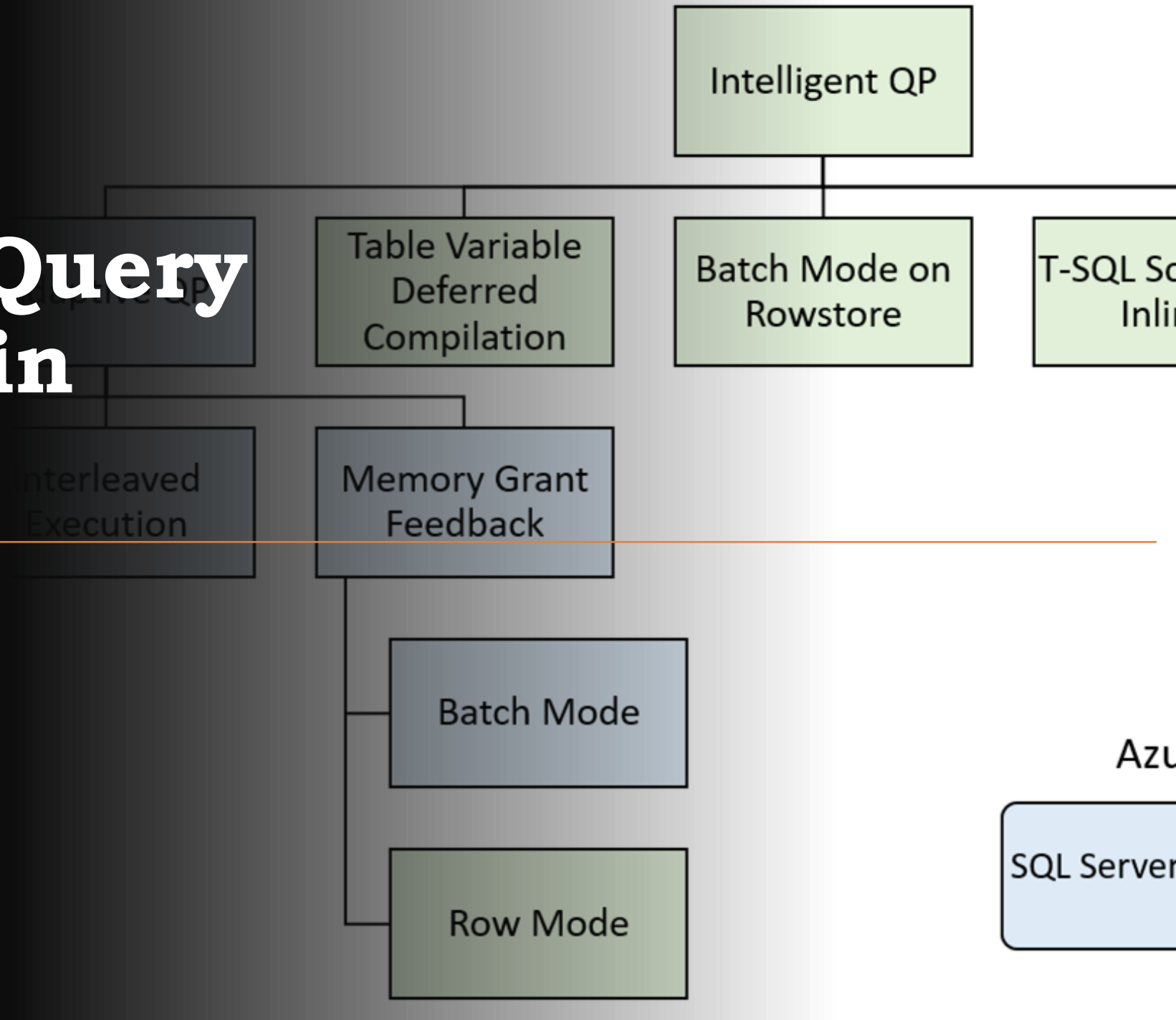
Intelligent Query Processing in SQL Server

Taiob Ali



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Data Professional

Microsoft Data Platform MVP. 14 Years working with Microsoft Data Platform. Microsoft and MongoDB certified. Worked in ecommerce, healthcare and finance industry.

Giving Back

Board member NESQL user group and PASS DBA virtual group. Organizer of Boston SQL Saturday. Frequent speaker at local and virtual user groups, SQL Saturdays, PASS Summit and Azure events.

When Not Working

Running – One 26.2 and many 13.1 miles. Learning US history. Shuttling 3 kids.

Parsing

Transformation

Compare Cost

Plan Cache

Query Execution

Cost

- Parallel
- Serial

Memory Grant

- In Memory
- Spill to Disk

Access Method

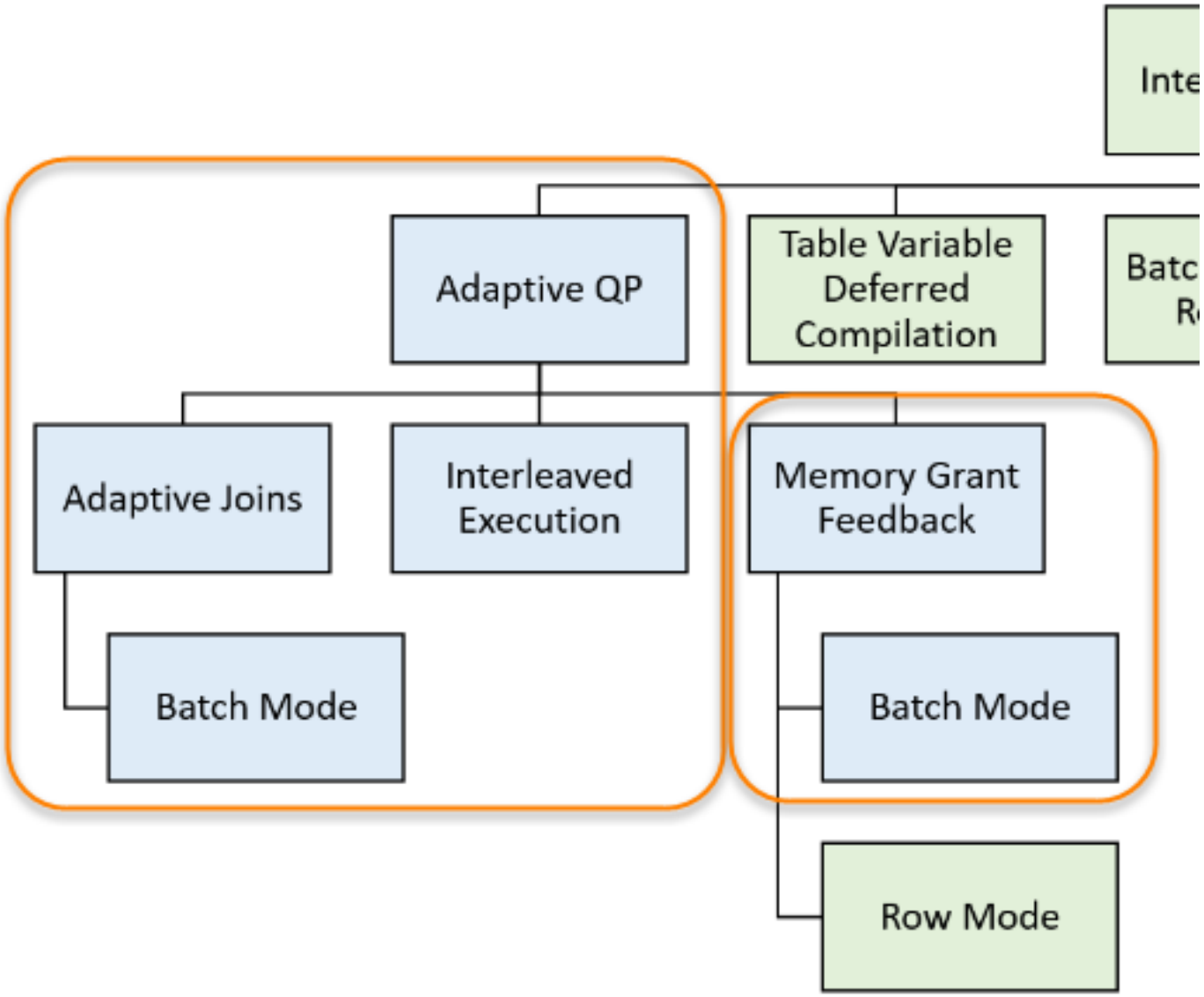
- Seek
- Scan
- Seek + Scan

Algorithm

- Join
- Aggregate
- Sort


SQL

2017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Adaptive QP
Table Variable Deferred Compilation
Batc
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Adaptive Joins
Interleaved Execution
Memory Grant Feedback
Batch Mode
Batch Mode
Row Mode


SQL

2019

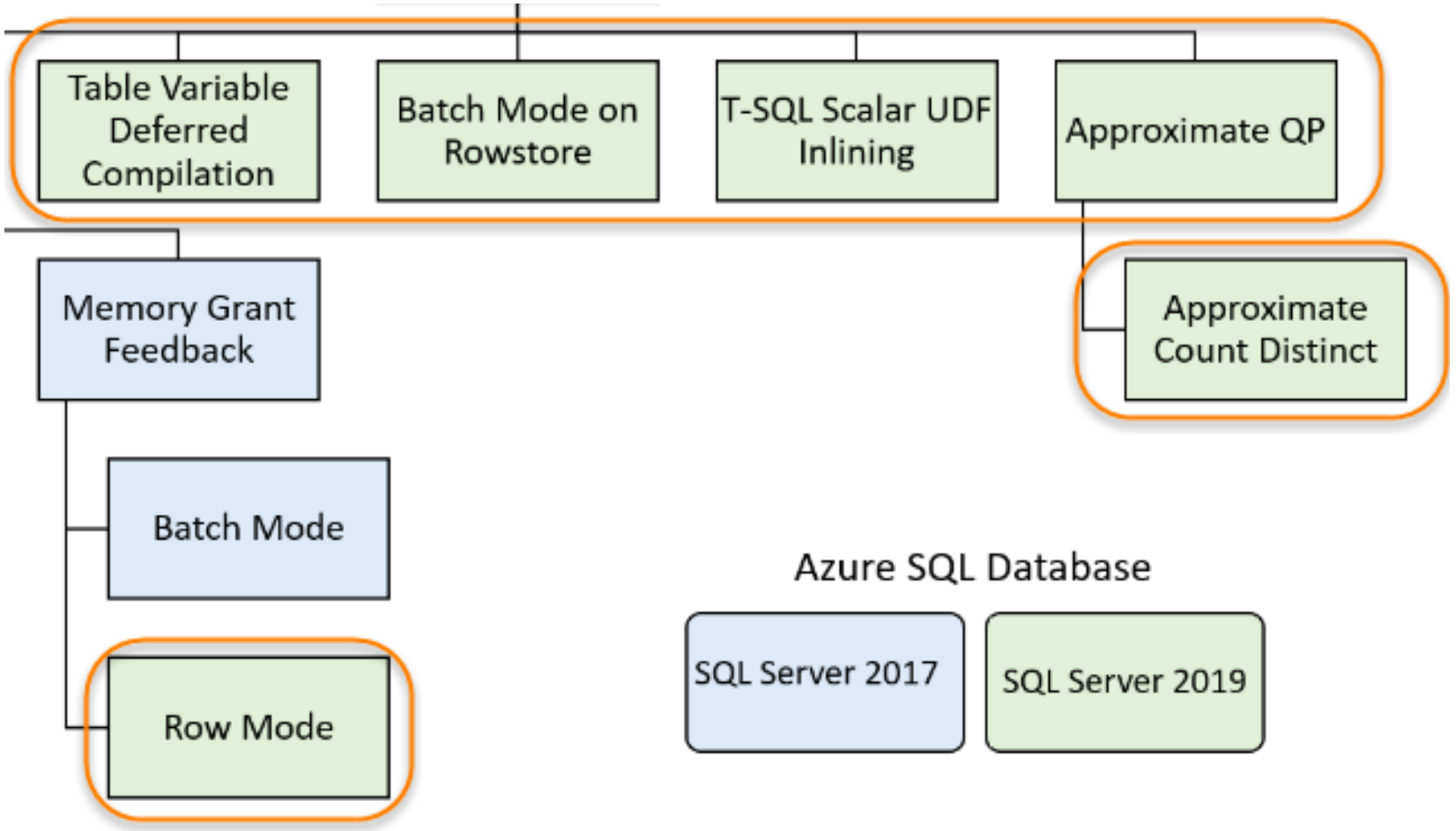
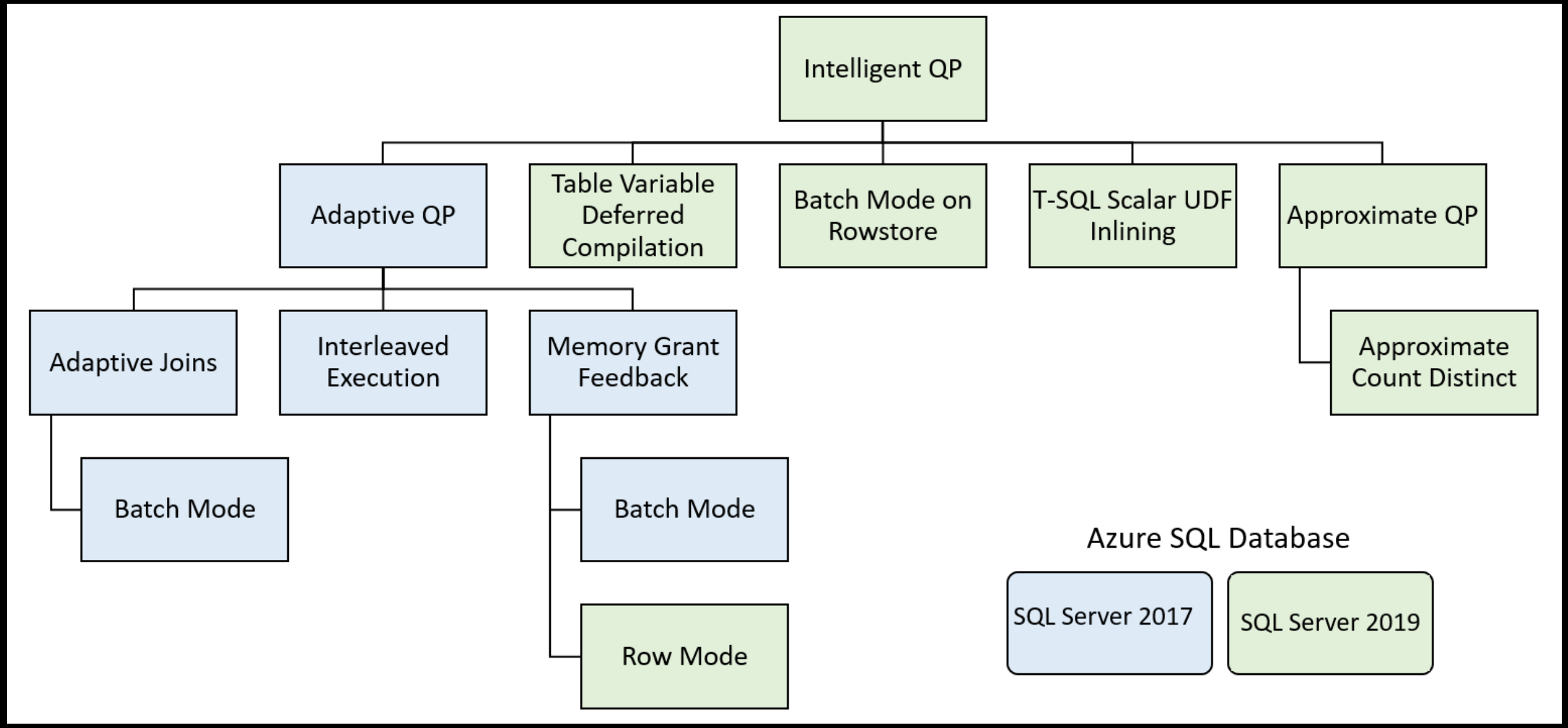


Table Variable Deferred Compilation
Batch Mode on Rowstore
T-SQL Scalar UDF Inlining
Approximate QP
Approximate Count Distinct
Memory Grant Feedback
Batch Mode
Row Mode
Azure SQL Database
SQL Server 2017
SQL Server 2019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SQL Server 2019

2021

Query Store Hints

- 2021, Preview, Azure SQL Database
- Add hints when you do not have access to the code
- Using query_id (from Query Store)
- Example
  - Recompile on each execution
  - Limit max degree of parallelism for specific queries
  - Disable **optimizer row goal**

2021

CE Feedback

- 2021, Preview, Azure SQL Database
- Significant model estimation errors
- Only repeating workload will qualify
  - Cache persistent plan
- During conflict hard-coded hint will prevail
- Only verified feedback will prevail
- Example
  - Correlation Analysis
  - Row Goal
  - Containment type

SYS.DATABASE_SCOPED_CONFIGURATIONS

SYS.DM_EXEC_VALID_USE_HINTS

Problem

Solution

Caution

Adaptive Joins
Batch Mode

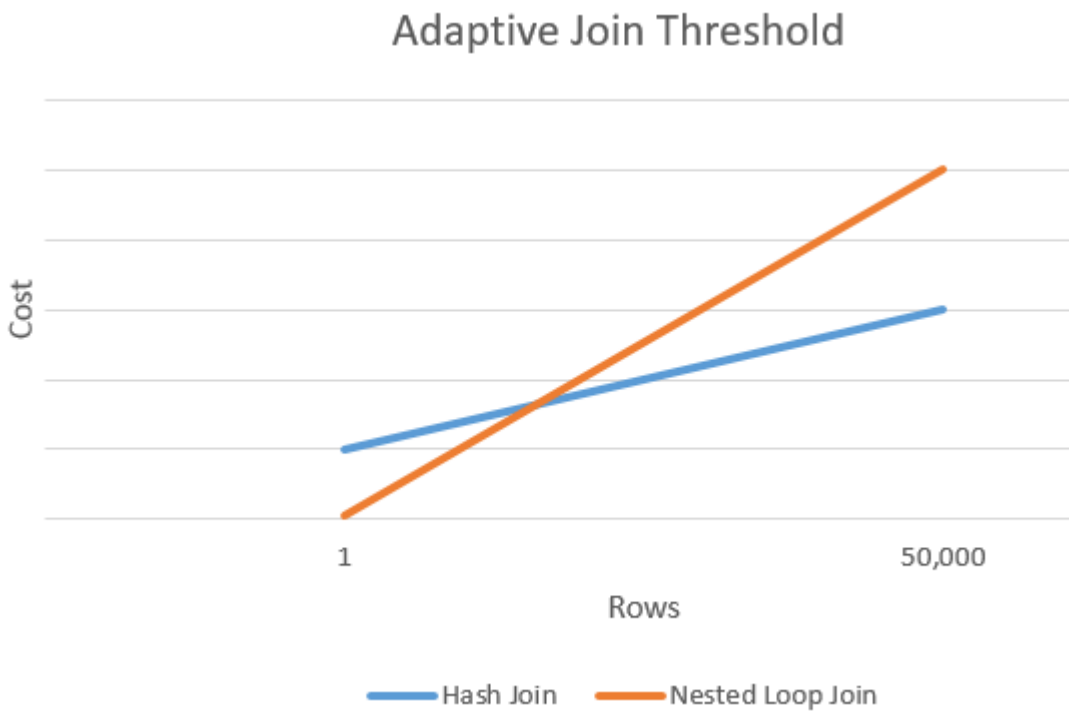
140
150

- Join Hint
- Parameter sensitive query

Adaptive Joins Batch Mode

140
150

- Dynamically switch to a better join
- Nested loop or Hash Join
- Based on threshold



https://docs.microsoft.com/en-us/sql/relational-databases/performance/media/6_aqpjointhreshold.png?view=sql-server-ver15

Adaptive Joins Batch Mode

140
150

- The query is a SELECT statement
- Join needs to be eligible with both Hash and Nested Loop join
- Hash join uses batch mode
- Both join should have same outer reference

Table Variable Deferred Compilation

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- Works ok with low number of rows but not as rows increase
- Table variables do not have statistics
- Table variables do not have ‘Automatic stats creation’
- Only inline index definitions
- Does not trigger recompile
- Fixed cardinality guess of 1

Table Variable Deferred Compilation

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- Optimizer delays the compilation
  - Same as what temporary table does today
- Accurate cardinality – better execution plan
  - Example Hash join instead of Nested loop join

Table Variable Deferred Compilation

150

- Does not change any other characteristics
- Does not increase recompilation frequency
- Does not fix Parament Sniffing issues

Interleaved Execution MSTVFs

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- MSTVFs have a fixed cardinality guess of
  - 100 in SQL Server 2014 (12.x)
  - 1 in earlier versions

Interleaved Execution MSTVFs

140
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- Actual row counts are used to make better-informed decision
- Greater performance impact with higher skew

Interleaved Execution MSTVFs

140
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- Must be read-only and NOT part of a data modification
- Must use runtime constant

Memory Grant Feedback Batch Mode

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- Performance suffers from incorrect Memory Grant
- Insufficient grant
  - Spill to disk
- Excessive grants
  - Wasted memory
  - Reduced concurrency

Memory Grant Feedback Batch Mode

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- Trigger recalculate
  - Result in a spill to disk
  - Granted memory > 2 x size of the actual used memory
- New SSMS property ‘IsMemoryGrantFeedbackAdjusted’ to track feedback

Memory Grant Feedback Batch Mode

140
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- Will disable itself for parameter sensitive queries
- Grants under 1 MB will not be recalculated
- Changes are currently not captured in the Query Store
- Memory Granted honors limitation by the resource governor or query hint

Memory Grant Feedback Row Mode

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- Row mode memory grant feedback expands on the batch mode

TSQL Scalar UDF Inlining

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- Iterative invocation
- Lack of costing
- Serial Execution
- Interpreted execution
- Imperative code does not scale

TSQL Scalar UDF Inlining

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- UDFs are automatically transformed into
  - Scalar Expressions
  - Scalar subqueries
- Further optimization followed by transformation
- Refactors the Imperative code into Relational Algebric Expression – Froid Framework
- Resulting execution plan
  - Efficient
  - Set-Oriented
  - Parallel
- New SSMS property ‘ContainsInlineScalarTsqlUdfs’ to track inlinng

TSQL Scalar UDF Inlining

150

- Requirements to be eligible
- Scalar UDF Inlining issues in SQL Server 2019
- sys.sql_modules – Can this UDF be inlined?
- Can disable within function definition

```
-- Transact-SQL Function Clauses
<function_option>::=
{
    [ ENCRYPTION ]
  | [ SCHEMABINDING ]
  | [ RETURNS NULL ON NULL INPUT | CALLED ON NULL INPUT ]
  | [ EXECUTE_AS_Clause ]
  | [ INLINE = { ON | OFF }]
}
```

Batch Mode on Rowstore

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- Row by Row processing is slow and cpu intensive
- Columnstore indexes may not be appropriate for some applications
- Features might restrict use of Columnstore index

Batch Mode on Rowstore

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- Uses heuristics – during estimation phase
  - Table sizes
  - Operators used
  - Estimated cardinalities
- Additional checkpoints, to evaluate plans with batch mode
- Support for all existing batch mode-enabled operator
- Workload consists of analytics queries especially with joins or aggregates
- Workload that is CPU bound

Batch Mode on Rowstore

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- Batch mode restriction always applicable
  - Example-Queries involving cursors
- Not applicable for in-memory OLTP tables
- Not applicable for any index other than on-disk heaps and B-trees
- Won’t kick in for
  - Large Object (LOB) column
  - XML column
  - Sparse column sets
- Two features are independent

Approximate Count Distinct

150

- Responsiveness is important than absolute precision
- Example
  - Dashboard scenarios
  - Data science trying to understand data distributions

Approximate Count Distinct

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- Access of data sets that are millions of rows or higher
- Aggregation of a column or columns that have many distinct values
- Use less memory compare to exhaustive COUNT DISTINCT
- Based on HyperLogLog algorithm

Approximate Count Distinct

150

- The function implementation guarantees up to a 2% error rate within a 97% probability

```
Disabling any of these features without changing the compatibility
level
-- SQL Server 2017
ALTER DATABASE SCOPED CONFIGURATION SET
DISABLE_BATCH_MODE_MEMORY_GRANT_FEEDBACK = ON;

-- Starting with SQL Server 2019, and in Azure SQL Database
ALTER DATABASE SCOPED CONFIGURATION SET
BATCH_MODE_MEMORY_GRANT_FEEDBACK = OFF;

You can also disable any of these features for a specific query by
using ‘USE HINT’ query hint
OPTION (USE HINT ('DISABLE_BATCH_MODE_MEMORY_GRANT_FEEDBACK'));
```

Resource

- Intelligent Query Processing in SQL databases
- Intelligent Query Processing Demos
- Compatibility Certification
- Query Processing Architecture Guide
- Get Your Scalar UDFs to Run Faster Without Code Changes
- Batch Mode Bitmaps in SQL Server by Paul White
- Introducing Batch Mode Adaptive Memory Grant Feedback by Joe Sack

SQL2019 CU8
SSMS 18.7.1

https://www.invotide.com/demo

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THANK
YOU