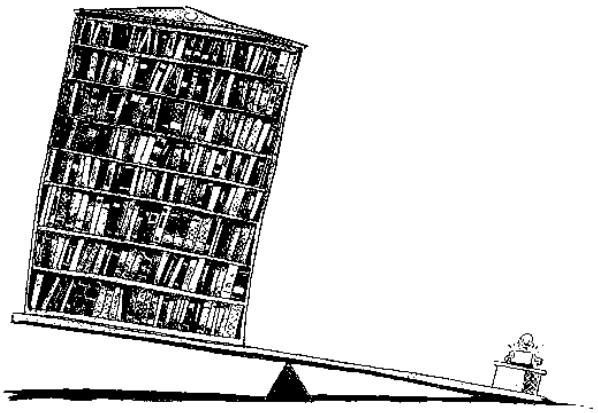
KE Texpress



Texql Guide

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Contents

Chapter 1

Introduction

Overview

The KE Texpress Information Management System is an object-oriented database package which provides numerous extensions to the traditional relational database model. The most significant extensions are in the area of complex object support. KE Texpress supports the inclusion of the following object components into an object definition:

- Text.
- Multi-valued fields
- References to foreign objects (objects in different formats controlled by software other than Texpress).

This manual describes the query language interface to Texpress. This query language, called Texql, includes both query and data manipulation facilities. While modelled on the industry standard SQL definition, it contains language extensions compatible with the object-oriented features of Texpress. This results in a distinctive SQL "feel" to the interface, significantly reducing the learning time for experienced SQL programmers. But Texql is still able to harness the power of the object-oriented model.

The most significant features of Texql are as follows:

- Support of text attributes
- Tuples.
- Nested tables
- Implicit joins using references

Texql can also be used in conjunction with Titan Version 3.4 databases.

In this manual, each of the Texql language features is presented with a definition and an example of its use and result. The remainder of this chapter discusses the conventions and terminology used throughout this manual as well as the Texpress tables used in the examples.

Chapter 2 describes how Texql is invoked and the many command line options available. A general description of the Texql user interface is also provided.

Chapter 3 discusses the types supported by Texql and how fields can be referenced.

The query interface of Texql is described in Chapter 4. This includes a description of all operators and functions.

The data manipulation interface, covering insertions, updates and deletions, is described in Chapter 5.

Appendix A includes a definition of the three example databases including all of the sample data.

Appendix B provides a list of the error and status messages which can be generated by Texql.

Terminology

Texpress uses terminology which reflects the object-oriented nature of the product, and thus highlights the distinction between it and relational database systems. However, Texql provides an interface to Texpress databases which attempts to simulate a standard SQL interface to a relational database.

This section describes the terminology used by Texql in terms of the appropriate terminology of Texpress. Refer to the Texpress Reference Manuals for a description of Texpress terminology.

The following terms are used throughout this manual:

Texql	KE Texpress
table	This refers to a single Texpress database. All Texpress databases, although controlled separately in terms of access privileges, etc., are accessible as Texql tables.
column	This refers to an item in a Texpress database.
nested table	This refers to a Texpress multi-field item which is not of type text or a multi-field text item without an associated Look-up table. Multi-field text items without Look-up tables are considered to be Texql text boxes, i.e. one atomic value of (continuous) text.
tuple or **row**	This refers to a record in a Texpress table or a record derived by Texql as the result of a query.

nested tuple The multi-field Key and library items of Texpress are represented as nested tuples in Texql. This means that these items can be treated as atomic values or, alternatively, their components can be individually manipulated.

atomic value This refers to a value in a column of a tuple, i.e. the value of a field within a Texpress record.

Notational Conventions

Texql is case insensitive except within text constants. Examples within this manual use the following conventions:

- Texql keywords and symbols are shown in **bold** font and in lower case.
- Table and nested table identifiers are shown in *italics*.
- Tuple identifiers and atomic attribute identifiers are shown in normal font.

For example within this manual, commands are displayed in the format:.

```
select  surname, maillist_tab
from    contacts
where   surname = 'Johnson';
```

This command is a common Select - From - Where (SFW) clause. Texql key words may be entered in upper case if desired.

Texql Features

Texql provides an SQL-like interface to Texpress databases. In keeping with the object-oriented nature of Texpress, Texql incorporates extensions to the relational model to support the text data type and multi-field items.

To provide text retrieval capabilities on text items in Texpress, Texql supports the **contains** operator which permits text matching facilities identical to Texpress. These facilities include word based queries, stemming and phonetic retrieval operators and phrase retrieval.

Multi-field items are supported in Texql by the definition of nested tables (with the exception of Texpress multi-field text items without a Look-up table which are considered to be atomic values of continuous text). These nested tables

consist of a single column only with each atomic value in each tuple in the nested table equating to a value in one of the fields of the appropriate multi-field item.

Nested tables maintain the object-oriented nature of Texpress applications by accurately representing hierarchically defined complex object structures. The equivalent relational model requires significant decomposition of these objects into a series of separate tables. This results in greatly increased complexity of design and subsequent query access. Although queries can be performed on these decomposed objects and the results of these queries combined, the appropriate hierarchical structure cannot be accurately recreated (as it can never be accurately represented in such systems). Also in relational systems the continual requirement for table joins is potentially very process expensive.

To access information in nested tables, Texql supports a recursive language definition which allows a query expression to contain nested query expressions. In fact, a select-from-where (SFW) expression in a Texql query can be used in any place that an explicit table reference can be used.

Texpress linked Keys are defined in Texql as references. A reference is an implicit join between two tables using a Key value identifier. Key operations are extremely efficient in Texpress and reference attributes mean that an entire table can appear to be nested as an attribute in another table.

In relational databases all join conditions must be provided explicitly. Texql also supports such explicit joins but, in addition, through the use of reference attributes, Texql supports implicit joins. A reference attribute has a domain consisting of the key values of the referenced table. In formulating a query on a table containing a reference attribute, the user is able to view the referenced table entries as belonging to the outer table.

Texql commands can also be expressed in an alternative functional notation. For example, a query to select the surname and mailing list columns for all tuples in the contacts table can be expressed using the standard notation as:

```
select surname, maillist_tab
from   contacts;
```

where the nested table, *maillist_tab*, in the same way atomic values are selected. The same query can also be expressed using the functional notation as:

```
contacts[surname,  maillist_tab];
```

Special Symbols

The following symbols are used in Texql:

( )	Tuple definition and grouping
{}	Row number selection
[ ]	Column selection
,	Separator.
= <>	Logical and relational operators
< <=	
> >=	
+ - * / %	Arithmetic operators
|	Multiple tuple separator.
'	Text constant begin and end delimiter
"	Identifier delimiter
:	Inner unnest operator.
:=	Temporary table assignment, used in with clause.
;	Statement delimiter
# **--**	Comments indicator

The following operators are supported within a Texql contains clause:

!	Not.
=	Exact word equivalence (case sensitive).
&	Fold case word equivalence (case insensitive).
~	Word stemming
@	Phonetic.
"	Phrase begin and end delimiter.

^ $ * ? Pattern matching
[ ] { }

Reserved Words

The following are reserved words in Texql and in general should not be used as identifiers.

after	all	and	as
asc	avg		
before	between	boolean	but
column	contains	count	
default	delete	desc	describe
distinct			
e	edit	except	exists
exit			
false	float	forming	from
h	has	help	history
ifnull	in	inner	insert
integer	intersect	into	is
join			
key			
like	list		
max	min		
nest	not	null	numwords
of	on	or	order
outer			
phonetic	preserve		
quit			
read	ref	restore	rownum
save	select	set	stem

```
subset      sum         superset

table       text        times       to

totuple     true

union       unnest      update

values

where       with        word        words

write
```

If an identifier the same as a reserved word is required then a delimited identifier (identifier in double quotes) may be used. For example a column name of **words** may be referenced using**"words"**.

Example Tables

The examples in this manual are based on a simple bank loan registration system. This example illustrates many of the features of Texql. However, it is not intended to be a complete design for such a loan registration system.

The loan registration system comprises the following three tables:

contacts This table contains information about the people or organisations who currently have a loan with the bank or are targeted by the bank for various loan promotions.

loantypes This table describes each of the available loan types available and the current applicable interest rate.

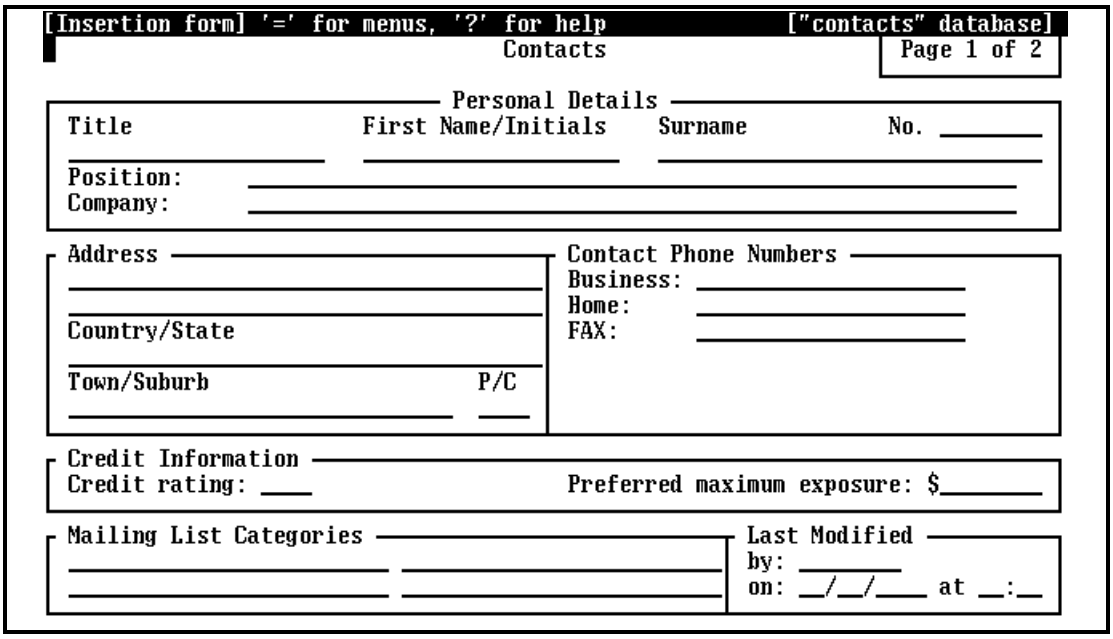
loans This table contains information about all current loans. It makes references to contacts, for the person or organisation taking out the loan, and loantypes, for the loan category information.

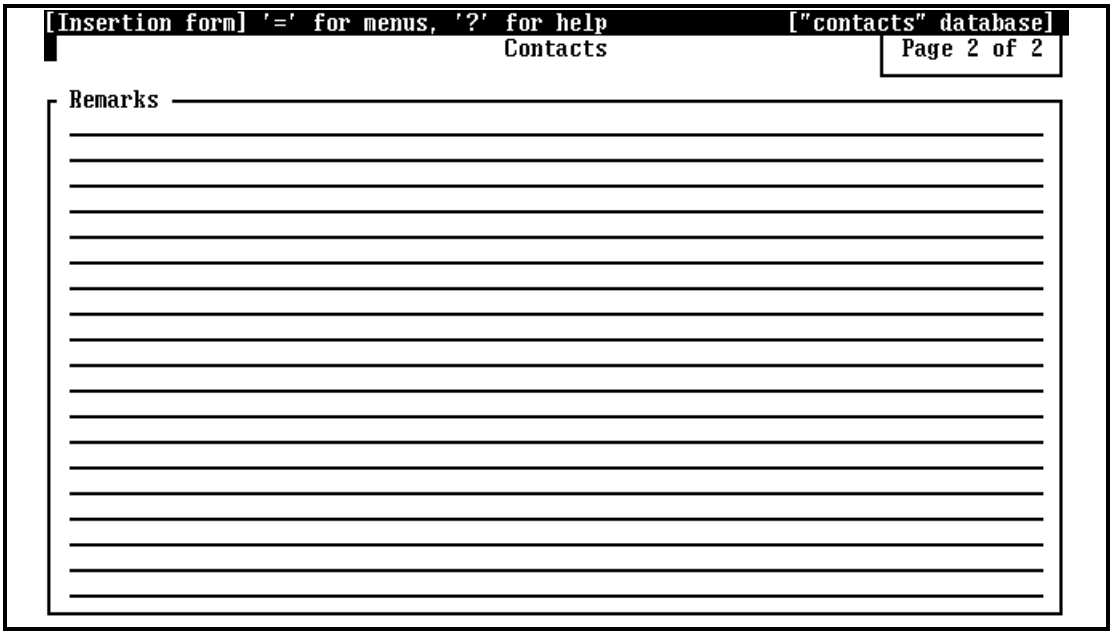
These tables can be described by the Texql describe command (refer to Chapter 2 for more information). The table descriptions are provided in the following sections.

Note that these table descriptions are repeated in Appendix A of this manual together along with a complete list of the data in each table.

Contacts Table

The Insertion Form for the *contacts* table is displayed in the folowing two figures.





The *contacts* Texql table description can be obtained using the command:

```
describe contacts;
```

and is as follows:.

```
contacts[
        contno          integer,
        title           text,
        firstnam        text,
        surname         text,
        position        text,
        company         text,
        address         text,
        country         text,
        town            text,
        postcode        text,
        phone           text,
        rating          text,
        exposure        integer,
        maillist_tab[
                maillist        text
        ],
        modby           text,
        modon(
                modon_1         integer,
                modon_2         integer,
                modon_3         integer
        ),
        modat(
                modat_1         integer,
                modat_2         integer
        ),
        remarks         text
];
```

This table contains a column for the contact number (an integer Key value) plus a variety of simple columns, containing atomic values only, for contact identification and address details.

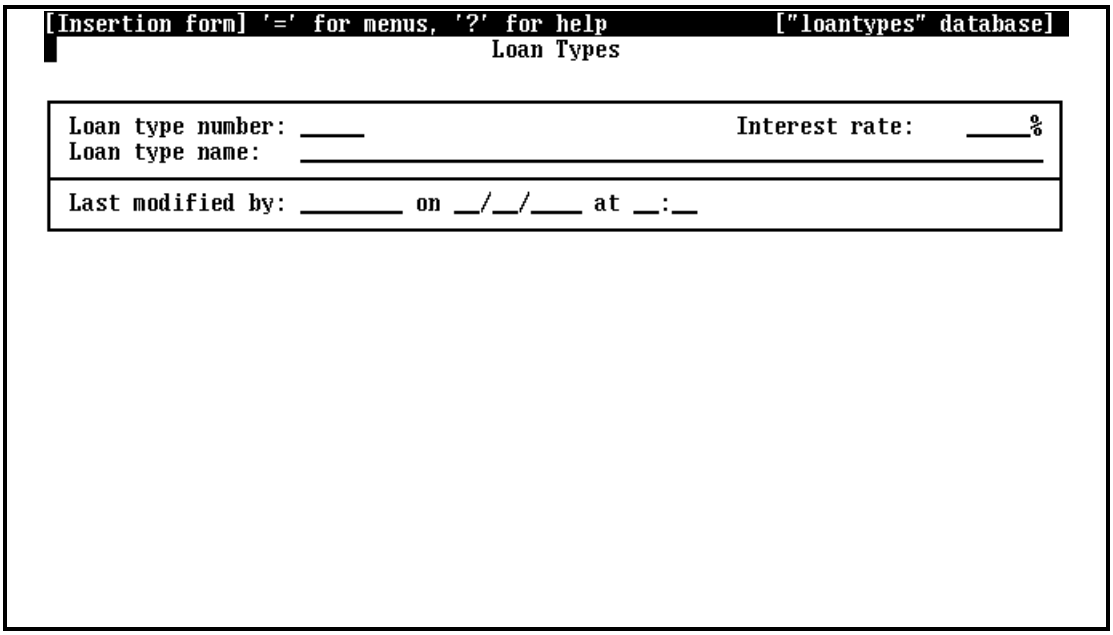
Each record in this table can include from zero to four mailing list categories. In Texpress terminology, this is a multi-field item. In Texql, it is defined as a nested table. The nested table name is defined as the Texpress item id concatenated with the string _tab. The nested table contains a single column whose name is the Texpress item id.

The *contacts* table also contains last modified information including Texpress date and time library items. These are defined in Texql nested tuples.

Finally, the remarks item of Texpress is a multi-field text item and is considered by Texql to be a simple atomic value of continuous text.

Loantypes Table

The Insertion Form for the *loantypes* table is displayed below.



The *loantypes* Texql table description can be obtained using the command:

```
describe loantypes;
```

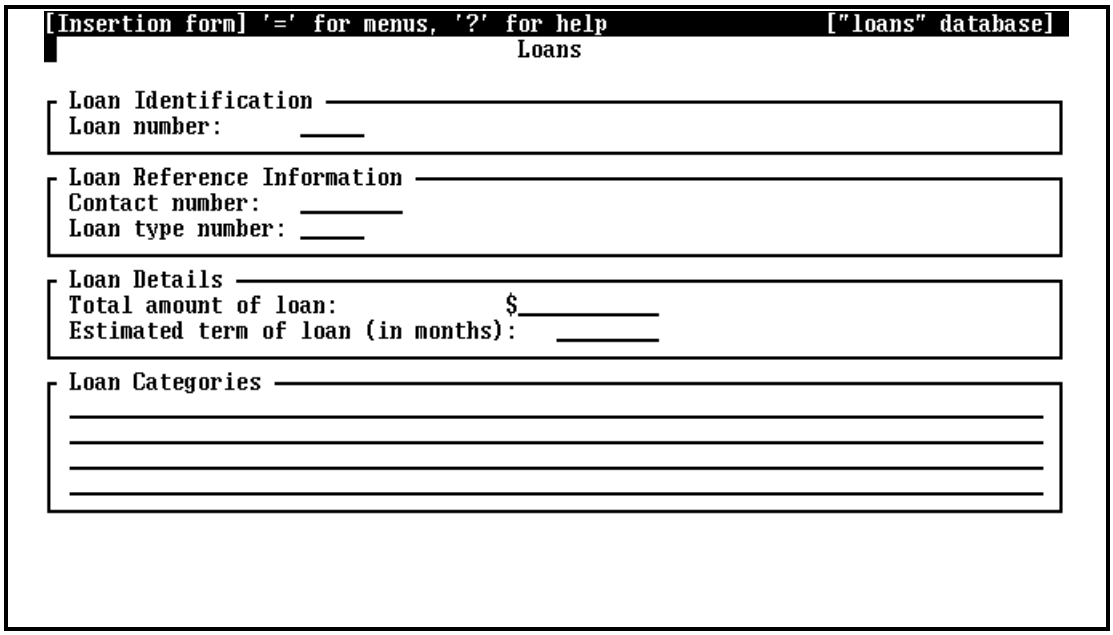
and is as follows:

```
loantypes[
        loanno          integer,
        interest        float,
        loanname        text,
        modby           text,
        modon(
                modon_1         integer,
                modon_2         integer,
                modon_3         integer
        ),
        modat(
                modat_1         integer,
                modat_2         integer
        )
];
```

This table is contains columns for loan number (an integer Key value), interest rate, loan type name and last modified information.

Loans Table

The Insertion Form for the *loans* table is displayed below.



The *loans* Texql table description can be obtained using the command:

```
describe loans;
```

and is as follows:

```
loans[
        loanno          integer,
        contno(
                contno          integer
        ) ref   contacts,
        typeno(
                loanno  integer
        ) ref   loantypes,
        amount          float,
        term            integer,
        category_tab[
                category        text
        ]
];
```

The *loans* table contains several simple columns and a nested table for the multi-field category item. However, this table also contains references to the *contacts* and *loantypes* tables.

Chapter 2

User Interface

Overview

Texql is a command line based interpreter. Texql commands may be entered interactively or saved in script files to be run in batch mode. Numerous command line options may be set in order to alter the default behaviour of Texql.

This chapter also describes the user interface features of Texql which are not part of the query or data manipulation languages. These facilities are provided for the entry and editing of Texql commands.

Invocation

Texql is invoked from the Unix command interpreter or shell by typing the command:

```
texql
```

This commences execution of the interpreter and results in the display of the Texql prompt.

There are many command line options available for Texql which alter the default operation of the command. The complete Texql usage message is as follows:

```
Usage: texql [-R] [-Ttermtype] [-ceis] [-hn]
                [-lfile] [-pstr] [-tstr] [table ...]
```

Options are as follows:

`-R` Read only mode. Tables may be accessed on a read only basis. Data manipulation commands are not permitted.

`-T`*termtype*

Terminal type. This command line option can be used to invoke texql using the Texpress terminal description, *termtype*. This can be useful for the correct interpretation and display of extended ASCII characters. Generally the terminal type setting is determined via the TERM environment variable but may set explicitly using this option.

`-c` Echo commandsAs each command line is read it is immediately echoed.

`-e` Print error/status codes with all system messages. The complexity of a language such as Texql results in a large number of possible input or execution errors. For programs developed to interface to Texql, it is essential to be able to identify and interpret returned error and status messagesso that appropriate action can be taken.

This option prefixes a unique numeric identifier to each error or status message. Refer to Appendix C for a complete list of error and status messages.

`-h`*n* Maintain a command historyof *n* commands.

By default, Texql retains a history of the last 100 commands performed during interactive sessions. By default, for non-interactive sessions, no history is retained.

A history of commands enables a user to select a previously performed command and re-execute it or modify it before re-executing. It can be very

useful for correction of simple syntax errors in complex statements or for step-wise refinement of complex operations.

The editing of history commands and the saving and restoring of histories is discussed in more detail later in this chapter.

`-i` Disable keyboard interrupts for the duration of the session

Texql responds to the keyboard interrupt, (typically generated by pressing the Ctrl+C or DEL key). During interactive sessions, an interrupt results in the current Texql operation being aborted and the next prompt displayed. For non-interactive sessions, an interrupt terminates the session.

`-l`*`file`*

Log error messages in *file*. Texql displays error messages directly on the screen before displaying the next prompt. This command line option can be used to also place all error messages in a specified file. This can be useful for debugging Texql scripts or files of commands.

`-p`*`str`*

Use a prompt of **str**. The default interactive prompt is:

```
texql n>
```

where *n* is the command number. There is no prompt by default for non-interactive sessions.

This command line option can be used to explicitly set the prompt. If *str* contains the character **!**, then this character is replaced by the current command number (unless it is preceded in the prompt by a backslash character, \). For example, the command:

```
texql -p"next !> "
```

produces the Texql prompt:

```
next n>
```

(where n is the command number), whereas the command:

```
texql -p"next\! "
```

produces the prompt:

```
next!>
```

`-s` Do not display status messages The data manipulation commands of Texql (insert, update and delete) provide a status message on completion which

indicates the number of rows (records) affected. This command line option can be used to suppress the display of these messages.

`-t`*`str`*

Text output delimiter. By default text on output is delimited by single quotes. This command line option can be used to change the begin and end output text delimiters to a different character(s) sequence. For example the command:

```
texql -t++
```

would produce text strings on output in the format:

```
++Johnson++
```

rather than the standard:

```
'Johnson'
```

Note that input text strings are not affected by this option and must still be delimited by single quotes.

`table` `...`

Texql opens each Texpress table as it is required, i.e. the first time it is referenced. However, it can be forced to access certain tables upon invocation by appending the table names to the command line. This results in all checks for appropriate access being performed before the first Texql statement involving that table is entered. If the user does not have appropriate access rights then Texql terminates.

The use of table names on the command line does not restrict the tables which can be accessed during that session.

Default Invocation

By default, Texql determines whether it is running interactively or its input has been redirected from a file, pipe or socket. For interactive sessions, Texql automatically displays a prompt between commands and sets the prompt to:

```
texql n>
```

where n is the command number, commencing from 1.

Commands are not echoed by Texql as echoing is generally performed by the terminal driver. The number of commands retained in the history is set to 100.

For non-interactive sessions, Texql automatically suppresses the display of the prompt. It also does not echo commands or status messages.

Comments

Comments are defined in Texql by using a **#** character or **--** character sequence. The remainder of the line after the comment marker is ignored. Comment markers are ignored within text literals (i.e. text enclosed in single or double quotes).

An example Texql command script including comments is as follows:

```
#  select all columns from loans table
#
select all from loans;

--  select all columns from  loantypes table
--  (SQL style comments)
select all       -- another comment
from loantypes;
```

Statement Terminator

All statements in Texql are terminated by a semi-colon, '**;**'. Statements are free format and may extend over numerous lines. The statement terminator is not recognised in text literals (text enclosed in single or double quotes). No other text (other than comments) should follow on the same line as the statement terminator.

The following two statements are completely equivalent:

```
#  select all columns from loans table.
#
select all from loans;


#  select all columns from loans table.
#
select
all
from
loans;
```

Help

The help command prints out some simple help information. An example of the help display is shown below.

```
texql 1> help;
help                    Print this information
list                    List names of tables
history or h            Print command history
edit [num]              Invoke editor on a command
save 'file'             Save history in a file
restore 'file'          Restore a saved history file
read 'file'             Read and execute commands from file
write 'file'            Write output to file
# or -- comments        Useful for script files (see read)
Terminate commands with ;               Surround text with ' (not ")

query:          select .. from .. where ..  nest/unnest  order
comparitive:    =,<>,>,>=,<,<=, between, like, contains, is [not] null
arithmetic:     +,-,*,/,%
functions:      max,min,avg,sum,count,distinct
boolean:        and,or,not,true,false

describe query          Print structure for result of query or tablename
insert into table values query_expr     Insert tuples into table
update table set set_clause query_expr  Update tuples in table
delete from table query_expr            Delete tuples from table
quit, exit or ^D to quit
texql 2>
```

Command History

By default, for all interactive sessions, Texql maintains a history of the last 100 commands performed in the current session. Non-interactive sessions, by default do not maintain a history. As described earlier in this chapter, Texql supports a command line argument to explicitly set the number of commands retained in the history. This is independent of whether the session is interactive or non-interactive..

The **history** command, (also selected by **h**), displays all of the commands retained in the history together with their command numbers.

In conjunction with this command history, Texql implements a simple history substitution mechanism based on that provided by the Unix csh. Previous commands in the history can be included in the current command using **!** followed by a number. If the number is greater than zero, then it is treated as an absolute command number. Otherwise, it is considered to be relative to the current command number. The derived number identifies a command in the command history and the exclamation mark and the command number are replaced by the text of that command.

For example, !5, refers to command number five. The sequence !-1, or alternatively !!, refers to the previous command.

```
texql 5> #  Display the history of commands
texql 5> #  in this session.
.......> #
.......> history;
  1 count(loantypes)
  2 select  all
    from    loantypes
    where   interest  < 10
  3 max(loantypes[interest])
  4 min(loantypes[interest])
texql 5> # Select the second command,
.......> # add another condition and repeat it.
.......> #
.......> !2  and interest  > 8;
```

The command statement terminator is not saved in the history. Also, the history command itself is never placed in the command history.

Editing Previous Commands

A command from the command history can be recalled and edited using the user's preferred editor. The preferred editor is designated during the Texpress installation process. If desired the shell environment variable, EDITOR, may be set to indicate a particular editor.

To edit a command, the user simply types **edit** (or **e**) and the command number, followed by a semi-colon. This invokes the preferred editor on a temporary file containing the command. If no command number is specified, the previous command is used. When the user saves the file and exits the editor, the new command is then added to the history. It is not executed automatically. The !! command must then be used to actually execute the command.

```
texql 5> #  Display the history of commands
.......> #  in this session.
.......> #
.......> history;
  1 count(loantypes)
  2 select  all
    from    loantypes
    where   interest  < 10
  3 max(loantypes[interest])
  4 min(loantypes[interest])
texql 5> # Edit the second command.
.......> #
.......> edit 2;
texql 5> # Invoke the newly edited command.
.......> #
.......> !!;
```

The edit command itself is never placed in the command history.

Saving Command Histories

A copy of the command history can be saved in a file using the command:

```
save 'filename';
```

This saves the command history in a format suitable for use with the restore command described below.

Restoring Command Histories

A command history saved in a file can be restored using the command:

```
restore 'filename';
```

This restores the saved command history, replacing any existing history.

Describe Command

Any valid Texql query statement can be preceded by the keyword, **describe**. This can be used to describe the table returned as a result of that query.

If the query accesses a single table only, then the describe command returns the name of that table. Otherwise the table name is left blank. Then it describes each of the columns of the table, giving the name of the column and its type, both derived from the original tables.

Statement:

```
#  Describe the  loantypes table
#
describe loantypes;
```

Output:

```
loantypes[
        loanno      integer,
        interest    float,
        loanname    text,
        modby       text,
        modon(
                modon_1     integer,
                modon_2     integer,
                modon_3     integer
        ),
        modat(
                modat_1     integer,
                modat_2     integer
        )
];
```

Statement:

```
#  Describe the result of a query joining two tables.
#
#  The query incorporates an explicit join
#  rather than the use of the reference.
#
describe
(
        select  loanname, term
        from    loantypes, loans
        where   loantypes.loanno =  loans.loanno
);
```

Output:

```
[
        loanname    text,
        term        integer
];
```

Listing Tables

The command, **list**, can be used to list all of the tables available on the system. The format of the list is similar to the format produced by the Texpress command,**tlsdb**, when used with the**-l** option.

Statement:

```
#  List all of the available tables.
#
list;
```

Output:

```
contacts        (texpress)      3 records       4.2%
loans           (texpress)      4 records       4.5%
loantypes       (texpress)      7 records       4.6%
```

A table name may also be specified as an optional argument.

Statement:

```
#  List just the contacts table.
#
list contacts;
```

Output:

```
contacts        (texpress)      3 records       4.2%
```

Reading Input from a File

Input to texql can be redirected from the shell command line, as well as by using the Texql **read** command. This command temporarily redirects input to come from the specified file. Commands are read until the end of the file is reached. These commands are not added to the history and history substitution is not performed. Any input errors result in the termination of the read and input again coming from standard input.

Assume that a file called ***saved.commands*** exists and contains the following Texql commands:

```
#  Commands saved in a file for later re-use.
#
select  all
from    loantypes
where   interest < 10;
count(loantypes);
max(loantypes[interest]);
min(loantypes[interest]);
```

Statement:

```
#  Read commands from the file,   saved.commands.
#
read    'saved.commands';
```

Output:

```
Reading from " saved.commands"
>> #  Commands saved in a file for later re-use.
>> #
>> select  all
>> from    loantypes
>> where   interest < 10;
(1,9.50,'First home  buyer','john',(15,06,1993),(11,50))
>> count(loantypes);
8
>> max(loantypes[interest]);
18.00
>> min(loantypes[interest]);
9.50
>>
Finished reading from " saved.commands"
```

It is possible to nest read commands so that a file containing commands to be executed can also contain a further read command.

Writing Output to a File

The command, **write**, causes all output from Texql to be duplicated and sent to both the standard output and to a file. The write command requires a single argument of a file name surrounded by single quotes.

Entering the write command without specifying a file name indicates that the duplication of output should be ceased.

A sequence such as:

```
#  Write output to the file,  saved.output and then
#  perform a variety of commands.
#
write   'saved.output';
select  all
from    loantypes
where   interest  < 10;
count(loantypes);
max(loantypes[interest]);
min(loantypes[interest]);
write;
```

would result in the following output being saved in the file ***saved.output*** as well as being displayed on the standard output of Texql.:

```
select  all
from    loantypes
where   interest  < 10;
(1,9.50,'First home  buyer','john',(15,06,1993),(11,50))
count(loantypes);
8
max(loantypes[interest]);
18.00
min(loantypes[interest]);
9.50
write;
```

Termination

An interactive Texql session can be terminated be entering **exit** or **quit** (followed by a semi-colon). Alternatively, Control-D (EOF) may be typed.

Non interactive sessions terminate when input end of file is detected.

```
#  Exit from Texql.
#
quit;
```

Chapter 3

Data Types and Attributes

Overview

This chapter describes the format and use of each of the Texql data types and more complex structure attributes of Texql. The mapping of Texpress data types to Texql data types is also described.

Atomic Data Types

Texql supports the following atomic data types:

text

This consists of a sequence of printable characters. Depending on the retrieval operators used text is either treated as a sequence of words, or a single string. Text is interpreted as words using the same rules as Texpress (i.e. the space character and most punctuation characters are word-break characters for most languages, while for multi-byte languages each ideographic character is considered as a separate word).

Text constants are surrounded by single quote characters. The following sequences can be embedded text constants:

\\ Replaced by\.

\' Replaced by'.

\" Replaced by".

\b Replaced by backspace.

\f Replaced by form feed.

\n Replaced bynewline.

\r Replaced by carriage return

\t Replacedby tab

\nnn Replaced by the character with octal ASCII code nnn (\0 not allowed).

\xnn
\Xnn Replaced by the character with hexadecimal ASCII code nn (\x0 not allowed).

\<return>

Removed from the text constant but results in joining two lines, e.g.

```
'The quick brown fox  jum\
ped over the lazy dog.'
```

is equivalent to the continuous string:

```
'The quick brown fox jumped over the lazy dog.'
```

Texpress items of type Text or String map directly to the Texql text atomic type. Expressions which return text values, together with the boolean operators for text expressions, are described in Chapter 4.

integer

This consists of an optional leading plus or minus sign followed by one or more digits, e.g.:

```
3053
```

The range of valid integer values is machine dependent but generally at least from -2^{31} to $2^{31} - 1$.

Texpress items of type Integer map directly to the Texql integer atomic type. Arithmetic expressions which return integers are described in Chapter 4.

float

This consists of an optional leading plus or minus sign followed by zero or more digits, then a decimal point and zero or more digits, e.g.:

```
-128.25
```

The range of valid float values is machine dependent.

Texpress items of type Real map directly to the Texql float atomic type. Arithmetic expressions which return floating point numbers are described in Chapter 4.

boolean

Boolean constants are the keywords **true** or **false**.

Expressions which return boolean values are described in Chapter 4.

Other Texpress data types, such as dates time, latitude and longitude, are defined as tuples of the appropriate basic data types.

Null Values

The Texql keyword, **null**, returns the null value. It is given a type that will match any other atomic type, with the exception of tuple and nested table attributes which cannot have null values. Therefore null can be used with text, integer, float and boolean columns.

Chapter 4 discusses how null values are handled by various operators.

Tuples

A tuple is a row or part of a row within a table or nested table. A tuple can be a subset of the attributes in another tuple. For example, Texpress multi-field Key and library items are represented as tuples. These tuples are composed of tuples and atomic attributes.

A constant of type tuple is a list of constants separated by commas and surrounded by (and). For example, the following tuple would be suitable for the loantypes database:

```
(9, 9.90, 'Bank Transfer', 'john', (18, 6, 1993), (12, 55))
```

Individual attributes can be extracted from a tuple by use of the **.** (dot) extract operator, and so are referenced as:

```
tuple_identifier.attribute_name.
```

If the above tuple identifier is loantype, then a reference to *loantype*.loanname would be replaced by the text 'Bank Transfer'. Note that where there can be no ambiguity, the tuple_identifier and extract operator can be omitted and so the above attribute could be referenced simply as:

```
loanname
```

For any reference to a tuple attribute, it is only necessary to provide sufficient identifiers to avoid ambiguity. So, for example, the query:

```
select  loans.typeno.modon.modon_2
from    loans;
```

could be written more simply as:

```
select  typeno.modon_2
from    loans;
```

or even:

```
loans[typeno.modon_2];
```

It is necessary to provide typeno in the above example as the *loans* table contains another modon_2 attribute through its reference to the *contacts* table.

The rules for resolving implicit extraction are described in Chapter 4.

Parentheses, (and), are used for the projection of attributes from a tuple while still maintaining the tuple structure. For example, the following statement creates a tuple structure for the year and month attributes of the modon nested tuple:

```
select  loanname, modon(modon_3, modon_2)
from    loantypes;
```

Parentheses are also used to construct tuples from other attributes. This is described in more detail in Chapter 4.

Tuple projection always returns a tuple structure whereas tuple extraction returns atomic values.

Tables and Nested Tables

A **table** is a top-level object which equates to a Texpress database. All tables are global and can be accessed by all users who have the appropriate privileges. A **nested table** is an attribute of a table or a structured attribute which could be another nested table.

The primary distinction between tables and nested tables is that a nested table is an ordered list oftuples whereas a table is an unordered collection oftuples.

The *contacts* table contains a nested table for mailing lists (called *maillist_tab*). An attribute of a nested table, such as maillist can be referenced as the nested select:

```
(
        select  maillist
        from    maillist_tab
)
```

or:

```
maillist_tab[ maillist]
```

which projects the maillist attribute from *maillist_tab* and returns a table of values.

A constant of type table or nested table is a list of rows separated by | and surrounded by **[** and **]**. For example, a table of data suitable for loading into the *loantypes* table could be expressed as:

```
[
 9, 9.0, 'Bank  Transfer','john', (17, 6, 1993), (12, 55) |
 10, 15, 'Investment',    ' ian',  (18, 6, 1993), (12, 55)
]
```

It is not possible for Texql to derive the structure of a table when it includes an empty nested table, unless this structure can be derived from another tuple in the table.

Reference Attributes

As described previously, Texql supports reference attributes. A reference attribute is a tuple comprising the key of the table referenced. It is defined in Texpress by use of a linked Key item

Reference attributes provide support for implicit joins which are described in Chapter 4.

Type Compatibility

Two expressions are type compatible if the types of the expressions are one of the following:

- The same type (for structured types this implies that all component attributes are also type compatible); or
- One is an integer and the other a floating point number, in which case the integer is converted to a floating point number; or
- One is a tuple with one attribute and the other is type compatible with that attribute.

Identifiers

All outer level tables and atomic, structured and reference attributes are accessed by use of the **identifier name** associated with them. An identifier is any sequence of letters, digits and underscores (_). The first character of the identifier name must be a letter.

Identifiers are case sensitive. Thus Loantypes, LOANTYPES and loantypes are the different identifiers.

A reserved word can be used as an identifier by enclosing it in double quotes, e.g. "from".

Atomic constants have an attribute identifier equal to the type of the constant. All other constants have empty attribute identifiers and so cannot be specified on a select line. Many queries also return tables with empty identifiers.

A query consisting of a single identifier which is a table name retrieves all of the records in that table.

Statement:

```
#  Display all data from all records in
#  the loantypes table.
#
loantypes;
```

Output:

```
(1,9.50,'First home  buyer','john',(15,06,1993),(11,50))
(2,12.90,'Investment  property','john',(15,06,1993),(11,50))
(3,15.50,'Personal  loan','john',(15,06,1993),(11,50))
(4,14.25,'Car','john',(15,06,1993),(11,50))
(5,10.75,'Home  improvement','john',(15,06,1993),(11,51))
(6,16.50,'General  loan','john',(15,06,1993),(11,51))
(7,18.00,'Overdraft','john',(15,06,1993),(11,51))
```

```
(8,17.00,'Travel','john',(15,06,1993),(14,19))
```

Within a table the attributes can also be referenced using the keyword, **column**, followed by the number of a column within that table. Column number referencing also applies to nested tables.

Statement:

```
#  Display columns 2 and 3 from all rows
#  in the  loantypes table.
#
select  column 2, column 3
from    loantypes;
```

Output:

```
(9.50,'First home buyer')
(12.90,'Investment property')
(15.50,'Personal loan')
(14.25,'Car')
(10.75,'Home improvement')
(16.50,'General loan')
(18.00,'Overdraft')
(17.00,'Travel')
```

Statement:

```
#  Display information via a combination
#  of column numbers and names, from all
#  rows in the loans table.
#
select  amount,  column 2.surname
from    loans ;
```

Output:

```
(65000.00,'Citizen')
(40000.00,'Citizen')
(5000.00,'Johnson')
(10000.00,'Rustings')
```

In general it is advisable to avoid the use of column number referencing as it is too heavily dependent on the table definition. However, occasionally it can be more convenient than using **as** to rename otherwise empty attribute identifiers (see Section 3.8).

Renaming Identifiers using As

Sometimes it is desirable to define an **alias** for a table, tuple or attribute identifier. Such an action is essential to clarify otherwise ambiguous references to variables, e.g. joining a table to itself, or to assign an identifier to an attribute or table for which no identifier exists, such as a derived table.

Aliases can be assigned to attribute and table identifiers by using the **as** keyword.

Statement:

```
#  Select title,  firstnam and surname columns
#  from contacts renaming each using as.
#
select  title as t, firstnam as f, surname  as s
from    contacts as c;
```

Output:

```
('Mr','John','Citizen')
('Ms','Jennifer','Johnson')
('Mr','Peter','Rustings')
```

Functional notation can also be applied when using aliases (refer to Chapter 4 for more information on functional notation).

Statement:

```
#  Select title,  firstnam and surname columns
#  from contacts renaming each using as
#  and using functional notation.
#
contacts[title,  firstnam, surname]  as c[t, f, s];
```

Output:

```
('Mr','John','Citizen')
('Ms','Jennifer','Johnson')
('Mr','Peter','Rustings')
```

Statement:

```
#  Create a temporary table of names and
#  select from it using as.
#
select  name
from    [ 'Albert Jones' |
          'Bob Brown' |
          'Craig Thomas' |
          'David Jeans' |
          'Eric Davis'
        ] as  names[name]
where    name = 'David Jeans' ;
```

Output:

```
('David Jeans')
```

It is also possible to use as to convert an attribute into a tuple with one attribute.

Statement:

```
#  Convert an atomic value into a  tuple using as.
#
'john' as names(name);
```

Output:

```
('john')
```

Chapter 4

Query Language

Overview

This chapter describes the query language component of Texql. Queries take the form of select-from-where. The following sections describe each of these components. Then follows a description of the scoping rules used in Texql.

Later in the chapter descriptions of Texql operators and built-in functions are provided.

Select-From-Where Expressions

A Select-From-Where (SFW) expression specifies a selection constraint on a sub-expression restricting which tuples may be retrieved (the where component) and a list of attributes, or expressions based on attributes, to for each tuple retrieved (the select component or projection).

A SFW expression is used to retrieve data stored in Texpress databases as well as to derive new data from this stored data.

The most common form of SFW expressions uses the words, **select**, **from** and **where**. An alternative form uses functional notation where the table referenced in the **from** component is specified first. This is followed by a list of projected attributes or expressions, in square brackets, equating to the **select** component.

A simple example is to project the loanname attribute from the loantypes table, selecting only the tuples (Texpress records) which contain an interest rate less than 10%.

Statement:

```
select  loanname
from    loantypes
where   interest < 10;
```

Output:

```
('First home buyer')
```

The functional notation for this query could be expressed as:

```
loantypes[loanname]
where   interest < 10;
```

Each of the **select**, **from** and **where** components are described in more detail in the following sections.

Select

The select component of an SFW expression provides a projection from the referenced tables. It creates a table structure from these projections. However, functions (such as the **min** function, described in Section 4.10), can be applied to SFW expressions to produce atomic values.

The select component is a list of attributes or sub-expressions forming new attributes from the table sub-expression on the from line. The order of attributes in the select line defines the attribute order in the resulting table.

The projected list of expressions can include atomic values, tuples and nested tables.

An example SFW expression to project the loan name and date/time of last modification to the record could be entered as follows:

Statement:

```
select  loanname, modon, modat
from    loantypes
where   interest < 10;
```

Output:

```
('First home buyer',(15,06,1993),(11,50))
```

All Columns

A projection of the keyword, **all** (or *****), selects all attributes of the tables listed in the from component. For example, to select all columns from the loantypes table, the followingSFW expression can be used:

Statement:

```
select  all
from    loantypes;
```

Output:

```
(1,9.50,'First home  buyer','john',(15,06,1993),(11,50))
(2,12.90,'Investment  property','john',(15,06,1993),(11,50))
(3,15.50,'Personal  loan','john',(15,06,1993),(11,50))
(4,14.25,'Car','john',(15,06,1993),(11,50))
(5,10.75,'Home  improvement','john',(15,06,1993),(11,51))
(6,16.50,'General  loan','john',(15,06,1993),(11,51))
(7,18.00,'Overdraft','john',(15,06,1993),(11,51))
(8,17.00,'Travel','john',(15,06,1993),(14,19))
```

The above SFW expression could be replaced by the following functional notation command:

```
loantypes;
```

Excluding Columns

Texql allows designated attributes to be excluded from a selection by the addition of a **but** component, as in the following example:

Statement:

```
select  all but loanno, modby
from    loantypes;
```

Output:

```
(9.50,'First home buyer',(15,06,1993),(11,50))
(12.90,'Investment property',(15,06,1993),(11,50))
(15.50,'Personal loan',(15,06,1993),(11,50))
(14.25,'Car',(15,06,1993),(11,50))
(10.75,'Home improvement',(15,06,1993),(11,51))
(16.50,'General loan',(15,06,1993),(11,51))
(18.00,'Overdraft',(15,06,1993),(11,51))
(17.00,'Travel',(15,06,1993),(14,19))
```

which is equivalent to the SFW expression:

```
select  interest, loanname, modon, modat
from    loantypes;
```

The excluded attributes in a but component can be a tuple or nested table or attributes from a tuple or nested table.

Structured Attributes

A projection of a tuple (or nested table) can be achieved by simply referencing that tuple's (or table's) identifier. However, a subset of the attributes of a tuple or nested table can also be selected.

A nested select component can be used to select a subset of the attributes of a nested table, as in the following example:

Statement:

```
select  surname, (
                        select  maillist
                        from    maillist_tab
                )
from    contacts;
```

Output:

```
('Citizen',['Home  improvement'|'Boating'])
('Johnson',['Home  buyer'|'Travel'])
('Rustings',['Better finance'])
```

Alternatively, a subset of the attributes of a nested tuple or a table can be projected using the following functional notation:

Statement:

```
select  surname, maillist_tab[maillist]
from    contacts;
```

Output:

```
('Citizen',['Home  improvement'|'Boating'])
('Johnson',['Home  buyer'|'Travel'])
('Rustings',['Better finance'])
```

New tuple attributes can be constructed in the select component by use of round brackets, **(** and **)**. For example, to create a tuple of the columns of a name from the contacts table, the following SFW expression could be used:

Statement:

```
select  (title, firstnam, surname) as name, company
from    contacts;
```

Output:

```
(('Mr','John','Citizen'),'Acme Electronics Pty. Ltd.')
(('Ms','Jennifer','Johnson'),'Channel Ten')
(('Mr','Peter','Rustings'),' Rustings Pty. Ltd.')
```

Nested tuple attributes can be collapsed into a collection of columns of atomic values. For example, the following query collapses the tuple structure for the column *modon*.

Statement:

```
select  surname, modon.all
from    contacts;
```

Output:

```
('Citizen',15,06,1993)
('Johnson',15,06,1993)
('Rustings',15,06,1993)
```

The sequence **.*** could have been used in place of **.all** in this example. This query is equivalent to the following query:

```
select  surname, modon_1, modon_2, modon_3
from    contacts;
```

If the identifier used was a reference attribute pointing to another table, then the **.all** would have caused the reference to be followed and so would have been replaced by all of the columns of the referenced table. Unnesting nested table attributes requires the special functional operators, **inner unnest** and **outer unnest**, which are described later in this Chapter.

Whenever a table name appears in both the select component and the from component then it refers to each tuple of the table, thus the above query could also be written as:

```
select  surname, contacts.modon.all
from    contacts;
```

However the following query returns a tuple containing a nested tuple equivalent in structure to the contacts table query:

```
select  contacts
from    contacts;
```

Reference Attributes

Reference attributes represent implicit joins between tuples in the table containing the reference and tuples in the referenced table. Each of the attributes in the referenced tuple is directly available, through this implicit join, when querying on thetuple containing the reference.

In the example tables, the *loans* table contains a reference to the *contacts* table and to the *loantypes* table. The following query results in two implicit joins being performed between the *loans* table and the *contacts* and *loantypes* tables following the defined references:

Statement:

```
select  surname, loanname
from    loans;
```

Output:

```
('Citizen','First home buyer')
('Citizen','General loan')
('Johnson','Travel')
('Rustings','Overdraft')
```

As there is no name clash for surname or loanname in the above example, the reference attribute identifier does not have to precede the referenced table attribute identifier.

Nested Selection

The recursively defined syntax of Texql allows an expression that returns a table to be used within a query at any place that a table can be used. This property of Texql is referred to as orthogonality and, in many cases, simplifies query formulation.

The recursive syntax allows a table to be joined at any level within a hierarchical structure. For example, the following query joins the nested table of mailing list entries with the outer table of loans.

Statement:

```
select  surname, maillist_tab[maillist]
from    loans;
```

Output:

```
('Citizen',['Home  improvement'|'Boating'])
('Citizen',['Home  improvement'|'Boating'])
('Johnson',['Home  buyer'|'Travel'])
('Rustings',['Better finance'])
```

When implicit joins refer to the same attributes from the same table it may necessary to rename attributes using **as**.

From

The **from** component within a SFW expression specifies the table (or tables) from which tuples are to be selected. Theoretically, when more than one table is given in the from component, tuples are selected from the cartesian product of tuples from each table. However, the Texql optimiser may use information from the where componentto provide enhanced performance.

Specifying multiple table names in the from component is the means by which a join query can be performed with the where component providing the actual join condition.

An explicit join could be used in the absence of a reference attribute. For example, the following query could be used to extract the surname and loanname of tuples in the loans table:

Statement:

```
select  contacts.surname, loantypes.loanname
from    contacts, loantypes, loans
where   loans.contno.contno = contacts.contno
and     loans.typeno.loanno = loantypes.loanno;
```

Output:

```
('Citizen','First home buyer')
('Citizen','General loan')
('Johnson','Travel')
('Rustings','Overdraft')
```

It is also possible to use a query expression in the from component of a Texql query. This is most useful when a query expression is to be applied to a derived table structure and not to a base or outer table. For example:

Statement:

```
select  surname, amount, annual
from
(
        select  surname, amount,
                amount * interest / 100  as annual
        from    loans
)
where   annual > 5000 ;
```

Output:

```
('Citizen',65000.00,6175.000000)
('Citizen',40000.00,6600.000000)
```

Where

The **where** component of a query determines the tuples from the tables in the corresponding from component which are used in computing the result of the SFW expression. The where component is optional.

The condition of the where component within a SFW expression must be a boolean expression, returning a result of either true or false. If the boolean expression evaluates to true for a particular tuple from the table(s) in the from component then it is returned in the result of the SFW-expression, projected through the select component.

Statement:

```
select  surname,  firstnam, amount
from    loans
where   amount > 10000;
```

Output:

```
('Citizen','John',65000.00)
('Citizen','John',40000.00)
```

A where component can accompany any nested select-from expression.

Statement:

```
#  Select loans with amounts which are above average.
#  Consider only loans of amounts >= 10000.
#
select  out.surname,  out.firstnam,  out.amount
from    loans as out
where   out.amount > avg
                (
                        select  tmp.amount
                        from    loans as tmp
                        where   tmp.amount >= 10000
                );
```

Output:

```
('Citizen','John',65000.00)
('Citizen','John',40000.00)
```

Aliasing a Sub-expression using With

SFW queries can use aliases to simplify their formulation and avoid duplication of some of their clauses. This can be achieved using the keyword, **with**.

A with clause follows a where clause, if any, and assigns a clause to an identifier. All occurrences of the identifier throughout the SFW query are replaced by the clause assigned to that identifier.

A query to select tuples from the contacts database which include mailing list entries containing the word 'home' could be expressed as follows:

Statement:

```
#  Select  tuples with a mailing list entry
#  containing the word 'home'.
#
select  surname
from    contacts
where   exists
        (
                maillist_tab
                where   maillist  contains 'home'
        );
```

Output:

```
('Citizen')
('Johnson')
```

However, if it were necessary to project the appropriate mailing list entries as well, then the following statement would be required:

Statement:

```
#  Select  tuples with a mailing list entry containing
#  the word 'home'. Then project the surname and the
#  relevant mailing list entries only.
#
select  surname,
                (
                        maillist_tab
                        where   maillist  contains 'home'
                )
from    contacts
where   exists
        (
                maillist_tab
                where   maillist  contains 'home'
        );
```

Output:

```
('Citizen',['Home improvement'])
('Johnson',['Home buyer'])
```

This could be expressed more simply using a **with** clause, as follows:

Statement:

```
#  Select  tuples with a mailing list entry containing
#  the word 'home'. Then project the surname and the
#  relevant mailing list entries only. Use a with clause
#  to simplify the query.
#
select  surname, homelist
from    contacts
where   exists(homelist)
with            homelist :=
                (
                        maillist_tab
                        where   maillist contains 'home'
                );
```

Scoping Rules

Resolution of identifiers is determined by the scoping rules of Texql. These rules specify how an identifier in an expression is bound to an attribute or table. There are two primary scoping rules in Texql:

1. Given a tuple and an attribute to extract from the tuple, Texql attempts to locate the attribute in the tuple.

2. Given an attribute identifier in an SFW expression, Texql determines which tables are searched (and in which order) to locate the attribute.

When locating an attribute, the former rule (1) is repeatedly applied for each table searched by the latter rule (2) until the attribute is located.

Extracting Attributes from Tuples

If the extract operator is used, (i.e. an identifier reference of the form, *tuple*.attribute), then the following steps are pursued until the attribute identifier is found:

1. Check the attributes of the tuple structure.

2. Recursively check the attributes in any nested tuple structures.

3. Recursively follow any reference attributes of the tuple.

Texql reports an error if any of the above steps results in an ambiguity, i.e. the identifier appears twice in a tuple structure or appears in two different nested tuple structures or appears following two different reference attributes.

Tuple extraction does not consider columns in nested tables. If this is necessary, then the unnest operators must be used (see Section 4.16.6).

Scoping Rules forSFW Expressions

A reference to a nested table (or tuple or attribute) refers to the table (or tuple or attribute) within the current tuple. Consider the following example query which contains selections from nested tables:

```
select  amount,
        (
                select  category
                from    category_tab
                where   category contains 'home'
                or      category contains 'car'
        ),
        (
                select  maillist
                from    contno.maillist_tab
                where   maillist contains 'home'
        )
from    loans;
```

The outer select is applied to every tuple in the loans table. The inner selects are applied to each tuple of the appropriate nested table within the current loans tuple.

The following rules are used to resolve references to table and attribute identifiers. The rules are followed, in order, until the identifier is resolved or until the completion of the rules at which point Texql gives an appropriate error message.

1. If an identifier appears on the right of an extract operator then it must be extracted from thetuple on the left.

2. If an identifier in a select or where component appears as an extractable attribute of a tuple in one of the tables in the from component then Texql attempts to locate the identifier in that table.

3. If an identifier in a select or where component appears in a from component then the attribute identifier refers to that table.

4. Steps 2 and 3 above are repeated, checking recursively the from components from innermost to outermostSFW expression

5. If the identifier is still unresolved but it is an outer level table identifier then it refers to that table.

Functional Notation

As described previously, Texql also supports a functional notation for the representation of SFW expressions. This notation replaces the select and from components with the table name followed by a projection list in square brackets. For example, the following SFW expression:

```
select  attrs1 but attrs2
from    table_name;
```

could be expressed as:

```
table_name[attrs1 but attrs2];
```

This notation also applies to projections from nested tables and derived tables.

Boolean Expressions

The boolean operators, **and**, **or**, and **not**, perform the appropriate logical boolean operations on the given boolean sub-expressions. Boolean sub-expressions may return null as a valid value. So the boolean operators must use a three-valued logic where null represents an unknown value.

The result of each boolean operator on all operand combinations is defined in the following sections. An example operator use is also provided.

And

The **and** evaluation table is:

and	true	null	false
true	true	null	false
null	null	null	false
false	false	false	false

Statement:

```
#  Find the surnames and loan amounts of loans which
#  exceed $20,000 and have a term of < 100 months.
#
loans[surname, amount]
where   amount > 20000
and term < 100;
```

Output:

```
('Citizen',40000.00)
```

Or

The **or** evaluation table is:

or	true	null	false
true	true	true	true
null	true	null	null
false	true	null	false

Statement:

```
#  Find the title, first name and surname of each
#  contact in Melbourne,  Nunawading or Blackburn.
#
contacts[title, firstnam, surname]
where   town = 'melbourne'
or              town = 'nunawading'
or              town = 'blackburn';
```

Output:

```
('Ms','Jennifer','Johnson')
('Mr','Peter','Rustings')
```

Not

The **not** evaluation table is:

not	
true	false
null	null
false	true

Statement:

```
#  Find details of loans to customers other
#  than Mr Citizen.
#
loans
where   not surname = 'citizen' ;
```

Output:

```
(3,(2),(8),5000.00,12,['Overseas Travel'])
(4,(3),(7),10000.00,36,['Overdraft'])
```

Relational Operators

The relational operatorsare as follows:

=	Equals.
<>	Does not equal.
<	Less than.
<=	Less than or equal to.
>	Greater than.
>=	Greater than or equal to.

These relational operators can be applied to boolean operands resulting in a boolean comparison being performed. If either operand is null, the expression returns null. Otherwise, for the purposes of boolean comparisons, true is considered greater than false.

Comparisons with Null

The operator, **is null**, returns true if the atomic sub-expression returns a null value and false otherwise. The operator, **is not null**, returns true if the atomic sub-expression does not return a null value and false otherwise.

These operators are not equivalent to = null and <> null, respectively.

Statement:

```
#  Identify contact  tuples with unknown surnames.
#
select  contno, company
from    contacts
where   surname  is null;
```

Output:

```
(no output)
```

Null Values

A **null value** in a tuple represents an unknown value. Generally, processing any list of values including a null results in a null value being returned (e.g. the **sum** function). In order to prevent such a result, it is generally necessary to explicitly prevent the selection of null values using a where clause including **is not null**.

To simplify processing of null values, Texql provides the function, **ifnull**, which returns its first argument if this is not null. If the first argument is null, ifnull returns its second argument.

Statement:

```
#  Example use of the ifnull function.
#
sum
(
        select  ifnull(amount, 0)
        from    loans
);
```

Output:

```
120000.000000
```

Relational Operators for Numeric Operands

The relational operators available for numeric operands are the same as those for boolean operands, described in Section 4.5.1.

If both operands of a relational operator are of the same type (i.e. either integer or floating point) then no conversion is necessary and the appropriate comparison is performed.

If one operand is integer and the other float then the integer operand is converted to float and the comparison is performed.

The null value is treated as an unknown value and so it is not considered equal to any other value including null. Hence, the comparison:

```
null = null
```

returns the value:

```
null
```

Between

A closed range of values can be requested using two relational operators combined using the boolean and operator. For example,

```
(val >= a) and (val <= b)
```

This can also be expressed using the **between** keyword as follows:

```
val between a and b
```

The between operator can only be applied to atomic values and all three expressions (val, a and b) must be type compatible.

Statement:

```
#  Find loans with amounts between 10000 and 50000
#
loans
where   amount between 10000 and 50000;
```

Output:

```
(2,(1),(6),40000.00,60,['Extension to family home'|'Car
purchase'|'Overseas Travel'])
(4,(3),(7),10000.00,36,['Overdraft'])
```

Text Operators

Most of the operators previously described can be applied to text operands. However, there are several other operators exclusively provided for text operations.

Equality

The standard equality operators, = (equals) and <> (does not equal) can be applied to text operands. The two operands are otherwise compared literally. Implicitly character case is insignificant.

Statement:

```
#  Find all contacts who are design engineers.
#
contacts[firstnam, surname]
where   position = 'design engineer' ;
```

Output:

```
('John','Citizen')
```

Statement:

```
#  Find all loan types except personal
#  and general loans.
#
loantypes
where   loanname <> 'general loan'
and     loanname <> 'personal loan' ;
```

Output:

```
(1,9.50,'First home buyer','john',(15,06,1993),(11,50))
(2,12.90,'Investment property','john',(15,06,1993),(11,50))
(4,14.25,'Car','john',(15,06,1993),(11,50))
(5,10.75,'Home improvement','john',(15,06,1993),(11,51))
(7,18.00,'Overdraft','john',(15,06,1993),(11,51))
(8,17.00,'Travel','john',(15,06,1993),(14,19))
```

An explicit case sensitive or case insensitive text comparison can be performed by preceding the text operand with the transformation operator, **=**, or, **&**, respectively.

Statement:

```
#  Find all contacts who are design engineers.
#  Character case sensitive.
#
contacts[firstnam, surname]
where   position = ='design engineer' ;
```

Output:

```
(no output)
```

Statement:

```
#  Find all contacts who are design engineers.
#  Character case insensitive.
#
contacts[firstnam, surname]
where   position = &'design engineer'  ;
```

Output:

```
('John','Citizen')
```

Relational Operators

The relational operators, >, >=, < and <= and **between**, can be applied to text operands. A comparison is performed based on the ASCII value of the characters in the operands. If either operand is null, the expression returns null.

Statement:

```
#  Find contacts with surnames beginning
#  with the letter A through M.
#
contacts[title, firstnam, surname]
where   surname between 'A' and 'M';
```

Output:

```
('Mr','John','Citizen')
('Ms','Jennifer','Johnson')
```

Like

As with SQL, Texql supports the specification of substrings in queries on text operands using the **like** operator. The like operator compares a text string operand using the pattern matching rules of Texpress.

If either operand of the like operator is a null, the expression returns null.

The like operator accepts the following pattern matching characters:

*****	Matches zero or more characters at that position in the operand.
?	Matches any single character at that position in the operand.
[*str*]	Matches a single character if that character is one of those in *str*. The *str* string may contain a sequence such as a-z which indicates the ASCII range of characters from a through to z.
[^*str*]	Matches a single character if that character is not one of those in *str*. Character ranges can be included as before.

{*str*} Matches zero or more characters which are contained in *str*. The *str* string is as defined above, supporting character ranges.

{^*str*} Matches zero or more characters which are not contained in *str*. The *str* string is as defined above, supporting character ranges.

Although the anchor characters,, ^ for start of string and **$** for end of string, are supported, they are redundant as the whole text must be matched by the pattern, not just a single word in the text.

Statement:

```
#  Find contacts with first names beginning with
#  a 'J', followed by any number of 'o', 'h' or 'e',
#  then followed by 'n' and then any other characters.
#
select  title, firstnam, surname
from    contacts
where   firstnam like 'j{ohe}n*';
```

Output:

```
('Mr','John','Citizen')
('Ms','Jennifer','Johnson')
```

Contains

Texql supports the searching of text columns using the **contains** operator. This operator enables the selection of tuples based on words, stems of words, sounds of words, phrasesor parts of words within the text attribute.

Within Texpress, a word is defined to be any sequence of letters, digits and underscore characters. The space character and most punctuation characters are word-break characters for most European languages, while for multi-byte languages, each ideographic character is considered a separate word.

The contains operator returns true if a text attribute (left hand side) contains the series of terms on the right hand side. The contents of the right hand side can be anything acceptable in a single text field of a Texpress Query form. The rules for matching are as defined by Texpress (refer to the Texpress Reference Manuals).

If multiple terms are specified in the text literal on the right hand side of the expression then all terms must match for the column to match (boolean 'and' relationship). Each term in the text literal can be one of the following:

term The word, *term*, must appear in the text. Implicitly case is insensitive.

=term The word, *term*, must appear in the text. Case is sensitive.

&term	The single word, *term*, must appear in the text. Case is insensitive.
~term	A word which is based on the same word stem as *term* must appear in the text.
@term	A word which sounds like *term* must appear in the text.
pattern	A word which matches the *pattern* (using the pattern matching rules described for the like operator) must appear in the text.
!term	The single word, *term*, must not appear in the text. Case is insensitive.
"term1 term2 ..."	The text must contain a phrase consisting of *term1* followed directly by *term2*, etc. Note that noise words are ignored within phrases. Each of the terms may take the form of any of the previous forms (exact terms, stems, sounds or patterns). One of the transformation operators, =, &, @ or ~, can immediately precede a phrase, in which case it is applied to all terms in the phrase. Also, the not operator, !, can immediately precede a phrase, in which case the search is for 'not' that phrase.

Any one of the transformation operators, =, &, ~ or @ may precede the literal text in which case the operator is applied to all terms in the text. A transformation explicitly specified within the text overrides any transformation operator specified outside the text.

Following are several examples of the use of the contains operator.

Statement:

```
#  Find contacts where the remarks column contains
#  the word, 'tattslotto'.
#
contacts[firstnam, surname, position]
where   remarks contains 'tattslotto' ;
```

Output:

```
('Peter','Rustings','Director')
```

Statement:

```
#  Find contacts where the position column contains
#  a word with the stem of 'market'.
```

```
#
contacts[firstnam, surname, position]
where   position contains '~market';
```

Output:

```
('Jennifer','Johnson','Marketing Officer')
```

Statement:

```
#  Find contacts where the surname column contains
#  a name sounding like 'jansen'.
#
contacts[firstnam, surname, position]
where   surname contains '@jansen';
```

Output:

```
('Jennifer','Johnson','Marketing Officer')
```

Statement:

```
#  Find contacts where the remarks column contains
#  a series of terms.
#
contacts
where   remarks
contains 'excellent "good loan ~prospects" @jenafer';
```

Output:

```
(2,'Ms','Jennifer','Johnson','Marketing Officer','Channel
Ten',
'34 James Court','VIC','NUNAWADING','3131','859 2717 844
7891', 'UNK',80000,['Home buyer'|'Travel'], 'john',
(15,06,1993), (14,11),
'Jennifer is a good loan prospect but with no previous
credit history (apart from a good bankcard record). She has
an excellent position, albeit with a difficult job ahead of
her, and so we can expect her to be able to service loans.
However, current thinking prefers to minimise our exposure
until there is more track record.')
```

Table and Tuple Operators

Many of the basic Texql operators can be applied to variables of type table, nested table or tuple. As described previously, a table is an unordered collection of tuples, while a nested table is an ordered list of tuples. Each can, of course, contain nested tuples.

Equality

The equality and inequality operators (= and <>) may be used for tables and tuples.

Two tuples are considered equal if they are type compatible and the pairs of values for each attribute in the tuples are equal.

Two tables are equal if they are type compatible, each of the tuples in the tables are equal and the tuples are in the same order.

Statement:

```
#  Check that all home loans and only home
#  loans are under 12% interest rate.
#
(
        loantypes
        where   loanname  contains 'home'
) =
(
        loantypes
        where   interest < 12
);
```

Output:

```
T
```

Tuple Existence

The **exists** operator returns true if its single operand, a table sub-expression, contains at least one tuple. It returns false otherwise.

Statement:

```
#  Display the surnames of loans for which
#  there exists a type containing 'car'.
#
#
loans[surname]
where   exists
        (
                category_tab
                where   category  contains 'car'
        );
```

Output:

```
('Citizen')
```

Subset and Superset

Two operators exist to determine if a table is a subset or a superset of another table. These operators, **subset of** and **superset of**, take two operands which must be tables identical in structure.

The subset of operator returns true if all of the tuples in the first table exist in the second, while the superset operator returns true if all of the tuples of the second table exist in the first.

The order of tuples in the tables is not important. Duplicate tuples are ignored during the evaluation of these operators.

Statement:

```
#  Ensure that all loans are registered to
#  people listed in the contacts table.
#
(
        loans[contno.contno]
) subset of
(
        contacts[contno]
);
```

Output:

```
T
```

Comparing Atomic Expressions with Tables

Two operators exist to compare an atomic or tuple expression with a table. These are the operators,**in** and **has**.

In

The **in** operator returns true if the left atomic or tuple sub-expression is contained within the set of values returned by the right table sub-expression. Otherwise false is returned.

Statement:

```
#  Find the surname of all contacts for
#  which there is a current loan tuple.
#
contacts[surname]
where   contno  in
                (
                        loans[contno]
                );
```

Output:

```
('Citizen')
('Johnson')
('Rustings')
```

Has

The **has** operator is functionally similar to the **in** operator. It returns true if the set of values returned by the left table sub-expression contains the right atomic or tuple sub-expression. Otherwise false is returned.

The right hand side of a has expression can also begin with one of the following operators (if none is specified then = is assumed):

- =
- <>
- >
- >=
- <
- <=
- between
- like
- contains
- subset of
- superset of

Statement:

```
#  Find the surname of all contacts for
#  which there is a current loan tuple.
#
contacts[surname]
where
(
        loans[contno]
) has contno;
```

Output:

```
('Citizen')
('Johnson')
('Rustings')
```

Arithmetic Expressions

Texql supports a rich suite of arithmetic operators, each of which is described in this section.

Unary Operators

The unary plus, **+**, and unary minus, **-**, operators can be applied to any sub-expression that returns a numeric value. The unary minus operator changes the sign of its operand. Both operators return null if the operand evaluates to null.

The type of the unary plus and unary minus expression is the same as the type of their operand, with the exception of tuples with a single numeric attribute which are first converted to an atomic numeric value.

Statement:

```
#  Prepare outstanding loan amounts
#  for inclusion on assets register.
#
select  -amount
from    loans;
```

Output:

```
(-65000.000000)
(-40000.000000)
(-5000.000000)
(-10000.000000)
```

Binary Operators

The binary arithmetic operators take two operands which are numeric, atomic sub-expressions. The operators are as follows:

+	Addition.
-	Subtraction.
*	Multiplication.
/	Division
%	Modulus.

If either operand returns a value of type float, then a floating point value is returned. Otherwise an integer value is returned. If either sub-expression returns null then null is returned.

Statement:

```
#  Recalculate loan amounts
#  given a 10% reduction.
#
select  amount * 0.9
from    loans;
```

Output:

```
(58500.000000)
(36000.000000)
(4500.000000)
(9000.000000)
```

The + operator can also be applied to text operands, in which case it performs a **concatenation** of its operands.

Statement:

```
#  Produce a table with a single text
#  attribute which is the concatenation
#  of the title, first name and surname
#  of all contacts.
#
select  title + ' ' + firstnam + ' ' + surname
from    contacts;
```

Output:

```
('Mr John Citizen')
('Ms Jennifer Johnson')
('Mr Peter Rustings')
```

Aggregate Functions

Texql supports the aggregate functions, **min**, **max**, **sum** and **avg**, which are designed to process a vector of values (such as a table with one column only). These functions generally take a SFW expression as their operand and produce a numeric result.

For each of these functions, the existence of a null value in an argument to the function causes the function to return the value null. Also if the table passed to these functions is empty, then the min, max and avg functions return null, while sum returns zero. This action can be overridden if a **default** component is added after the where component, if any. Thus a query such as:

```
avg(loans[amount] where amount > 100000) ;
```

would return null if no loan met the where condition. However, the statement:

```
avg(loans[amount] where  amount > 100000  default 0);
```

would return 0 rather than null.

These aggregate functions also create an implicit attribute identifier equal to the name of the function.

Min

The **min** function can be applied to any single attribute table. The attribute must be atomic and not a tuple or nested table.

If any of the values in the table are null, null is returned. If the table is empty, then the min function returns the default component, if any, otherwise null. The min function returns an atomic value whose type is the same as the attribute in its table operand.

When min is applied to a table whose single column is of text type, then it returns the value which is the first in lexicographic order (actually ASCII order).

Statement:

```
#  Determine the minimum loan amount.
#
min(loans[amount]);
```

Output:

```
5000.00
```

Max

The **max** function can be applied to any single attribute table. The attribute must be atomic and not a tuple or nested table.

If any of the values in the table are null, null is returned. If the table is empty, then the max function returns the default component, if any, otherwise null. The max function returns an atomic value whose type is the same as the attribute in its table operand.

When max is applied to a table whose single column is of type text or string, then it returns the value which is the last in lexicographic order (actually ASCII order).

Statement:

```
#  Determine the surname which is
#  last in lexicographic order.
#
max(contacts[surname]);
```

Output:

```
'Rustings'
```

Sum

The **sum** function can be applied to any single attribute table. The attribute must be atomic and not a tuple or nested table. The column of this table must be of a numeric type (integer or float).

If any of the values in the table are null, null is returned. If the table is empty, then the sum function returns the default component, if any, otherwise 0. The sum function returns an atomic value whose type is the same as the attribute in its table operand.

Statement:

```
#  Determine the sum of home loans.
#
sum
(
        loans[amount]
        where   exists
                (
                        category_tab
                        where   category contains 'home'
                )
);
```

Output:

```
105000.000000
```

Avg

The **avg** function can be applied to any single attribute table. The attribute must be atomic and not a tuple or nested table.

The column of this table must be of a numeric type (integer or float). If any of the values in the table are null, null is returned. If the table is empty, then the avg function returns the default component, if any, otherwise null. The atomic value returned by avg is always a floating point number.

Statement:

```
#  Create a temporary table of the loans columns plus
#  an additional column set to the average loan amount.
#  Then project from this table, the amount and the
#  average amount.
#
select  amount, "AVG"
from
(
        select  all,
                avg
                (
                        loans[amount]
                )
        from    loans as tmp
);
```

Output:

```
(65000.00,30000.000000)
(40000.00,30000.000000)
(5000.00,30000.000000)
(10000.00,30000.000000)
```

Counting Tuples

The **count** function can be applied to any table of any structure. The table may contain nested tables or null values. The count function always returns an integer value which is the number of tuples in the table. If an empty table is passed to this function, then zero is returned.

Statement:

```
#  Determine the number of loans
#  exceeding the average loan amount.
#
count
(
        loans[amount]  as tmp
        where   tmp.amount >  avg(loans[amount])
);
```

Output:

```
2
```

Forming Tuples from Tables

The function, **totuple**, makes the syntactic conversion of a table containing one tuple into the type, tuple. If the table does not contain exactly one tuple, this function returns an error. This function is necessary when passing the result of a SFW expression to a function, such as numwords (see Section 4.17), which operates on atomic values only.

Statement:

```
#  Output the amount of loan number 3
#  plus an extra $5,000.
#
totuple
(
        loans[amount]
        where   loanno = 3
) + 5000;
```

Output:

```
10000.000000
```

Tuple Numbers

The variable, **rownum**, returns the tuple number of the current tuple. This is the integer value representing the number of the tuple within the table or nested table. Tuples are numbered commencing from one.

Statement:

```
#  Select the rownum and amount of
#  tuples in the loans table from
#  row number 2 onwards.
#
select  rownum, amount
from    loans
where   rownum > 1;
```

Output:

```
(2,40000.00)
(3,5000.00)
(4,10000.00)
```

The rownum function also returns an attribute identifier of rownum.

Tuple Access

A single tuple can be selected from a table by adding {number} after the table reference. This is called **tuple access**. If the specified tuple does not exist in the table, a tuple of null values is returned.

Statement:

```
#  Access the fourth tuple of the loantypes table.
#
loantypes{4};
```

Output:

```
(4,14.25,'Car','john',(15,06,1993),(11,50))
```

Statement:

```
#  Access the name and second mailing list
#  entry of all contacts.
#
contacts[surname, maillist_tab{2}];
```

Output:

```
('Citizen',['Boating'])
('Johnson',['Travel'])
('Rustings',[])
```

A sub-range of tuplescan be accessed from a table by adding the sequence:

```
{num1 to num2}
```

after the table reference. This forms a table from rows *num1* through to *num2* or the number of rows in the table, whichever is smaller.

Statement:

```
#  Access the surname and first two
#  category entries for each loan.
#
loans[surname, category_tab{1 to 2}];
```

Output:

```
('Citizen',['First home purchase'])
('Citizen',,['Extension to family home'|'Car purchase'])
('Johnson',['Overseas Travel'])
('Rustings',['Overdraft'])
```

Table Expressions

There are several operators available for manipulating tables. Each of these return results which are also tables.

Times

The operator, **times**, returns the **cartesian product** of its operands, each of which must be tables. The resultant structure is a table containing two tuple attributes.

Join

The operator, **join**, implements a **natural join**. A natural join performs the cartesian product of its table operands, selecting only those tuples where all attributes with the same identifiers in the different tables have the same values, and then removes duplicate attributes

Unlike the times operator, join does not form tuples in the result.

Statement:

```
#  Without using the references, perform a
#  natural join of the loans, contacts and
#  loantypes tables and then select the
#  amount, surname and interest rate from
#  the resulting table.
#
select  amount, surname, interest
from
(
        (
                loans[loanno, contno.contno,
                        typeno.loanno as lno, amount]
        )
        join
        (
                contacts[contno, surname]
        )
        join
        (
                loantypes[loanno as lno, interest]
        )
);
```

Output:

```
(65000.00,'Citizen',9.50)
(40000.00,'Citizen',16.50)
(5000.00,'Johnson',17.00)
(10000.00,'Rustings',18.00)
```

Union

The **union** operator returns a table of the union of all tuples in each of its operands i.e. it returns any tuples which appear in either of its operands. Each operand must be of type table. Duplicate tuples are removed. If **union all** is used then duplicate tuples are not removed.

The table operands must be **union compatible**, which means that they must have the same attribute types and the attributes must appear in the same order. This must also be true recursively for any nested attributes.

Statement:

```
#  Find all loans of more than $5,000
#  together with all travel loans.
#
(
        loans
        where   amount > 5000
)
union all
(
        loans
        where   exists
                (
                        category_tab
                        where   category contains 'travel
                )
);
```

Output:

```
(1,(1),(1),65000.00,120,['First home purchase'])
(2,(1),(6),40000.00,60,['Extension to family home'|'Car
purchase'| 'Overseas Travel'])
(4,(3),(7),10000.00,36,['Overdraft'])
(2,(1),(6),40000.00,60,['Extension to family home'|'Car
purchase'| 'Overseas Travel'])
(3,(2),(8),5000.00,12,['Overseas Travel'])
```

Intersect

The **intersect** operator returns the intersection of all of the tuples in its operands, i.e. it only returns tuples that appear in both of the operands. The two operands must be union compatible tables.

If **union all** is specified, then the number of copies of any specific row value in the result is equal to the lesser number of such copies in the table indicated by the left operand and the number in the table indicated by the right operand.

Except

The operator, **except**, returns the set difference of its two operands, which must be union compatible tables, i.e. it returns all tuples that appear in the first operand except those that appear in the second. Duplicate tuples are removed.

If **except all** is specified, then the number of copies of any specific row value in the result is equal to the number of such copies in the table indicated by the left operand, less the number in the table indicated by the right operand

Nesting Data into Tables

The operator, **nest**, creates a tuple structure incorporating a nested table. It groups tuples with common values in unnested attributes to form a single new tuple.

Statement:

```
#  Nest loans on the contact number,
#  creating a new nested table of loan details.
#
nest
(
        loans[contno, typeno, amount, term]
)
on      contno
forming details;
```

Output:

```
((1),[((1),65000.00,120) | ((6),40000.00,60)])
((2),[((8),5000.00,12)])
((3),[((7),10000.00,36)])
```

The new table created by this example contains the loan details of each loan registered to a contact nested under the nested table called details.

A more complicated way of expressing the same query is as follows:

```
#  Nest loans on the contact number,
#  creating a new nested table of loan details.
#
distinct
(
        select  contno,
                (
                        select  typeno, amount, term
                        from    loans as details
                        where   lns.contno.contno =
                        details.contno.contno
                )
        from    loans as lns
);
```

Note, however, that the order of the tuples in the resulting table may be different from that returned by the first nesting example.

Unnesting Tables

The operator, **unnest**, can be used to collapse a single, nested table within a table. For each tuple in the nested table being collapsed, a new tuple is created containing the attributes of the nested table together with a copy of all of the other attributes in the table.

The keyword, **unnest**, can be preceded by one of the keywords, **inner** or **outer**, specifying the type of unnest to be performed. By default an unnest is an inner unnest operation..

If the nested table being collapsed does not contain any tuples, then an inner unnest does not produce a tuple, whereas an outer unnest produces a single tuple with the nested table attributes being assigned null values.

Statement:

```
#  Unnest the category_tab nested table
#  from the loans table and then select
#  the amount and category columns.
#
select  category, amount
from
(
        unnest  loans
        on      category_tab
);
```

Output:

```
('First home purchase',65000.00)
('Extension to family home',40000.00)
('Car purchase',40000.00)
('Overseas Travel',40000.00)
('Overseas Travel',5000.00)
('Overdraft',10000.00)
```

The operator, , can be used as an abbreviation for the **inner unnest** operator. So the above query could have been expressed as follows:

```
#  Unnest the category_tab nested table
#  from the loans table and then select
#  the amount and category columns.
#
select  category, amount
from    loans:category_tab;
```

Removing Duplicate Tuples

Similar to SQL, duplicate tuples are not removed from tables by Texql queries. For example, the following query:

```
loans[surname];
```

includes duplicate surnames, where a contact is registered as having more than one loan.

Duplicate tuples can be removed from a table using the operator, **distinct**. This operator takes a table as an argument and removes any duplicate.

Two tuples are considered to be duplicates if all atomic values are equal and any nested tables contain the same set of tuples where the ordering of tuples is significant.

The table returned has the same structure as the sub-expression but may contain less tuples. The ordering of tuples in the returned table is not guaranteed.

Statement:

```
distinct
(
        (
                loans
                where   amount > 5000
        )
        union
        (
                loans
                where   exists
                        (
                                category_tab
                                where   category
                                contains 'travel'
                        )
        )
);
```

Output:

```
(2,(1),(6),40000.00,60,['Extension to family home'|'Car
purchase'| 'Overseas Travel'])
(1,(1),(1),65000.00,120,['First home purchase'])
(4,(3),(7),10000.00,36,['Overdraft'])
(3,(2),(8),5000.00,12,['Overseas Travel'])
```

Sorting Tuples

The operator, **order**, sorts the tuples returned by a table sub-expression using one or more attributes. The sort attributes can be atomic attributes, tuples or nested tables, or selected attributes from tuples or nested tables. The dot notation for extracting attributes from tuples can be used.

The sorting direction, **asc** (ascending) or **desc** (descending), can also be specified with the default direction being ascending.

Nested tables are compared by comparing the first tuple, then the second and so on until the selected attribute or attributes differ in some way. An empty table is considered less than any other table.

Statement:

```
#  Order loans by descending order of
#  surname, first name and then
#  ascending order of amount.
#
order
(
        select  surname, firstnam, amount
        from    loans
)
on      surname desc,
        firstnam  desc,
        amount;
```

Output:

```
('Rustings','Peter',10000.00)
('Johnson','Jennifer',5000.00)
('Citizen','John',40000.00)
('Citizen','John',65000.00)
```

Miscellaneous Text Functions

Texql provides several text functions which can be useful when processing textual data. The description of each of these functions along with an example follows. Some examples use the following query as a sub-query.

Statement:

```
#  Query used as a sub-query in
#  miscellaneous text function examples.
#
contacts{1}[remarks];
```

Output:

```
('John presented well in his interview, confirming all
reports on him. His previous credit rating information is
excellent, reflecting a stable person with recognisable
commitment to repaying loans on time. John is also middle
class making him a good target for personal loans. His
particular interest in sailing makes him a good candidate
for the boating push we will soon commence.')
```

Stem

The function **stem**(*word*), returns the stem of the word, *word*.

Statement:

```
stem('electricity') ;
```

Output:

```
'electr'
```

Statement:

```
stem(word(totuple(contacts{1}[remarks]), 6));
```

Output:

```
'confirm'
```

Phonetic

The function **phonetic**(*word*) returns the phonetic encoding of the sound of the word, *word*.

Statement:

```
phonetic('electricity') ;
```

Output:

```
'e423'
```

Statement:

```
phonetic(word(totuple(contacts{1}[remarks]), 6));
```

Output:

```
'c516'
```

Numwords

The function **numwords**(*str*) returns the number of words, ignoring noise words, in the string,*str*.

Statement:

```
numwords('The quick brown fox jumped over the lazy dog')  ;
```

Output:

```
7
```

Statement:

```
numwords(totuple(contacts{1}[remarks])) ;
```

Output:

```
48
```

Word

The function **word**(*str*, *num*) selects the word number, *num*, from the string, *str*, ignoring noise words.

Statement:

```
word('The quick brown fox jumped over the lazy dog', 3)  ;
```

Output:

```
'fox'
```

Statement:

```
word(totuple(contacts{1}[remarks]), 6);
```

Output:

```
'confirming'
```

Words

The function **words**(*str*) returns as a list, the words in the string, *str*, ignoring noise words.

Statement:

```
words('The quick brown fox jumped over the lazy dog')  ;
```

Output:

```
('quick')
('brown')
('fox')
('jumped')
('over')
('lazy')
('dog')
```

Chapter 5

Data Manipulation Language

Overview

This chapter describes the data manipulation facilities provided by Texql. These facilities enable the creation, modification and deletion of records in Texpress databases through the Texql interpreter.

Insert

The Texql command, **insert**, is used to add new tuples to a table. When used in conjunction with the update command, it can also be used to insert new tuples into nested tables. The simplest form of the command is:

```
insert into table
values
[values ...] ;
```

where values contains a value for every column in the table. The use of this format is not generally recommended as it is not protected from changes to a table definition.

A more appropriate form of the insert command is:

```
insert into table[columns]
values
[values ...] ;
```

In this form, values must be supplied only for the columns listed. This is a more robust form of the insert command.

Multiple insertions can be performed with the one insert statement by defining multiple tuples inside the values square brackets. Multiple tuples are separated by |.

Statement:

```
#  Insert a new loan category into the loantypes table.
#
insert into  loantypes[loanno, interest, loanname]
values
[
  9,  9.0, 'Bank Transfer' |
  10, 15,  'Stock Market Investment'
];
```

Output:

```
Inserted 2 tuples
```

Insertions into tables which contain nested tables simply include one or more tuples in a nested tuple construct. These nested tuples are separated by | and the nested table surrounded by square brackets **[** and **]**.

Statement:

```
#  Insert a new contact into the contacts table.
#  Only a selection of the field values are known.
#
#  Note that, for readability, the remarks data
#  is broken into a series of text constants
#  that are concatenated using '+'.
#
insert into contacts[contno, title, surname,
                        country, town, rating, exposure,
                        maillist_tab, remarks]
values
[
  4, 'Ms', 'Thompson', 'VIC', 'Burwood', 'B', 40000,
  ['Boating' | 'Home improvement' | 'Travel'],
  'Little known information but a good prospect with ' +
  'high earning potential. Should be good for at ' +
  'least up to $40,000. On a home loan, we should '   +
  'accept up to $100,000 on an appropriate dwelling.'
];
```

Output:

```
Inserted 1 tuple
```

The result of any query can also be used as data for an insertion.

Statement:

```
#  Insert a new tuple into the loans database by
#  selecting an existing tuple and copying everything
#  except the unique identifier, loanno.
#  This is assigned explicitly.
#
insert into  loans
values  (
                select  5, all but loanno
                from    loans
                where   contno.surname = 'johnson'
        );
```

Output:

```
Inserted 1 tuple
```

Update

The **update** command is used to update tuples or nested tuples in a table. Update commands can be used to assign a new value to an atomic field, or modify nested tables using a nested Texql command. Thus an update command can contain nested insert, update or delete commands.

The **set** clauses are evaluated in the order of appearance (from left to right).

Statement:

```
#  Update the exposure field of all contact rows
#
update  contacts
set     exposure = 5000;
```

Output:

```
Updated 4 tuples
```

A **where** clause generally accompanies an update command to restrict the tuples which are updated.

Statement:

```
#  Replace all occurrences of 'Boating' with
#  'Yachting' for all records, regardless of
#  where it appears in the nested table.
#
update  contacts
set     (
                update  maillist_tab
                set     maillist = 'Yachting'
                where   maillist = 'boating'
        )
where   exists
        (
                maillist_tab
                where maillist = 'boating'
        );
```

Output:

```
Updated 2 tuples
```

When a tuple is being inserted into a nested table it is possible to specify whether it is to be inserted **before** or **after** the first tuple in the nested table meeting a "where"-style condition.

Statement:

```
#  Update a record by changing the first name,
#  adding a new mailing list entry and updating another.
#
update  contacts
set     firstnam = 'Jack',
        (
                insert into     maillist_tab
                values          ['Travel']
                after   maillist = 'Home improvement'
        ),
        (
                update  maillist_tab
                set     maillist = 'First home buyer'
                where   maillist = 'Home improvement'
        )
where   surname contains '@citason' ;
```

Output:

```
Updated 1 tuple
```

Delete

The **delete** statement removes matching tuples from a table or nested table. As described above, a delete command can be used on tuples in nested tables by nesting the command in an update statement.

Statement:

```
#  Delete all loans with amounts not more than $5,000.
#
delete from     loans
where           amount <= 5000;
```

Output:

```
Deleted 2 tuples
```

The delete command can be used to delete all tuples in a table.

Statement:

```
#  Delete all loans from the loans table.
#
delete from     loans;
```

Output:

```
Deleted 3 tuples
```

However this does not remove the table. A table can only be removed using the KE Texpress texdeletecommand.

Appendix A

Example Tables and Data

Contacts

Statement:

```
describe contacts;
```

Output:

```
contacts[
        contno          integer,
        title           text,
        firstnam        text,
        surname         text,
        position        text
        company         text
        address         text
        country         text,
        town            text,
        postcode        text
        phone           text
        rating          text
        exposure        integer,
        maillist_tab[
                maillist        text
        ],
        modby   text,
        modon(
                modon_1         integer,
                modon_2         integer,
                modon_3         integer
        ),
        modat(
                modat_1         integer,
                modat_2         integer
        ),
        remarks         text
];
```

Statement:

```
contacts;
```

Output:

```
(1,'Mr','John','Citizen','Design Engineer','Acme
Electronics Pty. Ltd.','123 Smith Street',
'VIC','GEELONG','3220','(053) 27 1645 (053) 27
8787','A+',150000,['Home improvement'|'Boating'],
'john',(15,06,1993),(14,06),
'John presented well in his interview, confirming all
reports on him. His previous credit rating information is
excellent, reflecting a stable person with recognizable
commitment to repaying loans on time. John is also middle
class making him a good target for personal loans. His
particular interest in sailing makes him a good candidate
for the boating push we will soon commence.')
(2,'Ms','Jennifer','Johnson','Marketing Officer','Channel
Ten','34 James Court', 'VIC','NUNAWADING','3131','859 2717
844 7891','UNK',80000,['Home buyer'|'Travel'],
'john',(15,06,1993),(14,11),
'Jennifer is a good loan prospect but with no previous
credit history (apart from a good bankcard record). She has
an excellent position, albeit with a difficult job ahead of
her, and so we can expect her to be able to service loans.
However, current thinking prefers to minimize our exposure
until there is more track record.')
(3,'Mr','Peter','Rustings','Director',
'Rustings Pty. Ltd.','P.O. Box 146',
'VIC','MELBOURNE','3001','662 2617 662 2617 662
2749','C',10000,['Better finance'],
'john',(15,06,1993),(14,15),
'Peter has a poor credit history and appears to be a
sizeable risk. We must ensure that all collateral offered
actually exists and is owned by him and generally keep
minimal exposure. However, we should try to keep his
business in case he wins Tattslotto.')
```

Loan Types

Statement:

```
describe loantypes;
```

Output:

```
loantypes[
        loanno          integer,
        interest        float,
        loanname        text,
        modby           text,
        modon(
                modon_1         integer,
                modon_2         integer,
                modon_3         integer
        ),
        modat(
                modat_1         integer,
                modat_2         integer
        )
];
```

Statement:

```
loantypes;
```

Output:

```
(1,9.50,'First home buyer','john',(15,06,1993),(11,50))
(2,12.90,'Investment property','john',(15,06,1993),(11,50))
(3,15.50,'Personal loan','john',(15,06,1993),(11,50))
(4,14.25,'Car','john',(15,06,1993),(11,50))
(5,10.75,'Home improvement','john',(15,06,1993),(11,51))
(6,16.50,'General loan','john',(15,06,1993),(11,51))
(7,18.00,'Overdraft','john',(15,06,1993),(11,51))
(8,17.00,'Travel','john',(15,06,1993),(14,19))
```

Loans

Statement:

```
describe loans;
```

Output:

```
loans[
        loanno          integer,
        contno(
                contno          integer
        )       ref             contacts,
        typeno(
                loanno          integer
        )       ref             loantypes,
        amount          float,
        term            integer,
        category_tab[
                category        text
        ]
];
```

Statement:

```
loans;
```

Output:

```
(1,(1),(1),65000.00,120,['First home purchase'])
(2,(1),(6),40000.00,60,['Extension to family home'|'Car
purchase'|'Overseas Travel'])
(3,(2),(8),5000.00,12,['Overseas Travel'])
(4,(3),(7),10000.00,36,['Overdraft'])
```

Appendix B

Error and Status Codes

Error Codes

001 "Internal error: %s"
002 "Expression failed"
003 "Link to REF failed"
004 "Validation failed"
005 "Permission denied"
006 "Table is readonly"
007 "Can't find \"%s\"table"
008 "You are not a registered user of \"%s\" table"
009 "Database \"%s\" not initialised"
010
011 "Database startup failed"
012 "Failed to read table"
013
014
015 "Cannot lock data file"
016 "Cannot lock duplicate data file"
017 "Cursor is not a query cursor"
018 "End of file"
019 "No more cursors available"
020 "Bad cursor"
021 "Can't determine user identity"
022 "Query does not return an atomic value"
023 "Column \"%s\" is of incorrect type "
024 "Unknown column name \"%s\""
025 "Atomic column %shas unknown (bad) type"
026 "Describe cursor cannot access data"
027 "Operation is not permitted on a nested cursor"
028 "Cursor is not a reference to KE Texpress database"
029 "Bad item name"
030 "Bad field number"
031 "Column operation performed before row has been accessed"
032 "Nested cursor operation performed before row has been accessed"
033 "The API cannot be run by the superuser"
034 "Permission denied"
035 "Operation interrupted by front-end"
036 "Column \"%s\" not a base KE Texpress table"
037 "Row lock failed"
038 "Row unlock failed"
039 "Row status failed"
040 "Merge arguments refer to different base tables"
041 "Merge arguments table paths differ"
042 "Column \"%s\" is read only"
043 "Sort of cursor failed"

044 "Incompatible versions of client library and KE Texpress server"
045 "Function not yet implemented in KE Texpress server"
046 "Reference column not permitted"
047 "New row has not been saved or discarded"
048 "Table does not have a primary key"
049 "Failed to assign primary key"
050 "Badly formed primary key"
051 "Duplicate primary key"
052 "Licence error"

200 "BUT caused all columns to be removed"
201 "Unable to resolve BUT identifier"
202 "Can't evaluate expression to atomic value"
203 "Illegal NULL value in expression evaluation"
204 "INSERT BEFORE/AFTER not permitted on base table"
205 "TOTUPLE cannot return row from empty table"
206 "TOTUPLE can only return a row from a table that has only one row"
207 "Too many tables to join on"
208 "Unknown table in PRESERVE clause"
209 ".ident can only be applied to a tuple"
210 ".%s not a column of the tuple"
211 "Unable to resolve \"%s\""
212 "Attribute specification too complex for GROUP"
213 "GROUP operator not being applied to table"
214 "Tuple projection not from tuple expression"
215 "UPDATE only works on tuples or tables"
216 "FROM line not a table expression"
217 "References too complex to follow"
218 "Identifier nesting too deep"
219 "Column number out of range"
220 "Ambiguous identifier"
221 "HAS on non table column"
222 "STEM makes no sense on incomplete word"
223 "PHONETIC makes no sense on incomplete word"
224 "A syntax error has occurred while parsing text"
225 "BUT must come last on SELECT line"
226 "Text constant must have at least one character (otherwise use NULL)"
227 "Incompatible tuples in constant table"
228 "AS expression is type incompatible"
229 "Left hand side of '=' must be an identifier"
230 "Identifier \"%s\" recursively defined"
231 "Arithmetic operator can only be applied to atomic types"
232 "Can't use arithmetic operator on type %s"
233 "Can only use IS NULL operator on atomic types"
234 "EXISTS can only be applied to table expressions"

235 "Illegal ROWNUM operator"
236 "Incorrect number of arguments to %s"
237 "%s can only be applied to TEXT values"
238 "COUNT can only be applied to tables"
239 "IFNULL can only be applied to atomic values"
240 "Arguments of IFNULL type incompatible"
241 "Arguments of %s must be atomic"
242 "First argument of %s must be of type TEXT"
243 "Second argument of %s must be of type INTEGER"
244 "%s requires a table that has a single column of atomic values"
245 "DEFAULT value of different type to table column for %s"
246 "%s requires a single numeric column table"
247 "DEFAULT value for %s is not an atomic value"
248 "DEFAULT value must numeric for %s"
249 "%s requires a table expression"
250 "Can only %s on boolean values"
251 "Can't use boolean operator on type %s"
252 "Can only %s on atomic values"
253 "Two sides of %s operator not of compatible types"
254 "Bad left hand side of LIKE"
255 "Right hand side of LIKE must be of type TEXT"
256 "CONTAINS used only on TEXT columns"
257 "Right hand operand of CONTAINS must be a TEXT constant"
258 "Left hand operand of HAS must be a single atomic valued column table"
259 "Right hand operand of HAS must be an atomic value"
260 "%s left and right hand operands are type incompatible"
261 "Left hand operand of IN must be an atomic value"
262 "Right hand operand of IN must be a single atomic valued column table"
263 "%s requires table expressions as operands"
264 "Can only apply BETWEEN to atomic values"
265 "Incompatible types in BETWEEN clause"
266 "WHERE not from a table"
267 "WHERE clause must return a boolean value"
268 "SELECT-FROM-WHERE expression not from a table"
269 "Tuple projection not from a tuple"
270 ".* only permitted on SELECT line"
271 ".* can only be applied to tuples"
272 "%s expression not from a table"
273 "%s must have boolean condition"
274 "%s must return a boolean value"
275 "Not a COLUMN to GROUP on"
276 "Illegal GROUP identifier"
277 "Can only GROUP tables"
278 "Can only %s tables"
279 "Can only %s nested tables"

280 "Can only insert into tables"
281 "Tuple structure different to table structure"
282 "Can only modify tables with %s"
283 "Incompatible types for SET"
284 "Range value must be of type INTEGER"
285 "Operand of [] must be of type TABLE"
286 "Referenced table no longer exists"
287 "ORDER cannot be applied to atomic values"
288 "ORDER can only be applied to table values"
289 "Badly formed identifier"
290 "PRESERVE without WHERE clause"
291 "Illegal PRESERVE"
292 "Syntax error"
293 "String not terminated at end of line"
294 "Division by zero"
295 "Modulus by zero"
296
297
298 "Database is full"
299 "Server panic"

Status Codes

150 "Query completed"
151 "Describe completed"
152 "Inserted %d tuples"
153 "Updated %d tuples"
154 "Deleted %d tuples"

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