



# SQL Server Plan Caching and Query Store

Module 8

## Learning Units covered in this Module

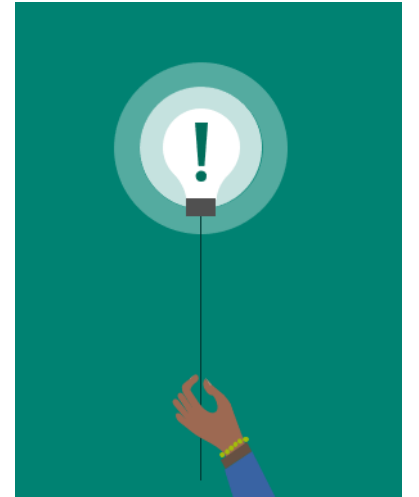
- Lesson 1: SQL Server Plan Cache
- Lesson 2: SQL Server Query Store

# Lesson 1: SQL Server Plan Cache

# Objectives

After completing this learning, you will be able to:

- Describe the purpose and contents of the plan cache.
- Query the plan cache using Dynamic Management Objects.
- Discuss the pros and cons of plan reuse.
- Explain why *ad hoc* SQL statements can be especially problematic.



# The Plan Cache

A pool of memory used to store query execution plans

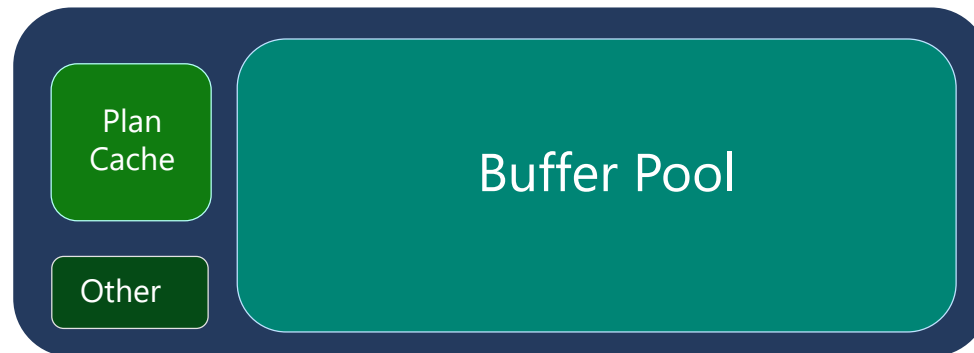
Used by all databases in a SQL Server instance

Exists to avoid repeated optimization and compilation

Reuse of reduce optimization and compilation costs

Size and contents vary over time.

SQL Server's  
Memory



With a fixed amount of memory, when the plan cache grows the buffer pool shrinks and vice-versa

# Plan Cache Contents

## Object plans:

- Stored procedures, functions, triggers

## SQL Plans:

- Prepared plans and *ad hoc* plans

## Other:

- Bound trees and extended stored procedure references

## Granularity:

- Execution plans are per-statement (not object).

## Plans per Statement:

- Multiple plans for a single statement may exist if differing execution contexts were used or if a parallel plan was generated.

# Dynamic Management Views and Functions

Category	Description
sys.dm_exec_%	Execution and connection information
sys.dm_os_%	Operating system related information
sys.dm_tran_%	Transaction management information
sys.dm_io_%	I/O related information
sys.dm_db_%	Database information

# Dynamic Management Objects

`sys.dm_exec_cached_plans`

- Plan type, size and handle

`sys.dm_exec_query_stats`

- Execution metrics for individual statements

`sys.dm_exec_query_plan()`

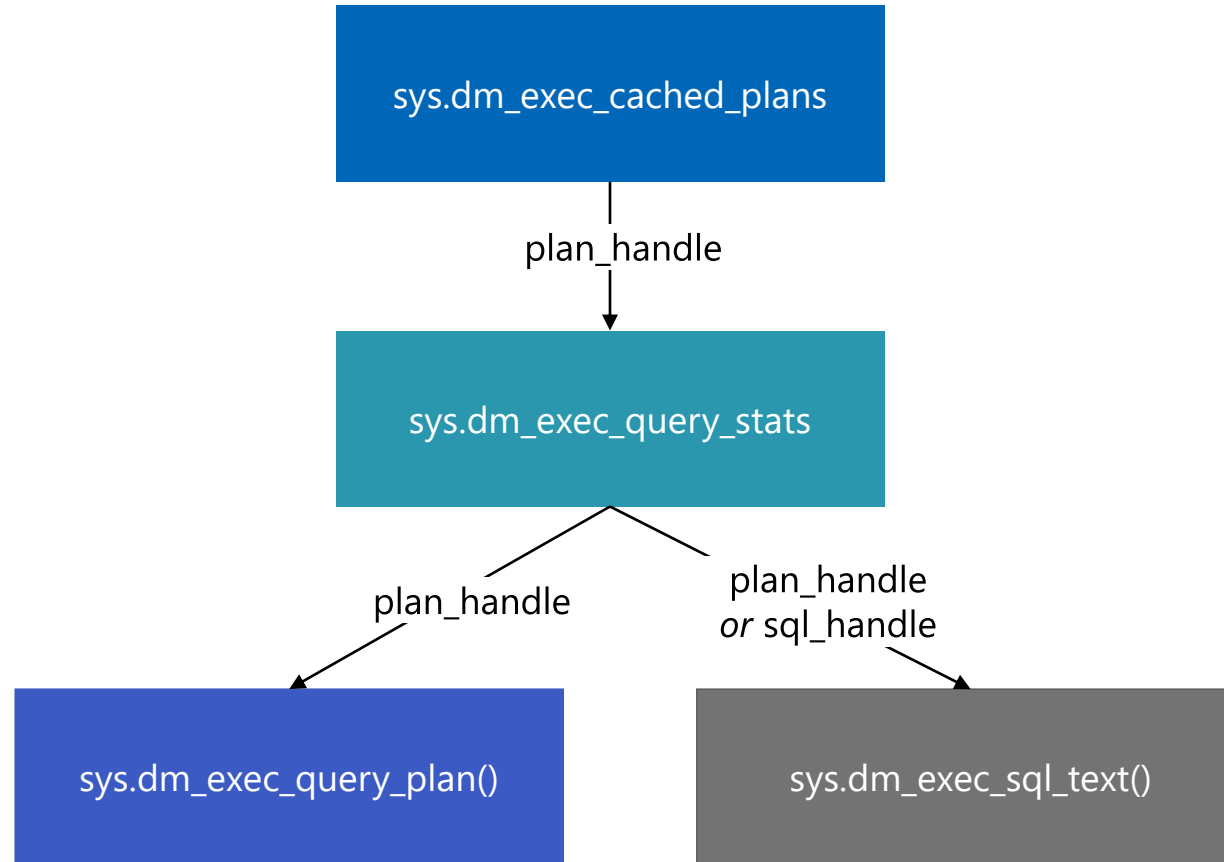
- Takes a plan\_handle and returns the associated XML plan

`sys.dm_exec_sql_text()`

- Takes a plan\_handle or sql\_handle and returns the associated SQL batch

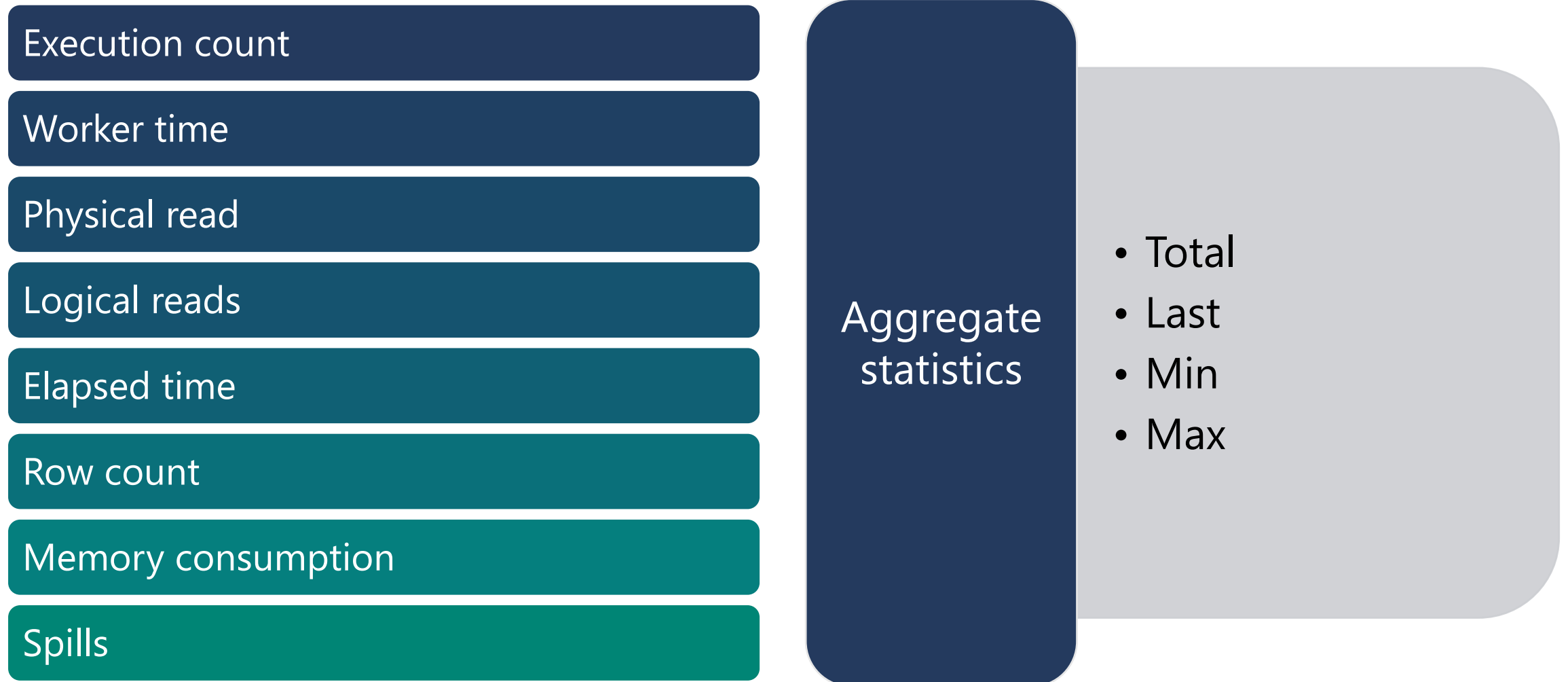


# Relationships between DMOs



# Captured Metrics (sys.dm\_exec\_query\_stats )

Partial listing



Compute Average:  $\text{Avg} = \text{Total} / \text{Execution count}$

# Mining the Plan Cache with T-SQL

Top 10 plans by logical reads

```
SELECT CASE st.dbid WHEN 32767 THEN 'resourcedb'
        WHEN NULL THEN 'NA' ELSE DB_NAME(st.dbid)END AS [database], OBJECT_NAME(st.objectid) AS object_name,
        SUBSTRING( st.text, ( qs.statement_start_offset / 2 ) + 1,
        (( CASE qs.statement_end_offset WHEN -1 THEN DATALength(st.text)
```

FROM

Results Messages								
	database	object_name	sql_statement	exec_count	avg_logical_reads	avg_CPU_ms	avg_time_ms	
1	AdventureWorksPTO	NULL	SELECT * FROM [Production].[BillOfMaterials]	3	22	3	298	
2	AdventureWorksPTO	NULL	SELECT * FROM [Production].[BillOfMaterials] WHERE...	2	22	12	449	
3	AdventureWorksPTO	NULL	SELECT * FROM [Production].[BillOfMaterials] WHERE...	2	15	1	3	
4	AdventureWorksPTO	NULL	SELECT * FROM [Production].[Product] WHERE Name ...	1	12	1	6	
5	AdventureWorksPTO	NULL	SELECT * FROM [HumanResources].[Employee]	5	9	6	219	
6	AdventureWorksPTO	NULL	SELECT * FROM [Production].[Product] WHERE [Produ...	1	4	0	6	
7	AdventureWorksPTO	NULL	SELECT * FROM [sales].[salesorderheader] WHERE [S...	10	3	0	1	
8	AdventureWorksPTO	NULL	SELECT * FROM [sales].[salesorderdetail] WHERE [Sal...	5	3	0	1	

```
FROM sys.dm_exec_query_stats
ORDER BY ( total_logical_reads / execution_count ) DESC ) AS qs
CROSS APPLY sys.dm_exec_sql_text(qs.plan_handle) st
CROSS APPLY sys.dm_exec_query_plan(qs.plan_handle) qp
ORDER BY qs.avg_logical_reads DESC
OPTION ( RECOMPILE );
```

# Cache Plan Bloat

Caused by *ad hoc* SQL

Heavy *ad hoc* workloads can bloat the plan cache

No benefit to caching single-use, ad hoc plans

Enable “optimize for ad hoc workload” to keep single-use plans out of the cache

```
-- Plan cache content
SELECT objtype, COUNT(*) AS count, AVG(used_kb) AS avg_kb, SUM(CAST(used_kb AS float)) AS sum_kb
FROM sys.dm_exec_query_plan
WHERE cacheobjtype = 1
GROUP BY objtype;
```

	objtype	count	avg_kb	sum_kb
1	Adhoc	1	250	250
2	Prep	1	5000	5000
3	Proc	1	937	937

```
EXEC sp_configure 'optimize for ad hoc workload', 1;
GO
RECONFIGURE
GO
```

```
1024) AS size_mb,
single_use_plans,
```

# Clearing the Plan Cache

Not always the best option!

The entire plan cache – all databases

- `DBCC FREEPROCCACHE;`

All plans of a specific type

- `DBCC FREESYSTEMCACHE ('SQL Plans');`

All plans for a single database

- `ALTER DATABASE SCOPED CONFIGURATION CLEAR PROCEDURE_CACHE;`

A specific plan

- `ALTER DATABASE SCOPED CONFIGURATION CLEAR PROCEDURE_CACHE(<plan_handle>);`

Performance impact as new plans are compiled

# Clearing the Plan Cache

Not your first option!

The screenshot shows the SQL Server Enterprise Manager interface. The top pane displays a query in the 'SQLQuery19.sql' file. The query is as follows:

```
5 SELECT plan_handle, st.text
6 FROM sys.dm_exec_cached_plans
7 CROSS APPLY sys.dm_exec_sql_text(plan_handle) AS st
8 WHERE text LIKE N'SELECT * FROM Person.Address%';
```

The bottom pane shows the 'Results' tab, which is currently empty. The 'Messages' tab is also visible. The interface includes a toolbar with a zoom level set to 200% and a scroll bar.

# Plan Reuse

Requires that SQL statements match exactly

- Any difference in casing, white space or literal values will affect a hashed value

Less likely for *ad hoc* SQL statements

- Simple (on by default) or Forced Parameterization can improve reuse

Most easily achieved using:

- Stored procedures, Functions, Triggers
- Prepared statements and parameterized queries (sp\_executesql)

```
-- Small changes in case or white space yield differing hashes
SELECT HASHBYTES('MD5', 'SELECT * FROM Person.Person') UNION ALL
SELECT HASHBYTES('MD5', 'SELECT * FROM person.Person') UNION ALL
SELECT HASHBYTES('MD5', 'SELECT * FROM Person.Person')
/*
    0xF2D4F28DA93156A5BB487B019F1F0191
    0x76F700BB3DC09FF482E1E4A77C7392E8
    0xB1D875A858F4D410D9E866C40E523683
*/
```

# Plan Reuse

## Benefit

- Improved performance as reuse saves time and CPU

## Drawback

- Degraded performance when reused plan is not optimal for all parameter values

## Parameter Sniffing

- Optimizer's ability to see (sniff) parameter values at compile time and so create a cost-effective execution plan.
- This is generally beneficial.
- Only problematic when compile parameters aren't representative

## Recompile hints

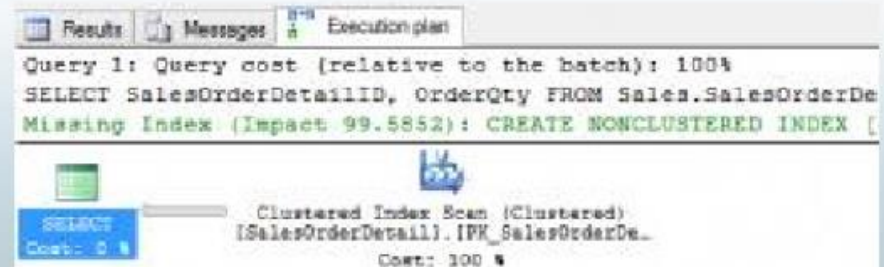
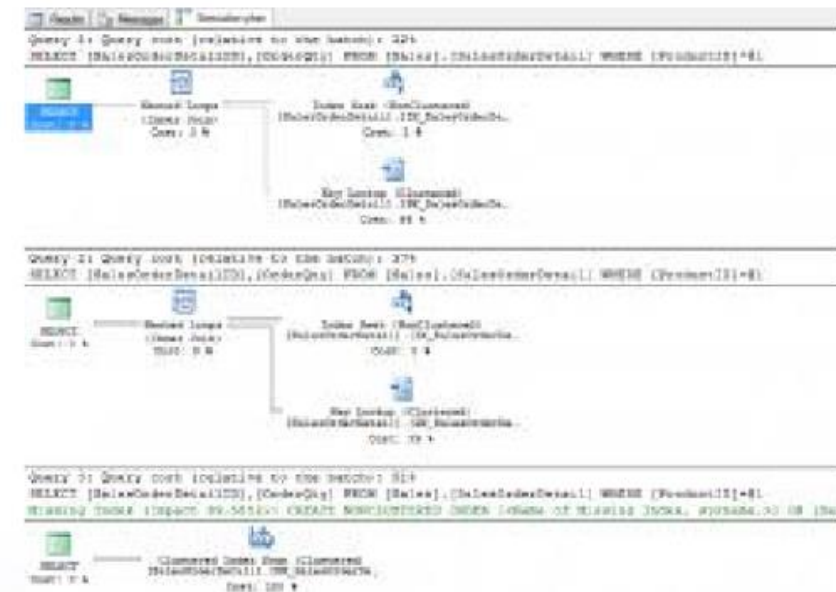
- Prevent caching of plans at the object or statement (preferred) level
- `sp_recompile <object_name>` to manually force recompilation



# Parameter Sniffing

```
1 SELECT SalesOrderDetailID, OrderQty
2 FROM Sales.SalesOrderDetail
3 WHERE ProductID = 897
4
5 SELECT SalesOrderDetailID, OrderQty
6 FROM Sales.SalesOrderDetail
7 WHERE ProductID = 945
8
9 SELECT SalesOrderDetailID, OrderQty
10 FROM Sales.SalesOrderDetail
11 WHERE ProductID = 870
```

```
1 CREATE PROCEDURE Get_OrderQuantity
2 (@ProductID int)
3 AS
4 SELECT SalesOrderDetailID, OrderQty
5 FROM Sales.SalesOrderDetail
6 WHERE ProductID = @ProductID
```



# Demonstration

## Caching and Parameter sniffing

- Caching and reuse of *ad hoc* vs. stored procedure query plans
- Parameter sniffing
- Querying the plan cache



Questions?



# Knowledge Check

Is the size of the plan cache fixed?

How long do query plans remain in the plan cache?

Why is plan caching helpful?

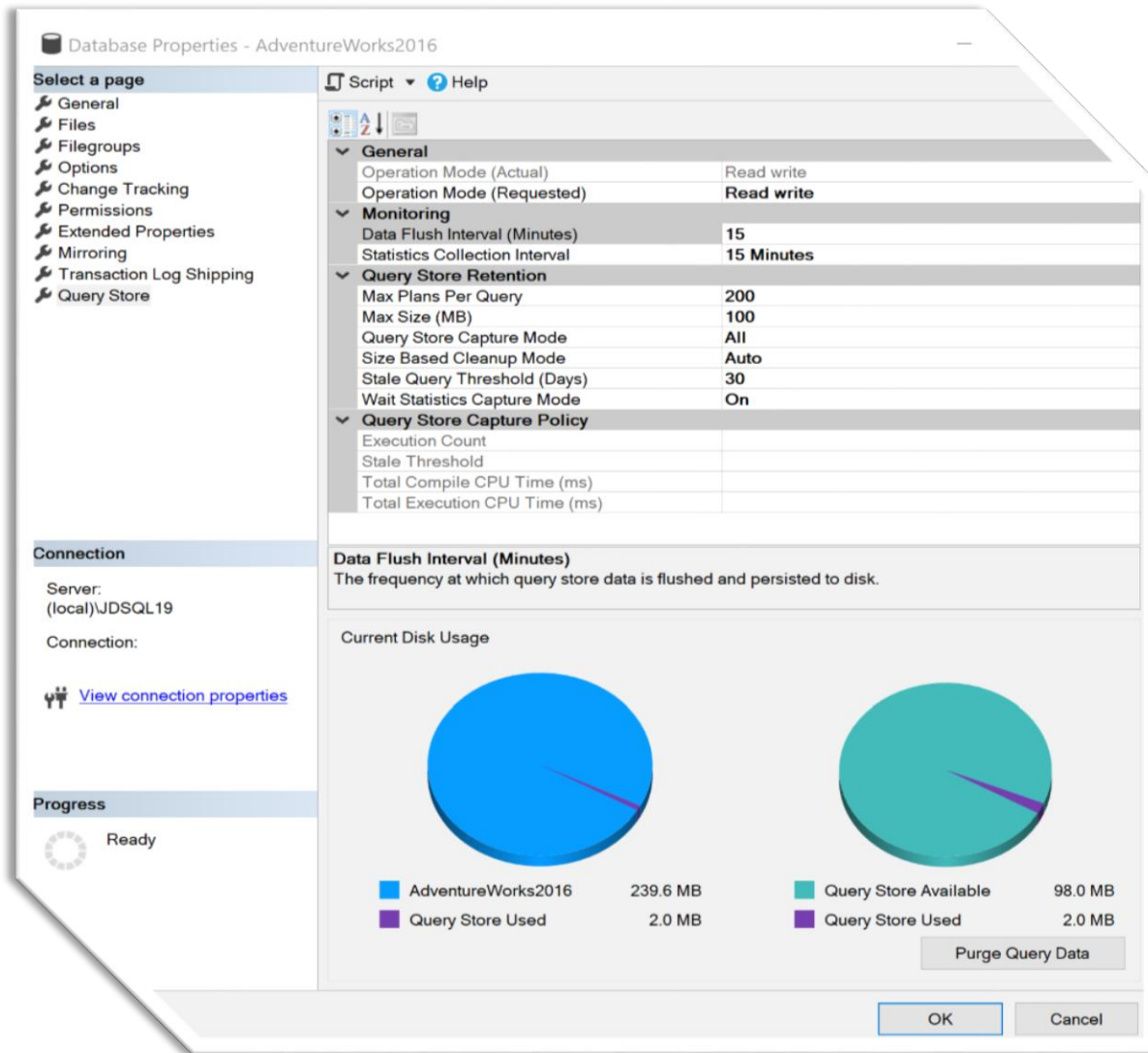
Why are *ad hoc* query plans sometimes problematic?

What can be done to lessen the impact of an *ad hoc* workload?

What can be done to address a parameter sniffing issue?

## Lesson 2: SQL Server Query Store

# Introducing the Query Store



Query Store is set at the database level

Cannot be used for Master or TempDB system databases but can be enabled for the Model and MSDB system databases.

The user database stores the data in internal tables that can be accessed by using built-in Query Store views.

SQL Server retains this data until the space allocated to Query Store is full or manually purged.



# Why use Query Store?

## Before Query Store

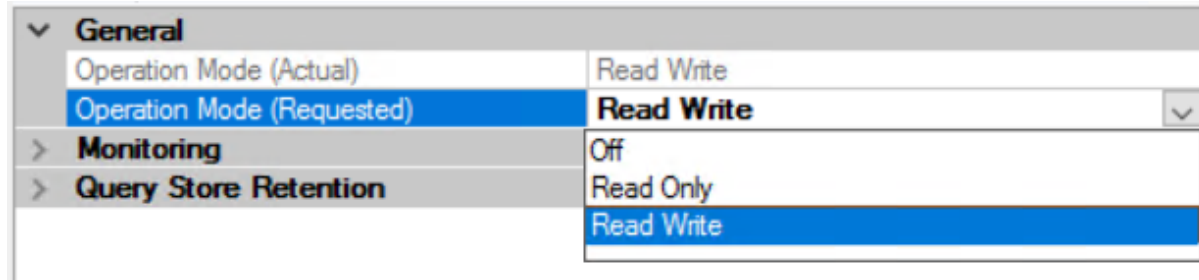
- Requires manual proactive monitoring to identify execution plan problems.
- Only the latest plan was stored in the procedure cache
- Restart caused data to be lost
- Frequent recompiles of procedures or use of DBCC FREEPROCACHE
- No history or aggregated gathering of data available.

## With Query Store

- It stores the history of the execution plans for each query
- It establishes a performance baseline for each plan over time
- It identifies queries that may have regressed
- It is possible to force plans quickly and easily
- It works across server restarts, upgrades, and query recompilation

# Query Store Operation Modes

**Operation Mode** can be set under database properties



**Operation Mode** can be enabled two ways using T-SQL. If only using the ON option, the Mode defaults to **Read\_Write**

```
ALTER DATABASE [AdventureWorks2016] SET QUERY_STORE = ON;
```

```
ALTER DATABASE [AdventureWorks2016] SET QUERY_STORE  
(OPERATION_MODE = READ_WRITE);
```



# Query Store Monitoring Settings

**Data Flush Interval** determines the frequency at which data written to the query store is persisted to disk.  
(Default is **15 Minutes**).

Monitoring	
Data Flush Interval (Minutes)	15
Statistics Collection Interval	1 Hour

```
ALTER DATABASE [AdventureWorks2016] SET QUERY_STORE  
(INTERVAL_LENGTH_MINUTES = 1,  
DATA_FLUSH_INTERVAL_SECONDS = 60)
```

# Query Store Monitoring Settings

**Statistics Collection Interval** determines the time interval at which runtime execution statistics data is aggregated into the query store. Only the values of 1, 5, 10, 15, 60, and 1440 minutes is allowed. (Default is **60**).

Monitoring	
Data Flush Interval (Minutes)	15
Statistics Collection Interval	1 Hour

```
ALTER DATABASE [AdventureWorks2016] SET QUERY_STORE  
(INTERVAL_LENGTH_MINUTES = 1,  
DATA_FLUSH_INTERVAL_SECONDS = 60)
```

# Query Store Retention Settings

**Max Plans Per Query** is a new retention setting introduced in SQL Server 2017 and is an integer representing the maximum number of plans maintained for each query. (Default is **200**).

▼ Query Store Retention	
Max Plans Per Query	200
Max Size (MB)	100
Query Store Capture Mode	Custom
Size Based Cleanup Mode	Auto
Stale Query Threshold (Days)	30
Wait Statistics Capture Mode	On

```
ALTER DATABASE AdventureWorks2016 SET QUERY_STORE  
(MAX_PLANS_PER_QUERY = 200,  
MAX_STORAGE_SIZE_MB = 100,  
QUERY_CAPTURE_MODE = AUTO,  
SIZE_BASED_CLEANUP_MODE = AUTO,  
CLEANUP_POLICY = (STALE_QUERY_THRESHOLD_DAYS = 367),  
WAIT_STATS_CAPTURE_MODE = ON);  
GO
```

# Query Store Retention Settings

**Max Size (MB)** configures the maximum storage size for the query store. (Default is **100MB**) When the query store limit is reached, query store changes the state from read-write to read-only.

▼ Query Store Retention	
Max Plans Per Query	200
Max Size (MB)	100
Query Store Capture Mode	Custom
Size Based Cleanup Mode	Auto
Stale Query Threshold (Days)	30
Wait Statistics Capture Mode	On

```
ALTER DATABASE AdventureWorks2016 SET QUERY_STORE  
(MAX_PLANS_PER_QUERY = 200,  
MAX_STORAGE_SIZE_MB = 100,  
QUERY_CAPTURE_MODE = AUTO,  
SIZE_BASED_CLEANUP_MODE = AUTO,  
CLEANUP_POLICY = (STALE_QUERY_THRESHOLD_DAYS = 367),  
WAIT_STATS_CAPTURE_MODE = ON);  
GO
```

# Query Store Retention Settings

**Query Store Capture Mode** determines to capture all the queries (Default is **ALL**), or relevant queries based on execution count and resource consumption (**AUTO**) or stop capturing queries (**NONE**). SQL Server 2019 introduces an additional (**CUSTOM**) setting.

▼ Query Store Retention	
Max Plans Per Query	200
Max Size (MB)	100
Query Store Capture Mode	Custom
Size Based Cleanup Mode	Auto
Stale Query Threshold (Days)	30
Wait Statistics Capture Mode	On

```
ALTER DATABASE AdventureWorks2016 SET QUERY_STORE
(MAX_PLANS_PER_QUERY = 200,
MAX_STORAGE_SIZE_MB = 100,
QUERY_CAPTURE_MODE = AUTO,
SIZE_BASED_CLEANUP_MODE = AUTO,
CLEANUP_POLICY = (STALE_QUERY_THRESHOLD_DAYS = 367),
WAIT_STATS_CAPTURE_MODE = ON);
GO
```

# Query Store Retention Settings

**Size Based Cleanup Mode** determines whether the cleanup process will be automatically activated when the total amount of data gets close to the maximum size. (Default is **Auto**).

▼ Query Store Retention	
Max Plans Per Query	200
Max Size (MB)	100
Query Store Capture Mode	Custom
Size Based Cleanup Mode	Auto
Stale Query Threshold (Days)	30
Wait Statistics Capture Mode	On

```
ALTER DATABASE AdventureWorks2016 SET QUERY_STORE
(MAX_PLANS_PER_QUERY = 200,
MAX_STORAGE_SIZE_MB = 100,
QUERY_CAPTURE_MODE = AUTO,
SIZE_BASED_CLEANUP_MODE = AUTO,
CLEANUP_POLICY = (STALE_QUERY_THRESHOLD_DAYS = 367),
WAIT_STATS_CAPTURE_MODE = ON);
GO
```

# Query Store Retention Settings

**Stale Query Threshold (Days)** determines the number of days to retain data in the query store. (Default is **30 days** and Maximum is **367 days**).

▼ Query Store Retention	
Max Plans Per Query	200
Max Size (MB)	100
Query Store Capture Mode	Custom
Size Based Cleanup Mode	Auto
Stale Query Threshold (Days)	30
Wait Statistics Capture Mode	On

```
ALTER DATABASE AdventureWorks2016 SET QUERY_STORE
(MAX_PLANS_PER_QUERY = 200,
MAX_STORAGE_SIZE_MB = 100,
QUERY_CAPTURE_MODE = AUTO,
SIZE_BASED_CLEANUP_MODE = AUTO,
CLEANUP_POLICY = (STALE_QUERY_THRESHOLD_DAYS = 367),
WAIT_STATS_CAPTURE_MODE = ON);
GO
```

# Query Store Retention Settings

**Wait Statistics Capture Mode** is a new retention setting introduced in SQL Server 2017 that controls if Query Store captures wait statistics information.  
(Default = **ON**).

▼ Query Store Retention	
Max Plans Per Query	200
Max Size (MB)	100
Query Store Capture Mode	Custom
Size Based Cleanup Mode	Auto
Stale Query Threshold (Days)	30
Wait Statistics Capture Mode	On

```
ALTER DATABASE AdventureWorks2016 SET QUERY_STORE  
(MAX_PLANS_PER_QUERY = 200,  
MAX_STORAGE_SIZE_MB = 100,  
QUERY_CAPTURE_MODE = AUTO,  
SIZE_BASED_CLEANUP_MODE = AUTO,  
CLEANUP_POLICY = (STALE_QUERY_THRESHOLD_DAYS = 367),  
WAIT_STATS_CAPTURE_MODE = ON);  
GO
```



# Query Store Capture Policy Settings

Introduced in SQL Server 2019 and available if the Query Store Capture Mode setting has been set to **CUSTOM**.

The value for the **EXECUTION COUNT** is the value a query must exceed within the Stale Threshold time period to be captured by the Query Store.

▼ Query Store Capture Policy	
Execution Count	30
Stale Threshold	1 Hour
Total Compile CPU Time (ms)	1000
Total Execution CPU Time (ms)	100

```
ALTER DATABASE AdventureWorks2016 SET QUERY_STORE
(QUERY_CAPTURE_POLICY =
  (EXECUTION_COUNT = 100,
  STALE_CAPTURE_POLICY_THRESHOLD = 24 Hours,
  TOTAL_COMPILE_CPU_TIME_MS = 2000,
  TOTAL_EXECUTION_CPU_TIME_MS = 1000));
GO
```

# Query Store Capture Policy Settings

Introduced in SQL Server 2019 and available if the Query Store Capture Mode setting has been set to **CUSTOM**.

The value for the **Stale Threshold** can be from 1 hour up to 7 days. This setting specifies the time given to exceed the values of the three other settings for a query to be captured.

▼ Query Store Capture Policy	
Execution Count	30
Stale Threshold	1 Hour
Total Compile CPU Time (ms)	1000
Total Execution CPU Time (ms)	100

```
ALTER DATABASE AdventureWorks2016 SET QUERY_STORE
(QUERY_CAPTURE_POLICY =
(EXECUTION_COUNT = 100,
STALE_CAPTURE_POLICY_THRESHOLD = 24 Hours,
TOTAL_COMPILE_CPU_TIME_MS = 2000,
TOTAL_EXECUTION_CPU_TIME_MS = 1000));
GO
```

# Query Store Capture Policy Settings

Introduced in SQL Server 2019 and available if the Query Store Capture Mode setting has been set to **CUSTOM**.

The value for the **Total Compile CPU Time (ms)** is the value in milliseconds that a query must exceed within the **Stale Threshold** time period to be captured by the Query Store.

▼ Query Store Capture Policy	
Execution Count	30
Stale Threshold	1 Hour
Total Compile CPU Time (ms)	1000
Total Execution CPU Time (ms)	100

```
ALTER DATABASE AdventureWorks2016 SET QUERY_STORE
(QUERY_CAPTURE_POLICY =
(EXECUTION_COUNT = 100,
STALE_CAPTURE_POLICY_THRESHOLD = 24 Hours,
TOTAL_COMPILE_CPU_TIME_MS = 2000,
TOTAL_EXECUTION_CPU_TIME_MS = 1000));
GO
```

# Query Store Capture Policy Settings

Introduced in SQL Server 2019 and available if the Query Store Capture Mode setting has been set to **CUSTOM**.

The value for the **Total Execution CPU Time (ms)** is the value in milliseconds that a query must exceed within the **Stale Threshold** time period to be captured by the Query Store.

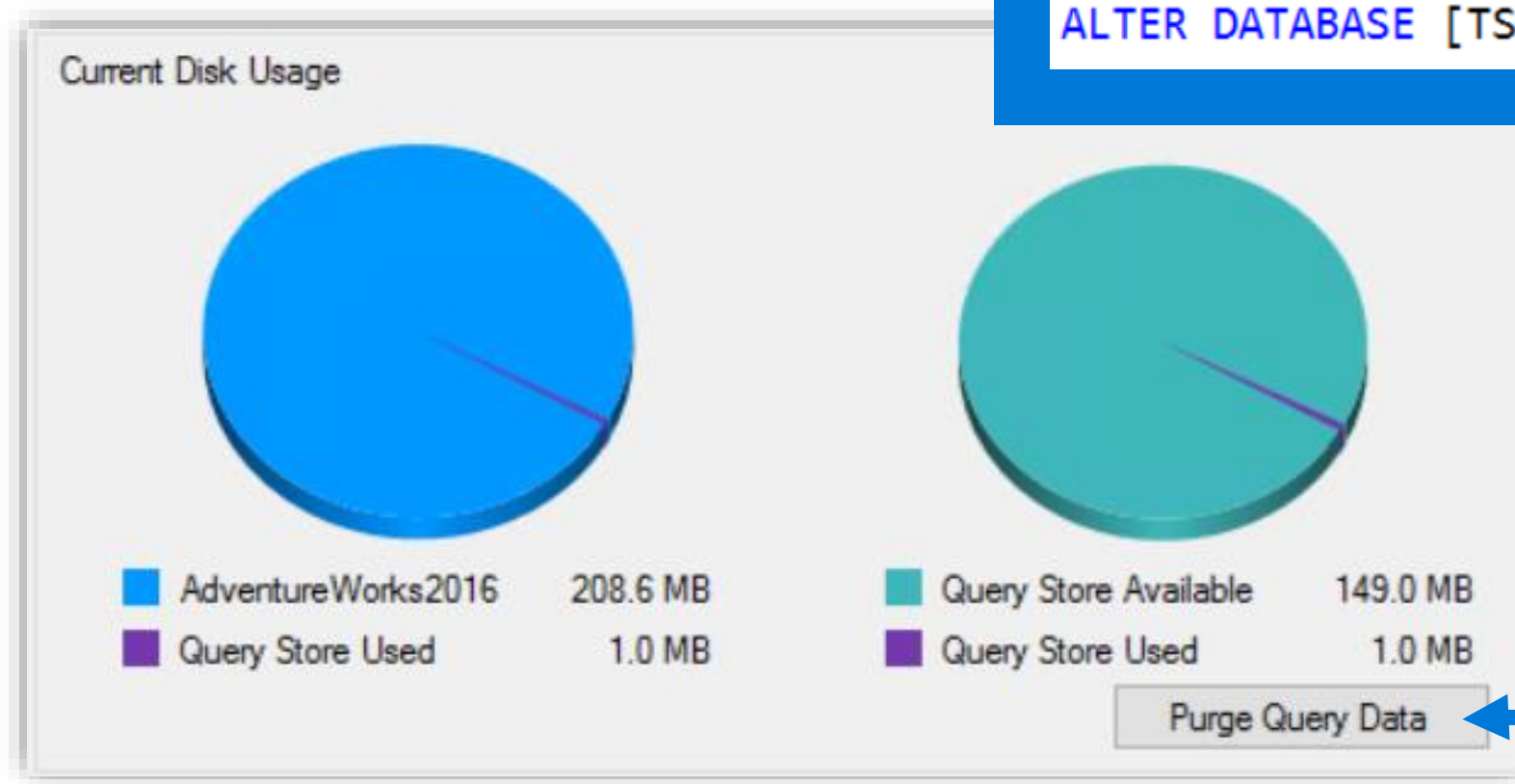
▼ Query Store Capture Policy	
Execution Count	30
Stale Threshold	1 Hour
Total Compile CPU Time (ms)	1000
Total Execution CPU Time (ms)	100

```
ALTER DATABASE AdventureWorks2016 SET QUERY_STORE
(QUERY_CAPTURE_POLICY =
(EXECUTION_COUNT = 100,
STALE_CAPTURE_POLICY_THRESHOLD = 24 Hours,
TOTAL_COMPILE_CPU_TIME_MS = 2000,
TOTAL_EXECUTION_CPU_TIME_MS = 1000));
GO
```

# Purge Query Data

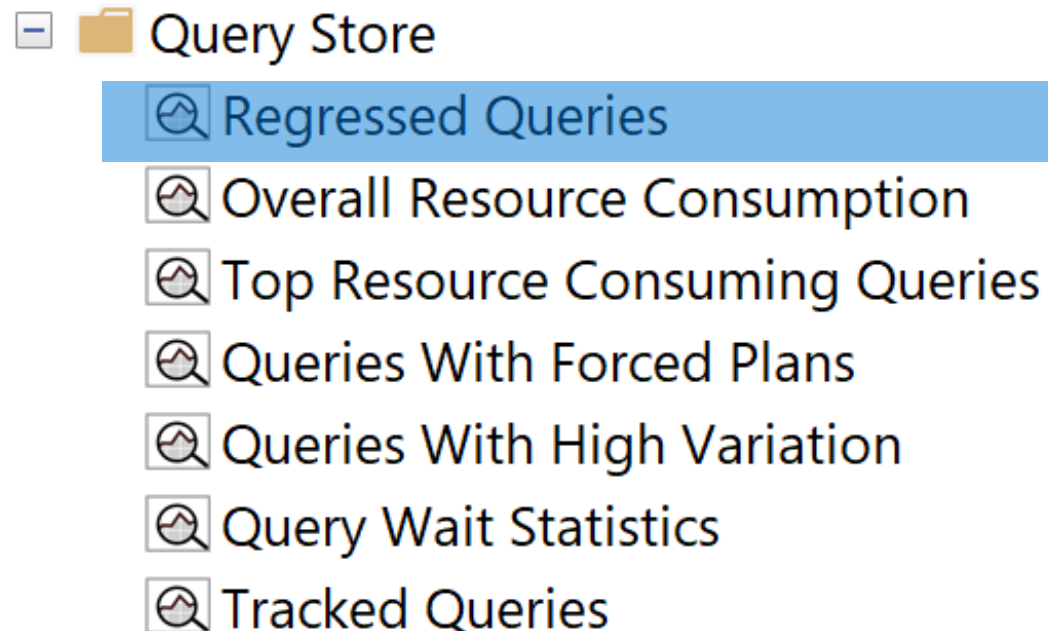
Data can be manually purged from the Query Store.

```
ALTER DATABASE [TSQL] SET QUERY_STORE CLEAR;
```



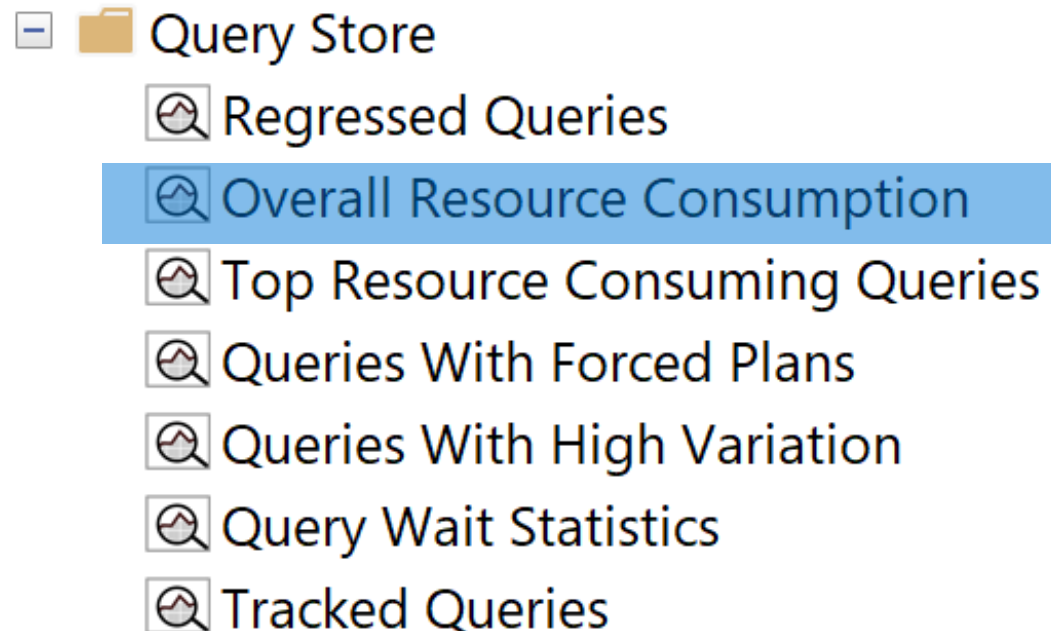
# Query Store Reports

**Regressed Queries:** Use this dashboard to review queries that might have regressed because of execution plan changes












# Query Store Reports

**Overall Resource Consumption:** Use this dashboard to visualize overall resource consumption during the last month in four charts: duration, execution count, CPU time, and logical reads



# Query Store Reports

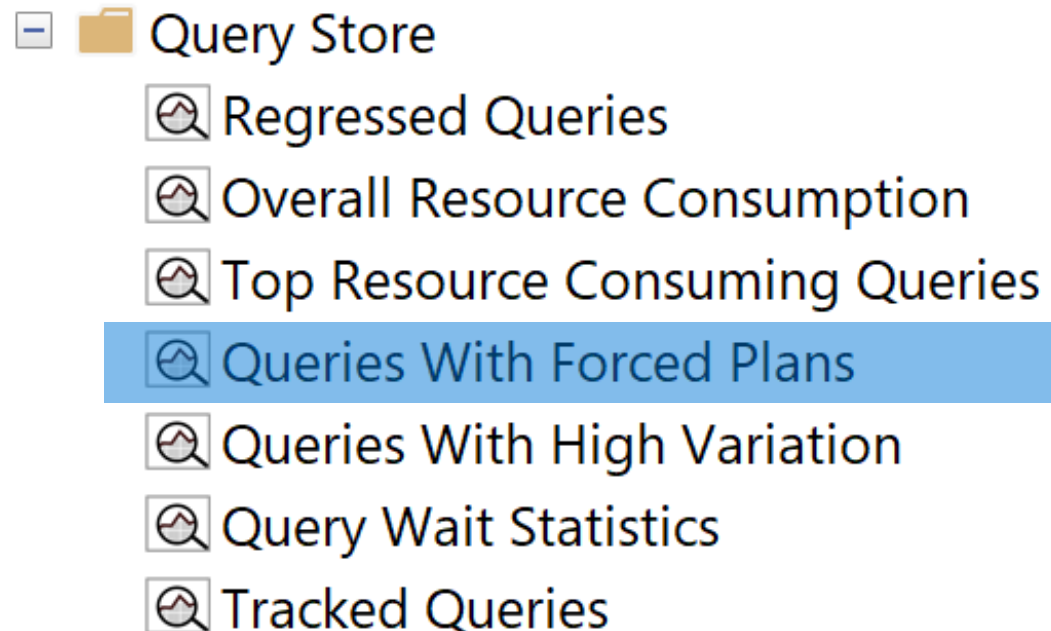
**Top Resource Consuming Queries:** Use this dashboard to review queries in the set of top 25 resource consumers during the last hour

-   Query Store
  -  Regressed Queries
  -  Overall Resource Consumption
  -  **Top Resource Consuming Queries**
  -  Queries With Forced Plans
  -  Queries With High Variation
  -  Query Wait Statistics
  -  Tracked Queries



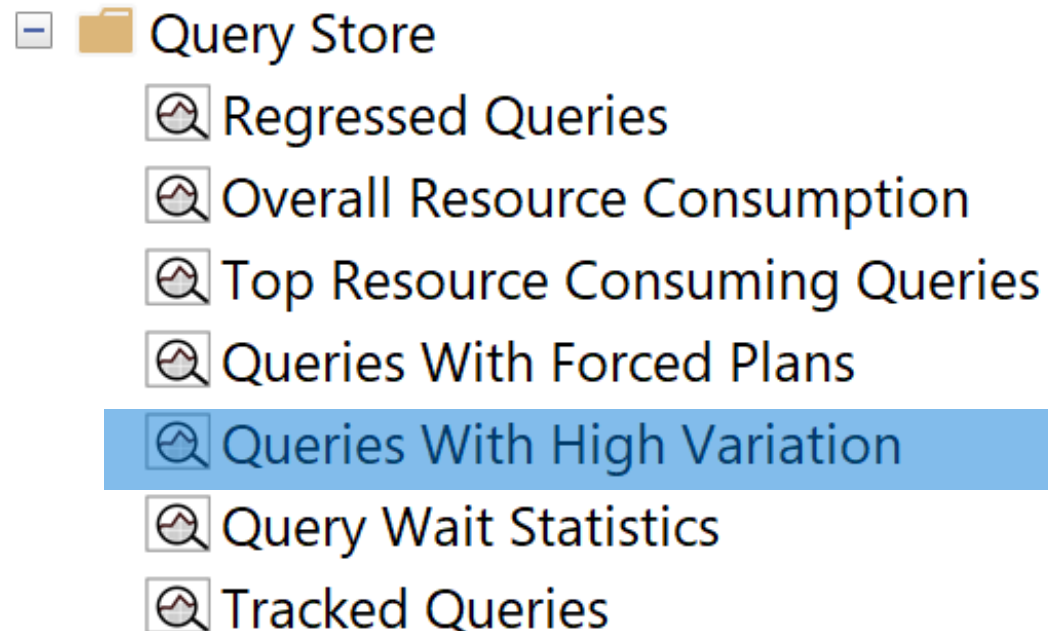
# Query Store Reports

**Queries With Forced Plans:** Used to isolate queries that have been given a forced plan. Requires SQL Server 2016 SP1 or later.



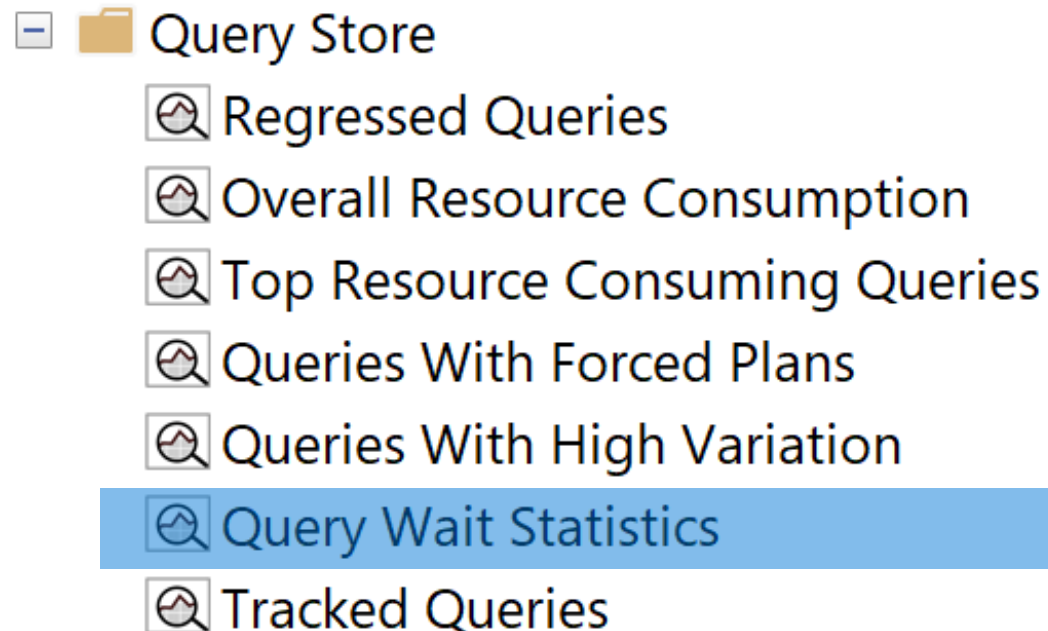
# Query Store Reports

**Queries With High Variation:** Used to locate queries with high variation in query execution. Useful to locate queries with parameterization problems. Requires SQL Server 2016 SP1 or later.



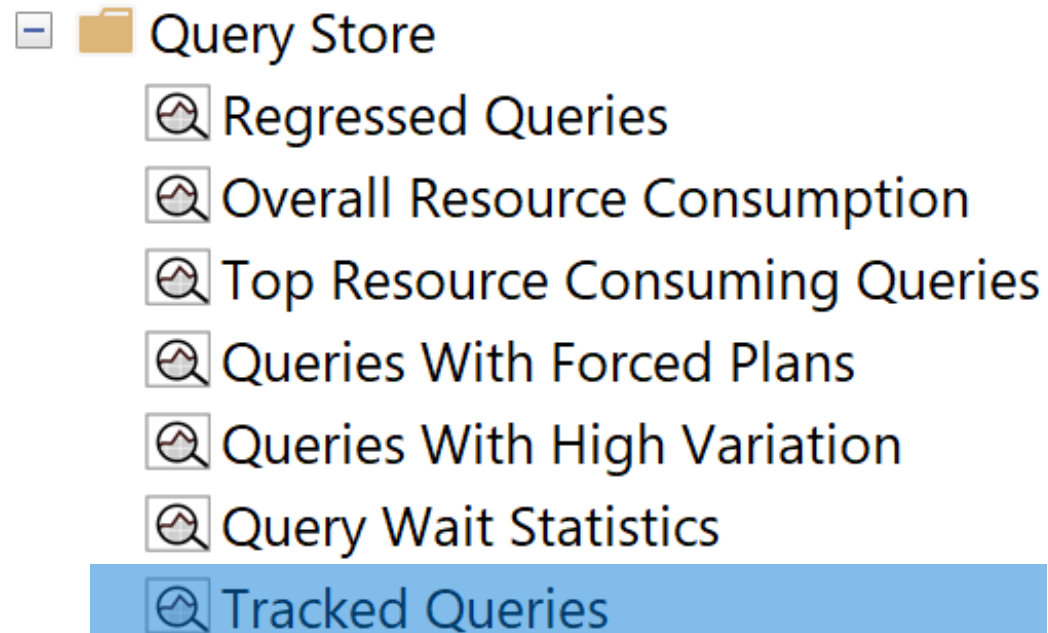
# Query Store Reports

**Query Wait Statistics** shows a bar chart containing the top wait categories in the Query Store. Use the drop down at the top to select an aggregate criteria for the wait time: avg, max, min, std dev, and **total** (default). Requires SQL Server 2017.

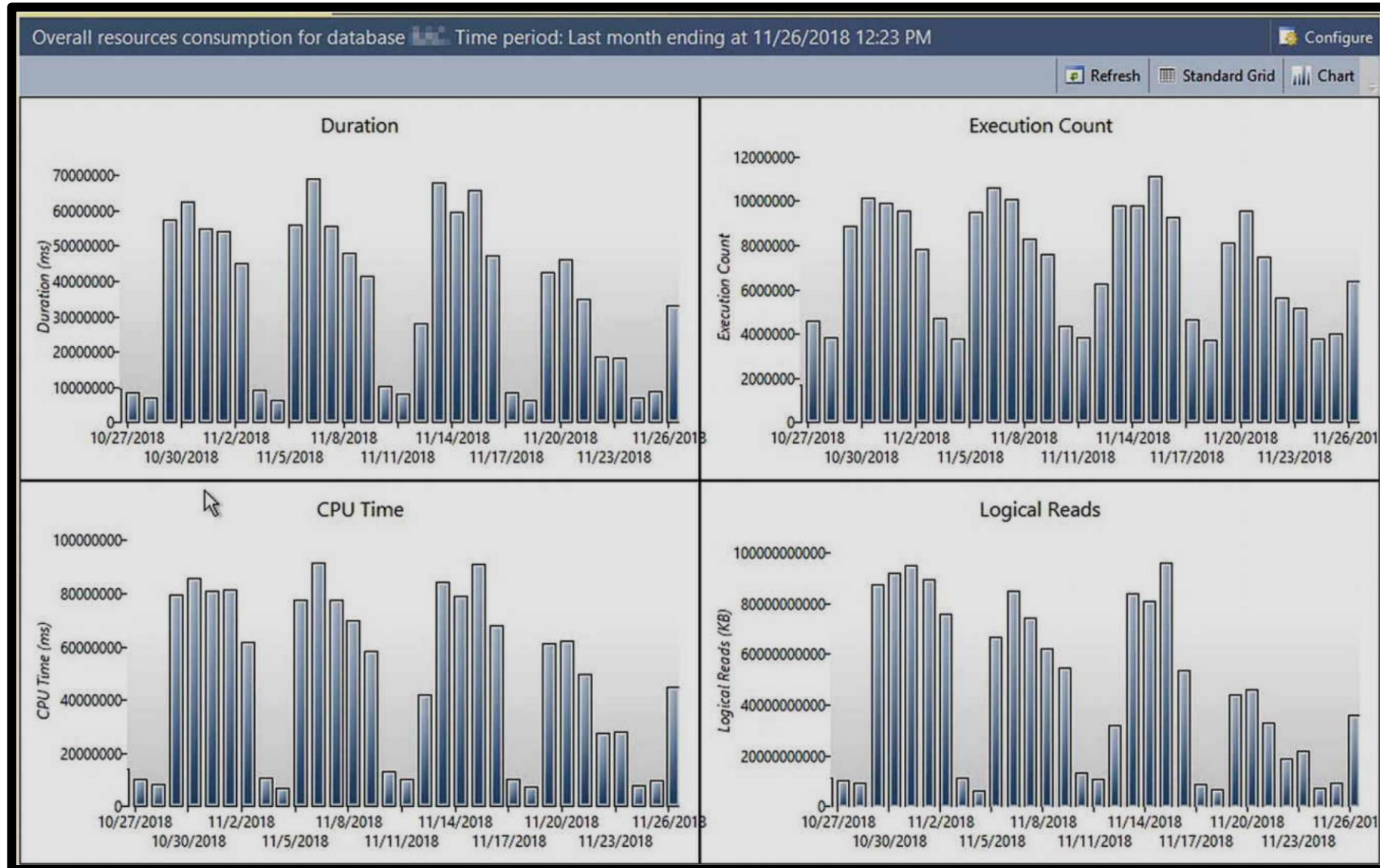


# Query Store Reports

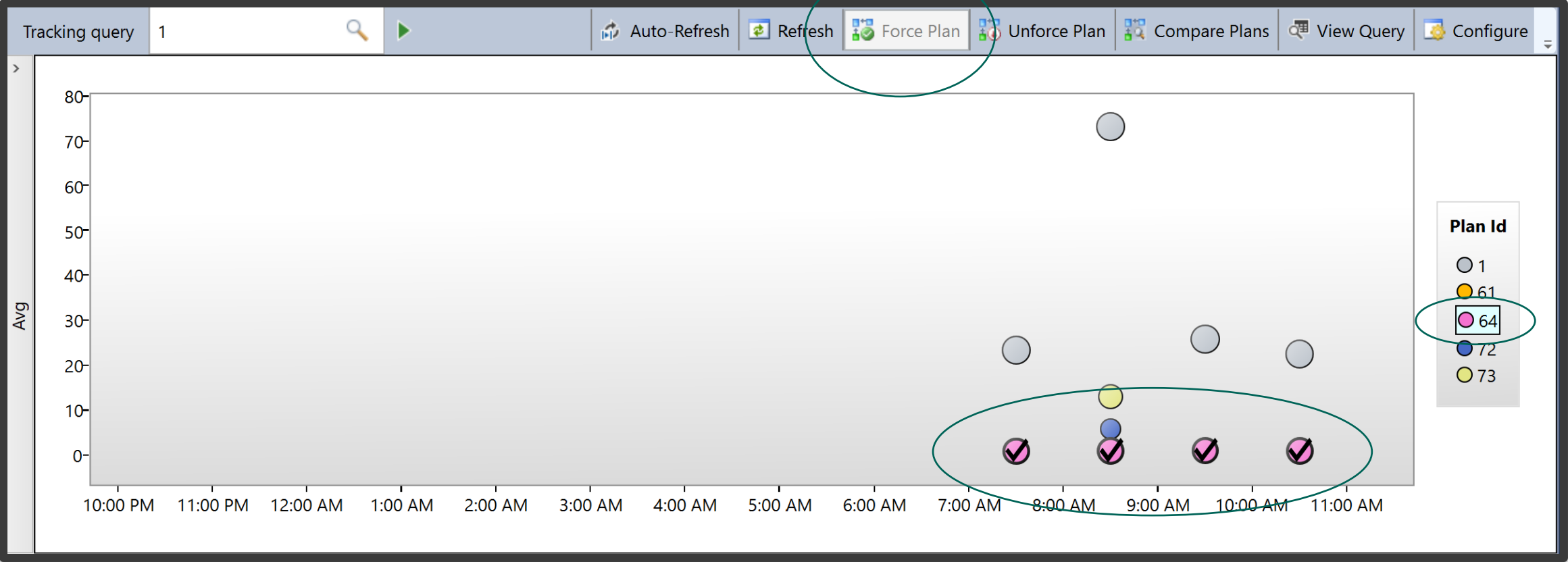
**Tracked Queries:** Use this dashboard to monitor the execution plans and regression of a specify query



# Establishing a Baseline



# Force Plan



# Plan Compare

Plan 64  
SELECT ProductID, OrderQty, UnitPrice FROM Sales.SalesOrderData...

Index Seek (No...  
[SalesOrderDet...  
Cost: 100 %

Plan 73  
SELECT ProductID, OrderQty, UnitPrice FROM Sales.SalesOrderData...

Nested...  
(Inner...  
Cost: 0 %

Index Seek (No...  
[SalesOrderDet...  
Cost: 0 %

Key Lookup (Cl...  
[SalesOrderDet...  
Cost: 99 %

Properties

Top Plan  
Index Seek (NonClustered)

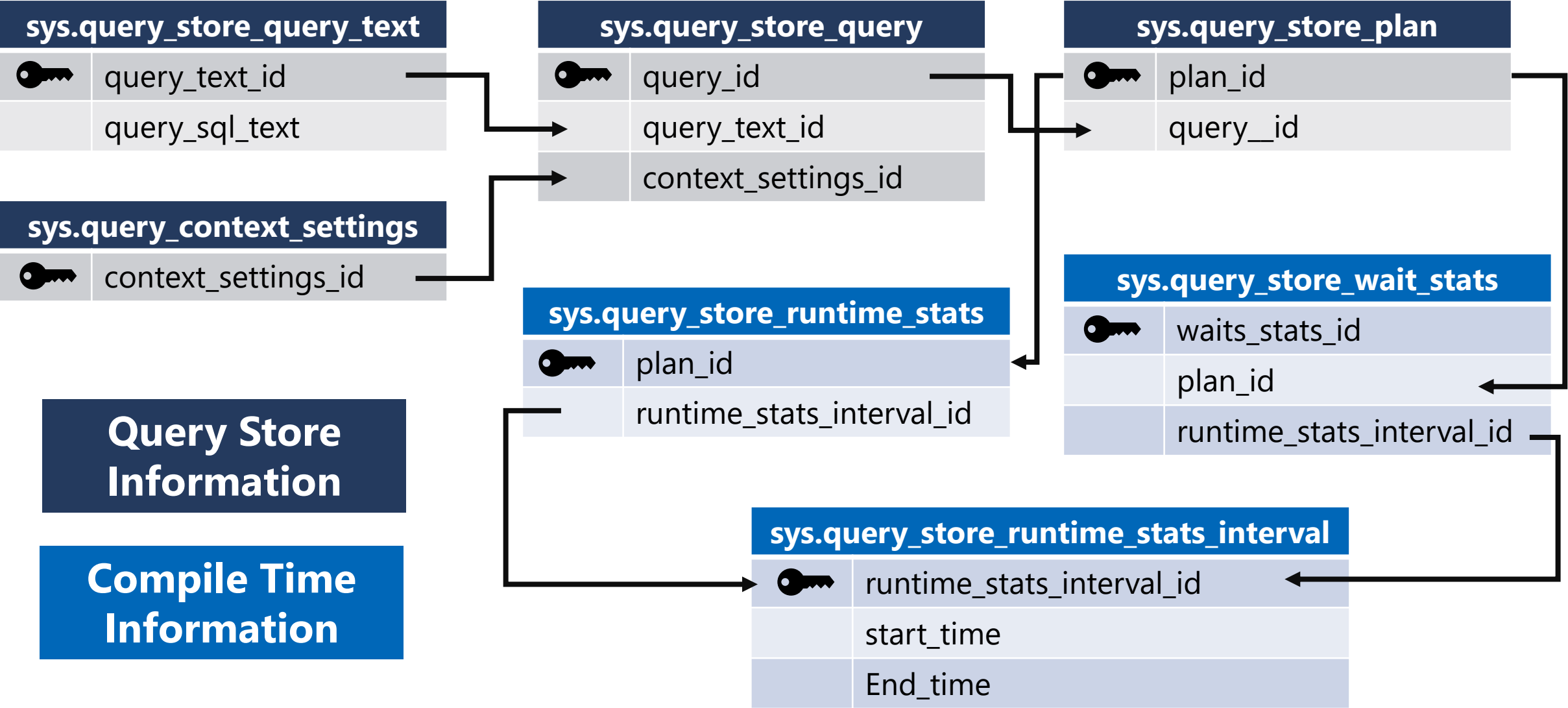
Defined Values	[AdventureWorks2016]
Description	Scan a particular range
Estimated CPU Cost	0.0053138
Estimated Execution Row	
Estimated I/O Cost	0.0144923
Estimated Number of Rows	1
Estimated Number of Rows	4688
Estimated Number of Rows	4688
Estimated Operator Cost	0.0198061 (100%)
Estimated Rebinds	0
Estimated Rewinds	0
Estimated Row Size	21 B
Estimated Subtree Cost	0.0198061
Forced Index	False
ForceScan	False
ForceSeek	False
Logical Operation	Index Seek
Node ID	0
NoExpandHint	False
Object	[AdventureWorks2016]
Ordered	True
Output List	[AdventureWorks2016]
Parallel	False
Physical Operation	Index Seek
Scan Direction	FORWARD
Seek Predicates	Seek Keys[1]: Prefix: [
Storage	RowStore
TableCardinality	121317

Bottom Plan  
Key Lookup (Clustered)

Defined Values	[AdventureWorks2016]
Description	Uses a supplied cluster
Estimated CPU Cost	0.0001581
Estimated Execution Row	
Estimated I/O Cost	0.003125
Estimated Number of Rows	242
Estimated Number of Rows	1
Estimated Operator Cost	0.722865 (99%)
Estimated Rebinds	241
Estimated Rewinds	0
Estimated Row Size	17 B
Estimated Subtree Cost	0.722865
Forced Index	False
ForceScan	False
ForceSeek	False
Logical Operation	Key Lookup
Lookup	True
Node ID	4
NoExpandHint	False
Object	[AdventureWorks2016]
Ordered	True
Output List	[AdventureWorks2016]
Parallel	False
Physical Operation	Key Lookup
Scan Direction	FORWARD
Seek Predicates	Seek Keys[1]: Prefix: [
Storage	RowStore
TableCardinality	121317



# Query Store Catalog Views





# Using Query Store Catalog Views

Finding the TOP 10 most frequently executed SQL Server Queries in the Query Store.

```
SELECT TOP 10 t.query_sql_text, q.query_id
FROM sys.query_store_query_text as t
JOIN sys.query_store_query as q
ON t.query_text_id = q.query_text_id
JOIN sys.query_store_plan as p
ON q.query_id = p.query_id
JOIN sys.query_store_runtime_stats as rs
ON p.plan_id = rs.plan_id
WHERE rs.count_executions > 1
GROUP BY t.query_sql_text, q.query_id
ORDER BY SUM(rs.count_executions)
```

# Troubleshooting Using the Query Store



Questions?



# Knowledge Check

If upgrading from SQL Server 2012 to 2019. Which report should figure prominently in your upgrade plans?

In a report's bar chart what does each bar represent?

Which report can help troubleshoot a parameter sniffing issue?

Querying the wait statistics DMV it returns high PAGEIOLATCH waits. Which report can help identify queries with high IO wait times?

Someone has dropped an index needed by a forced plan. What happens the next time the query executes? What happens if the index is recreated?

