

# Accessing PostgreSQL Databases

## The pgsq module

The pgsq module is used to access PostgreSQL databases. It is a Lua binding to libpq, the PostgreSQL C language interface and offers more or less the same functionality.

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PostgreSQL Database Management System

(formerly known as Postgres, then as Postgres95)

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## Database connection control functions

The following functions deal with making a connection to a PostgreSQL backend server. An application program can have several backend connections open at one time. (One reason to do that is to access more than one database.) Each connection is represented by a connection object, which is obtained from the function `connectdb`. The status function should be called to check the return value for a successful connection before queries are sent via the connection object.

`connectdb(conninfo)`

Makes a new connection to the database server. This function opens a new database connec -

tion using the parameters taken from the string `conninfo`. The passed string can be empty to use all default parameters, or it can contain one or more parameter settings separated by white-space, or it can contain a URI.

`connectStart(conninfo)`

Make a connection to the database server in a nonblocking manner. With `connectStart`, the database connection is made using the parameters taken from the string `conninfo` as described above for `connectdb`.

`ping(conninfo)`

`ping` reports the status of the server. It accepts connection parameters identical to those of `connectdb`, described above. It is not necessary to supply correct user name, password, or database name values to obtain the server status; however, if incorrect values are provided, the server will log a failed connection attempt.

`conn:connectPoll()`

If `connectStart` succeeds, the next stage is to poll `libpq` so that it can proceed with the connection sequence. Use `conn:socket` to obtain the descriptor of the socket underlying the database connection. Loop thus: If `conn:connectPoll()` last returned `PGRES_POLLING_READING`, wait until the socket is ready to read (as indicated by `select()`, `poll()`, or similar system function). Then call `conn:connectPoll()` again. Conversely, if `conn:connectPoll()` last returned `PGRES_POLLING_WRITING`, wait until the socket is ready to write, then call `conn:connectPoll()` again. If you have yet to call `connectPoll`, i.e., just after the call to `connectStart`, behave as if it last returned `PGRES_POLLING_WRITING`. Continue this loop until `conn:connectPoll()` returns `PGRES_POLLING_FAILED`, indicating the connection procedure has failed, or `PGRES_POLLING_OK`, indicating the connection has been successfully made.

`conn:finish()`

Closes the connection to the server. Also frees memory used by the underlying connection object. Note that even if the server connection attempt fails (as indicated by status), the application should call `finish` to free the memory used by the underlying connection object. The connection object must not be used again after `finish` has been called.

`conn:reset()`

Resets the communication channel to the server. This function will close the connection to the server and attempt to reestablish a new connection to the same server, using all the same parameters previously used. This might be useful for error recovery if a working connection is lost.

`conn:resetStart()`

Reset the communication channel to the server, in a nonblocking manner.

`conn:resetPoll()`

## Connection status functions

`conn:db()`

Returns the database name of the connection.

`conn:user()`

Returns the user name of the connection.

`conn:pass()`

Returns the password of the connection.

`conn:host()`

Returns the server host name of the connection.

`conn:port()`

Returns the port of the connection.

`conn:tty()`

Returns the debug TTY of the connection. (This is obsolete, since the server no longer pays attention to the TTY setting, but the function remains for backward compatibility.)

`conn:options()`

Returns the command-line options passed in the connection request.

`conn:status()`

Returns the status of the connection.

The status can be one of a number of values. However, only two of these are seen outside of an asynchronous connection procedure: `CONNECTION_OK` and `CONNECTION_BAD`. A good connection to the database has the status `CONNECTION_OK`. A failed connection attempt is signaled by status `CONNECTION_BAD`. Ordinarily, an OK status will remain so until PQfinish, but a communications failure might result in the status changing to `CONNECTION_BAD` prematurely. In that case the application could try to recover by calling `reset`.

`conn:transactionStatus()`

Returns the current in-transaction status of the server.

The status can be `PQTRANS_IDLE` (currently idle), `PQTRANS_ACTIVE` (a command is in progress), `PQTRANS_INTRANS` (idle, in a valid transaction block), or `PQTRANS_INERROR` (idle, in a failed transaction block). `PQTRANS_UNKNOWN` is reported if the connection is bad. `PQTRANS_ACTIVE` is reported only when a query has been sent to the server and not yet completed.

`conn:parameterStatus(paramName)`

Looks up a current parameter setting of the server.

Certain parameter values are reported by the server automatically at connection startup or whenever their values change. `parameterStatus` can be used to interrogate these settings. It returns the current value of a parameter if known, or nil if the parameter is not known.

Parameters reported as of the current release include `server_version`, `server_encoding`, `client_encoding`, `application_name`, `is_superuser`, `session_authorization`, `DateStyle`, `IntervalStyle`, `TimeZone`, `integer_datetimes`, and `standard_conforming_strings`. (`server_encoding`, `TimeZone`, and `integer_datetimes` were not reported by releases before 8.0; `standard_conforming_strings` was not reported by releases before 8.1; `IntervalStyle` was not reported by releases before 8.4; `application_name` was not reported by releases before 9.0.) Note that `server_version`, `server_encoding` and `integer_datetimes` cannot change after startup.

Pre-3.0-protocol servers do not report parameter settings, but `pgsql` includes logic to obtain values for `server_version` and `client_encoding` anyway. Applications are encouraged to use `parameterStatus` rather than ad hoc code to determine these values. (Beware however that on a pre-3.0 connection, changing `client_encoding` via `SET` after connection startup will not be reflected by `parameterStatus`.) For `server_version`, see also `serverVersion`, which returns the information in a numeric form that is much easier to compare against.

If no value for `standard_conforming_strings` is reported, applications can assume it is off, that is, backslashes are treated as escapes in string literals. Also, the presence of this parameter can be taken as an indication that the escape string syntax (`E'...'`) is accepted.

`conn:protocolVersion()`

Interrogates the frontend/backend protocol being used.

Applications might wish to use this function to determine whether certain features are supported. Currently, the possible values are 2 (2.0 protocol), 3 (3.0 protocol), or zero (connection bad). The protocol version will not change after connection startup is complete, but it could theoretically change during a connection reset. The 3.0 protocol will normally be used when communicating with PostgreSQL 7.4 or later servers; pre-7.4 servers support only protocol 2.0. (Protocol 1.0 is obsolete and not supported by `pgsql`.)

`conn:serverVersion()`

Returns an integer representing the backend version.

Applications might use this function to determine the version of the database server they are connected to. The number is formed by converting the major, minor, and revision numbers into two-decimal-digit numbers and appending them together. For example, version 8.1.5 will be returned as 80105, and version 8.2 will be returned as 80200 (leading zeroes are not shown). Zero is returned if the connection is bad.

`conn:errorMessage()`

Returns the error message most recently generated by an operation on the connection.

Nearly all `pgsql` functions will set a message for `errorMessage` if they fail. Note that by `pgsql` con -

vention, a nonempty errorMessage result can consist of multiple lines, and will include a trailing newline.

conn:socket()

Obtains the file descriptor number of the connection socket to the server. A valid descriptor will be greater than or equal to 0; a result of -1 indicates that no server connection is currently open. (This will not change during normal operation, but could change during connection setup or re-set.)

conn:backendPID()

Returns the process ID (PID) of the backend process handling this connection.

The backend PID is useful for debugging purposes and for comparison to NOTIFY messages (which include the PID of the notifying backend process). Note that the PID belongs to a process executing on the database server host, not the local host!

conn:connectionNeedsPassword()

Returns true (1) if the connection authentication method required a password, but none was available. Returns false (0) if not.

This function can be applied after a failed connection attempt to decide whether to prompt the user for a password.

conn:connectionUsedPassword()

Returns true (1) if the connection authentication method used a password. Returns false (0) if not.

This function can be applied after either a failed or successful connection attempt to detect whether the server demanded a password.

## Command execution functions

conn:exec(command)

Submits a command to the server and waits for the result.

The command string can include multiple SQL commands (separated by semicolons). Multiple queries sent in a single exec call are processed in a single transaction, unless there are explicit BEGIN/COMMIT commands included in the query string to divide it into multiple transactions. Note however that the returned result object describes only the result of the last command executed from the string. Should one of the commands fail, processing of the string stops with it and the returned result describes the error condition.

conn:execParams(command [, param] ...)

Submits a command to the server and waits for the result, with the ability to pass parameters separately from the SQL command text.

The primary advantage of execParams over exec is that parameter values can be separated from

the command string, thus avoiding the need for tedious and error-prone quoting and escaping.

Unlike `exec`, `execParams` allows at most one SQL command in the given string. (There can be semicolons in it, but not more than one nonempty command.) This is a limitation of the underlying protocol, but has some usefulness as an extra defense against SQL-injection attacks.

`conn:prepare()`

Submits a request to create a prepared statement with the given parameters, and waits for completion.

`prepare` creates a prepared statement for later execution with `execPrepared`. This feature allows commands that will be used repeatedly to be parsed and planned just once, rather than each time they are executed. `prepare` is supported only in protocol 3.0 and later connections; it will fail when using protocol 2.0.

The function creates a prepared statement named `stmtName` from the query string, which must contain a single SQL command. `stmtName` can be `""` to create an unnamed statement, in which case any pre-existing unnamed statement is automatically replaced; otherwise it is an error if the statement name is already defined in the current session. If any parameters are used, they are referred to in the query as `$1`, `$2`, etc.

As with `exec`, the result is normally a result object whose contents indicate server-side success or failure. A null result indicates out-of-memory or inability to send the command at all. Use `errorMessage` to get more information about such errors.

`conn:execPrepared()`

Sends a request to execute a prepared statement with given parameters, and waits for the result.

`execPrepared` is like `execParams`, but the command to be executed is specified by naming a previously-prepared statement, instead of giving a query string. This feature allows commands that will be used repeatedly to be parsed and planned just once, rather than each time they are executed. The statement must have been prepared previously in the current session. `PQexecPrepared` is supported only in protocol 3.0 and later connections; it will fail when using protocol 2.0.

The parameters are identical to `execParams`, except that the name of a prepared statement is given instead of a query string, and the `paramTypes[]` parameter is not present (it is not needed since the prepared statement's parameter types were determined when it was created).

`conn:describePrepared()`

Submits a request to obtain information about the specified prepared statement, and waits for completion.

`describePrepared` allows an application to obtain information about a previously prepared statement. `describePrepared` is supported only in protocol 3.0 and later connections; it will fail when using protocol 2.0.

stmtName can be "" or NULL to reference the unnamed statement, otherwise it must be the name of an existing prepared statement. On success, a result with status PGRES\_COMMAND\_OK is returned. The functions nparams and paramtype can be applied to this result to obtain information about the parameters of the prepared statement, and the functions nfields, fname, ftype, etc provide information about the result columns (if any) of the statement.

conn:describePortal(portalName)

Submits a request to obtain information about the specified portal, and waits for completion.

describePortal allows an application to obtain information about a previously created portal. (libpq does not provide any direct access to portals, but you can use this function to inspect the properties of a cursor created with a DECLARE CURSOR SQL command.) PQdescribePortal is supported only in protocol 3.0 and later connections; it will fail when using protocol 2.0.

portalName can be "" or NULL to reference the unnamed portal, otherwise it must be the name of an existing portal. On success, a result with status PGRES\_COMMAND\_OK is returned. The functions nfields, fname, ftype, etc can be applied to the result to obtain information about the result columns (if any) of the portal.

## Result functions

res:status()

Returns the result status of the command.

PQresultStatus can return one of the following values:

PGRES\_EMPTY\_QUERY

The string sent to the server was empty.

PGRES\_COMMAND\_OK

Successful completion of a command returning no data.

PGRES\_TUPLES\_OK

Successful completion of a command returning data (such as a SELECT or SHOW).

PGRES\_COPY\_OUT

Copy Out (from server) data transfer started.

PGRES\_COPY\_IN

Copy In (to server) data transfer started.

PGRES\_BAD\_RESPONSE

The server's response was not understood.

PGRES\_NONFATAL\_ERROR

A nonfatal error (a notice or warning) occurred.

`PGRES_FATAL_ERROR`

A fatal error occurred.

`PGRES_COPY_BOTH`

Copy In/Out (to and from server) data transfer started. This feature is currently used only for streaming replication, so this status should not occur in ordinary applications.

`PGRES_SINGLE_TUPLE`

The result contains a single result tuple from the current command. This status occurs only when single-row mode has been selected for the query.

If the result status is `PGRES_TUPLES_OK` or `PGRES_SINGLE_TUPLE`, then the functions described below can be used to retrieve the rows returned by the query. Note that a `SELECT` command that happens to retrieve zero rows still shows `PGRES_TUPLES_OK`. `PGRES_COMMAND_OK` is for commands that can never return rows (`INSERT` or `UPDATE` without a `RETURNING` clause, etc.). A response of `PGRES_EMPTY_QUERY` might indicate a bug in the client software.

A result of status `PGRES_NONFATAL_ERROR` will never be returned directly by `exec` or other query execution functions; results of this kind are instead passed to the notice processor.

`res:resStatus(status)`

Converts the enumerated type returned by `PQresultStatus` into a string constant describing the status code.

`res:errorMessage()`

Returns the error message associated with the command, or an empty string if there was no error.

If there was an error, the returned string will include a trailing newline.

Immediately following an `exec` or `getResult` call, `errorMessage` (on the connection) will return the same string as `resultErrorMessage` (on the result). However, a result will retain its error message until destroyed, whereas the connection's error message will change when subsequent operations are done. Use `resultErrorMessage` when you want to know the status associated with a particular result; use `errorMessage` when you want to know the status from the latest operation on the connection.

`res:errorField(fieldcode)`

Returns an individual field of an error report.

`fieldcode` is an error field identifier; see the symbols listed below. `NULL` is returned if the result is not an error or warning result, or does not include the specified field. Field values will normally not include a trailing newline.



The following field codes are available:

#### PG\_DIAG\_SEVERITY

The severity; the field contents are ERROR, FATAL, or PANIC (in an error message), or WARNING, NOTICE, DEBUG, INFO, or LOG (in a notice message), or a localized translation of one of these. Always present.

#### PG\_DIAG\_SQLSTATE

The SQLSTATE code for the error. The SQLSTATE code identifies the type of error that has occurred; it can be used by front-end applications to perform specific operations (such as error handling) in response to a particular database error. For a list of the possible SQLSTATE codes, see Appendix A. This field is not localizable, and is always present.

#### PG\_DIAG\_MESSAGE\_PRIMARY

The primary human-readable error message (typically one line). Always present.

#### PG\_DIAG\_MESSAGE\_DETAIL

Detail: an optional secondary error message carrying more detail about the problem. Might run to multiple lines.

#### PG\_DIAG\_MESSAGE\_HINT

Hint: an optional suggestion what to do about the problem. This is intended to differ from detail in that it offers advice (potentially inappropriate) rather than hard facts. Might run to multiple lines.

#### PG\_DIAG\_STATEMENT\_POSITION

A string containing a decimal integer indicating an error cursor position as an index into the original statement string. The first character has index 1, and positions are measured in characters not bytes.

#### PG\_DIAG\_INTERNAL\_POSITION

This is defined the same as the PG\_DIAG\_STATEMENT\_POSITION field, but it is used when the cursor position refers to an internally generated command rather than the one submitted by the client. The PG\_DIAG\_INTERNAL\_QUERY field will always appear when this field appears.

#### PG\_DIAG\_INTERNAL\_QUERY

The text of a failed internally-generated command. This could be, for example, a SQL query issued by a PL/pgSQL function.

#### PG\_DIAG\_CONTEXT

An indication of the context in which the error occurred. Presently this includes a call stack trace back of active procedural language functions and internally-generated queries. The trace is one entry per line, most recent first.

#### PG\_DIAG\_SCHEMA\_NAME

If the error was associated with a specific database object, the name of the schema containing that object, if any.

PG\_DIAG\_TABLE\_NAME

If the error was associated with a specific table, the name of the table. (Refer to the schema name field for the name of the table's schema.)

PG\_DIAG\_COLUMN\_NAME

If the error was associated with a specific table column, the name of the column. (Refer to the schema and table name fields to identify the table.)

PG\_DIAG\_DATATYPE\_NAME

If the error was associated with a specific data type, the name of the data type. (Refer to the schema name field for the name of the data type's schema.)

PG\_DIAG\_CONSTRAINT\_NAME

If the error was associated with a specific constraint, the name of the constraint. Refer to fields listed above for the associated table or domain. (For this purpose, indexes are treated as constraints, even if they weren't created with constraint syntax.)

PG\_DIAG\_SOURCE\_FILE

The file name of the source-code location where the error was reported.

PG\_DIAG\_SOURCE\_LINE

The line number of the source-code location where the error was reported.

PG\_DIAG\_SOURCE\_FUNCTION

The name of the source-code function reporting the error.

The client is responsible for formatting displayed information to meet its needs; in particular it should break long lines as needed. Newline characters appearing in the error message fields should be treated as paragraph breaks, not line breaks.

Errors generated internally by postgresql will have severity and primary message, but typically no other fields. Errors returned by a pre-3.0-protocol server will include severity and primary message, and sometimes a detail message, but no other fields.

Note that error fields are only available from result objects, not conn objects; there is no `errorField` function.

## Retrieving query result information

These functions are used to extract information from a result object that represents a successful query result (that is, one that has status `PGRES_TUPLES_OK` or `PGRES_SINGLE_TUPLE`). They can also be used to extract information from a successful Describe operation: a Describe's result has all the same column information that actual execution of the query would provide, but it has

zero rows. For objects with other status values, these functions will act as though the result has zero rows and zero columns.

`res:ntuples()`

Returns the number of rows (tuples) in the query result. Because it returns an integer result, large result sets might overflow the return value on 32-bit operating systems.

`res:nfields()`

Returns the number of columns (fields) in each row of the query result.

`res:fname(columnNumber)`

Returns the column name associated with the given column number. Column numbers start at 1.

`res:fnumber(columnName)`

Returns the column number associated with the given column name.

-1 is returned if the given name does not match any column.

The given name is treated like an identifier in an SQL command, that is, it is downcased unless double-quoted.

`res:ftable(columnNumber)`

Returns the OID of the table from which the given column was fetched. Column numbers start at 1.

`res:ftablecol(columnNumber)`

Returns the column number (within its table) of the column making up the specified query result column. Query-result column numbers start at 1.

`res:fformat(columnNumber)`

Returns the format code indicating the format of the given column. Column numbers start at 1.

Format code zero indicates textual data representation, while format code one indicates binary representation. (Other codes are reserved for future definition.)

`res:ftype(columnNumber)`

Returns the data type associated with the given column number. The integer returned is the internal OID number of the type. Column numbers start at 1.

You can query the system table `pg_type` to obtain the names and properties of the various data types. The OIDs of the built-in data types are defined in the file `src/include/catalog/pg_type.h` in the PostgreSQL source tree.

`res:fmod(columnNumber)`

Returns the type modifier of the column associated with the given column number. Column numbers start at 1.

The interpretation of modifier values is type-specific; they typically indicate precision or size limits. The value -1 is used to indicate "no information available". Most data types do not use modifiers, in which case the value is always -1.

`res:fsize(columnNumber)`

Returns the size in bytes of the column associated with the given column number. Column numbers start at 1.

`fsize` returns the space allocated for this column in a database row, in other words the size of the server's internal representation of the data type. (Accordingly, it is not really very useful to clients.) A negative value indicates the data type is variable-length.

`res:binaryTuples()`

Returns 1 if the result contains binary data and 0 if it contains text data.

This function is deprecated (except for its use in connection with `COPY`), because it is possible for a single result to contain text data in some columns and binary data in others. `format` is preferred. `binaryTuples` returns 1 only if all columns of the result are binary (format 1).

`res:getvalue(rowNumber, columnNumber)`

Returns a single field value of one row of a result. Row and column numbers start at 1.

For data in text format, the value returned by `getvalue` is a string representation of the field value. For data in binary format, the value is in the binary representation determined by the data type's `typsend` and `typreceive` functions. (The value is actually followed by a zero byte in this case too, but that is not ordinarily useful, since the value is likely to contain embedded nulls.)

An empty string is returned if the field value is null. See `getisnull` to distinguish null values from empty-string values.

`res:getisnull(rowNumber, columnNumber)`

Tests a field for a null value. Row and column numbers start at 1.

This function returns 1 if the field is null and 0 if it contains a non-null value. (Note that `getvalue` will return an empty string, not nil, for a null field.)

`res:getlength(rowNumber, columnNumber)`

Returns the actual length of a field value in bytes. Row and column numbers start at 1.

This is the actual data length for the particular data value, that is, the size of the object pointed to by `getvalue`. For text data format this is the same as `strlen()`. For binary format this is essential information. Note that one should not rely on `fsize` to obtain the actual data length.

`res:nparams()`

Returns the number of parameters of a prepared statement.

`res:paramtype(paramNumber)`

Returns the data type of the indicated statement parameter. Parameter numbers start at 1.

This function is only useful when inspecting the result of `describePrepared`. For other types of queries it will return zero.

## Retrieving other result information

These functions are used to extract other information from result objects.

`res:cmdStatus()`

Returns the command status tag from the SQL command that generated the result.

Commonly this is just the name of the command, but it might include additional data such as the number of rows processed.

`res:cmdTuples()`

Returns the number of rows affected by the SQL command.

This function returns a string containing the number of rows affected by the SQL statement that generated the result. This function can only be used following the execution of a `SELECT`, `CREATE TABLE AS`, `INSERT`, `UPDATE`, `DELETE`, `MOVE`, `FETCH`, or `COPY` statement, or an `EXECUTE` of a prepared query that contains an `INSERT`, `UPDATE`, or `DELETE` statement. If the command that generated the result was anything else, `cmdTuples` returns an empty string.

`res:oidValue()`

Returns the OID of the inserted row, if the SQL command was an `INSERT` that inserted exactly one row into a table that has OIDs, or a `EXECUTE` of a prepared query containing a suitable `INSERT` statement. Otherwise, this function returns `InvalidOid`. This function will also return `InvalidOid` if the table affected by the `INSERT` statement does not contain OIDs.

`res:oidStatus()`

This function is deprecated in favor of `oidValue` and is not thread-safe. It returns a string with the OID of the inserted row, while `oidValue` returns the OID value.

## Escaping strings for inclusion in SQL commands

`conn:escapeLiteral(str)`

`escapeLiteral` escapes a string for use within an SQL command. This is useful when inserting data values as literal constants in SQL commands. Certain characters (such as quotes and backslashes) must be escaped to prevent them from being interpreted specially by the SQL parser. `escapeLiteral` performs this operation.

`escapeLiteral` returns an escaped version of the `str` parameter. The return string has all special characters replaced so that they can be properly processed by the PostgreSQL string literal parser. A terminating zero byte is also added. The single quotes that must surround PostgreSQL string literals are included in the result string.

On error, `escapeLiteral` returns nil and a suitable message is stored in the conn object.

Note that it is not necessary nor correct to do escaping when a data value is passed as a separate parameter in `execParams` or its sibling routines.

`conn:escapeString(str)`

`Escape` escapes string literals, much like `escapeLiteral`.

`conn:escapeIdentifier(str)`

`escapeIdentifier` escapes a string for use as an SQL identifier, such as a table, column, or function name. This is useful when a user-supplied identifier might contain special characters that would otherwise not be interpreted as part of the identifier by the SQL parser, or when the identifier might contain upper case characters whose case should be preserved.

`escapeIdentifier` returns a version of the `str` parameter escaped as an SQL identifier. The return string has all special characters replaced so that it will be properly processed as an SQL identifier. A terminating zero byte is also added. The return string will also be surrounded by double quotes.

On error, `escapeIdentifier` returns nil and a suitable message is stored in the conn object.

`conn:escapeBytea(str)`

Escapes binary data for use within an SQL command with the type `bytea`. As with `escapeString`, this is only used when inserting data directly into an SQL command string.

Certain byte values must be escaped when used as part of a `bytea` literal in an SQL statement. `escapeBytea` escapes bytes using either hex encoding or backslash escaping.

On error, nil is returned, and a suitable error message is stored in the conn object. Currently, the only possible error is insufficient memory for the result string.

`conn:unescapeBytea(str)`

Converts a string representation of binary data into binary data — the reverse of `escapeBytea`. This is needed when retrieving `bytea` data in text format, but not when retrieving it in binary format.

## Asynchronous command processing

The `exec` function is adequate for submitting commands in normal, synchronous applications. It has a few deficiencies, however, that can be of importance to some users:

- `exec` waits for the command to be completed. The application might have other work to do (such as maintaining a user interface), in which case it won't want to block waiting for the response.
- Since the execution of the client application is suspended while it waits for the result, it is hard for the application to decide that it would like to try to cancel the ongoing command. (It can be done from a signal handler, but not otherwise.)

- `exec` can return only one result object. If the submitted command string contains multiple SQL commands, all but the last result are discarded by `exec`.
- `exec` always collects the command's entire result, buffering it in a single result. While this simplifies error-handling logic for the application, it can be impractical for results containing many rows.

Applications that do not like these limitations can instead use the underlying functions that `exec` is built from: `sendQuery` and `getResult`. There are also `sendQueryParams`, `sendPrepare`, `sendQueryPrepared`, `sendDescribePrepared`, and `sendDescribePortal`, which can be used with `getResult` to duplicate the functionality of `execParams`, `prepare`, `execPrepared`, `describePrepared`, and `describePortal` respectively.

`conn:sendQuery(command)`

Submits a command to the server without waiting for the result(s). 1 is returned if the command was successfully dispatched and 0 if not (in which case, use `errorMessage` to get more information about the failure).

After successfully calling `sendQuery`, call `getResult` one or more times to obtain the results. `sendQuery` cannot be called again (on the same connection) until `getResult` has returned a null pointer, indicating that the command is done.

`conn:sendQueryParams(command [[, param] ..])`

Submits a command and separate parameters to the server without waiting for the result(s).

This is equivalent to `sendQuery` except that query parameters can be specified separately from the query string. The function's parameters are handled identically to `execParams`. Like `execParams`, it will not work on 2.0-protocol connections, and it allows only one command in the query string.

`conn:sendPrepare(stmtName, query [[, param] ..])`

Sends a request to create a prepared statement with the given parameters, without waiting for completion.

This is an asynchronous version of `prepare`: it returns 1 if it was able to dispatch the request, and 0 if not. After a successful call, call `PQgetResult` to determine whether the server successfully created the prepared statement. The function's parameters are handled identically to `prepare`. Like `prepare`, it will not work on 2.0-protocol connections.

`conn:sendQueryPrepared(stmtName [[, param] ..])`

Sends a request to execute a prepared statement with given parameters, without waiting for the result(s).

This is similar to `sendQueryParams`, but the command to be executed is specified by naming a previously-prepared statement, instead of giving a query string. The function's parameters are handled identically to `execPrepared`. Like `execPrepared`, it will not work on 2.0-protocol connections.

tions.

`conn:sendDescribePrepared(stmtName)`

Submits a request to obtain information about the specified prepared statement, without waiting for completion.

This is an asynchronous version of `describePrepared`: it returns 1 if it was able to dispatch the request, and 0 if not. After a successful call, call `getResult` to obtain the results. The function's parameters are handled identically to `describePrepared`. Like `describePrepared`, it will not work on 2.0-protocol connections.

`conn:sendDescribePortal(portalName)`

Submits a request to obtain information about the specified portal, without waiting for completion.

This is an asynchronous version of `describePortal`: it returns 1 if it was able to dispatch the request, and 0 if not. After a successful call, call `getResult` to obtain the results. The function's parameters are handled identically to `describePortal`. Like `describePortal`, it will not work on 2.0-protocol connections.

`conn:getResult()`

Waits for the next result from a prior `sendQuery`, `sendQueryParams`, `sendPrepare`, `sendQueryPrepared`, `sendDescribePrepared`, or `sendDescribePortal` call, and returns it. `nil` is returned when the command is complete and there will be no more results.

`getResult` must be called repeatedly until it returns `nil`, indicating that the command is done. (If called when no command is active, `getResult` will just return `nil` at once.) Each non-`nil` result from `getResult` should be processed using the same result accessor functions previously described. Note that `getResult` will block only if a command is active and the necessary response data has not yet been read by `consumeInput`.

Note: Even when `resultStatus` indicates a fatal error, `getResult` should be called until it returns a `nil`, to allow `pgsql` to process the error information completely.

Using `sendQuery` and `getResult` solves one of `exec`'s problems: If a command string contains multiple SQL commands, the results of those commands can be obtained individually. (This allows a simple form of overlapped processing, by the way: the client can be handling the results of one command while the server is still working on later queries in the same command string.)

By itself, calling `getResult` will still cause the client to block until the server completes the next SQL command. This can be avoided by proper use of two more functions:

`conn:consumeInput()`

If input is available from the server, consume it.

`consumeInput` normally returns 1 indicating "no error", but returns 0 if there was some kind of trouble (in which case `errorMessage` can be consulted). Note that the result does not say



whether any input data was actually collected. After calling `consumeInput`, the application can check `isBusy` and/or `notifies` to see if their state has changed.

`consumeInput` can be called even if the application is not prepared to deal with a result or notification just yet. The function will read available data and save it in a buffer, thereby causing a `select()` read-ready indication to go away. The application can thus use `consumeInput` to clear the `select()` condition immediately, and then examine the results at leisure.

`conn:isBusy()`

Returns 1 if a command is busy, that is, `getResult` would block waiting for input. A 0 return indicates that `getResult` can be called with assurance of not blocking.

`isBusy` will not itself attempt to read data from the server; therefore `PQconsumeInput` must be invoked first, or the busy state will never end.

A typical application using these functions will have a main loop that uses `select()` or `poll()` to wait for all the conditions that it must respond to. One of the conditions will be input available from the server, which in terms of `select()` means readable data on the file descriptor identified by `socket`. When the main loop detects input ready, it should call `consumeInput` to read the input. It can then call `isBusy`, followed by `getResult` if `isBusy` returns false (0). It can also call `notifies` to detect NOTIFY messages.

A client that uses `sendQuery/getResult` can also attempt to cancel a command that is still being processed by the server. But regardless of the return value of `cancel`, the application must continue with the normal result-reading sequence using `getResult`. A successful cancellation will simply cause the command to terminate sooner than it would have otherwise.

By using the functions described above, it is possible to avoid blocking while waiting for input from the database server. However, it is still possible that the application will block waiting to send output to the server. This is relatively uncommon but can happen if very long SQL commands or data values are sent. (It is much more probable if the application sends data via COPY IN, however.) To prevent this possibility and achieve completely nonblocking database operation, the following additional functions can be used.

`conn:setnonblocking()`

Sets the nonblocking status of the connection.

Sets the state of the connection to nonblocking if `arg` is 1, or blocking if `arg` is 0. Returns 0 if OK, -1 if error.

In the nonblocking state, calls to `sendQuery`, `putline`, `putnbytes`, and `endcopy` will not block but instead return an error if they need to be called again.

Note that `exec` does not honor nonblocking mode; if it is called, it will act in blocking fashion anyway.

`conn:isnonblocking()`

Returns the blocking status of the database connection.

Returns 1 if the connection is set to nonblocking mode and 0 if blocking.

`conn:flush()`

Attempts to flush any queued output data to the server. Returns 0 if successful (or if the send queue is empty), -1 if it failed for some reason, or 1 if it was unable to send all the data in the send queue yet (this case can only occur if the connection is nonblocking).

After sending any command or data on a nonblocking connection, call `PQflush`. If it returns 1, wait for the socket to be write-ready and call it again; repeat until it returns 0. Once `PQflush` returns 0, wait for the socket to be read-ready and then read the response as described above.

## Retrieving Query Results Row-By-Row

Ordinarily, `pgsql` collects a SQL command's entire result and returns it to the application as a single result. This can be unworkable for commands that return a large number of rows. For such cases, applications can use `sendQuery` and `getResult` in single-row mode. In this mode, the result row(s) are returned to the application one at a time, as they are received from the server.

To enter single-row mode, call `setSingleRowMode` immediately after a successful call of `sendQuery` (or a sibling function). This mode selection is effective only for the currently executing query. Then call `getResult` repeatedly, until it returns `nil`. If the query returns any rows, they are returned as individual result objects, which look like normal query results except for having status code `PGRES_SINGLE_TUPLE` instead of `PGRES_TUPLES_OK`. After the last row, or immediately if the query returns zero rows, a zero-row object with status `PGRES_TUPLES_OK` is returned; this is the signal that no more rows will arrive. (But note that it is still necessary to continue calling `getResult` until it returns `nil`.) All of these result objects will contain the same row description data (column names, types, etc) that an ordinary result object for the query would have.

`conn:setSingleRowMode()`

Select single-row mode for the currently-executing query.

This function can only be called immediately after `sendQuery` or one of its sibling functions, before any other operation on the connection such as `consumeInput` or `getResult`. If called at the correct time, the function activates single-row mode for the current query and returns 1. Otherwise the mode stays unchanged and the function returns 0. In any case, the mode reverts to normal after completion of the current query.

## Canceling queries in progress

`conn:cancel()`

Requests that the server abandon processing of the current command.

## Asynchronous notification functions

PostgreSQL offers asynchronous notification via the LISTEN and NOTIFY commands. A client session registers its interest in a particular notification channel with the LISTEN command (and can stop listening with the UNLISTEN command). All sessions listening on a particular channel will be notified asynchronously when a NOTIFY command with that channel name is executed by any session. A "payload" string can be passed to communicate additional data to the listeners.

pgsql applications submit LISTEN, UNLISTEN, and NOTIFY commands as ordinary SQL commands. The arrival of NOTIFY messages can subsequently be detected by calling notifies.

`conn:notifies()`

The function notifies returns the next notification from a list of unhandled notification messages received from the server. It returns nil if there are no pending notifications. Once a notification is returned from notifies, it is considered handled and will be removed from the list of notifications.

notifies does not actually read data from the server; it just returns messages previously absorbed by another pgsql function.

A good way to check for NOTIFY messages when you have no useful commands to execute is to call `consumeInput`, then check `notifies`. You can use `select()` to wait for data to arrive from the server, thereby using no CPU power unless there is something to do. (See `socket` to obtain the file descriptor number to use with `select()`.) Note that this will work OK whether you submit commands with `sendQuery/getResult` or simply use `exec`. You should, however, remember to check `notifies` after each `getResult` or `exec`, to see if any notifications came in during the processing of the command.

## Functions associated with the COPY command

The COPY command in PostgreSQL has options to read from or write to the network connection used by pgsql. The functions described in this section allow applications to take advantage of this capability by supplying or consuming copied data.

The overall process is that the application first issues the SQL COPY command via `exec` or one of the equivalent functions. The response to this (if there is no error in the command) will be a result object bearing a status code of `PGRES_COPY_OUT` or `PGRES_COPY_IN` (depending on the specified copy direction). The application should then use the functions of this section to receive or transmit data rows. When the data transfer is complete, another result object is returned to indicate success or failure of the transfer. Its status will be `PGRES_COMMAND_OK` for success or `PGRES_FATAL_ERROR` if some problem was encountered. At this point further SQL commands can be issued via `exec`. (It is not possible to execute other SQL commands using the same connection while the COPY operation is in progress.)

If a COPY command is issued via `exec` in a string that could contain additional commands, the application must continue fetching results via `getResult` after completing the COPY sequence. Only when `PQgetResult` returns NULL is it certain that the `PQexec` command string is done and

it is safe to issue more commands.

The functions of this section should be executed only after obtaining a result status of PGRES\_COPY\_OUT or PGRES\_COPY\_IN from `exec` or `getResult`.

A result object bearing one of these status values carries some additional data about the COPY operation that is starting. This additional data is available using functions that are also used in connection with query results:

`res:nfields()`

Returns the number of columns (fields) to be copied.

`res:binaryTuples()`

0 indicates the overall copy format is textual (rows separated by newlines, columns separated by separator characters, etc). 1 indicates the overall copy format is binary. See COPY for more information.

`res:fformat()`

Returns the format code (0 for text, 1 for binary) associated with each column of the copy operation. The per-column format codes will always be zero when the overall copy format is textual, but the binary format can support both text and binary columns. (However, as of the current implementation of COPY, only binary columns appear in a binary copy; so the per-column formats always match the overall format at present.)

## Functions for sending COPY data

These functions are used to send data during COPY FROM STDIN. They will fail if called when the connection is not in COPY\_IN state.

`conn:putCopyData(buffer)`

Sends data to the server during COPY\_IN state.

Transmits the COPY data in the specified buffer, to the server. The result is 1 if the data was sent, zero if it was not sent because the attempt would block (this case is only possible if the connection is in nonblocking mode), or -1 if an error occurred. (Use `errorMessage` to retrieve details if the return value is -1. If the value is zero, wait for write-ready and try again.)

The application can divide the COPY data stream into buffer loads of any convenient size. Buffer-load boundaries have no semantic significance when sending. The contents of the data stream must match the data format expected by the COPY command.

`conn:putCopyEnd(errormsg)`

Sends end-of-data indication to the server during COPY\_IN state.

Ends the COPY\_IN operation successfully if `errormsg` is nil. If `errormsg` is not nil then the COPY is forced to fail, with the string pointed to by `errormsg` used as the error message. (One should not assume that this exact error message will come back from the server, however, as the server

might have already failed the COPY for its own reasons. Also note that the option to force failure does not work when using pre-3.0-protocol connections.)

The result is 1 if the termination data was sent, zero if it was not sent because the attempt would block (this case is only possible if the connection is in nonblocking mode), or -1 if an error occurred. (Use PQerrorMessage to retrieve details if the return value is -1. If the value is zero, wait for write-ready and try again.)

After successfully calling putCopyEnd, call getResult to obtain the final result status of the COPY command. One can wait for this result to be available in the usual way. Then return to normal operation.

## Functions for receiving COPY data

These functions are used to receive data during COPY TO STDOUT. They will fail if called when the connection is not in COPY\_OUT state.

`conn:getCopyData(async)`

Receives data from the server during COPY\_OUT state.

Attempts to obtain another row of data from the server during a COPY. Data is always returned one data row at a time; if only a partial row is available, it is not returned. Successful return of a data row involves allocating a chunk of memory to hold the data.

When a row is successfully returned, the return value is the number of data bytes in the row (this will always be greater than zero). The returned string is always null-terminated, though this is probably only useful for textual COPY. A result of zero indicates that the COPY is still in progress, but no row is yet available (this is only possible when async is true). A result of -1 indicates that the COPY is done. A result of -2 indicates that an error occurred (consult errorMessage for the reason).

When async is true (not zero), getCopyData will not block waiting for input; it will return zero if the COPY is still in progress but no complete row is available. (In this case wait for read-ready and then call consumeInput before calling getCopyData again.) When async is false (zero), getCopyData will block until data is available or the operation completes.

After getCopyData returns -1, call getResult to obtain the final result status of the COPY command. One can wait for this result to be available in the usual way. Then return to normal operation.

## Control functions

`conn:clientEncoding()`

Returns the client encoding.

`conn:setClientEncoding(encoding)`

Sets the client encoding.

`conn:setErrorVerbosity()`

Determines the verbosity of messages returned by `errorMessage` and `resultErrorMessage`.

`setErrorVerbosity` sets the verbosity mode, returning the connection's previous setting. In `TERSE` mode, returned messages include severity, primary text, and position only; this will normally fit on a single line. The default mode produces messages that include the above plus any detail, hint, or context fields (these might span multiple lines). The `VERBOSE` mode includes all available fields. Changing the verbosity does not affect the messages available from already-existing result objects, only subsequently-created ones.

`conn:trace(file)`

Enables tracing of the client/server communication to a debugging file stream obtained via `io.open()`.

`conn:untrace()`

Disables tracing started by `conn:trace()`.

## Miscellaneous functions

`encryptPassword()`

Prepares the encrypted form of a PostgreSQL password.

This function is intended to be used by client applications that wish to send commands like `ALTER USER joe PASSWORD 'pwd'`. It is good practice not to send the original cleartext password in such a command, because it might be exposed in command logs, activity displays, and so on. Instead, use this function to convert the password to encrypted form before it is sent. The arguments are the cleartext password, and the SQL name of the user it is for. The return value is a string allocated by `malloc`, or `NULL` if out of memory. The caller can assume the string doesn't contain any special characters that would require escaping.

`libVersion()`

Return the version of the underlying `libpq` that is being used.

The result of this function can be used to determine, at run time, if specific functionality is available in the currently loaded version of `libpq`. The function can be used, for example, to determine which connection options are available for `connectdb` or if the hex bytea output added in PostgreSQL 9.0 is supported.

The number is formed by converting the major, minor, and revision numbers into two-decimal-digit numbers and appending them together. For example, version 9.1 will be returned as 90100, and version 9.1.2 will be returned as 90102 (leading zeroes are not shown).

## Notice processing

Notice and warning messages generated by the server are not returned by the query execution functions, since they do not imply failure of the query. Instead they are passed to a notice han-

dling function, and execution continues normally after the handler returns. The default notice handling function prints the message on stderr, but the application can override this behavior by supplying its own handling function.

For historical reasons, there are two levels of notice handling, called the notice receiver and notice processor. The default behavior is for the notice receiver to format the notice and pass a string to the notice processor for printing. However, an application that chooses to provide its own notice receiver will typically ignore the notice processor layer and just do all the work in the notice receiver.

```
conn:setNoticeReceiver()
```

```
conn:setNoticeProcessor()
```

The function `setNoticeReceiver` sets or examines the current notice receiver for a connection object. Similarly, `setNoticeProcessor` sets or examines the current notice processor.

Each of these functions returns the previous notice receiver or processor function pointer, and sets the new value. If you supply a null function pointer, no action is taken, but the current pointer is returned.

When a notice or warning message is received from the server, or generated internally by libpq, the notice receiver function is called. It is passed the message in the form of a `PGRES_NONFATAL_ERROR` result. (This allows the receiver to extract individual fields using `resultErrorField`, or the complete preformatted message using `resultErrorMessage`.) The same void pointer passed to `setNoticeReceiver` is also passed. (This pointer can be used to access application-specific state if needed.)

The default notice receiver simply extracts the message (using `resultErrorMessage`) and passes it to the notice processor.

The notice processor is responsible for handling a notice or warning message given in text form. It is passed the string text of the message (including a trailing newline), plus a void pointer that is the same one passed to `setNoticeProcessor`. (This pointer can be used to access application-specific state if needed.)

Once you have set a notice receiver or processor, you should expect that that function could be called as long as either the conn object or result objects made from it exist. At creation of a result, the conn's current notice handling pointers are copied into the result for possible use by functions like `getvalue`.

## Large objects

```
conn:lo_create(lobjId)
```

Creates a new large object. The OID to be assigned can be specified by `lobjId`; if so, failure occurs if that OID is already in use for some large object. If `lobjId` is `InvalidOid` (zero) then `lo_create` assigns an unused OID (this is the same behavior as `lo_creat`). The return value is the OID that was assigned to the new large object, or `InvalidOid` (zero) on failure.

lo\_create is new as of PostgreSQL 8.1; if this function is run against an older server version, it will fail and return InvalidOid.

To import an operating system file as a large object, call

```
conn:lo_import(filename)
```

filename specifies the operating system name of the file to be imported as a large object. The return value is the OID that was assigned to the new large object, or InvalidOid (zero) on failure. Note that the file is read by the client interface library, not by the server; so it must exist in the client file system and be readable by the client application.

The function

```
conn:lo_import_with_oid(filename, lojld)
```

also imports a new large object. The OID to be assigned can be specified by lojld; if so, failure occurs if that OID is already in use for some large object. If lojld is InvalidOid (zero) then lo\_import\_with\_oid assigns an unused OID (this is the same behavior as lo\_import). The return value is the OID that was assigned to the new large object, or InvalidOid (zero) on failure.

lo\_import\_with\_oid is new as of PostgreSQL 8.4 and uses lo\_create internally which is new in 8.1; if this function is run against 8.0 or before, it will fail and return InvalidOid.

To export a large object into an operating system file, call

```
conn:lo_export(lojld, filename)
```

The lojld argument specifies the OID of the large object to export and the filename argument specifies the operating system name of the file. Note that the file is written by the client interface library, not by the server. Returns 1 on success, -1 on failure.

To open an existing large object for reading or writing, call

```
conn:lo_open(lojld)
```

The lojld argument specifies the OID of the large object to open. The mode bits control whether the object is opened for reading (INV\_READ), writing (INV\_WRITE), or both. (These symbolic constants are defined in the PostgreSQL header file libpq/libpq-fs.h.) lo\_open returns a (non-negative) large object descriptor for later use in lo\_read, lo\_write, lo\_lseek, lo\_lseek64, lo\_tell, lo\_tell64, lo\_truncate, lo\_truncate64, and lo\_close. The descriptor is only valid for the duration of the current transaction. On failure, -1 is returned.

The server currently does not distinguish between modes INV\_WRITE and INV\_READ |

INV\_WRITE: you are allowed to read from the descriptor in either case. However there is a significant difference between these modes and INV\_READ alone: with INV\_READ you cannot write on the descriptor, and the data read from it will reflect the contents of the large object at the time of the transaction snapshot that was active when lo\_open was executed, regardless of later writes by this or other transactions. Reading from a descriptor opened with INV\_WRITE returns data that reflects all writes of other committed transactions as well as writes of the current transaction. This



is similar to the behavior of REPEATABLE READ versus READ COMMITTED transaction modes for ordinary SQL SELECT commands.

## Large object functions

The function

`lo:write(buf, len)`

writes `len` bytes from `buf` (which must be of size `len`) to large object. The number of bytes actually written is returned (in the current implementation, this will always equal `len` unless there is an error). In the event of an error, the return value is `-1`.

Although the `len` parameter is declared as `size_t`, this function will reject length values larger than `INT_MAX`. In practice, it's best to transfer data in chunks of at most a few megabytes anyway.

The function

`lo:read(len)`

reads up to `len` bytes from large object descriptor `fd` into `buf` (which must be of size `len`). The `fd` argument must have been returned by a previous `lo_open`. The number of bytes actually read is returned; this will be less than `len` if the end of the large object is reached first. In the event of an error, the return value is `-1`.

Although the `len` parameter is declared as `size_t`, this function will reject length values larger than `INT_MAX`. In practice, it's best to transfer data in chunks of at most a few megabytes anyway.

To change the current read or write location associated with a large object descriptor, call

`lo:lseek(offset, whence)`

This function moves the current location pointer for the large object descriptor identified by `fd` to the new location specified by `offset`. The valid values for `whence` are `SEEK_SET` (seek from object start), `SEEK_CUR` (seek from current position), and `SEEK_END` (seek from object end). The return value is the new location pointer, or `-1` on error.

When dealing with large objects that might exceed 2GB in size, instead use

`lo:lseek64(offset, whence)`

This function has the same behavior as `lo:lseek`, but it can accept an offset larger than 2GB and/or deliver a result larger than 2GB. Note that `lo:lseek` will fail if the new location pointer would be greater than 2GB.

`lo:lseek64` is new as of PostgreSQL 9.3. If this function is run against an older server version, it will fail and return `-1`.

To obtain the current read or write location of a large object descriptor, call

`lo:tell()`

If there is an error, the return value is `-1`.

When dealing with large objects that might exceed 2GB in size, instead use

`lo:tell64()`

This function has the same behavior as `lo_tell`, but it can deliver a result larger than 2GB. Note that `lo_tell` will fail if the current read/write location is greater than 2GB.

`lo_tell64` is new as of PostgreSQL 9.3. If this function is run against an older server version, it will fail and return -1.

To truncate a large object to a given length, call

`lo:truncate(len)`

This function truncates the large object to length `len`. If `len` is greater than the large object's current length, the large object is extended to the specified length with null bytes ('\0'). On success, `lo:truncate` returns zero. On error, the return value is -1.

The read/write location associated with the descriptor `fd` is not changed.

Although the `len` parameter is declared as `size_t`, `lo_truncate` will reject length values larger than `INT_MAX`.

When dealing with large objects that might exceed 2GB in size, instead use

`lo:truncate64(len)`

This function has the same behavior as `lo_truncate`, but it can accept a `len` value exceeding 2GB.

`lo_truncate` is new as of PostgreSQL 8.3; if this function is run against an older server version, it will fail and return -1.

`lo_truncate64` is new as of PostgreSQL 9.3; if this function is run against an older server version, it will fail and return -1.

A large object descriptor can be closed by calling

`lo:close()`

## Notify functions

`notify:relname()`

Return the `relname` field of a notification.

`notify:pid()`

Return the `pid` field of a notification.

`notify:extra()`

Return the extra data field of a notification.