# Database Systems

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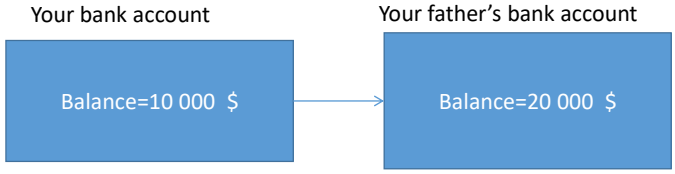
## Transactions

- What is a transaction?




**Transfer 5 000 $ from your account to your Father's account:**

- Debit 5 000 $ from your bank account (Subtract 5 000 $)
- Credit 5 000 $ to your father's bank account (Add 5 000 $)

## Transactions

What is a transaction?

- A transaction is a sequence of one or more SQL operations treated as a unit
- Also known as a Unit of Work (UOW)
- Transactions appear to run in isolation
- If the system fails, each transaction's changes are reflected either entirely or not at all
- Transactions ensure that multiple data modifications are processed together or not at all
- The transaction log ensures that updates are complete and recoverable
- Transactions use locks

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## Transactions

- A transaction starts with any SQL statement and ends with a COMMIT or ROLLBACK
- COMMIT statement makes changes permanent to the database
- ROLLBACK statement reverses changes
- COMMIT and ROLLBACK statements release all locks

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# Example of transactions

```
INSERT INTO emp VALUES (100, 'John')
INSERT INTO emp VALUES (200, 'Mary')
COMMIT
```

First SQL statement starts transaction

| EmpID | Name |
|---|---|
| 100 | John |
| 200 | Mary |

No changes applied due to ROLLBACK

```
DELETE FROM emp WHERE name='Mary'
UPDATE emp SET EmpID=101
WHERE name='John'
ROLLBACK
```

| EmpID | Name |
|---|---|
| 100 | John |
| 200 | Mary |

```
UPDATE emp SET name='Peter'
WHERE EmpID=100
COMMIT

ROLLBACK
```

There is nothing to rollback

| EmpID | Name |
|---|---|
| 100 | Peter |
| 200 | Mary |

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# Transactions – ACID rules

- **A**tomicity
  - All statements in the transaction are treated as a unit.
  - If the transaction completes successfully, everything is committed
  - If the transaction fails, everything done up to the point of failure is rolled back.
- **C**onsistency
  - Any transaction will take the data from one consistent state to another, so only valid consistent data is stored in the database
- **I**solation
  - Concurrent transactions cannot interfere with each other
- **D**urability
  - Committed transactions have their changes persisted in the database

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# Concurrency & Locking



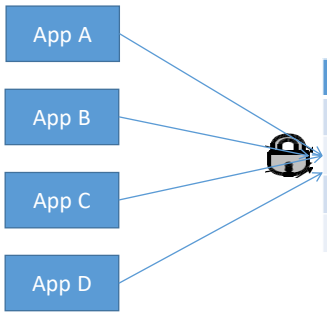
## What Are Locks?

- **Two main types of lock:**
  - Read locks – allow others to read but not write
  - Write locks – stop others reading or writing
- **Deadlocks can occur**
- **Locks prevent update conflicts**
  - Locking ensures that transactions are serialized
  - Locking is automatic
  - Locks enable concurrent use of data

## What Is Concurrency Control?

- **Pessimistic**
  - Locks data when data is read in preparation for an update
  - Other users are blocked until lock is released
  - Use where high contention for data exists
- **Optimistic**
  - Locks data when an update is performed
  - Error received if data was changed since initial read
  - Use when low contention for data exists

# Concurrency and Locking




| ID | Name | Age |
|---|---|---|
| 3 | Peter | 33 |
| 5 | Josef | 24 |
| 22 | Mary | 35 |
| 35 | Ann | 22 |

- Concurrency:
  - Multiple users accessing the same resources at the same time
- Locking:
  - Mechanism to ensure data integrity and consistency

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## Locking

- Locks are acquired automatically as needed to support a transaction based on “isolation levels”
- COMMIT and ROLLBACK statements release all locks
- Two basic types of locks:
  - Share locks (S locks) – acquired when an application wants to read and prevent others from updating the same row
  - Exclusive locks (X locks) – acquired when an application updates, inserts, or deletes a row

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## Managing transactions

## Autocommit Transactions

- **Default transaction mode**
- **Every statement is committed or rolled back when it has completed**
  - If it completes successfully – it is committed
  - If it fails – it is rolled back
- **Compile errors result in a batch not being executed**

## Explicit Transactions

- **BEGIN TRANSACTION**
- **COMMIT TRANSACTION**
- **ROLLBACK TRANSACTION**

```
BEGIN TRANSACTION fund_transfer
  EXEC debit_checking '100', 'account1'
  EXEC credit_savings '100', 'account2'
COMMIT TRANSACTION
```

- **SAVE TRANSACTION**
- **Transaction log**

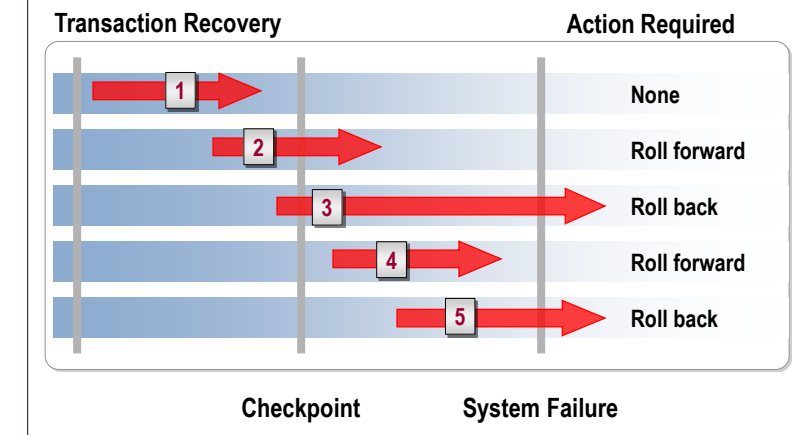
## Implicit Transactions

- Setting implicit transaction mode on

```
SET IMPLICIT_TRANSACTION ON
```

- An implicit transaction starts when one of the following statements is executed
  - ALTER DATABASE
  - CREATE
  - DELETE
  - DROP
  - FETCH
  - GRANT
  - INSERT
  - OPEN
  - REVOKE
  - SELECT
  - TRUNCATE TABLE
  - UPDATE
- Transaction must be explicitly completed with COMMIT or ROLLBACK TRANSACTION

## Transaction Recovery



## Considerations for Using Transactions

- **Keep transactions as short as possible**
  - Use caution with certain Transact-SQL statements
  - Avoid transactions that require user interaction
  - Do not browse data during a transaction
  - Affect the least rows possible with DML statements
  - Access the least rows possible with SELECT statements
- **Issues with nested transactions**
  - Allowed, but not recommended
  - Use **@@trancount** to determine nesting level

## Restricted Statements

- **Certain statements may not be included in explicit transactions, such as:**
  - ALTER DATABASE
  - BACKUP
  - CREATE DATABASE
  - DROP DATABASE
  - RECONFIGURE
  - RESTORE DATABASE
  - RESTORE
  - UPDATE STATISTICS
- **Full-text system stored procedure calls may not be included in explicit transactions**
- **You cannot use the following in implicit or explicit transactions:**
  - sp_dboption
  - System stored procedures that modify master

## SQL SERVER Locking Architecture

## What Concurrency Problems Are Prevented by Locks?

- Some undesirable effects may encounter when many users access the same data source:
  - Lost updates
  - Uncommitted dependencies (dirty read)
  - Inconsistent analysis (nonrepeatable read)
  - Phantom reads
- To guarantee the integrity of the data, some sort of modification rules are required to control the use of data

## Lockable Resources

| Item | Description |
|---|---|
| **RID** | Row identifier |
| **KEY** | Row lock within an index |
| **PAGE** | Data page or index page |
| **EXTENT** | Group of pages |
| **TABLE** | Entire table |
| **HOBT** | A heap or B-tree |
| **FILE** | A database file |
| **APPLICATION** | An application-specified resource |
| **METADATA** | Metadata locks |
| **ALLOCATION_UNIT** | An allocation unit |
| **DATABASE** | Entire database |

## Types of Locks

- **Basic locks**
  - Shared
  - Exclusive
- **Special situation locks**
  - Intent
  - Update
  - Schema
  - Bulk update

## Lock Compatibility

- **Some locks are compatible with other locks, and some locks are not**
- **Examples**
  - Shared locks are compatible with all locks except exclusive
  - Exclusive locks are not compatible with any other locks
  - Update locks are compatible only with shared locks

An example

# Pisa Tours Agency Reservation System



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# Lost Update

- Same data is retrieved and updated by two users concurrently
- Last successful change kept, first change overridden

**reservations**

| Seat | Name | ... |
|---|---|---|
| 7C | Steven | |
| 7B | | |
| . . . | | |

App A

**UPDATE reservations**
**SET Name = 'Susan'**
**WHERE Seat = '7C'**
**AND Name IS NULL**

App B

**UPDATE reservations**
**SET Name = 'Steven'**
**WHERE Seat = '7C'**
**AND Name IS NULL**

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## Uncommitted read (also known as “dirty read”)

Can read or view data changed or added that has not committed yet

**reservations**

| Seat | Name | … |
|---|---|---|
| 7C | | |
| 7B | | |
| . . . | | |

App A

**UPDATE reservations**
**SET Name = 'John'**
**WHERE Seat = '7C’**
**AND Name IS NULL**

ROLLBACK

App B

**SELECT Name**
**FROM reservations**
**WHERE Seat = '7C'**

John

**Further processing in App B uses incorrect /uncommitted value of „John”**

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## Non-repeatable read

Same SELECT statement returns different result set within the same transaction

**reservations**

| Seat | Name | … |
|---|---|---|
| 7C | John | |
| 7B | | |
| . . . | | |

App A

**SELECT Seat**
**FROM reservations**
**WHERE Name ISNULL**

7C

7B

**SELECT Seat**
**FROM reservations**
**WHERE Name ISNULL**

7B

App B

**UPDATE reservations**
**SET Name="John"**
**WHERE Seat = "7C"**

**The same SELECT (read) returns a different result: Less rows (in this case '7C' doesn't show anymore). This is a non-repeatable read.**

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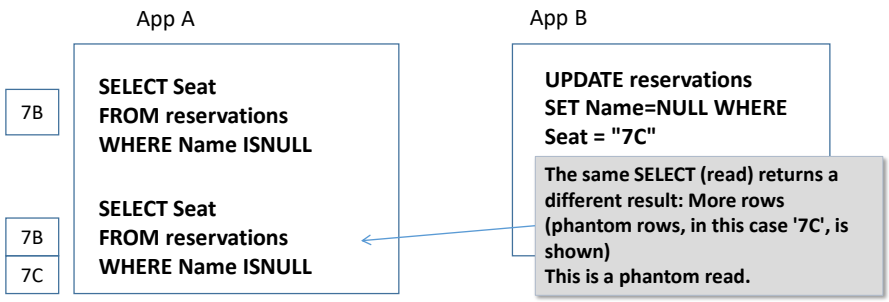
## Phantom Read

Application executes same SQL twice, second result set contains additional rows

**reservations**

| Seat | Name | ... |
|---|---|---|
| 7C | | |
| 7B | | |
| . . . | | |




## Isolation levels

- **"Policies" to control when locks are taken**
- **Database provides different levels of protection to isolate data**
- **Transaction isolation level**
  - Read Uncommitted — weak
  - Read Committed (default)
  - Repeatable Read
  - Serializable — strong
- **Locking timeout**
  - Limits time waiting for a locked resource
  - Use SET LOCK_TIMEOUT

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## Isolation levels and Concurrency Problems

| | Dirty reads | Non-repeatable read | Phantoms |
|---|---|---|---|
| Read Uncommitted | Yes | Yes | Yes |
| Read Committed | No | Yes | Yes |
| Repeatable read | No | No | Yes |
| Serializable | No | No | No |

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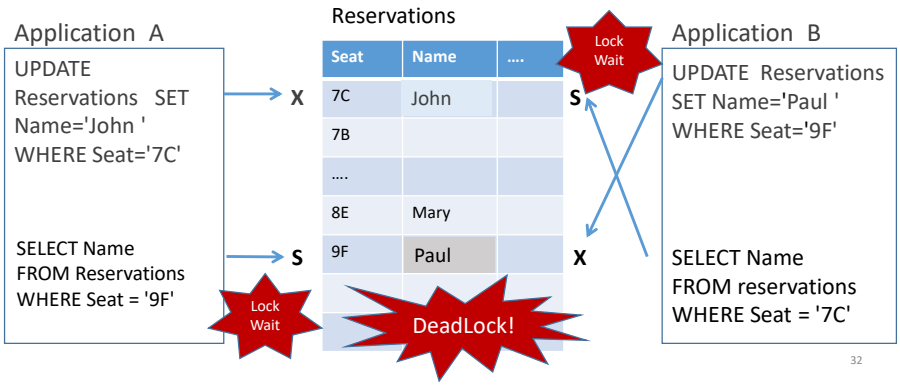
## Deadlocks

- Occurs when two or more applications wait indefinitely for a resource
- Each application is holding a resource that the other needs
- Waiting is never resolved

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## Deadlocks

### Database servers :

- provide a deadlock detector
- set the time interval for checking for deadlocks
- When a deadlock is detected, database server uses an internal algorithm to pick which transaction to roll back, and which one to continue.
- The transaction that is forced to roll back gets a SQL error. The rollback causes all of its locks to be released.

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## Deadlocks in MS SQL Server

- A separate thread called LOCK_MONITOR checks the system for deadlocks every 5 seconds
- Lock Monitor checks for deadlocks by inspecting the list of waiting locks for any cycles.
- SQL Server attempts to choose as the victim the process that would be least expensive to roll back.
- That process is killed and error message 1205 is sent to the corresponding client connection.
- Certain operations are marked as golden, or unkillable, and cannot be chosen as the deadlock victim.

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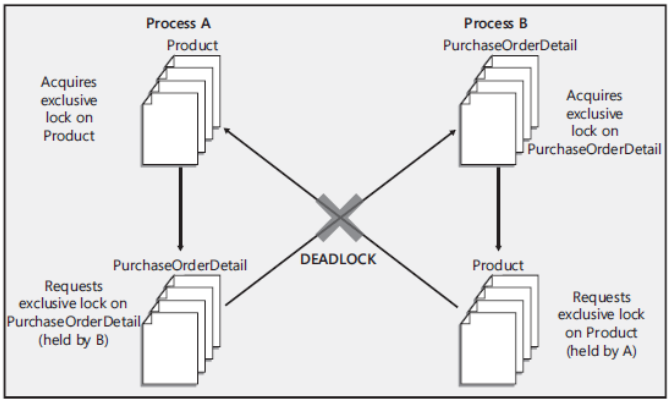
# MS SQL Server Deadlock

```
Msg 1205, Level 13, State 51, Line 1
Transaction (Process ID 57) was deadlocked on lock resources with another process and has
been chosen as the deadlock victim. Rerun the transaction.
```




A cycle deadlock resulting from two processes, each holding a resource needed by the other

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# Special Type of data

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## Geometry and Geography data types

- Geometry data type
  - The GEOMETRY data type might be used for a warehouse application to store the location of each product in the warehouse
  - The GEOMETRY data type follows a "flat Earth" model, with basically X, Y, and Z coordinates.
- Geography data type
  - The GEOGRAPHY data type can be used to store data that can be used in mapping software. You may wonder why two types that both store locations exist. The GEOGRAPHY data type represents the "round Earth" model, storing longitude and latitude. These data types implement international standards for spatial data.
- These data types supports the OpenGIS Simple Features for SQL standard, which is a specification published by an international regulatory body known as the Open Geospatial Consortium (OGC):
  - Well-Known Text (WKT),
  - Well-Known Binary (WKB),
  - Geography Markup Language (GML).

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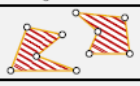
- Shapes are projected onto spatial models using vector objects—which are collections of points, lines, and polygons (closed shapes). Both the geometry and geography data types support the same Well-Known Text (WKT) markup language, which is a convention that expresses the vector objects that you define using a syntax governed by the OGC.

| Examples of WKT Strings | |
|---|---|
| WKT String | Description |
| POINT(6 10) | A single point at xy-coordinates 6, 10 |
| POINT(-111.06687 45.01188) | A single point on the earth (longitude/latitude coordinates) |
| LINESTRING(3 4,10 50,20 25) | A two-part line, drawn between three points specified as xy-coordinates |
| POLYGON(( -75.17031 39.95601, -75.16786 39.95778, -75.17921 39.96874, -75.18441 39.96512, -75.17031 39.95601)) | An enclosed shape on the earth drawn between the points specified as longitude/latitude coordinates |

As you can see, the same WKT syntax is used for expressing spatial elements using either the planar or the geodetic model. Also notice that geodetic coordinates are always expressed in WKT with the longitude value first, followed by the latitude value.

## Geometry data type

| | | | |
|---|---|---|---|
| POINT |  | MULTIPOINT |  |
| LINESTRING |  | MULTILINESTRING |  |
| CIRCULARSTRING |  | COMPOUNDCURVE |  |
| POLYGON |  | MULTIPOLYGON |  |
| CURVEPOLYGON |  | GEOMETRY-COLLECTION |  |
| FULLGLOBE |  | | |

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## Geometry and Geography data types

- These complex types are based on the CLR (Common Language Runtime). New data types similar to these built-in complex types can be created with a .NET language. We should know how to use the built-in CLR types.
- These types are in .NET as a class library (DLL) and offer us more than 90 methods. The name of these methods begin with the ST characters symbolize that support the OGC standard.
- Some of the methods are static and some of them are object instance methods.

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## Geometry data type

- Planar model is a flat surface where shapes are plotted using two-dimensional x- and y-coordinates
- These coordinates are based on an arbitrary measurement system, so you can define any measurement unit you want (for example, centimeters, meters, kilometers, inches, feet, miles, pixels, and so on).
- Our first example demonstrates the geometry data type in a very simple scenario. You will define and store shapes representing different objects.
- The first thing you need to do is create tables to hold the shapes that define the warehouse and objects to place in it.
- You can give the area, and distance between them.

```
CREATE TABLE Warehouse(ObjectName nvarchar(20),
                       Place GEOMETRY);
```

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## Geometry datatype

- Let be walls of the warehouse:

```
INSERT Warehouse VALUES ('Walls', 'LINESTRING(0 0, 40 0, 40 40, 0 40, 0 0)')
```

- Put some object into it.

```
INSERT Warehouse VALUES('Bean','POINT(5 35)');
INSERT Warehouse VALUES('Rod','LINESTRING(10 10, 25 25)');
INSERT Warehouse VALUES('Table','POLYGON((15 18, 35 18, 35 28, 15 28, 15 18))');
INSERT Warehouse VALUES('Swimbelt','CURVEPOLYGON(CIRCULARSTRING(0 4,4 0,8 4,4 8,0 4),
CIRCULARSTRING(2 4,4 2,6 4,4 6,2 4))');
```

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# Geometry datatype

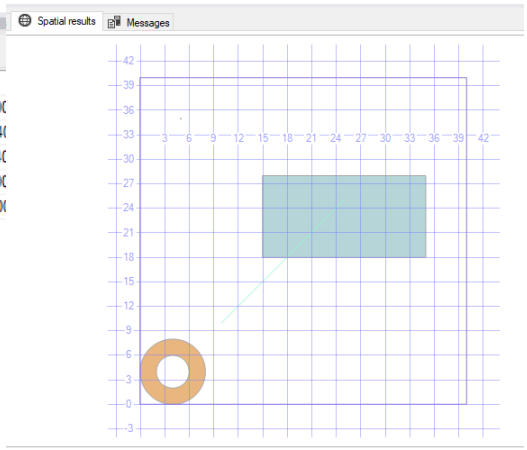
- List the content of the warehouse:

```
SELECT *
FROM Warehouse;
GO
```

100 %

Results | Spatial results | Messages

| | ObjectName | Place |
|---|---|---|
| 1 | Walls | 0x000000000104050000000000000( |
| 2 | Bean | 0x00000000010C000000000000144( |
| 3 | Rod | 0x000000000114000000000000244( |
| 4 | Table | 0x000000000104050000000000000( |
| 5 | Swimbelt | 0x0000000002040A000000000000( |




# Geometry datatype

- Calculate the area occupied by objects:

```
SELECT *, Place.STArea() as Area
FROM Warehouse;
```

100 %

Results | Spatial results | Messages

| | ObjectName | Place | AREA |
|---|---|---|---|
| 1 | Walls | 0x000000000104050000000000000000000000000000000000... | 0 |
| 2 | Bean | 0x00000000010C000000000000144000000000000804140 | 0 |
| 3 | Rod | 0x000000000114000000000000244000000000000244000... | 0 |
| 4 | Table | 0x000000000104050000000000000000002E400000000000... | 200 |
| 5 | Swimbelt | 0x0000000002040A000000000000000000000000000000000... | 37,6991118430775 |

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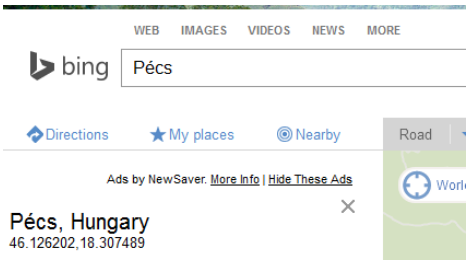
# Geography datatype

- Create City table with location

```
-- Create CITY table
CREATE TABLE CITY(CityID INTEGER IDENTITY(1,1) PRIMARY KEY NOT NULL,
   CityName nvarchar(12),CityLoc Geography);
GO
```

Add data to the City table

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# Geography datatype

- Insert data into the City table:

```
-- INSERT Data into the City table, Longitude, Latitude
INSERT City(CityName,CityLoc)
VALUES('Budapest', 'POINT(19.064819 47.506221)')
INSERT City(CityName,CityLoc)
VALUES('Pécs', 'POINT(18.307489 46.126202)')
INSERT City(CityName,CityLoc)
VALUES('London', 'POINT(-0.127140 51.506321)')
INSERT City(CityName,CityLoc)
VALUES('Athens', 'POINT(23.736410 37.976150)')
INSERT City(CityName,CityLoc)
VALUES('New York', 'POINT(-74.007118 40.714550)')
INSERT City(CityName,CityLoc)
VALUES('Cape Town', 'POINT(18.421989 -33.919090)')
INSERT City(CityName,CityLoc)
VALUES('Cairo', 'POINT(31.235711 30.0444196)')
GO
```

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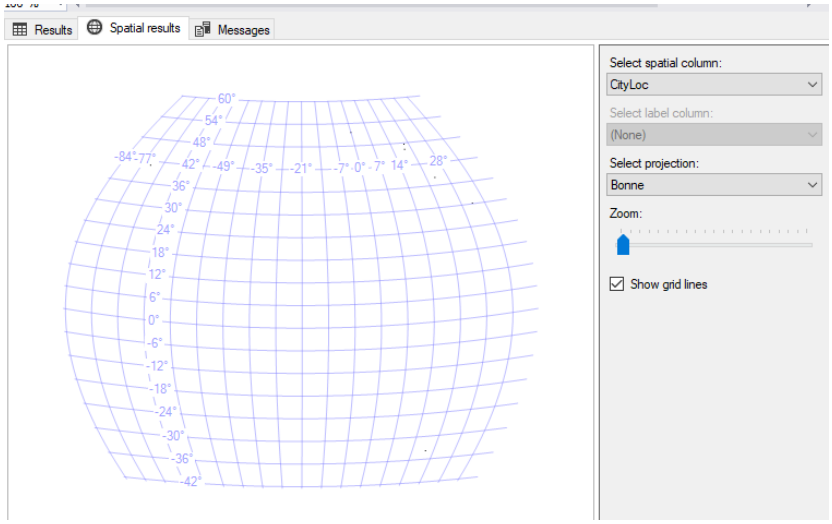
# The result




The distance between two city is calculated with STDISTANCE() function

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# The distances between cities

```
SELECT
C1.CityName As City1, C2.CityName AS City2,
 ROUND(C1.CityLoc.STDistance(C2.CityLoc)/1000,2) AS Km
FROM City AS C1 JOIN City AS C2 ON C1.CityID<C2.CityID
ORDER BY C1.CityID;
```

Results | Messages

| | City1 | City2 | Km |
|---|---|---|---|
| 1 | Budapest | Pécs | 163,94 |
| 2 | Budapest | London | 1454,51 |
| 3 | Budapest | Athens | 1125,11 |
| 4 | Budapest | New York | 7027,36 |
| 5 | Budapest | Cape Town | 9018,44 |
| 6 | Budapest | Cairo | 2202,07 |
| 7 | Pécs | London | 1474,88 |
| 8 | Pécs | Athens | 1010,07 |
| 9 | Pécs | New York | 7059,6 |
| 10 | Pécs | Cape Town | 8864,81 |
| 11 | Pécs | Cairo | 2108,71 |
| 12 | London | Athens | 2396,11 |
| 13 | London | New York | 5585,27 |
| 14 | London | Cape Town | 9635,63 |
| 15 | London | Cairo | 3513,89 |
| 16 | Athens | New York | 7945,69 |
| 17 | Athens | Cape Town | 7978,51 |
| 18 | Athens | Cairo | 1118,89 |
| 19 | New York | Cape Town | 12552,02 |
| 20 | New York | Cairo | 9040,98 |
| 21 | Cape Town | Cairo | 7206,9 |

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Thank you for your attention!