selectivity value out of sync with reality.

The ris.sql SQL script helps users recompute index selectivity on demand for various sets of indices via the stored procedure `COMPUTE_INDEX_SELECTIVITY` which recomputes index selectivity for a given range of indices. You can find `ris.sql` on `%ProgramData%\Embarcadero\InterBase\gds_db\examples`. The stored procedure accepts the following parameters:

`index_scope (string)` can accept the following values:

DATABASE - All user indices for the whole database.
TABLE - All indices for a given table name.
INDEX - Just the given index name.
SYSTEM - All system indices except for the ones on `RDB$ENCRYPTIONS`.
Run the following as `SYSDSO` user if you want to reset selectivity on `RDB$ENCRYPTIONS` indices.

```
UPDATE RDB$INDICES SET RDB$STATISTICS = -1.0
WHERE RDB$RELATION_NAME = 'RDB$ENCRYPTIONS'
COMMIT;
```

`entity_name` - Name of the table or index. If you are not using quoted identifier names, make sure you provide the entity name in upper case ASCII. This should be NULL if the `index_scope` specified is database-wide ('DATABASE', or, 'SYSTEM')

Make sure you execute a `COMMIT` after executing the stored procedure.

Limitations

- You need to have database ownership/sysdba rights to execute this procedure for the whole database.

- Since the stored procedure uses EXECUTE STATEMENT, this script can only be used with InterBase XE or later versions.

Examples

- Recompute selectivity for all user indices in the database.

```
EXECUTE PROCEDURE COMPUTE_INDEX_SELECTIVITY ('DATABASE', NULL);
COMMIT;
```

- Recompute selectivity for a particular table. This is useful when a particular table has undergone bulk data insert/update/delete operation.

```
EXECUTE PROCEDURE COMPUTE_INDEX_SELECTIVITY ('TABLE', 'EMPLOYEE');
COMMIT;
```

- Recompute selectivity for a particular index.

```
EXECUTE PROCEDURE COMPUTE_INDEX_SELECTIVITY ('INDEX', 'RDB$PRIMARY2');
COMMIT;
```

- Recompute selectivity for all system indices in the database.

```
EXECUTE PROCEDURE COMPUTE_INDEX_SELECTIVITY ('SYSTEM', NULL);
COMMIT;
```

- SQL to check index selectivity for user indices.

```
select cast (RDB$RELATION_NAME as varchar(32)) AS TABLE_NAME,
       cast (RDB$INDEX_NAME as varchar(32)) AS INDEX_NAME,
       RDB$STATISTICS
  from rdb$indices
 where coalesce (rdb$system_flag, 0) = 0
 order by RDB$STATISTICS;
```

7.2. Performing Regular Backups

There are several performance-related benefits to doing periodic backup and restore of an InterBase database. See About InterBase backup and restore options.

7.2.1. Increasing Backup Performance

- Disable garbage collection if you are just going to replace the database immediately anyway; this can make the backup execute faster.

- Back up to a different disk drive.

7.2.2. Increasing Restore Performance

- Restore from a different disk drive.
- Disable indexes on restore; this makes the restore execute faster, so you have a usable database quickly. You must then have to activate manually the indexes after the restore is complete.

Tip:
Create a SQL script with all the `ALTER INDEX` statements necessary to activate your indexes, and keep that handy. Use it like a batch file with `isql -i script.sql` to help automate this procedure. You can create this script with this query:

```
SELECT 'ALTER INDEX ' || RDB$INDEX_NAME || ' ACTIVE;'
FROM RDB$INDICES
WHERE RDB$SYSTEM_FLAG = 0 OR RDB$SYSTEM_FLAG IS NULL;
```

You can get the database up and restored more quickly, and then activate indexes afterwards. The data is accessible even if the indexes are inactive, but it is slower to query the tables.

7.3. Facilitating Garbage Collection

By default, InterBase databases have a built-in function to automatically sweep old record versions when they become too numerous. However, sweeping is partially inhibited by outstanding active transactions. If the server cannot do complete garbage collection, it has to do extra work to maintain each client's snapshot of the database.

Design your client applications to explicitly start and `COMMIT` transactions promptly, to reduce the number of outstanding transactions.

See Overview of Sweeping for more details on sweeping, garbage collection, and the database snapshot.

8. Application Design Techniques

This section describes general application programming methods for InterBase, that help to create high-performance clients.

8.1. Using Transaction Isolation Modes

InterBase multigenerational architecture requires that any query or other operation be associated with an active transaction. Without a transaction, an operation has no context with which to maintain its snapshot of the database. IBConsole tools do a certain amount of automatic

transaction management, but it is helpful for performance to manually start and finish transactions.

In the InterBase server engine, a snapshot is generated by making a copy of the state of all other transactions in the database. This snapshot is static for the current transaction. This means that any data committed to the database after the snapshot is created is not visible to operations using that snapshot. This is the repeatable read transaction mode. Two identical queries made at different times are guaranteed to get the same result set, even if other clients are updating data in the database.

Starting a transaction and making a snapshot data structure for the new transaction incurs some amount of overhead. This overhead is magnified when using automatic transaction-handling, because the typical automatic transaction behavior is to start a new transaction and commit it for every statement executed against the database.

8.2. Using Correlated Subqueries

Subqueries are `SELECT` statements which are included as a clause or expression within another statement. They are typically used to generate a value or result set that are used in conditions of the superior query.

A correlated subquery is one in which the conditions of the subquery are different for each row in the parent query, because they depend on values that y from row to row. InterBase executes the subquery many times, once for each row in the parent query. Evaluating each row has a large cost in performance relative to a non-correlated subquery. InterBase optimizes non-correlated subqueries out of the loop, executes once, and uses the result as a fixed dataset.

Example as correlated subquery:

```
SELECT * FROM DEPARTMENT D
WHERE EXISTS (SELECT * FROM EMPLOYEE E
WHERE E.EMP_NO = D.MNGR_NO AND E.JOB_COUNTRY = 'England')
```

Example as join:

```
SELECT D.*
FROM DEPARTMENT D JOIN EMPLOYEE E
ON D.MNGR_NO = E.EMP_NO WHERE E.JOB_COUNTRY = 'England'
```

InterBase optimizer executes a non-correlated subquery once, and uses the result set as many times as necessary in the parent query.

Sometimes a correlated subquery is necessary, given the semantics of the SQL language. However, these types of queries should be used with care and with the understanding that their performance is geometric in relation to the size of the dataset on which they operate.

8.3. Preparing Parameterized Queries

Any dynamic SQL (DSQL) statement must go through a cycle of parse, prepare, and execute. You can submit a DSQL statement to go through this process for each invocation, or you can separate the steps. If you have a situation where you execute the same statement multiple times, or the same form of statement with different parameters, you should explicitly prepare the statement once, then execute it as your looping action.

With *parameterized queries*, you can prepare a statement, but defer supplying the specific values for certain elements of the query.

InterBase supports parameterized queries in DSQL, for cases when a given statement is to be executed multiple times with different values. For example, loading a table with data might require a series of INSERT statements with values for each record inserted. Executing parameterized queries has a direct performance benefit, because the InterBase engine keeps the internal representation and optimization of the query after preparing it once.

Use parameterized DSQL queries in Delphi by following these steps:

1. Place a named parameter in the statement with the Delphi `:PARAMETER` syntax. in place of a constant value in a query. InterBase supports parameters in place constants. Tables and column names cannot be parameterized.
2. Prepare the statement. Use the TQuery method `Prepare`. Delphi automatically prepares a query if it is executed without first being prepared. After execution, Delphi unprepares the query. When a query will be executed a number of times, an application should always explicitly prepare the query to avoid multiple and unnecessary prepares and unprepares.
3. Specify parameters. For example, with the TQuery component, use the `ParamByName` method to supply values for each parameter in the query.
4. Execute the statement. `SELECT` statements should use the `Open` method of TQuery. `INSERT`, `UPDATE`, and `DELETE` statements should use the `ExecSQL` method. These methods prepares the statement in SQL property for execution if it has not already been prepared. To speed performance, an application should ordinarily call Prepare before calling `ExecSQL` for the first time.
5. Repeat steps 3 and 4 as needed.
6. Unprepare the query.

In some real-world cases involving repetitive operations, using parameterized queries has increased performance 100%.

8.4. Designing Query Optimization Plans

The *optimization plan* describes the way the optimizer has chosen to execute a query. For certain types of queries, the optimizer might not select the truly optimal plan. A human can analyze different alternate plans and specify a plan overriding the analysis of the optimizer. The result can

be amazing improvements in performance for some types of queries. In some dramatic cases, this has been used to reduce a 15 minute query to three seconds.

The elements of plan selection are:

- Assigning indexes
- Combining indexes
- Determining join order
- Generating rivers
- Cost estimation
- Sort merges

InterBase supports syntax with the `SELECT` expression in embedded SQL and DSQL to allow the user to specify the `PLAN` for a query. The syntax also works with `SELECT` statements in the body of a view, a stored procedure, or a trigger.

It is beyond the scope of this chapter to describe in detail the syntax of the `PLAN` clause for specifying the execution plan, or techniques for analyzing queries manually. The section on `SELECT` in the *Language Reference* includes some examples of using `PLAN`.

8.5. Deferring Index Updates

Inserting and updating data requires indexes to be updated, which can cause performance to suffer during `INSERT` or `UPDATE` operations.

To minimize the performance hit during `INSERT` or `UPDATE` operations, consider temporarily disabling indexes during high-volume `INSERT` operations. Make sure to re-enable the indexes afterwards. This approach only requires the indexes to rebalance once for all the inserted data.

9. Application Development Tools

This section describes ways you can develop applications that are efficient, using various popular development environments and tools.

9.1. InterBase Express™ (IBX)

For more information on IBX refer to Getting Started with InterBase Express.

9.2. IB Objects

for more information on IB Objects refer to `http://www.ibobjects.com`.

9.3. Visual Components

This section describes visual components that developers commonly use in Delphi and C++Builder to access data from InterBase. Follow the recommendations below for better client/server performance.

9.3.1. Understanding Fetch-all Operations

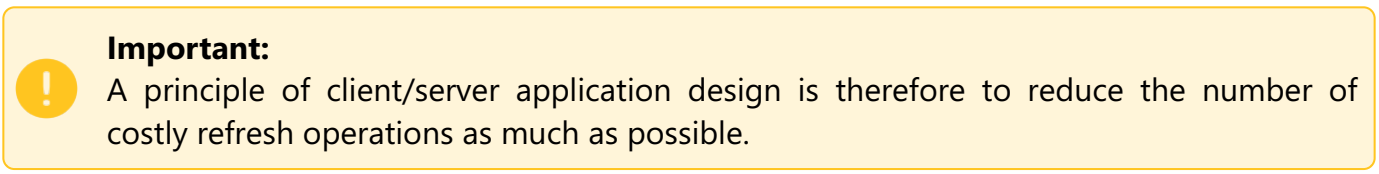
In a client/server configuration, a "fetch-all" is the nadir of performance, because it forces BDE to request that the database generate a dataset again and send it over the network.

InterBase and most relational databases do not keep datasets in cache on the server in case the client requests a refresh. InterBase must execute the SQL query again when the BDE requests a refresh. If the query involves a large quantity of data, or complex joining or sorting operations, it is likely to take a long time to generate the dataset.

It is also costly for the server to transfer a large dataset across a network interface. It is more costly by far than it is for a desktop database like Paradox to return a dataset, because a desktop database typically runs locally to the application

It is often the case that software developers choose to use a relational database like InterBase because they are managing a larger amount of data than a desktop database like Paradox can handle efficiently. Naturally, larger datasets take more time to generate and to send over a network.

The person using the client application perceives that it has better performance if the user does not have to wait for refreshes. The less often the client application requests a refresh of the dataset, the better it is for the user.



Important:
A principle of client/server application design is therefore to reduce the number of costly refresh operations as much as possible.

9.3.2. TQuery

- `CachedUpdates` = False

Allows the server to handle updates, deletes, and conflicts.

- `RequestLive` = False

Setting `RequestLive` to False can prevent the VCL from keeping a client-side copy of rows; this has a benefit to performance because it reduces the network bandwidth requirement

- Below are some operations in which a TQuery perform a fetch-all. Avoid these as much as possible, or be aware of the cost of such operations.

Using the `Locate` method:

You should use `Locate` only on local datasets.

Using the `RecordCount` property:

It's convenient to get the information on how many records are in a dataset, but when using InterBase, calculation of the `RecordCount` itself forces a fetch-all. For this reason, referencing the `RecordCount` property takes as much time as fetching the entire result dataset of the query.

A common use of `RecordCount` is to determine if the result set of an opened TQuery contains any records, or if it contains zero records. If this is the case, you can determine this without performing a fetch-all by testing for both `EOF` and `BOF` states. If both end of file and beginning of file are true for the dataset, then no records are in the result set. These operations do not involve a fetch-all.

For example, for a given `TQuery` instance called `qryTest` :

```
qryTest.Open;
if qryTest.BOF and qryTest.EOF then begin
// There are no result set records.
end
else begin
// There are some result set records.
end;
```

Using the `Constraints` property:

Let the server enforce the constraint.

Using the `Filter` property:

For the TQuery to filter records, it must request a much larger dataset than that which it subsequently displays. The InterBase server can perform the filtering in a much more efficient manner before returning the filtered dataset. You should use a `WHERE` clause in your SQL query. Even if you use a `WHERE` clause, any use of the `TQuery.Filter` property still forces a fetch-all.

9.3.3. TTable

The `TTable` component is designed for use on relatively small tables in a local database, accessed in core memory. `TTable` gathers information about the metadata of the table and tries to maintain a cache of the dataset in memory. `TTable` refreshes its client-side copy of data when you issue the `TTable.post` method and when you use the `TDatabase.rollback` method. This incurs a huge network overhead for client/server databases, which tend to have larger datasets and are accessed over a network. You can observe the activity of `TTable` with the SQL Monitor tool. This reports all calls to the BDE and InterBase API.

Though `TTable` is very convenient for its RAD Studio methods and its abstract data-aware model, you should use it sparingly with InterBase or any other client/server database. `TTable` was not designed to be used for client/server applications.

MIGRATING TO INTERBASE

InterBase is a mature product that was originally architected before current standards came into existence. As the standards evolved, it became clear that bringing InterBase into compliance with them would produce a somewhat challenging migration path.

With the advent of InterBase 6, InterBase 6 introduced an increased compliance with the SQL-92 standard, but migrating older (InterBase 5 and earlier) clients and databases might, in some cases, require considerable attention to detail.

The feature areas affected are: the use of double quotes, which are now reserved for delimited identifiers; the meaning of the `DATE` data type; the behavior of exact numeric data types, and the existence of new keywords that might conflict with older metadata names.

This document describes how to plan and execute a smooth migration from earlier versions of InterBase to InterBase 6 or later.

The earlier pages of this guide discuss the issues involved in the migration. Near the end, you will find detailed, step-by-step instructions for both in-place migration and for migrating an old database to a new one. See Migrating Servers and Databases,

1. Migration Process

These are the steps you must take to migrate servers, databases, and clients. Each is discussed in detail in later sections:

1.1. Server and Database Migration

1. Backup all databases to be migrated.
2. Install the latest InterBase server.
3. Restore databases to be migrated using the most recent `gbak`; at this point, you have dialect 1 databases.
4. Validate migrated databases.
5. Migrate databases to SQL dialect 3 (Migrating Databases to Dialect 3).

1.2. Client Migration

1. Identify the clients that must be upgraded.
2. Identify areas in your application which may need upgrading.
3. Install the InterBase client to each machine that requires it.
4. Upgrade SQL applications to SQL dialect 3.

2. Migration Issues

Before migrating your databases, you need to learn about InterBase SQL dialects and understand their effect on servers, clients, and the use of certain features introduced in InterBase 6 and later.

2.1. InterBase SQL Dialects

InterBase recognizes different client and database dialects to allow users more mobility in how their legacy databases are used, accessed, and updated. Beginning with InterBase 6, each client and database has a SQL dialect: an indicator that instructs an InterBase 6 or later server how to interpret transition features: those features whose meanings have changed between InterBase versions. The following transition features have different meanings based on the dialect used by the client applications:

- Double quote (“): changed from a synonym for the single quote (‘) to the delimiter for an object name.
- `DECIMAL` and `NUMERIC` data types with precision greater than 9: now stored as INT64 data types instead of DOUBLE PRECISION.
- `DATE`, `TIME`, and `TIMESTAMP` data types: DATE has changed from a 64-bit quantity containing both date and time information to a 32-bit quantity containing only date information. TIME is a 32-bit quantity containing only time information, while TIMESTAMP is a 64-bit quantity containing both date and time information (the same as DATE in pre-Version 6 SQL).

2.2. Clients and Databases

Clients and databases each have dialects. Servers do not themselves have a dialect, but they interpret data structures and client requests based on the dialect of each. Applications using an older version of the InterBase client work with InterBase 6 and later servers and their databases with some restrictions:

- Version 5 clients cannot access dialect 3 columns that are stored as `INT64`, `TIME`, or `DATE`. (`DECIMAL` and `NUMERIC` columns with precision greater than 9 are stored as `INT64`.)
- Version 5 clients cannot display new data types in metadata using the `SHOW` command, or any equivalent.
- Version 5 clients interpret the `DATE` data type as `TIMESTAMP`, since that was the definition of `DATE` prior to InterBase 6.
- Version 5 clients cannot access any object named with a delimited identifiers.

2.3. Keywords Used as Identifiers

Version 5 clients have one advantage over version 6 clients: If you migrate an older database that uses some version 6 keywords as identifiers to version 6 dialect 1, these older version 5 clients can still access those keyword objects. Version 6 dialect 1 cannot do so. Dialect 3 clients can access these keyword objects if the objects are delimited in double quotes.

If version 5 clients use any InterBase 6 or 7 keywords as object names, the InterBase 6 server permits this without error because it recognizes that these clients were created at a time when these were not keywords.

Example: For example, the following statement uses the new keyword word `TIME`:

```
SELECT TIME FROM atable;
```

This statement, when executed via a pre-InterBase 6 client returns the information as it did in previous versions. If this same query is issued using a version 6 or 7 client, an error is returned since `TIME` is now a reserved word. See the New InterBase Keywords.

2.4. Understanding SQL Dialects

Below are explanations of server and client behavior with SQL dialects 1, 2, and 3.

2.4.1. Dialect 1 Clients and Databases

In dialect 1, the InterBase 6 and later servers interpret transition features exactly as an InterBase 5 server does:

- Double quoted text is interpreted as a string literal. Delimited identifiers are not available.
- The `DATE` data type contains both time and date information and is interpreted as `TIMESTAMP`; the name has changed but the meaning has not. Dialect 1 clients expect the entire timestamp to be returned. In dialect 1, `DATE` and `TIMESTAMP` are identical.
- The `TIME` data type is not available.
- Dialect 1 databases store `DECIMAL` and `NUMERIC` data types with precision greater than 9 as `DOUBLE PRECISION`, not `INT64`.
- Dialect 1 clients expect information stored `DECIMAL` and `NUMERIC` data types to be returned as double precision; such clients cannot create database fields to hold 64-bit integers.

InterBase 6 and later servers recognize all the other InterBase features in dialect 1 clients and databases.

2.4.2. Dialect 2 Clients

Dialect 2 is available only on the client side. It is intended for assessing possible problems in legacy metadata that is being migrated to dialect 3. To determine where the problem spots are when you migrate a database from dialect 1 to dialect 3, you extract the metadata from the database, set `isql` to dialect 2, and then run that metadata file through `isql`. `isql` issues warning whenever it encounters double quotes, `DATE` data types, or large exact numerics to alert you to places where you might need to change the metadata in order to make a successful migration to dialect 3.

To detect problem areas in the metadata of a database that you are migrating, extract the metadata and run it through a dialect 2 client, which will report all instances of transition features. For example:

```
isql -i v5metadata.sql
```

Do not assign dialect 2 to databases.

2.4.3. Dialect 3 Clients and Databases

In dialect 3, the InterBase server interprets transition features as InterBase 6 SQL 92-compliant:

- Double quoted strings are treated as delimited identifiers.
- Dialect 3 `DATE` data type fields contain only date information. Dialect 3 clients expect only date information from a field of data type `DATE`.
- The `TIME` data type is available, and stores only time information.
- Dialect 3 databases store `DECIMAL` and `NUMERIC` data types with precision greater than 9 as `INT64` if, and only if, they are in columns that were created in dialect 3.
- Dialect 3 clients expect `DECIMAL` and `NUMERIC` data types with precision greater than 9 to be returned as `INT64`.

To learn how to migrate older data to `INT64` storage, see Do you really need to migrate your NUMERIC and DECIMAL Data Types? and Migrating NUMERIC and DECIMAL Data Types.

3. Setting SQL Dialects

You can set the SQL dialect for a server or client in a variety of ways. For example, the IBConsole user interface has menu options for specifying the SQL dialect. See Using IBConsole and Tools for a complete explanation of using IBConsole. This section explores the command-line methods for setting a dialect.

3.1. Setting the isql Client Dialect

To use `isql` to create a database in a particular dialect, first set `isql` to the desired dialect and then use it to create the database.You can set `isql` dialect in the following ways:

- On the command line, start `isql` with option - `sql_dialect n` , where **<n>** is 1, 2, or 3.

isql -sql_dialect **<n>**

- Within an `isql` session or in a SQL script, you can issue this statement:

`SET SQL DIALECT` **<n>**

The following table shows the precedence for setting `isql` dialect:

Ranking	How dialect is set
Lowest	Dialect of an attached Version 6 and later database
Next lowest	Dialect specified on the command line: `isql -sql_dialect n`
Next highest	Dialect specified during the session: `SET SQL DIALECT n;`
Highest	Dialect of an attached Version 5 database (=1)

In InterBase 6 and later, `isql` has the following behavior with respect to dialects:

- If you start `isql` and attach to a database without specifying a dialect, `isql` takes on the dialect of the database.
- If you specify a dialect on the command line when you invoke `isql` , it retains that dialect after connection unless explicitly changed.
- When you change the dialect during a session using `SET SQL DIALECT` **<n>**,

`isql` continues to operate in that dialect until explicitly changed.

- When you create a database using `isql` , the database is created with the dialect of the `isql` client; for example, if `isql` has been set to dialect 1, when you create a database, it is a dialect 1 database.
- If you create a database without first specifying a dialect for the `isql` client or attaching to a database, `isql` creates the database in dialect 3.

The statements above are true whether you are running `isql` as a command-line utility or are accessing it through IBConsole, InterBase new interface.

> **Important:**
> Any InterBase 6 and later `isql` client that attaches to a version 5 database resets to dialect 1.

3.2. Setting the gpre Dialect

In InterBase 6 and later, default behavior of `gpre` is to take on the dialect of the database to which it is connected. This enables `gpre` to parse pre-Version 6 source files without moderation.

There are two ways to change the dialect of `gpre`:

- Start `gpre` with option `-sql_dialect n`. For example, this command sets `gpre` to dialect 3:

gpre -sql_dialect 3

- Specify dialect within the source, for example:

```
EXEC SQL
SET SQL DIALECT n
```

The dialect precedence for `gpre` is as follows:

Lowest	Dialect of an attached database
Middle	Command line specification: `gpre -sql_dialect n`

Highest	Dialect explicitly specified within the source, for example
	`EXEC SQL`
	`SET SQL DIALECT n`

3.3. Setting the Database Dialect

To set the dialect of an ODS 10 or later database, attach to the database as either the owner or SYSDBA. Use `gfix` with the command-line option - `sql_dialect n`, where n is 1 or 3. For example, the following statement sets `mydb.ib` to dialect 3:

```
gfix -sql_dialect 3 mydb.ib
```

See Migrating Databases to Dialect 3 for details about issues to consider before you issue the command.

4. Features and Dialects

Many of the features introduced in InterBase 6 and later operate without reference to dialect. Other features are dialect-specific. The dialect-specific features are discussed below:

4.1. Features Available in All Dialects

The following new features are available in both dialect 1 and dialect 3:

4.1.1. IBConsole, InterBase's Graphical Interface

IBConsole, InterBase graphical user interface, combines the functionality of the older Server Manager and InterBase Windows isql. You now create and maintain databases, configure and maintain servers, and execute interactive SQL from one integrated interface.

4.1.2. Read-only Databases Feature

You can make InterBase 6 and later databases be read-only. This permits distribution on read-only media and reduces the chance of accidental or malicious changes to databases.

4.1.3. Altering Column Definitions

The `ALTER COLUMN` clause of the `ALTER TABLE` statement can change a name, data type, or position of a column.

4.1.4. Altering Domain Definitions

`ALTER DOMAIN` now includes the ability to change the name or data type of a domain definition.

4.1.5. The EXTRACT() Function

The new `EXTRACT` () function extracts information from the new `DATE`, `TIMESTAMP`, and `TIME` data types. In dialect 1, you can use it to extract information from the `TIMESTAMP` data type.

Note: `DATE` is new in the sense that it has a different meaning in dialect 3 databases than it did previously.

4.1.6. SQL Warnings

The InterBase API function set now returns warnings and informational messages along with error messages in the status vector.

4.1.7. The Services API, Install API, and Licensing API

InterBase now provides three new function libraries. The Services API, which is part of the InterBase client library, provides functions for database maintenance tasks, software activation, requesting information about the configuration of databases and server, and working with user entries in the security database.

4.1.8. New gbak Functionality

In InterBase 6 and later, the functionality of `gbak` has been extended. gbak can now perform all of the following actions:

- Back up to multiple files and restore to multiple files.
- Perform server-side backups and restores using the - `service` switch.
- Set databases to read-only mode when restoring.

4.1.9. InterBase Express™ (IBX) Feature

IBX provides native Delphi components for InterBase data access, services, and installation. Embarcadero C++Builder also can access IBX components.

4.2. Features Available Only in Dialect 3 Databases

The following features are available only in dialect 3 clients and databases because they conflict with dialect 1 usage.

4.2.1. Delimited Identifiers Feature

Identifiers can now be keywords, contain spaces, be case sensitive, and contain non-ASCII characters. Such identifiers must be delimited by double quotes. String constants must be delimited by single quotes.

4.2.2. INT64 Data Storage

In dialect 3 databases, data stored in `DECIMAL` and `NUMERIC` columns is stored as `INT64` when the precision is greater than 9. This is true only for columns that are *created* in dialect 3. These same data types are stored as `DOUBLE PRECISION` in dialect 1 and in all older InterBase versions. This change in storage also requires different arithmetic algorithms.

4.2.3. DATE and TIME Data Types

In dialect 3, the `DATE` data type holds only date information. This is a change from earlier InterBase versions in which it stored the whole timestamp.

Dialect 3 allows the use of the `TIME` data type, which only holds the time portion of the timestamp.

See Also

- Delimited Identifiers
- DATE, TIME, and TIMESTAMP Data Types
- DECIMAL and NUMERIC Data Types

4.3. New InterBase Keywords

These keywords are reserved words in all dialects.

- Beginning with InterBase 6, you cannot create objects in a dialect 1 database that have any of these keywords as object names (identifiers).
- You can migrate a version 5 database that contains these keywords used as identifiers to version 6 or later dialect 1 without changing the object names: a column could be named "YEAR", for instance.

- Version 5 clients can access these keyword identifiers without error.
- Version 6 and later clients *cannot* access keywords that are used as identifiers. In a dialect 1 database, you must change the names so that they are not keywords.
- If you migrate directly to dialect 3, you can retain the names, but you must delimit them with double quotes. To retain accessibility for older clients, put the names in all upper case. Delimited identifiers are case sensitive.

- Although `TIME` is a reserved word in version 6 and later dialect 1, you cannot use it as a data type because such databases guarantee data type compatibility with version 5 clients.
- In dialect 3 databases and clients, any reserved word can be used as an identifier as long as it is delimited with double quotes.

ACTION	ACTIVE	ADD	ADMIN
AFTER	ALL	ALTER	AND
ANY	AS	ASC	ASCENDING
AT	AUTO	AUTODDL	AVG
BASED	BASENAME	BASE_NAME	BEFORE
BEGIN	BETWEEN	BLOB	BLOBEDIT
BOOLEAN	BUFFER	BY	CACHE
CASCADE	CASE	CAST	CHAR
CHARACTER	CHARACTER_LENGTH	CHAR_LENGTH	CHECK
CHECK_POINT_LEN	CHECK_POINT_LENGTH	COALESCE	COLLATE
COLLATION	COLUMN	COMMIT	COMMITTED
COMPILETIME	COMPUTED	CLOSE	CONDITIONAL
CONNECT	CONSTRAINT	CONTAINING	CONTINUE
COUNT	CREATE	CSTRING	CURRENT
CURRENT_DATE	CURRENT_TIME	CURRENT_TIMESTAMP	CURSOR
DATABASE	DATE	DAY	DB_KEY
DEBUG	DEC	DECIMAL	DECLARE
DECRYPT	DEFAULT	DELETE	DESC
DESCENDING	DESCRIBE	DESCRIPTOR	DISCONNECT
DISPLAY	DISTINCT	DO	DOMAIN
DOUBLE	DROP	ECHO	EDIT
ELSE	ENCRYPT	ENCRYPTION	END
ENTRY_POINT	ESCAPE	EVENT	EXCEPTION
EXECUTE	EXISTS	EXIT	EXTERN
EXTERNAL	EXTRACT	FALSE	FETCH
FILE	FILTER	FLOAT	FOR
FOREIGN	FOUND	FREE_IT	FROM
FULL	FUNCTION	GDSCODE	GENERATOR
GEN_ID	GLOBAL	GOTO	GRANT
GROUP	GROUP_COMMIT_WAIT	GROUP_COMMIT_WAIT_TIME	HAVING

HELP	HOUR	IF	IMMEDIATE
IN	INACTIVE	INDEX	INDICATOR
INIT	INNER	INPUT	INPUT_TYPE
INSERT	INT	INTEGER	INTO
IS	ISOLATION	ISQL	JOIN
KEY	LC_MESSAGES	LC_TYPE	LEFT
LENGTH	LEV	LEVEL	LIKE
LOGFILE	LOG_BUFFER_SIZE	LOG_BUF_SIZE	LONG
MANUAL	MAX	MAXIMUM	MAXIMUM_SEGMENT
MAX_SEGMENT	MERGE	MESSAGE	MIN
MINIMUM	MINUTE	MODULE_NAME	MONTH
NAMES	NATIONAL	NATURAL	NCHAR
NO	NOAUTO	NOT	NULL
NULLIF	NUMERIC	NUM_LOG_BUFS	NUM_LOG_BUFFERS
OCTET_LENGTH	OF	ON	ONLY
OPEN	OPTION	OR	ORDER
OUTER	OUTPUT	OUTPUT_TYPE	OVERFLOW
PAGE	PAGELENGTH	PAGES	PAGE_SIZE
PARAMETERS	PASSWORD	PERCENT	PLAN
POSITION	POST_EVENT	PRECISION	PREPARE
PRESERVE	PROCEDURE	PROTECTED	PRIMARY
PRIVILEGES	PUBLIC	QUIT	
RAW_PARTITIONS	RDB$DB_KEY	READ	REAL
RECORD_VERSION	REFERENCES	RELEASE	RESERV
RESERVING	RESTRICT	RETAIN	RETURN
RETURNING_VALUES	RETURNS	REVOKE	RIGHT
ROLE	ROLLBACK	ROW	ROWS
RUNTIME	SCHEMA	SECOND	SEGMENT
SELECT	SET	SHADOW	SHARED
SHELL	SHOW	SINGULAR	SIZE
SMALLINT	SNAPSHOT	SOME	SORT

SQLCODE	SQLERROR	SQLWARNING	STABILITY
STARTING	STARTS	STATEMENT	STATIC
SUSPEND	TABLE	TABLESPACE	TEMPORARY
TERMINATOR	THEN	TIES	TIME
TIMESTAMP	TO	TRANSACTION	TRANSLATE
TRANSLATION	TRIGGER	TRIM	TRUE
TYPE	UNCOMMITTED	UNION	UNIQUE
UNKNOWN	UPDATE	UPPER	USER
USING	VALUE	VALUES	VARCHAR
VARIABLE	VARYING	VERSION	VIEW
WAIT	WEEKDAY	WHEN	WHENEVER
WHERE	WHILE	WITH	WORK
WRITE	YEAR	YEARDAY	

Note: The following keywords are specific to InterBase and are not part of the SQL standard.

WEEKDAY	YEARDAY

4.4. Delimited Identifiers

To increase compliance with the SQL 92 standard, InterBase 6 and later introduces *delimited identifiers*. An identifier is the name of any database object; for instance a table, a column, or a trigger. A delimited identifier is an identifier that is enclosed in double quotes. Because the quotes delimit the boundaries of the name, the possibilities for object names are greatly expanded from previous versions of InterBase. Object names can now:

- mimic keywords
- include spaces (except trailing spaces)
- be case sensitive

4.4.1. How Double Quotes have Changed

Up to and including version 5, InterBase allowed the use of either single or double quotes around string constants. The concept of delimited identifiers did not exist. Beginning with InterBase 6

(dialect 3), anything in single quotes is interpreted as a string constant and anything in double quotes is interpreted as a delimited identifier. Here is the summary:

- In all versions of InterBase, anything inside single quotes is treated as a string constant.
- In InterBase version 5 and older, anything within double quotes is treated as a string constant, because those versions do not have the concept of a delimited identifier.
- Version 6 dialect 1 is a transition mode that behaves like older versions of InterBase with respect to quote marks: it interprets strings within either single or double quotes as string constants.
- Beginning with version 6 dialect 3, InterBase interprets anything inside double quotes as a delimited identifier. Anything inside single quotes is interpreted as a string constant.
- When InterBase servers version 6 or later detect that the client is dialect 1, they permit client DML (data manipulation) statements to contain double quotes and they correctly handle these as string constants. However, they do not permit double quotes in client DDL (data definition) statements because that metadata would not be allowed in dialect 3. Version 6 servers all insist that string constants be delimited with single quotes when clients create new metadata.

See Also

- Features Available Only in Dialect 3 Databases

4.5. DATE, TIME, and TIMESTAMP Data Types

InterBase 6 and later dialect 3 replace the old InterBase `DATE` data type, which contains both date and time information, with SQL-92 standard `TIMESTAMP`, `DATE`, and TIME data types. The primary migration problem exists in the source code of application programs that use the InterBase 5 DATE data type. In InterBase 6 and later, the `DATE` keyword represents a date-only data type, while a Version 5 `DATE` represents a date-and-time data type.

Columns and domains that are defined as `DATE` data type in InterBase 5 `DATE` appear as `TIMESTAMP` columns when the database is restored in InterBase 6. However, a `TIMESTAMP` data type has four decimal points of precision, while a Version 5 `DATE` data type has only two decimal points of precision.

If you migrate your database to dialect 3 and you require only date or only time information from a `TIMESTAMP` column, you can use `ALTER COLUMN` to change the data type to `DATE` or `TIME`. These columns each take only four bytes, whereas `TIMESTAMP` and the InterBase 5 `DATE` columns each take eight bytes. If your `TIMESTAMP` column holds both date and time information, you cannot change it to an InterBase 6 and later `DATE` or `TIME` column using `ALTER COLUMN`, because `ALTER COLUMN` does not permit data loss. Dialect use also enforces certain rules:

- In dialect 1, only `TIMESTAMP` is available. `TIMESTAMP` is the equivalent of the `DATE` data type in previous versions. When you back up an older database and restore it in version 6

and later, all the `DATE` columns and domains are automatically restored as `TIMESTAMP`. DATE and TIMESTAMP data types are both available and both mean the same thing in dialect 1.

- In dialect 3, `TIMESTAMP` functions as in dialect 1, but two additional data types are available: `DATE` and `TIME`. These data types function as their names suggest: `DATE` holds only date information and `TIME` holds only time.
- In dialect 3, `DATE` and `TIME` columns require only four bytes of storage, while `TIMESTAMP` columns require eight bytes.

The following example shows the differences between dialect 1 and dialect 3 clients when date information is involved.

Example: `CREATE TABLE table1 (fld1 DATE, fld2 TIME);`

```
INSERT INTO table1 VALUES (CURRENT_DATE, CURRENT_TIME);
```

Using dialect 1 clients :

```
SELECT * FROM table1;
Statement failed, SQLCODE = -804
Dynamic SQL Error
-SQL error code = -804
-datatype unknown
-Client SQL dialect 1 does not support reference to TIME data type

SELECT fld1 FROM table1;
Statement failed, SQLCODE = -206
Dynamic SQL Error
-SQL error code = -206
-Column unknown
-FLD1
-Client SQL dialect 1 does not support reference to DATE data type
```

Using dialect 3 clients :

```
SELECT * FROM table1;
FLD1         FLD2
=========== =============
1999-06-25   11:32:30.0000
SELECT fld1 FROM table1;
FLD1
===========
1999-06-25
```

Example: `CREATE TABLE table1 (fld1 TIMESTAMP);`

```
INSERT INTO table1 (fld1) VALUES (CURRENT_TIMESTAMP);
SELECT * FROM table1;
```

In dialect 1 :

```
FLD1
===========
25-JUN-1999
```

In dialect 3 :

```
FLD1
=========================
1999-06-25 10:24:35.0000
```

Example: `SELECT CAST (fld1 AS CHAR(5)) FROM table1;`

In dialect 1 :

```
======
25-JU
```

In dialect 3 :

```
Statement failed, SQLCODE = -802
arithmetic exception, numeric overflow, or string truncation
```

4.5.1. Converting TIMESTAMP Columns to DATE or TIME

Once you have migrated a database to dialect 3, any columns that previously had the `DATE` data type will have the `TIMESTAMP` data type. If you want to store that data in a `DATE` or `TIME` column, follow these steps:

1. Use `ALTER TABLE` to create a new column of the desired type.
2. Insert the values from the original column into the new column:

   ```
   UPDATE tablename SET new_field = CAST (old_field AS new_field);
   ```

3. Use `ALTER TABLE` to drop the original column.
4. Use `ALTER TABLE ... ALTER COLUMN` to rename the new column.

4.5.2. Casting Date/time Data Types

InterBase 6 and later dialect 3 no longer allow the use of the `CAST` operator to remove the date portion of a timestamp by casting the timestamp value to a character value. When you cast a `TIMESTAMP` to a `CHAR` or `CHAR` in dialect 3, the destination type must be at least 24 characters

in length or InterBase will report a string overflow exception. This is required by the SQL3 standard.

You can use the `CAST()` function in `SELECT` statements to translate between date/time data types and various character-based data types. The character data type must be at least 24 characters in length. You can, however, cast a `TIMESTAMP` to a `DATE` and then cast the `DATE` to a `CHAR` of less than 24 characters. For example:

```
SELECT CAST (CAST (timestamp_col AS DATE) AS CHAR(10)) FROM table1;
```

It is not possible to cast a date/time data type to or from `BLOB`, `SMALLINT`, `INTEGER`, `FLOAT`, `DOUBLE PRECISION`, `NUMERIC`, or `DECIMAL` data types.

For more information, refer to "Using `CAST()` to convert dates and times" in the Embedded SQL Guide.

The table below outlines the results of casting *to* date/time data types:

Cast From	To TIMESTAMP	DATE	TIME
`CHAR` (**<n>**) `CHARACTER` (**<n>**) `CSTRING` (**<n>**)	String must be in format YYYY-MM-DD HH:MM:SS.thousands	See below.	String must be in format HH:MM:SS.thousands
`TIMESTAMP`	Always succeeds	Date portion of timestamp	Time portion of timestamp
`DATE`	Always succeeds; time portion of timestamp set to 0:0:0.0000	Always succeeds	Error
`TIME`	Always succeeds; date portion of timestamp set to current date	Error	Always succeeds

Casting DATE to string results in YYYY-MM-DD where "MM" is a two-digit month. If the result does not fit in the string variable, a string truncation exception is raised. In earlier versions, this case results in DD-Mon-YYYY HH:mm:SS.hundreds where "Mon" was a 3-letter English month abbreviation. Inability to fit in the string variable resulted in a silent truncation.

Casting a string to a date now permits strings of the form:

```
'yyyy-mm-dd' 'yyyy/mm/dd' 'yyyy mm dd' 'yyyy:mm:dd' 'yyyy.mm.dd'
```

In all of the forms above, you can substitute a month name or 3-letter abbreviation in English for the 2-digit numeric month. However, the order must always be 4-digit year, then month, then day.

In previous versions of InterBase, you could enter date strings in a number of forms, including ones that had only two digits for the year. Those forms are still available in InterBase 6 and later. If you enter a date with only two digits for the year, InterBase uses its "sliding window" algorithm to assign a century to the years.

The following forms were available in earlier versions of InterBase and are still permitted in InterBase 6 and later:

```
'mm-dd-yy' 'mm-dd-yyyy' 'mm/dd/yy' 'mm/dd/yyyy'
'mm dd yy' 'mm dd yyyy' 'mm:dd:yy' 'mm:dd:yyyy'
'dd.mm.yy' 'dd.mm.yyyy'
```

If you write out the month name in English or use a three-character English abbreviation, you can enter either the month or the day first. In the following examples, "xxx" stands for either a whole month name or a three-letter abbreviation. All of the following forms are acceptable:

```
'dd-xxx-yy' 'dd-xxx-yyyy' 'xxx-dd-yy' 'xxx-dd-yyyy'
'dd xxx yy' 'dd xxx yyyy' 'xxx dd yy' 'xxx dd yyyy'
'dd:xxx:yy' 'dd:xxx:yyyy' 'xxx:dd:yy' 'xxx:dd:yyyy'
```

For example, the following `INSERT` statements all insert the date "January 22, 1943":

```
INSERT INTO t1 VALUES ('1943-01-22');
INSERT INTO t1 VALUES ('01/22/1943');
INSERT INTO t1 VALUES ('22.01.1943');
INSERT INTO t1 VALUES ('jan 22 1943');
```

The following statement would enter the date "January 22, 2043": `INSERT INTO t1 VALUES ('01/22/43');` The table below outlines the results of casting *from* date/time data types:

Cast From	To CHAR(<n>), CHARACTER (<n>), or CSTRING(<n>)
`TIMESTAMP`	Succeeds if **<n>** is 24 or more. Resulting string is in format YYYY-MM-DD HH:MM:SS.thousands.

Cast From	To CHAR(<n>), CHARACTER (<n>), or CSTRING(<n>)
DATE	Succeeds if **<n>** is 10 or more. Resulting string is in the format YYYY-MM-DD.
TIME	Succeeds if **<n>** is 13 or more. Resulting string is the format HH:MM:SS.thousands.

4.5.3. Adding and Subtracting Datetime Data Types

The following table shows the result of adding and subtracting DATE, TIME, TIMESTAMP, and numeric values. "Numeric value" refers to any value that can be cast as an exact numeric value by the database engine (for example, INTEGER, DECIMAL, or NUMERIC).

Adding and Subtracting Date/time Data Types

Operand1	Operator	Operand2	Result
DATE	+	DATE	Error
DATE	+	TIME	TIMESTAMP (concatenation)
DATE	+	TIMESTAMP	Error
DATE	+	Numeric value	DATE + number of days: fractional part ignored
TIME	+	DATE	TIMESTAMP (concatenation)
TIME	+	TIME	Error
TIME	+	TIMESTAMP	Error

Operand1	Operator	Operand2	Result
TIME	+	Numeric value	TIME + number of seconds: 24-hour modulo arithmetic
TIMESTAMP	+	DATE	Error
TIMESTAMP	+	TIME	Error
TIMESTAMP	+	TIMESTAMP	Error
TIMESTAMP	+	Numeric value	TIMESTAMP : DATE + number of days; TIME + fraction of day converted to seconds
DATE	–	DATE	DECIMAL (9,0) representing the number of days
DATE	–	TIME	Error
DATE	–	TIMESTAMP	Error
DATE	–	Numeric value	DATE: number of days; fractional part ignored
TIME	–	DATE	Error
TIME	–	TIME	DECIMAL (9,4) representing number of seconds
TIME	–	TIMESTAMP	Error
TIME	–	Numeric value	TIME : number of seconds; 24-hour modulo arithmetic

Operand1	Operator	Operand2	Result
TIMESTAMP	–	DATE	Error
TIMESTAMP	–	TIME	Error
TIMESTAMP	–	TIMESTAMP	DECIMAL (18,9) representing days and fraction of day
TIMESTAMP	–	Numeric value	TIMESTAMP : DATE – number of days; TIME : fraction of day converted to seconds

Note:
Numeric value + DATE, TIME, or TIMESTAMP is symmetric to DATE, TIME, or TIMESTAMP + numeric value.

4.5.4. Using Date/time Data Types with Aggregate Functions

You can use the date/time data types with the MIN(), MAX(), COUNT() functions, the DISTINCT argument to those functions, and the GROUP BY argument to the SELECT() function. An attempt to use SUM() or AVG() with date/time data types returns an error.

4.5.5. Default Clauses

CURRENT_DATE, CURRENT_TIME, and CURRENT_TIMESTAMP can be specified as the default clause for a domain or column definition.

4.5.6. Extracting Date and Time Information

The EXTRACT() function extracts date and time information from databases. In dialect 3, the EXTRACT operator allows you to return different parts of a TIMESTAMP value. The EXTRACT operator makes no distinction between dialects when formatting or returning the information. EXTRACT() has the following syntax:

EXTRACT (**<part>** FROM **<value>**)

The value passed to the `EXTRACT()` expression must be `DATE`, `TIME`, or `TIMESTAMP`. Extracting a part that doesn't exist in a data type results in an error. For example:

EXTRACT (TIME FROM aTime)

A statement such as `EXTRACT (YEAR from aTime)` would fail.

The data type of `EXTRACT()` expressions depends on the specific part being extracted:

Extract	Resulting data type	Representing
`YEAR`	`SMALLINT`	Year, range 0-5400
`MONTH`	`SMALLINT`	Month, range 1-12
`DAY`	`SMALLINT`	Day, range 1-31
`HOUR`	`SMALLINT`	Hour, range 1-23
`MINUTE`	`SMALLINT`	Minute, range 1-59
`SECOND`	`DECIMAL(6,4)`	Second, range 0-59.9999
`WEEKDAY`	`SMALLINT`	Day of the week, range 0-6 (0 = Sunday, 1 = Monday, and so on)
`YEARDAY`	`SMALLINT`	Day of the year, range 1-366

```
SELECT EXTRACT (YEAR FROM timestamp_fld) FROM table_name;
=======
1999
SELECT EXTRACT (YEAR FROM timestamp_fld) FROM table_name;
=======
1999
SELECT EXTRACT (MONTH FROM timestamp_fld) FROM table_name;
=======
6
SELECT EXTRACT (DAY FROM timestamp_fld) FROM table_name;
=======
25
SELECT EXTRACT (MINUTE FROM timestamp_fld) FROM table_name;
```

```
=======
24
SELECT EXTRACT (SECOND FROM timestamp_fld) FROM table_name;
============
35.0000
SELECT EXTRACT (WEEKDAY FROM timestamp_fld) FROM table_name;
=======
5
SELECT EXTRACT (YEARDAY FROM timestamp_fld) FROM table_name;
=======
175
SELECT EXTRACT (MONTH FROM timestamp_fld) ||
'-' || EXTRACT (DAY FROM timestamp_fld) ||
'-' || EXTRACT (YEAR FROM timestamp_fld) FROM table_name;
====================
6-25-1999
```

4.6. DECIMAL and NUMERIC Data Types

The following sections highlight some of the changes introduced by InterBase 6 and later when dealing with numeric values. They need to be considered carefully when migrating your database from dialect 1 to dialect 3. When considering these issues, keep in mind that in order to make use of the new functionality, the statements must be created with a client dialect setting of 3.

The most notable migration issues involve using the division operator and the AVG() function (which also implies division) with exact numeric operands. Exact numeric refers to any of the following data types: `INTEGER`, `SMALLINT`, `DECIMAL`, `NUMERIC`. `NUMERIC` and `DECIMAL` data types that have a precision greater than 9 are called "large exact numerics" in this discussion. Large exact numerics are stored as `DOUBLE PRECISION` in dialect 1 and as `INT64` in columns created in dialect 3.

Important:
When you migrate an exact numeric column to dialect 3 it is still stored as `DOUBLE PRECISION`. The migration does not change the way the data is stored because `INT64` cannot store the whole range that `DOUBLE PRECISION` can store. There is potential data loss, so InterBase does not permit direct conversion. If you decide that you want your data stored as `INT64`, you must create a new column and copy the data. Only exact numeric columns that are *created* in dialect 3 are stored as `INT64`. The details of the process are provided in Migrating Databases to Dialect 3.

You might or might not want to change exact numeric columns to `INT64` when you migrate to dialect 3. See Do you really need to migrate your NUMERIC and DECIMAL Data Types? for a discussion of issues.

Dialect 3 features and changes include

- Support for 64 bit integers.

- Overflow protection. In dialect 1, if the product of two integers was bigger than 31 bits, the product was returned modulo 2^{32}. In dialect 3, the true result is returned as a 64-bit integer. Further, if the product, sum, difference, or quotient of two exact numeric values is bigger than 63 bits, InterBase issues an arithmetic overflow error message and terminates the operation. (Previous versions sometimes returned the least-significant portion of the true result.). The stored procedure `bignum` below demonstrates this.

Operations involving division return an exact numeric if both operands are exact numerics in dialect 3. When the same operation is performed in dialect 1, the result is a `DOUBLE PRECISION`.

To obtain a `DOUBLE PRECISION` quotient of two exact numeric operands in dialect 3, explicitly cast one of the operands to `DOUBLE PRECISION` before performing the division:

```
CREATE TABLE table 1 (n1 INTEGER, n2 INTEGER);
INSERT INTO table 1 (n1, n2) VALUES (2, 3);
SELECT n1 / n2 FROM table1;
======================
0
```

Similarly, to obtain a double precision value when averaging an exact numeric column, you must cast the argument to double precision before the average is calculated:

```
SELECT AVG(CAST(int_col AS DOUBLE PRECISION))FROM table1;
```

4.7. Compiled Objects

The behavior of a compiled object such as a stored procedure, trigger, check constraint, or default value depends on the dialect setting of the client at the time the object is compiled. Once compiled and validated by the server the object is stored as part of the database and its behavior is constant regardless of the dialect of the client that calls it.

Example: Consider the following procedure:

```
CREATE PROCEDURE exact1 (a INTEGER, b INTEGER) RETURNS (c INTEGER)
AS BEGIN
c = a / b;
EXIT;
END;
```

When created by a dialect 1 client:

`EXECUTE PROCEDURE exact 1` returns 1 when executed by either a dialect 1 or dialect 3 client.

When created by a dialect 3 client:

`EXECUTE PROCEDURE exact 1` returns 0 when executed by either a dialect 1 or dialect 3 client.

Example: Consider the following procedure:

```
CREATE PROCEDURE bignum (a INTEGER, b INTEGER) RETURNS (c NUMERIC(18,0)
AS BEGIN
c = a * b;
EXIT;
END;
```

When created by a dialect 1 client:

`EXECUTE PROCEDURE bignum` (65535, 65535) returns –131071.0000 when executed by either a dialect 1 or dialect 3 client.

When created by a dialect 3 client:

`EXECUTE PROCEDURE bignum` (65535, 65535) returns `*ERROR* can't access INT64` when executed by a dialect 1 client.

`EXECUTE PROCEDURE bignum` (65535, 65535) returns 4294836225 when executed by a dialect 3 client.

4.8. Generators

InterBase 6 and later generators return a 64-bit value, and only wrap around after 2^{64} invocations (assuming an increment of 1), rather than after 2^{32} as in InterBase 5. Applications should use an `ISC_INT64` variable to hold the value returned by a generator. A client using dialect 1 receives only the least significant 32 bits of the updated generator value, but the entire 64-bit value is incremented by the engine even when returning a 32-bit value to a client that uses dialect 1. If your database was using an `INTEGER` field for holding generator values, you need to recreate the field so that it can hold 64-bit integer values.

4.9. Miscellaneous Issues

- `IN` clauses have a limit of 1500 elements

Resolution If you have more than 1500 elements, place the values in a temporary table and use a SELECT subquery in place of the list elements.

- Arithmetic operations on character fields are no longer permitted in client dialect 3.

Resolution Explicitly cast the information before performing arithmetic calculations.

- Using `isql` to select from a `TIMESTAMP` column displays all information when client dialect is 3.

Resolution In versions of InterBase prior to 6.0, the time portion of a timestamp displayed only if `SET TIME ON` was in effect. In 6.0 and later client dialect 3, the time portion of the timestamp always displays.

5. Migrating Servers and Databases

You can migrate your servers and applications to InterBase 6 at and later different times. They are separate migrations. Bear the following issues in mind as you plan your migration:

- Older clients can still access databases that have been migrated to InterBase 6 and later. You must be aware, however, that they cannot access new data types or data stored as INT64, and they always handle double quoted material as strings.
- InterBase strongly recommends that you establish a migration testbed to check your migration procedures before migrating production servers and databases. The testbed does not need to be on the same platform as the production clients and servers that you are migrating.

The migration path varies somewhat depending on whether you are replacing an existing server or installing a new server and moving old databases there. Upgrading an existing server costs less in money, but may cost more in time and effort. The server and all the databases you migrate with it are unavailable during the upgrade. If you have hardware available for a new InterBase 6 and later server, the migration can be done in parallel, without interrupting service more than very briefly. This option also offers an easier return path if problems arise with the migration.

5.1. "In-place" Server Migration

This section describes the recommended steps for replacing an InterBase 5 server with an InterBase 6 server.

1. Shut down each database before backup to ensure that no transactions are in progress.
2. Back up all databases on the version 5 server. Include `isc4.ib` if you want to preserve your configured user IDs.
   As a precaution, you should validate your databases before backing up and then restore each database to ensure that the backup file is valid.
3. Shut down the version 5 server. If your current server is a Superserver, you are not required to uninstall the server if you intend to install over it, although uninstalling is always good practice. You cannot have multiple versions of InterBase on the same machine. If your current server is Classic, you *must* uninstall before installing InterBase 6.
4. Install the version 6 server.

> **Note:**
> The install does not overwrite `isc4.ib` or `isc4.gbk`.

5. Start the new server.
   - On UNIX/Linux platforms, issue the following command to start the InterBase Superserver as user "InterBase":
     echo "/usr/InterBase/bin/ibmgr -start -forever" | su InterBase
     Note that InterBase can run only as user "root" or user "InterBase" on UNIX.
6. To restore the list of valid users, follow these steps:
   1. Restore `isc4.gbk` to `isc4_old.ib`.
   2. Shut down the server.
   3. Copy `isc4_old.ib` over `isc4.gdb`.
   4. Copy `isc4_old.gbk` over `isc4.gbk`.
   5. Restart the server.
7. Delete each older database file. Restore each database from its backup file. This process creates databases in the current version. For databases that were 5.x or older when they were backed up, the dialect is 1. For later databases, the dialect is preserved.
8. Perform a full validation of each database.

After performing these steps, you have an InterBase 6 and later server and InterBase 6 and later, dialect 1 databases. See About InterBase 6 and Later, Dialect 1 Databases to understand more about these databases. See Migrating Databases to Dialect 3 for a description of how to migrate databases to dialect 3. See Migrating Clients for an introduction to client migration.

5.2. Migrating to a New Server

This section describes the recommended steps for installing InterBase 6 or newer as a new server and then migrating databases from a previous InterBase 5 or older installation. The process differs only slightly from an in-line install.

In the following steps, *older* refers to databases that are on a version 5 or older InterBase server. *Newer* and *new* refer to an InterBase version 6 or newer server.

1. Shut down the older databases before backup to ensure that no transactions are in progress.
2. Back up all databases that are on the older server. Include `isc4.ib` if you want to preserve your configured user IDs.
3. Install the new server.
4. Start the new server.
   - On UNIX/Linux platforms, issue the following command to start the InterBase Superserver as user "InterBase":

```
# echo "/usr/{{Product}}/bin/ibmgr -start -forever" | su {{Product}}
```

Note that InterBase can run only as user “root” or user “InterBase” on UNIX.

5. Copy the database backup files to the new server and restore each database from its backup file. This process creates databases that have the current version, ODS, and dialect. (Note: In later versions of InterBase, it creates the appropriate current ODS, but always dialect 1.) Save your backup files until your migration to dialect 3 is complete.
6. To restore the list of valid users, follow these steps:
    1. Restore `isc4.gbk` to `isc4_old.ib`
    2. Shut down the server.
    3. Copy `isc4_old.ib` over `isc4.gdb`.
    4. Copy `isc4_old.gbk` over `isc4.gbk`.
    5. Restart the server.
7. Perform a full validation of each database on the new server.

After performing these steps, you have an InterBase 6 and later server and InterBase 6 and later, dialect 1 databases. See About InterBase 6 and Later, Dialect 1 Databases to understand more about these databases. See Migrating Databases to Dialect 3 for a description of how to migrate databases to dialect 3. See Migrating Clients for an introduction to client migration.

5.3. About InterBase 6 and Later, Dialect 1 Databases

When you back up a version 5 database and restore it in InterBase 6, what do you have?

- A version 5 client can access everything in the database with no further changes.
- If there are object names – column or table names, for instance – that include any of the 17 new keywords, you must change these names in order to access these objects with a version 6 dialect 1 client. The new `ALTER COLUMN` clause of `ALTER TABLE` makes it easy to implement column name changes.

- Version 5 clients can still access the columns.
- Dialect 3 clients can access these columns as long as they delimit them with double quotes.

- The 17 new keywords are reserved words. However, the new data types `TIME` and `DATE` are not available to use as data types. `DATE` columns have the old meaning—both date and time. The new meaning of `DATE` – date only – is available only in dialect 3.
- All columns that were previously `DATE` data type are now `TIMESTAMP` data type. `TIMESTAMP` contains exactly the information that `DATE` did in previous versions.
- Exact numeric columns – those that have a `DECIMAL` or `NUMERIC` data type with precision greater than 9 – are still stored as `DOUBLE PRECISION` data types. All arithmetic algorithms that worked before on these columns still work as before. It is not possible to store data as `INT64` in dialect 1.

6. Migrating Databases to Dialect 3

There are four major areas of concern when migrating a database from dialect 1 to dialect 3:

- Double quotes
- The `DATE` data type
- Large exact numerics (for purposes of this discussion, `NUMERIC` and `DECIMAL` data types that have a precision greater than 9)
- Keywords

The process varies somewhat depending on whether you can create an application to move data from your original database to an empty dialect 3 database. If you do not have access to such a utility, you need to perform an in-place migration of the original database.

6.1. Overview

In either method, you begin by extracting the metadata from your database, examining it for problem areas, and fixing the problems.

- If you are performing an in-place migration, you copy corrected SQL statements from the metadata file into a new script file, modify them, and run the script against the original database. Then you set the database to dialect 3. There are some final steps to take in the dialect 3 database to store old data as `INT64`.
- If you have a utility for moving data from the old database to a newly created empty database, you use the modified metadata file to create a new dialect 3 database and use the utility to transfer data from the old database to the new.

In both cases, you must make changes to the new database to accommodate migrated columns that must be stored as `INT64` and column constraints and defaults that originally contained double quotes.

The two methods are described below.

6.2. Method One: In-place Migration

1. If you have not migrated the database to version 6 and later, dialect 1, do so first. Back up the database again.
2. Extract the metadata from the database using `isql -x`. If you are migrating legacy databases that contain GDML, see Migrating Older Databases.
3. Prepare an empty text file to use as a script file. As you fix data structures in the metadata files, you will copy them to this file to create a new script.

> **Note:**
> You could also proceed by removing unchanged SQL statements from the original

metadata file, but this is more likely to result in problems from statements that were left in error. Embarcadero recommends creating a new script file that contains only the statements that need to be run against the original database.

For the remaining steps, use a text editor to examine and modify the metadata and script files. Place copied statements into the new script file in the same order they occur in the metadata file to avoid dependency errors.

4. Search for each instance of double quotes in the extracted metadata file. These can occur in triggers, stored procedures, views, domains, table column defaults, and constraints. Change each double quote that delimits a string to a single quote. Make a note of any tables that have column-level constraints or column defaults in double quotes.
   Copy each changed statement to your script file, but do not copy `ALTER TABLE` statements whose only double quotes are in column-level constraints or column defaults.

   Important:
   When copying trigger or stored procedure code, be sure to include any associated `SET TERM` statements.

   Quoted quotes If there is any chance that you have single or double quotes *inside* of strings, you must search and replace on a case-by-case basis to avoid inappropriate changes. The handling of quotation marks within strings is as follows:

String:	`In "peg" mode`
Double-quoted:	`"In ""peg"" mode"`
Single-quoted:	`'In "peg" mode'`
String:	`O'Reilly`
Double-quoted:	`"O'Reilly"`
Single-quoted:	`'OReilly'`

5. In the new script file, search for occurrences of the `TIMESTAMP` data type. In most cases, these were `DATE` data types in your pre-6 database. For each one, decide whether you want it to be `TIME`, `TIMESTAMP`, or `DATE` in your dialect 3 database. Change it as needed.
6. Repeat step 5 in the metadata file. Copy each changed statement to your new script file.

7. In the new script file, search for occurrences of reserved words that are used as object names and enclose them in double quotes; that makes them delimited identifiers.
8. Repeat step 7 in the metadata file. Copy each changed statement to your new script file.
9. In each of the two files, search for each instance of a `DECIMAL` or `NUMERIC` data type with a precision greater than 9. Consider whether or not you want data stored in that column or with that domain to be stored as `DOUBLE PRECISION` or `INT64`. See Do you really need to migrate your NUMERIC and DECIMAL Data Types? for a discussion of issues. For occurrences that should be stored as `DOUBLE PRECISION`, change the data type to that. Leave occurrences that you want to be stored as `INT64` alone for now. Copy each changed statement that occurs in the metadata file to your new script file.

   Perform the following steps in your new script file:

10. Locate each `CREATE TRIGGER` and `CREATE DOMAIN` statement and change it to `ALTER TRIGGER` or `ALTER DOMAIN` as appropriate.
11. Locate each `CREATE VIEW` statement. Precede it by a corresponding `DROP` statement. For example, if you have a `CREATE VIEW` **<foo>** statement, put a `DROP VIEW` **<foo>** statement right before it, so that when you run this script against your database, each view first gets dropped and then re-created.
12. If you have any `ALTER TABLE` statements that you copied because they contain named table-level constraints, modify the statement so that it does nothing except drop the named constraint and then add the constraint back with the single quotes.
13. Check that stored procedure statements are `ALTER PROCEDURE` statements. This should already be the case.
14. At the beginning of the script, put a `CONNECT` statement that connects to the original database that you are migrating.
15. Make sure your database is backed up and run your script against the database.
16. Use `gfix` to change the database dialect to 3.

    ```
    gfix -sql_dialect 3 <database.ib>
    ```

    Note:
    To run `gfix` against a database, you must attach as either the database owner or `SYSDBA`.

17. At this point, `DECIMAL` and `NUMERIC` columns with a precision greater than 9 are still stored as `DOUBLE PRECISION`. To store the data as `INT64`, read Do you really need to migrate your NUMERIC and DECIMAL Data Types? and, if necessary, follow the steps in Migrating NUMERIC and DECIMAL Data Types.
18. Validate the database using either IBConsole or `gfix`.

That's it. You have got a dialect 3 database. There is a little more work to do if you want your `NUMERIC` and `DECIMAL` columns with a precision of greater than 9 to be stored as `INT64`. At this point, they are still stored as `DOUBLE PRECISION`. To decide whether you want to change

the way data is stored in these columns, read Do you really need to migrate your NUMERIC and DECIMAL Data Types? and Migrating NUMERIC and DECIMAL Data Types.

In addition, there are some optional steps you can take that are described in the following sections, Column Defaults and Column Constraints and Unnamed Table Constraints.

Important:
If you ever extract metadata from the dialect 3 database that you created using the steps above, and if you plan to use that metadata to create a new database, check to see if the extracted metadata contains double quotes delimiting string constants in column defaults, column constraints, or unnamed table constraints. Change any such occurrences to single quotes before using the metadata to create the new database.

6.2.1. Column Defaults and Column Constraints

The steps on the parent page permitted you to retain double quoted string constants in column defaults, column constraints, and unnamed table constraints. This is possible because, once created, InterBase stores them in binary form.

Following the steps above creates a dialect 3 database that is fully functional, but if it contains double quoted string constants in column defaults, column constraints, or unnamed column constraints, inconsistencies are visible when you `SHOW` metadata or extract it. You can choose to resolve these inconsistencies by following these steps:

1. Back up the database.
2. Examine the metadata to detect each occurrence of a column default or column constraint that uses double quotes.
3. For each affected column, use the `ALTER COLUMN` clause of the `ALTER TABLE` statement to give the column a temporary name. If column position is likely to be an issue with any of your clients, change the position as well.
4. Create a new column with the desired data type, giving it the original column name and position.
5. Use `UPDATE` to copy the data from old column to the new column:

```
UPDATE table_name
 SET new_col = old_col;
```

6. Drop the old column.

6.2.2. Unnamed Table Constraints

Read the first two paragraphs under Column Defaults and Column Constraints to understand why you do not always need to change constraints with double quotes to single-quoted form, and why you might want to change them.

To bring unnamed table constraints that contain double quotes into compliance with the dialect 3 standard, follow these steps:

1. Back up the database.
2. Examine the metadata to detect each occurrence of an unnamed table constraint that uses double quotes.
3. For each occurrence, use `SHOW TABLE` to see the name that InterBase has assigned to the constraint.
4. Use `ALTER TABLE` to drop the old constraint, using the name given in the `SHOW TABLE` output and add a new constraint. For ease in future handling, give the constraint a name.
   If `SHOW TABLE` shows that InterBase stores the unnamed constraint as "`INTEG_2`", then issue the following statement to change the constraint:

```
ALTER TABLE foo
 DROP CONSTRAINT INTEG_2,
 ADD CONSTRAINT new_name
 CHECK (col_name IN ('val1', 'val2', 'val3'));
```

6.2.3. About NUMERIC and DECIMAL Data Types

If you back up a `NUMERIC` or `DECIMAL` column with a precision greater than 9 (for example, `NUMERIC` (12,2)) in an InterBase 5 or earlier database and restore the database as InterBase 6 and later, the column is still stored as `DOUBLE PRECISION`. Because InterBase does not allow data type conversions that could potentially result in data loss, you cannot use the `ALTER COLUMN` statement to change the column data type from `DOUBLE PRECISION` to `INT64`. To migrate a `DOUBLE PRECISION` column to an `INT64` column, you must create a new `INT64` column and copy the contents of the older column into it.

In InterBase 6 and later dialect 3, when you create a `NUMERIC` or `DECIMAL` column with a precision of greater than 9, data in it is automatically stored as an `INT64` exact numeric.

If you want `NUMERIC` and `DECIMAL` data types with a precision greater than 9 to be stored as exact numerics, you must take some extra steps after migrating to dialect 3. The following sections tell you how to decide whether you really need to take these steps and how to perform them if you decide you want the exact numerics.

Do you really need to migrate your NUMERIC and DECIMAL Data Types?

As you migrate your databases to dialect 3, consider the following questions about columns defined with `NUMERIC` and `DECIMAL` data types:

- Is the precision less than 10? If so, there is no issue. You can migrate without taking any action and there will be no change in the database and no effect on clients.
- For `NUMERIC` and `DECIMAL` columns with precision greater than 9, is `DOUBLE PRECISION` an appropriate way to store your data?

- In many cases, the answer is "yes." If you want to continue to store your data as `DOUBLE PRECISION`, change the data type of the column to `DOUBLE PRECISION` either before or after migrating your database to dialect 3. This does not change any functionality in dialect 3, but it brings the declaration into line with the storage mode. In a dialect 3 database, newly-created columns of this type are stored as INT64, but migrated columns are still stored as `DOUBLE PRECISION`. Changing the declaration avoids confusion.
- `DOUBLE PRECISION` may not be appropriate or desirable for financial applications and others that are sensitive to rounding errors. In this case, you need to take steps to migrate your column so that it is stored as `INT64` in dialect 3. As you make this decision, remember that INT64 does not store the same range as `DOUBLE PRECISION`. Check whether you will experience data loss and whether this is acceptable.

Migrating NUMERIC and DECIMAL Data Types

Read Do you really need to migrate your NUMERIC and DECIMAL Data Types? to decide whether you have columns in a dialect 1 database that would be best stored as 64-bit integers in a dialect 3 database. If this is the case, follow these steps for each column:

1. Migrate your database to InterBase 6 and later as described in Method One: In-place Migration.
2. Use the `ALTER COLUMN` clause of the `ALTER DATABASE` statement to change the name of each affected column to something different from its original name. If column position is going to be an issue with any of your clients, use `ALTER COLUMN` to change the positions as well.
3. Create a new column for each one that you are migrating. Use the original column names and if necessary, positions. Declare each one as a `DECIMAL` or `NUMERIC` with precision greater than 9.
4. Use `UPDATE` to copy the data from each old column to its corresponding new column:

```
UPDATE tablename
SET new_col = old_col;
```

5. Check that your data has been successfully copied to the new columns and drop the old columns.

6.3. Method Two: Migrating to a New Database

If you can create a data transfer utility that copies data between databases, the process of migrating a database to dialect 3 is considerably simplified.

Overview Extract the metadata from your database, examine it for problem areas, and fix the problems. Use the modified metadata file to create a new dialect 3 database and use an application to transfer data from the old database to the new.

1. If you have not migrated the database to version 6, dialect 1, do so first. Back up the database again.
2. Extract the metadata from the database using `isql`. If you are migrating a database that contains data structures created with GDML, see Migrating Older Databases.

   For the following steps, use a text editor to examine and modify the metadata file.

3. Search for each occurrence of the `TIMESTAMP` data type. In most cases, these were `DATE` data types in your pre-6 database. Decide whether you want it to be `TIME`, `TIMESTAMP`, or `DATE` in your dialect 3 database. Change it as needed.
4. Find all instances of reserved words that are used as object names and enclose them in double quotes to make them delimited identifiers.
5. Search for each instance of double quotes in the extracted metadata file. These can occur in triggers, stored procedures, views, domains, exceptions, table column defaults, and constraints. Change each double quote to a single quote.
6. Search for each instance of a `DECIMAL` or `NUMERIC` data type with a precision greater than 9. Consider whether or not you want that data stored as `DOUBLE PRECISION` or `INT64`. See Do you really need to migrate your NUMERIC and DECIMAL Data Types? for a discussion of issues. For occurrences that should be stored as `DOUBLE PRECISION`, change the data type to that. Leave occurrences that you want stored as `INT64` alone for now.
7. At the beginning of the file, enter `SET SQL DIALECT 3`. On the next line, uncomment the `CREATE DATABASE` statement and edit it as necessary to create a new database.
8. Run the metadata file as a script to create a new database.
9. Use your data transfer utility to copy data from the old database to the new dialect 3 database. In the case of a large database, allow significant time for this.
10. Validate the database using `gfix`.
11. At this point, `DECIMAL` and `NUMERIC` columns with a precision greater than 9 are still stored as `DOUBLE PRECISION`. To store the data as `INT64`, read Do you really need to migrate your NUMERIC and DECIMAL Data Types? and, if necessary, follow the steps in Migrating NUMERIC and DECIMAL Data Types.

6.4. Migrating Older Databases

If you have legacy databases in which some data structures were created with GDML, you may need to extract metadata in a slightly different way.

1. Try extracting metadata as described in Step 2 on page Method One: In-place Migration and examine it to see if all tables and other DDL structures are present. If they are not, delete the metadata file and extract using the `-a` switch instead of the `-x` switch. This extracts objects created in GDML.
2. You may have to change some of the code to SQL form. For example, the following domain definition

   ```
   CREATE DOMAIN NO_INIT_FLAG AS SMALLINT
    ( no_init_flag = 1 or
    no_init_flag = 0 or
    no_init_flag missing);
   ```

   needs to be translated to:

   ```
   CREATE DOMAIN NO_INIT_FLAG AS SMALLINT
    CHECK ( VALUE = 1 OR VALUE = 0 OR VALUE IS NULL );
   ```

3. Some code may be commented out. For example:

   ```
   CREATE TABLE BOILER_PLATE (BOILER_PLATE_NAME NAME,
   DATE DATE,
   CREATED_DATE COMPUTED BY /* Date */);
   ```

   needs to be changed to:

   ```
   CREATE TABLE BOILER_PLATE (BOILER_PLATE_NAME NAME,
   "DATE" DATE,
   CREATED_DATE COMPUTED BY "DATE");
   ```

7. Migrating Clients

It is good practice to recompile and relink the application and make note of field names, data type use, and so on in the new application. When you recompile, state the dialect explicitly:

```
SET SQL DIALECT n;
```

Important:
If you have databases that use any of the new 2020 keywords as object identifiers and you are not migrating those databases to dialect 3, you might consider not migrating

any older version clients. If you migrate them to 2020 dialect 1, you lose the ability to access those keyword columns. See InterBase Keywords.

When you recompile an existing `gpre` client, you must recompile it with the `gpre -sql_dialect n` switch.

There are several paths that allow you to create dialect 3 clients that access all new InterBase features:

- In Delphi, make calls to functions in the InterBase Express (IBX) package.
- To write embedded SQL applications that address all InterBase 2020 dialect 3 functionality, compile them using `gpre -sql_dialect 3`.

Client	How to migrate
Older applications such as InterBase version 5 applications	• Dialect is 1; there is no way to change the dialect. • A version 5 client application becomes version 6 dialect 1 client whenever the InterBase 2020 client is installed on the machine with the client.

isql	• Issue the following command-line option:
	`-sql_dialect n`
	• Or issue this command:
	`SET SQL DIALECT n;`

GPRE	• Issue the following command line option:
	`-sql_dialect n`
	• Or issue this command:
	`EXEC SQL SET SQL DIALECT n;`

BDE	All applications use SQL dialect 1. To access InterBase dialect 3 features from Delphi, use the IBX components.
InterClient	InterBase 6: All applications use SQL dialect 1. InterBase 7 introduced InterClient 3, which is a dialect 3 client.

Client	How to migrate
Direct API calls	When you call `isc_dsql_execute_immediate()`, `isc_dsql_exec_immed2()` or `isc_dsql_prepare()`, set the dialect parameter to the desired dialect value: 1 or 3.

8. Migrating Data from Other DBMS Products

If you have a large amount of data in another DBMS such as Paradox, the most efficient way to bring the data into InterBase is to export the data from the original DBMS into InterBase external file format. (See the Data Definition Guide for more information about InterBase external files.) Then insert the data from the external files into the internal tables. It is best not to have any constraints on new internal tables; you can validate the database more easily once the data is in InterBase. If constraints do exist, you will need triggers to massage the incoming data.

INTERBASE LIMITS

This appendix defines the limits of a number of InterBase characteristics. The values the following table lists are design limits, and in most cases are further restricted by finite resource restrictions in the operating system or computer hardware.

1. Various InterBase Limits

Characteristic	Value
Maximum number of clients connected to one server	There is no single number for the maximum number of clients the InterBase server can serve – it depends on a combination of factors including capability of the operating system, limitations of the hardware, and the demands that each client puts on the server. Applications that engage in high levels of contention or that perform complex or high-volume operations could cause the practical number of clients to be fewer. In applications that do not generate much contention, InterBase can support a large number of users, where "large" is not well-defined.
Maximum database size	No limit is imposed by InterBase; maximum size is defined by the operating system. Limit depends on database page size: • 1KB page size: largest DB is 2TB • 2KB page size: largest DB is 4TB • 4KB page size: largest DB is 8TB • 8KB page size: largest DB is 16TB • 16KB page size: largest DB is 32TB Limits for a database with 254 secondary tablespaces. • 1KB page size: largest DB is 510TB • 2KB page size: largest DB is 1PB • 4KB page size: largest DB is 2PB • 8KB page size: largest DB is 4PB • 16KB page size: largest DB is 8PB
Maximum number of tablespaces	• The maximum number of tablespaces is 254, not including the PRIMARY tablespace contained by the main database file(s).

Characteristic	Value
Maximum number of files per database	By design, 32,767 + 254(1 file per secondary tablespace) , because we use a signed 16-bit integer. Shadow files count toward this limit. This is a design parameter of InterBase, but most operating systems have a much lower limit on the number of files that a single process can have open simultaneously. In some cases, the OS provides a means to raise this limit. Refer to your OS documentation for the default open files limit, and the means to raise this limit.
Maximum number of cache pages per database	750,000. Not all database page sizes will be able to accommodate this limit in a 32-bit address space. When applying a large cache, other considerations must be taken into account such as the number of connections, statements or other database using memory at the same time. A large cache size will depend on whether a 32-bit executable is running on a 64-bit OS or how a 32-bit OS has been configured. This number depends on system memory, OS, InterBase version and DB page size: • 750,000 pages for 32-bit InterBase • 75,000,000 pages for 64-bit InterBase
Maximum number of databases open in one transaction	No restriction. The parameters in a transaction parameter buffer comprise a linked list, so there is no limit except that imposed by system resources.
Maximum number of tables per database	32,640
Maximum table size	Limit depends on database page size. Note that the total size for all tables cannot exceed maximum database size. • 1KB page size: largest table is 2TB • 2KB page size: largest table is 4TB • 4KB page size: largest table is 8TB • 8KB page size: largest table is 16TB • 16KB page size: largest table is 32TB
Maximum versions per table	255; then no more metadata changes until the database has been backed up and restored.

INTERBASE LIMITS

Characteristic	Value
Maximum row size	64KB. Each Blob and array contributes eight bytes to this limit in the form of their Blob handle. Systems tables (tables maintained by the InterBase engine for system data) have a row size limit of 128KB.
Maximum number of rows and columns per table	By design, 2^{64} rows, are enumerated with a 64-bit unsigned integer per table, current implementation limits the numbe rof rows to 2^{40}. Number of columns in a row depends on data types used. One row can be 64K. For example, you can define 16,384 columns of type INTEGER (four bytes each) in one table. Depends on row characteristics and compression, but as many rows as can be stored in maximum table size. The highest row number is 2**38 - 1 (274,877,906,943).
Maximum number of indexes per table	It is possible to create 255 indexes on a single table in InterBase. A larger DB page size always enables more index definitions than smaller DB page sizes. If your DB page size is not sufficient, you will receive the error “cannot add index, index root page is full.”
Maximum number of indexes per database	By design, 2^{32}, because you can create 2^{16} tables per database, and each table can have 2^{16} indexes. Maximum number of tables x Maximum number of indexes per table 32,640 x 64 = 2,089,960

Characteristic	Value
Maximum index key size	With the ODS 15 databases the maximum index key size limit is increased. Now larger column data can use this for both single-byte character sets and multi-byte (such as UTF8) columns. Because InterBase supports UTF8 and multiple other multi-byte character sets, the limit has been increased. For example, a single-column key using 4-byte UTF8 character would calculate to 1020/4 = 254 UTF8 characters with a 4KB page size. • ODS 15 and above databases automatically allow index definitions where the underlying key size is now a factor of the database page size. An index key can now be up to 4 bytes less than 1/4th the page size. • By default, InterBase databases are created with a 4KB page size. This can be overridden up to 16KB page size by the database developer. • The 4KB page size database would allow indexes that can accommodate 1020 bytes per key. • A 16KB page size can accommodate a 4092 bytes per key and so on. Caution: Databases created with engines enabled with this functionality cannot be moved back to older versions of InterBase. Also a database restore to a smaller page size will fail if indexes with large key size cannot fit within the limit specified above. No user interface or actions are required by the user to enable this functionality. Each time a database restore is performed, the indices are recreated. Only ODS 15 and later databases have support for larger index keys. If you want to use this facility, restore your database to ODS 15. Other indices that use a smaller size than 252 bytes continue to have the same on-disk storage without any penalty. Note that multibyte character sets must fit within the key by counting bytes, not by counting characters. It is good practice to keep index keys as small as possible. This limits the depth of indexes and increases their efficiency.
Maximum number of events per stored procedure	No restriction by design, but there is a practical limit, given that there is a limit on the length of code in a stored procedure or trigger (see below).

Characteristic	Value
Maximum stored procedure or trigger code size	48KB of `BLR`, the bytecode language compiled from stored procedure or trigger language.
Maximum Blob size	The size of the largest single Blob depends on the database page size: 1KB page size: largest Blob is 64MB 2KB page size: largest Blob is 512MB 4KB page size: largest Blob is 4GB 8KB page size: largest Blob is 32GB 16KB page size: largest Blob is 256GB A Blob is a stream of many segments. The maximum Blob segment size is 64KB.
Maximum tables in a `JOIN`	No restriction by design, but the task of joining tables is exponential in relation to number of tables in the join. The largest practical number of tables in a `JOIN` is about 16, but experiment with your application and a realistic volume of data to find the most complex join that has acceptable performance.
Maximum levels of nested queries	There is no restriction by design. The practical limit depends on the type of queries you nest. Experiment with your application and a realistic volume of data to find the deepest nested query that has acceptable performance.
Maximum number of columns per one composite index	16
Levels of nesting per stored procedure or trigger	• 750 on Windows platforms • 1000 for UNIX platforms
Maximum size of key in `SORT` clause	32 KB
Maximum size of external table file	64-bit file offset allows up to 16 Exabytes of information.
Range of date values	January 1, 100 a.d. to February 29, 32768 a.d.

Characteristic	Value
Transaction Limits	• Databases with ODS <=15 need to be backed up and restored before they hit the 2 Billion transaction ID limit. • Databases with ODS >=16 can continue to be online beyond 2 billion transactions since they support 64-bit Transaction ID. A benefit of this is you can have your databases online to service your applications closer to a 24/7 scenario without having to backup/restore due to this earlier 32-bit limit.
Maximum number of generators per database	• The maximum number of generators in a database is 32,767. However, the number of user defined generators is lower because system tables use some generator IDs for internal use from the same ID namespace.