



Azure SQL VM Best Practices

Module 7

Learning Units covered in this Module

- Lesson 1: SQL Assessment with the IaaS Agent extension
- Lesson 2: Azure SQL VM Monitoring & Metrics

Lesson 1: SQL Assessment with the IaaS Agent extension

SQL Assessment for SQL Server on Azure VMs

The SQL Assessment feature evaluates your SQL Server on Azure Virtual Machines (VMs) to identify possible performance issues and provide recommendations for indexing, statistics, deprecated features, missing trace flags, etc.

Uses a large set of pre-defined rules provided by the SQL Assessment API to follow best practices.









Results are uploaded to your Log Analytics workspace using the Microsoft Monitoring Agent.

To use the SQL Assessment feature, you must have the following prerequisites:

- SQL Server VM must be registered with the SQL Server IaaS extension in full mode.
- A Log Analytics workspace in the same subscription as your SQL Server VM
- SQL Server needs to be 2012 or higher version.

Enable SQL Assessments

Settings

-  Configure
-  Storage Configuration
-  Patching
-  Backups
-  Additional features
-  High Availability (Preview)
-  SQL Assessment (Preview)
-  Properties

SQL Assessment

SQL Assessment provides a mechanism to evaluate the configuration of your Azure SQL VM for best practices like indexes, deprecated features, trace flag usage, statistics, etc. Assessment results are uploaded to your Log Analytics workspace using Microsoft Monitoring Agent (MMA). The run time depends on your environment (number of databases, objects). [Learn more](#)

Enable SQL Assessments

Configure SQL Assessments

SQL Assessment configuration

SQL Assessment results are uploaded to Log Analytics workspace. You can either use the existing connection or configure MMA using this blade. [Learn more](#)

Enable SQL Assessments *

☒

Log Analytics workspace name *

SQLDemoLogAnalytics

i If you have not already associated a Log Analytics workspace with this VM, please select one for assessment results to be uploaded using Microsoft Monitoring Agent. [Learn more](#)

Enable scheduling

☒

Frequency

☒ Weekly

☐ Monthly

Day of week

Monday

Recurrence

Every 1 week

Assessment start (local VM time)

00:00 (12:00 midnight)

Run SQL Assessments

 Run assessment  Refresh  Configuration  Feedback

SQL Assessment

SQL Assessment provides a mechanism to evaluate the configuration of your Azure SQL VM for best practices like indexes, deprecated features, trace flag usage, statistics, etc. Assessment results are uploaded to your Log Analytics workspace using Microsoft Monitoring Agent (MMA). The run time depends on your environment (number of databases, objects). [Learn more](#)

Run assessment

View latest successful assessment

Assessment results

The latest in progress and completed results are shown below. Select any completed assessment to view recommendations in an Azure workbook. Once you are in the workbook, you can also select to view older results.

Assessments

Status

2022-01-31 12:00 AM UTC



Scheduled

View SQL Assessments

ResultsTrends

SQL Assessment Results

collected at2022-01-31 11:32 AM U... ▾

All Issues

New Issues (113)

Resolved Issues (2)

Insights

Total Issues

399

Passed

262

Medium

115

Low

14

Info

5

High

3

Passed

Medium

Low

Info

High

Severity	↑↓	Tags	↑↓	Check Id
High		DBConfiguration,Performance		InstantFileIniti
High		Performance,Memory		LockedPagesSl
High		Performance,DBFileConfiguration,DBConfigur...		AzTempDbFile
Medium		Index,Performance		UnusedIndex
Medium		Index,Performance		IndexFragmen
Medium		DBCC,Performance,DataIntegrity		DbIntegrity
Medium		Backup		FullBackup
Medium		Performance,QueryOptimizer		PlansUseRatio
Medium		NUMA,CPU,Memory,Performance		NUMANodeSi
Medium		Configuration,Performance		AzErrorLogLoc
Medium		Naming		FnNaming
Medium		Performance,Indexes		FKNoIndexes

Lesson 2: Azure SQL Monitoring

It Is Still Just SQL Server

Locked Pages in
Memory (Windows)

Set Max Server
Memory
90% or up to 50 GB
left for the OS

Instant File
Initialization
(Windows)

Apply Standard
Performance Best
Practices and Tuning

Leverage key features
like Columnstore
Indexing, data
compression, QDS

SQL Server
Performance
Best Practices
Article

Enable data page
compression

Disable auto-shrink
for your databases

Backup to URL with
compressed
backups

Move SQL Server
error log and trace
file directories to
data disks

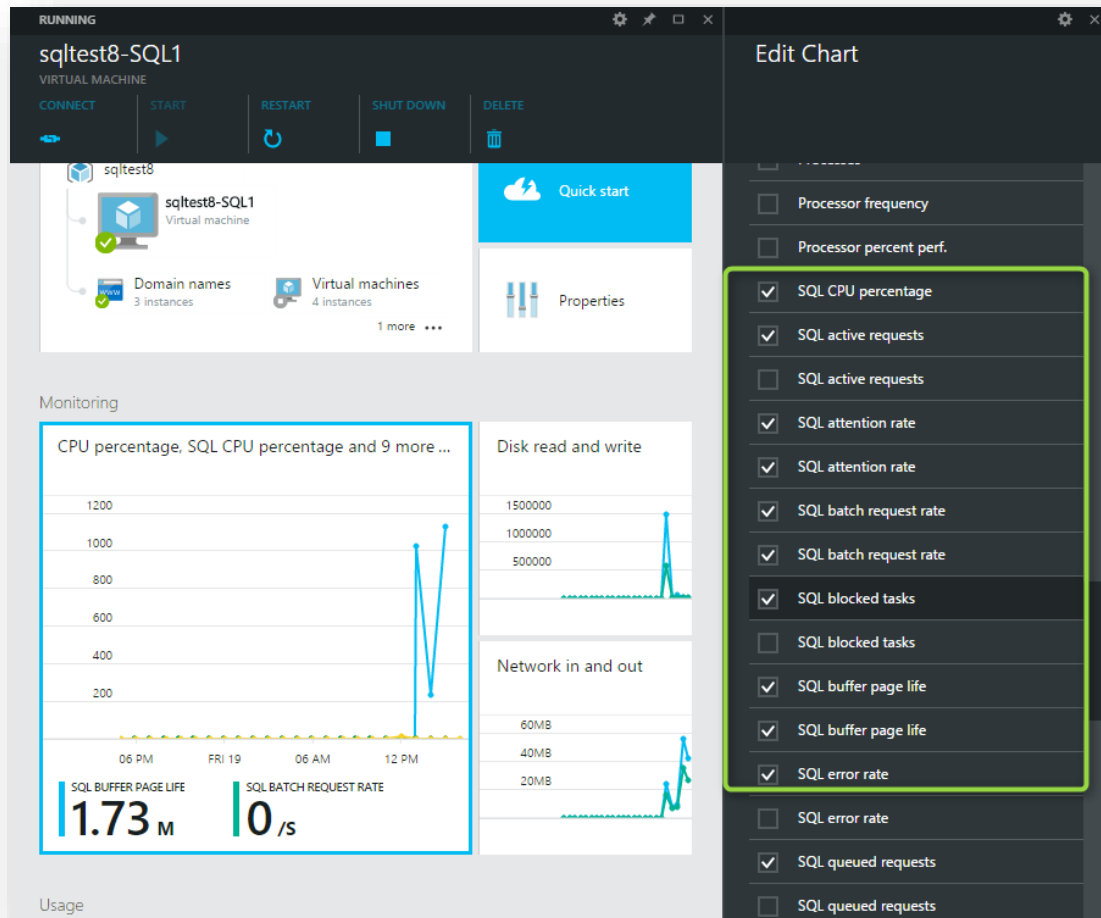
Use multiple Temp
DB files, 1 file per
core, up to 8 files

Enable soft NUMA

<https://aka.ms/SQLIaaSPerf>
<http://aka.ms/SQLPerfCenter>

Azure SQL VM – Monitoring Solutions

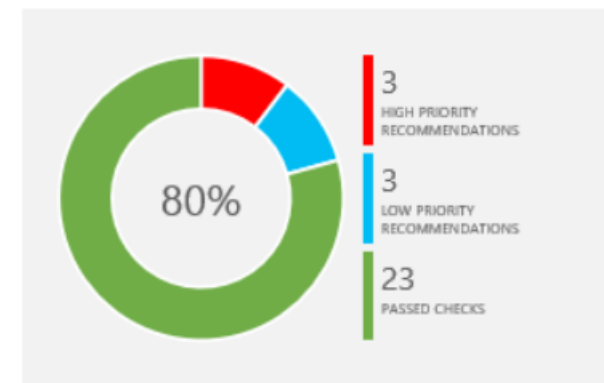
Monitor SQL Perf Counters in Azure Portal



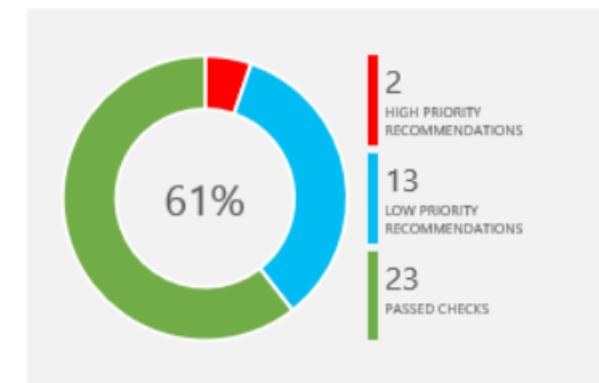
Operations Insights Portal

Evaluates ~100 best practices

AVAILABILITY AND BUSINESS CONTINUITY



PERFORMANCE AND SCALABILITY

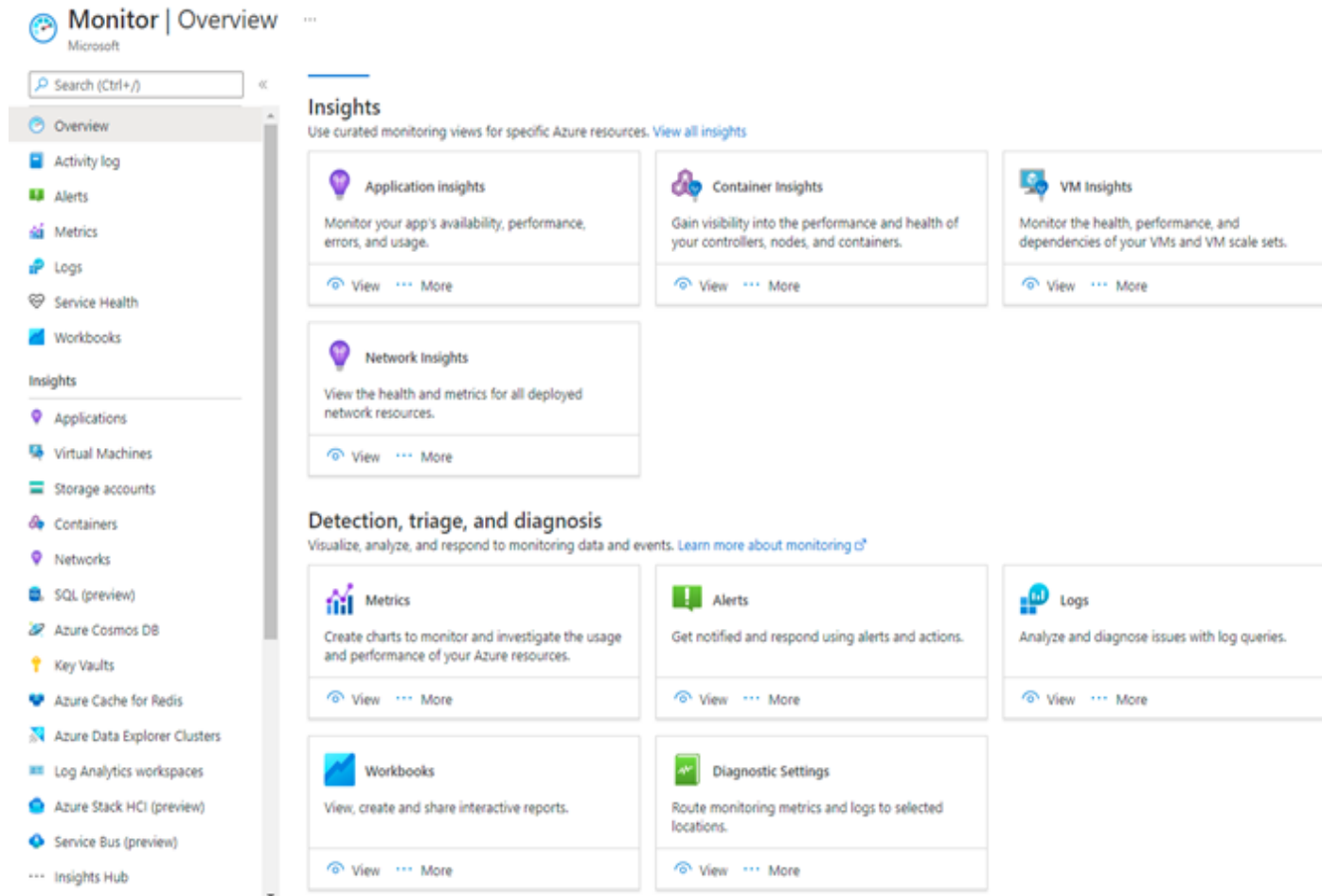


Plus:

- System Center
- DMVs, Profiler, Xevents
- Query Store

[What is VM insights? - Azure Monitor | Microsoft Docs](#)

Azure Monitor – Metrics and Logs at scale



Azure Monitor delivers a comprehensive solution for collecting, analyzing, and acting on telemetry from your cloud and on-premises environments.

All data collected by Azure Monitor falls into one of two categories, metrics and logs

Azure Monitor allows for alerting IT staff based on rules, roles, and groups configured for prompt and rapid response

Detect and diagnose issues across applications and dependencies with [Application Insights](#)

Correlate infrastructure issues with [VM insights](#) and [Container insights](#).

Drill into your monitoring data with [Log Analytics](#) for troubleshooting and deep diagnostics

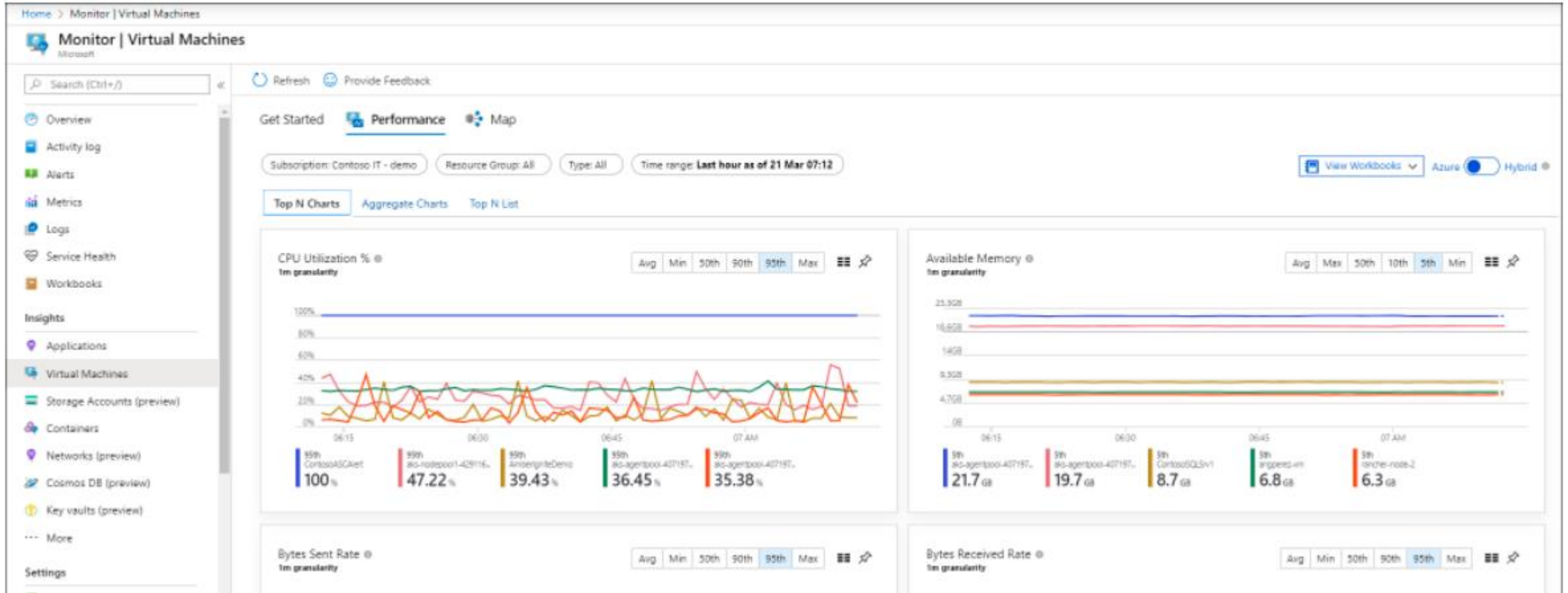
Support operations at scale with [smart alerts](#) and [automated actions](#)

Create visualizations with Azure [dashboards](#) and [workbooks](#)

Collect data from [monitored resources](#) using [Azure Monitor Metrics](#)

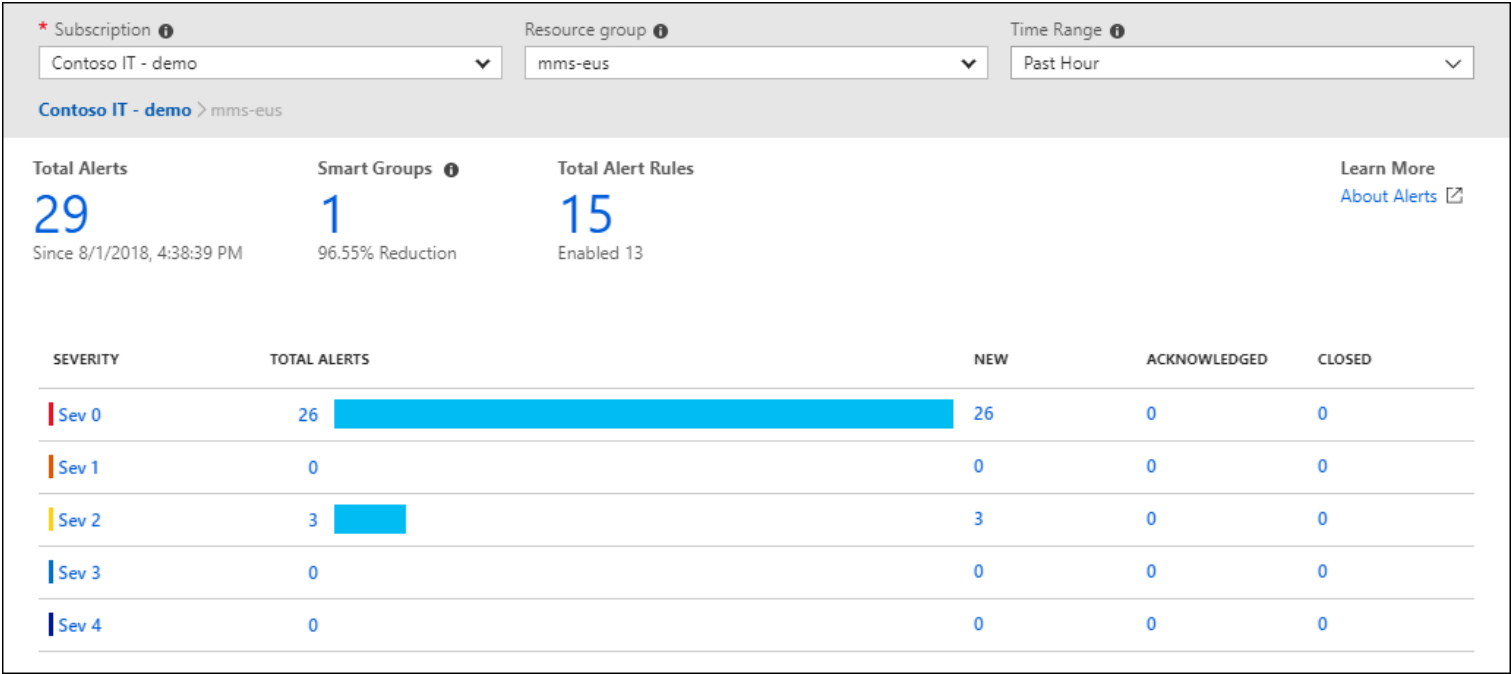
Azure Monitor – Metrics and Logs at scale

Use Azure Monitor to monitor all your Azure Virtual Machines.



[How to chart performance with VM insights - Azure Monitor | Microsoft Docs](#)

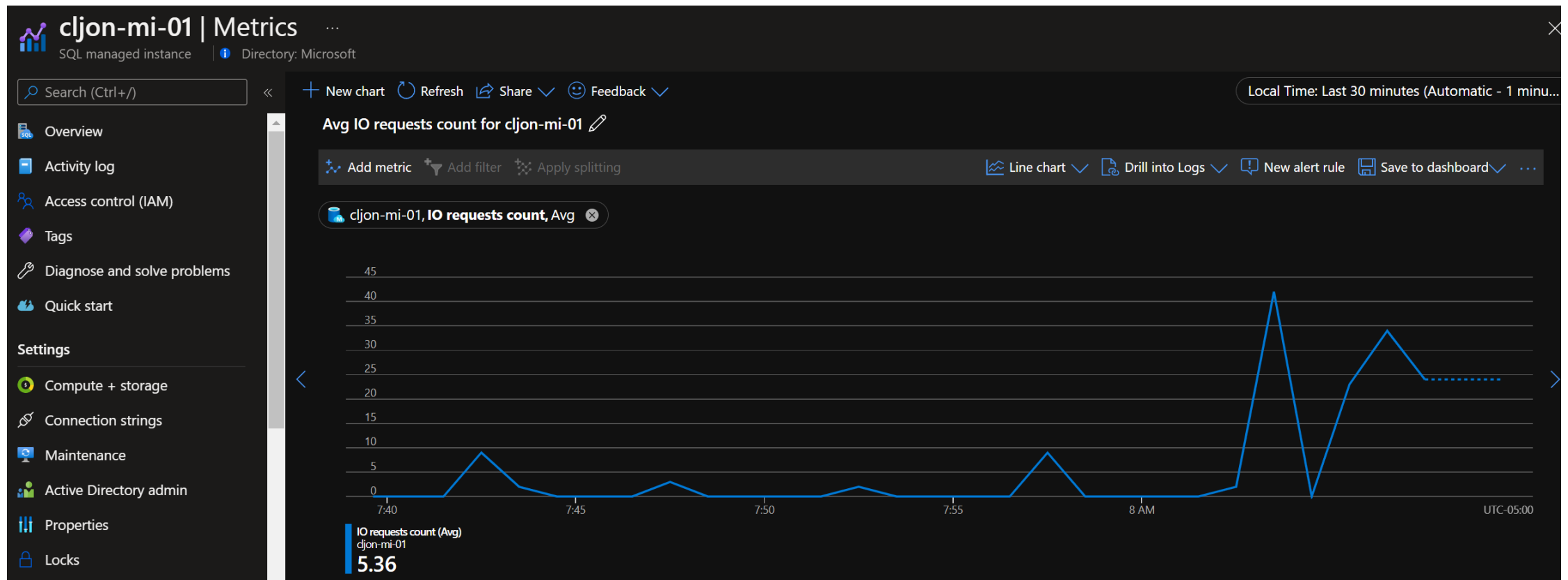
Azure Monitor: Alerts



- Alerts allow for proactive or reactive signaling of issues on monitored items
- This allows for IT staff to take corrective action potentially before an incident occurs
- Alerts based on metrics allow for near real-time notification of threshold breaches
- Alerts based on logs allow for logic that can be used across multiple sources for alerting

Azure Monitor Metrics: Graph

- Graphs can be created based on metrics data flowing into azure monitor
- Multiple graphs can be created on one page to view different metrics
- Time series data and legends can be customized to suit individual customer needs



Azure Monitor VM Insights

Allows the monitoring of Windows and Linux VM's both on Azure or on-prem

The screenshot displays the Azure Monitor VM Insights interface, which is divided into two main panels: 'Monitor - Virtual Machines (preview)' on the left and 'DC01 - Insights (preview)' on the right.

Monitor - Virtual Machines (preview) Panel:

- Subscription:** Microsoft Azure
- Resource group:** InfraLab
- Guest VM health:** 1 VM in critical condition (Out of 5), 3 Unknown, 0 Warning, 0 Healthy.
- VM distribution by operating system:**

OPERATING SYSTEM	OS TYPE
Microsoft Windows Server 2016 D...	Windows
Red Hat Enterprise Linux Server rel...	Linux
- VM distribution by component health:**

COMPONENTS	CRITICAL
CPU	0
Disk	1
Memory	4
Network	0
- VM distribution by core services:**

SERVICE	CRITICAL
DHCP Client	2
DNS Client	2
Firewall	3

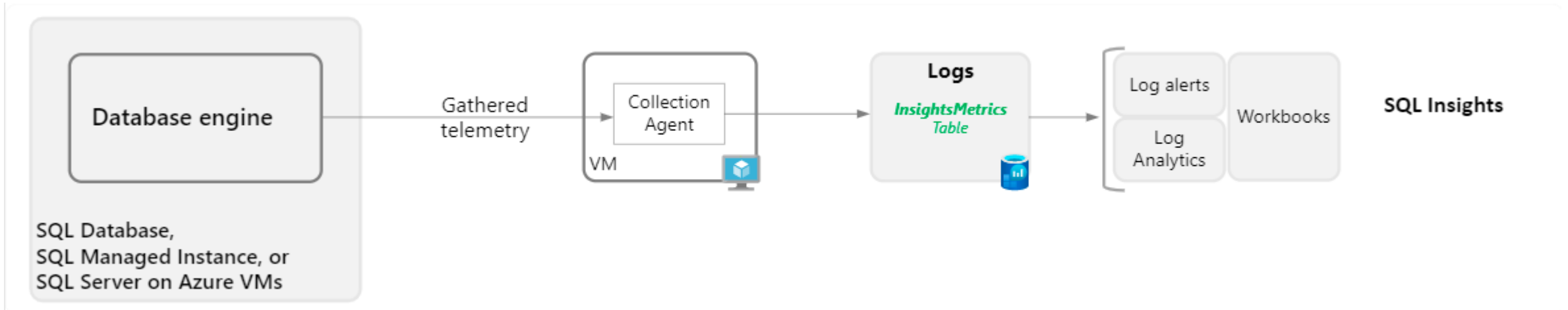
DC01 - Insights (preview) Panel:

- Platform health:** Available
- Guest VM health:** 18
- Component health:**

COMPONENTS	HEALTH STATUS
CPU	Healthy
Disk	Warning
Memory	Critical
Network	Healthy
- Core services health:**

SERVICES	HEALTH STATUS
DHCP Client	Unknown
DNS Client	Unknown
Firewall	Critical
RPC Service Health	Critical
Windows Remote Management	Unknown

Azure Monitor SQL Insights



- SQL Insights (preview) is a comprehensive solution for monitoring any product in the [Azure SQL family](#)
- SQL Insights uses [dynamic management views](#) to expose the data that you need to monitor health, diagnose problems, and tune performance
- SQL Insights performs all monitoring remotely. Monitoring agents on dedicated virtual machines connect to your SQL resources and remotely gather data
- The gathered data is stored in [Azure Monitor Logs](#) to enable easy aggregation, filtering, and trend analysis
- You can view the collected data from the SQL Insights [workbook template](#), or you can delve directly into the data by using [log queries](#)
- Recommendation: Wait until the next version of this tool releases

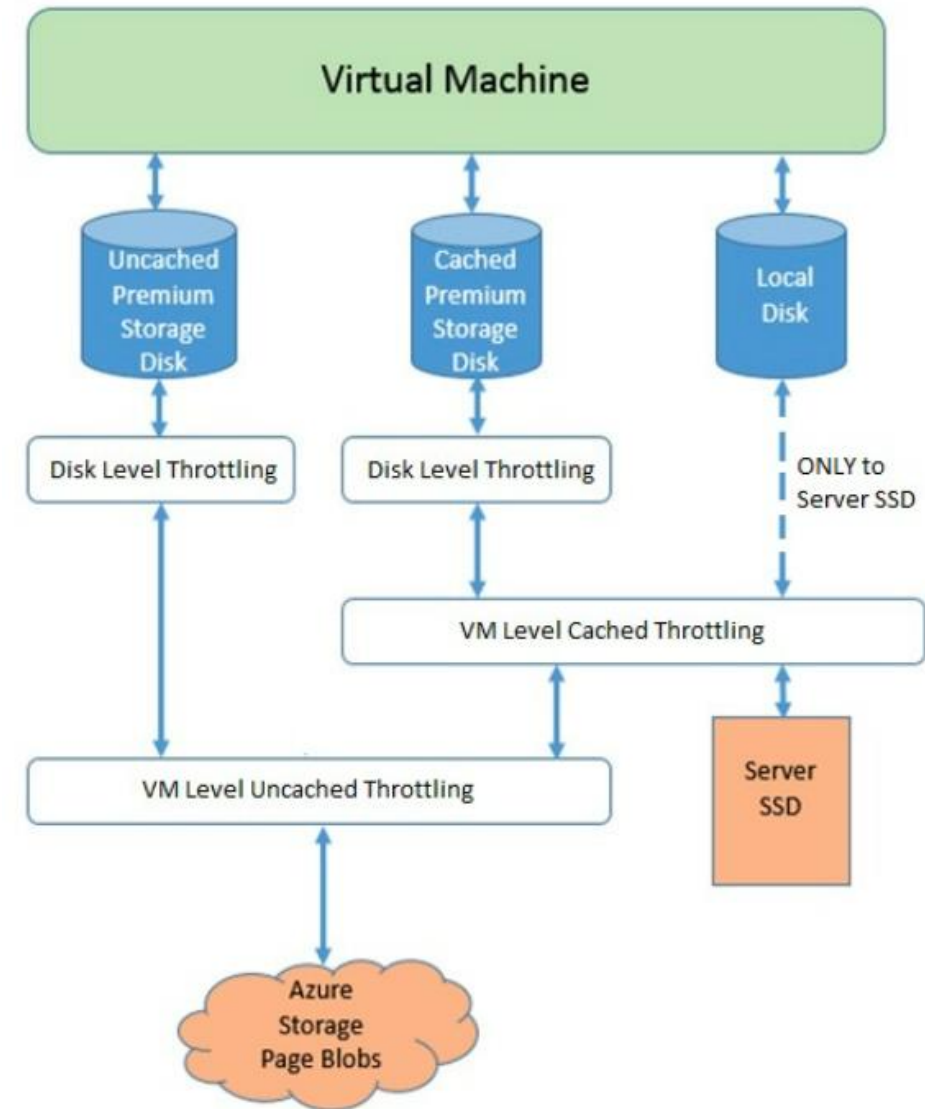
Azure VM and IO Throttling/Capping

Azure VM's use software to Cap input/output operations.

- VMs have IOPS and throughput performance limits based on the virtual machine type and size
- The disks have their own IOPS and throughput limits
- The maximum IOPS limits per VM and per disk are different and independent of each other
- Make sure that the application is driving IOPS within the limits of the VM as well as the premium disks attached to it

Capping is managed at 3 places for Azure VMs

- Disk Level IO
- VM Level Cached IO
 - The max *cached* storage throughput limit is a separate limit when you enable host caching
- VM Level Uncached IO
 - The max *uncached* disk throughput is the default storage maximum limit that the virtual machine can handle



[Virtual machine and disk performance - Azure Virtual Machines | Microsoft Docs](#)
[Disk allocation and performance](#)

[Azure Disk Storage overview - Azure Virtual Machines | Microsoft Docs](#)
[Azure VM Storage Performance and Throttling Demystified | Microsoft Docs](#)

Azure VM and IO Throttling/Capping - Recommendations

- VM sizes with 4 or more vCPUs like the [E4ds v5](#) or higher
- Place data, log, and tempdb files on separate drives
 - For the data drive, only use [premium P30 and P40 disks](#) to ensure the availability of cache support
 - For the log drive plan for capacity and test performance versus cost while evaluating the [premium P30 - P80 disks](#)
 - Place tempdb on the local ephemeral SSD (default D:\) drive for most SQL Server workloads that are not part of Failover Cluster Instance (FCI)

Premium SSD sizes	P30	P40	P50	P60	P70	P80
Disk size in GiB	1,024	2,048	4,096	8,192	16,384	32,767
Provisioned IOPS per disk	5,000	7,500	7,500	16,000	18,000	20,000
Provisioned Throughput per disk	200 MB/sec	250 MB/sec	250 MB/sec	500 MB/sec	750 MB/sec	900 MB/sec

Size	vCPU	Memory: GiB	Temp storage (SSD) GiB	Max data disks	Max cached and temp storage throughput: IOPS/MBps*	Max uncached disk throughput: IOPS/MBps	Max burst uncached disk throughput: IOPS/MBps ⁵	Max NICs	Max network bandwidth (Mbps)
Standard_E4ds_v5	4	32	150	8	19000/250	6400/145	20000/1200	2	12500
Standard_E8ds_v5	8	64	300	16	38000/500	12800/290	20000/1200	4	12500
Standard_E16ds_v5	16	128	600	32	75000/1000	25600/600	40000/1200	8	12500

* These IOPS values can be guaranteed by using [Gen2 VMs](#)

- The **max *uncached* disk throughput** is the default storage maximum limit that the virtual machine can handle
- The **max *cached* storage throughput** limit is a separate limit when you enable host caching

Azure VM and IO Throttling/Capping - Alerts

- Enable Alerts to track Data Disk IOPS
- Send emails to notify when IOPS exceed a percentage (95%)

Set up alert rules on this resource

Get notified on important monitoring events by enabling commonly used alert rules or creating your own custom rules.

Enable recommended alert rules (preview)

Create alert rule



Enable recommended alert rules (preview)

Alert me if

☒ Percentage CPU is greater than %

☒ Available Memory Bytes is less than GB

☒ Data Disk IOPS Consumed Percentage is greater than %

☒ OS Disk IOPS Consumed Percentage is greater than %

☒ Network In Total is greater than GB

☒ Network Out Total is greater than GB

[More alerting options](#)

Notify me by

☒ Email

☐ Azure Resource Manager Role

☐ Azure mobile app notification

☐ Use an existing action group

Estimated monthly total: \$0.60

Enable

Cancel

Lesson 3: Azure SQL Monitoring

Azure SQL VM Best Practices



The performance of a relational database in a public cloud depends on many factors

The size of a virtual machine
The configuration of the data disks



There is typically a trade-off between

Optimizing for costs
Optimizing for performance



This performance best practices series is focused on getting the best performance for SQL Server on Azure Virtual Machines



If your workload is less demanding, you might not require every recommended optimization



Consider performance needs, costs, and workload patterns as you evaluate these recommendations



[Checklist: Best practices & guidelines - SQL Server on Azure VMs | Microsoft Docs](#)

Performance Best Practices - VM Sizing (1)

Collect peak IOPS and throughput requirement for Data, Log and tempdb

Choose the VM size that can scale to the total* IOPS requirement

- Consider **cached I/O** limits for Data and tempdb **reads**
- Consider **uncached I/O** limits for **Log reads** and **writes** and Data **writes**

Ensure the VM has local SSD storage capacity to host tempdb

Use Read-Only cache enabled Premium SSD disks for Data Files

Provision Ultra SSD only for Log file

Match memory and core requirements based on performance history

Enable read caching on data/tempdb drives

If tempdb is very write intensive put it on local SSD

No databases on temporary drive

Performance Best Practices - VM Sizing (2)

Use VM sizes with **4 or more vCPUs** like the **E4ds_v5 or higher**

Use **memory optimized virtual machine sizes** for the best performance of SQL Server workloads

Optimal **memory-to-vCore ratio** required for **OLTP workloads**

- The **Edsv5** series offers the best price-performance for SQL Server workloads on Azure VMs. Consider this series first for most SQL Server workloads
- The **M** series VMs offer the **highest memory-to-vCore ratio** in Azure. Consider these VMs for mission critical and data warehouse workloads

Leverage Azure Marketplace images to deploy your SQL Server Virtual Machines as the SQL Server settings and storage options are configured for optimal performance

Collect the target workload's performance characteristics and use them to determine the appropriate VM size for your business

Tools for choosing the right VM size for your existing SQL Server workload

- Data Migration Assistant SKU recommendation
- Azure Data Studio using the Azure SQL Migration Extension

Performance Best Practices - TempDB and Buffer Pool Extension Placement

For VMs that support Premium Storage (DS-series, DSv2-series, and GS-series), we recommend storing TempDB on a disk that supports Premium Storage with read caching enabled

For D-series, Dv2-series, and G-series VMs, the temporary drive on these VMs is SSD-based

- If your TempDB usage is write-intense you can achieve higher performance by storing TempDB on the D: drive as it will result in higher TempDB throughput and lower TempDB latency
- If you use Buffer Pool Extension, place it on the D: drive

Configure storage directly from the SQL Server for Azure Virtual Machine blade in the Azure portal

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

Configure tempDb data files

Customize the number and initial size of tempDb data files and how much autogrowth of all the data files need to expend at once.

Number of files *
4

Initial size (MB) *
8

Autogrowth size (MB) *
64

Configure tempDb log file

Customize the initial size of the tempDb log file and its autogrowth.

Initial size (MB) *
8

Autogrowth size (MB) *
64

Performance Best Practices - Enable VM Diagnostics

Enable Guest Level Monitoring.

- Virtual Machine/Monitoring/Diagnostic Settings

Requires a Storage Account

Enable:

- Storage account diagnostics
 - Review data under Settings Disks
- CPU bottleneck
- Memory bottleneck
- Disk bottleneck

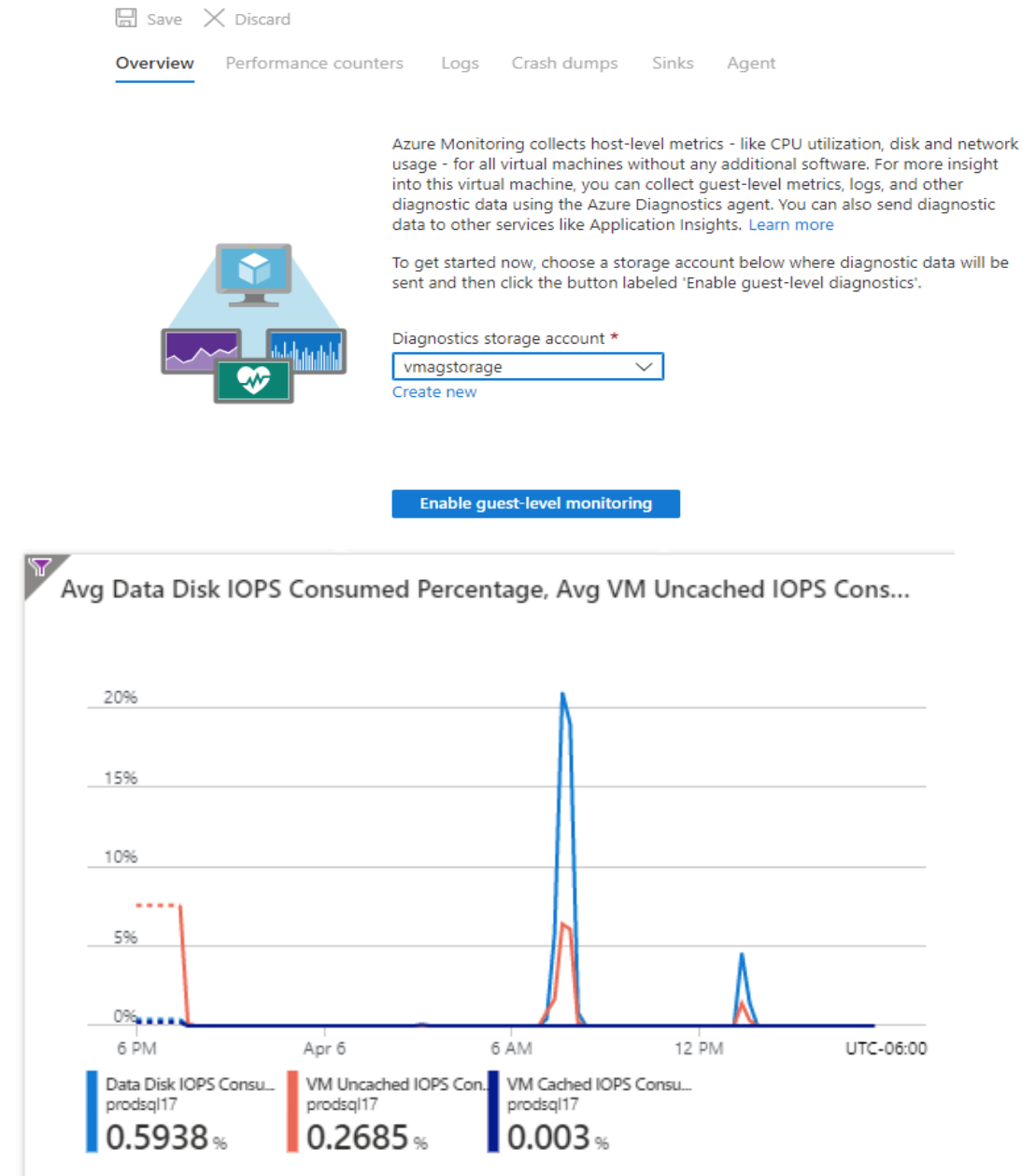
Monitor for VM and Storage throttling

- VM Cached IOPS Consumed Percentage
- VM Uncached IOPS Consumed Percentage
- Data Disk IOPS Consumed Percentage
- OS Disk IOPS Consumed Percentage

Choices:

- Metrics and Alerts from each VM Blade
- Metrics and Alerts from Azure Monitor

[Troubleshoot Azure virtual machine performance on Linux or Windows - Virtual Machines | Microsoft Docs](#)
[Azure VM and Disk Throttling - Developer Support \(microsoft.com\)](#)
[Tutorial - Collect resource logs from an Azure resource - Azure Monitor | Microsoft Docs](#)
[Performance diagnostics for Azure virtual machines - Virtual Machines | Microsoft Docs](#)
[Azure VM Storage Performance and Throttling Demystified | Microsoft Docs](#)



Performance Best Practices - Optimized Storage

Azure VMs have a multi-tier caching technology called Blob Cache when used with Premium Disks

Blob Cache uses a combination of the Virtual Machine RAM and local SSD for caching

Disk caching for Premium SSD can be **ReadOnly**, **ReadWrite** or **None**

- **ReadWrite**
 - Should not be used to host SQL Server files. SQL does not support data consistency with the ReadWrite cache
- **None cache**
 - Use for disks hosting SQL Server Log file. The log file is written sequentially and does not benefit from ReadOnly caching. Also, writes waste capacity of the ReadOnly blob cache and latencies slightly increase if writes go through ReadOnly blob cache layers
- **ReadOnly caching**
 - Highly beneficial for SQL Server data files that are stored on Premium Storage
 - It brings low Read latency and very high Read IOPS and Throughput because:
 - **Reads performed from cache**, which is on the VM memory and local SSD, are **much faster** than reads from the data disk, which is on the Azure blob storage
 - **Premium Storage does not count the Reads served from cache**, towards the disk IOPS and Throughput. Therefore, your application is able to achieve higher total IOPS and Throughput

[Announcing Performance Optimized Storage Configuration for SQL Server on Azure VMs with SQL VM RP](#)

Performance Best Practices - Host VM Caching

OS disk

↔ Swap OS disk


Disk name	Storage type	Size (GiB)	Max IOPS	Max throughput (...)	Encryption ⓘ	Host caching ⓘ
Storageconfigtestadbadram_OsDisk_1_a3bf684cf	Premium SSD	127	500	100	SSE with PMK	Read/write ▼

Data disks

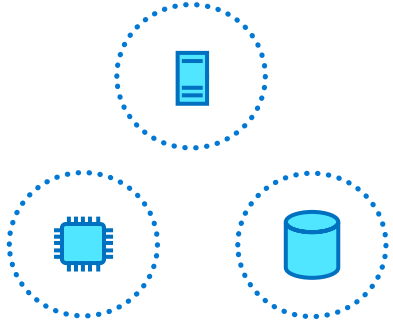
🔍 Filter by name

Showing 2 of 2 attached data disks

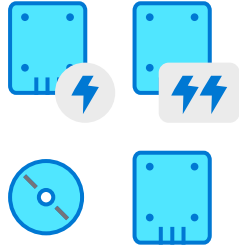
+ Create and attach a new disk 🔗 Attach existing disks

LUN ⓘ	Disk name	Storage type	Size (GiB)	Max IOPS	Max throughput (...)	Encryption ⓘ	Host caching ⓘ
0	Storageconfigtestadbadram_DataDisk_0	Premium SSD	1024	5000	200	SSE with PMK	Read-only ▼ 
1	Storageconfigtestadbadram_DataDisk_1	Premium SSD	1024	5000	200	SSE with PMK	None ▼ 

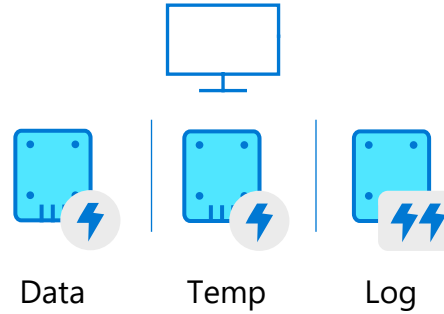
Performance Best Practices - Summary



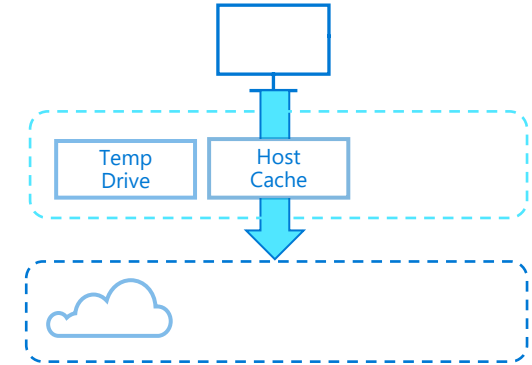
Choose the right VM
to optimize the storage



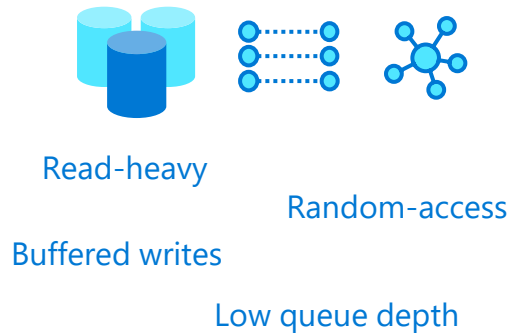
Choose the right disk
mapped to IOPS, BW and latency



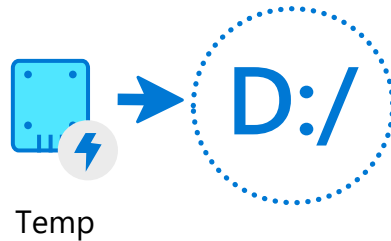
Isolate files
to optimize read vs write traffic



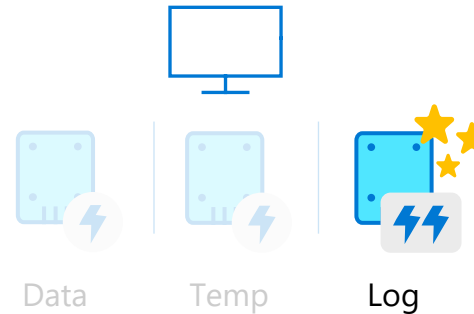
Enable host cache
for improved IOPS and latency



Optimize configuration
based on workload behavior



Leverage ephemeral disk
local ephemeral disk for tempdb performance



Enable Write Accelerator
optimize writes for log files



Leverage Azure Monitor
watch disk and VM counters for capping



Questions?

Dankie Faleminderit **Shukran** Chnorakaloutioun Hvala Blagodaria

Děkuji **Tak** Dank u Tānan Kiitos **Merci** Danke Ευχαριστώ A dank

Mahalo מודה. **Dhanyavād** Köszönöm Takk Terima kasih **Grazie** Grazzi

Thank you!

감사합니다 Paldies Choukrane Ačiū **Благодарам** ありがとうございます

谢谢 Баярлалаа **Dziękuję** Obrigado Mulțumesc **Спасибо** Ngiyabonga

Ďakujem Tack Nandri Kop khun **Teşekkür ederim** Дякую Хвала Diolch

