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Tutorial

Database Communication in LabVIEW

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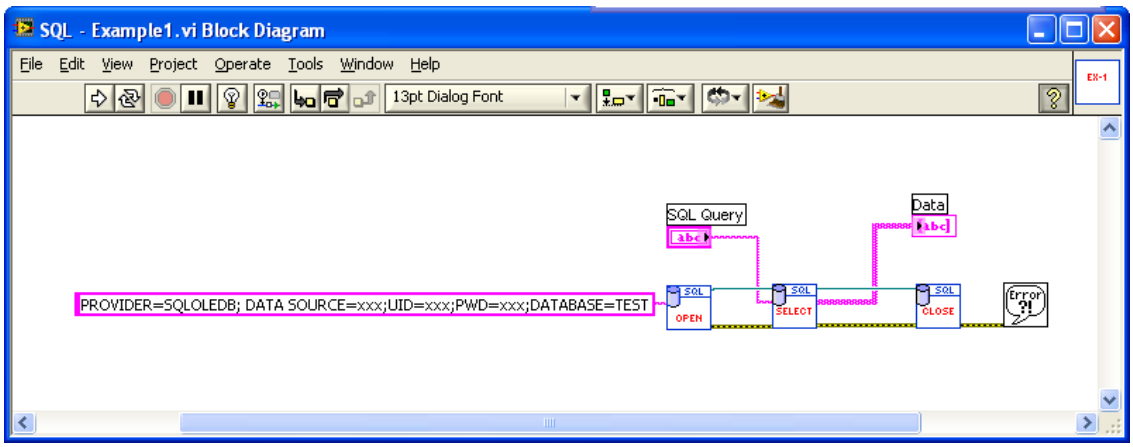

Preface

This document explains the basic concepts of a database system and how to communicate with a database from LabVIEW.

You should have some basic knowledge about LabVIEW, e.g., the "**An Introduction to LabVIEW**" training. This document is available for download at http://home.hit.no/~hansha/.

In addition to LabVIEW Professional Development System, you need to install the "LabVIEW Database Connectivity Toolkit".

For more information about LabVIEW and Databases, visit my Blog: http://home.hit.no/~hansha/

Some text in this document is based on text from www.wikipedia.org and "LabVIEW Database Connectivity Toolkit User Manual".

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1Introduction to LabVIEW

LabVIEW (short for **Lab**oratory **V**irtual **I**nstrumentation **E**ngineering **W**orkbench) is a platform and development environment for a visual programming language from National Instruments. The graphical language is named "G". Originally released for the Apple Macintosh in 1986, LabVIEW is commonly used for data acquisition, instrument control, and industrial automation on a variety of platforms including Microsoft Windows, various flavors of UNIX, Linux, and Mac OS X. The latest version of LabVIEW is version LabVIEW 2009, released in August 2009. Visit National Instruments at www.ni.com.

The code files have the extension ".vi", which is a abbreviation for "Virtual Instrument". LabVIEW offers lots of additional Add-Ons and Toolkits.

1.1 Dataflow programming

The programming language used in LabVIEW, also referred to as G, is a dataflow programming language. Execution is determined by the structure of a graphical block diagram (the LV-source code) on which the programmer connects different function-nodes by drawing wires. These wires propagate variables and any node can execute as soon as all its input data become available. Since this might be the case for multiple nodes simultaneously, G is inherently capable of parallel execution. Multi-processing and multi-threading hardware is automatically exploited by the built-in scheduler, which multiplexes multiple OS threads over the nodes ready for execution.

1.2 Graphical programming

LabVIEW ties the creation of user interfaces (called front panels) into the development cycle. LabVIEW programs/subroutines are called virtual instruments (VIs). Each VI has three components: a block diagram, a front panel, and a connector panel. The last is used to represent the VI in the block diagrams of other, calling VIs. Controls and indicators on the front panel allow an operator to input data into or extract data from a running virtual instrument. However, the front panel can also serve as a programmatic interface. Thus a virtual instrument can either be run as a program, with the front panel serving as a user interface, or, when dropped as a node onto the block diagram, the front panel defines the inputs and outputs for the given node through the connector pane. This implies each VI can be easily tested before being embedded as a subroutine into a larger program.

The graphical approach also allows non-programmers to build programs simply by dragging and dropping virtual representations of lab equipment with which they are already familiar. The LabVIEW

programming environment, with the included examples and the documentation, makes it simple to create small applications. This is a benefit on one side, but there is also a certain danger of underestimating the expertise needed for good quality "G" programming. For complex algorithms or large-scale code, it is important that the programmer possess an extensive knowledge of the special LabVIEW syntax and the topology of its memory management. The most advanced LabVIEW development systems offer the possibility of building stand-alone applications. Furthermore, it is possible to create distributed applications, which communicate by a client/server scheme, and are therefore easier to implement due to the inherently parallel nature of G-code.

1.3 Benefits

One benefit of LabVIEW over other development environments is the extensive support for accessing instrumentation hardware. Drivers and abstraction layers for many different types of instruments and buses are included or are available for inclusion. These present themselves as graphical nodes. The abstraction layers offer standard software interfaces to communicate with hardware devices. The provided driver interfaces save program development time. The sales pitch of National Instruments is, therefore, that even people with limited coding experience can write programs and deploy test solutions in a reduced time frame when compared to more conventional or competing systems. A new hardware driver topology (DAQmxBase), which consists mainly of G-coded components with only a few register calls through NI Measurement Hardware DDK (Driver Development Kit) functions, provides platform independent hardware access to numerous data acquisition and instrumentation devices. The DAQmxBase driver is available for LabVIEW on Windows, Mac OS X and Linux platforms.

2Database Systems

A database is an integrated collection of logically related records or files consolidated into a common pool that provides data for one or more multiple uses.

One way of classifying databases involves the type of content, for example: bibliographic, full-text, numeric, and image. Other classification methods start from examining database models or database architectures.

The data in a database is organized according to a database model. The relational model is the most common.

A Database Management System (**DBMS**) consists of software that organizes the storage of data. A DBMS controls the creation, maintenance, and use of the database storage structures of organizations and of their end users. It allows organizations to place control of organization-wide database development in the hands of Database Administrators (DBAs) and other specialists. In large systems, a DBMS allows users and other software to store and retrieve data in a structured way.

Database management systems are usually categorized according to the database model that they support, such as the network, relational or object model. The model tends to determine the query languages that are available to access the database. One commonly used query language for the relational database is SQL, although SQL syntax and function can vary from one DBMS to another. A great deal of the internal engineering of a DBMS is independent of the data model, and is concerned with managing factors such as performance, concurrency, integrity, and recovery from hardware failures. In these areas there are large differences between products.

2.1 RDBMS Components

A Relational Database Management System (DBMS) consists of the following components:

- **Interface drivers** - A user or application program initiates either schema modification or content modification. These drivers are built on top of SQL. They provide methods to prepare statements, execute statements, fetch results, etc. An important example is the ODBC driver.
- **SQL engine** - This component interprets and executes the SQL query. It comprises three major components (compiler, optimizer, and execution engine).
- **Transaction engine** - Transactions are sequences of operations that read or write database elements, which are grouped together.
- **Relational engine** - Relational objects such as Table, Index, and Referential integrity constraints are implemented in this component.

- **Storage engine** - This component stores and retrieves data records. It also provides a mechanism to store metadata and control information such as undo logs, redo logs, lock tables, etc.

2.2 Data warehouse

A data warehouse stores data from current and previous years — data extracted from the various operational databases of an organization. It becomes the central source of data that has been screened, edited, standardized and integrated so that it can be used by managers and other end-user professionals throughout an organization.

2.3 Relational Database

A relational database matches data using common characteristics found within the data set. The resulting groups of data are organized and are much easier for people to understand.

For example, a data set containing all the real-estate transactions in a town can be grouped by the year the transaction occurred; or it can be grouped by the sale price of the transaction; or it can be grouped by the buyer's last name; and so on.

Such a grouping uses the relational model (a technical term for this is schema). Hence, such a database is called a "relational database."

The software used to do this grouping is called a relational database management system. The term "relational database" often refers to this type of software.

Relational databases are currently the predominant choice in storing financial records, manufacturing and logistical information, personnel data and much more.

Strictly, a relational database is a collection of relations (frequently called tables).

2.4 Real-time databases

A real-time database is a processing system designed to handle workloads whose state may change constantly. This differs from traditional databases containing persistent data, mostly unaffected by time. For example, a stock market changes rapidly and dynamically. Real-time processing means that a transaction is processed fast enough for the result to come back and be acted on right away. Real-time databases are useful for accounting, banking, law, medical records, multi-media, process control, reservation systems, and scientific data analysis. As computers increase in power and can store more data, real-time databases become integrated into society and are employed in many applications

2.5 Database Management Systems

There are Database Management Systems (DBMS), such as:

- Microsoft SQL Server
- Oracle
- Sybase
- dBase
- Microsoft Access
- MySQL from Sun Microsystems (Oracle)
- DB2 from IBM
- etc.

This document will focus on Microsoft Access and Microsoft SQL Server.

2.6 MDAC

The Microsoft Data Access Components (**MDAC**) is the framework that makes it possible to connect and communicate with the database. MDAC includes the following components:

- **ODBC** (Open Database Connectivity)
- **OLE DB**
- **ADO** (ActiveX Data Objects)

MDAC also installs several data providers you can use to open a connection to a specific data source, such as an MS Access database.

2.6.1 ODBC

Open Database Connectivity (ODBC) is a native interface that is accessed through a programming language that can make calls into a native library. In MDAC this interface is defined as a DLL. A separate module or driver is needed for each database that must be accessed.

2.6.2 OLE DB

OLE allows MDAC applications access to different types of data stores in a uniform manner. Microsoft has used this technology to separate the application from the data store that it needs to access. This was done because different applications need access to different types and sources of data, and do not necessarily need to know how to access technology-specific functionality. The technology is conceptually divided into consumers and providers. The consumers are the applications

that need access to the data, and the provider is the software component that exposes an OLE DB interface through the use of the Component Object Model (or COM).

2.6.3 ADO (ActiveX Data Objects)

ActiveX Data Objects (ADO) is a high level programming interface to OLE DB. It uses a hierarchical object model to allow applications to programmatically create, retrieve, update and delete data from sources supported by OLE DB. ADO consists of a series of hierarchical COM-based objects and collections, an object that acts as a container of many other objects. A programmer can directly access ADO objects to manipulate data, or can send an SQL query to the database via several ADO mechanisms.

3Relational Databases

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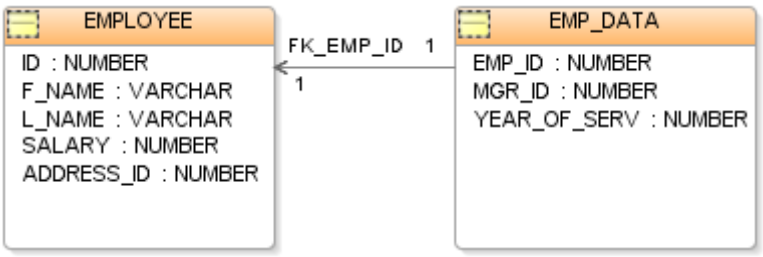
Relational databases are currently the predominant choice in storing financial records, manufacturing and logistical information, personnel data and much more.

3.1 Tables

The basic units in a database are tables and the relationship between them. Strictly, a relational database is a collection of relations (frequently called tables).



3.2 Unique Keys and Primary Key

In relational database design, a **unique key** or primary key is a candidate key to uniquely identify each row in a table. A unique key or primary key comprises a single column or set of columns. No two distinct rows in a table can have the same value (or combination of values) in those columns. Depending on its design, a table may have arbitrarily many unique keys but at most one primary key.

A unique key must uniquely identify all possible rows that exist in a table and not only the currently existing rows. Examples of unique keys are Social Security numbers or ISBNs.

A **primary key** is a special case of unique keys. The major difference is that for unique keys the implicit NOT NULL constraint is not automatically enforced, while for primary keys it is enforced. Thus, the values in unique key columns may or may not be NULL. Another difference is that primary keys must be defined using another syntax.

Primary keys are defined with the following syntax:

```
CREATE TABLE table_name (
     id_col  INT,
     col2    CHARACTER VARYING(20),
     ...
     CONSTRAINT tab_pk PRIMARY KEY(id_col),
     ...
)
```

If the primary key consists only of a single column, the column can be marked as such using the following syntax:

```
CREATE TABLE table_name (
     id_col  INT  PRIMARY KEY,
     col2    CHARACTER VARYING(20),
     ...
)
```

The definition of unique keys is syntactically very similar to primary keys.

Likewise, unique keys can be defined as part of the CREATE TABLE SQL statement.

```
CREATE TABLE table_name (
     id_col   INT,
     col2     CHARACTER VARYING(20),
     key_col  SMALLINT,
     ...
     CONSTRAINT key_unique UNIQUE(key_col),
     ...
)
```

Or if the unique key consists only of a single column, the column can be marked as such using the following syntax:

```
CREATE TABLE table_name (
     id_col  INT  PRIMARY KEY,
     col2    CHARACTER VARYING(20),
     ...
     key_col  SMALLINT UNIQUE,
     ...
)
```

3.3 Foreign Key

In the context of relational databases, a foreign key is a referential constraint between two tables. The foreign key identifies a column or a set of columns in one table that refers to a column or set of columns in another table. The columns in the referencing table must be the primary key or other candidate key in the referenced table. The values in one row of the referencing columns must occur in a single row in the referenced table. Thus, a row in the referencing table cannot contain values that don't exist in the referenced table. This way references can be made to link information together and it is an essential part of database normalization. Multiple rows in the referencing table may refer to the same row in the referenced table. Most of the time, it reflects the one (master table, or referenced table) to many (child table, or referencing table) relationship.

The referencing and referenced table may be the same table, i.e. the foreign key refers back to the same table. Such a foreign key is known as self-referencing or recursive foreign key.

A table may have multiple foreign keys, and each foreign key can have a different referenced table. Each foreign key is enforced independently by the database system. Therefore, cascading relationships between tables can be established using foreign keys.

Improper foreign key/primary key relationships or not enforcing those relationships are often the source of many database and data modeling problems.

Foreign keys can be defined as part of the CREATE TABLE SQL statement.

```
CREATE TABLE table_name (
   id    INTEGER  PRIMARY KEY,
   col2  CHARACTER VARYING(20),
   col3  INTEGER,
   ...
   CONSTRAINT col3_fk FOREIGN KEY(col3)
      REFERENCES other_table(key_col),
   ... )
```

If the foreign key is a single column only, the column can be marked as such using the following syntax:

```
CREATE TABLE table_name (
   id    INTEGER  PRIMARY KEY,
   col2  CHARACTER VARYING(20),
   col3  INTEGER REFERENCES other_table(column_name),
   ... )
```

3.4 Views

In database theory, a view consists of a stored query accessible as a virtual table composed of the result set of a query. Unlike ordinary tables in a relational database, a view does not form part of the physical schema: it is a dynamic, virtual table computed or collated from data in the database. Changing the data in a table alters the data shown in subsequent invocations of the view.

Views can provide advantages over tables:

- Views can represent a subset of the data contained in a table
- Views can join and simplify multiple tables into a single virtual table
- Views can act as aggregated tables, where the database engine aggregates data (sum, average etc) and presents the calculated results as part of the data
- Views can hide the complexity of data; for example a view could appear as Sales2000 or Sales2001, transparently partitioning the actual underlying table
- Views take very little space to store; the database contains only the definition of a view, not a copy of all the data it presents
- Views can limit the degree of exposure of a table or tables to the outer world

Syntax:

```
CREATE VIEW <ViewName>
AS
…
```

3.5 Functions

In SQL databases, a user-defined function provides a mechanism for extending the functionality of the database server by adding a function that can be evaluated in SQL statements. The SQL standard distinguishes between scalar and table functions. A scalar function returns only a single value (or NULL), whereas a table function returns a (relational) table comprising zero or more rows, each row with one or more columns.

User-defined functions in SQL are declared using the CREATE FUNCTION statement.

Syntax:

```
CREATE FUNCTION <FunctionName>
      (@Parameter1 <datatype>,
      @ Parameter2 <datatype>,
      …)

RETURNS <datatype>
AS
…
```

3.6 Stored procedures

A stored procedure is executable code that is associated with, and generally stored in, the database. Stored procedures usually collect and customize common operations, like inserting a tuple into a relation, gathering statistical information about usage patterns, or encapsulating complex business logic and calculations. Frequently they are used as an application programming interface (API) for security or simplicity.

Stored procedures are not part of the relational database model, but all commercial implementations include them.

Stored procedures are called or used with the following syntax:

```
CALL procedure(…)
```

or

```
EXECUTE procedure(…)
```

Stored procedures can return result sets, i.e. the results of a SELECT statement. Such result sets can be processed using cursors by other stored procedures by associating a result set locator, or by applications. Stored procedures may also contain declared variables for processing data and cursors that allow it to loop through multiple rows in a table. The standard Structured Query Language provides IF, WHILE, LOOP, REPEAT, CASE statements, and more. Stored procedures can receive variables, return results or modify variables and return them, depending on how and where the variable is declared.

3.7 Triggers

A database trigger is procedural code that is automatically executed in response to certain events on a particular table or view in a database. The trigger is mostly used for keeping the integrity of the information on the database. For example, when a new record (representing a new worker) added to the employees table, new records should be created also in the tables of the taxes, vacations, and salaries.

The syntax is as follows:

```
CREATE TRIGGER <TriggerName> ON <TableName>
FOR INSERT, UPDATE, DELETE
AS
…
```

4Structured Query Language (SQL)

SQL (Structured Query Language) is a database computer language designed for managing data in relational database management systems (RDBMS).

4.1 Queries

The most common operation in SQL is the query, which is performed with the declarative SELECT statement. SELECT retrieves data from one or more tables, or expressions. Standard SELECT statements have no persistent effects on the database.

Queries allow the user to describe desired data, leaving the database management system (DBMS) responsible for planning, optimizing, and performing the physical operations necessary to produce that result as it chooses.

A query includes a list of columns to be included in the final result immediately following the SELECT keyword. An asterisk ("*") can also be used to specify that the query should return all columns of the queried tables. SELECT is the most complex statement in SQL, with optional keywords and clauses that include:

- The **FROM** clause which indicates the table(s) from which data is to be retrieved. The FROM clause can include optional JOIN subclauses to specify the rules for joining tables.
- The **WHERE** clause includes a comparison predicate, which restricts the rows returned by the query. The WHERE clause eliminates all rows from the result set for which the comparison predicate does not evaluate to True.
- The **GROUP BY** clause is used to project rows having common values into a smaller set of rows. GROUP BY is often used in conjunction with SQL aggregation functions or to eliminate duplicate rows from a result set. The WHERE clause is applied before the GROUP BY clause.
- The **HAVING** clause includes a predicate used to filter rows resulting from the GROUP BY clause. Because it acts on the results of the GROUP BY clause, aggregation functions can be used in the HAVING clause predicate.
- The **ORDER BY** clause identifies which columns are used to sort the resulting data, and in which direction they should be sorted (options are ascending or descending). Without an ORDER BY clause, the order of rows returned by an SQL query is undefined.

Example:

The following is an example of a SELECT query that returns a list of expensive books. The query retrieves all rows from the Book table in which the price column contains a value greater than 100.00. The result is sorted in ascending order by title. The asterisk (*) in the select list indicates that all columns of the Book table should be included in the result set.

```
SELECT *
FROM Book
WHERE price > 100.00
ORDER BY title;
```

The example below demonstrates a query of multiple tables, grouping, and aggregation, by returning a list of books and the number of authors associated with each book.

```
SELECT Book.title,count(*) AS Authors
FROM Book
JOIN Book_author ON Book.isbn = Book_author.isbn
GROUP BY Book.title
```

Example output might resemble the following:

```
Title                    Authors
-------------------------------
SQL Examples and Guide     4
The Joy of SQL             1
An Introduction to SQL     2
Pitfalls of SQL            1
```

4.2 Data manipulation

The **Data Manipulation Language (DML)** is the subset of SQL used to add, update and delete data.

The acronym **CRUD** refers to all of the major functions that need to be implemented in a relational database application to consider it complete. Each letter in the acronym can be mapped to a standard SQL statement:

Operation	SQL
Create	INSERT
Read (Retrieve)	SELECT
Update	UPDATE
Delete (Destroy)	DELETE

Example: INSERT

INSERT adds rows to an existing table, e.g.,:

```
INSERT INTO My_table field1, field2, field3)
VALUES ('test', 'N', NULL)
```

Example: UPDATE

UPDATE modifies a set of existing table rows, e.g.,:

```
UPDATE My_table
SET field1 = 'updated value'
WHERE field2 = 'N'
```

Example: DELETE

DELETE removes existing rows from a table, e.g.,:

```
DELETE FROM My_table
WHERE field2 = 'N'
```

4.3 Data definition

The **Data Definition Language (DDL)** manages table and index structure. The most basic items of DDL are the CREATE, ALTER, RENAME and DROP statements:

- **CREATE** creates an object (a table, for example) in the database.
- **DROP** deletes an object in the database, usually irretrievably.
- **ALTER** modifies the structure an existing object in various ways—for example, adding a column to an existing table.

Example: CREATE

Create a Database Table

```
CREATE TABLE My_table
(
    my_field1   INT,
    my_field2   VARCHAR(50),
    my_field3   DATE         NOT NULL,
    PRIMARY KEY (my_field1)
)
```

4.4 Data types

Each column in an SQL table declares the type(s) that column may contain. ANSI SQL includes the following datatypes.

4.4.1 Character strings

- CHARACTER(n) or CHAR(n) — fixed-width n-character string, padded with spaces as needed
- CHARACTER VARYING(n) or VARCHAR(n) — variable-width string with a maximum size of n characters
- NATIONAL CHARACTER(n) or NCHAR(n) — fixed width string supporting an international character set
- NATIONAL CHARACTER VARYING(n) or NVARCHAR(n) — variable-width NCHAR string

4.4.2 Bit strings

- BIT(n) — an array of n bits
- BIT VARYING(n) — an array of up to n bits

4.4.3 Numbers

- INTEGER and SMALLINT
- FLOAT, REAL and DOUBLE PRECISION
- NUMERIC(precision, scale) or DECIMAL(precision, scale)

4.4.4 Date and Time

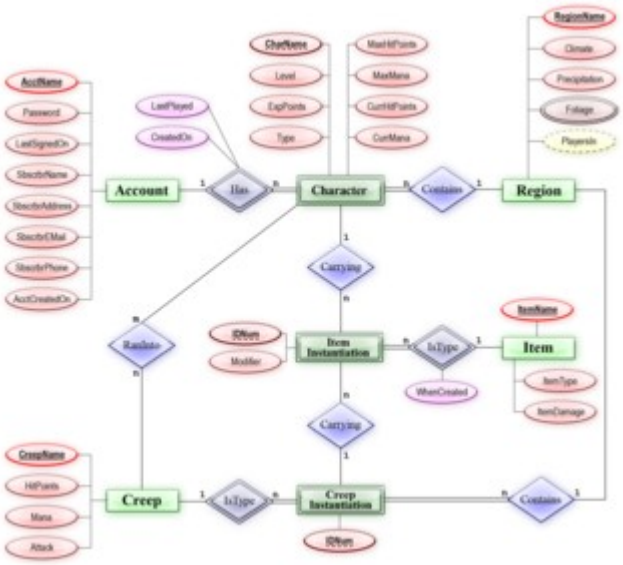
- DATE
- TIME
- TIMESTAMP
- INTERVAL

5Database Modelling

5.1 ER Diagram

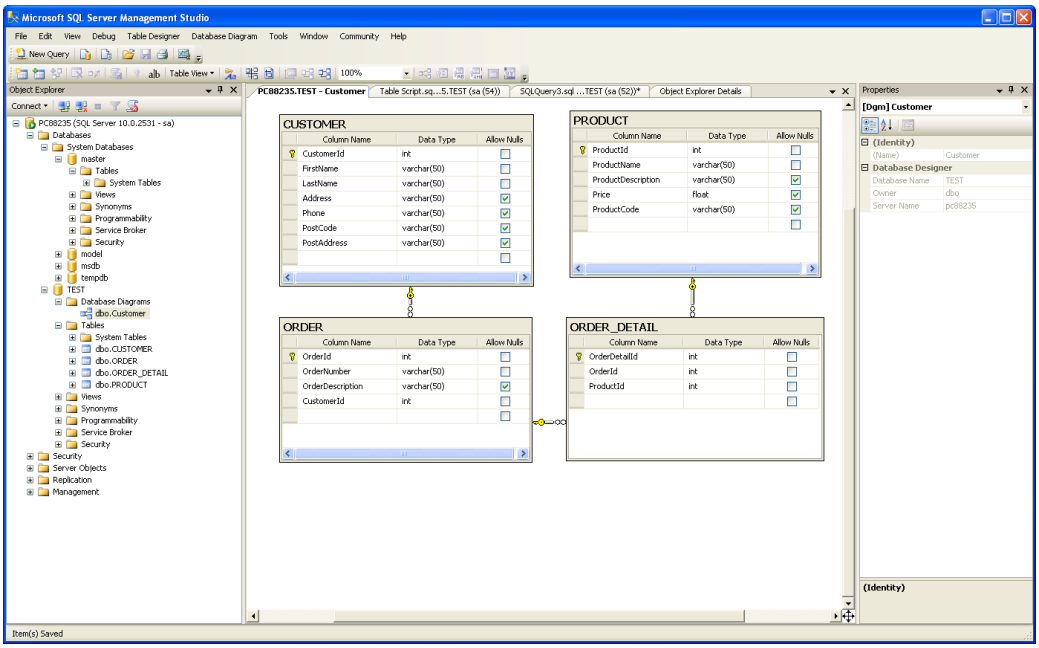
In software engineering, an Entity-Relationship Model (ERM) is an abstract and conceptual representation of data. Entity-relationship modeling is a database modeling method, used to produce a type of conceptual schema or semantic data model of a system, often a relational database, and its requirements in a top-down fashion.

Diagrams created using this process are called entity-relationship diagrams, or ER diagrams or ERDs for short.



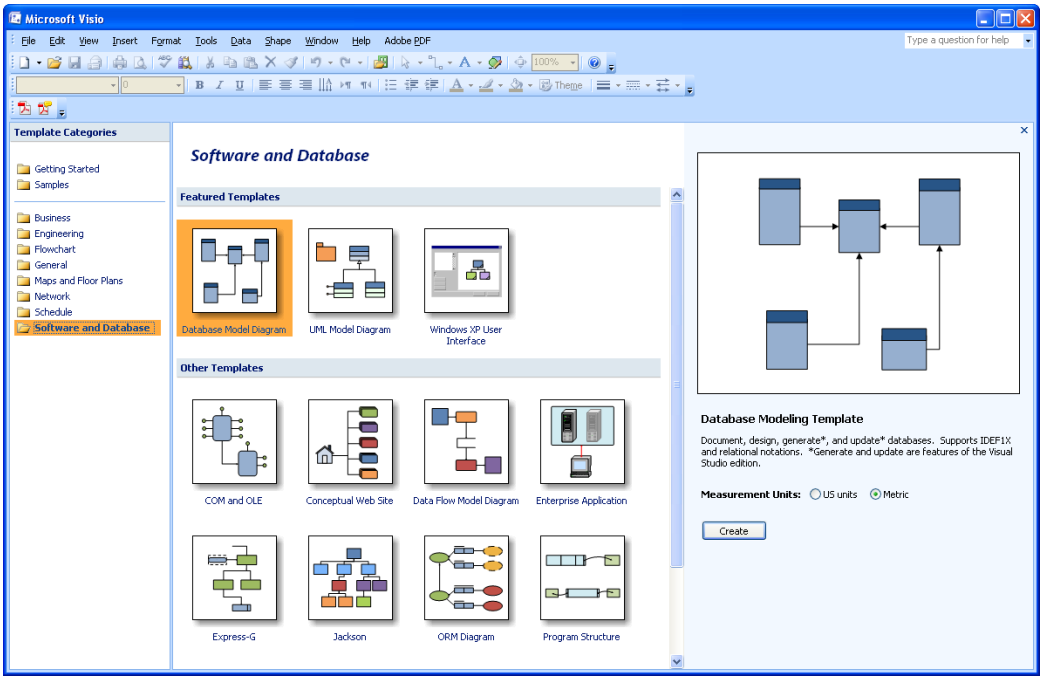
There are many ER diagramming tools. Some of the proprietary ER diagramming tools are ERwin, Enterprise Architect and Microsoft Visio.

Microsoft SQL Server has also a built-in tool for creating Database Diagrams.

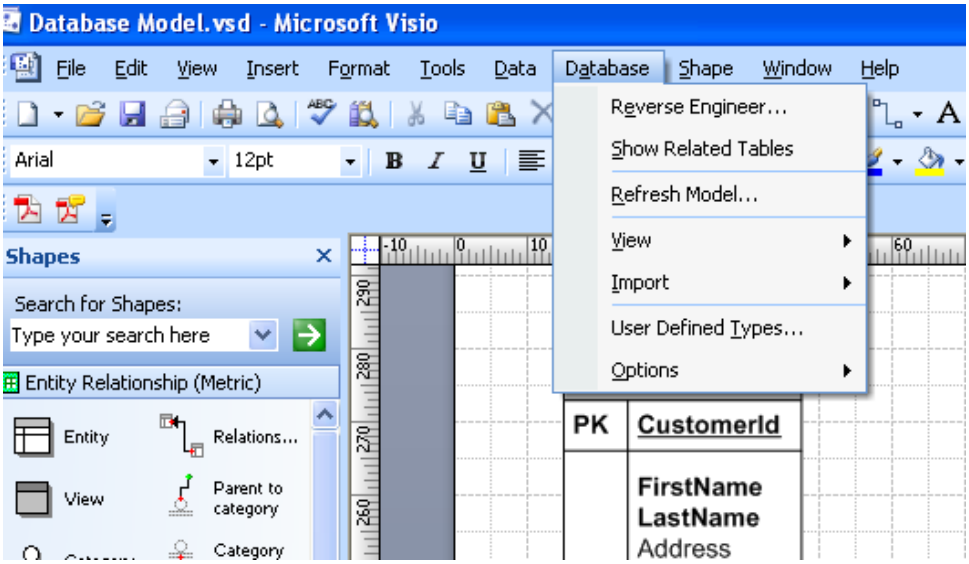


5.2 Microsoft Visio

Microsoft Visio is a diagramming program for creating different kinds of diagrams. Visio have a template for creating Database Model Diagrams.



In the Database menu Visio offers lots of functionality regarding your database model.



"Reverse Engineering" is the opposite procedure, i.e., extraction of a database schema from an existing database into a database model in Microsoft Visio.

5.3 EXERCISES

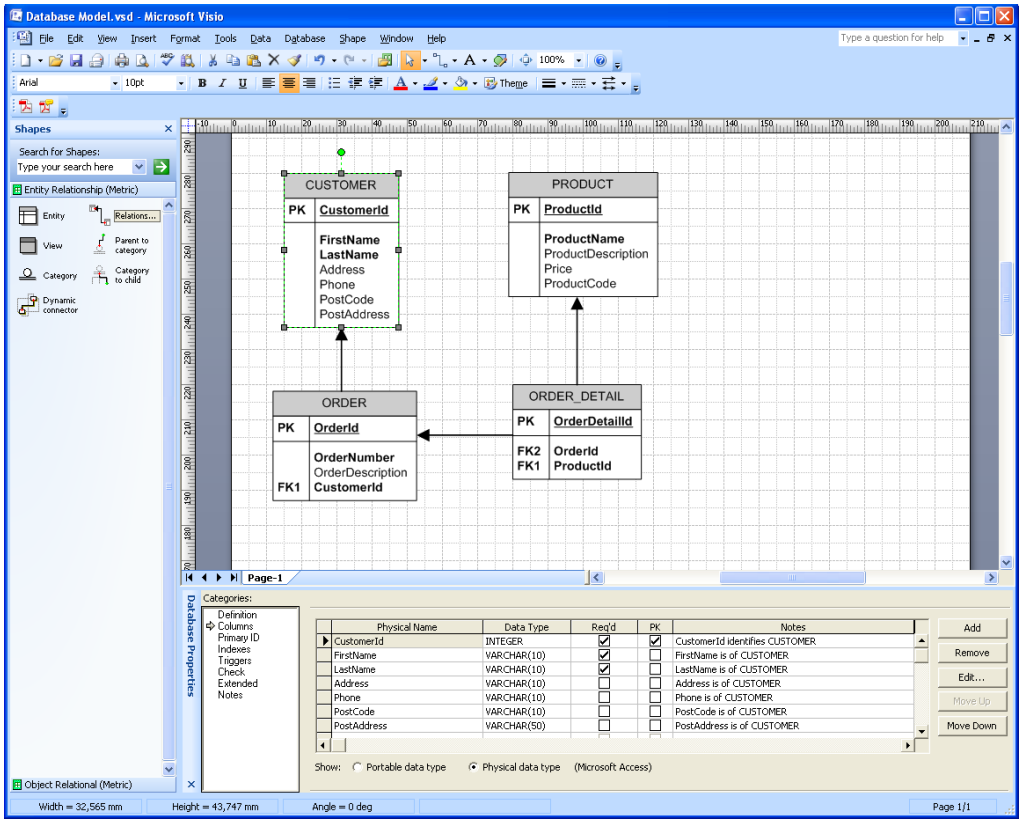
Exercise: Database Diagram

Create the following tables in an ER Diagram using MS Visio.

- CUSTOMER
  - **CustomerId (PK)**
  - FirstName
  - LastName
  - Address
  - Phone
  - PostCode
  - PostAddress
- PRODUCT
  - **ProductId (PK)**
  - ProductName
  - ProductDescription
  - Price
  - ProductCode

- ORDER
  - **OrderId (PK)**
  - OrderNumber
  - OrderDescription
  - **CustomerId (FK)**
- ORDER_DETAIL
  - OrderDetailId (PK)
  - **OrderId (FK)**
  - **ProductId (FK)**

Database Diagram:



6Microsoft SQL Server

6.1 Introduction

Microsoft SQL Server is a relational model database server produced by Microsoft. Its primary query languages are T-SQL and ANSI SQL.

The latest version is Microsoft SQL Server 2008.

Microsoft SQL Server homepage: www.microsoft.com/sqlserver

The Microsoft SQL Server comes in different versions, such as:

- SQL Server Developer Edition
- SQL Server Enterprise Edition
- SQL Server Web Edition
- SQL Server Express Edition
- Etc.

The SQL Server Express Edition is a freely-downloadable and -distributable version.

6.2 Requirements

In order to install SQL Server 2008, you need:

- Microsoft .NET Framework 3.5 SP1
- Windows Installer 4.5
- Windows PowerShell 1.0

Note: You must have administrative rights on the computer to install Microsoft SQL Server 2008.

6.3 SQL Server Express

The SQL Server Express Edition is a freely-downloadable and -distributable version.

However, the Express edition has a number of technical restrictions which make it undesirable for large-scale deployments, including:

- Maximum database size of 4 GB per. The 4 GB limit applies per database (log files excluded); but in some scenarios users can access more data through the use of multiple interconnected databases.
- Single physical CPU, multiple cores
- 1 GB of RAM (runs on any size RAM system, but uses only 1 GB)

SQL Server Express offers a GUI tools for database management in a separate download and installation package, called **SQL Server Management Studio Express**.

6.4 AdventureWorks

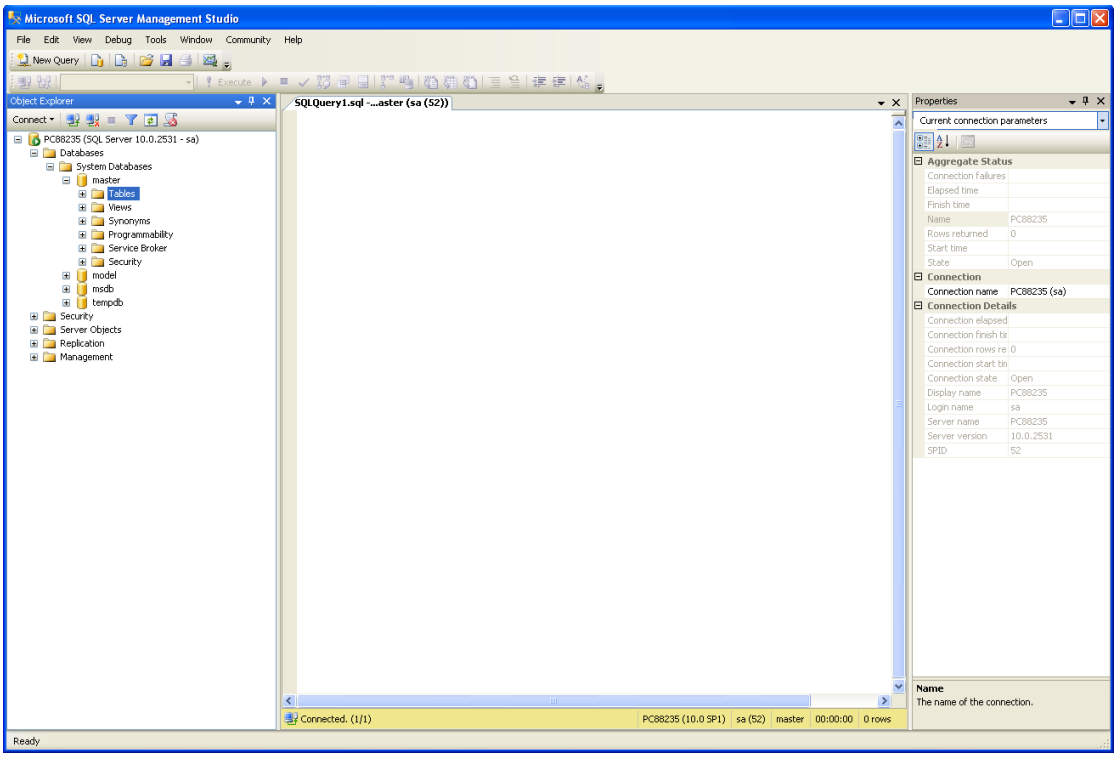
The **AdventureWorks** is a sample Database with lots of examples, etc.

You should install this sample Database because some of the examples in this document will use the AdventureWorks database.

6.5 SQL Server Management Studio

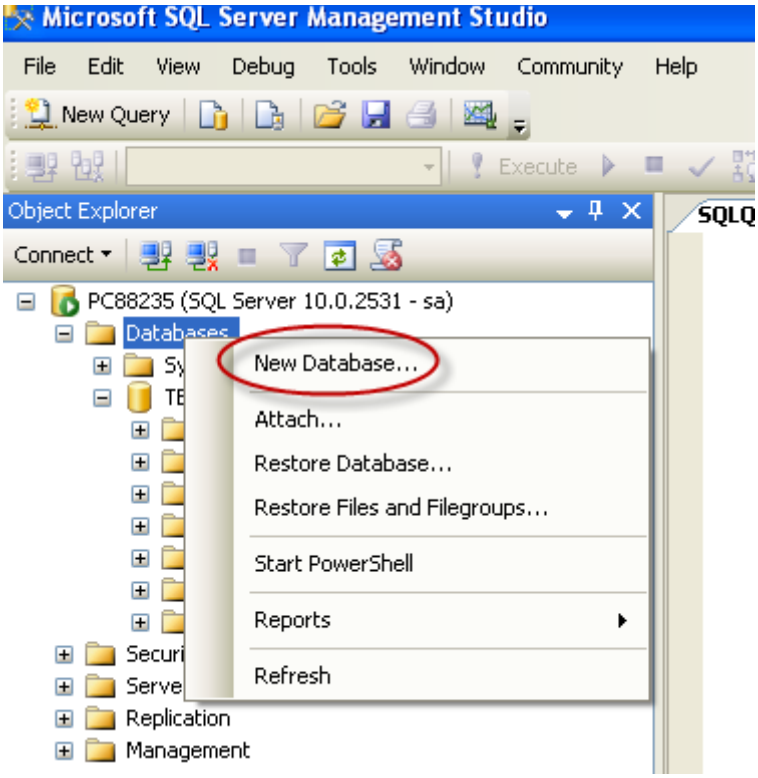
SQL Server Management Studio is a GUI tool included with SQL Server for configuring, managing, and administering all components within Microsoft SQL Server. The tool includes both script editors and graphical tools that work with objects and features of the server. As mentioned earlier, version of SQL Server Management Studio is also available for SQL Server Express Edition, for which it is known as SQL Server Management Studio Express.

A central feature of SQL Server Management Studio is the Object Explorer, which allows the user to browse, select, and act upon any of the objects within the server. It can be used to visually observe and analyze query plans and optimize the database performance, among others. SQL Server Management Studio can also be used to create a new database, alter any existing database schema by adding or modifying tables and indexes, or analyze performance. It includes the query windows which provide a GUI based interface to write and execute queries.

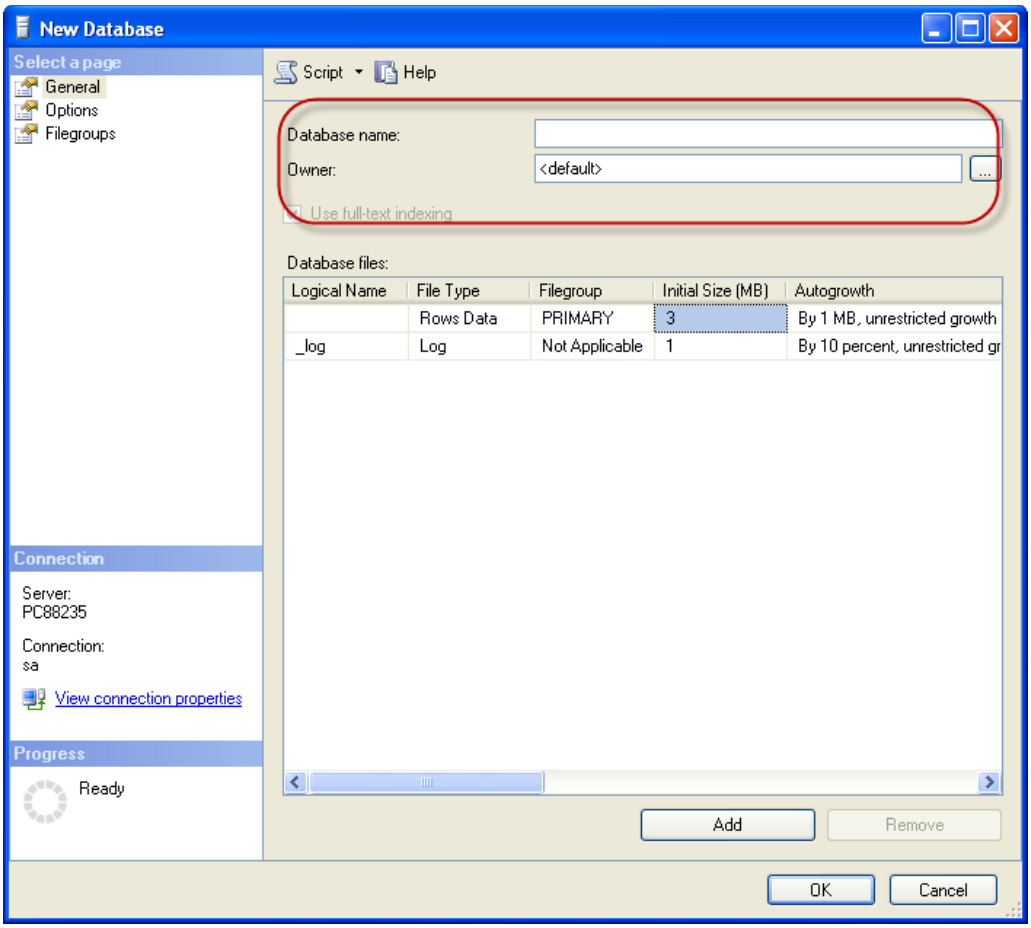


6.6 Create a new Database

It is quite simple to create a new database in Microsoft SQL Server. Just right-click on the “Databases” node and select “New Database…”



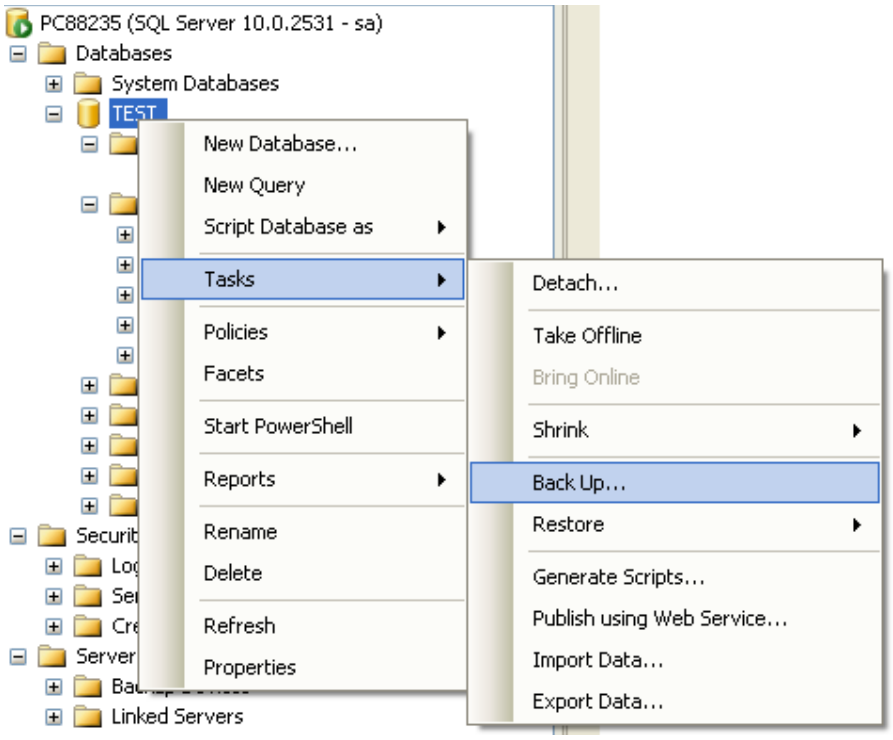
There are lots of settings you may set regarding your database, but the only information you must fill in is the name of your database:

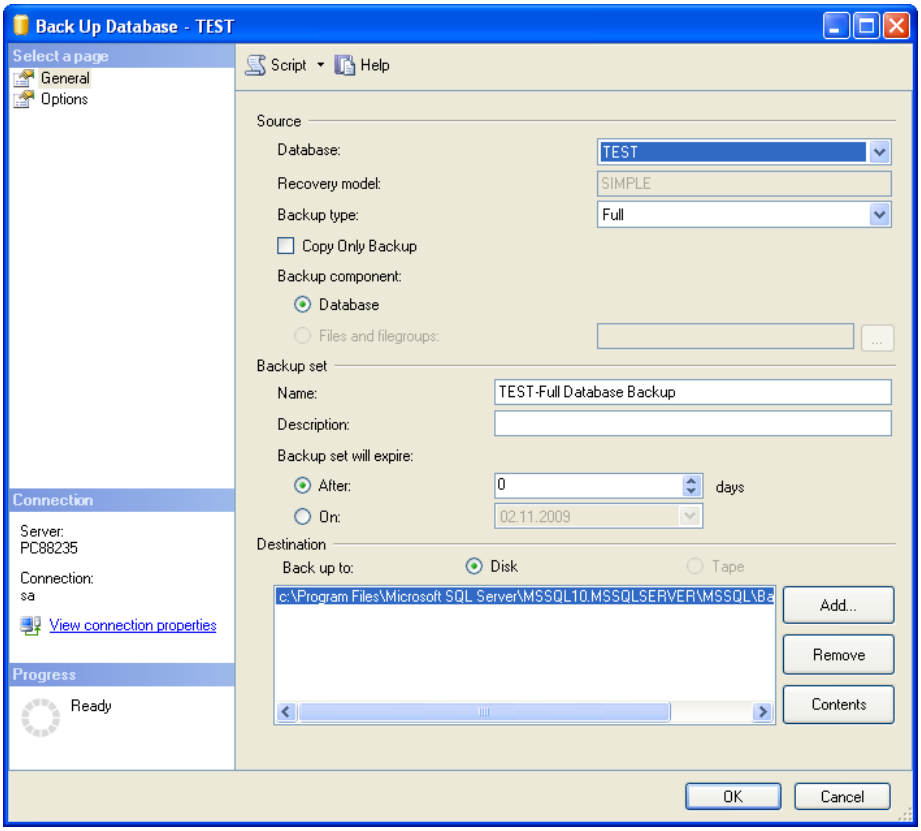


6.7 Backup/Restore

An important task in database systems is to take backup of the database with regular intervals, e.g., during the night when the system is not in use.

Database backup and Restore:

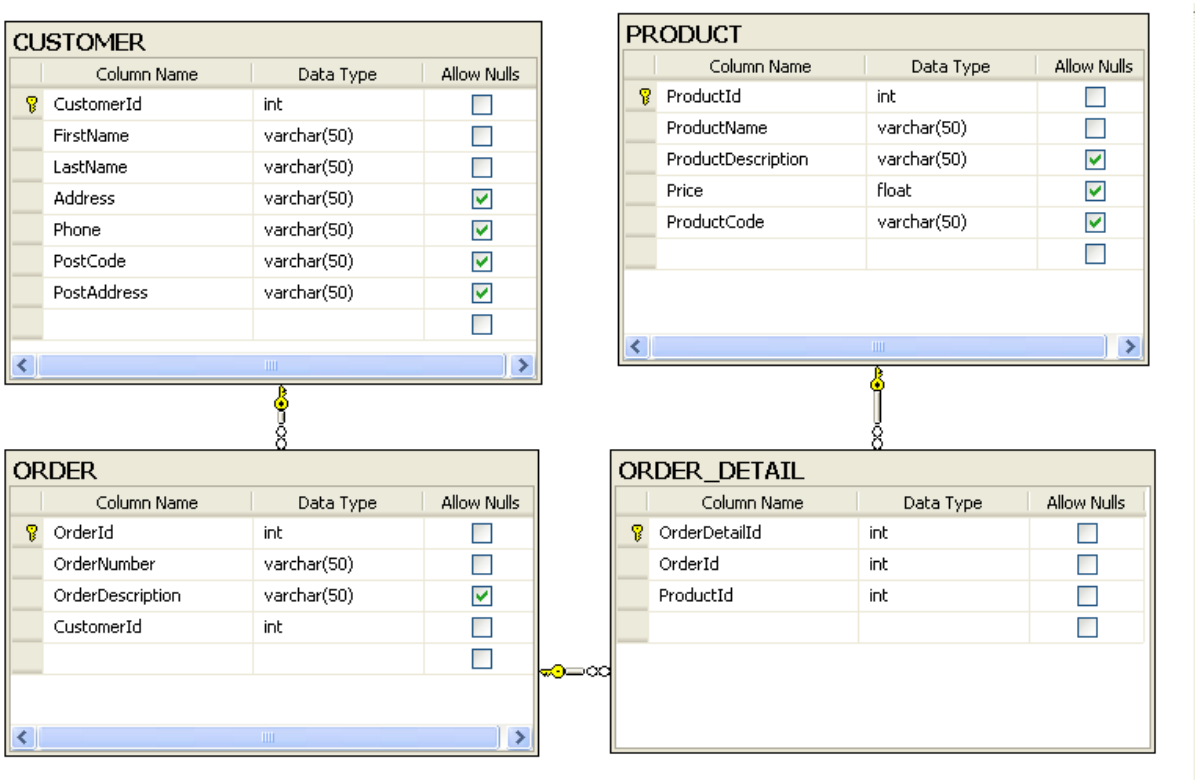




6.8 Example Database

Examples and exercises in this training are based on some basic tables. The Example Database consists of the following Tables:

- CUSTOMER
  - **CustomerId (PK)**
  - FirstName
  - LastName
  - Address
  - Phone
  - PostCode
  - PostAddress
- PRODUCT
  - **ProductId (PK)**
  - ProductName
  - ProductDescription
  - Price
  - ProductCode
- ORDER
  - **OrderId (PK)**
  - OrderNumber
  - OrderDescription
  - **CustomerId (FK)**
- ORDER_DETAIL
  - OrderDetailId (PK)
  - **OrderId (FK)**
  - **ProductId (FK)**



6.9 Exercises

Exercise: New Database

Create a new Database in MS SQL Server called TEST_SQLSERVER.

Exercise: Database Diagram

Create the tables in the Example Database using the Diagram Designer Tool in Microsoft SQL Server.

Exercise: Database Script

Create the tables in the Example Database Tables using SQL Code. Save the Tables as a SQL Script file (.sql). Use The Query Tool in Microsoft SQL Server.

Exercise: ODBC

Create an ODBC connection for the Database.

7Microsoft Office Access

7.1 Introduction

Microsoft Office Access, previously known as Microsoft Access, is a relational database management system from Microsoft that combines the relational Microsoft Jet Database Engine with a graphical user interface and software development tools. It is a member of the Microsoft Office suite of applications and is included in the Professional and higher versions for Windows. Access stores data in its own format based on the Access Jet Database Engine.

Microsoft Access is used by programmers and non-programmers to create their own simple database solutions.

Microsoft Access is a file server-based database. Unlike client-server relational database management systems (RDBMS), e.g., Microsoft SQL Server, Microsoft Access does not implement database triggers, stored procedures, or transaction logging. All database tables, queries, forms, reports, macros, and modules are stored in the Access Jet database as a single file. This makes Microsoft Access useful in small applications, teaching, etc. because it is easy to move from one computer to another.

7.2 Example Database

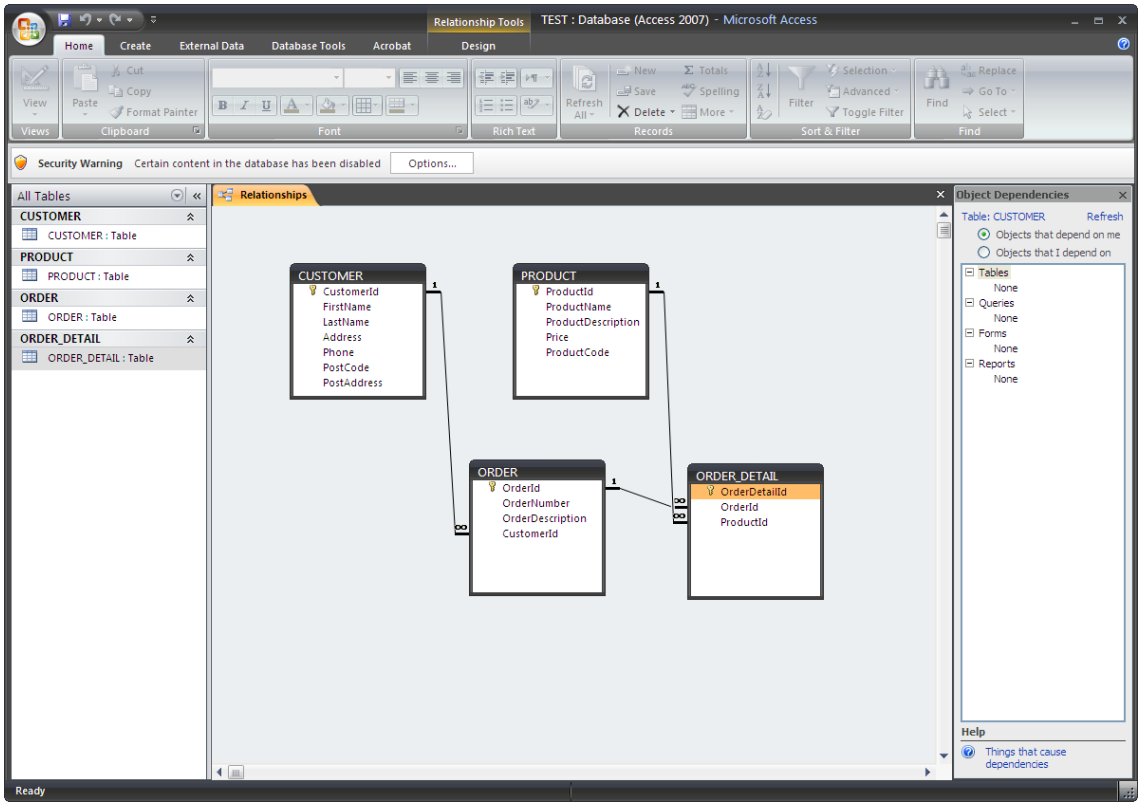
I will present an example database in Microsoft Access 2007 which will be used in some of the examples and exercises in this document.

The database consists of the following tables:

- CUSTOMER
  - **CustomerId (PK)**
  - FirstName
  - LastName
  - Address
  - Phone
  - PostCode
  - PostAddress
- PRODUCT
  - **ProductId (PK)**
  - ProductName

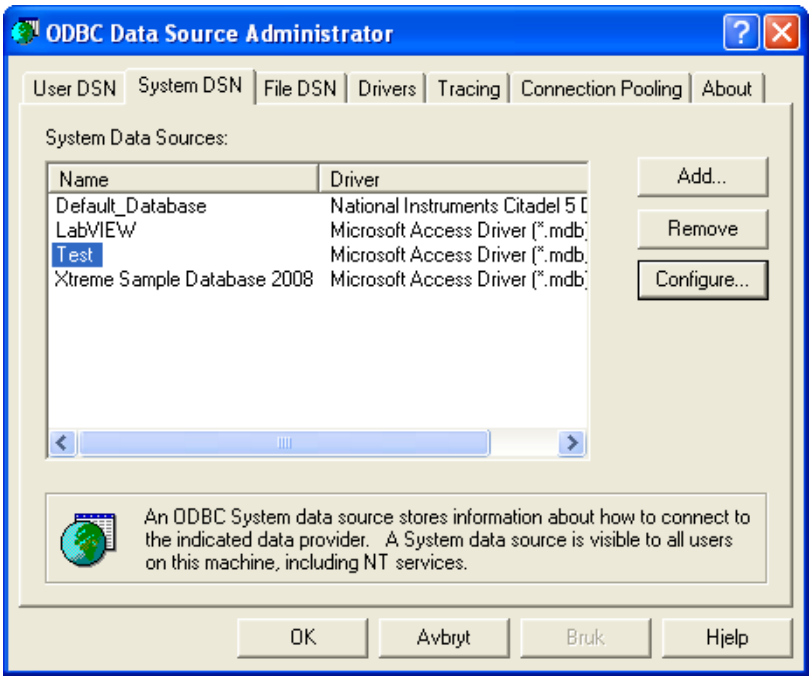
- ProductDescription
- Price
- ProductCode

- ORDER
  - **OrderId (PK)**
  - OrderNumber
  - OrderDescription
  - **CustomerId (FK)**
- ORDER_DETAIL
  - OrderDetailId (PK)
  - **OrderId (FK)**
  - **ProductId (FK)**



ODBC Connection:

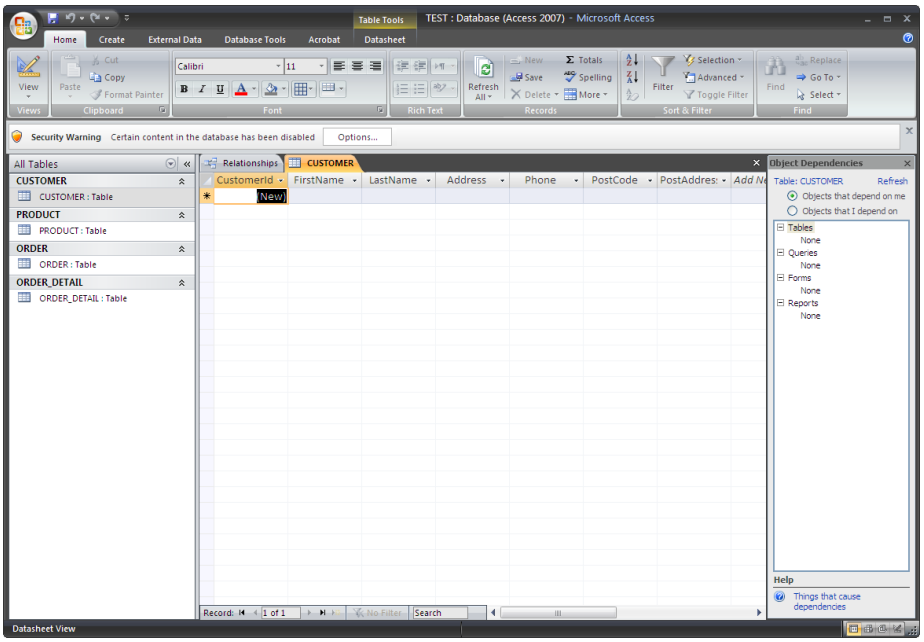
Administrative Tools → Data Sources (ODBC)



7.3 Exercises

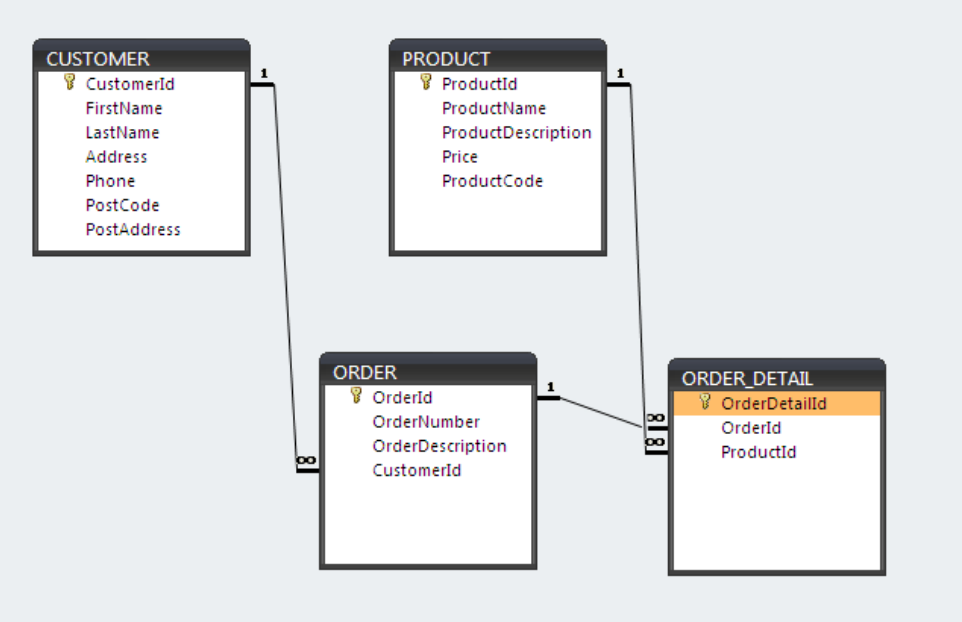
Exercise: Database

Create a new Database in MS Access called TEST.



Exercise: Database Tables

Create the tables in the Example Database Tables using the Diagram Designer Tool in Microsoft SQL Server.



Exercise: ODBC

Create an ODBC connection for the Database.

8ODBC

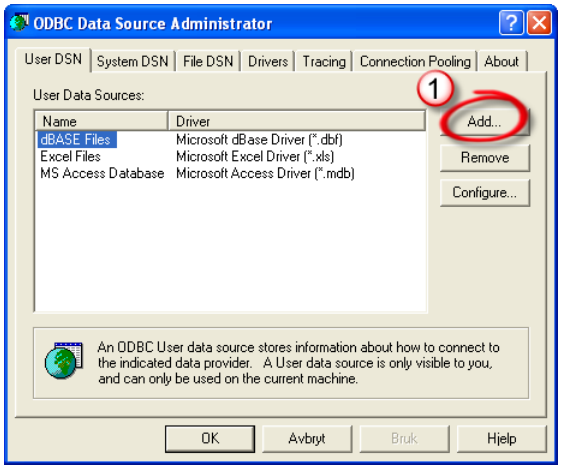
8.1 What is ODBC?

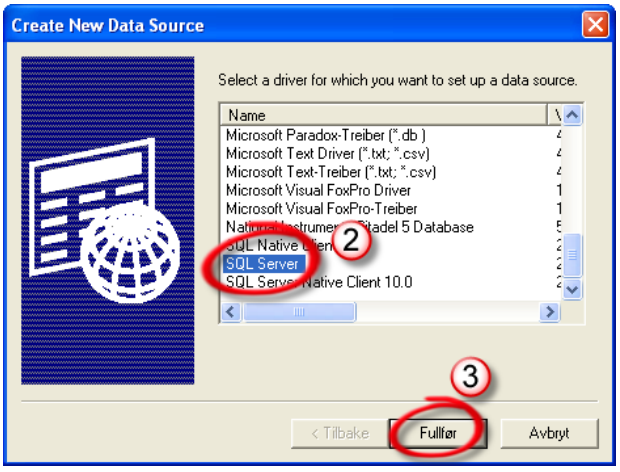
In computing, Open Database Connectivity (ODBC) provides a standard software API method for using database management systems (DBMS). The designers of ODBC aimed to make it independent of programming languages, database systems, and operating systems.

8.2 Create an ODBC Connection in "ODBC Data Source Administrator"

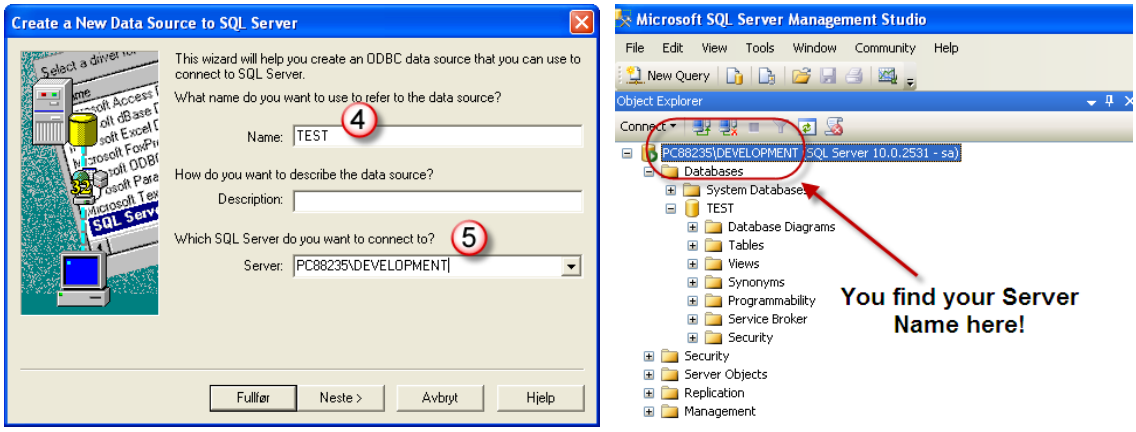
Follow these steps:

Add a new Data Source and select the SQL Server driver:

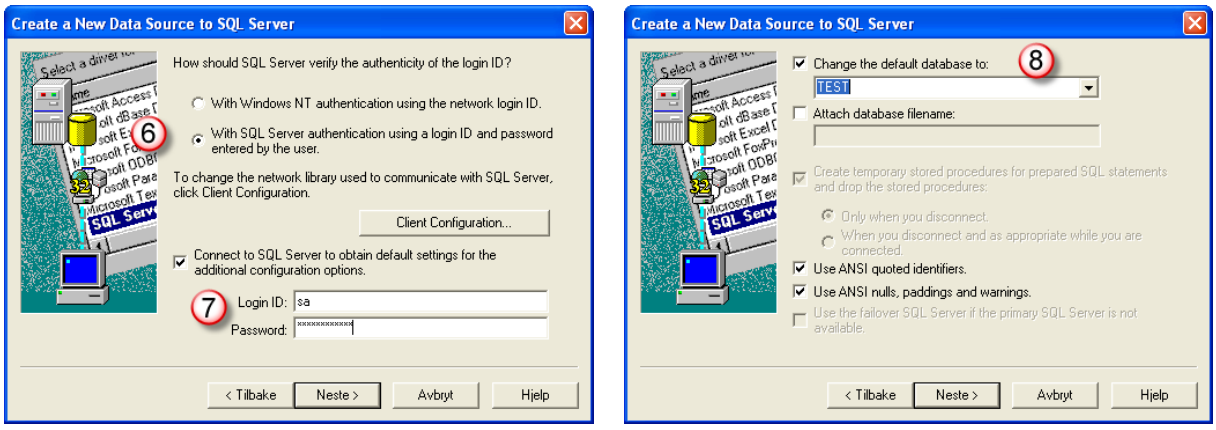




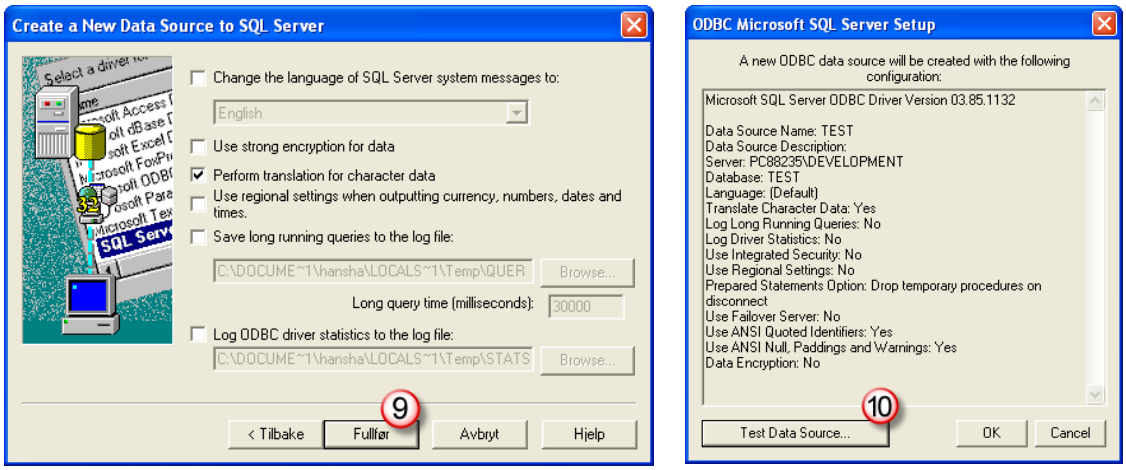
Type a Name for your Connection and your SQL Server Name. You find your Server name as shown below:



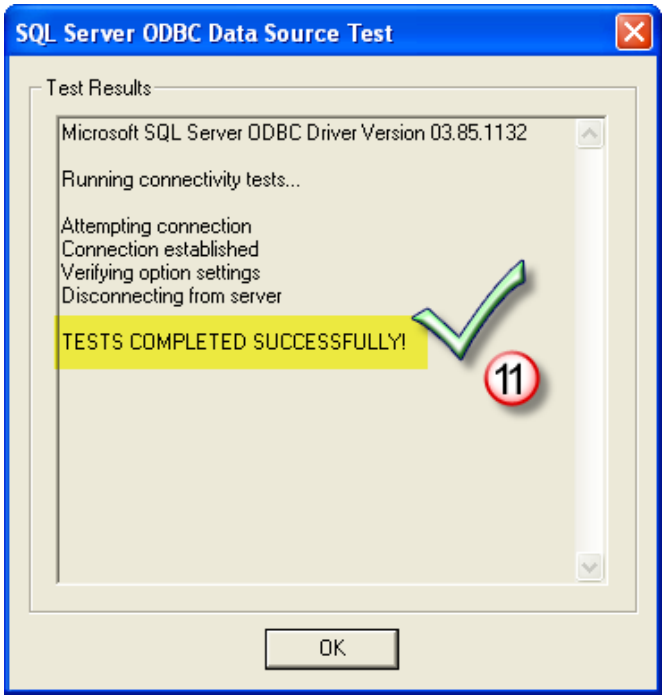
Select SQL Server authentication and type your sa password (System Administrator). You defined the password for the sa user during the setup procedure of SQL Server:



Complete your configuration and Test your data source to see if its OK:



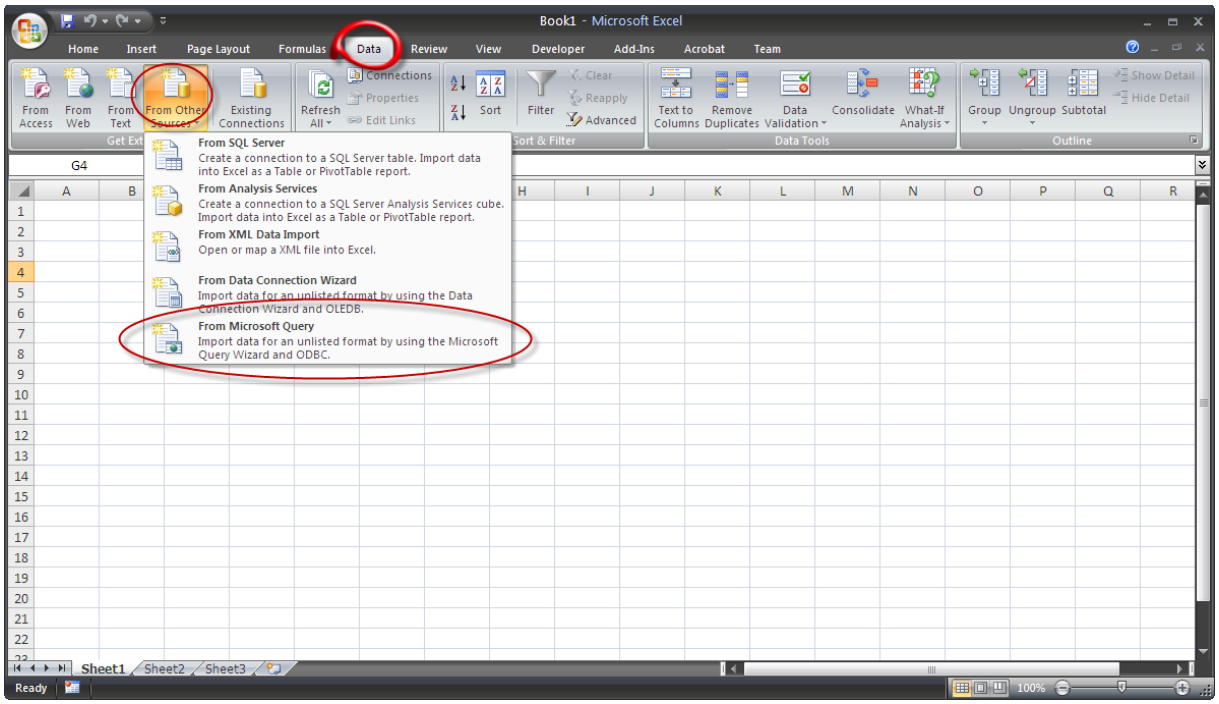
If you get this message you have succeeded:



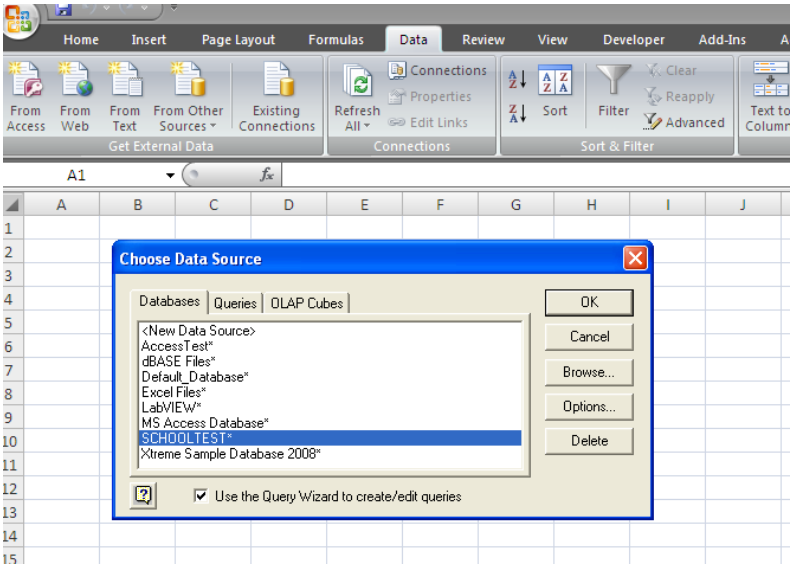
8.3 Get data into Excel using your ODBC Connection

The purpose is to use Excel as a client and get data into Excel from your SQL Server.

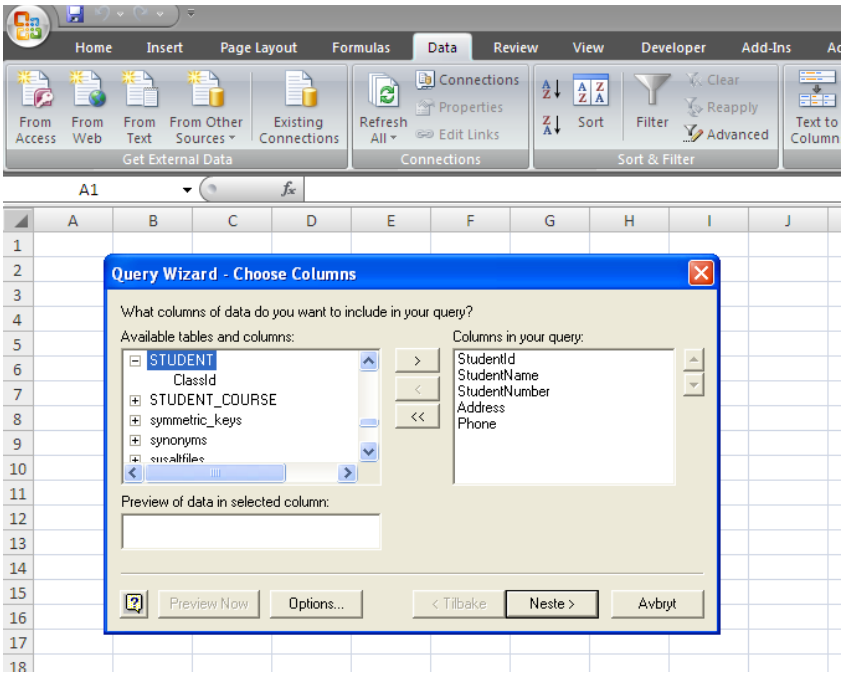
Step 1: Open Excel and go to the Data section:



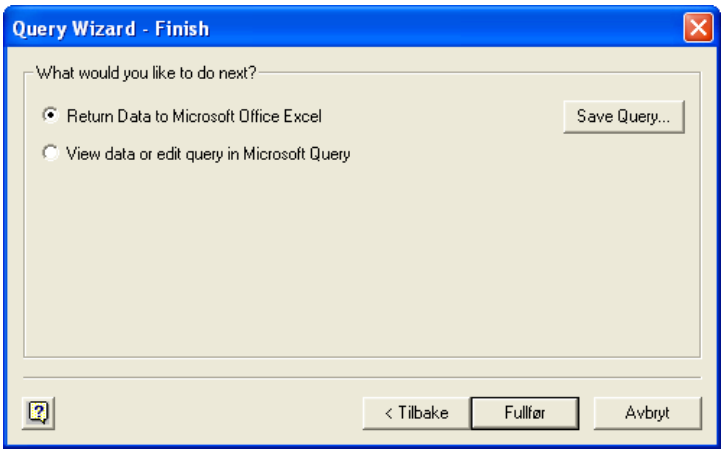
Step 2: Select your ODBC connection



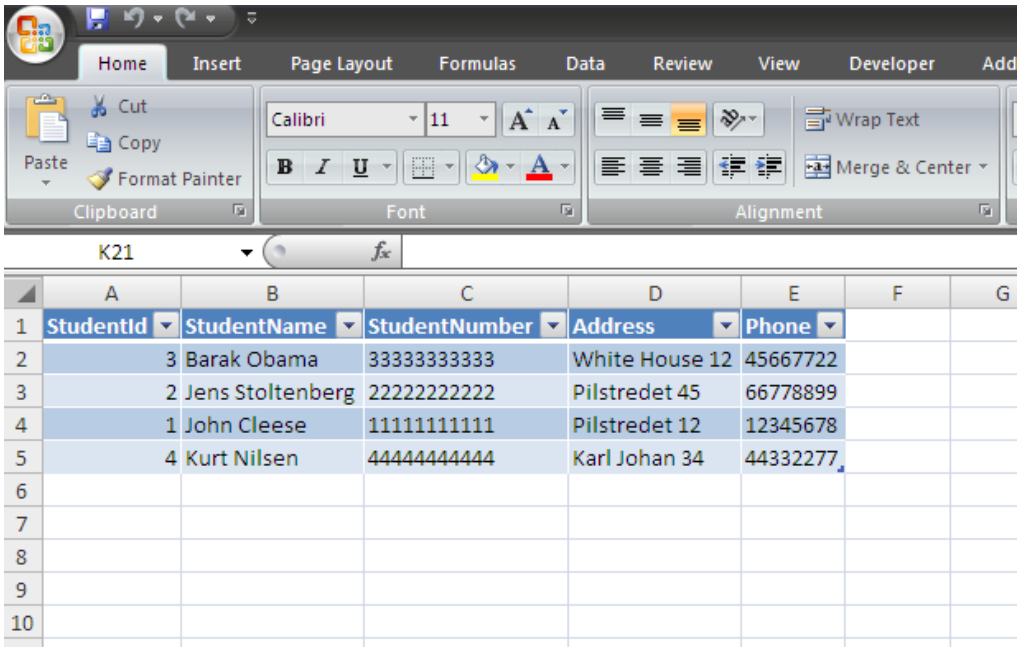
Step 3: Select your Table(s)



Step 4: Insert Data into Excel



The results should look something like this:

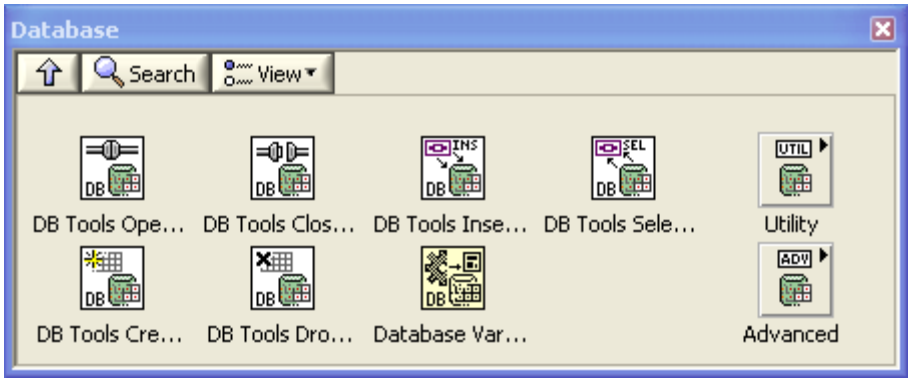


	A	B	C	D	E	F	G
1	StudentId	StudentName	StudentNumber	Address	Phone		
2	3	Barak Obama	33333333333	White House 12	45667722		
3	2	Jens Stoltenberg	22222222222	Pilstredet 45	66778899		
4	1	John Cleese	11111111111	Pilstredet 12	12345678		
5	4	Kurt Nilsen	44444444444	Karl Johan 34	44332277		
6							
7							
8							
9							
10							

9LabVIEW Database Connectivity Toolkit

LabVIEW offers an additional Toolkit called “LabVIEW Database Connectivity Toolkit”. With this toolkit you can communicate with different databases, such as SQL Server, Oracle, etc.

Functions Palette: Connectivity → Database



The following list describes the main features of the Database Connectivity Toolkit:

- Works with any provider that adheres to the Microsoft ActiveX Data Object (ADO) standard.
- Works with any database driver that complies with ODBC or OLE DB.
- Maintains a high level of portability. In many cases, you can port an application to another database by changing the connection information you pass to the DB Tools Open Connection VI.
- Converts database column values from native data types to standard Database Connectivity Toolkit data types, further enhancing portability.
- Permits the use of SQL statements with all supported database systems, even non-SQL systems.
- Includes VIs to retrieve the name and data type of a column returned by a SELECT statement.
- Creates tables and selects, inserts, updates, and deletes records without using SQL statements.

Some of the text in this chapter is based on the “LabVIEW Database Connectivity Toolkit User Manual”.

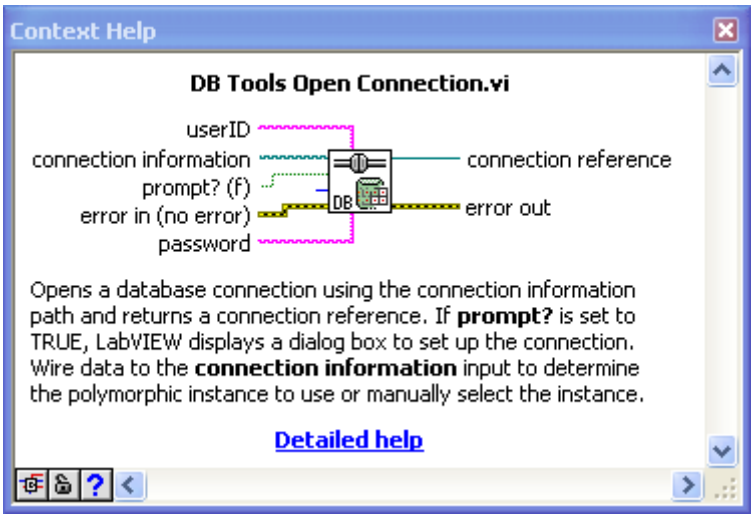
9.1 Connect to the Database

Before you can access data in a table or execute SQL statements, you must establish a connection to a database. You may use different methods in order to connect to the database:

- ODBC Data Source Name (DSN)
- Universal Data Link (UDL)
- Connection String

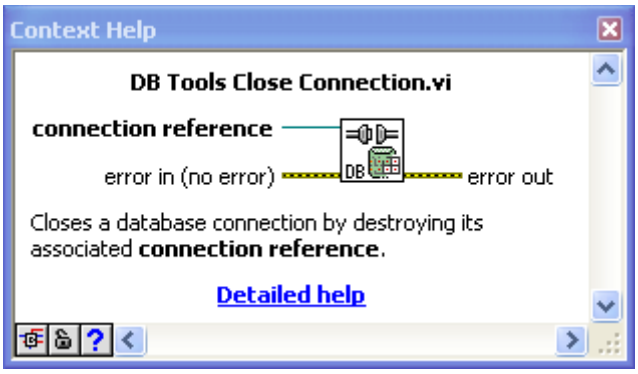
These different methods are explained below.

For all of these methods, you will use the same VI:



Connecting to a database is where most errors occur because each database management system (DBMS) uses different parameters for the connection and different levels of security. The different standards also use different methods of connecting to databases. For example, ODBC uses Data Source Names (DSN) for the connection, whereas the Microsoft ActiveX Data Object (ADO) standard uses Universal Data Links (UDL) for the connection. The “DB Tools Open Connection.vi” VI supports all these methods for connecting to a database.

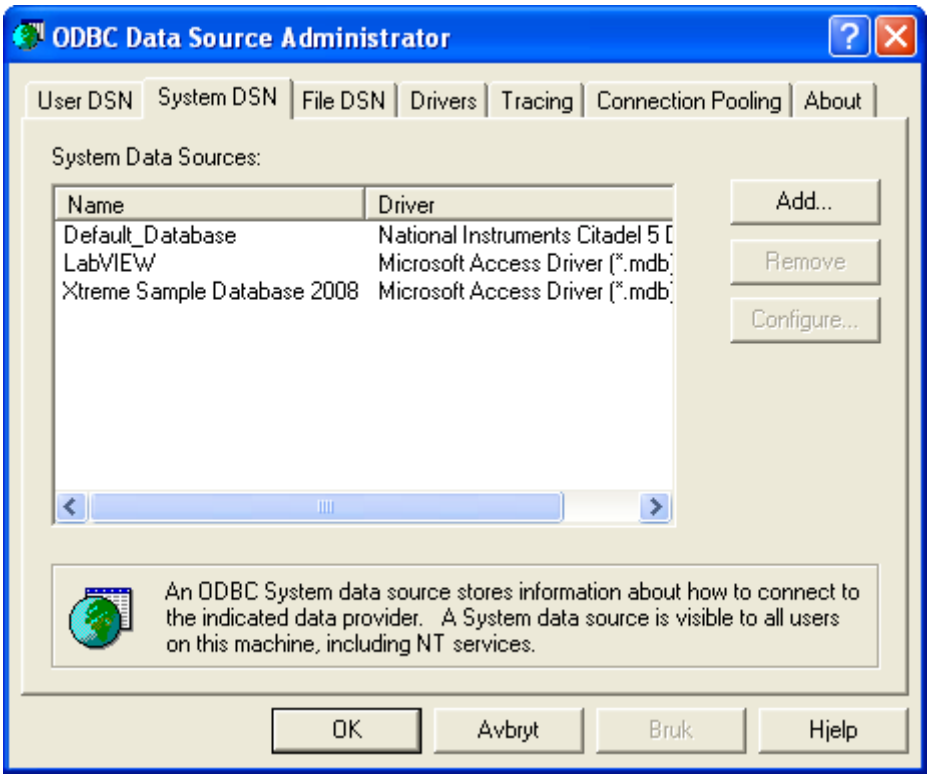
When you are finished with reading from the database and writing to the database, you should always close the Connection. Use the “DB Tools Close Connection.vi”.



9.1.1 DSN

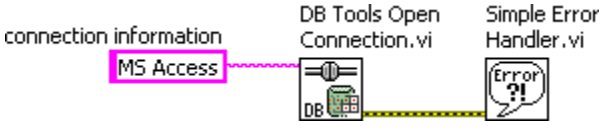
A **DSN (ODBC Data Source Name (DSN))** is the name of the data source, or database, to which you are connecting. The DSN also contains information about the ODBC driver and other connection attributes including paths, security information, and read-only status of the database. Two main types of DSNs exist: machine DSNs and file DSNs. Machine DSNs are in the system registry and apply to all users of the computer system or to a single user. DSNs that apply to all users of a computer system are system DSNs. DSNs that apply to single users are user DSNs. A file DSN is a text file with a .dsn extension and is accessible to anyone with proper permissions. File DSNs are not restricted to a single user or computer system. Use the ODBC Data Source Administrator to create and configure DSNs.

In the Control Panel, Administrative Tools, you find the ODBC Data Source Administrator tool.



Example: DSN

This Example specifies a DSN called MS Access to open a connection to that specific database.

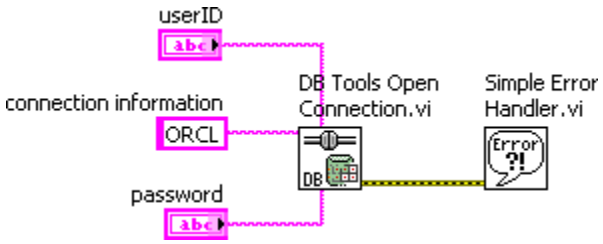


Example: DSN from File

You can use a path to specify a file DSN. This example specifies a path to a file DSN called "access.dsn" to open a connection to the database.

Example: DSN with UserId and Password

Most Database systems (DBMS – Database Management Systems) also require a UserId and a Password.

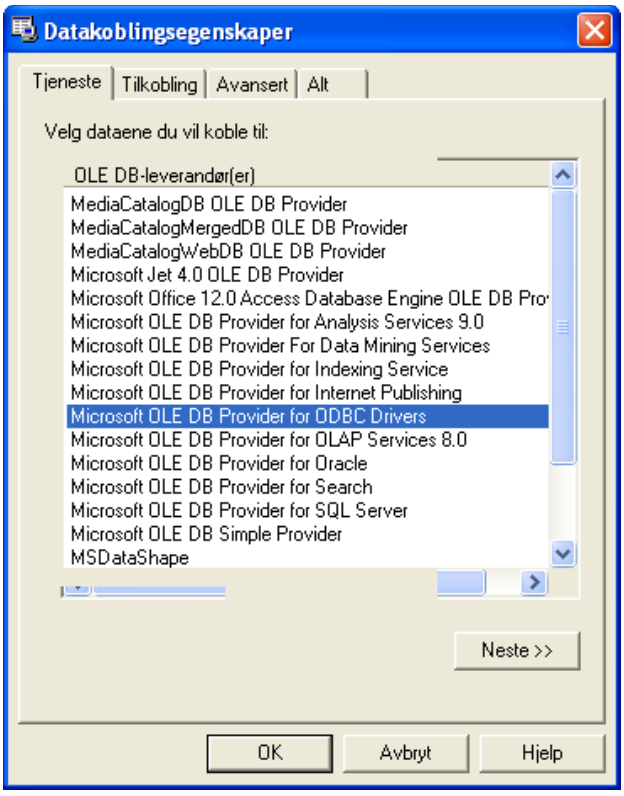


9.1.2 UDL

Whereas you must create a DSN to connect to a database using ODBC, you use **UDL (Universal Data Link)** to connect to databases that use ADO and OLE DB.

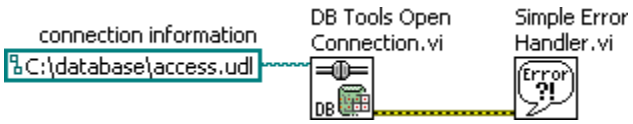
A UDL is similar to a DSN in that it describes more than just the data source. A UDL specifies what OLE DB provider is used, server information, the user ID and password, the default database, and other related information.

In order to create a new UDL file, create an empty text file and change the file extension of this document from .txt to .udl. You then can double-click the UDL file to display the Data Link Properties dialog box.



Example: UDL

Connect to a Database using UDL:



9.1.3 Connection String

Rather than including an existing UDL in an application, you also can use an ODBC connection string with the Microsoft ActiveX Data Object (ADO) standard.

A connection string is written like this:

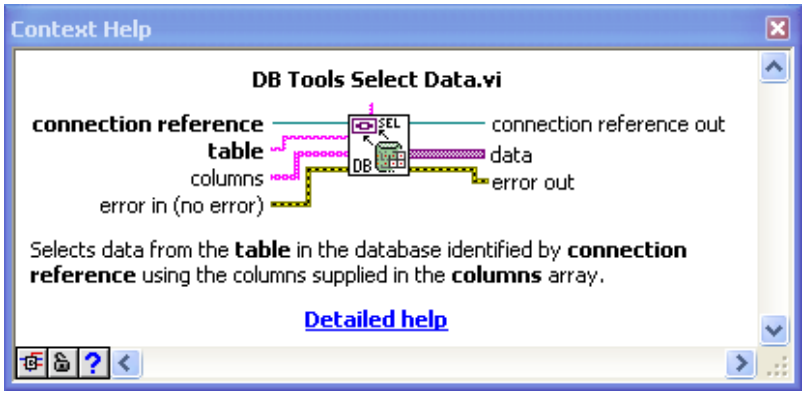
```
PROVIDER=SQLOLEDB;DATA
SOURCE=server_name;UID=user_name;PWD=password;DATABASE=database_name;
```

You could use more parameters, but the parameters used above are the most common ones.

9.2 Reading Data from the Database

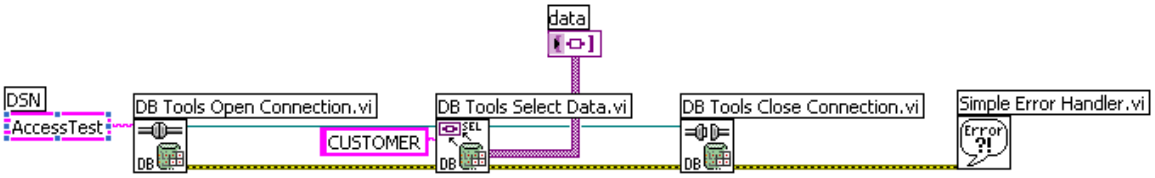
Reading data from a database table is similar to writing data to the database. You open a connection to the database, select the data from a table, and then close the connection.

The “DB Tools Select Data.vi" is used to read data from the Database:



Example: Select Data from MS Access

The following example gets data from the CUSTOMER table in MS Access.



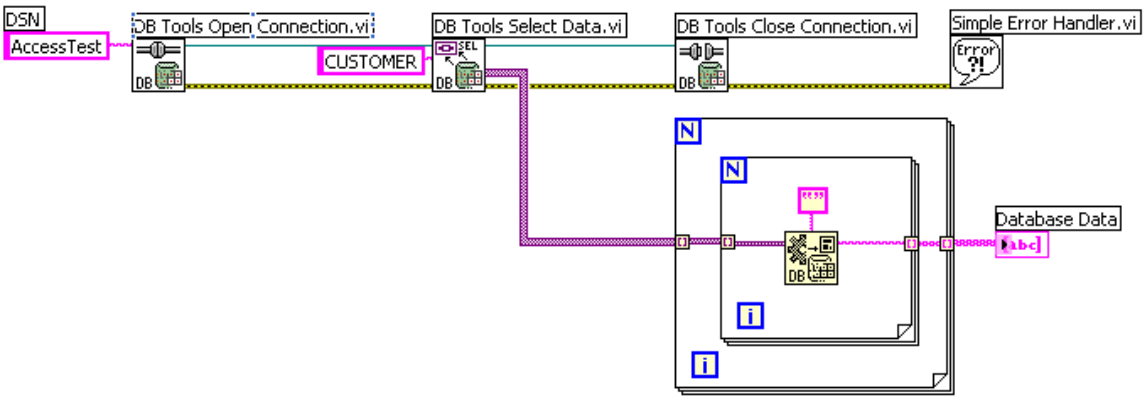
The Front Panel looks like this:

Notice in Figures 5-4 and 5-5 that the database data is returned as a two-dimensional array of variants. As the name implies, the Microsoft ActiveX Data Object (ADO) standard is based on ActiveX, which defines variants as its data types. Variants work well in languages such as Visual Basic that are not strongly typed. Because LabVIEW is strongly typed, you must use the Database Variant To Data

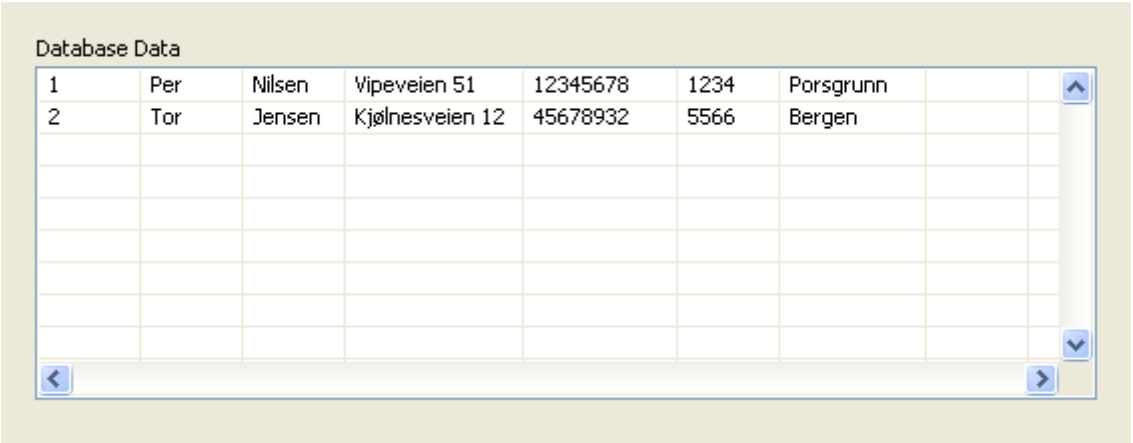
function to convert the variant data to a LabVIEW data type before you can display the data in standard indicators such as graphs, charts, and LEDs.

Example: Select Data from MS Access

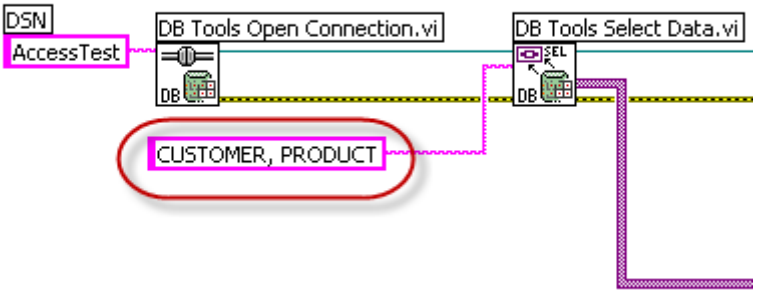
The following example gets data from the CUSTOMER table in MS Access and converts the data to text.



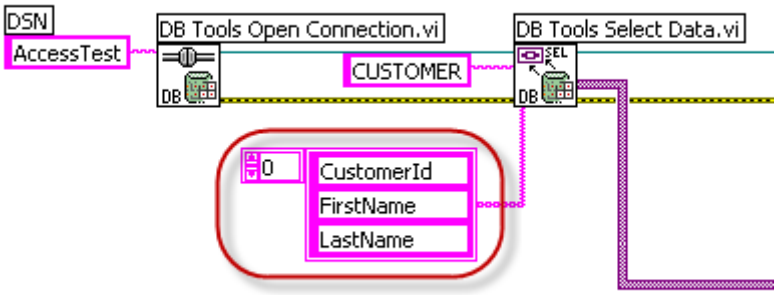
The Front Panel looks like this:



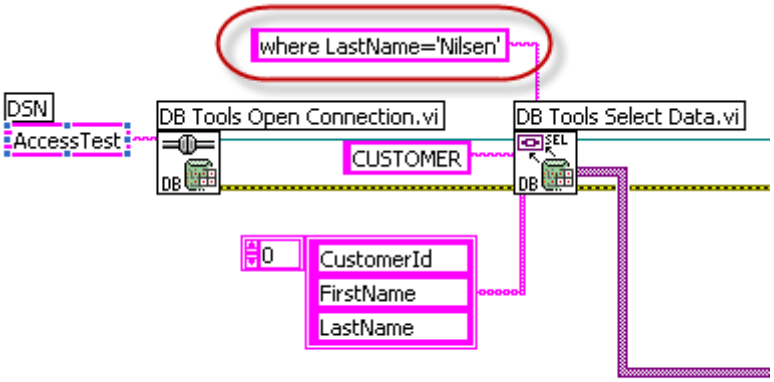
You may read from more than one table if you use a comma-delimited string to specify multiple table names:



You may select which columns you want to read by using the “Columns” input:

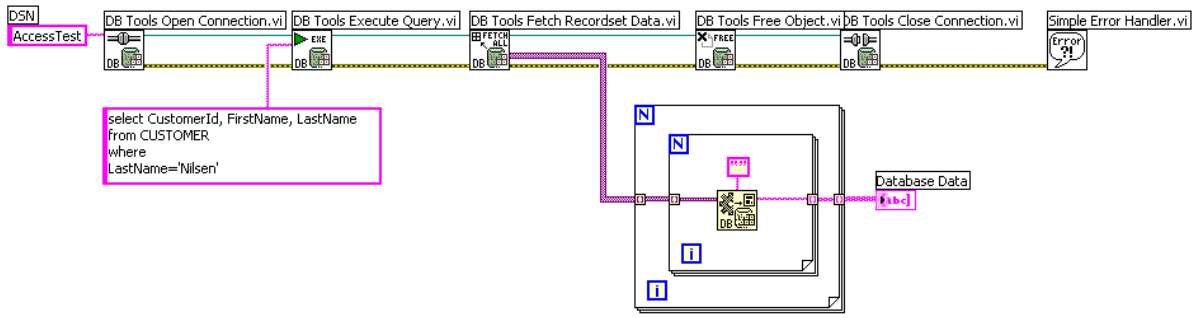


You may also restrict which data to receive using the “optional Clause” input:



Example: Read Data

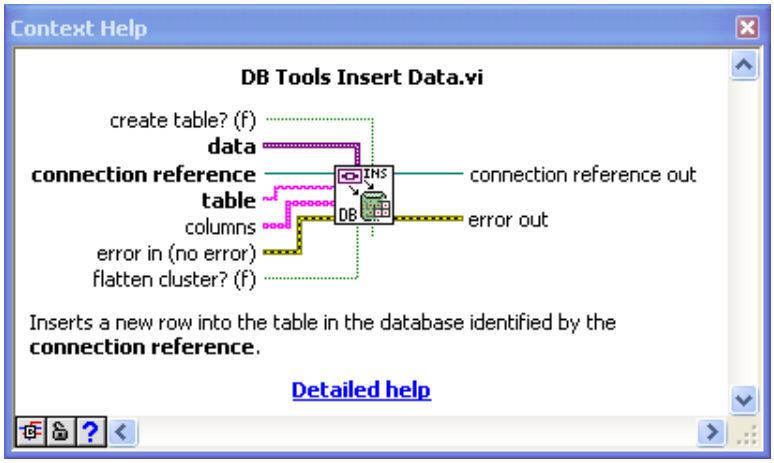
Using some VIs from the “Advanced” palette, create the following example:



9.3 Writing Data to the Database

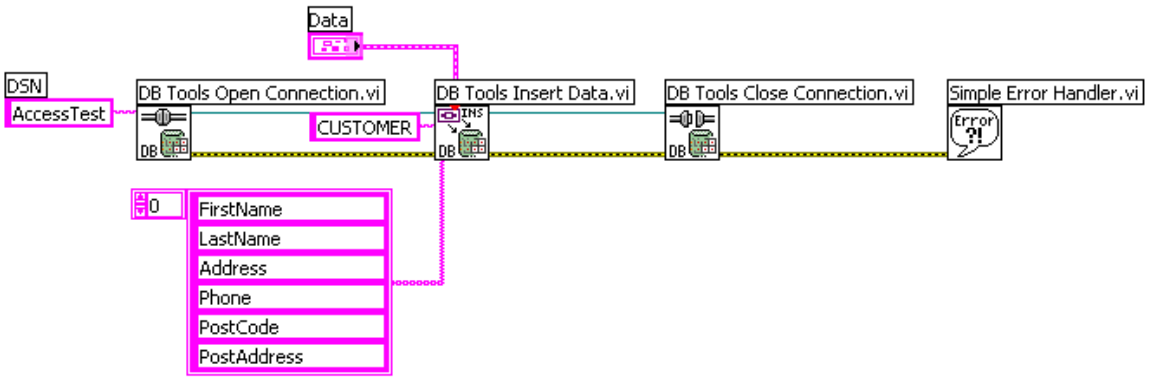
Writing data to a database with the LabVIEW Database Connectivity Toolkit is similar to reading data to a file. You open a connection, insert the data, and close the connection when you are finished.

The “DB Tools Insert Data.vi" is used to write data to the Database:



Example: Write Data

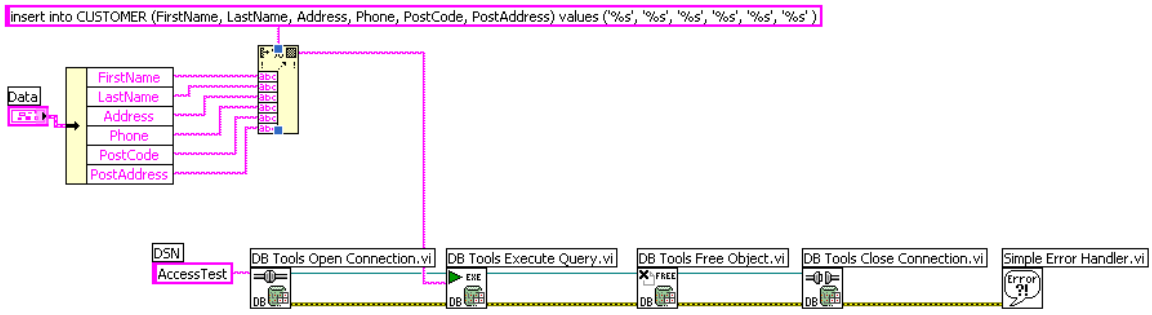
Create the following block diagram:



Front Panel:

Example: Write Data

Create the following block diagram using some VIs from the “Advanced” palette.

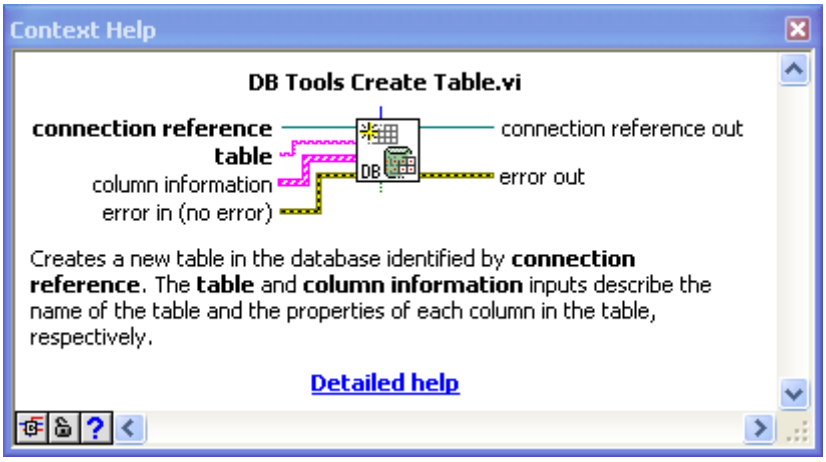


9.4 Creating and Dropping Tables

You may use standard SQL syntax in order to create:

```
CREATE TABLE <TableName> (…)
```

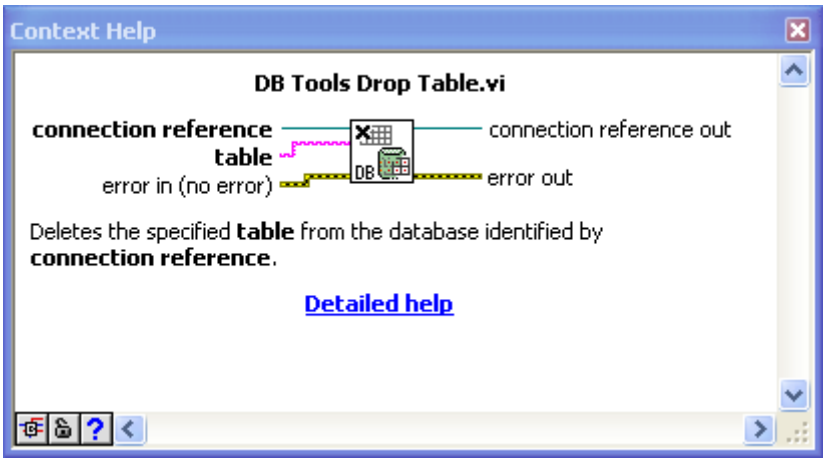
Or you may use the “DB Tools Create Table.vi” in order to create a table.



You may use standard SQL syntax in order to drop tables (delete tables):

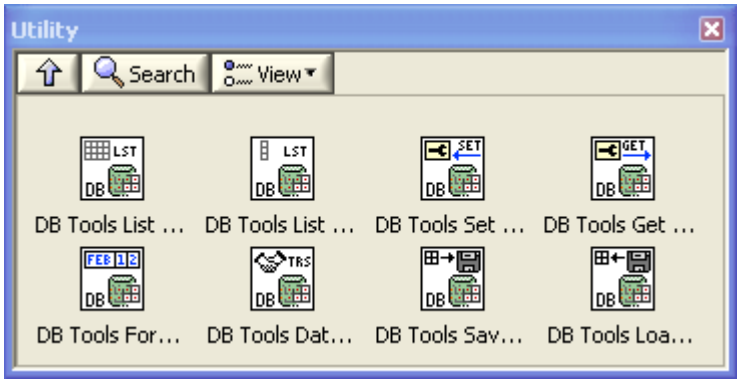
```
DROP TABLE <TableName>
```

Or you may use the “DB Tools Drop Table.vi” in order to drop/delete a table.



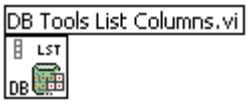
9.5 Using the Database Connectivity Toolkit Utility VIs

In the "**Utility**" palette there are several useful VIs for getting more information about tables, saving to text files, etc.

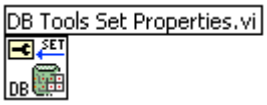


Here is a short description of the VIs located in the "Utility" palette:

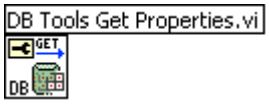
This VI lists the tables in the database identified by connection reference.



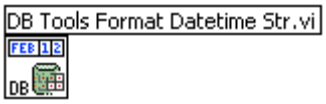
This VI lists the columns present in table. The column information includes the name, the data type, and the defined size of the column.



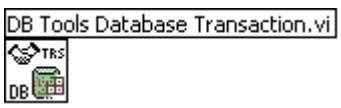
This VI sets properties on the object as determined by the inputs.



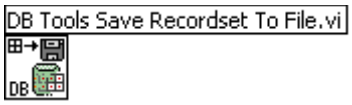
This VI gets properties of the object as determined by the inputs.



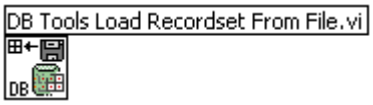
This VI Returns a string containing the formatted date and time, and identifies the string as a date/time string so other VIs can interpret it.



This VI begins, commits, or rolls back a transaction for any type of reference.



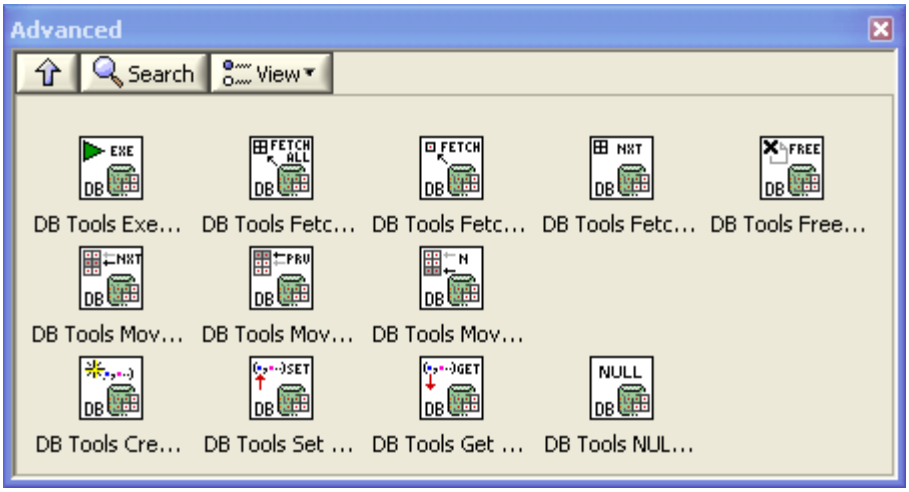
This VI saves the recordset identified by the recordset reference to either an XML or ADTG file. The ADTG file format is a proprietary format that only the LabVIEW Database Connectivity Toolkit can interpret. The ADTG format results in a smaller file than the XML format.



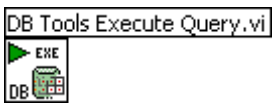
This VI loads a recordset from a file and returns a recordset reference that identifies this recordset. You can retrieve data from this recordset like any other recordset, but some properties might not be available on this recordset.

9.6 Performing Advanced Database Operations

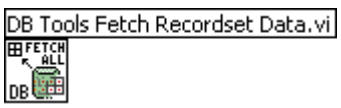
When creating real programs you will soon need some of the VIs in the "**Advanced**" palette.



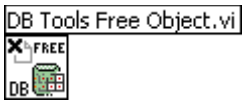
Here is a short description of some of the VIs located in the "Advanced" palette:



This VI Executes an SQL query and returns a recordset reference that you must eventually free with the DB Tools Free Object VI.



This VI retrieves the data in the recordset identified by the recordset reference input. You can convert each element in the array to its native LabVIEW data type using the "Database Variant To Data function".



This VI frees an object by destroying its associated reference and returns a different reference object.

10 Creating and Using Tables

The SQL syntax for creating a Table is as follows:

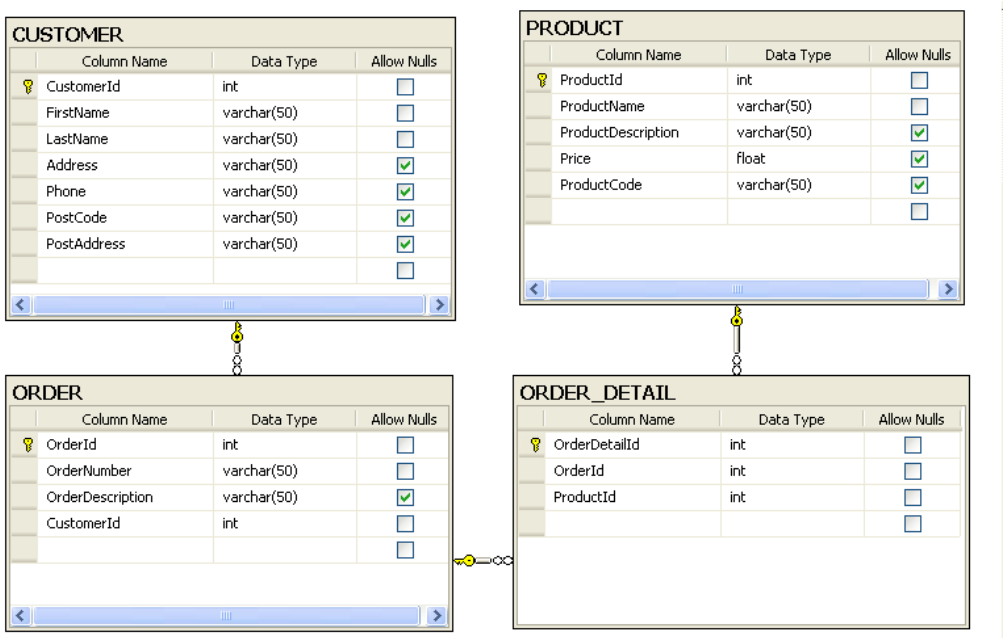
```
CREATE TABLE <TableName>
(
<ColumnName> <datatype>
…
)
```

The SQL syntax for inserting Data into a Table is as follows:

```
INSERT INTO <TableName> (<Column1>, <Column2>, …)
VALUES(<Data for Column1>, <Data for Column2>, …)
```

Example: Insert Data into Tables

We will insert some data into our tables:



The following SQL Query inserts some example data into these tables:

```
--CUSTOMER
INSERT INTO [CUSTOMER]
([FirstName],[LastName],[Address],[Phone],[PostCode],[PostAddress]) VALUES
('Per', 'Nilsen', 'Vipeveien 12', '12345678', '1234', 'Porsgrunn')
GO
INSERT INTO [CUSTOMER]
([FirstName],[LastName],[Address],[Phone],[PostCode],[PostAddress]) VALUES
('Tor', 'Hansen', 'Vipeveien 15', '77775678', '4455', 'Bergen')
GO
INSERT INTO [CUSTOMER]
([FirstName],[LastName],[Address],[Phone],[PostCode],[PostAddress]) VALUES
('Arne', 'Nilsen', 'Vipeveien 17', '12345778', '4434', 'Porsgrunn')
GO

--PRODUCT
INSERT INTO [PRODUCT]
([ProductName],[ProductDescription],[Price],[ProductCode]) VALUES ('Product
A', 'This is product A', 1000, 'A-1234')
GO
INSERT INTO [PRODUCT]
([ProductName],[ProductDescription],[Price],[ProductCode]) VALUES ('Product
B', 'This is product B', 1000, 'B-1234')
GO
INSERT INTO [PRODUCT]
([ProductName],[ProductDescription],[Price],[ProductCode]) VALUES ('Product
C', 'This is product C', 1000, 'C-1234')
GO

--ORDER
INSERT INTO [ORDER] ([OrderNumber],[OrderDescription],[CustomerId]) VALUES
('10001', 'This is Order 10001', 1)
GO
INSERT INTO [ORDER] ([OrderNumber],[OrderDescription],[CustomerId]) VALUES
('10002', 'This is Order 10002', 2)
GO
INSERT INTO [ORDER] ([OrderNumber],[OrderDescription],[CustomerId]) VALUES
('10003', 'This is Order 10003', 3)
GO


--ORDER_DETAIL
INSERT INTO [ORDER_DETAIL] ([OrderId],[ProductId]) VALUES (1, 1)
GO
INSERT INTO [ORDER_DETAIL] ([OrderId],[ProductId]) VALUES (1, 2)
GO
INSERT INTO [ORDER_DETAIL] ([OrderId],[ProductId]) VALUES (1, 3)
GO
INSERT INTO [ORDER_DETAIL] ([OrderId],[ProductId]) VALUES (2, 1)
GO
INSERT INTO [ORDER_DETAIL] ([OrderId],[ProductId]) VALUES (2, 2)
GO
INSERT INTO [ORDER_DETAIL] ([OrderId],[ProductId]) VALUES (3, 3)
GO
INSERT INTO [ORDER_DETAIL] ([OrderId],[ProductId]) VALUES (3, 1)
GO
INSERT INTO [ORDER_DETAIL] ([OrderId],[ProductId]) VALUES (3, 2)
GO
```

```
INSERT INTO [ORDER_DETAIL] ([OrderId],[ProductId]) VALUES (3, 3)
GO
```

Executing the following Queries then gives:

```
select * from CUSTOMER
```

Results | Messages

	CustomerId	FirstName	LastName	Address	Phone	PostCode	PostAddress
1	1	Per	Nilsen	Vipeveien 12	12345678	1234	Porsgrunn
2	2	Tor	Hansen	Vipeveien 15	77775678	4455	Bergen
3	3	Arne	Nilsen	Vipeveien 17	12345778	4434	Porsgrunn

```
select * from PRODUCT
```

Results | Messages

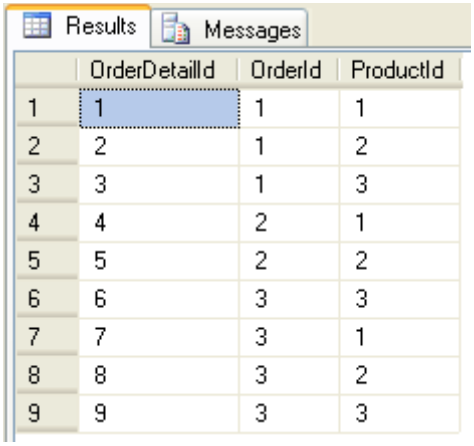
	ProductId	ProductName	ProductDescription	Price	ProductCode
1	1	Product A	This is product A	1000	A-1234
2	2	Product B	This is product B	1000	B-1234
3	3	Product C	This is product C	1000	C-1234

```
select * from [ORDER]
```

Results | Messages

	OrderId	OrderNumber	OrderDescription	CustomerId
1	1	10001	This is Order 10001	1
2	2	10002	This is Order 10002	2
3	3	10003	This is Order 10003	3

```
select * from ORDER_DETAIL
```



Results | Messages

	OrderDetailId	OrderId	ProductId
1	1	1	1
2	2	1	2
3	3	1	3
4	4	2	1
5	5	2	2
6	6	3	3
7	7	3	1
8	8	3	2
9	9	3	3

10.1 Exercises

Run the queries above from LabVIEW.

11 Creating and Using Views

In database theory, a view consists of a stored query accessible as a virtual table composed of the result set of a query. Unlike ordinary tables in a relational database, a view does not form part of the physical schema: it is a dynamic, virtual table computed or collated from data in the database. Changing the data in a table alters the data shown in subsequent invocations of the view.

Views can provide advantages over tables:

- Views can represent a subset of the data contained in a table
- Views can join and simplify multiple tables into a single virtual table
- Views can act as aggregated tables, where the database engine aggregates data (sum, average etc) and presents the calculated results as part of the data
- Views can hide the complexity of data; for example a view could appear as Sales2000 or Sales2001, transparently partitioning the actual underlying table
- Views take very little space to store; the database contains only the definition of a view, not a copy of all the data it presents
- Depending on the SQL engine used, views can provide extra security
- Views can limit the degree of exposure of a table or tables to the outer world

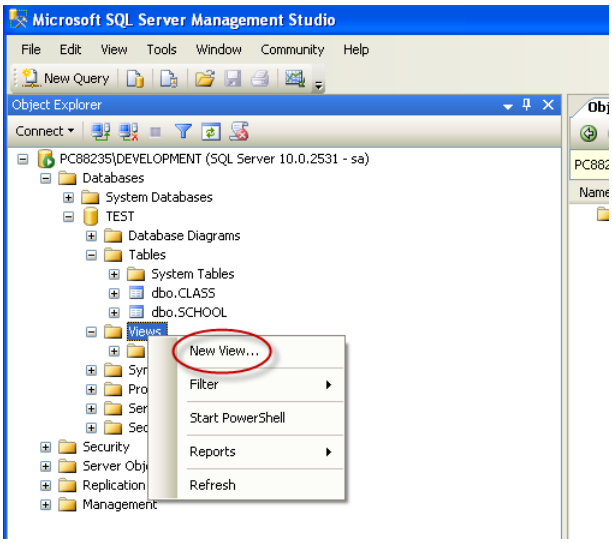
Just as functions (in programming) can provide abstraction, so database users can create abstraction by using views. In another parallel with functions, database users can manipulate nested views, thus one view can aggregate data from other views.

Syntax:

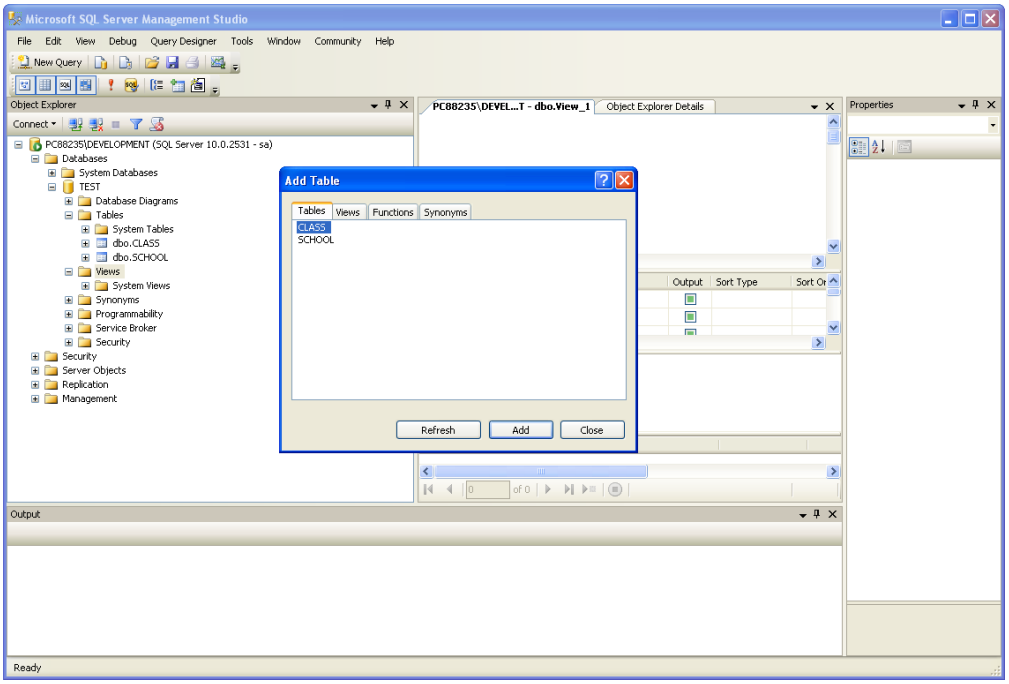
```
CREATE VIEW <ViewName>
AS
…
```

Create a VIEW:

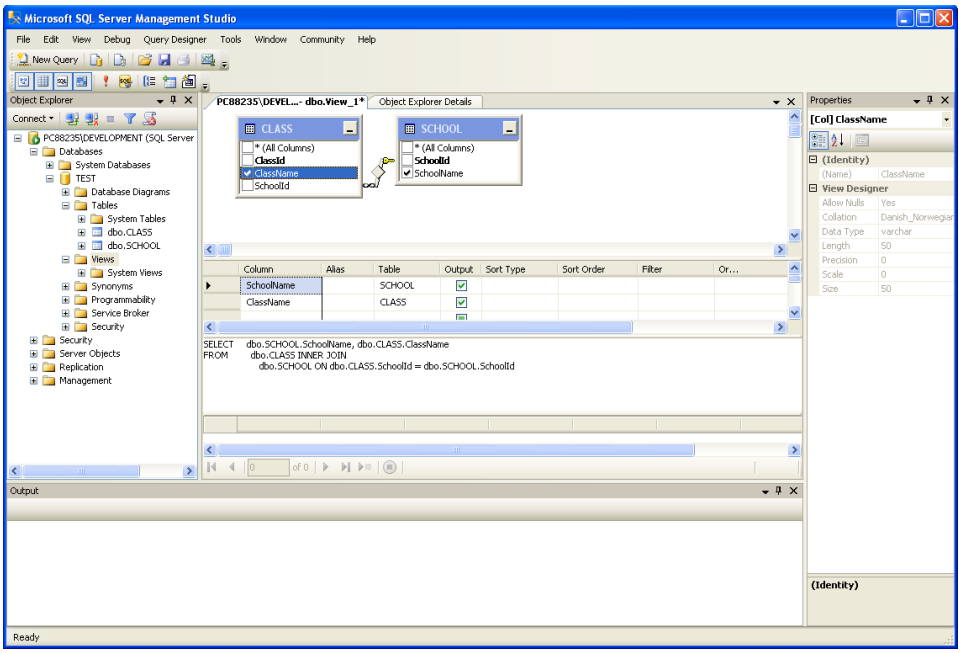
Step 1: Create a new View



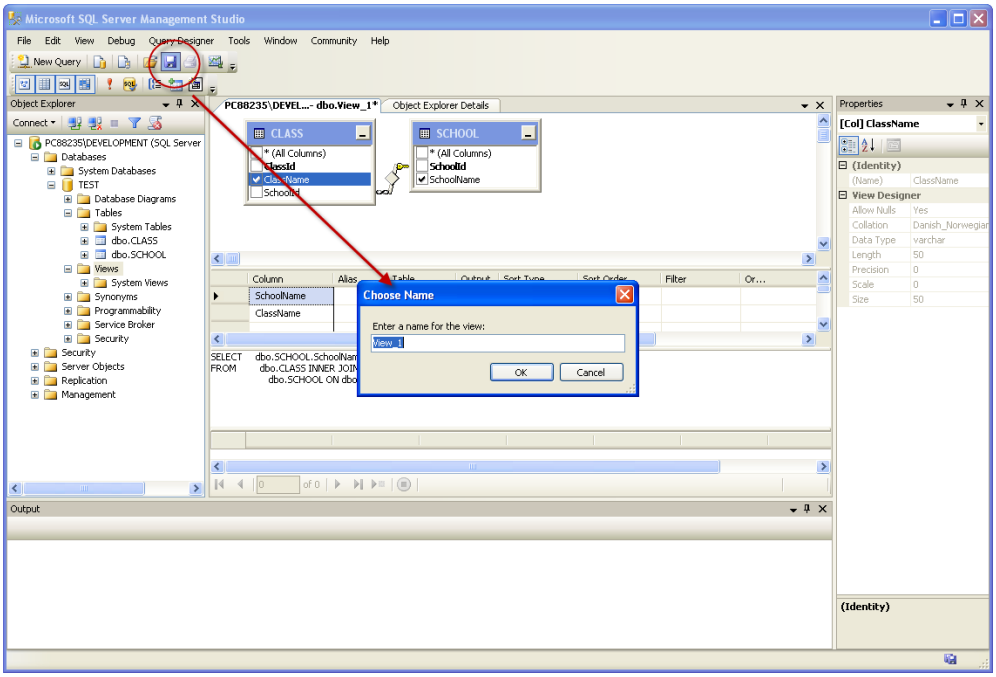
Step 2: Add your tables



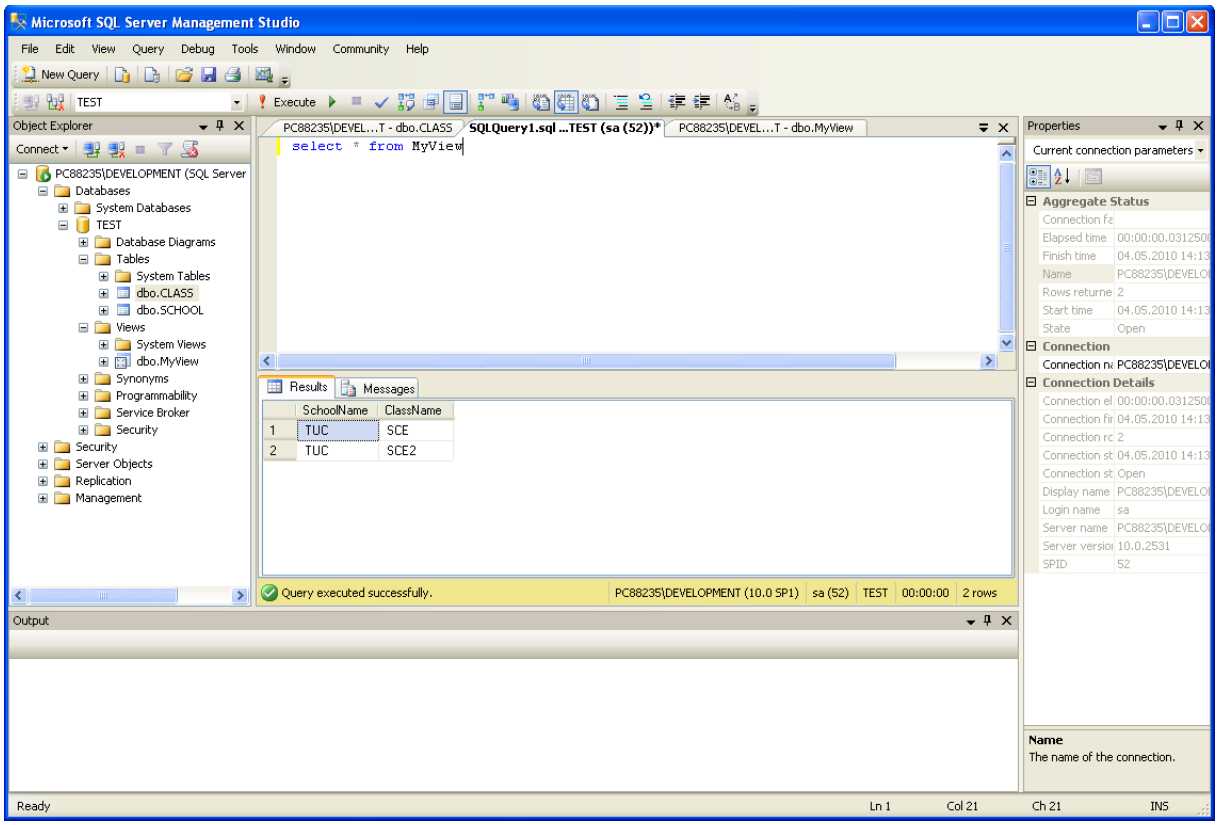
Step 3: Add your columns



Step 4: Save it



Using the VIEW in a Query:



11.1 Exercises

Create a simple view based on the example tables and run the view from LabVIEW.

12 Creating and using Stored Procedures

A stored procedure is a subroutine available to applications accessing a relational database system. Typical uses for stored procedures include data validation (integrated into the database) or access control mechanisms. Furthermore, stored procedures are used to consolidate and centralize logic that was originally implemented in applications. Large or complex processing that might require the execution of several SQL statements is moved into stored procedures, and all applications call the procedures only.

A stored procedure is a precompiled collection of SQL statements and optional control-of-flow statements, similar to a macro. Each database and data provider supports stored procedures differently. Stored procedures offer the following benefits to your database applications:

Performance—Stored Procedures are usually more efficient and faster than regular SQL queries because SQL statements are parsed for syntactical accuracy and precompiled by the DBMS when the stored procedure is created. Also, combining a large number of SQL statements with conditional logic and parameters into a stored procedure allows the procedures to perform queries, make decisions, and return results without extra trips to the database server.

Maintainability—Stored Procedures isolate the lower-level database structure from the application. As long as the table names, column names, parameter names, and types do not change from what is stated in the stored procedure, you do not need to modify the procedure when changes are made to the database schema. Stored procedures are also a way to support modular SQL programming because after you create a procedure, you and other users can reuse that procedure without knowing the details of the tables involved.

Security—When creating tables in a database, the Database Administrator can set EXECUTE permissions on stored procedures without granting SELECT, INSERT, UPDATE, and DELETE permissions to users. Therefore, the data in these tables is protected from users who are not using the stored procedures.

Stored procedures are similar to user-defined functions. The major difference is that functions can be used like any other expression within SQL statements, whereas stored procedures must be invoked using the CALL statement.

The syntax for creating a Stored Procedure is as follows:

```
CREATE PROCEDURE <ProcedureName>
@<Parameter1> <datatype>
```

```
...
```

Example: Create a Stored Procedure

This Procedure gets Customer Data based on a specific Order Number.

```
IF EXISTS (SELECT name
         FROM   sysobjects
         WHERE  name = 'sp_CustomerOrders'
         AND         type = 'P')
      DROP PROCEDURE sp_CustomerOrders
GO

CREATE PROCEDURE sp_CustomerOrders
@OrderNumber varchar(50)

AS

/*-----------------------------------------------------------------------
Last Updated Date:      2009.11.03
Last Updated By:        hans.pr.halvorsen@hit.no
Description:            Get Customer Information from a specific Order Number
-----------------------------------------------------------------------*/
SET NOCOUNT ON

declare @CustomerId int

select @CustomerId = CustomerId from [ORDER] where OrderNumber = @OrderNumber


select CustomerId, FirstName, LastName, [Address], Phone from CUSTOMER where
CustomerId=@CustomerId


SET NOCOUNT OFF
GO
```

Example: Using a Stored Procedure

Using the Stored procedure like this

```
exec sp_CustomerOrders '10002'
```

gives the following result:

12.1 Exercises

Run the Stored Procedure created above from LabVIEW.

13 Creating and Using Triggers

A database trigger is procedural code that is automatically executed in response to certain events on a particular table or view in a database. The trigger is mostly used for keeping the integrity of the information on the database. For example, when a new record (representing a new worker) added to the employees table, new records should be created also in the tables of the taxes, vacations, and salaries.

Triggers are commonly used to:

- prevent changes (e.g. prevent an invoice from being changed after it's been mailed out)
- log changes (e.g. keep a copy of the old data)
- audit changes (e.g. keep a log of the users and roles involved in changes)
- enhance changes (e.g. ensure that every change to a record is time-stamped by the server's clock, not the client's)
- enforce business rules (e.g. require that every invoice have at least one line item)
- execute business rules (e.g. notify a manager every time an employee's bank account number changes)
- replicate data (e.g. store a record of every change, to be shipped to another database later)
- enhance performance (e.g. update the account balance after every detail transaction, for faster queries)

The major features of database triggers, and their effects, are:

- do not accept parameters or arguments (but may store affected-data in temporary tables)
- cannot perform commit or rollback operations because they are part of the triggering SQL statement
- can cancel a requested operation
- can cause mutating table errors, if they are poorly written.

Microsoft SQL Server supports triggers either after or instead of an insert, update, or delete operation.

The syntax is as follows:

```
CREATE TRIGGER <TriggerName>  on <TableName>
FOR INSERT, UPDATE, DELETE
AS
… Create your Code here
GO
```

- Replace <TriggerName> with the Name of your Trigger
- Replace <TableName> with the Name of your Table

Define when the Trigger should be execute

- If the Trigger should be executed only when you insert data into the table: `FOR INSERT`
- If the Trigger should be executed only when you update data into the table: `FOR UPDATE`
- If the Trigger should be executed only when you delete data into the table: `FOR DELETE`
- If the Trigger should be executed when you insert and update data into the table: `FOR INSERT, UPDATE`
- Etc.

Example: Trigger

The Example above change the "below" in the Table "SCHOOL" from 'TUC' to 'Telemark University College'

```
CREATE TRIGGER CheckSchoolData on SCHOOL
FOR INSERT, UPDATE
AS

DECLARE
@SchoolName varchar(50)


select @SchoolName=SchoolName from INSERTED

If @SchoolName='TUC'
      update SCHOOL set SchoolName='Telemark University College' where
SchoolName=@SchoolName

GO
```

Note! Note the use of a temporary table called "**INSERTED**". This temporary table contains the last inserted record into the SCHOOL table

Note! In SQL you define a variable like this

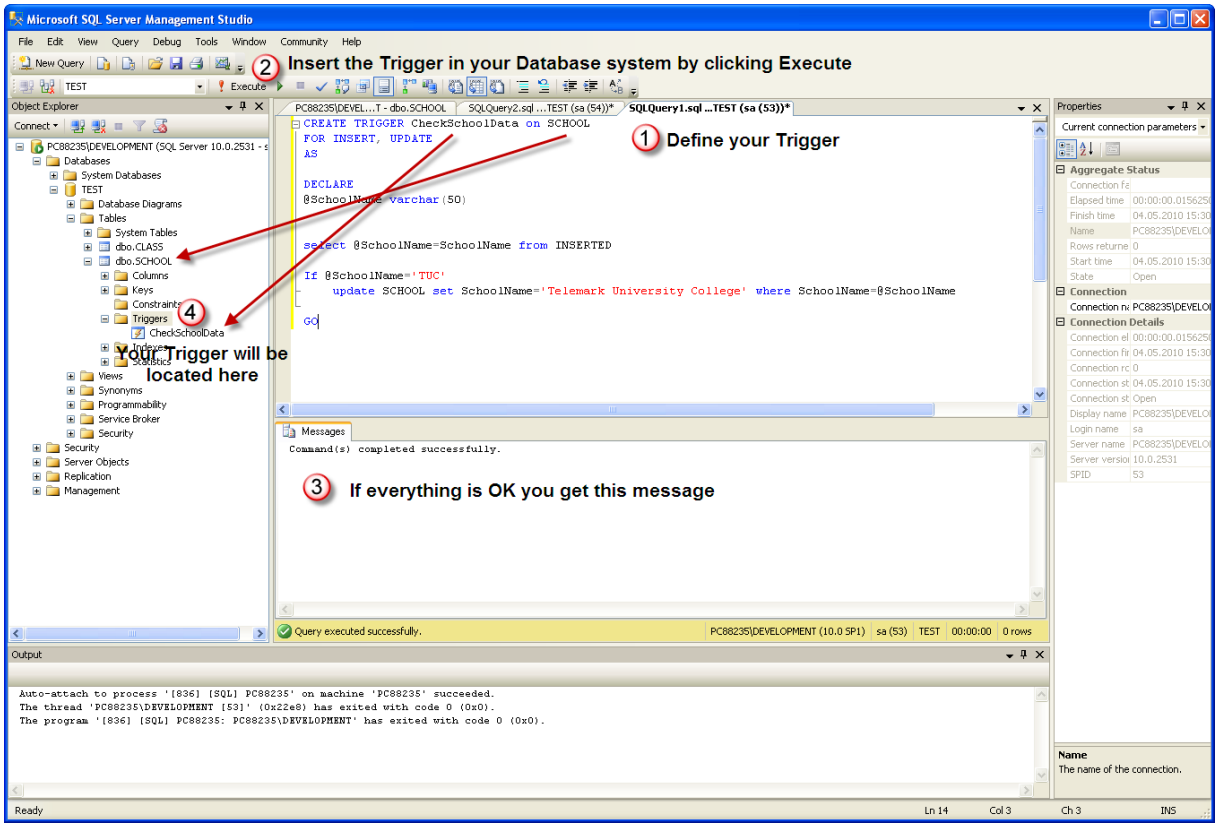
```
DECLARE
@myVariable <datatype>
```

Example:

```
DECLARE
@SchoolName varchar(10)
```

Note! You have to use the symbol "**@**" before the name of the variable!!!

Below we see how we create a Trigger from the "**SQL Server Management Studio**":



Check if the Trigger is working as expected:

Procedure:

Step 1: Check the data in your table before you do anything, e.g.:

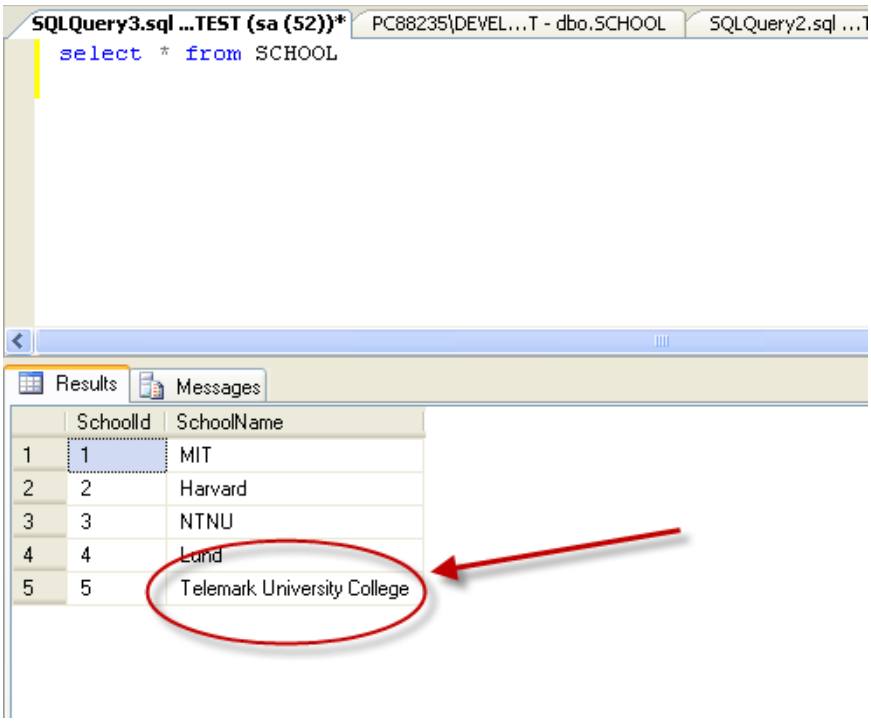
```
select * from SCHOOL
```

Step 2: Insert some test data into your table, e.g.:

```
insert into SCHOOL (SchoolId, SchoolName) values (5, 'TUC')
```

Step 3: Check the data has been updated according to your code in the Trigger:

```
select * from SCHOOL
```



→ As you see the data you inserted into the table has been automatically been changed by the Trigger

13.1 Exercises

Create a Trigger that adds “+47” to all Phone numbers in the CUSTOMER table.

Test and see if the Trigger works properly by inserting and updating some data in the CUSTOMER table.

14 Creating and using Functions

In SQL databases, a user-defined function provides a mechanism for extending the functionality of the database server by adding a function that can be evaluated in SQL statements. The SQL standard distinguishes between scalar and table functions. A scalar function returns only a single value (or NULL), whereas a table function returns a (relational) table comprising zero or more rows, each row with one or more columns.

Stored Procedures vs. Functions:

- Only functions can return a value (using the RETURN keyword).
- Stored procedures can use RETURN keyword but without any value being passed[1]
- Functions could be used in SELECT statements, provided they don't do any data manipulation and also should not have any OUT or IN OUT parameters.
- Functions must return a value, but for stored procedures this is not compulsory.
- A function can have only IN parameters, while stored procedures may have OUT or IN OUT parameters.
- A function is a subprogram written to perform certain computations and return a single value.
- A stored procedure is a subprogram written to perform a set of actions, and can return multiple values using the OUT parameter or return no value at all.

User-defined functions in SQL are declared using the CREATE FUNCTION statement.

14.1 Exercises

Create a simple function that finds number of order for a specific customer and use it in the following query:

```
"Select FirstName, LastName, fn_NumberOfOrders(CustomerId) from CUSTOMER"
```

15 SQL Toolkit

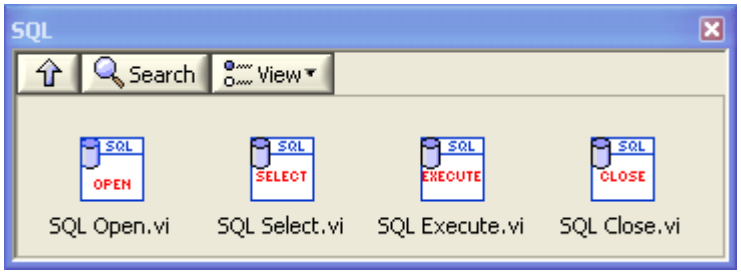
I have made a simple and easy to-use SQL Toolkit. The SQL Toolkit is available for download from my Blog: http://home.hit.no/~hansha/

15.1 Installation

The installation procedure is as follows:

1. Download the zip file SQLToolkit.zip from my Blog
2. Unzip the file
3. Copy "SQLToolkit.mnu" to ...\LabVIEW 2009\menus\Categories\
4. Copy "SQLToolkit.llb" to ...\LabVIEW 2009\vi.lib\
5. The SQL Toolkit is ready to use and in the Functions palette in LabVIEW a new palette named "SQL" will appear.

The SQL Toolkit palette in available in LabVIEW:



The SQL Toolkit contains the following VIs:

"**SQL Open.vi**" - This VI open a connection to the database specified in the Connection string. The connection string may be as follows:

```
"PROVIDER=SQLOLEDB; DATA SOURCE=xxx;UID=xxx;PWD=xxx;DATABASE=xxx"
```

You need to replace the "xxx" with the parameters from your database.

"**SQL Select.vi**" -This VI get data from the database specified in the SQL Query. The output is a 2D string array with data.

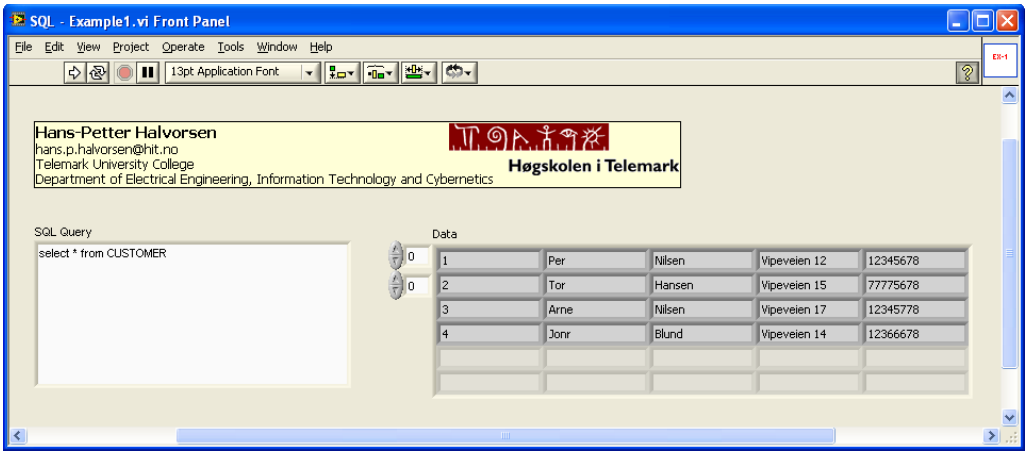
"**SQL Execute.vi**" - This VI executes a Query with no return Data, e.g., an INSERT statement

"**SQL Close.vi**" - This VI Close the connection to the database opened by "SQL Open.vi"

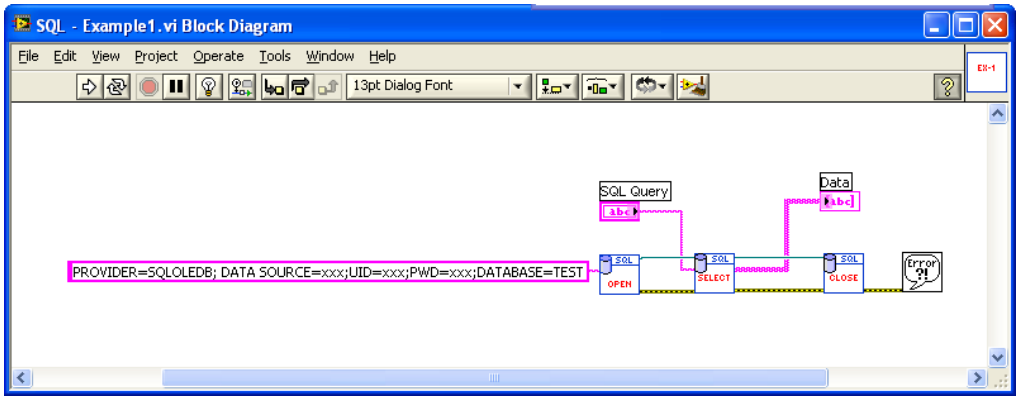
Two examples are also included:

"**SQL – Example 1.vi**" – This example selects data from a table. The example uses "SQL Select.vi" in order to get data from the database.

Front panel:

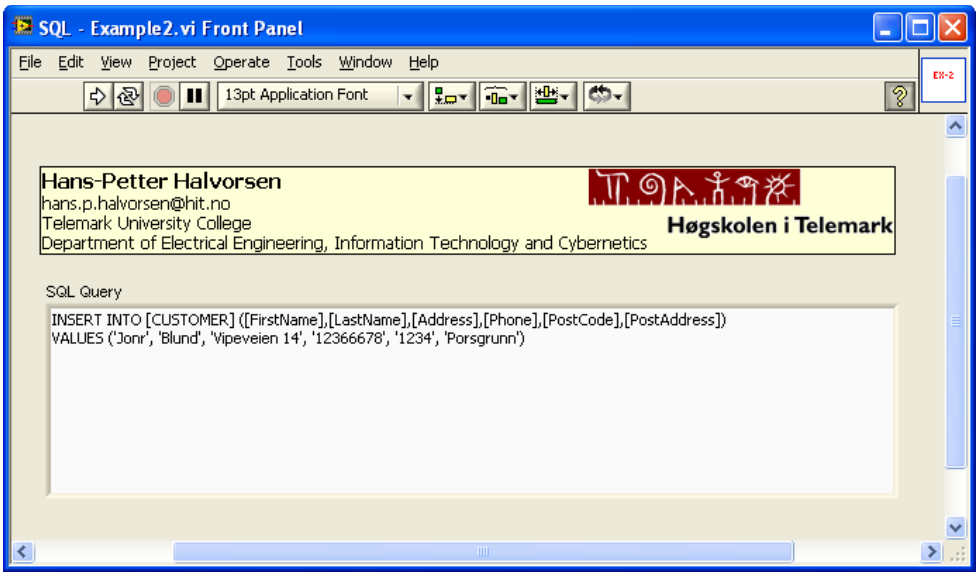


Block Diagram:

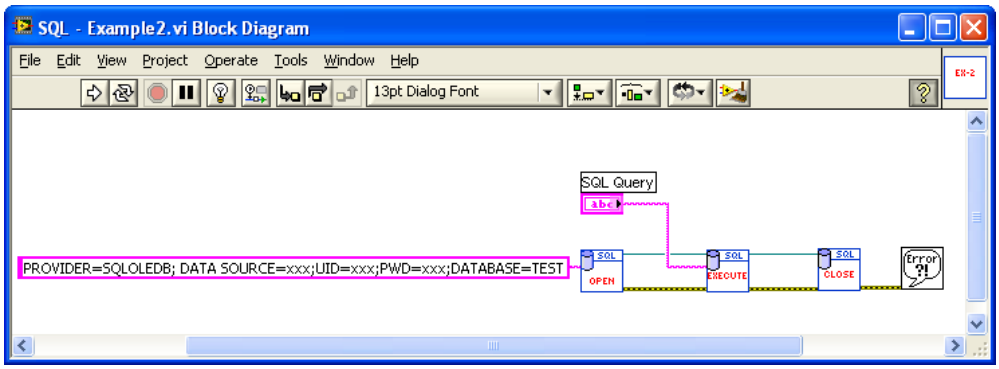


"**SQL – Example 2.vi**" – This example inserts data into a table. The example uses "SQL Execute.vi" in order to insert data into the database. No data is returned.

Front panel:



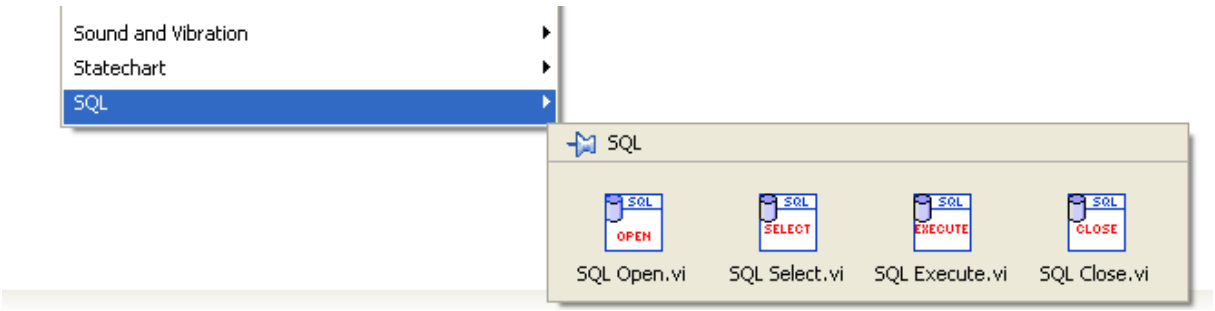
Block Diagram:



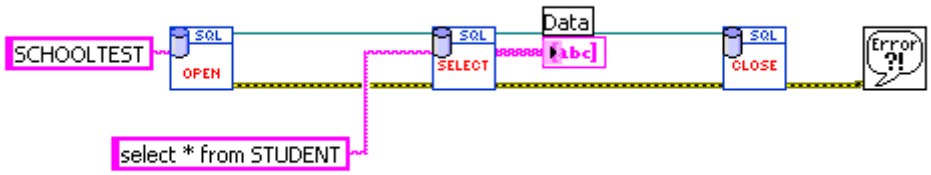
Example: Get Data into LabVIEW using SQL Toolkit

Download the SQL toolkit from the Homepage of the Database Lab and follow the instructions in the ReadMe file.

On the Functions palette on your Block Diagram the following palette should appear:

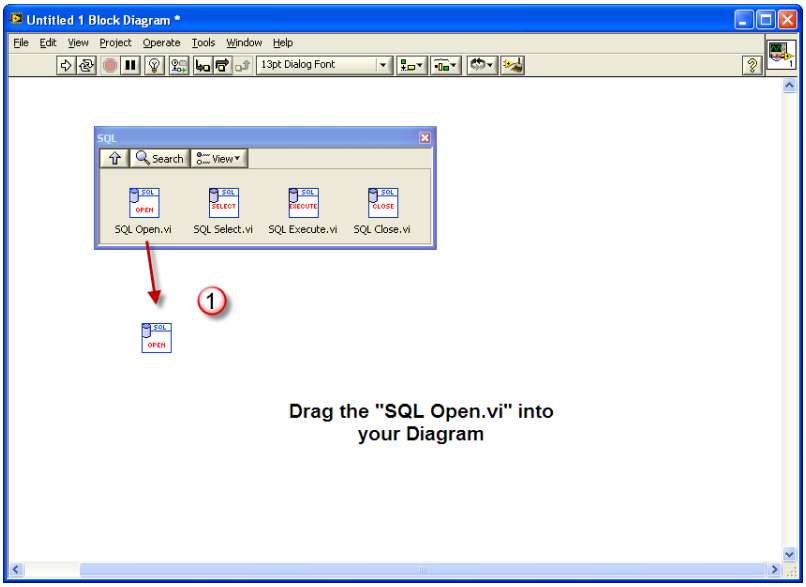


Here is a simple example of how you get data from the database into LabVIEW:

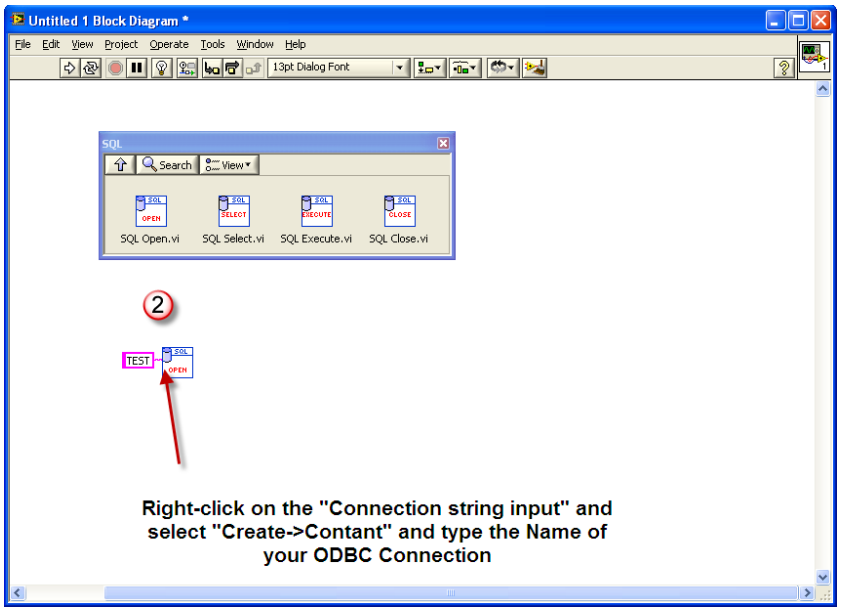


The procedure is as follows:

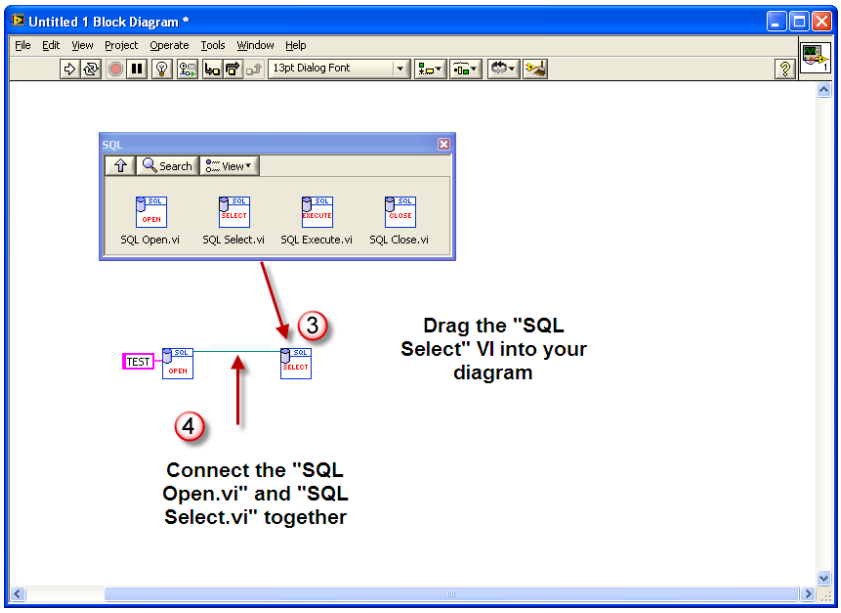
Step 1:



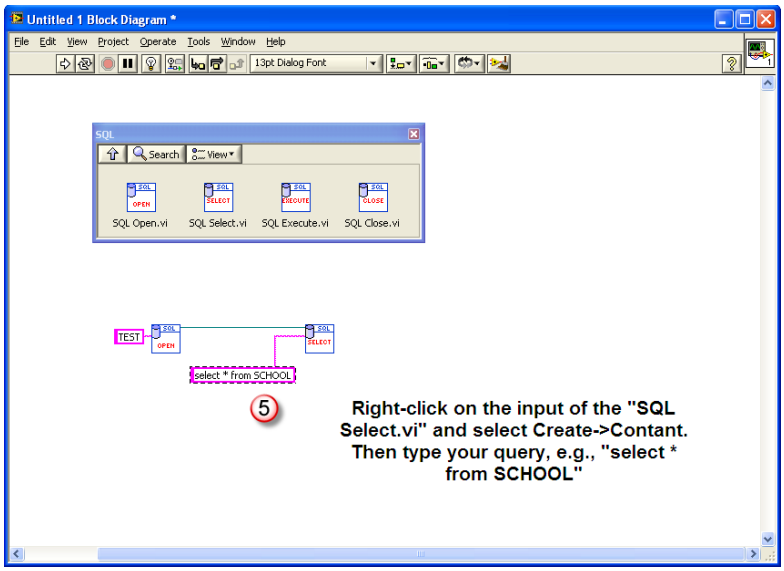
Step 2:



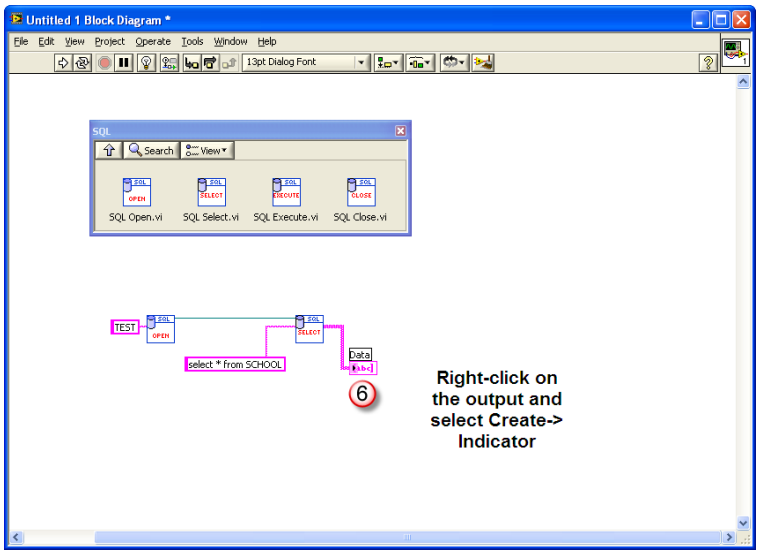
Step 3 and 4:



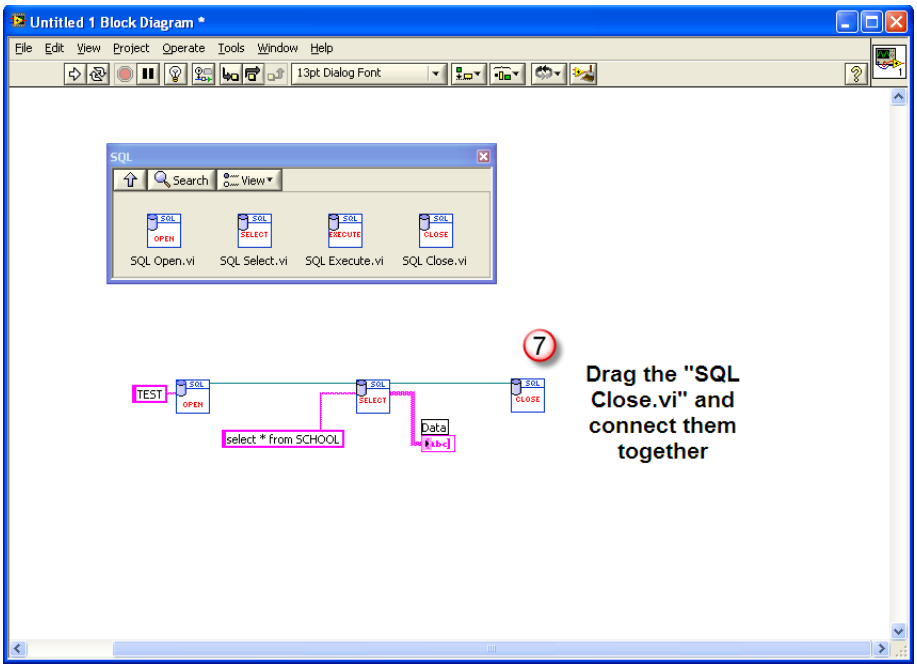
Step 5:


Untitled 1 Block Diagram *
File Edit View Project Operate Tools Window Help
13pt Dialog Font
SQL
Search
View
SQL Open.vi
SQL Select.vi
SQL Execute.vi
SQL Close.vi
TEST
select * from SCHOOL
5
Right-click on the input of the "SQL Select.vi" and select Create->Contant. Then type your query, e.g., "select * from SCHOOL"

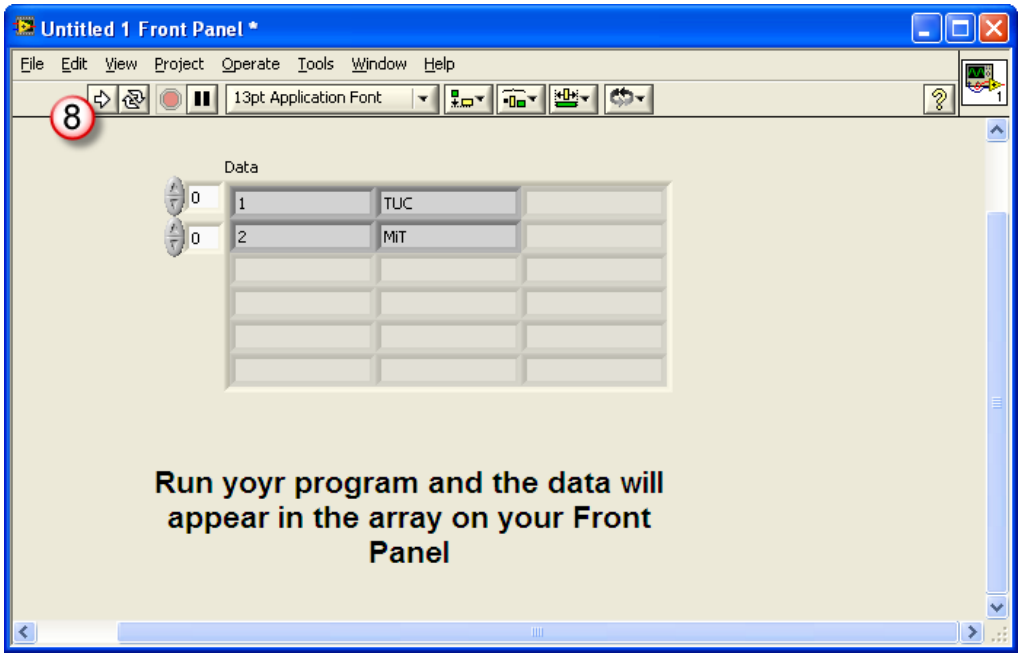
Step 6:


Untitled 1 Block Diagram *
File Edit View Project Operate Tools Window Help
13pt Dialog Font
SQL
Search
View
SQL Open.vi
SQL Select.vi
SQL Execute.vi
SQL Close.vi
TEST
select * from SCHOOL
Data
6
Right-click on the output and select Create-> Indicator

Step 7:


Untitled 1 Block Diagram *
File Edit View Project Operate Tools Window Help
13pt Dialog Font
SQL
Search View
SQL Open.vi
SQL Select.vi
SQL Execute.vi
SQL Close.vi
7
TEST
select * from SCHOOL
Data
Drag the "SQL Close.vi" and connect them together

Step 8:


Untitled 1 Front Panel *
File Edit View Project Operate Tools Window Help
13pt Application Font
8
Data
0
1
TUC
0
2
MIT
Run yoyr program and the data will appear in the array on your Front Panel

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