

Seminar 5

Performance Tuning in SQL Server

Query Tuning Methodology

- identify waits (bottleneck) at the server level
 - locks
 - transaction log
 - I/O
 - etc.
- correlate waits with queues
- drill down to database / file level
- drill down to process level
- tune problematic queries
- * DMVs - dynamic management views

Identify Waits

- `sys.dm_os_wait_stats`

- returned table

- `wait_type`

- resource waits (locks, latches, network, I/O), queue waits, external waits

- `waiting_tasks_count`

- `wait_time_ms`

- `max_wait_time_ms`

- `signal_wait_time_ms`

- reset DMV values

- `DBCC SQLPERF ('sys.dm_os_wait_stats', CLEAR);`

Correlate Waits with Queues

- **sys.dm_os_performance_counters**
 - *object_name* - the category of the counter
 - *counter_name* - the name of the counter
 - *instance_name* - the name of the specific instance of the counter; often contains the name of the database
 - *cntr_value* - the current value of the counter
 - *cntr_type* - the type of the counter (as defined by the Windows performance architecture)

Correlate Waits with Queues

- **sys.dm_os_performance_counters**
- > 500 counters: Access Methods, User Settable, Buffer Manager, Broker Statistics, SQL Errors, Latches, Buffer Partition, SQL Statistics, Locks, Buffer Node, Plan Cache, Cursor Manager by Type, Memory Manager, General Statistics, Databases, Catalog Metadata, Broker Activation, Broker/DBM Transport, Transactions, Cursor Manager Total, Exec Statistics, Wait Statistics, etc.
- *cntr_type* = 65792 → *cntr_value* contains the actual value

Correlate Waits with Queues

- `sys.dm_os_performance_counters`
- `cntr_type = 537003264` → `cntr_value` contains real-time results, which are divided by a “base” to obtain the actual value; by themselves, they are useless
 - to get a ratio: divide by a “base” value
 - to get a percentage: multiply the result by 100.0

Correlate Waits with Queues

- `sys.dm_os_performance_counters`
- `cntr_type = 272696576`
 - time-based, cumulative counters
 - a secondary table can be used to log intermediate values

Correlate Waits with Queues

- `sys.dm_os_performance_counters`
- `cntr_type = 1073874176` and `cntr_type = 1073939712` → poll both the value (1073874176) and the base value (1073939712)
- poll both values again (e.g., after 15 seconds) ☺
- to obtain the desired result, compute:
$$\text{UnitsPerSec} = (\text{cv2} - \text{cv1}) / (\text{bv2} - \text{bv1}) / 15.0$$

Drill Down to Database / File Level

■ `sys.dm_io_virtual_file_stats`

- returns I/O information about *data files* and *log files*

■ parameters

■ `database_ID`

- NULL = all databases
- useful function: DB_ID

■ `file_ID`

- NULL = all files
- useful function: FILE_IDEX

Drill Down to Database / File Level

■ `sys.dm_io_virtual_file_stats`

■ returned table

- `database_ID`
- `file_ID`
- `sample_ms` - # of milliseconds since the computer was started
- `num_of_reads` - number of reads issued on the file
- `num_of_bytes_read` - number of bytes read on the file
- `io_stall_read_ms` - total time users waited for reads issued on the file

Drill Down to Database / File Level

■ `sys.dm_io_virtual_file_stats`

■ returned table

- `num_of_writes` - number of writes
- `num_of_bytes_written` - total number of bytes written to the file
- `io_stall_write_ms` - total time users waited for writes to be completed on the file
- `io_stall` - total time users waited for the completion of I/O operations (ms)
- `file_handle`

Drill Down to the Process Level

- a filter on duration / I/O only isolates individual processes (batch / proc / query)
- aggregate performance information by query pattern
 - patterns can be easily identified when using stored procedures
 - when one doesn't use stored procedures:
 - quick and dirty approach: LEFT(query string, n)
 - use a parser to identify the query pattern

Indexes

- one of the major factors influencing query performance
 - impact on: filtering, joins, sorting, grouping; blocking and deadlock avoidance, etc.
 - effect on modifications: positive effect (locating the rows); negative effect (cost of modifying the index)
- understanding indexes and their internal mechanisms
 - clustered/nonclustered, single/multicolumn, indexed views, indexes on computed columns, covering scenarios, intersection

Indexes

- one should carefully judge whether additional index maintenance costs are justified by improvements in query performance
 - take into account the environment and the ratio between SELECT queries and data modifications
- *multicolumn indexes*
 - tend to be more useful than single-column indexes
 - the query optimizer is more likely to use such indexes to cover a query

Indexes

- *indexed views* come with a higher maintenance cost than standard indexes
 - mandatory option
 - WITH SCHEMABINDING

Tools to Analyze Query Performance

- graphical execution plan
- STATISTICS IO - scan count, logical reads, physical reads, *read-ahead* reads
- STATISTICS TIME - duration and net CPU time
- SHOWPLAN_TEXT - SQL Server returns detailed information about how the statements are executed
- SHOWPLAN_ALL - SQL Server returns detailed information about how the statements are executed, provides estimates of the resource requirements

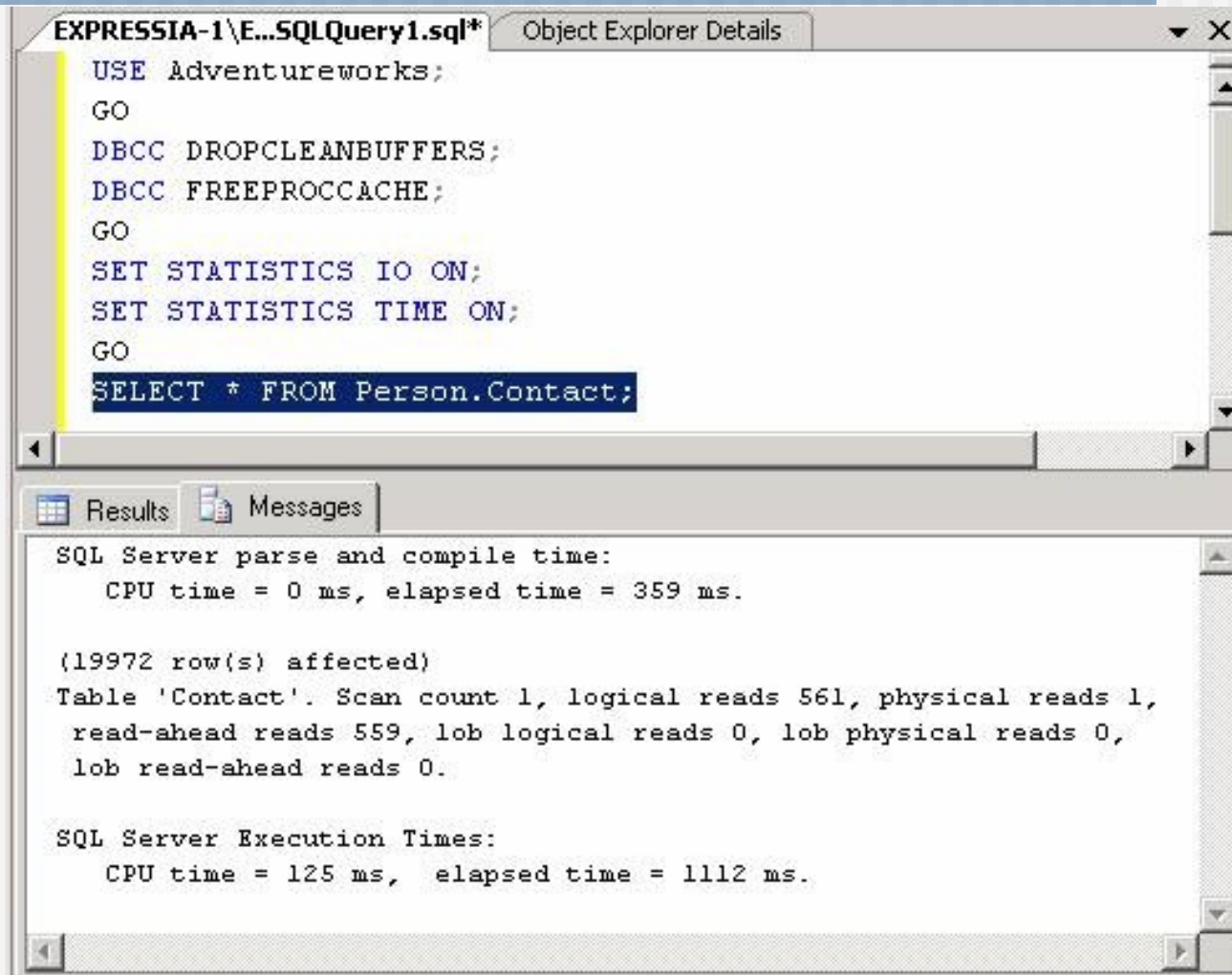
Tools to Analyze Query Performance

- STATISTICS PROFILE - a profile of the query execution
- STATISTICS XML - actual plan information in XML format
- SHOWPLAN_XML - estimated plan information in XML format

Query Optimization

- evaluating execution plans
 - sequences of physical/logical operations
- optimization - factors
 - search predicate
 - tables involved in joins
 - join conditions
 - result set size
 - list of indexes
- goal - avoid worst query plans
- SQL Server uses a *cost-based* query optimizer

STATISTICS IO and STATISTICS TIME



The screenshot shows a SQL Server Enterprise Manager window titled 'EXPRESSIA-1\E...SQLQuery1.sql*'. The query window contains the following SQL code:

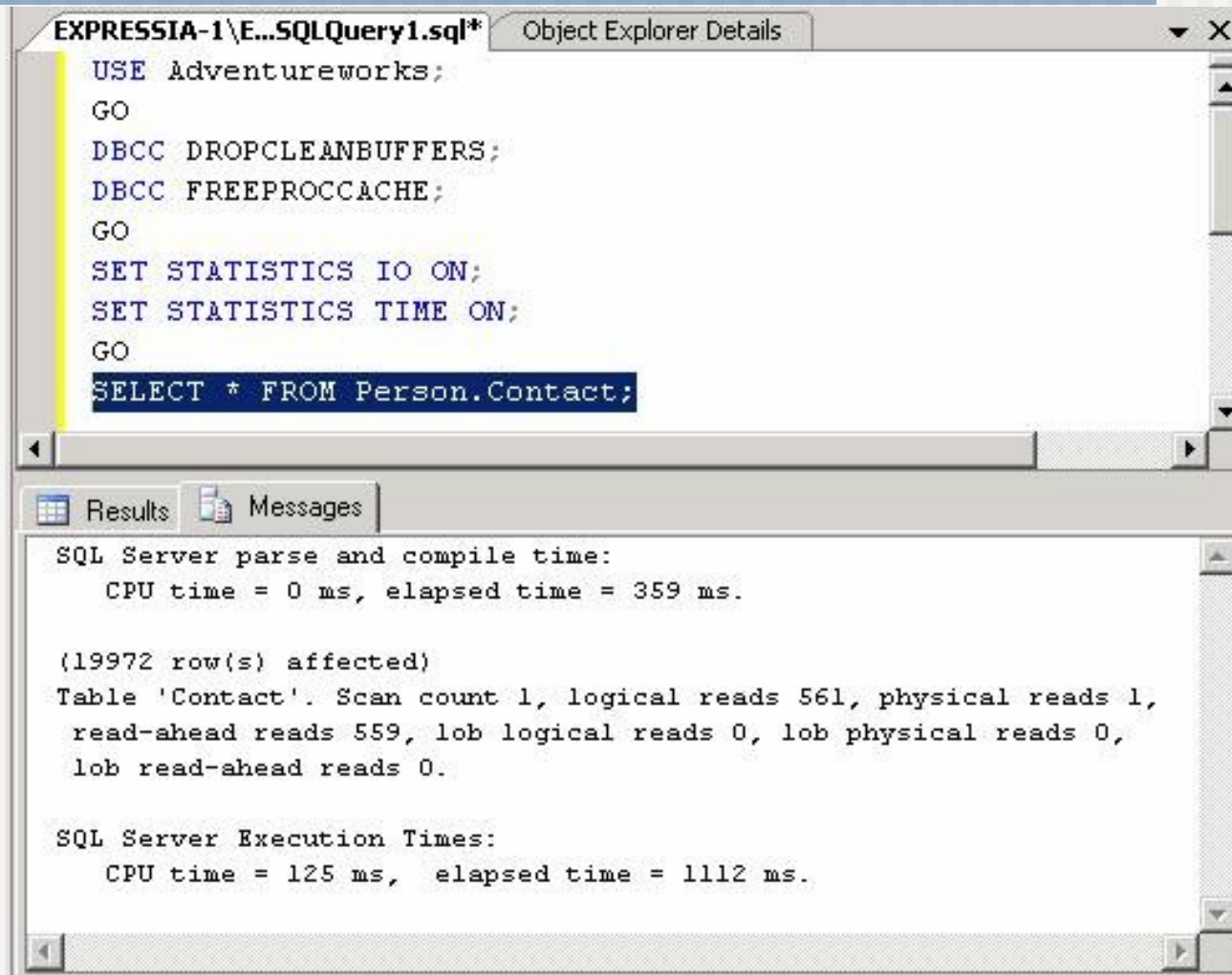
```
USE Adventureworks;  
GO  
DBCC DROPCLEANBUFFERS;  
DBCC FREEPROCCACHE;  
GO  
SET STATISTICS IO ON;  
SET STATISTICS TIME ON;  
GO  
SELECT * FROM Person.Contact;
```

The 'Results' tab is selected, displaying the following output:

```
SQL Server parse and compile time:  
    CPU time = 0 ms, elapsed time = 359 ms.  
  
(19972 row(s) affected)  
Table 'Contact'. Scan count 1, logical reads 561, physical reads 1,  
    read-ahead reads 559, lob logical reads 0, lob physical reads 0,  
    lob read-ahead reads 0.  
  
SQL Server Execution Times:  
    CPU time = 125 ms,  elapsed time = 1112 ms.
```

- DBCC DROPCLEANBUFFERS – clear data from the cache
- DBCC FREEPROCCACHE – clear execution plans from the cache

STATISTICS IO and STATISTICS TIME



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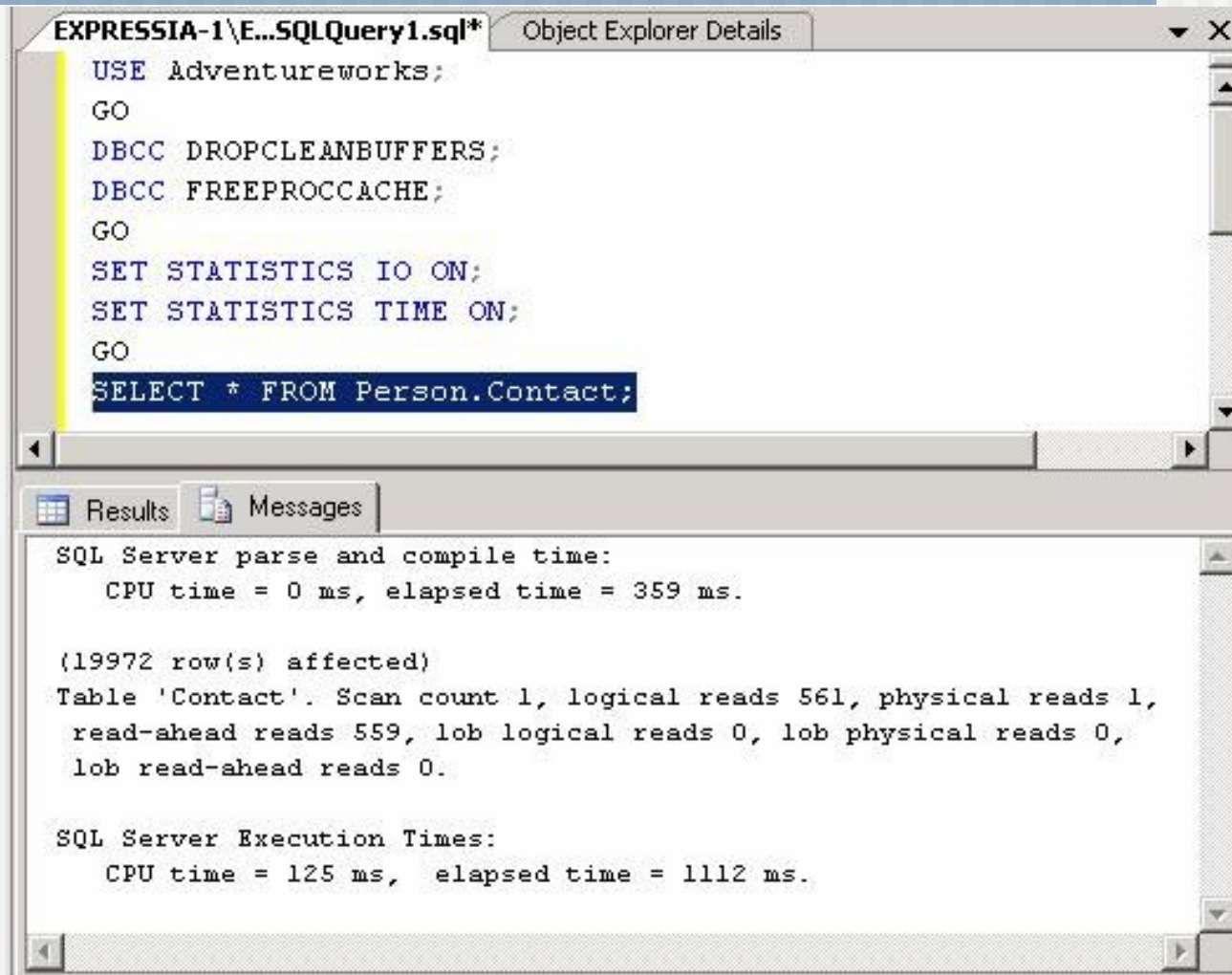
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SQL Server Execution Times:  
    CPU time = 125 ms,  elapsed time = 1112 ms.
```

- *CPU time, elapsed time* – CPU time and elapsed time to parse and compile the query, and to execute it

STATISTICS IO and STATISTICS TIME



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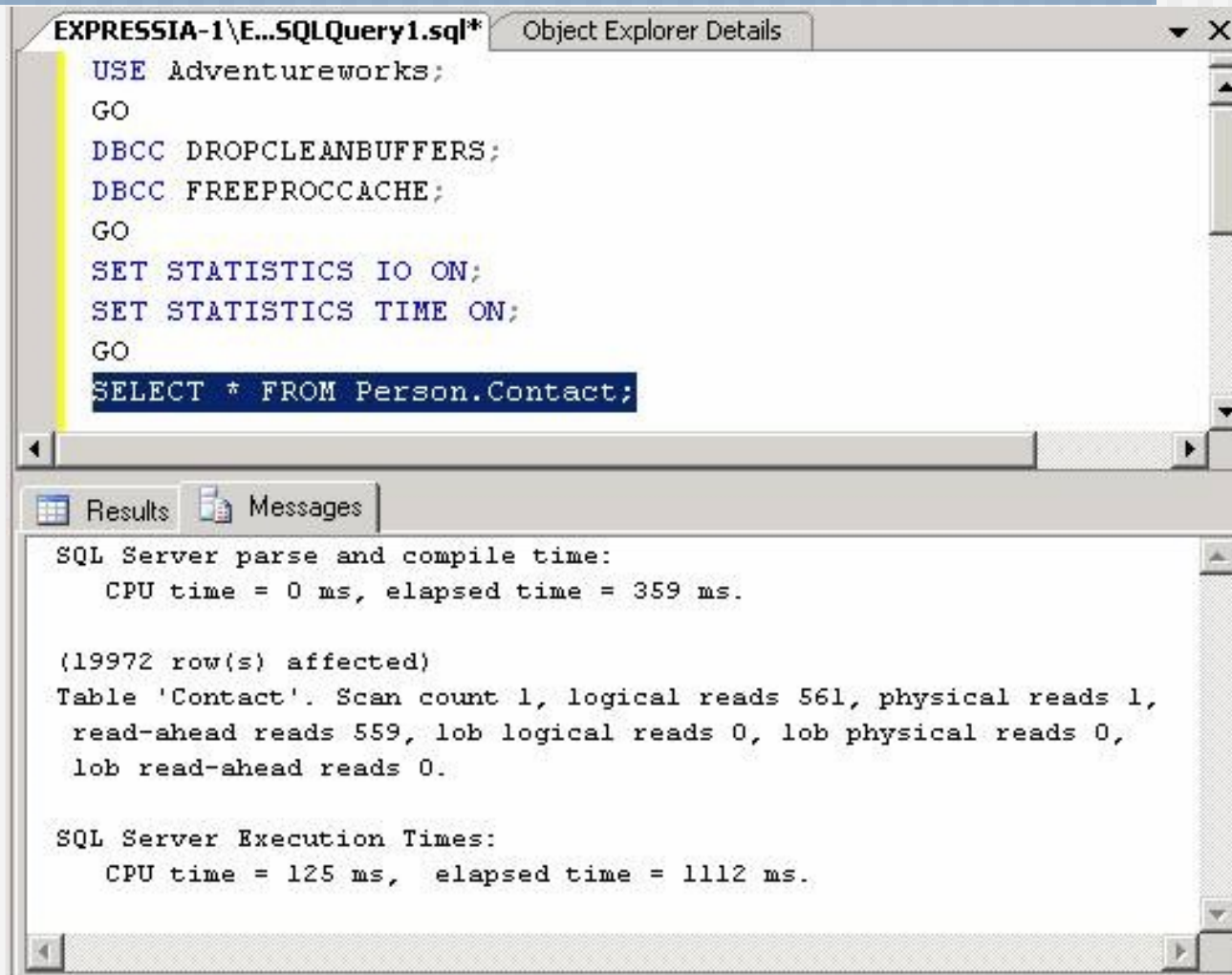
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GO  
DBCC DROPCLEANBUFFERS;  
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GO  
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    lob read-ahead reads 0.  
  
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```

- *physical reads* - number of pages read from the disk
- *read-ahead reads* - number of pages placed in the cache for the query

STATISTICS IO and STATISTICS TIME



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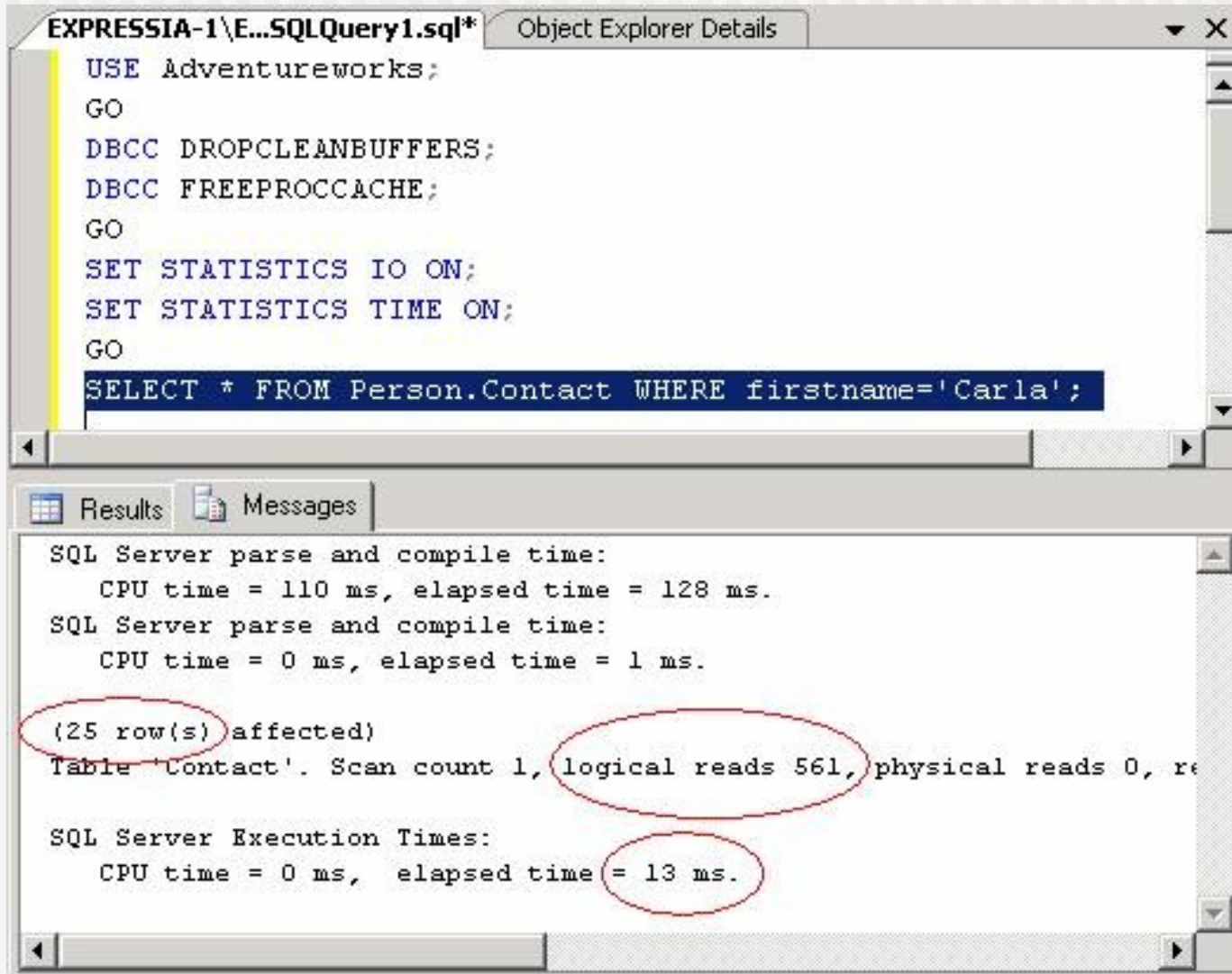
```
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GO  
DBCC DROPCLEANBUFFERS;  
DBCC FREEPROCCACHE;  
GO  
SET STATISTICS IO ON;  
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    lob read-ahead reads 0.  
  
SQL Server Execution Times:  
    CPU time = 125 ms,  elapsed time = 1112 ms.
```

- *scan count* - number of seeks or scans after reaching the leaves
- *logical reads* - number of pages read from the data cache

STATISTICS IO and STATISTICS TIME



The screenshot shows a SQL Server Enterprise Manager window with a query window titled "EXPRESSIA-1\E...SQLQuery1.sql*" and an "Object Explorer Details" pane. The query window contains the following SQL code:

```
USE Adventureworks;  
GO  
DBCC DROPCLEANBUFFERS;  
DBCC FREEPROCCACHE;  
GO  
SET STATISTICS IO ON;  
SET STATISTICS TIME ON;  
GO  
SELECT * FROM Person.Contact WHERE firstname='Carla';
```

Below the query window, the "Results" pane shows the execution statistics for the query. The statistics are as follows:

```
SQL Server parse and compile time:  
  CPU time = 110 ms, elapsed time = 128 ms.  
SQL Server parse and compile time:  
  CPU time = 0 ms, elapsed time = 1 ms.  
(25 row(s) affected)  
Table 'Contact'. Scan count 1, logical reads 561, physical reads 0, re  
SQL Server Execution Times:  
  CPU time = 0 ms, elapsed time = 13 ms.
```

Red circles highlight the following values in the results:

- (25 row(s) affected)
- logical reads 561
- elapsed time = 13 ms.

STATISTICS IO and STATISTICS TIME

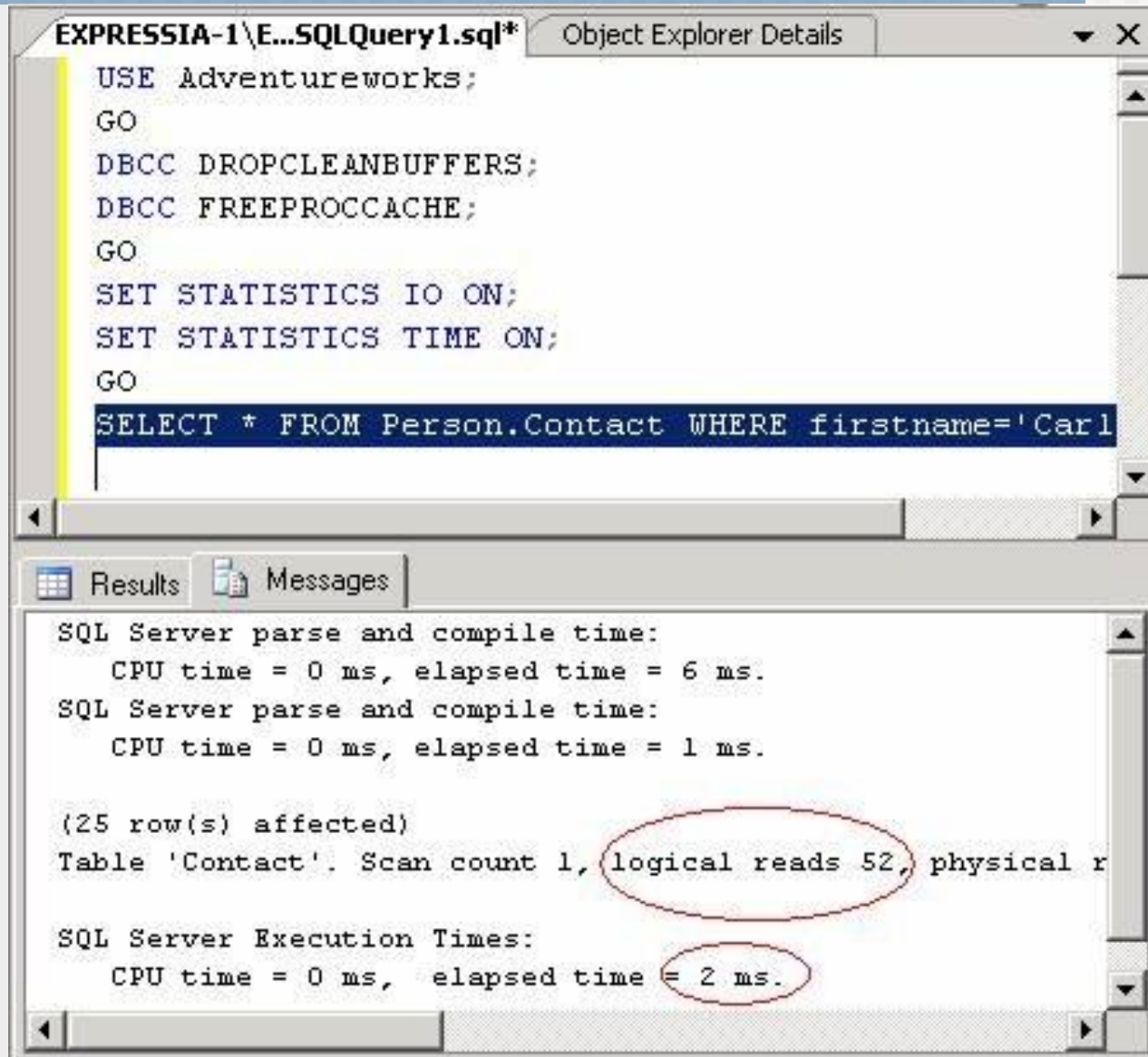
```
USE AdventureWorks
```

```
GO
```

```
CREATE NONCLUSTERED INDEX IDX_FirstName  
    ON Person.Contact (FirstName ASC)
```

```
GO
```


STATISTICS IO and STATISTICS TIME



The screenshot shows a SQL query window with the following text:

```
USE Adventureworks;
GO
DBCC DROPLEANBUFFERS;
DBCC FREEPROCCACHE;
GO
SET STATISTICS IO ON;
SET STATISTICS TIME ON;
GO
SELECT * FROM Person.Contact WHERE firstname='Carl'
```

Below the query window, the 'Results' tab is selected, displaying the following execution statistics:

```
SQL Server parse and compile time:
    CPU time = 0 ms, elapsed time = 6 ms.
SQL Server parse and compile time:
    CPU time = 0 ms, elapsed time = 1 ms.

(25 row(s) affected)
Table 'Contact'. Scan count 1, logical reads 52, physical r

SQL Server Execution Times:
    CPU time = 0 ms, elapsed time = 2 ms.
```

In the statistics output, the values 'logical reads 52' and 'elapsed time = 2 ms.' are circled in red.

Graphical Execution Plan

```
USE AdventureWorks
GO
SELECT COUNT(*) cRows
FROM HumanResources.Shift;
GO
```

Results Execution plan

Query 1: Query cost (relative to the batch): 100%
SELECT COUNT(*) cRows FROM HumanResources.Shift;



SHOWPLAN_ALL

```
SET SHOWPLAN_ALL ON;  
GO  
SELECT COUNT(*) cRows  
FROM HumanResources.Shift;  
GO  
SET SHOWPLAN_ALL OFF;  
GO
```

Results

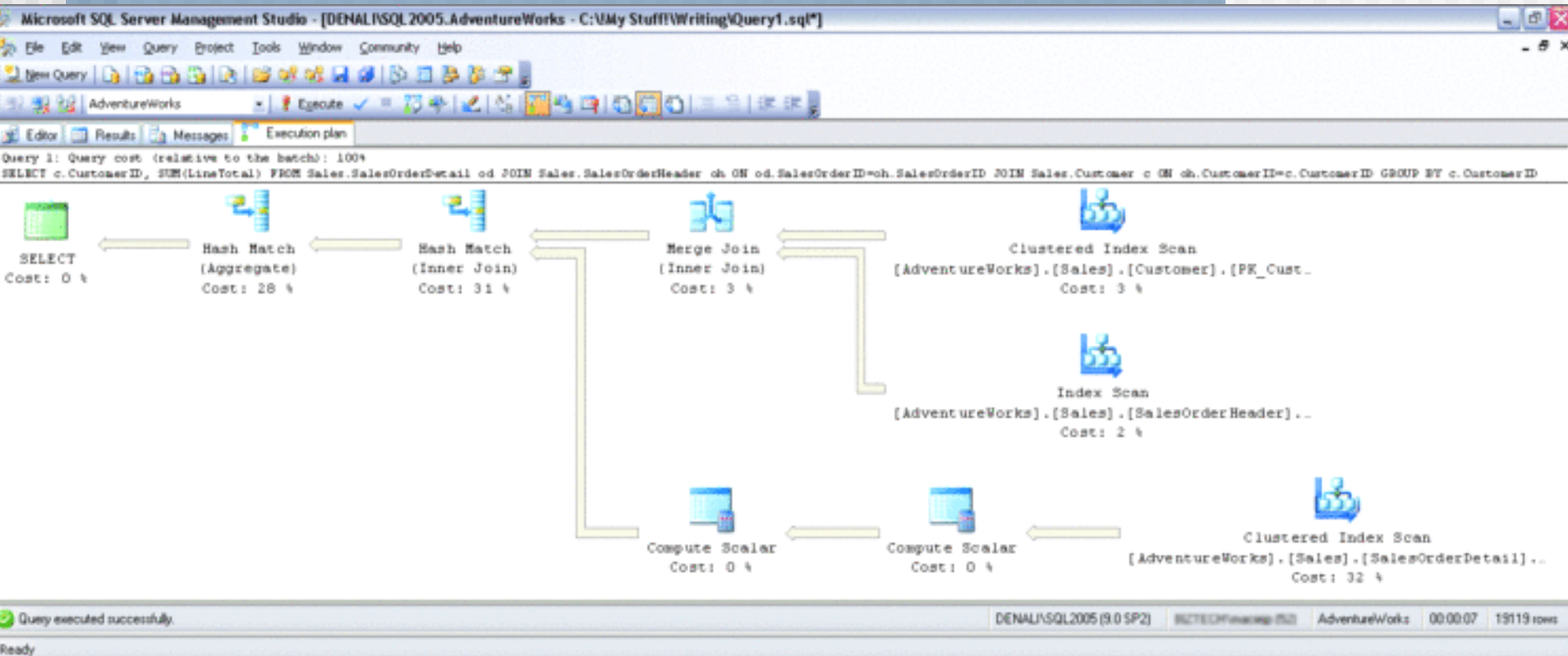
StmtText

```
-----  
SELECT COUNT(*) cRows  
FROM HumanResources.Shift;  
|--Compute Scalar(DEFINE:([Expr1003]=CONVERT_IMPLICIT(int,[Expr1004],0)))  
--Stream Aggregate(DEFINE:([Expr1004]=Count(*)))  
|--Index Scan(OBJECT:([master].[HumanResources].[Shift].[AK_Shift])  
  
(4 row(s) affected)
```

Graphical Execution Plan

```
SELECT c.CustomerID, SUM(LineTotal)
FROM Sales.SalesOrderDetail od
    JOIN Sales.SalesOrderHeader oh ON
        od.SalesOrderID = oh.SalesOrderID
    JOIN Sales.Customer c ON
        oh.CustomerID = c.CustomerID
GROUP BY c.CustomerID
```

Graphical Execution Plan



Graphical Execution Plan



SELECT

Cost: 0 %



Hash Match
(Aggregate)

SELECT

Cached plan size	40 B
Degree of Parallelism	0
Memory Grant	812
Estimated Operator Cost	0 (0%)
Estimated Subtree Cost	3,31365
Estimated Number of Rows	19045

Statement

```
SELECT c.CustomerID, SUM(LineTotal)
FROM Sales.SalesOrderDetail od JOIN
Sales.SalesOrderHeader oh
ON od.SalesOrderID=oh.SalesOrderID
JOIN Sales.Customer c ON
oh.CustomerID=c.CustomerID
GROUP BY c.CustomerID
```



Clustered Index Scan

[AdventureWorks].[Sales].[SalesOrderDetail]...

Cost: 32 %

Clustered Index Scan

Scanning a clustered index, entirely or only a range.

Physical Operation	Clustered Index Scan
Logical Operation	Clustered Index Scan
Actual Number of Rows	121317
Estimated I/O Cost	0,915718
Estimated CPU Cost	0,133606
Estimated Operator Cost	1,04932 (32%)
Estimated Subtree Cost	1,04932
Estimated Number of Rows	121317
Estimated Row Size	29 B
Actual Rebinds	0
Actual Rewinds	0
Ordered	False
Node ID	8

Object

[AdventureWorks].[Sales].[SalesOrderDetail].
[PK_SalesOrderDetail_SalesOrderID_SalesOrderDetailID]
[od]

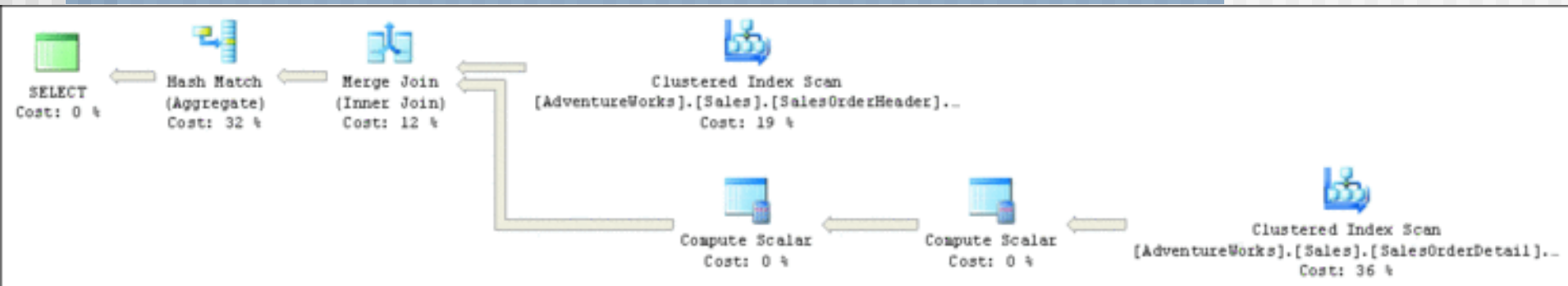
Output List

[AdventureWorks].[Sales].
[SalesOrderDetail].SalesOrderID; [AdventureWorks].
[Sales].[SalesOrderDetail].OrderQty; [AdventureWorks].
[Sales].[SalesOrderDetail].UnitPrice; [AdventureWorks].
[Sales].[SalesOrderDetail].UnitPriceDiscount

Graphical Execution Plan

```
SELECT oh.CustomerID, SUM(LineTotal)
FROM Sales.SalesOrderDetail od
      JOIN Sales.SalesOrderHeader oh ON
          od.SalesOrderID=oh.SalesOrderID
GROUP BY oh.CustomerID
```

Graphical Execution Plan



Graphical Execution Plan

```
CREATE INDEX IDX_OrderDetail_OrderID_TotalLine  
ON Sales.SalesOrderDetail (SalesOrderID)  
INCLUDE (LineTotal)
```

