Microsoft

DP-300
Administering Microsoft Azure SQL Solutions

Microsoft

Monitor and optimize operational resources in Azure SQL

Introduction to performance monitoring, understand performance problems, and proper configuration options

Objective

- Monitor activity and compare to a baseline
- Explore maintenance tasks related to performance
- Identify major causes of performance problems
- Configure databases and resources for optimal performance

Describe performance monitoring

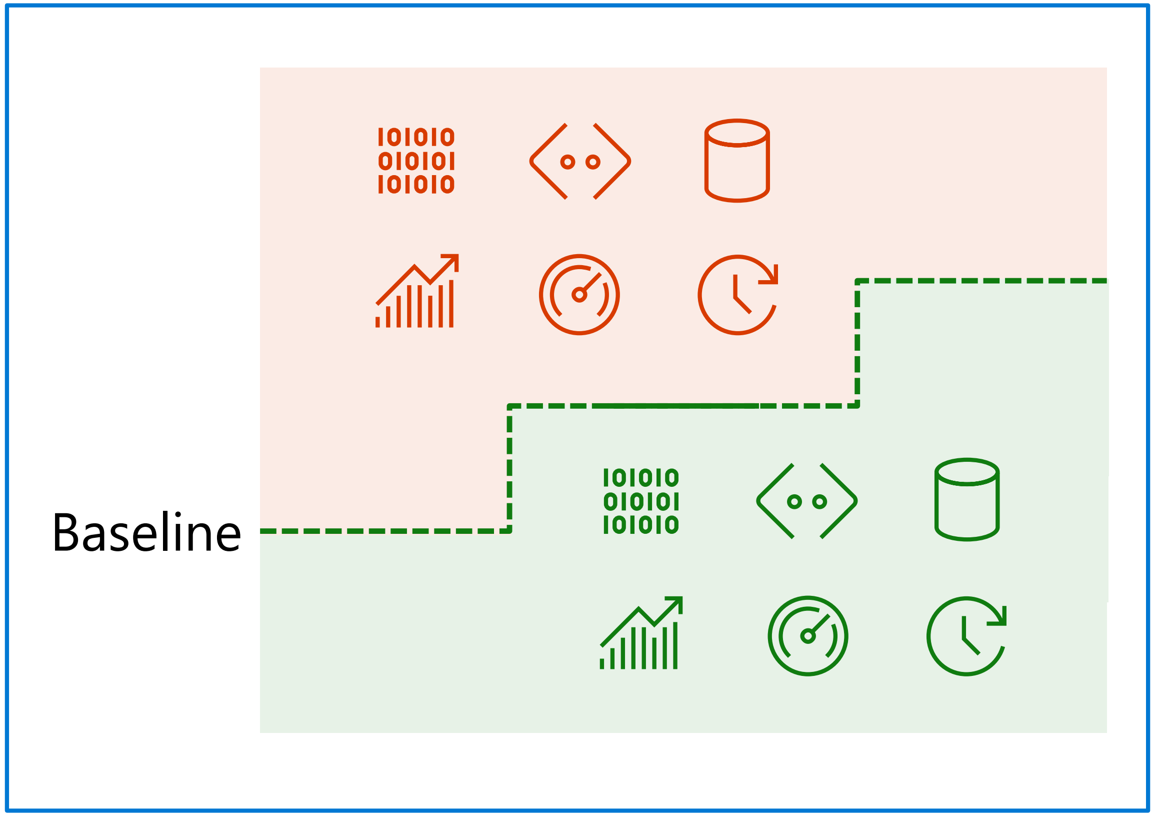
Objectives

- Understand methods to review potential performance issues
- Learn how to collect metrics for an established baseline
- Understand Extended Events and Azure Intelligent Insights

What is a baseline?

A baseline

A general set of metrics around performance and utilization that allow you to easily separate performance anomalies from normal usage patterns



Establishing a baseline

Having a baseline of system performance data allows you to make better decisions for performance tuning

You can separate code problems from simple increased utilization

You may also proactively allocate more compute resources as your workload increases over time

Performance on an Azure Virtual Machine

Built-in tool in the Windows operating system

- Collect detailed, granular performance data about SQL Server and Windows operations
- Group Performance Monitor counters together to easily gather and analyze performance data
- Data can be easily exported to archive

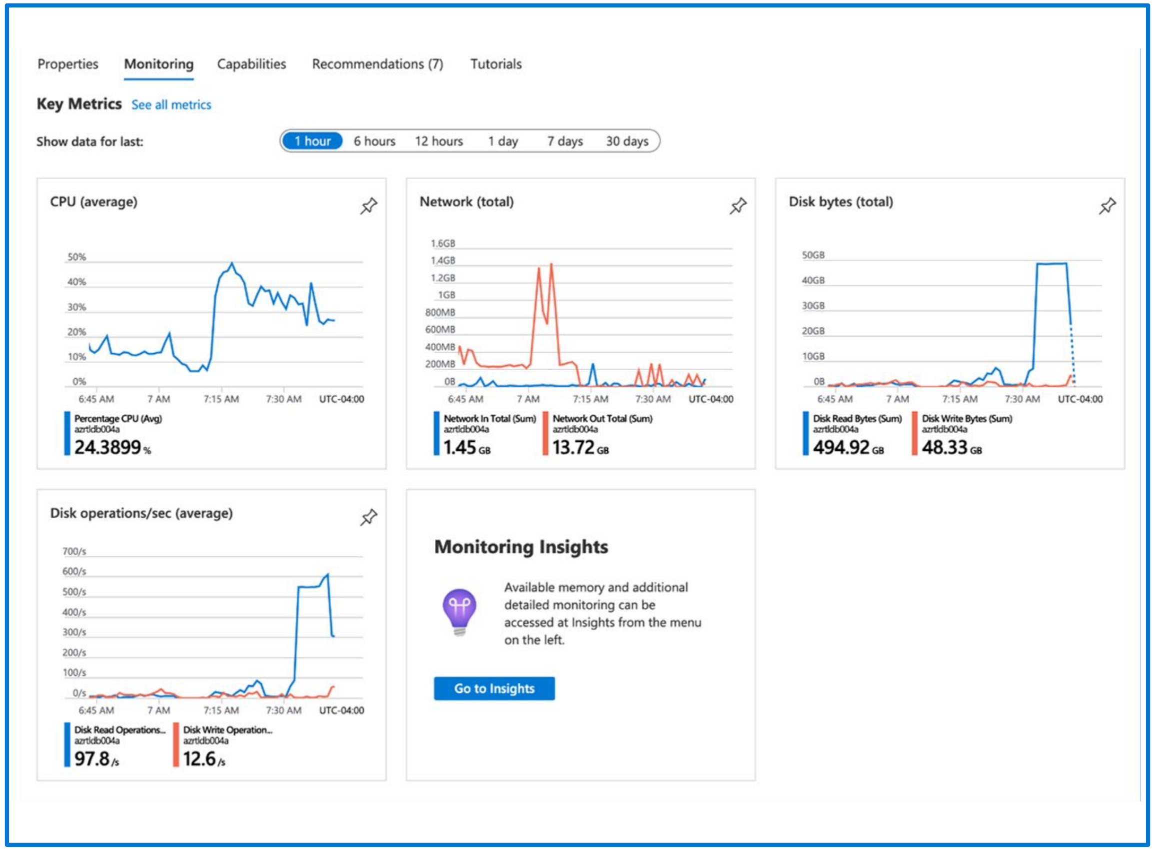
Performance monitoring tools – Azure Monitor

All Azure resources collect a set of metrics through the Azure Monitor service

Enhanced data may be collected through the Azure Monitoring Insights for virtual machine resources

Data is stored in Azure Log Analytics

Metrics available to monitor will vary depending on the type of resource



Key Metrics

Show data for last: 1 hour

CPU (average)

Percentage CPU (Avg)
azrtidb004a
24.3899 %

Network (total)

Network In Total (Sum)
azrtidb004a
1.45 GB

Network Out Total (Sum)
azrtidb004a
13.72 GB

Disk bytes (total)

Disk Read Bytes (Sum)
azrtidb004a
494.92 GB

Disk Write Bytes (Sum)
azrtidb004a
48.33 GB

Disk operations/sec (average)

Disk Read Operations...
azrtidb004a
97.8 /s

Disk Write Operation...
azrtidb004a
12.6 /s

Monitoring Insights

Available memory and additional detailed monitoring can be accessed at Insights from the menu on the left.

Review of Azure metric alerts

Overview

Azure has a built-in alerting system that allows you to create alerts

The alerts can be configured:

- In a static manner
- In a dynamic fashion using Dynamic Thresholds

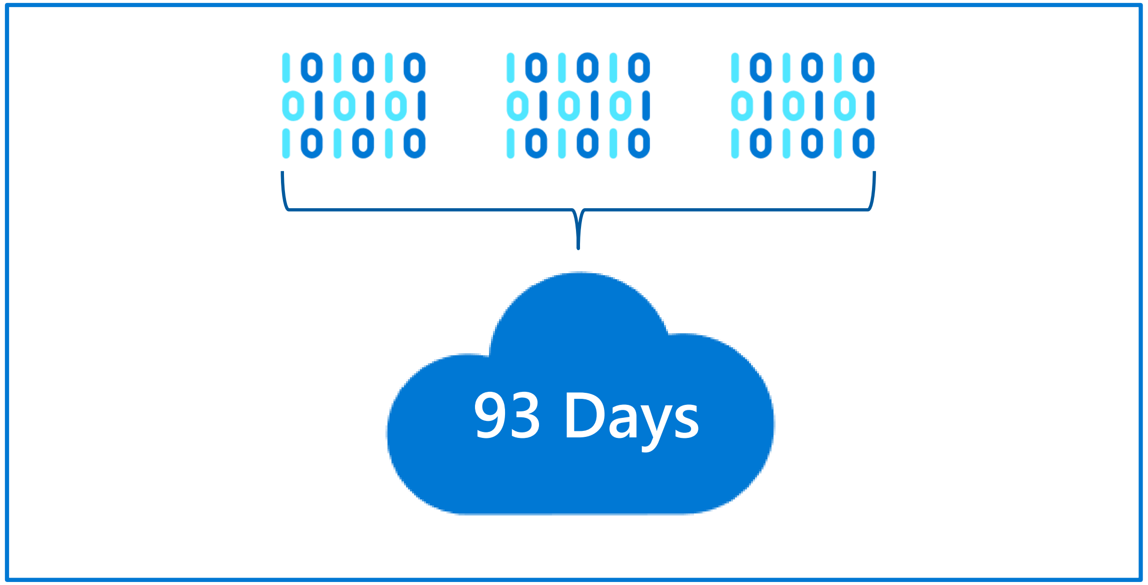
Creating metric alerts

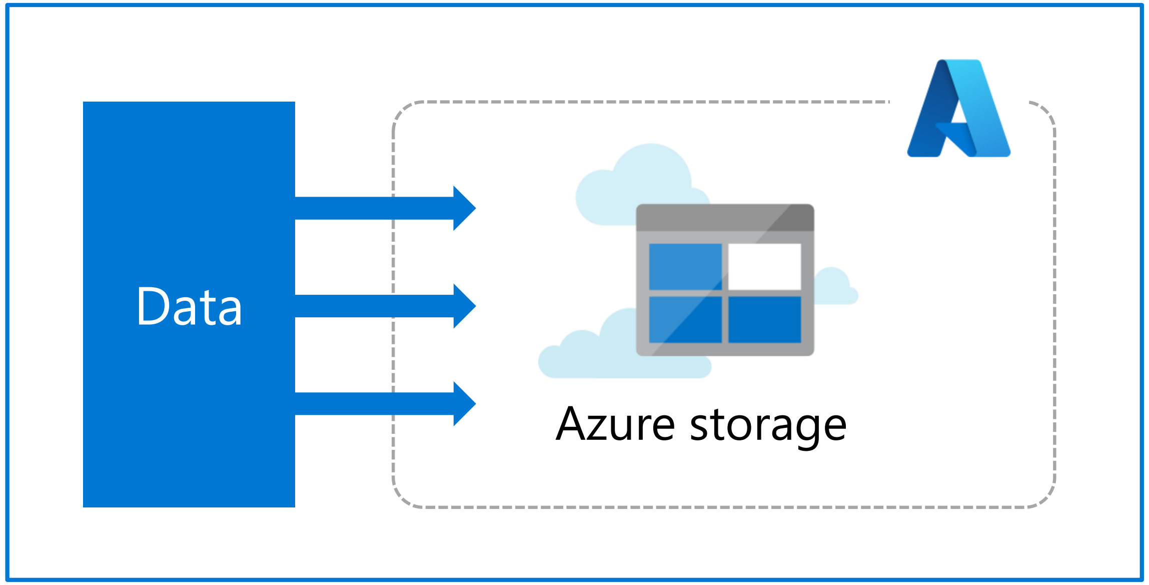
Metric alerts can be defined on IaaS or PaaS resources

Alerts can be scoped by:

- VM
- Subscription
- Resource Group

Reviewing performance data history





Azure Monitor stores data from **93 days**, which covers three months of data

You may archive data to Azure storage for historical analysis

SQL Server metrics that matter

Processor(_Total)% Processor Time

Paging File(_Total)% Usage

PhysicalDisk(_Total)\Avg. Disk sec/Read and Avg. Disk sec/Write

System\Processor Queue Length

SQLServer:Buffer Manager\Page life expectancy

SQLServer:SQL Statistics\Batch Requests/sec

SQLServer:SQL Statistics\SQL Compilations/sec and SQL Re-Compilations/sec

What are Extended Events?

A lightweight and extensive diagnostic system that is built into the SQL Server engine

- **Extended Events are supported on all the Azure SQL platforms**
- **Event sessions can be used to trace activity within the database which can help you troubleshoot issues like:**
    - Blocking and deadlocking performance issues
    - Identify long-running queries
    - Observing Memory Pressure in your database
- **The Extended Event framework allows you to filter your data collection**

What can I monitor with Extended Events?

- Extended events cover all aspects of the database engine. Specifically they are divided into four channels:

Admin

Events targeted for end users and administrators, like a deadlock report

Operational

Used for analysis and diagnosis of common problems, like an Availability Group failover

Analytical

Commonly used for tracing query execution

Debug

Used in conjunction with Microsoft support. May not be fully documented

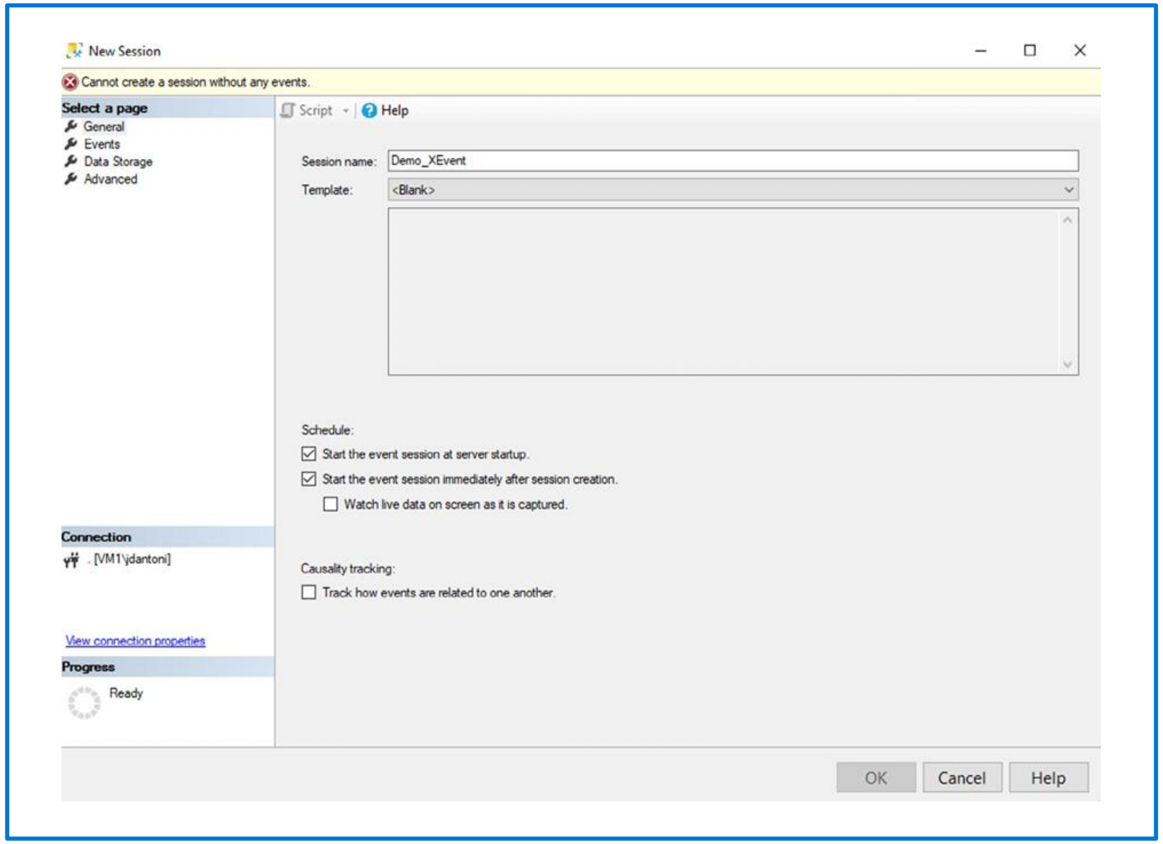
- Events can be groups together into sessions for easier monitoring

How to create an Extended Events session

SSMS has a wizard to create an Extended Events session

SSMS also includes predefined templates for monitoring specific resources

You can also use T-SQL which is more common for advanced administrators



Cannot create a session without any events.

Session name: Demo_XEvent

Template: <Blank>

Schedule:

☑ Start the event session at server startup.

☑ Start the event session immediately after session creation.

□ Watch live data on screen as it is captured.

Causality tracking:

□ Track how events are related to one another.

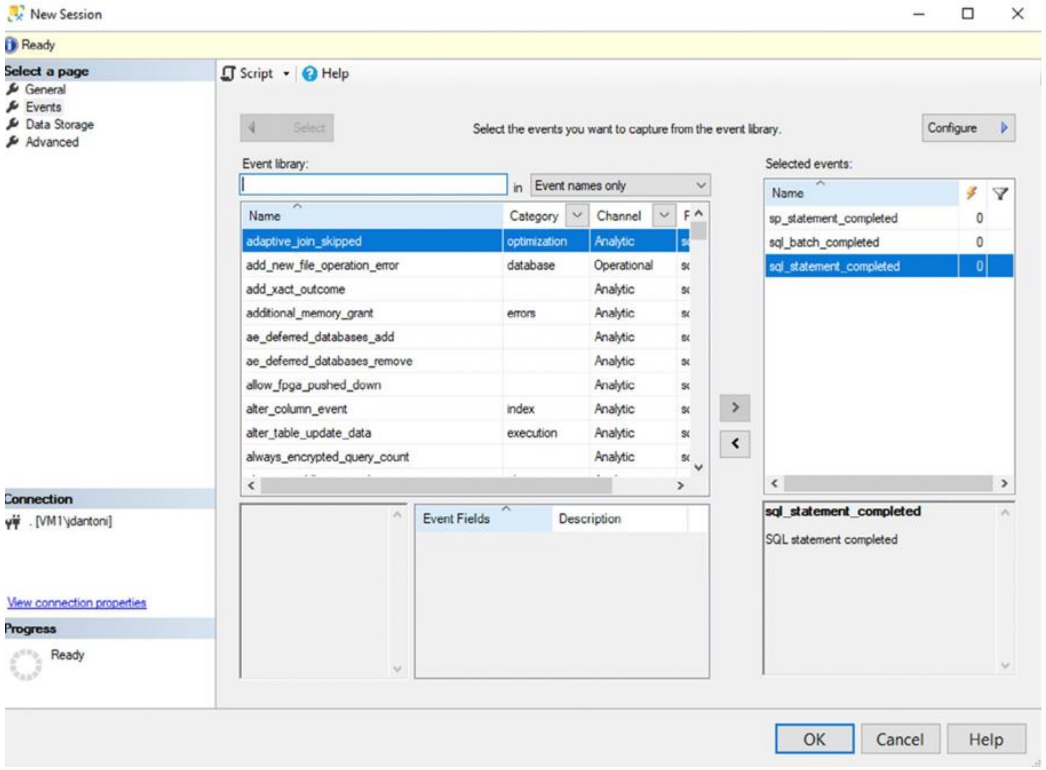
. [VM1\jdantoni]

Ready

Extended Events components

Event Sessions consists of events and targets

Events represent the engine action you are capturing and include fields that can both be filtered and select individually



. [VM1\jdantoni]

Ready

Select the events you want to capture from the event library.

Event library: in Event names only

Name	Category	Channel	F
adaptive_join_skipped	optimization	Analytic	s
add_new_file_operation_error	database	Operational	s
add_xact_outcome		Analytic	s
additional_memory_grant	errors	Analytic	s
ae_deferred_databases_add		Analytic	s
ae_deferred_databases_remove		Analytic	s
allow_fpga_pushed_down		Analytic	s
alter_column_event	index	Analytic	s
alter_table_update_data	execution	Analytic	s
always_encrypted_query_count		Analytic	s

Event Fields	Description

Selected events:

Name	⚡	▽
sp_statement_completed	0	
sql_batch_completed	0	
sql_statement_completed	0	

sql_statement_completed

SQL statement completed

Extended Events storage

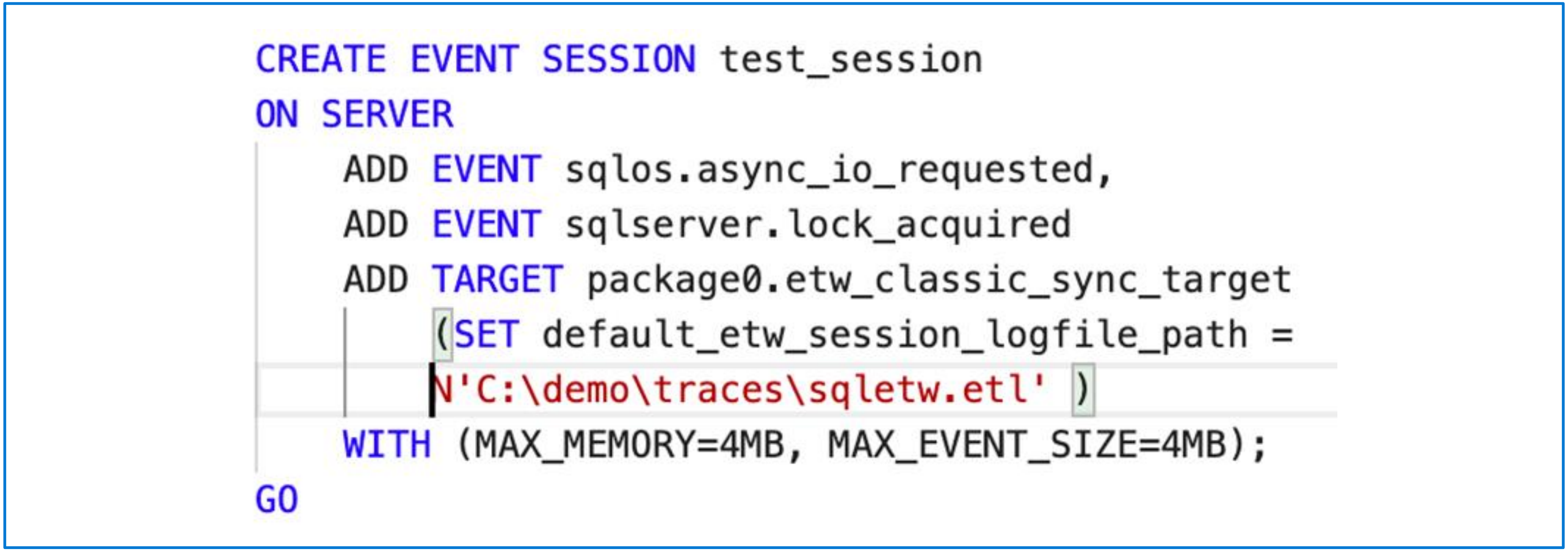
Events are persisted to disk for further analysis

There are multiple targets depending on the nature of your data collection

The most commonly used storage target is the event file, which writes the file to a local disk

You can also use the ring buffer, a non-persistent area of memory to perform real-time analysis of an event session

Extended Events with T-SQL



```
CREATE EVENT SESSION test_session
ON SERVER
    ADD EVENT sqlos.async_io_requested,
    ADD EVENT sqlserver.lock_acquired
    ADD TARGET package0.etw_classic_sync_target
        (SET default_etw_session_logfile_path =
        N'C:\demo\traces\sqletw.etl' )
    WITH (MAX_MEMORY=4MB, MAX_EVENT_SIZE=4MB);
GO
```

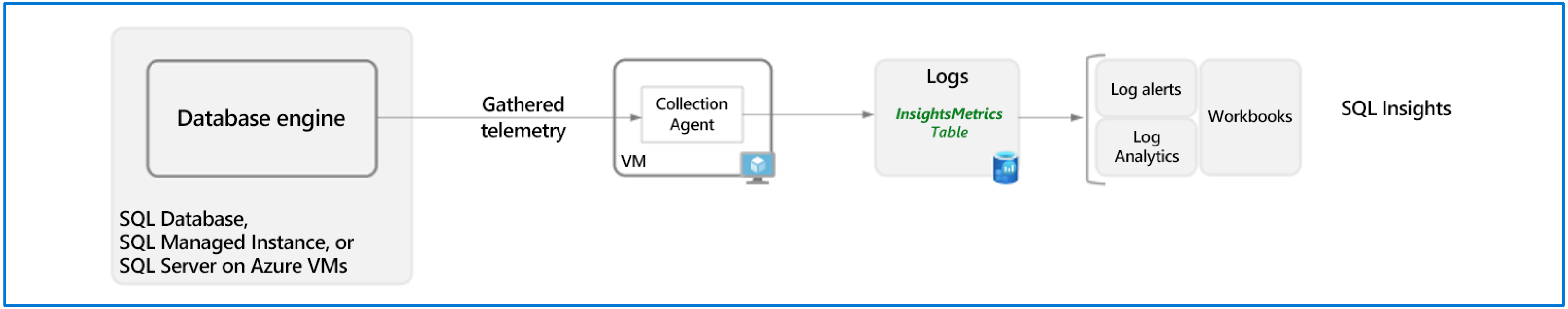
Azure SQL Insights

1 Monitoring profile can include SQL Database, SQL Managed Instance, and SQL Server on Azure VMs

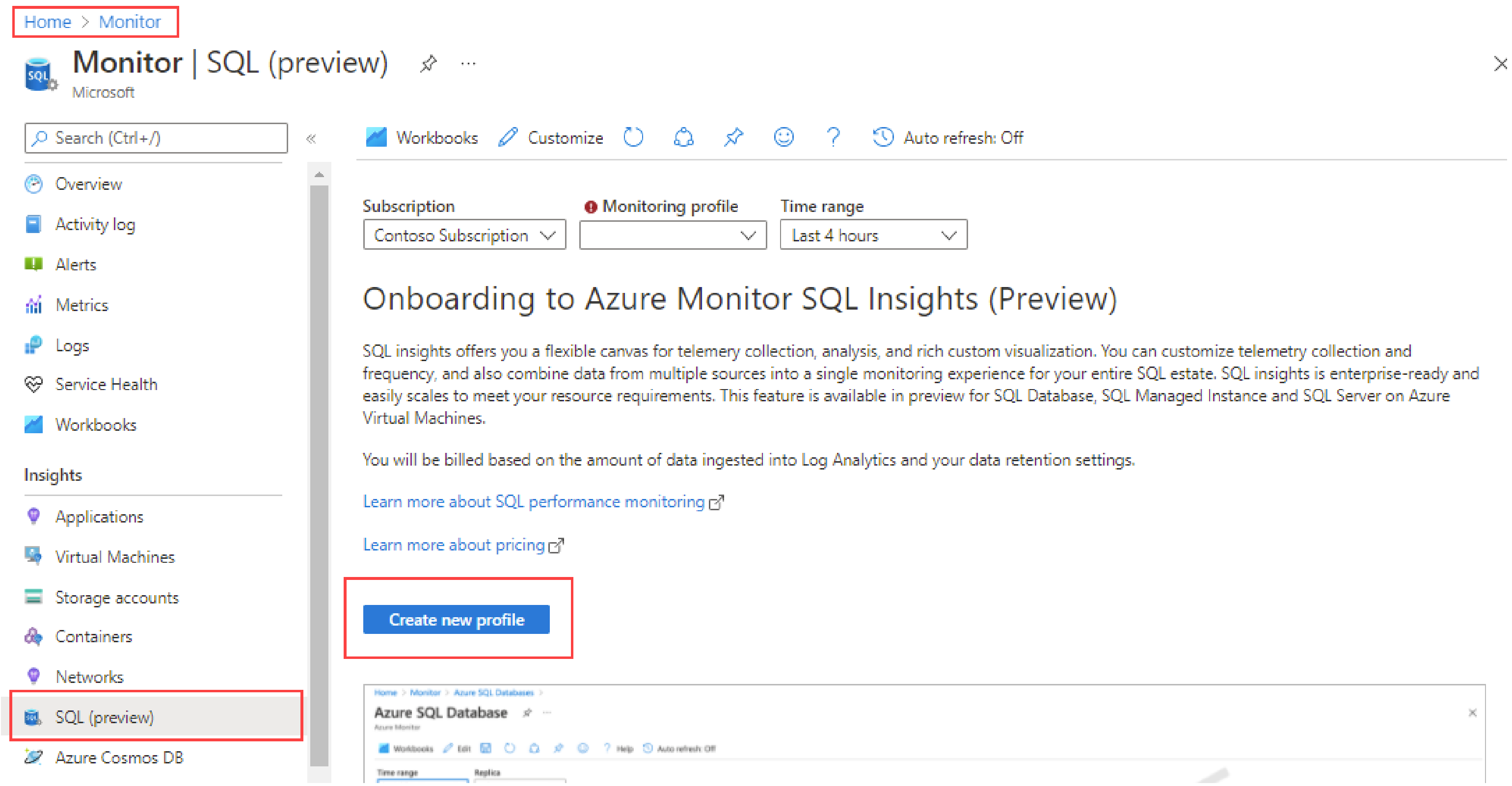
2 Collection agent is installed on a dedicated virtual machine that will monitor and remotely collect data from your SQL servers

3 Insight metrics are stored in Azure Log Analytics

4 Access performance data from the SQL Insights workbook template, or directly from the monitoring logs



Azure SQL Insights – Creating a new profile



Subscription: Contoso Subscription

Monitoring profile:

Time range: Last 4 hours

Onboarding to Azure Monitor SQL Insights (Preview)

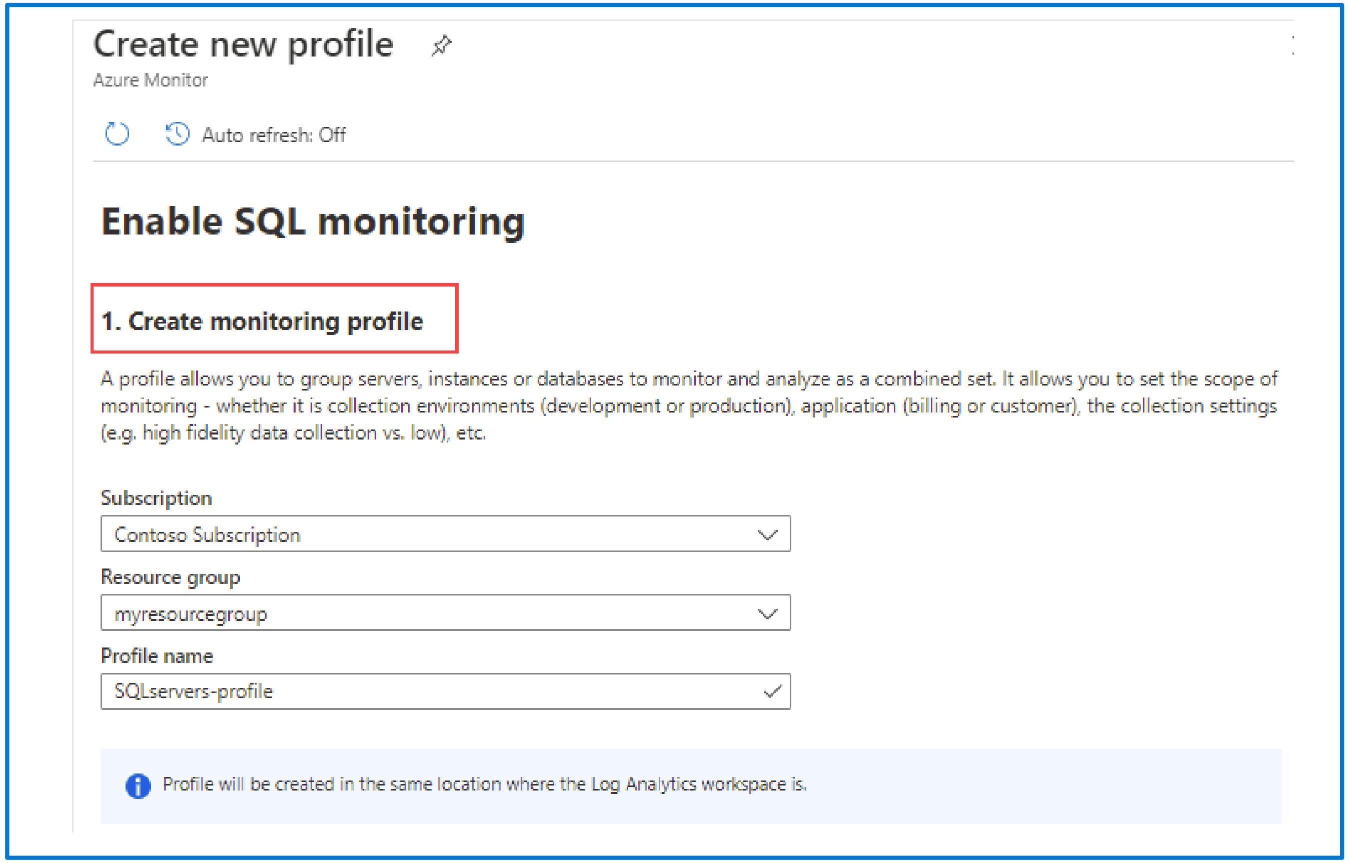
SQL insights offers you a flexible canvas for telemery collection, analysis, and rich custom visualization. You can customize telemetry collection and frequency, and also combine data from multiple sources into a single monitoring experience for your entire SQL estate. SQL insights is enterprise-ready and easily scales to meet your resource requirements. This feature is available in preview for SQL Database, SQL Managed Instance and SQL Server on Azure Virtual Machines.

You will be billed based on the amount of data ingested into Log Analytics and your data retention settings.

Learn more about SQL performance monitoring

Learn more about pricing

Azure SQL Insights – Creating a new profile cont’d



Create new profile

Azure Monitor

Auto refresh: Off

Enable SQL monitoring

1. Create monitoring profile

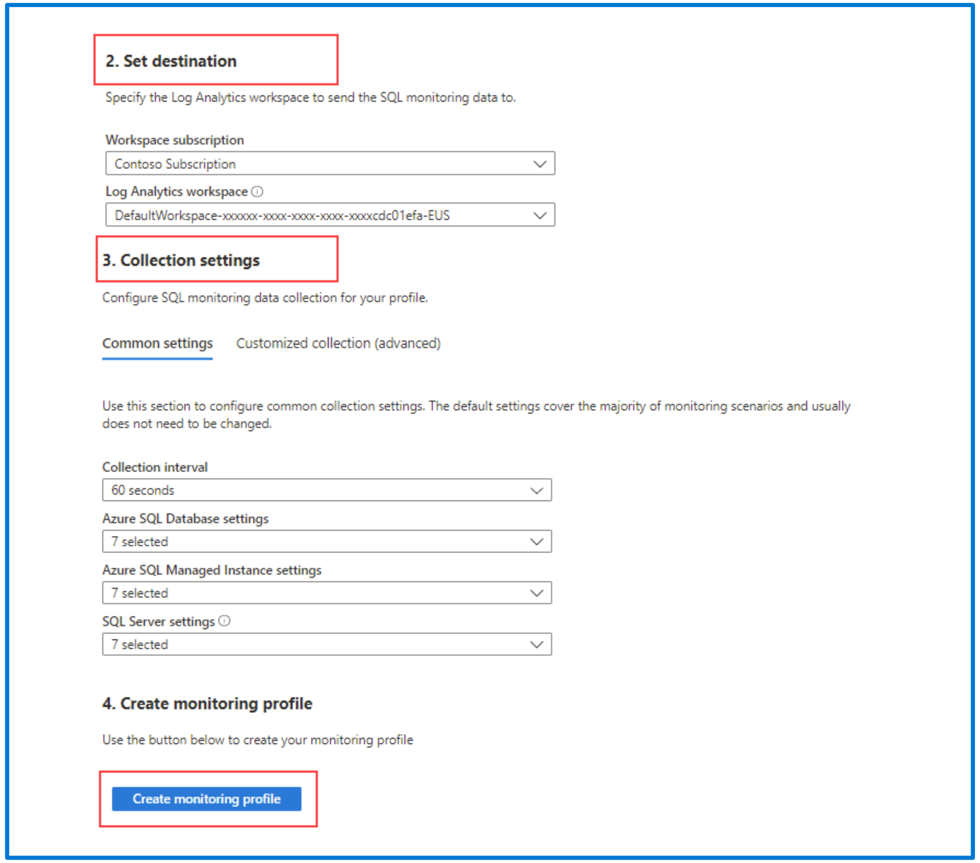
A profile allows you to group servers, instances or databases to monitor and analyze as a combined set. It allows you to set the scope of monitoring - whether it is collection environments (development or production), application (billing or customer), the collection settings (e.g. high fidelity data collection vs. low), etc.

Subscription: Contoso Subscription

Resource group: myresourcegroup

Profile name: SQLservers-profile

Profile will be created in the same location where the Log Analytics workspace is.



2. Set destination

Specify the Log Analytics workspace to send the SQL monitoring data to.

Workspace subscription: Contoso Subscription

Log Analytics workspace: DefaultWorkspace-xxxxxx-xxxx-xxxx-xxxx-xxxxcdc01efa-EUS

3. Collection settings

Configure SQL monitoring data collection for your profile.

Use this section to configure common collection settings. The default settings cover the majority of monitoring scenarios and usually does not need to be changed.

Collection interval: 60 seconds

Azure SQL Database settings: 7 selected

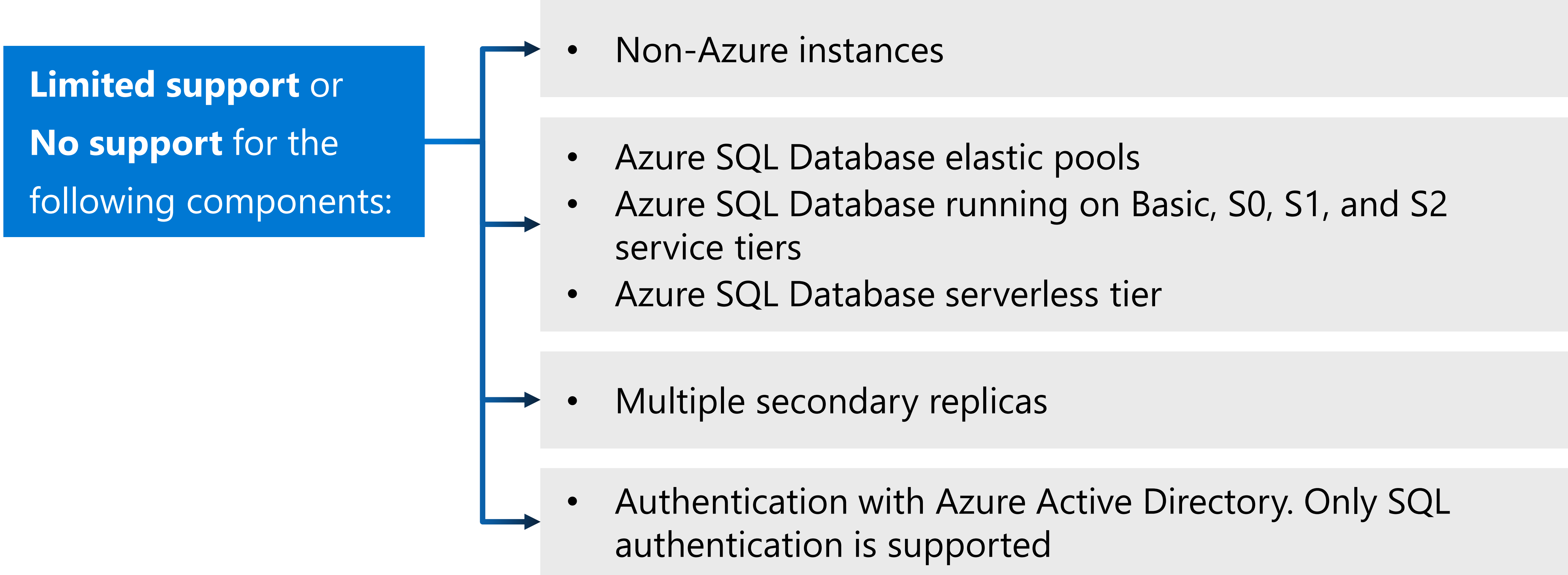
Azure SQL Managed Instance settings: 7 selected

SQL Server settings: 7 selected

4. Create monitoring profile

Use the button below to create your monitoring profile

Azure SQL Insights limitations



Limited support or **No support** for the following components:

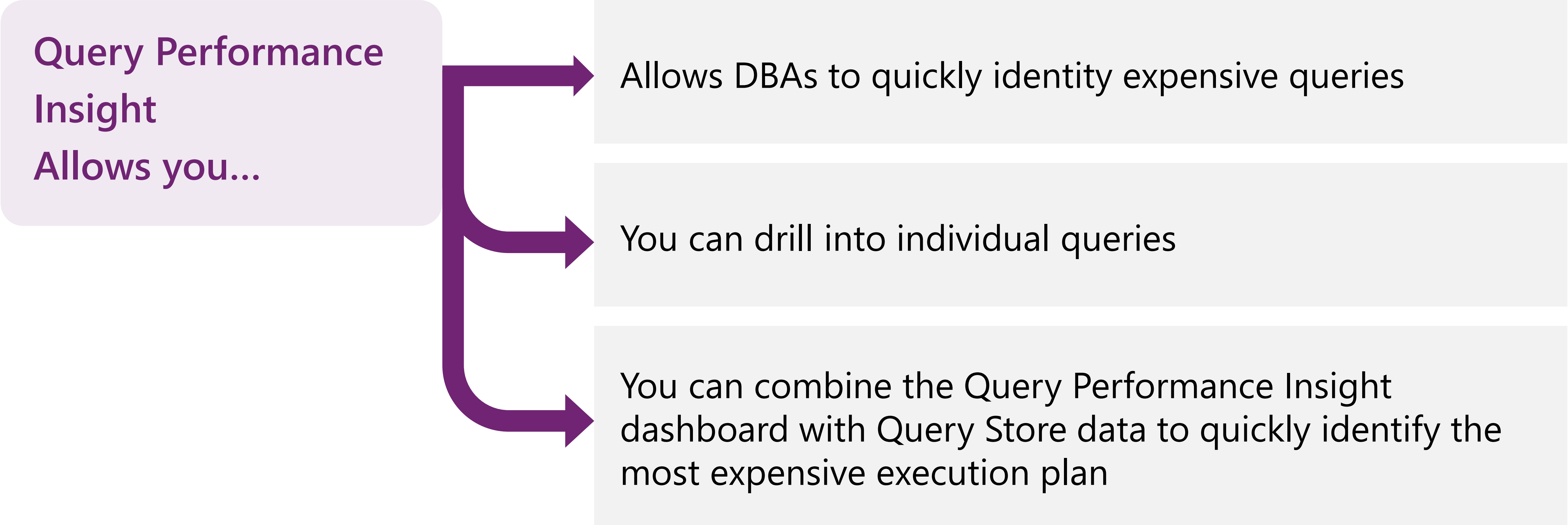
- Non-Azure instances

- Azure SQL Database elastic pools
- Azure SQL Database running on Basic, S0, S1, and S2 service tiers
- Azure SQL Database serverless tier

- Multiple secondary replicas

- Authentication with Azure Active Directory. Only SQL authentication is supported

Query Performance Insights



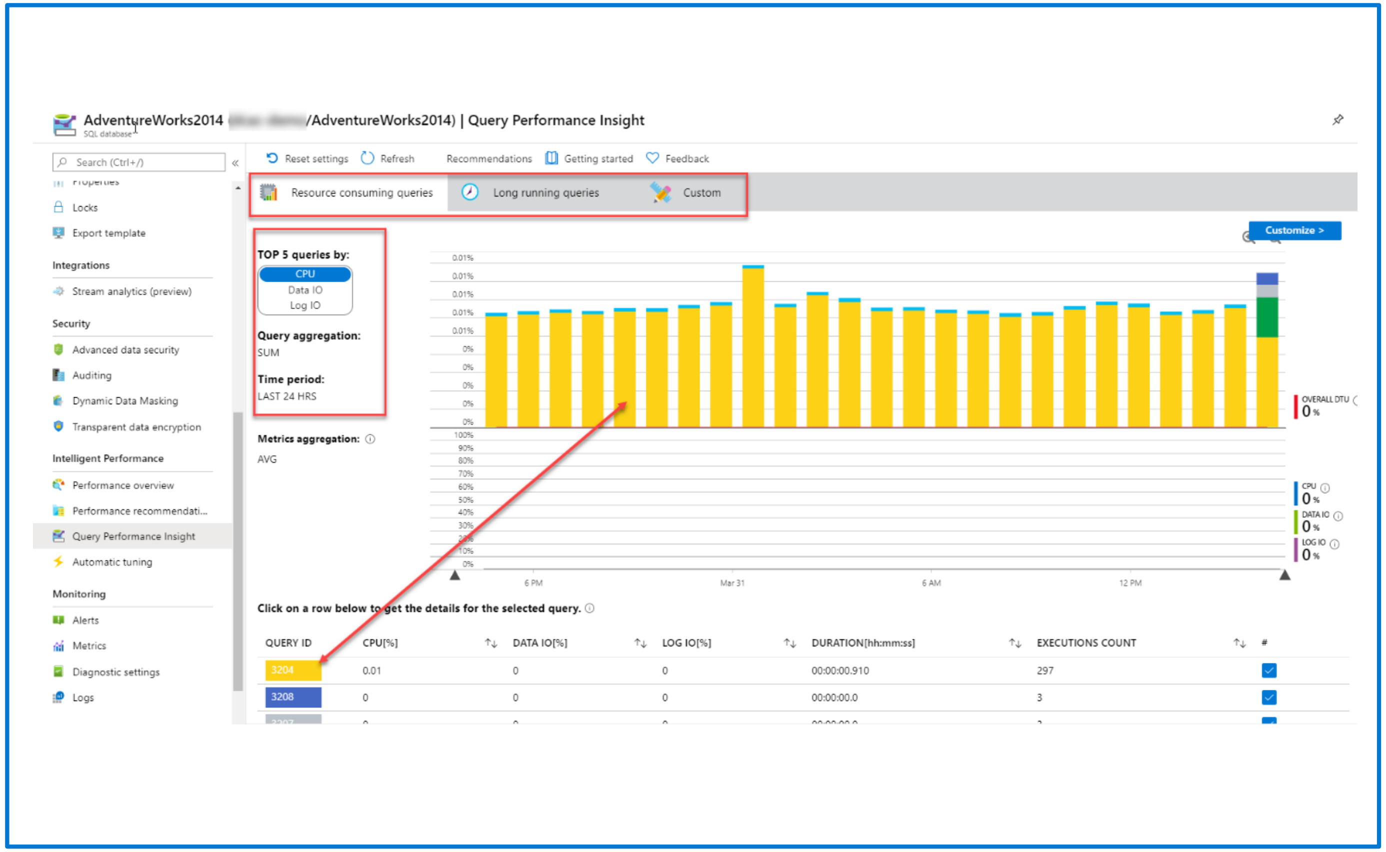
Query Performance Insight Allows you...

Allows DBAs to quickly identity expensive queries

You can drill into individual queries

You can combine the Query Performance Insight dashboard with Query Store data to quickly identify the most expensive execution plan

Query Performance Insights



AdventureWorks2014 [redacted]/AdventureWorks2014) | Query Performance Insight

TOP 5 queries by: CPU / Data IO / Log IO

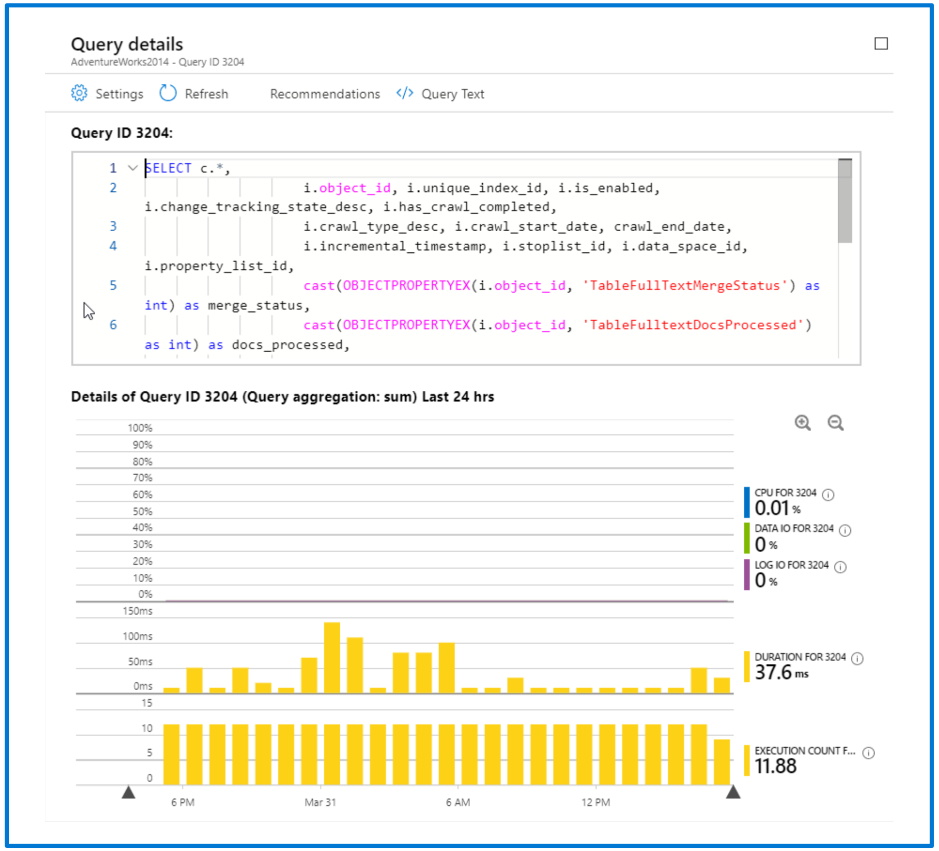
Query aggregation: SUM

Time period: LAST 24 HRS

Metrics aggregation: AVG

Click on a row below to get the details for the selected query.

QUERY ID	CPU[%]	DATA IO[%]	LOG IO[%]	DURATION[hh:mm:ss]	EXECUTIONS COUNT	#
3204	0.01	0	0	00:00:00.910	297	☑
3208	0	0	0	00:00:00.0	3	☑
3207	0	0	0	00:00:00.0	3	☑



Query details

AdventureWorks2014 - Query ID 3204

Query ID 3204:

```
SELECT c.*,
                    i.object_id, i.unique_index_id, i.is_enabled,
i.change_tracking_state_desc, i.has_crawl_completed,
                    i.crawl_type_desc, i.crawl_start_date, crawl_end_date,
                    i.incremental_timestamp, i.stoplist_id, i.data_space_id,
i.property_list_id,
                    cast(OBJECTPROPERTYEX(i.object_id, 'TableFullTextMergeStatus') as
int) as merge_status,
                    cast(OBJECTPROPERTYEX(i.object_id, 'TableFulltextDocsProcessed')
as int) as docs_processed,
```

Details of Query ID 3204 (Query aggregation: sum) Last 24 hrs

Knowledge check

Which Performance Monitor counter reflects how long SQL Server expects to retain data in memory?

☑ Page Life Expectancy
□ Processor Queue Length
□ Paging File Usage

Which Extended Events target only writes to memory and is not persisted ?

☑ Ring Buffer
□ Target File
□ Event Tracking for Windows

If you want to see the sizes of your SQL Server Databases running in an Azure VM, which tool should you use?

□ Azure Monitor
☑ The SQL VM Resource Provider
□ Intelligent Insights

Instructor led labs: Isolate performance problems through monitoring

Review CPU utilization in Azure portal

Identify high CPU queries

Configure SQL Server resources for optimal performance

Objectives

- Understand your options for configuration of Azure Storage
- Learn how to configure TempDB data files in SQL Server
- Learn how to choose the right type of VM for SQL Server workloads
- Understand the use cases and configuration of Resource Governor in SQL Server

Azure Storage

Azure Storage is a scalable, secure storage platform that meets a variety of application data storage needs beyond just VM storage.

SQL Server can use three types of Azure Storage:

Blob Storage

Can be used for database backups

File Storage

File shares that can be used for Failover Cluster Instances

Disk Storage

Managed block storage that is used to provide storage to VMs

Azure Managed Disks

- Azure VMs use Managed Disks for their storage
- SQL Server VMs should use either Premium SSD or Ultra Disk for optimal performance

Azure Managed Disks are offered in four types:

Ultra Disk

Support high-IO workloads for mission critical databases with extremely low latency

Premium SSD

High-throughput and low latency and can meet the needs of most database workloads running in the cloud

Standard SSD

Designed for lightly used dev/test workloads or web servers that do a small amount of IO and require predictable latency

Standard HDD

Suitable for backups and file storage that is infrequently accessed

Striping disks for maximum throughput

Disks are striped with no redundancy at the operating system level

This allows for you volumes to have the sum of IOPS and data size

For **Premium SSDs** it can be beneficial to scale both IOPs and storage volume

For **Ultra Disk**, you can scale IOPs, throughput, and maximum size independently on a single disk

SQL Server storage best practices

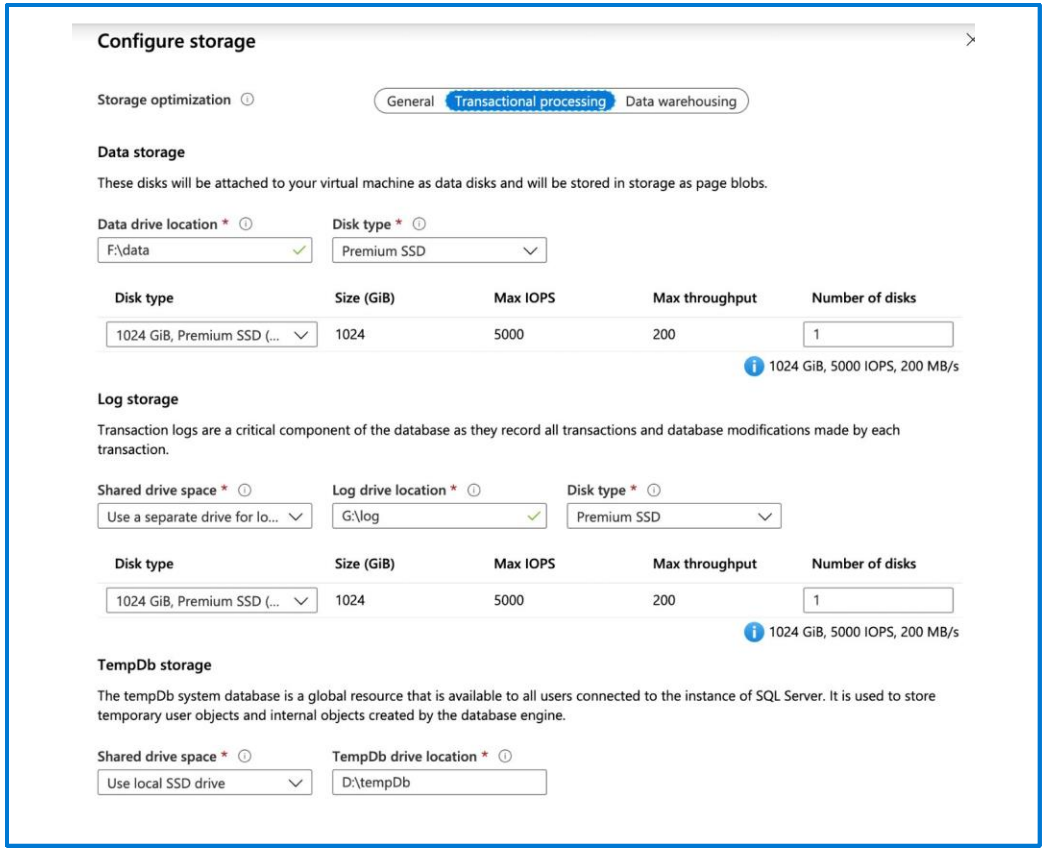
- Create a separate volume for data and transaction log files
- Enable read caching on the data file volume
- Do not enable any caching on the log file volume
- Use the D: drive (the locally attached SSD) for TempDB files
- Enable instant file initialization to reduce the impact of file-growth activities

Azure SQL VM resource provider

The SQL VM resource provider can configure storage based on your workload

You specify the number of IOPs and data volume your database requires and the provider will allocate the disks and configure them in the O/S

You can also configure TempDB on the D: drive



Configure storage

Storage optimization: General | **Transactional processing** | Data warehousing

Data storage

These disks will be attached to your virtual machine as data disks and will be stored in storage as page blobs.

Data drive location *: F:\data ✓

Disk type *: Premium SSD

Disk type	Size (GiB)	Max IOPS	Max throughput	Number of disks
1024 GiB, Premium SSD (...	1024	5000	200	1

1024 GiB, 5000 IOPS, 200 MB/s

Log storage

Transaction logs are a critical component of the database as they record all transactions and database modifications made by each transaction.

Shared drive space *: Use a separate drive for lo...

Log drive location *: G:\log ✓

Disk type *: Premium SSD

Disk type	Size (GiB)	Max IOPS	Max throughput	Number of disks
1024 GiB, Premium SSD (...	1024	5000	200	1

1024 GiB, 5000 IOPS, 200 MB/s

TempDb storage

The tempDb system database is a global resource that is available to all users connected to the instance of SQL Server. It is used to store temporary user objects and internal objects created by the database engine.

Shared drive space *: Use local SSD drive

TempDb drive location *: D:\tempDb

TempDB configuration

SQL Server uses TempDB for many internal operations

- The I/O performance of TempDB can be critical to the performance of the SQL Server
- TempDB should have the same number of data files as the server has CPU cores, up to 8
- The data files should all be the same size and have the same autogrowth settings

Resource Governor

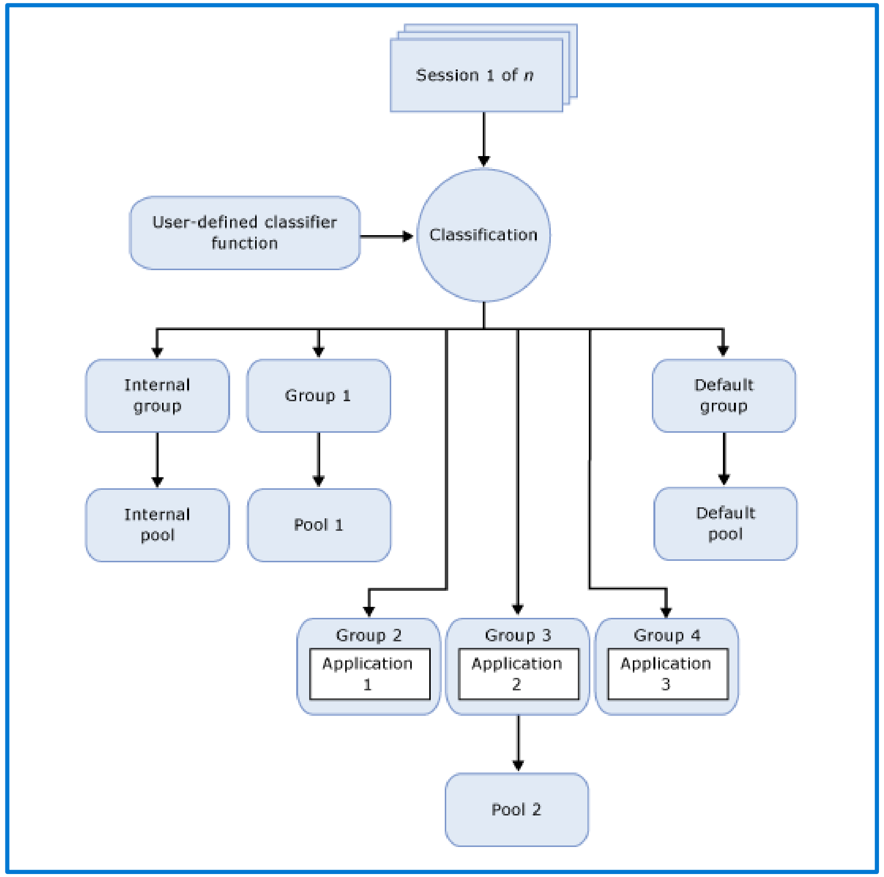
- Allows to balance conflicting workloads that have different resource demands at different times
- Workloads are divided into resource pools which allow you to limit CPU, memory, and IOPs for user sessions
- Workloads are classified using a classifier function

Resource Governor components:

Resource pool

Workload group

Classification



Knowledge check

Which type of storage should be used in conjunction with Azure VMs for SQL Server data files?

- ☐ Table Storage
- ☐ Blob Storage
- ☑ Disk Storage

Which of the following can be limited using Resource Governor?

- ☐ Buffer Pool Allocation
- ☑ Write IOPs
- ☐ Recompilation

Which is an option from the SQL Server Resource Provider for Azure VMs?

- ☑ Storage configuration
- ☐ Maintenance plan
- ☐ Resource Governor

Configure databases for optimal performance

Objectives

- Understand database scoped configuration options
- Understand the features of Intelligent Query Processing (IQP)
- Explore the automatic tuning feature in Azure
- Understand related maintenance tasks related to indexing and statistics

SQL Server maintenance activities

Databases need regular maintenance activities. Some common examples of these activities include:

- Database Backups
- Database Consistency Checks
- Index Maintenance
- Statistics Updates

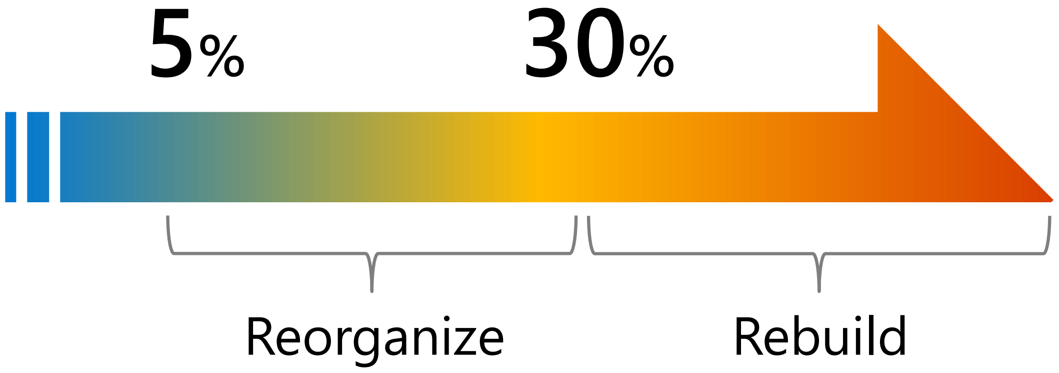
Fragmentation in data files

- Fragmentation in database files can occur within indexes or tables
- As data is inserted and updated, records can move into pages which no longer match the physical ordering of the data pages on the disk
- Fragmentation can degrade the performance of queries
- Fragmentation can be reduced by **reorganizing** or **rebuilding indexes**

Index maintenance tasks

Indexes should be regularly rebuilt and reorganized as they reach defined levels of fragmentation

SQL Server and Azure SQL support resumable index maintenance as well as online index rebuilds to allow your workload to continue as maintenance operations occur



Index maintenance tasks – REORGANIZE vs. REBUILD

Reorganize	Rebuild
• Physically reorder the leaf-level index pages to match the logical sorted order of the leaf nodes	• Drops and recreates the pages of the index
• Compacts the index pages based on the index's fill factor setting	• Causes the statistics to be updated
• It is an **online** activity	• Can be either online or offline
	• When fragmentation is greater than **30%**
`ALTER INDEX ALL ON Production.Product REORGANIZE`	`ALTER INDEX ALL ON Production.Product REBUILD`

Index maintenance tasks on SQL Server

- Since you have the full surface area of Windows and SQL Server (including the SQL Server Agent) you can use the Agent to perform maintenance activities

- If you are migrating from on-premises your maintenance activities should be the same as your on-premises workloads

- You can use **SQL Agent** or **Task Scheduler** to create custom maintenance jobs

Index maintenance tasks on Azure SQL Database

While the Azure platform performs activities like consistency checks and backups, index and statistics maintenance are still the responsibility of the DBA

Azure SQL Database does not have the SQL Server Agent, but there are other options for scheduling tasks:

- Azure Automation Runbooks
- Azure SQL Elastic Jobs
- SQL Agent Job from SQL Server in an Azure VM

Index maintenance tasks on Azure SQL Managed Instance

Azure SQL Managed Instance includes the **SQL Agent** and the MSDB database

This means you can used scheduled tasks like on-premises servers or Azure VMs

Any tasks that need to access the file system will need to be modified as that is not supported

Statistics maintenance tasks

The database engine uses statistics on columns and indexes to build execution plans

It is important that statistics be kept up to date for all objects

SQL Server defaults to having auto-update statistics on

The database engine uses a sliding scale to determine the number of modifications required to kick off a statistics update

Database scoped configuration options

Databases have two types of configuration options, which are defined based on how they are set:

- Database Scoped Configuration options are configured using ALTER DATABASE SCOPED CONFIGURATION syntax
- Database options are configured using ALTER DATABASE SET syntax

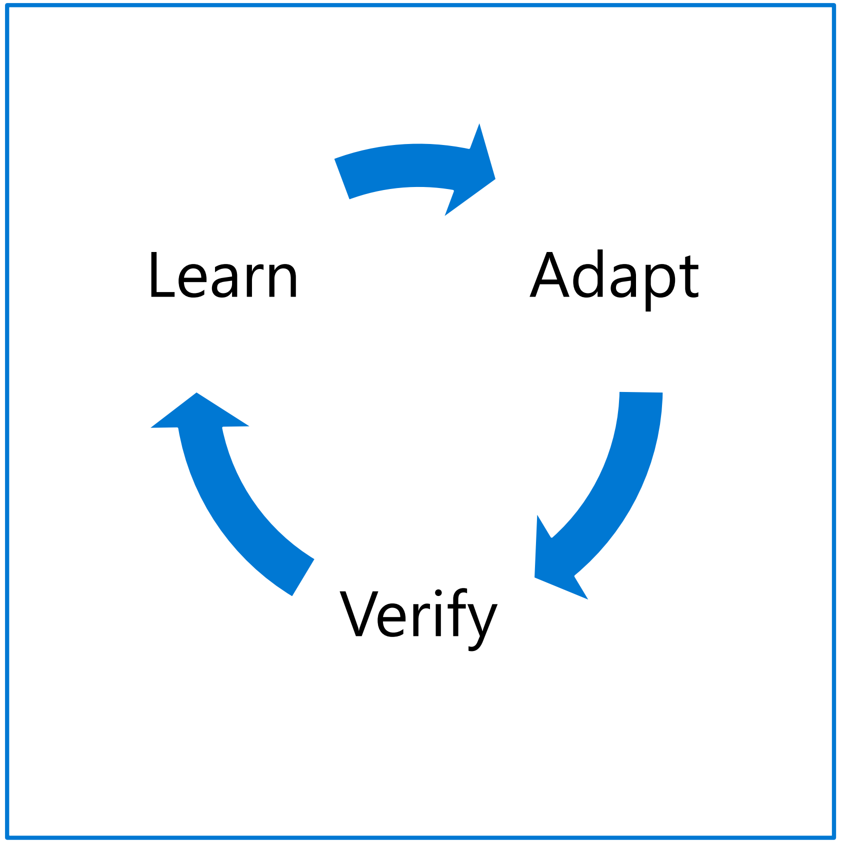
Options include recovery model, isolation level, automatic tuning, and the Intelligent Query Processing features

Automatic tuning

SQL Server and Azure SQL Database have an automatic tuning features that uses the query store for a data source

This can be helpful for sudden unexpected query execution plan changes that cause regressions in performance

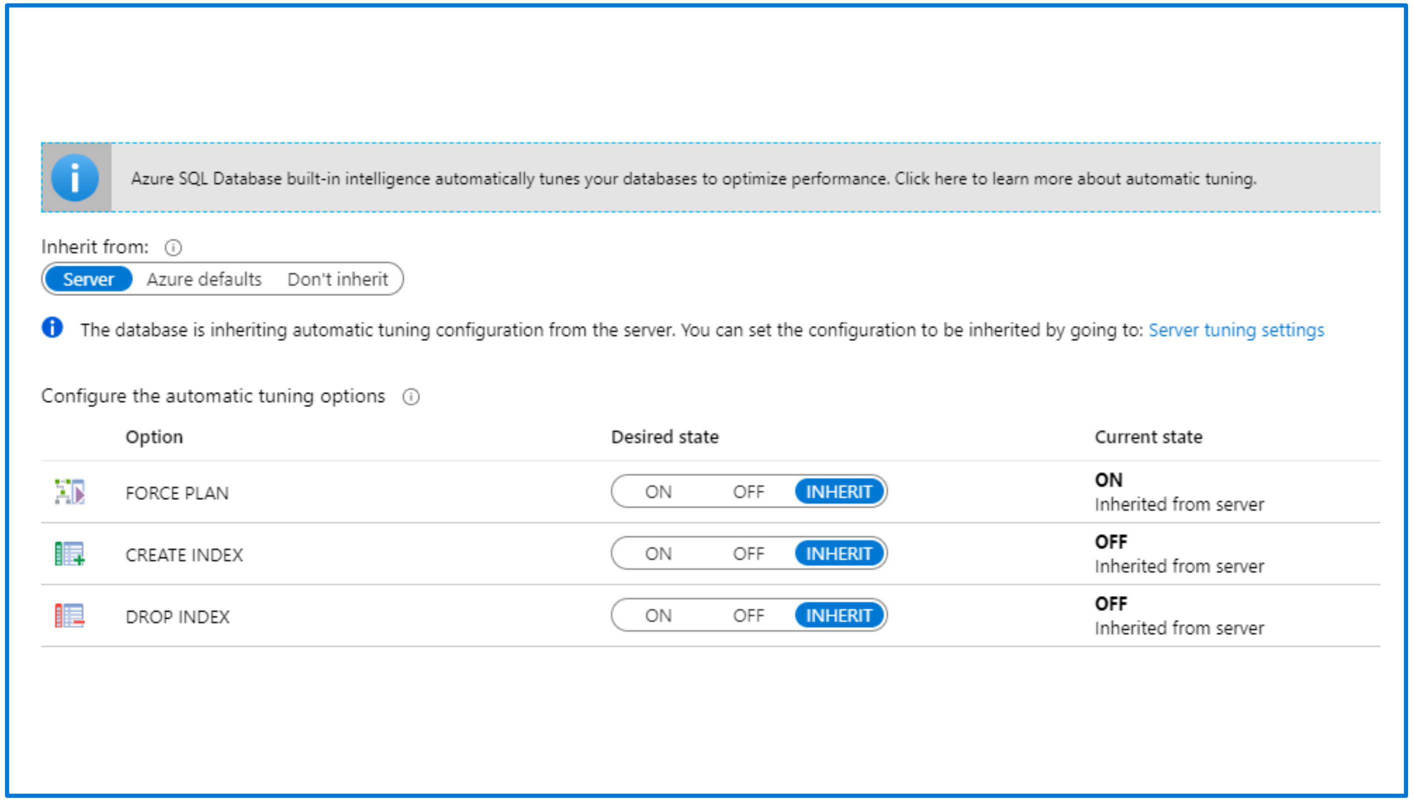
Automatic tuning will revert to the last known good execution plan after fifteen executions of a significantly regressed query



Automatic index management

Azure SQL Database supports index analysis through automatic index management

This feature can add and remove indexes, in addition to forcing a better execution plan in the event of a regression



Azure SQL Database built-in intelligence automatically tunes your databases to optimize performance. Click here to learn more about automatic tuning.

Inherit from: [✓ Server] Azure defaults Don't inherit

The database is inheriting automatic tuning configuration from the server. You can set the configuration to be inherited by going to: Server tuning settings

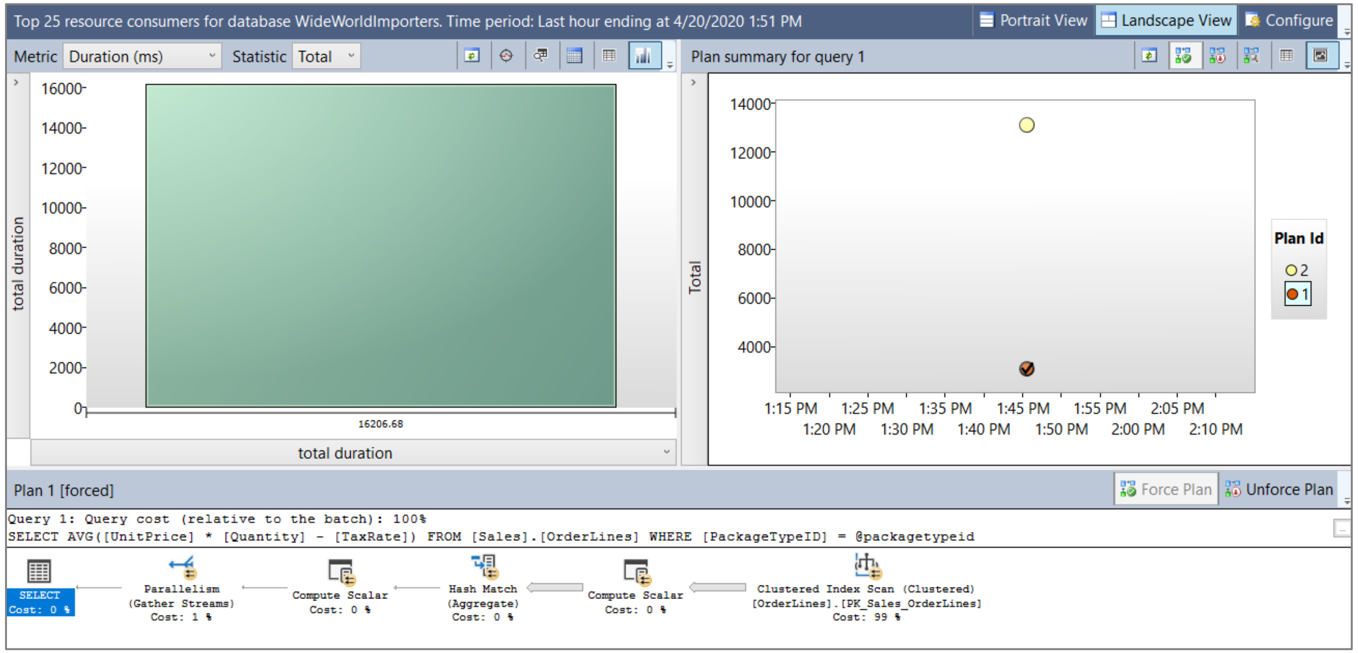
Configure the automatic tuning options

Option	Desired state	Current state
FORCE PLAN	ON OFF [✓ INHERIT]	**ON** Inherited from server
CREATE INDEX	ON OFF [✓ INHERIT]	**OFF** Inherited from server
DROP INDEX	ON OFF [✓ INHERIT]	**OFF** Inherited from server

Automatic plan correction

Identifies when query execution plans have regressed in their performance

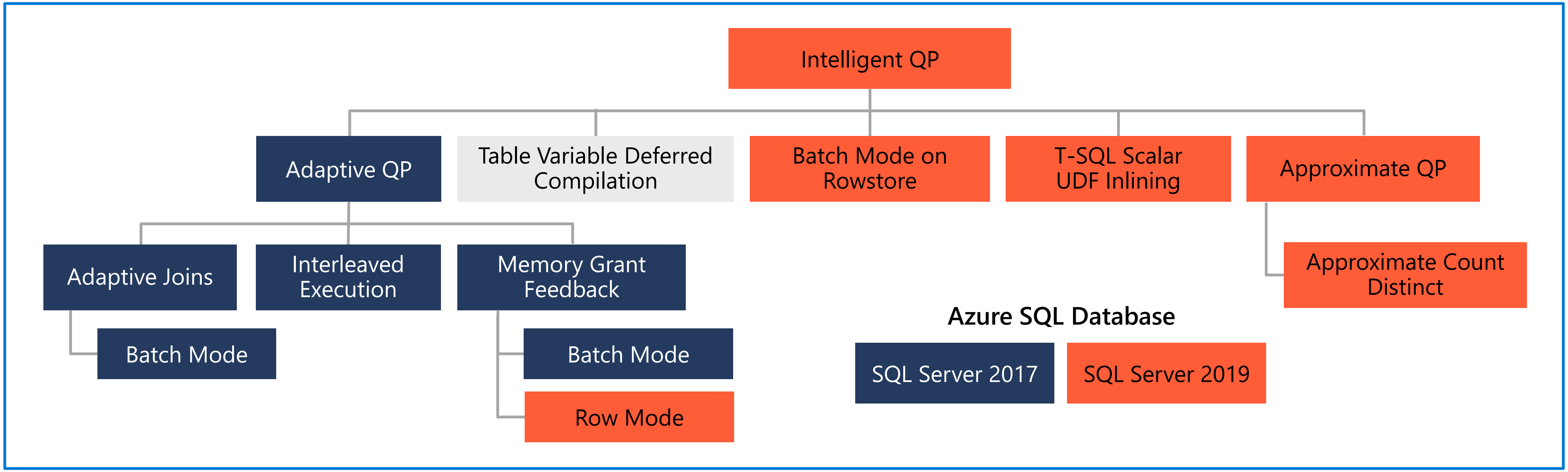
ALTER DATABASE [<Database Name>] SET AUTOMATIC_TUNING (FORCE_LAST_GOOD_PLAN = ON);



```
Query 1: Query cost (relative to the batch): 100%
SELECT AVG([UnitPrice] * [Quantity] - [TaxRate]) FROM [Sales].[OrderLines] WHERE [PackageTypeID] = @packagetypeid
```

Intelligent Query Processing (IQP)

Intelligent query processing is a family of features that allows the database engine to make better choices to provide better overall performance.



Knowledge check

Which intelligent query processing feature allows for faster calculations of a large number of rows?

☑ Batch Mode on Row Store
□ Approximate Count Distinct
□ Interleaved Execution

Which component of resource governor allows you to configure limits on system resources?

□ Workload Groups
□ Classifier Functions
☑ Resource Pools

You need to migrate a set of databases that use distributed transactions from on-premises SQL Server. Which of the following options should you choose?

☑ Azure SQL Managed Instance
□ Azure SQL Database
□ SQL Server in an Azure VM

Instructor led labs: Detect and correct fragmentation issues

Investigate index fragmentation

Rebuild fragmented indexes

Validate performance improvements

Summary

Describe performance monitoring:

- Understanding methods to review potential performance issues
- Identify critical Azure metrics
- Explore Azure SQL Insights

Configure SQL Server resources for optimal performance:

- Understand your options and configuration for Azure Storage
- Learn how to configure TempDB data files in SQL Server
- Understand Resource Governor in SQL Server

Configure databases for optimal performance:

- Understand Database Scoped Configuration Options
- Understand related maintenance tasks related to indexing and statistics
- Obtain knowledge on the auto-tuning feature in Azure

References

Overview of Azure Monitor

https://docs.microsoft.com/azure/azure-monitor/overview

Monitoring performance by using the Query Store

https://docs.microsoft.com/sql/relational-databases/performance/monitoring-performance-by-using-the-query-store

Overview of Extended Events

https://docs.microsoft.com/sql/relational-databases/extended-events/extended-events

Intelligent Query Processing

https://docs.microsoft.com/sql/relational-databases/performance/intelligent-query-processing

Microsoft

Thank you