Gianluca Hotz

#sqlsat

PASS SQLSATURDAY

SQL Server 2019 CTP2.2

inn0va community

CONSORZIO UNIVERSITARIO DI PORDENONE

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fluentis

PALAZZETTI IL CALORE CHE PIACE ALLA NATURA

WÜRTHPHOENIX

Who am I?

Gianluca Hotz | @glhotz | ghotz@ugiss.org

Independent Consultant, Founder and Mentor SolidQ

- 20+ years on SQL Server (from 4.21 in 1996)
- Database modeling and development, sizing and administration, upgrade and migration, performance tuning

Interests

- Relational model, DBMS architecture, Security, High Availability and Disaster Recovery

Community

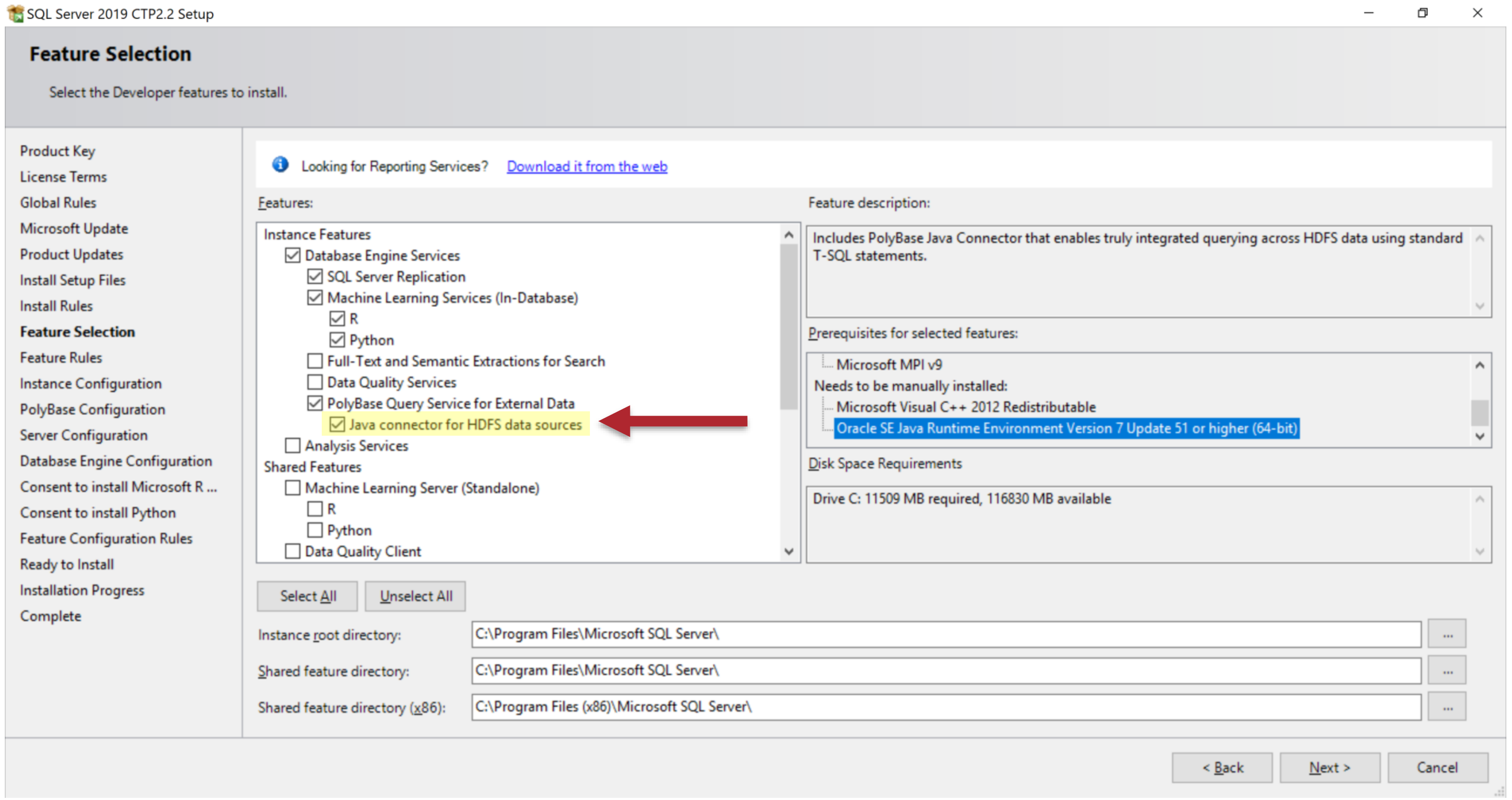
- 20 years Microsoft MVP SQL Server (from 1998)
- Founder and President UGISS
  - User Group Italiano SQL Server (PASS Chapter)

Configuration

Installation

- Most new things in 2016/2017
  - Separate downloads
  - IFI and tempdb configuration
  - Linux
  - R and Python integration
  - Polybase
  - Integration Services Scale-out
- Polybase
  - SQL Server 2016+: Azure Blob Storage, Hadoop (**separate option in 2019**)
  - SQL Server 2019: **SQL Server**, **Oracle**, **Teradata**, **MongoDB**

PolyBase Java Connector for HDFS



SQL Server 2019 CTP2.2 Setup

Feature Selection

Select the Developer features to install.

Looking for Reporting Services? Download it from the web

Features:

- Instance Features
  - [✓] Database Engine Services
    - [✓] SQL Server Replication
    - [✓] Machine Learning Services (In-Database)
      - [✓] R
      - [✓] Python
    - [ ] Full-Text and Semantic Extractions for Search
    - [ ] Data Quality Services
    - [✓] PolyBase Query Service for External Data
      - [✓] Java connector for HDFS data sources
  - [ ] Analysis Services
- Shared Features
  - [ ] Machine Learning Server (Standalone)
    - [ ] R
    - [ ] Python
  - [ ] Data Quality Client

Feature description:

Includes PolyBase Java Connector that enables truly integrated querying across HDFS data using standard T-SQL statements.

Prerequisites for selected features:

Microsoft MPI v9
Needs to be manually installed:
Microsoft Visual C++ 2012 Redistributable
Oracle SE Java Runtime Environment Version 7 Update 51 or higher (64-bit)

Disk Space Requirements

Drive C: 11509 MB required, 116830 MB available

Instance root directory:	C:\Program Files\Microsoft SQL Server\
Shared feature directory:	C:\Program Files\Microsoft SQL Server\
Shared feature directory (x86):	C:\Program Files (x86)\Microsoft SQL Server\

SQL Server on Linux

Replication support

- Snapshot, Transactional and Merge

Support for Microsoft Distributed Transaction Coordinator (MSDTC)

Always On Availability Group on Docker containers with Kubernetes

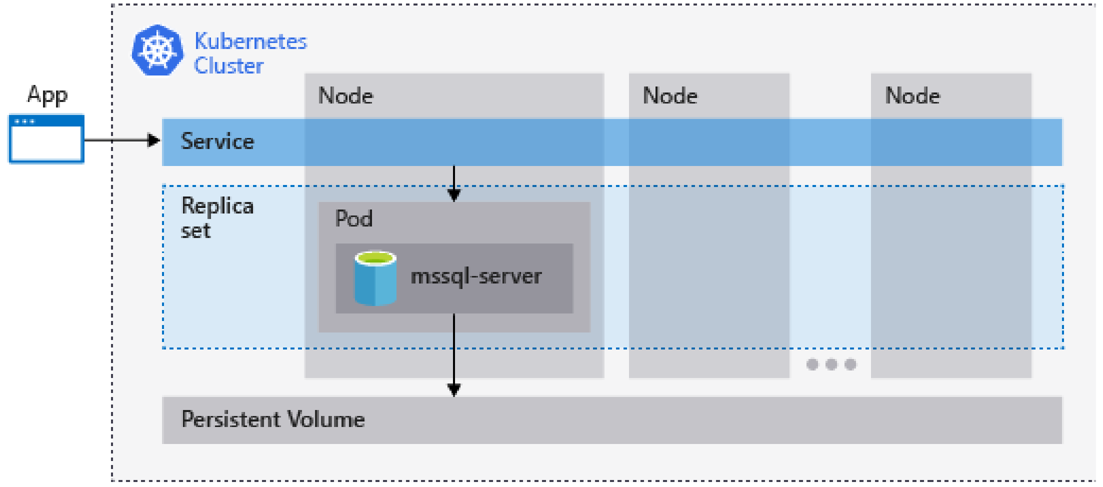
- Kubernetes operator deploys StatefulSet including container with mssql-server container and health monitor

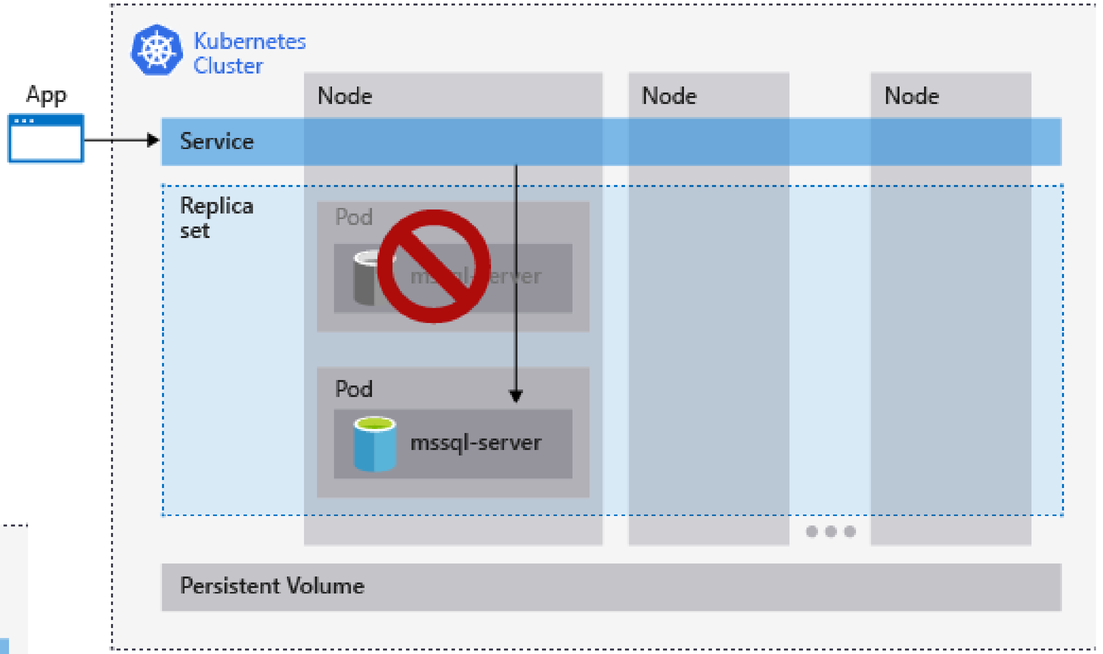
OpenLDAP support for third-party AD providers

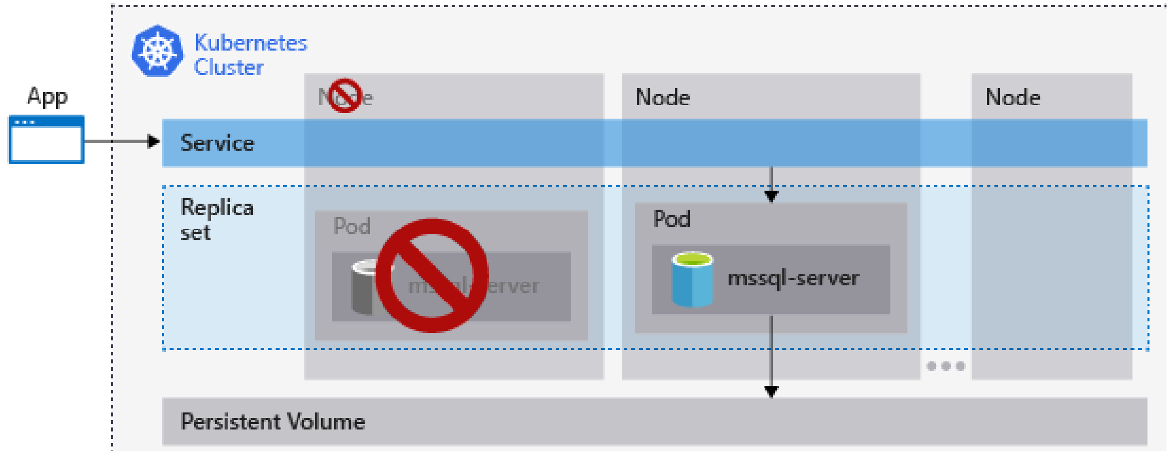
Machine Learning Services (In-Database) on Linux

New container registry

HA solution in Azure Kubernetes Service







Other Services

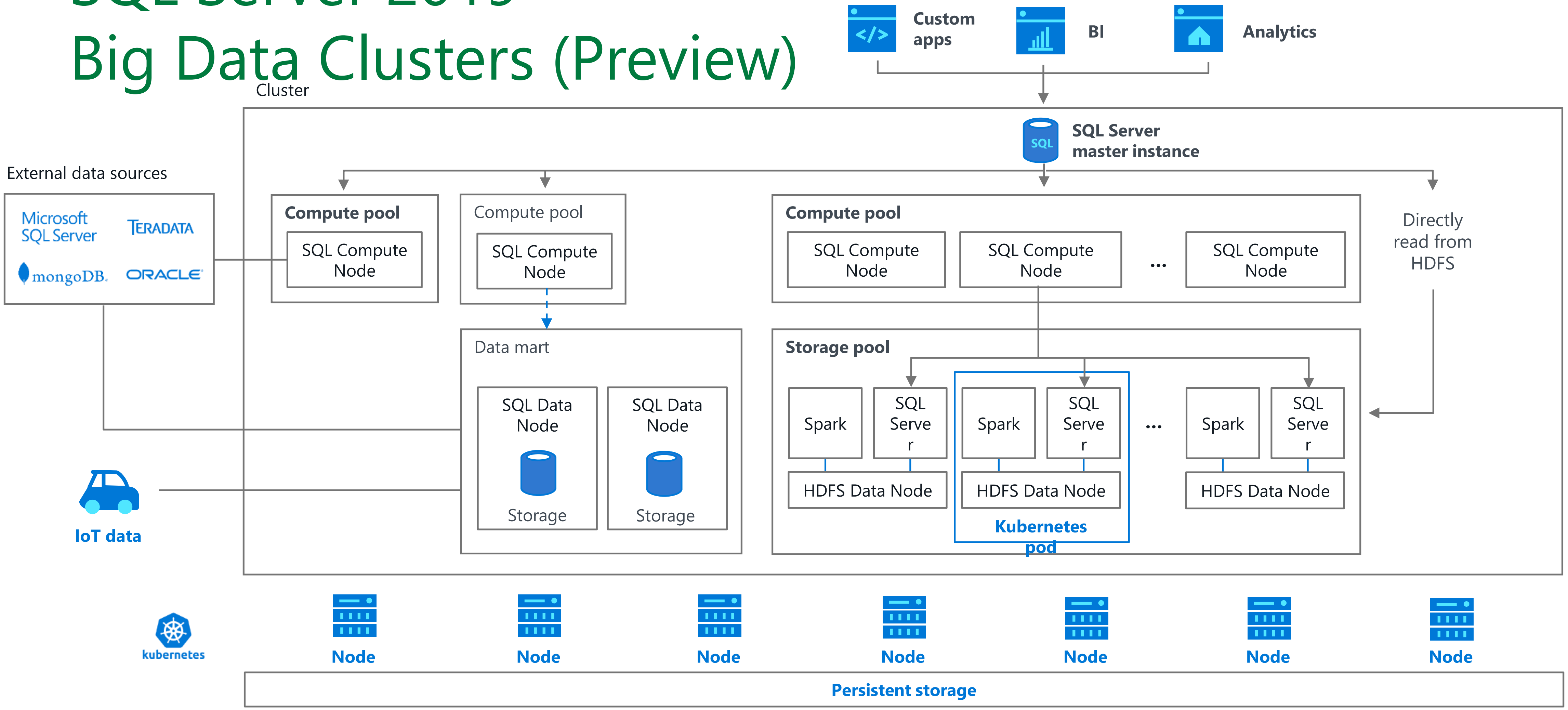
Master Data Services

- Silverlight controls replaced with HTML

SQL Server Machine Learning Services

- Windows Server Failover Cluster support
- Partition-Based modeling

SQL Server 2019 Big Data Clusters (Preview)



Administration

Tools

SQL Server Management Studio V18 (Preview 6)

Azure Data Studio (was Operations Studio)

Resumable online index operations

Resume after index creation/rebuild failed (e.g. out of disk space)

Pause and resume later (e.g. free temporarily resources)

Create/rebuild large indexes using less log an shorter transactions

Fit rebuild operations into limited maintenance windows

- REBUILD WITH (ONLINE = ON, RESUMABLE = ON, **MAX_DURATION = 30 MINUTES**);

Columnstore Indexes

Online build/rebuild Clustered Columnstore

DBCC CLONEDATABASE

Instantaneous schema-only copy of a database for troubleshooting

- No data, full-schema, statistics and Query Store
- Non-blocking
- Read-only by default (can be changed)
- Optionally **NO_STATISTICS**, **NO_QUERYSTORE**
- SQL Server 2012 SP4, 2014 SP2 CU3, 2016 SP1, 2017

New in SQL Server 2019

- Columnstore Statistics

Accelerated Database Recovery

Benefits

- Fast and consistent database recovery
  - Number/size of active transactions don't impact recovery time
- Instantaneous transaction rollback
  - Active time and number of updates don't impact rollback time
- Aggressive Log Truncation
  - Even with long running transactions, prevents growing out of control

High level

- Versioning all physical database modifications
- Only logical operations undone (are limited and can be undone instantly)
- Active transactions at crash time are marked as aborted
- Any versions generated aborted transactions can be ignored user queries

Currently available in Preview in Azure SQL Database

Accelerated Database Recovery Components

Persisted Version Store (PVS)

- New version store, stored in the database instead of tempdb
- Enable also resource isolation

Logical Revert

- Asynchronous process performing row level version based undo
  - Keeps track of all aborted transactions
  - Performs rollback using PVS
  - Releases all locks immediately after transaction abort

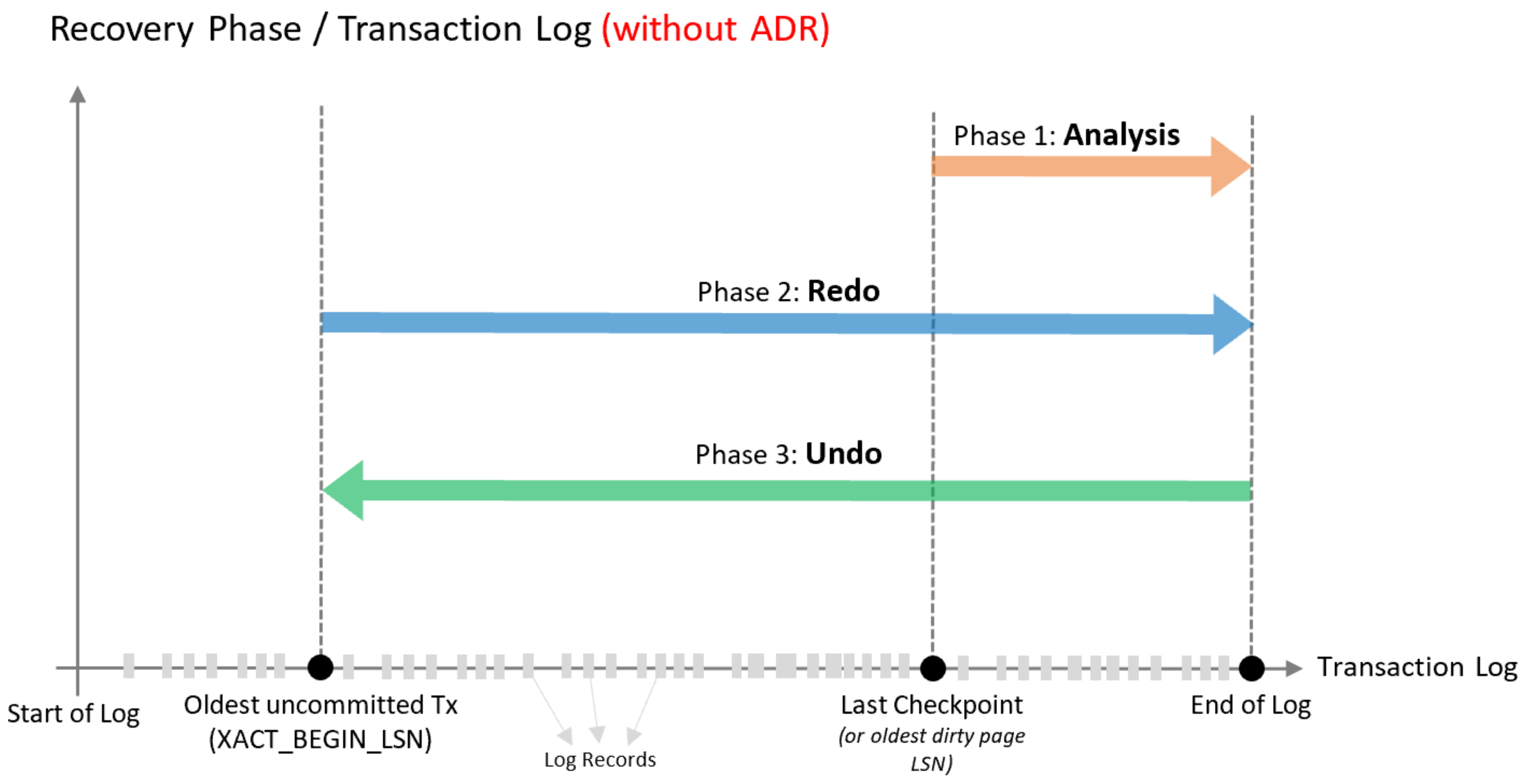
sLog

- Secondary log stream storing log records for non versioned operations
  - Low volume and in-memory
  - Serialized on disk during CHECKPOINT
  - Enables aggressive transaction log truncation

Cleaner

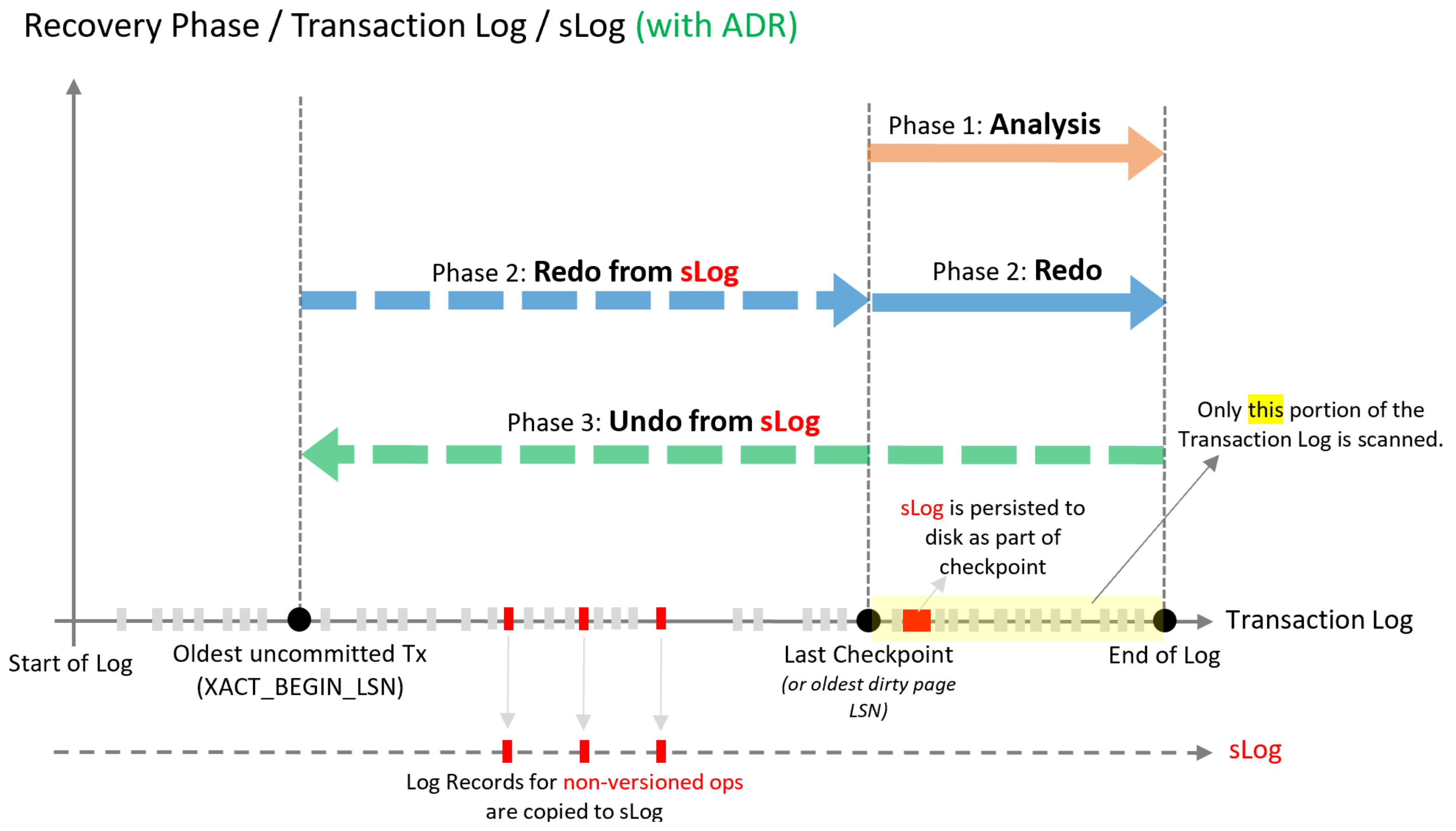
- Asynchronous process that cleans page versions

Current database recovery process



Recovery Phase / Transaction Log (without ADR)
Phase 1: **Analysis**
Phase 2: **Redo**
Phase 3: **Undo**
Transaction Log
Start of Log
Oldest uncommitted Tx (XACT_BEGIN_LSN)
Log Records
Last Checkpoint *(or oldest dirty page LSN)*
End of Log

Accelerated database recovery process



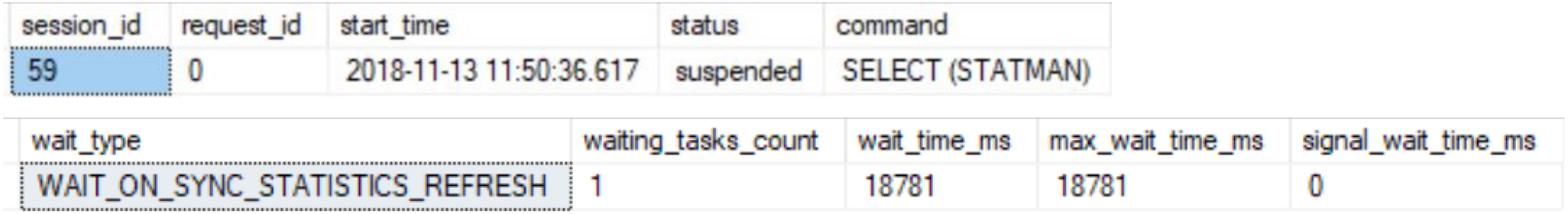
Recovery Phase / Transaction Log / sLog (with ADR)
Phase 1: Analysis
Phase 2: Redo from sLog
Phase 2: Redo
Phase 3: Undo from sLog
Only this portion of the Transaction Log is scanned.
sLog is persisted to disk as part of checkpoint
Transaction Log
Start of Log
Oldest uncommitted Tx (XACT_BEGIN_LSN)
Last Checkpoint (or oldest dirty page LSN)
End of Log
sLog
Log Records for non-versioned ops are copied to sLog

Improved diagnostic data for stats blocking

Query Waiting for synchronous update operations

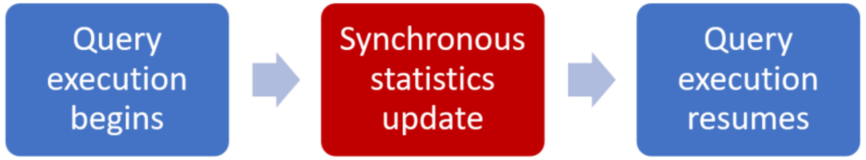
Now **sys.dm_exec_requests** shows **SELECT (STATMAN)**

New **WAIT_ON_SYNC_STATISTICS_REFRESH** wait stat



session_id	request_id	start_time	status	command
59	0	2018-11-13 11:50:36.617	suspended	SELECT (STATMAN)

wait_type	waiting_tasks_count	wait_time_ms	max_wait_time_ms	signal_wait_time_ms
WAIT_ON_SYNC_STATISTICS_REFRESH	1	18781	18781	0



Availability Groups Enhancements

- More synchronous replicas
  - SQL Server 2012 4 replicas, 2 synchronous
  - SQL Server 2014 8 replicas, 2 synchronous
  - SQL Server 2017 8 replicas, 3 synchronous
  - SQL Server 2019 8 replicas, 5 synchronous
- Secondary-to-primary read/write redirection
  - READ_WRITE_ROUTING_URL and ApplicationIntent=ReadWrite (default)
  - Killer feature to replace Listener
    - Cluster technology not offering listener-like features
    - Multi-subnet scenarios too complex to setup/maintain (e.g. Pacemaker)
    - Read scale-out or DR with cluster type NONE

Storage Class Memory / PMEM

- Allows low latency I/O
  - memory-mapped memcpy-like operations in user mode
- SQL Server 2016 SP1
  - NVDIMM-N for tail of the log caching
- SQL Server 2019
  - PMEM devices Linux
  - support for data, log In-Memory OLTP checkpoint files placement
- Hybrid Buffer Pool
  - Clean pages direct referenced on PMEM devices without copy
  - Dirty pages still kept in DRAM

Estimating Data Compression savings

sp_estimate_data_compression_savings

- Returns specified object’s current size and estimates

SQL Server < 2019

- ROW and PAGE compression

SQL Server 2019+

- Adds COLUMNSTORE and COLUMNSTORE_ARCHIVE compression
- Object type determines Columnstore type
    - E.g. Heap -> Clustered, Clustered index -> Clustered

Other SQL Server 2019 Enhancements

Lightweight query profiling infrastructure enabled by default

- Profiling mechanism introduced in SQL Server 2016 SP1
- 2% expected CPU overhead vs. 75%

Internal pages information

- Undocumented DBCC PAGE
- New in SQL Server 2019
  - **sys.dm_db_page_info(DatabaseId, FileId, PageId, Mode)**
  - **page_resource** column in **sys.dm_exec_requests** and **sys.sysprocesses**
  - **sys.fn_PageResCracker(page_resource)** to get db_id, file_id, page_id

Development

Truncation error messages

- Error message 8152 too generic
  - String or binary data would be truncated
- SQL Server 2019 introduces message 2628
  - String or binary data would be truncated in **table** '%.*ls', **column** '%.*ls'. Truncated **value**: '%.*ls’
- Enabled with Trace Flag 460
  - Opt-in required to avoid breaking parsing applications

Extensibility Framework

Secure external script execution

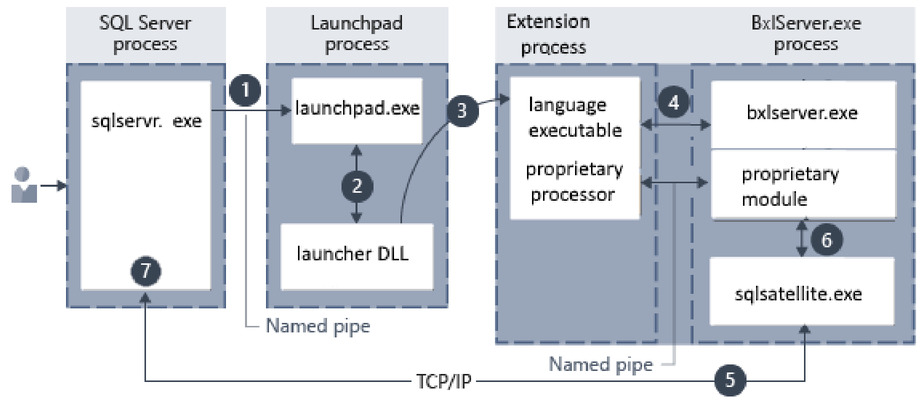
Scale/optimization opportunities

SQL Server integration (e.g. store procedures, PREDICT)

Language Support

- SQL Server 2016+ Support for R
- SQL Server 2017+ Support for Python
- SQL Server 2019+ Support for Java

Extensibility Framework Architecture



Extensibility Framework Components

Launchpad Service

- One per SQL Server instance (with Machine Learning Services)
- Provides security isolation

BxlServer

- Manage communications between SQL Server and external processes
- Binary Exchange Language data format

SQLSatellite

- Extensibility API used by BxlServer
- I/O data/arguments , error handling

Java Language extension

Leverages Extensibility Framework

- Through **sp_execute_external_script**

Current support

- On Windows version 1.10 (JRE 10, JDK 10)
- On Linux version 1.8 (JRE 8, JDK 8)

UTF-8 Support

Full support for import/export, collations, replication, …

- Still not for Linked Servers, In-Memory OLTP, External Table (Polybase)

CHAR and VARCHAR support (Windows collations only)

UTF8 in collation names

- E.g. LATIN1_GENERAL_100_CI_AS_SC_UTF8

Can provide storage savings

- E.g. 50% from NCHAR(10) to CHAR(10) with UTF8 (20 vs 10 bytes)

SQL Graph enhancements

- Derived tables and view support in MATCH queries
  - Set of nodes/edges using UNION ALL
  - Useful for heterogeneous entities or connections between them
- MATCH support in MERGE
- Edge Constraints
  - CONNECTION constraint

Security

Certificate Management

- Extended in SQL Server Configuration manager
  - View and validate certificates installed
  - View certificates close to expiration
  - Deploy Certificates across machine in Availability Groups
  - Deploy Certificates across machine in Failover Cluster Instances

SQL Data Discovery and Classification

SQL Server management Studio Tool (V17.5)

Discovery & Recommendations, Labeling, Reporting

Metadata con be persisted and queried

- Based on Extended Properties
  - **sys_information_type_name**, **sys_sensitivity_label_name**

Support for SQL Server 2008+ and Azure SQL Database

SQL Server Sensitivity Classification

SQL Server 2019+

(already available in Azure SQL Database)

T-SQL command **ADD|DROP SENSITIVITY CLASSIFICATION**

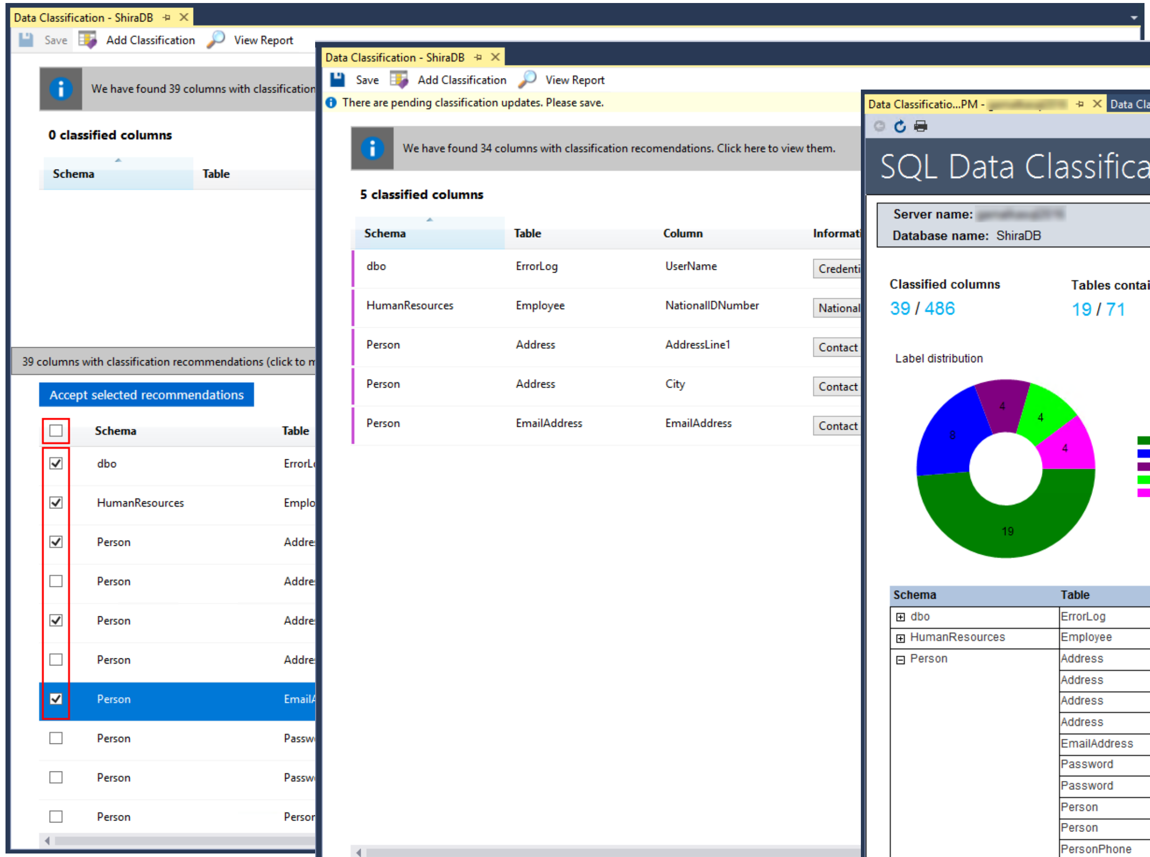
applies to tables, columns

LABEL, **LAtBEL_ID**, **INFORMATION_TYPE**, **INFORMATION_TYPE_ID**

Metadata stored in **sys.sensitivity_classifications**

SQL Server Audit add column **data_sensitivity_information**

Data Discovery and Classification Demo



Data Classification - ShiraDB

Save | Add Classification | View Report

We have found 39 columns with classification

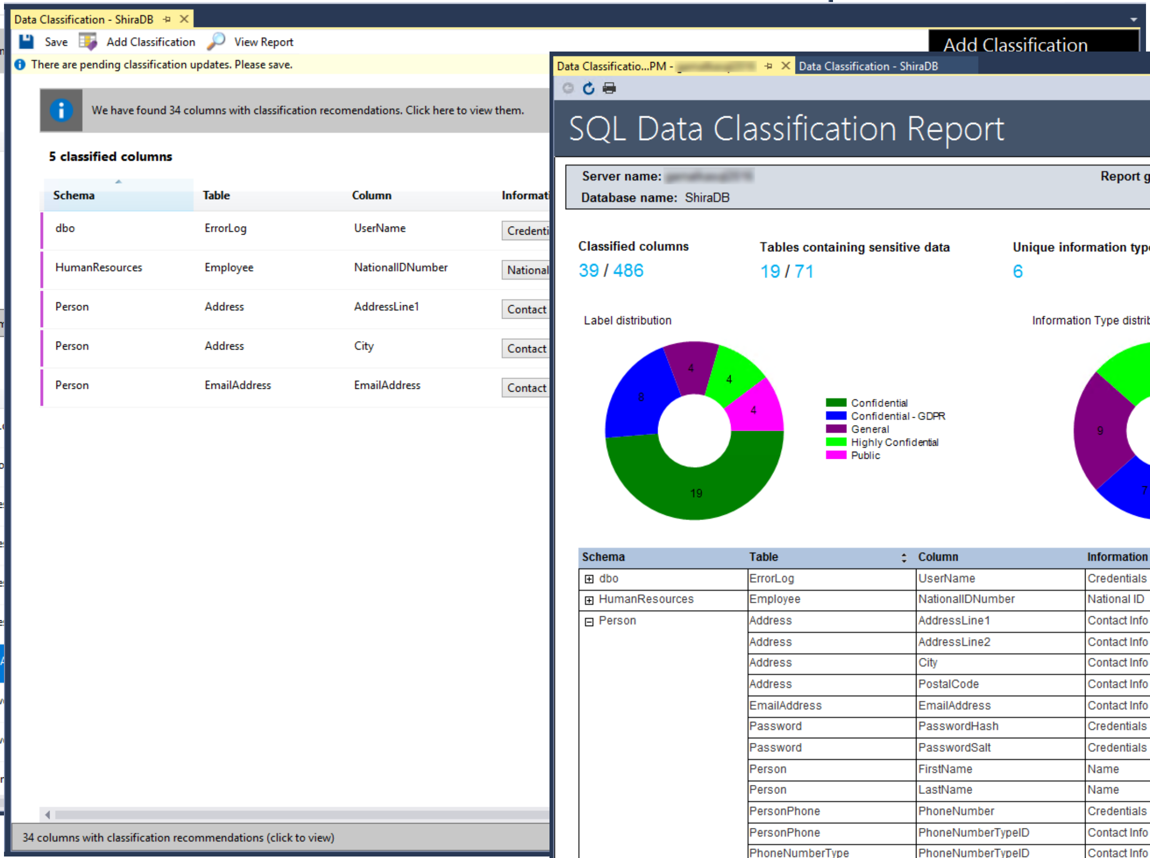
0 classified columns

Schema	Table

39 columns with classification recommendations (click to

Accept selected recommendations

	Schema	Table
☐		
☑	dbo	ErrorL
☑	HumanResources	Emplo
☑	Person	Addre
☐	Person	Addre
☑	Person	Addre
☐	Person	Addre
☑	Person	EmailA
☐	Person	Passw
☐	Person	Passw
☐	Person	Persor



Data Classification - ShiraDB

Save | Add Classification | View Report

Add Classification

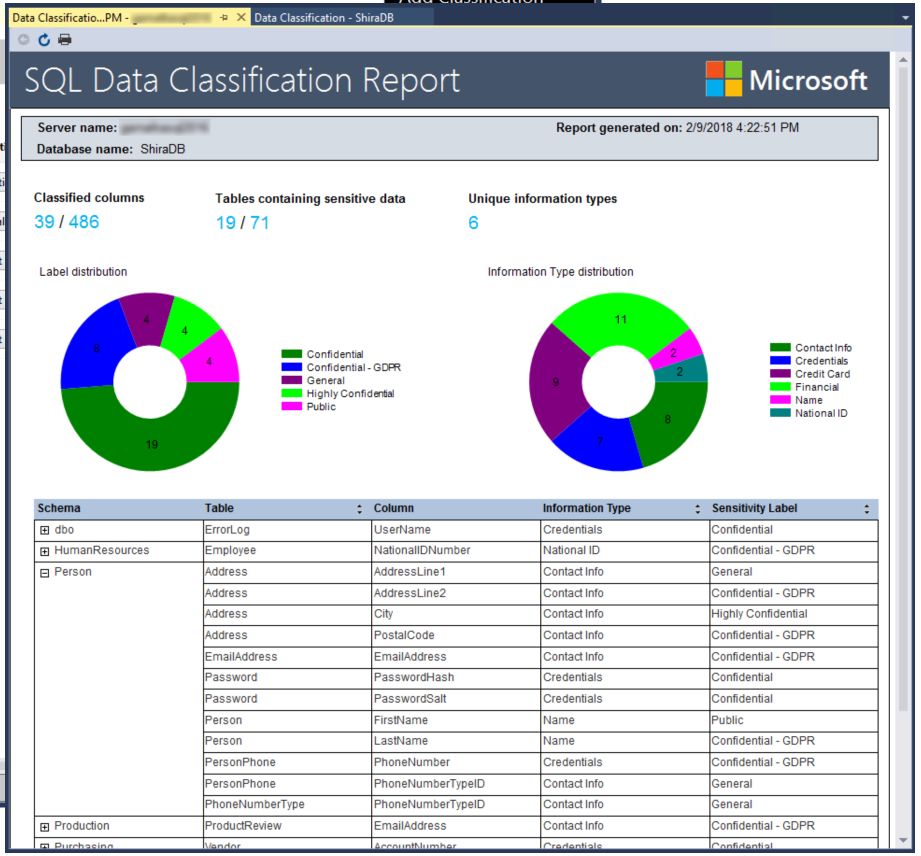
There are pending classification updates. Please save.

We have found 34 columns with classification recomendations. Click here to view them.

5 classified columns

Schema	Table	Column	Informati
dbo	ErrorLog	UserName	Credenti
HumanResources	Employee	NationalIDNumber	National
Person	Address	AddressLine1	Contact
Person	Address	City	Contact
Person	EmailAddress	EmailAddress	Contact

34 columns with classification recommendations (click to view)



Data Classificatio...PM - [redacted] | Data Classification - ShiraDB

SQL Data Classification Report

Microsoft

Server name: [redacted] **Report generated on:** 2/9/2018 4:22:51 PM

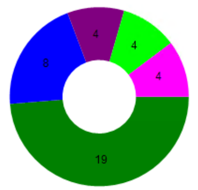
Database name: ShiraDB

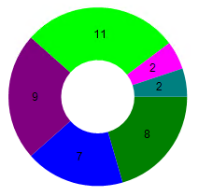
Classified columns	Tables containing sensitive data	Unique information types
39 / 486	19 / 71	6

Label distribution

Information Type distribution

Schema	Table	Column	Information Type	Sensitivity Label
⊞ dbo	ErrorLog	UserName	Credentials	Confidential
⊞ HumanResources	Employee	NationalIDNumber	National ID	Confidential - GDPR
⊟ Person	Address	AddressLine1	Contact Info	General
	Address	AddressLine2	Contact Info	Confidential - GDPR
	Address	City	Contact Info	Highly Confidential
	Address	PostalCode	Contact Info	Confidential - GDPR
	EmailAddress	EmailAddress	Contact Info	Confidential - GDPR
	Password	PasswordHash	Credentials	Confidential
	Password	PasswordSalt	Credentials	Confidential
	Person	FirstName	Name	Public
	Person	LastName	Name	Confidential - GDPR
	PersonPhone	PhoneNumber	Credentials	Confidential - GDPR
	PersonPhone	PhoneNumberTypeID	Contact Info	General
	PhoneNumberType	PhoneNumberTypeID	Contact Info	General
⊞ Production	ProductReview	EmailAddress	Contact Info	Confidential - GDPR
⊞ Purchasing	Vendor	AccountNumber	Credentials	Confidential





Always Encrypted with Secure Enclaves

Basic architecture as SQL Server 2016+ implementation

Now allows server-side computation on encrypted columns

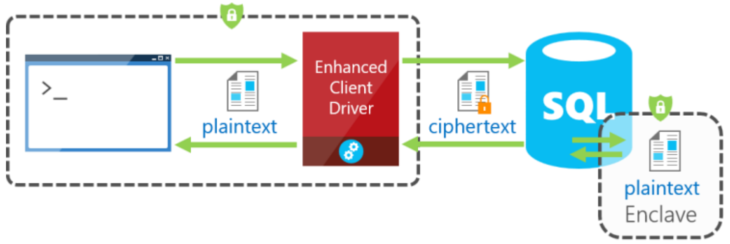
- In-Place Encryption (ALTER TABLE for initial encryption)
- Rich computations (e.g. range comparisons, LIKE predicates, …)

Inside secure enclaves

- Virtualization-based Security (VBS) secure memory enclaves
  - also known as Virtual Secure Mode(VSM) enclaves
- Operation on plaintexts cannot be disclosed outside enclave
- Column Master Keys sent over secure channel by client driver

Still some limitations (no indexing)

Performance optimizations pending…



Data Masking

Dynamic Data Masking	**Static Data Masking**
On the original database	On a copy of the database
Original data intact	Original data not retrievable
On-the-fly at query time	At storage level
Based on user permissions	Masked for everyone

Static Data Masking

Component of SQL Server Management Studio V18 Preview5+

Define per-column masking configuration

- NULL, Single-Value, Shuffle, Group Shuffle, String Composite
- Can save and load it

It’s basically a backup/restore and modify data according to config

No automation yet ☹

Static Data Masking Limitations

No temporal and memory-optimzed tables

No computed and identity columns

No geometry and geography types

Azure SQL Database Hyperscale service tier not supported

Statistics not updated

No cleanup in case of error

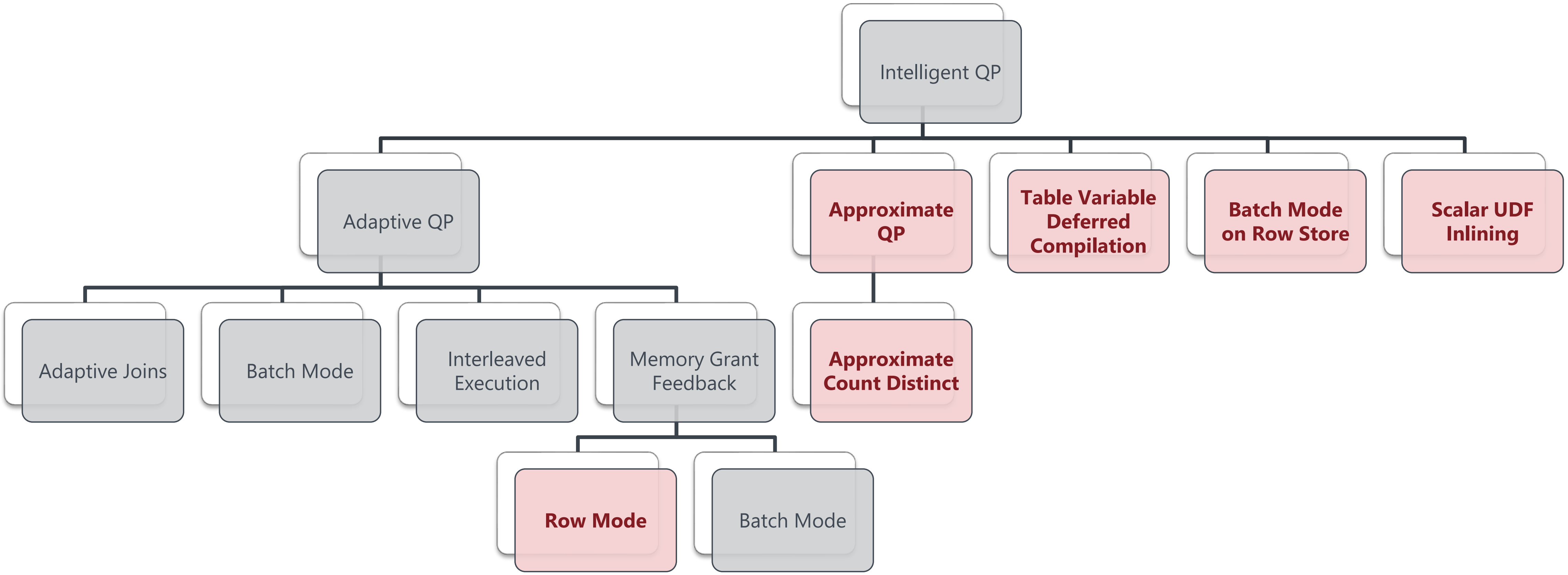
- can leave sensitive data copies (backupset)

Data and log files may contain sensitive data

- retrievable with hex editor

Performance

Intelligent Query Processing



Execution Modes

Row Mode

- Execution tree iterators consume 1 row at a time
- Traditional execution mode for Rowstore

Batch Mode

- Execution tree iterators consume a batch of rows at a time
- Optimal with large scan operations (e.g. large table aggregates or joins)
- SQL Server 2012 introduced to leverage Columnstore Indexes
- SQL Server 2016/2017 extended usage scenarios for CI
- SQL Server 2019 extended usage scenarios to Rowstore

Batch Mode on RowStore

Help reducing CPU Consumption

Columnstore still a better choice

- for OLAP workload that is I/O bound
- can't always create it (e.g. impact on OLTP, features not supported)

Limitations

- In-Memory tables not supported (only heaps & disk-based b-trees)
- Not used when fetching/filtering LOB columns
  - (including sparse columns sets & XML)

Batch Mode on Rowstore Control

SQL Server < 2019

- Some scenarios covered with tricks… (article part1, part2, part3)

SQL Server 2019+

- Scenarios supported directly by Query Processor
- On by default with database compatibility level **150+**
- ALTER DATABASE SCOPED CONFIGURATION
  SET **BATCH_MODE_ON_ROWSTORE** = ON|OFF
- OPTION (USE HINT ('**ALLOW_BATCH_MODE**'));
- OPTION (USE HINT ('**DISALLOW_BATCH_MODE**'));

Memory Grant

Excessive Grant

- Too much memory allocated vs. memory used
- Impact: blocking, out-of-memory, reduced concurrency

Poor Grant

- Not enough memory allocated resulting in data spill to tempdb
- Impact: slow query, excessive disk usage (tempdb)

Grant increase

- dynamic grants increase allocation too much
- impact: server instability, unpredictable performance

Memory Grant Feedback

Post-execution evaluation

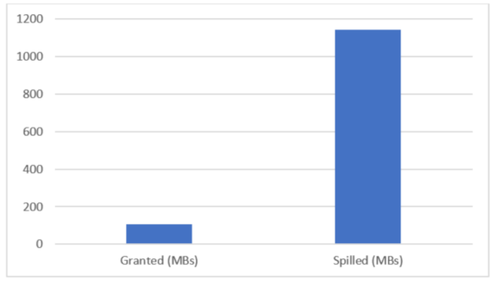
- Updates grant value for cached plan
- E.g. more memory if spilled, less if excessive grant

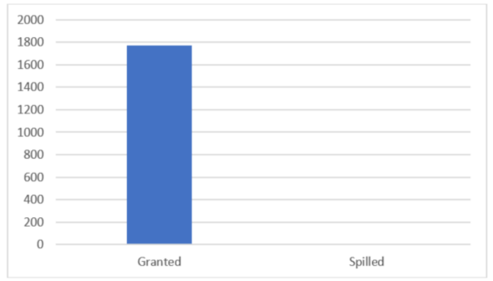
Version support

- SQL Server 2017+ Batch Mode
- SQL Server 2019+ Row Mode

Plan caching

- Not persistent (i.e. not save in Query Store)
- OPTION(RECOMPILE) prevents caching and memory grant feedback





Memory Grant Feedback Control

Batch Mode

On by default with database compatibility level **140+**

ALTER DATABASE SCOPED CONFIGURATION
SET **BATCH_MODE_MEMORY_GRANT_FEEDBACK** = ON|OFF

OPTION (USE HINT('**DISABLE_BATCH_MODE_MEMORY_GRANT_FEEDBACK**'));

Row Mode

On by default with database compatibility level **150+**

ALTER DATABASE SCOPED CONFIGURATION
SET **ROW_MODE_MEMORY_GRANT_FEEDBACK** = ON|OFF

OPTION (USE HINT ('**DISABLE_ROW_MODE_MEMORY_GRANT_FEEDBACK**'));

Troubleshooting Memory Grant Feedback

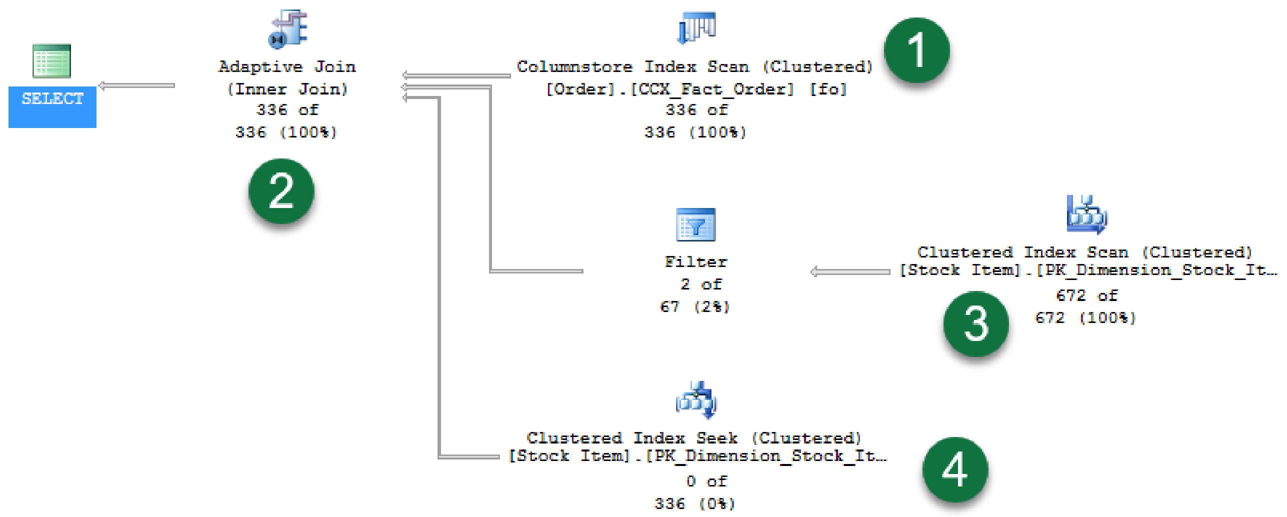
- Parameter sensitive scenarios
  - Some queries requires different plans with different grants
  - Memory grant feedback will disable itself when unstable
- Extended Events to monitor changes
  - SQL Server 2017+ **memory_grant_feedback_loop_disabled**
  - SQL Server 2019+ **memory_grant_updated_by_feedback**
- SQL Server 2019+ execution plan attributes
  - **IsMemoryGrantFeedbackAdjusted**
    - No: First Execution, Accurate Grant, Feedback disabled
    - Yes: Adjusting, Stable
  - **LastRequestedMemory**

Batch mode adaptive joins

Scenario

- Nested loop algorithm better for small build join inputs
- Hash algorithm better for bigger inputs

Adaptive joins defer choice after first input scanned


SELECT
Adaptive Join
(Inner Join)
336 of
336 (100%)
2
Columnstore Index Scan (Clustered)
[Order].[CCX_Fact_Order] [fo]
336 of
336 (100%)
1
Filter
2 of
67 (2%)
Clustered Index Scan (Clustered)
[Stock Item].[PK_Dimension_Stock_It...
672 of
672 (100%)
3
Clustered Index Seek (Clustered)
[Stock Item].[PK_Dimension_Stock_It...
0 of
336 (0%)
4

Interleaved Execution

Problem with multi-statement table valued functions (MSTVFs)

- SQL Server <= 2012 optimize with cardinality = 1
- SQL Server 2014 & 2016 optimize with cardinality = 100

SQL Server >= 2017

- Start optimization
- Pause and executes MSTVFs if candidate
- Resume optimization with correct cardinality

Table Variable vs Temporary Tables

Area	Temporary Tables	Table Variables
Manual statistics creation and update	Yes	No\
Indexes	Yes	Only inline index definitions allowed
Constraints	Yes	Only PRIMARY KEY, UNIQUE and CHECK
Automatic statistics creation	Yes	No
Creating and using a temporary object in a single batch	Compilation of a statement that references a temporary table that doesn't exist is deferred until the first execution of the statement	A statement that references a table variable is compiled along with all other statements before any statement that populates the Table Variable is executed, so compilation sees it as 1

Table Variable Deferred Compilation

Before SQL Server 2019

- Statement referencing TV compiled before population
- Number of row estimate fixed at 1

Starting with SQL Server 2019

- Behaves like Temporary Tables
- Statement referencing non existing TV is deferred until first execution
- Number of row estimate much better

Control

- On by default with database compatibility level **150+**
- ALTER DATABASE SCOPED CONFIGURATION
  SET **DEFERRED_COMPILATION_TV** = ON|OFF
- OPTION (USE HINT ('**DISABLE_DEFERRED_COMPILATION_TV**'));

Scalar UDF inlining

T-SQL user defined functions that returns a single data value

Performance problems

- Iterative invocation
  - once per row, context switching especially with query execution
- Lack of costing
  - before, only relational operators were costed, assumption to be cheap…
- Interpreted execution
  - each statement executes in isolation, no cross-statement optimizations
- Serial execution
  - Intra-query parallelism not allowed

Scalar UDF Automatic inlining

In SQL Server 2019 Scalar UDF automatically transformed into

- Scalar Expressions
- Scalar Subqueries

Optimize the whole plan (UDFs no longer visible)

Control

- On by default with database compatibility level **150+**
- ALTER DATABASE SCOPED CONFIGURATION
  SET **TSQL_SCALAR_UDF_INLINING** = ON|OFF
- OPTION (USE HINT ('**DISABLE_TSQL_SCALAR_UDF_INLINING**'));
- CREATE FUNCTION … WITH **INLINE** = ON | OFF

Scalar UDF inlining example

```
CREATE FUNCTION dbo.discount_price(@price DECIMAL(12,2), @discount DECIMAL(12,2))
RETURNS DECIMAL (12,2) AS BEGIN RETURN @price * (1 - @discount); END

SELECT L_SHIPDATE, O_SHIPPRIORITY
, SUM(dbo.discount_price(L_EXTENDEDPRICE, L_DISCOUNT))
FROM LINEITEM, ORDERS
WHERE O_ORDERKEY = L_ORDERKEY
GROUP BY L_SHIPDATE, O_SHIPPRIORITY
ORDER BY L_SHIPDATE
```

10GB CCI compressed TPC-H Schema, 2 x CPUs (12 cores), 96GB RAM, SSD storage

	Query without UDF	Query with UDF (no inlining)	Query with UDF (inlining)
Execution time	1.6 seconds	29 minutes 11 seconds	1.6 seconds

Scalar UDF inlining requirements

Written using the following constructs

- DECLARE, SET (var declaration/assignments)
- SELECT (single/multiple var assignments)
- IF/ELSE (arbitrary nesting levels)
- RETURN (single or multiple)
- UDF nested/recursive function calls
- Relational operations like EXISTS, ISNULL

No invocation of functions that are

- time-dependent (GETDATE())
- has side effects (NEWSEQUENTIALID())

Uses EXECUTE AS CALLER (default)

No table variables references

No table-valued parameters references

No user-defined types references

Not natively compiled

- interop supported

Not a partition function

Not referenced in

- GROUP BY clauses
- computed columns
- check constraints

No signatures added to it

Scalar UDF inlining troubleshoting

Column **is_inlineable** in **sys.sql_modules**

Doesn't imply it will always be inlined! (e.g. 1000s lines of code)

Execution Plan

If inlined successfully, xml node **<UserDefinedFunction>** will be missing

Extended Events

tsql_scalar_udf_not_inlineable

APPROX_COUNT_DISTINCT

Returns **approximate** number of unique non-null values in groups

- HyperLogLog algorithm guarantees
  up to 2% error rate within 97% probability

Fast data exploration with low memory footprint

- E.g. dashboards, trend analysis, feature selection, etc.
- Think 10 billion rows,
  1 user using 1,5GB memory vs 100 users using 12MBs
- Tradeoff: precision, only scenarios where exact values are not necessary!

Q&A