Microsoft

Optimize performance and costs by using Azure Disk Storage

Learning objectives

- The disk types that are available in Azure
- How disk performance works
- Performance-scaling options

Introduction

- Suppose you work for a medium-sized financial services company. Your Chief Technology Officer (CTO) wants to migrate several applications, databases, and support files to the cloud. This migration will reduce the number of physical servers that your company maintains in its datacenter. As part of your migration strategy, you must determine a suitable approach for your cloud-based storage infrastructure.

- After this session, you will be able to optimizes performance and costs with the right type of disks and capabilities for the cloud migration.

Choose the right Azure Disk Storage option

Azure Block Storage for every workload

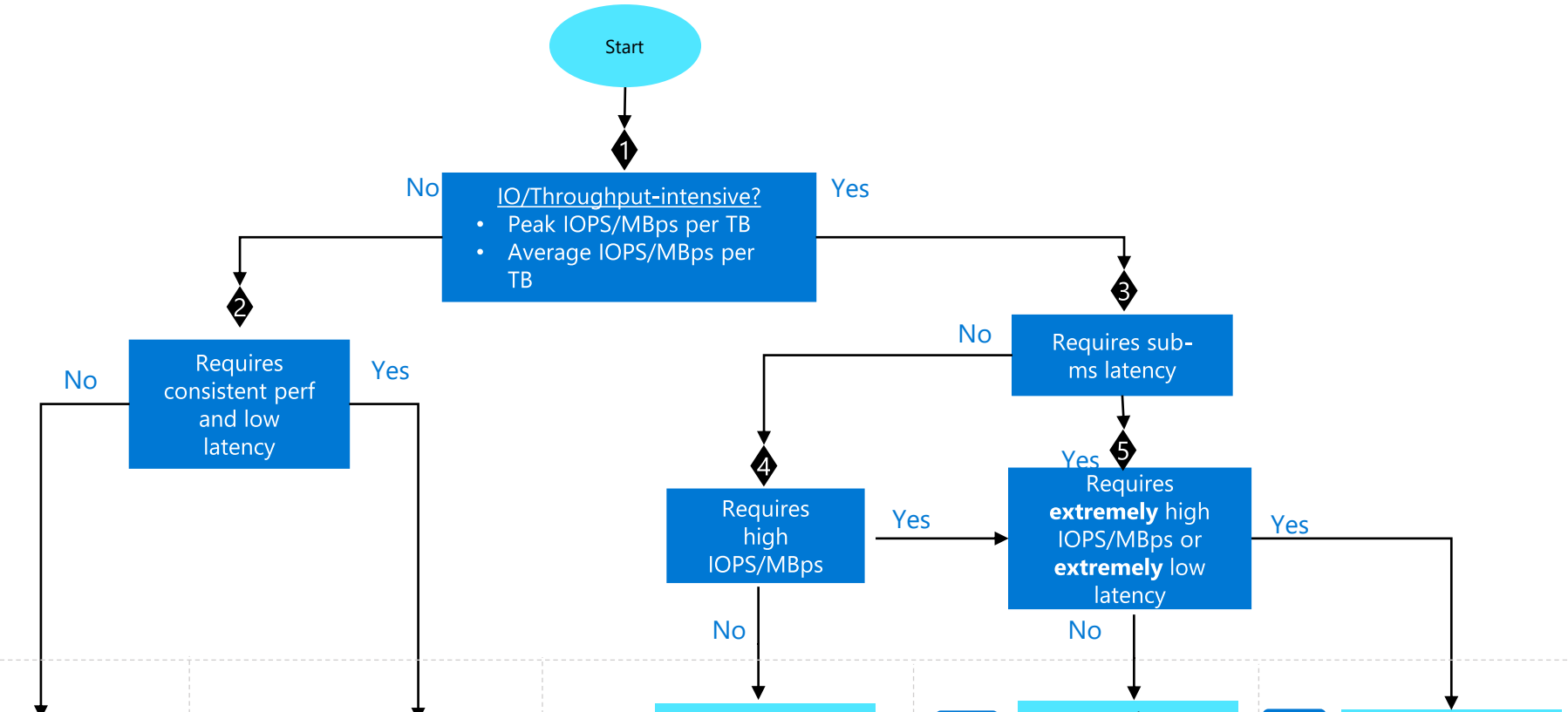
	Azure Disk – Optimized for Virtual Machines					Azure Elastic SAN (Preview)	
	Standard HDD	Standard SSD	Premium SSD	Premium SSD v2	Ultra Disk	Elastic SAN	
	Low-cost storage	Consistent performance	High performance	Sub-millisecond latency	Low sub-millisecond latency	Cost efficiency at scale	
Workloads	Backups, low end file server, test & dev	Big Data, entry-level apps, small DBs, Web Servers	IO-intensive, database, production workloads, container volumes	SAP HANA, SAN, Tier-1 workloads	SAP HANA, SAN, Tier-1 workloads	Tier 1 & 2 workloads, Databases, VDI hosted on any Compute options (VM, Containers, AVS*)	
Size	32 TiB	32 TiB	32 TiB	64 TiB	64 TiB	**Volume** 64 TiB	**SAN** 1 PiB
IOPS	2,000	6,000	20,000 (burst to 30,000)	80,000	160,000	64,000	2,000,000
Throughput	500 MB/s	750 MB/s	900 MB/s (burst to 1,000 MB/s)	1,200 MB/s	4,000 MB/s	1,000 MB/s	32,000 MB/s
Provisioning model	Performance scales with capacity	Performance scales with capacity	Performance scales with capacity	Flexible scaling at 1GiB granularity	Flexible performance scaling	Per GiB provisioning granularity	Flexible model at TiB granularity

Single disk max value

Choose Azure Disk type for performance

Primary Considerations:

- Latency
- IOPS
- Throughput



Disk Types	Standard HDD	Standard SSD	Premium SSD	Premium SSDv2	Ultra Disk
Disk Characteristics	Most cost-efficient storage on HDD	Entry level SSD with lowest GB cost on Cloud	Great balance for cost and performance	Best price performance on Azure	Fastest Disks and most flexible cost model

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Demo: how to flexibly config your Premium SSD V2 and Ultra SSD disks

Fixed Disk tier configurations

Pick the right size of disk that comes with pre-set IOPS and throughput limit

Standard HDD

Disk tier name	Disk size (GiB)	IOPS	Throughput (MBps)
S4	32	500	60
S6	64	500	60
…	…	…	…
S80	32,767	2,000	500

Standard SSD

Disk tier name	Disk size (GiB)	IOPS	Throughput (MBps)
E1	4	500	60
E2	8	500	60
…	…	…	…
E80	32,767	6,000	750

Premium SSD

Disk tier name	Disk size (GiB)	IOPS	Throughput (MBps)
P1	4	120	25
P2	8	120	25
…	…	…	…
P80	32,767	20,000	900

Flexible performance configurations

Capacity, throughput and IOPS can be set independently

Premium SSD v2

Disk Size	Max IOPS	Max throughput (MB/s)
1 GiB-64 TiBs	3,000-80,000 (Increases by 500 IOPS per GiB from 6 GiB)	125-1,200 (Increases by 0.25 MB/s per set IOPS)

Ultra Disk

Disk Size (GiB)	4	8	16	32	64	128	256	512	1,024-65,536
Max IOPs	1,200	2,400	4,800	9,600	19,200	38,400	76,800	153,600	160000
Max Throughput (MB/s)	300	600	1,200	2,400	4,000	4,000	4,000	4,000	4000

For more information on disk configuration and pricing please visit: https://azure.microsoft.com/en-us/pricing/details/managed-disks/

Understand disk performance characteristics

Disk performance characteristics

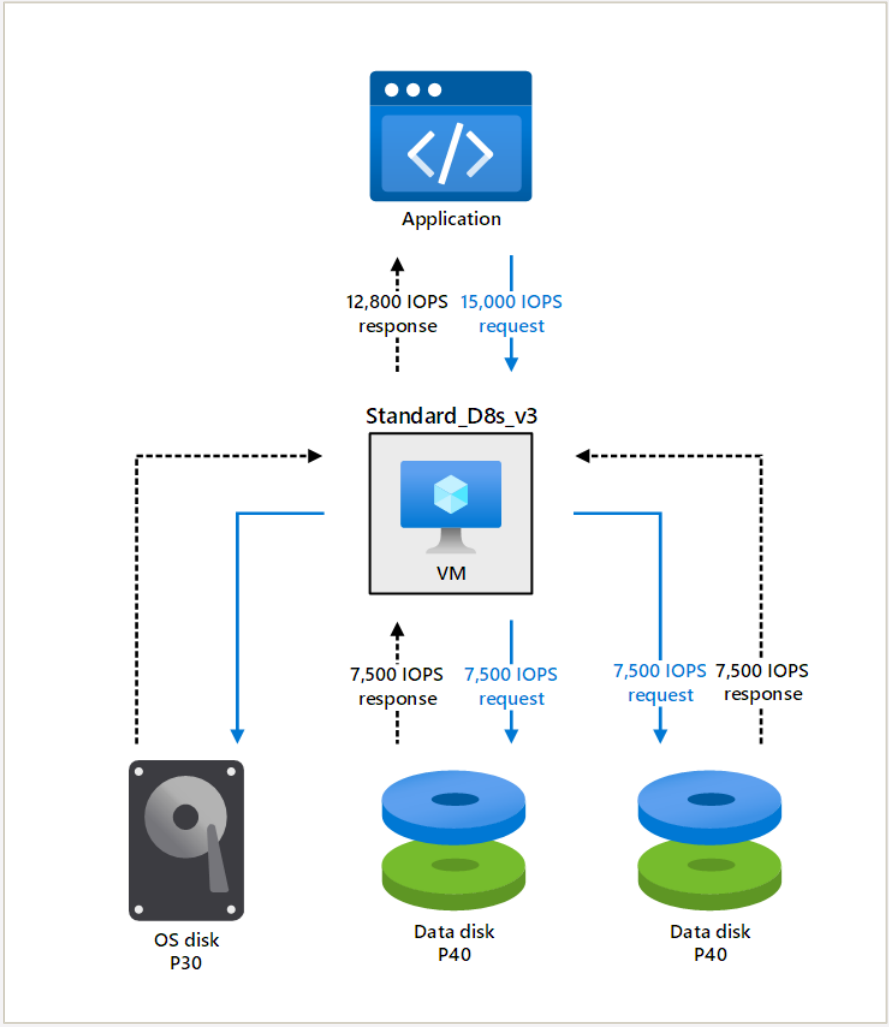
- To choose the right disk type, it's important that you understand the performance indicators.

  - **IOPS**: IOPS is the number of requests that your application sends to the disks in one second. IOPS directly affects your application performance. Some applications, like retail websites, need high IOPS to manage all the small and random input/output (I/O) requests that must be processed quickly to keep the site responsive. Higher performance disks have higher IOPS values.
  - **Throughput**: Throughput is the amount of data that your application sends to the disks in a specified interval. Throughput is also called *data transfer rate* and is measured in MB/s. If your application is performing I/O with large blocks of data, it requires high throughput. Higher performance disks have higher throughput.

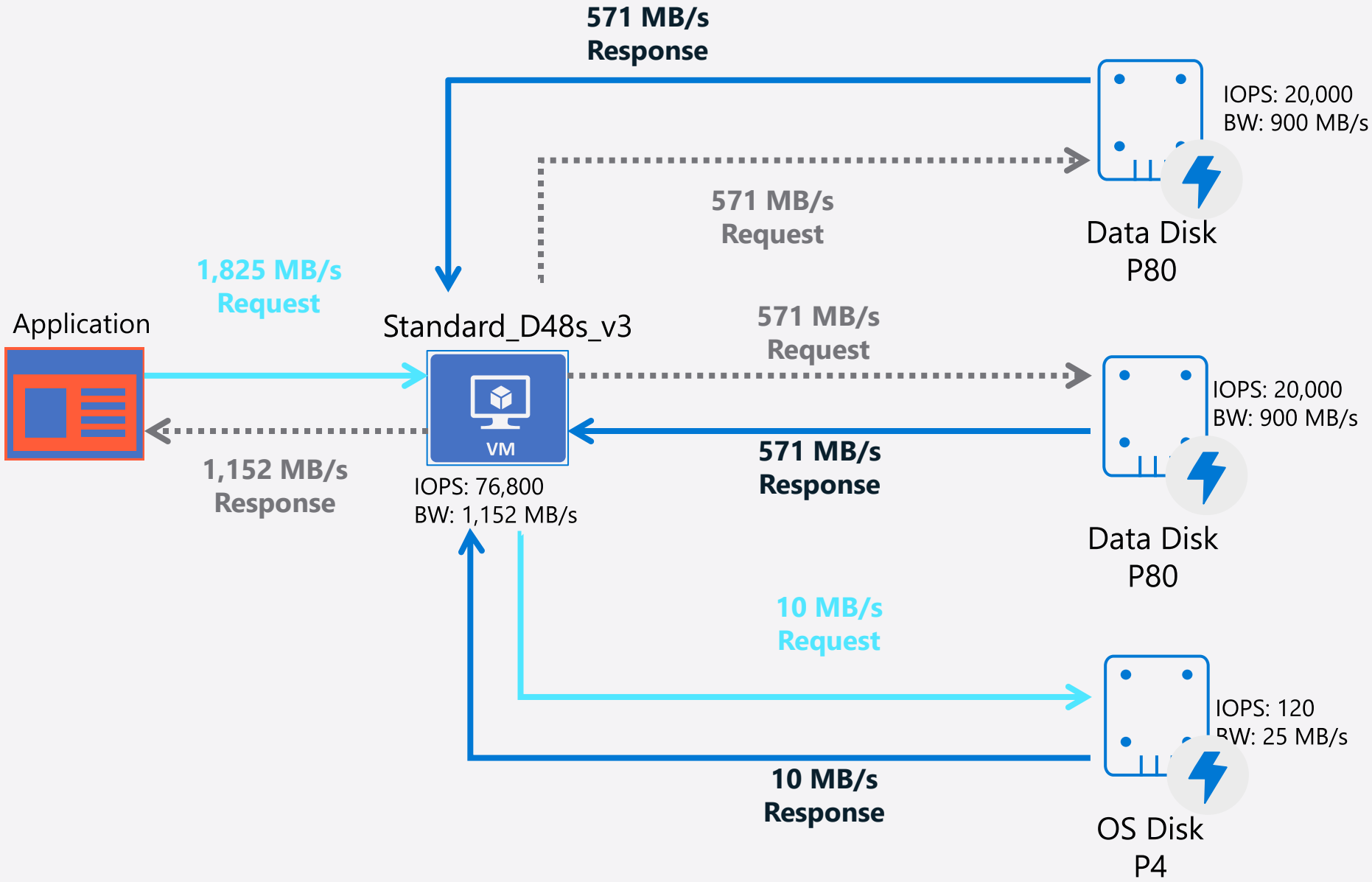
    To get a theoretical limit of throughput, you can use formula: IOPS × I/O size = throughput.
  - **Latency**: Latency expresses the time it takes your app to send a request to the disk and receive a response. Latency puts a limit on effective IOPS. For example, (with a queue depth of 1) if your disk can handle 5,000 IOPS but each operation takes 10 ms to process, your app will be capped at 100 operations per second because of the processing time. The latency is significantly improved if you enable ReadOnly host caching.

Virtual machine/Disk I/O capping

- If you don't size the VM correctly for the storage performance an application requires, the VM itself becomes a bottleneck.
- If you don't size the VM correctly for the storage performance an application requires, the Disks can also become a bottleneck.



VM + disk combination mismatch – VM Bandwidth Capped



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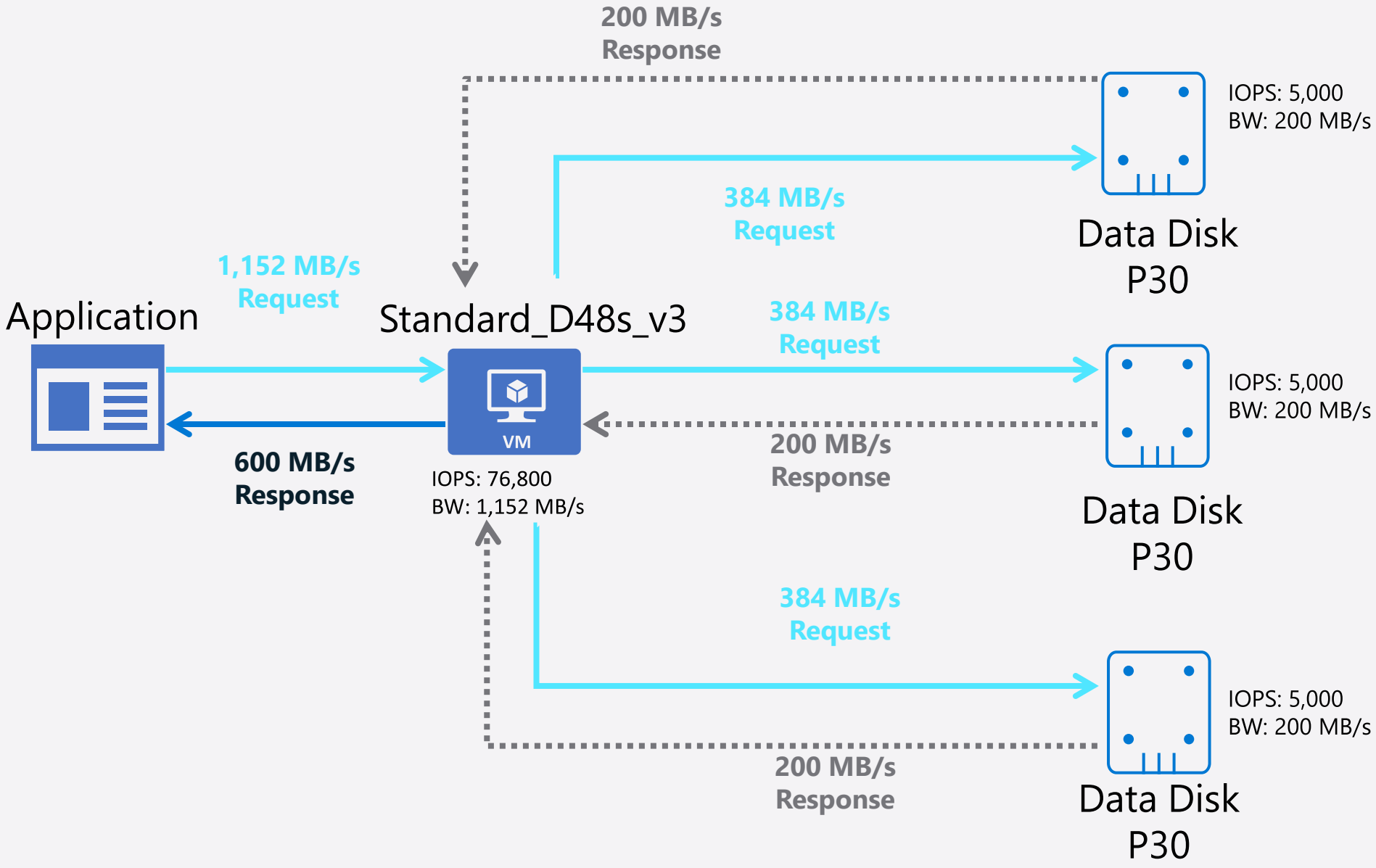
VM + disk combination mismatch – Disk Bandwidth Capped



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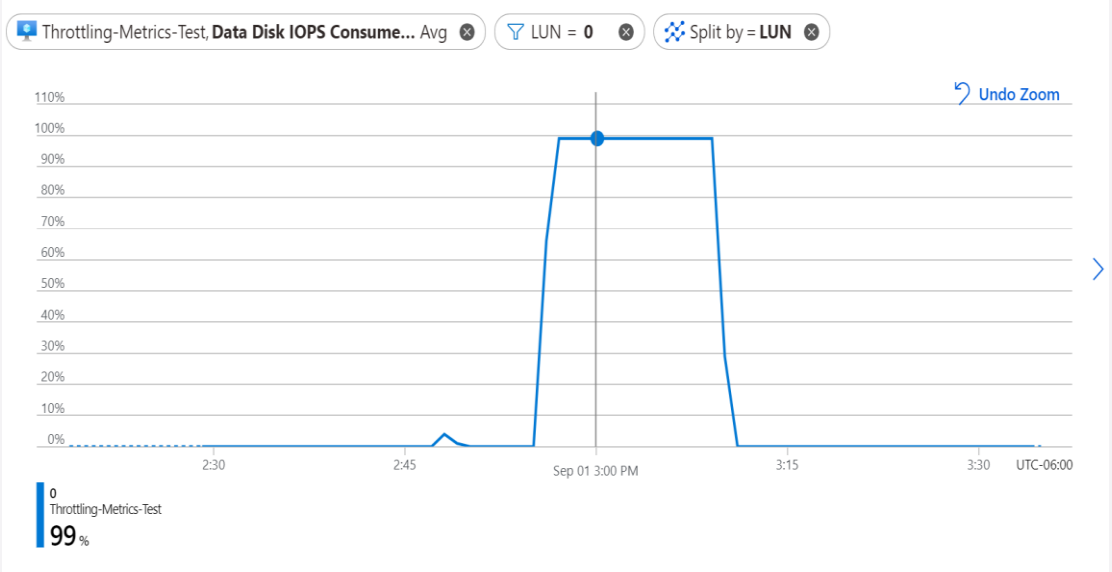
IO Utilization Metrics

Disk IO Utilization Metrics

- Data Disk IOPS consumed percentage
- Data Disk bandwidth consumed percentage
- OS Disk IOPS consumed percentage
- OS Disk bandwidth consumed percentage

VM IO Utilization Metrics

- VM Cached IOPS consumed percentage
- VM Cached bandwidth consumed percentage
- VM UnCached IOPS consumed percentage
- VM UnCached bandwidth consumed percentage



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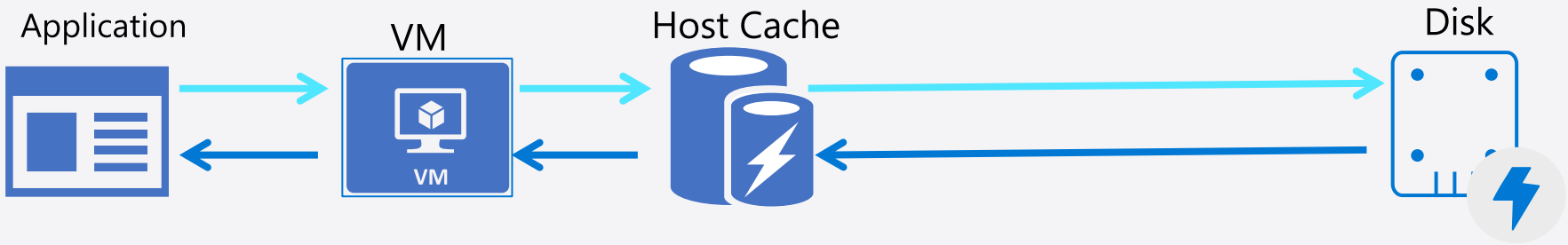
Host/Disk caching

Low-latency and high-performance IO

- Brings storage closer to our virtual machines to increase performance
- Combination of host's cache and local SSDs
- Can configure host cache to workload's IO Pattern
  - Read-only, read/write
- Independent limits of non-host caching performance
- Enables high performance that can exceed the Azure Disk



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Host/Disk caching

VM Spec - Example

Size	vCPU	Memory: GiB	Temp storage (SSD) GiB	Max data disks	Max cached and temp storage throughput: IOPS/MBps (cache size in GiB)	Max burst cached and temp storage throughput: IOPS/MBps[2]	Max uncached disk throughput: IOPS/MBps	Max burst uncached disk throughput: IOPS/MBps[1]
Standard_D2s_v3[3]	2	8	16	4	4000/32 (50)	4000/100	3200/48	4000/100
Standard_D4s_v3	4	16	32	8	8000/64 (100)	8000/200	6400/96	8000/200
Standard_D8s_v3	8	32	64	16	16000/128 (200)	16000/400	12800/192	16000/400
Standard_D16s_v3	16	64	128	32	32000/256 (400)	32000/800	25600/384	32000/800
Standard_D32s_v3	32	128	256	32	64000/512 (800)	64000/1600	51200/768	64000/1600
Standard_D48s_v3	48	192	384	32	96000/768 (1200)	96000/2000	76800/1152	80000/2000
Standard_D64s_v3	64	256	512	32	128000/1024 (1600)	128000/2000	80000/1200	80000/2000

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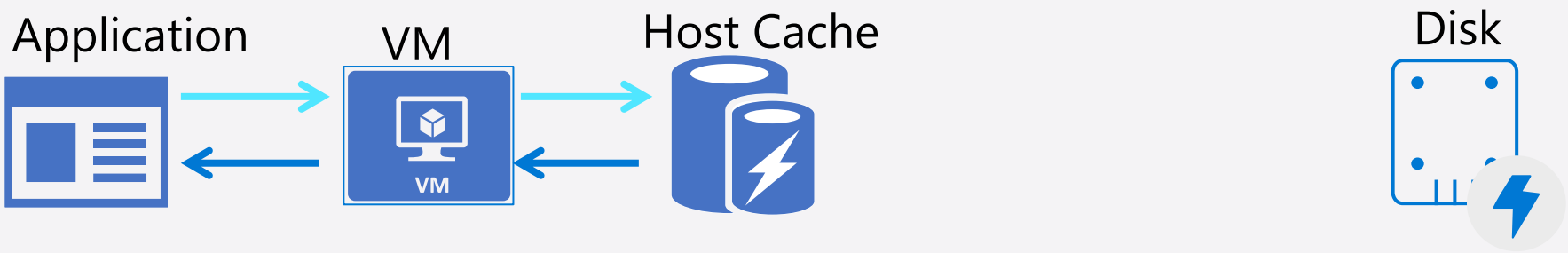
Host/Disk caching

Read-Only – Cache hit example

- Recommended for data disks with read-heavy IO patterns
- Remote disks IO is not affected by Reads which are served from the Cache
    - Applications can achieve higher throughput than the underlying remote disk



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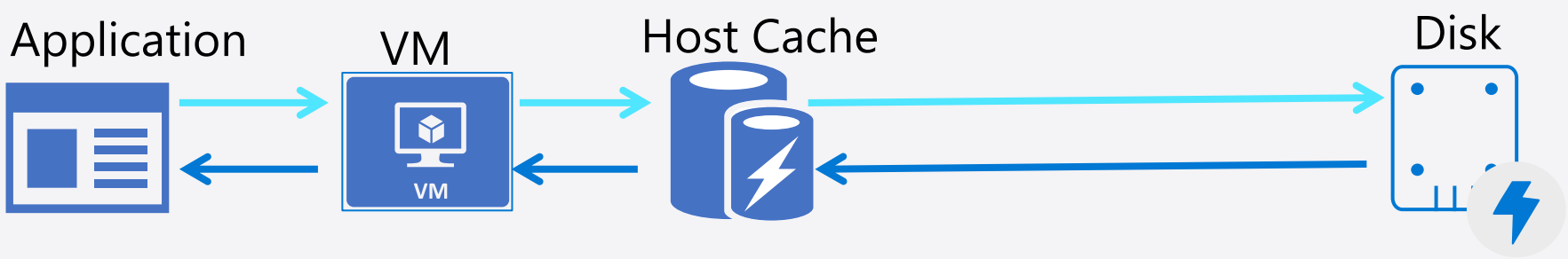
Host/Disk caching

Read-Only – Cache miss example

- Recommended for data disks with read-heavy IO patterns
- If the data is not in the cache, the read must go through to the remote disk
    - Read on a cache miss effects both cache limits and disk limits



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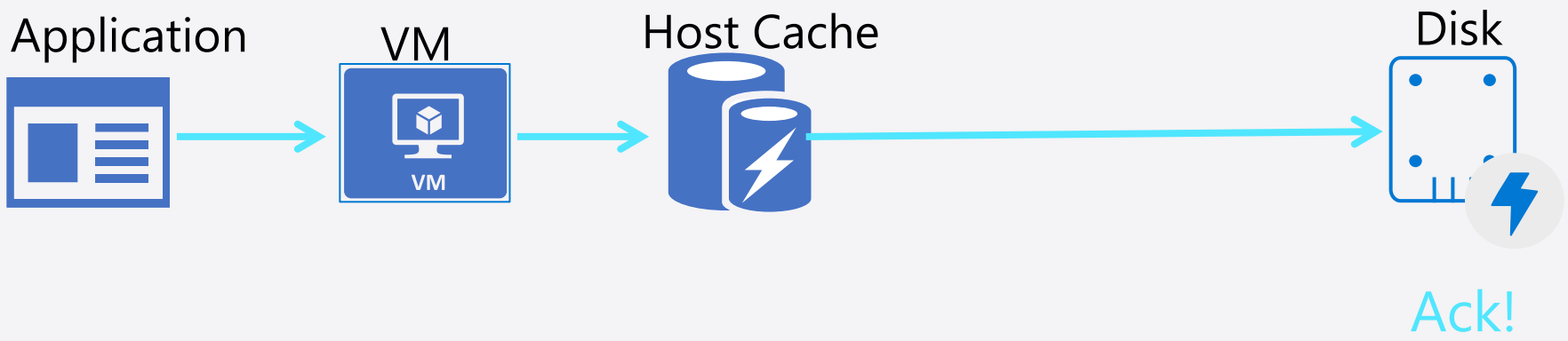
Host/Disk caching

Read-Only – Write example

- Recommended for data disks with read-heavy IO patterns
- The write must go through to the remote disk to Persist
    - Write on read-only cache effects both cache limits and disk limits



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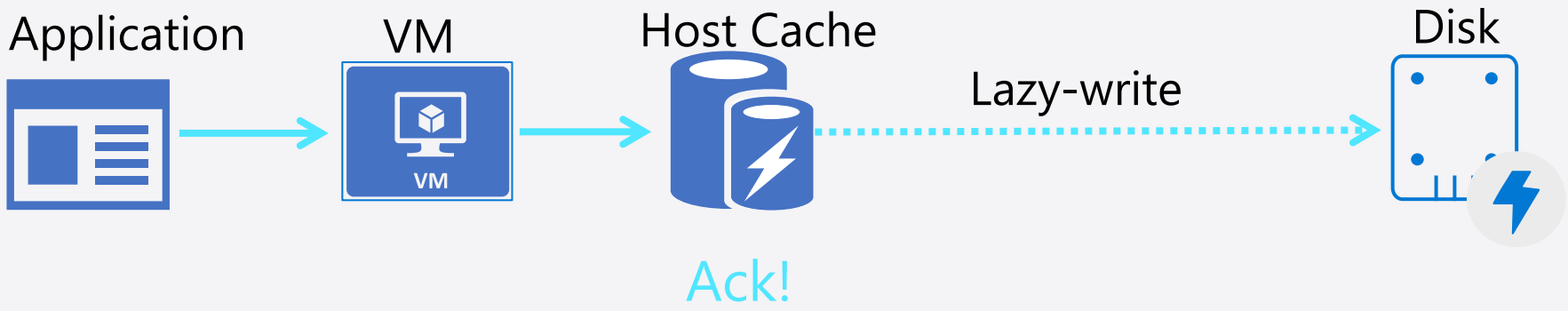
Host/Disk caching

Read/write caching - write

- Reading on read/write caching is just like read cache
- If customers are using read/write caching, their application must have a proper way to write the data from cache to persistent disks.
    - SQL Server handles writing cached data to the persistent storage disks on its own.
- Writing on read/write caching has a lazy-write back to remote storage



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Optimize performance and costs using performance-scaling options

Performance tiers

Scale performance up & down without increasing disk size

Lower costs by provisioning for baseline performance needs

Ideal for events that temporarily require a consistently higher level of performance

Change performance tiers with no downtime

Change the performance tier on Premium SSD disks while they are in use

You can change the performance tier of a Premium SSD disk without downtime and without dismounting the disk from the VM.

Azure CLI

```
$subscriptionId="yourSubscriptionID"
$resourceGroupName="yourResourceGroupName"
$diskName="yourDiskName"
$performanceTier="yourDesiredPerformanceTier"


az login
az account set --subscription $subscriptionId

az disk update -n $diskName -g $resourceGroupName --
set tier=$performanceTier
```

Credit-based bursting

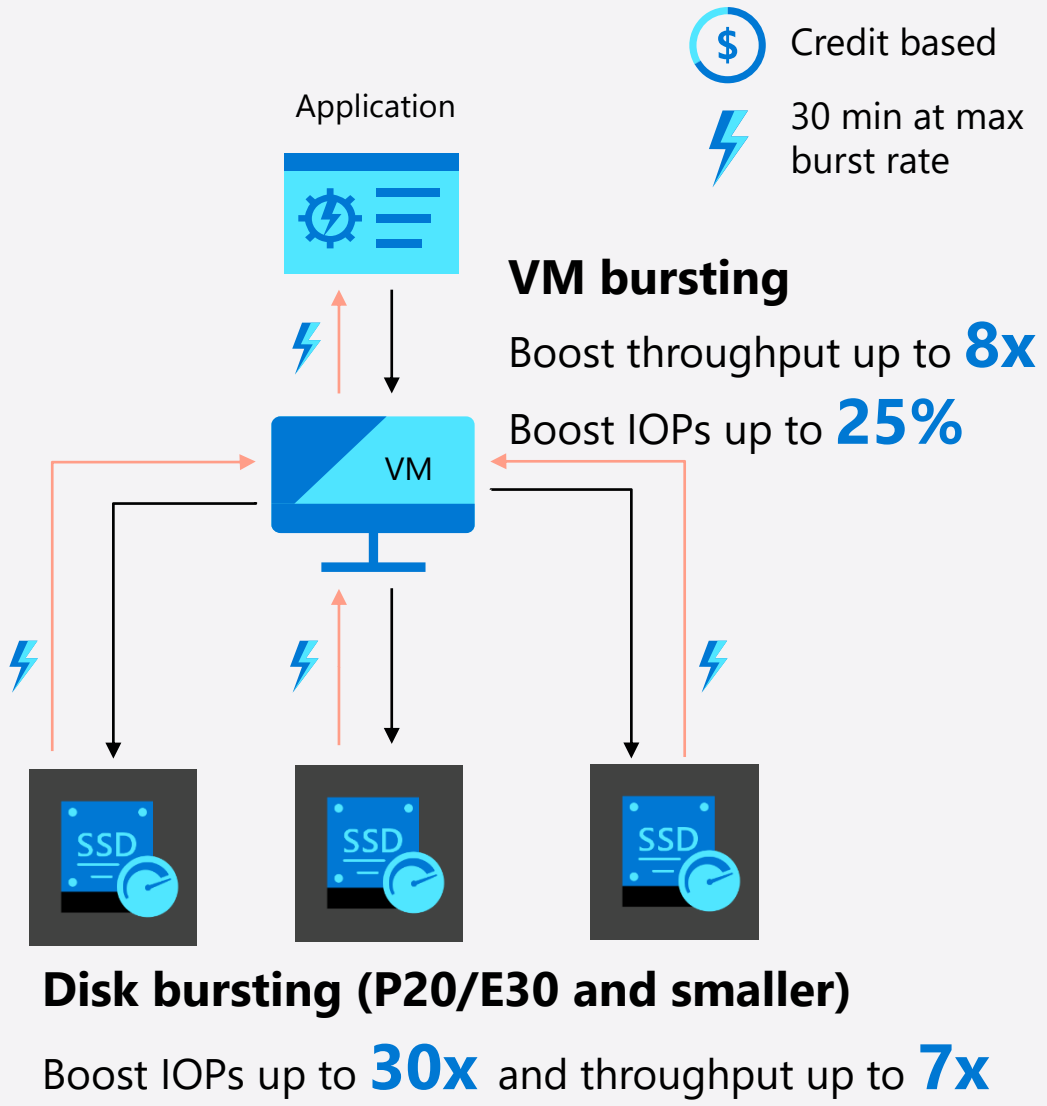
Get high short-term performance
Bursting enables you to get short-term, higher performance for workloads with unexpected or cyclical disk traffic

Cost savings
Save costs by provisioning VMs and smaller disk sizes for your baseline performance needs while still achieving higher performance

No additional costs or steps required
Bursting is enabled on new and existing deployments by default on supported VMs (Linux and Windows) and disks

Bursting on your VM and disk
Combine both VM and disk bursting to get higher performance on your VM and disks without overprovisioning

New metrics for improved observability!



VM bursting

Boost throughput up to **8x**

Boost IOPs up to **25%**

Disk bursting (P20/E30 and smaller)

Boost IOPs up to **30x** and throughput up to **7x**

http://aka.ms/diskbursting

On-demand bursting on Premium SSD

- Premium SSD Disks larger than 512GB
- Up to 30,000 IOPs and 1 GB/s of throughput on a single disk
- Pay for additional performance you use
- Enablement fee
- Figure out the right size for your workload

```
Set-AzContext -SubscriptionName
"yourSubscriptionName“

$diskConfig = New-AzDiskConfig -Location
"WestCentralUS" -CreateOption Empty -DiskSizeGB 1024
-SkuName Premium_LRS -BurstingEnabled $true

$dataDisk = New-AzDisk -ResourceGroupName
"myResourceGroupDisk" -DiskName "myDataDisk" -Disk

$diskConfig
```

Performance Plus

Increase IOPs and Throughput limits

Free of charge

Enabled during disk creation, While VM is deallocated or disk is detached

Available on Standard HDD, Standard SSD, and Premium SSD sized 1TB and larger!

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Performance Plus – new IO and throughput limits

Standard HDD

Up to 12X improvement on IOPS

Up to 8.3X improvement on throughput

Size	Regular IOPS Limits	New Performance+ IOPS limits	Regular Bandwidth Limits	New Performance+ BW (MB/s)
S30	~~500~~	1,500	~~60~~	150
S40	~~500~~	3,000	~~60~~	300
S50	~~500~~	3,000	~~60~~	500
S60	~~1,300~~	3,000	~~60~~	500
S70	~~2,000~~	3,000	~~300~~	500
S80	~~2,000~~	3,000	~~500~~	500

Premium SSD

Up to 2.6X improvement on IOPS

Up to 3.6X improvement on throughput

Size	Regular IOPS Limits	New Performance+ IOPS limits	Regular Bandwidth Limits	New Performance+ BW (MB/s)
P30	~~5,000~~	8,000	~~200~~	300
P40	~~7,500~~	16,000	~~250~~	600
P50	~~7,500~~	20,000	~~250~~	900
P60	~~16,000~~	20,000	~~500~~	900
P70	~~18,000~~	20,000	~~750~~	900
P80	~~20,000~~	20,000	~~900~~	900

Standard SSD

Up to 12X improvement on IOPS

Up to 10X improvement on throughput

Size	Regular IOPS Limits	New Performance+ IOPS limits	Regular Bandwidth Limits	New Performance+ BW (MB/s)
E30	~~500~~	1,500	~~60~~	150
E40	~~500~~	3,000	~~60~~	300
E50	~~500~~	6,000	~~60~~	600
E60	~~2,000~~	6,000	~~400~~	750
E70	~~4,000~~	6,000	~~600~~	750
E80	~~6,000~~	6,000	~~750~~	750

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Costs

- Before deciding on which disk type suits your needs the most, consider how the billing for that disk is done.
  - The region the disk is deployed in (all disks)
  - The size of the disk (all disks)
  - The number of transactions made involving the disk (all transactions for Standard HDD and Standard SSD. For Premium SSD, burst transactions only)
  - The redundancy option selected (Standard SSD and Premium SSD only)
  - Whether on-demand bursting is enabled (Premium SSD only)
  - The disk's IOPS (Ultra Disks and Premium SSD v2 only)
  - The disk's throughput (Ultra Disks and Premium SSD v2 only)

Standard SSD Billed Transaction Limits

- Same great performance as usual for Standard SSD
- New limitations on the number of billable transactions
- New pricing in effect on 3/6/2023
- Transactions are IO Sized 256 KB and smaller
  - If IO sized > 256 of throughput are considered multiple I/Os of size 256 KiB.

Product	LRS Transaction Cap (# of Trx / hr)	ZRS Transaction Cap (# of Trx / hr)
E1	6,800	7,800
E2	13,400	15,400
E3	26,600	30,600
E4	43,400	61,000
E6	81,200	114,400
E10	147,200	214,000
E15	274,000	398,400
E20	502,000	737,600
E30	829,200	1,238,800
E40	893,000	1,344,700
E50	1,578,400	2,405,600
E60	2,777,500	4,243,900
E70	4,379,300	7,353,100
E80	9,478,400	14,706,200

Reminder:

Standard SSD/HDD TCO = Capacity costs + Transaction cost

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Standard SSD and HDD TCO comparison

TCO Comparison between a Standard SSD 32GB Disk (E4) and a Standard HDD 32GB Disk(S4) averaging 100 IOPs/month

Standard SSD

Without the transaction cap, the 100 transactions/second would have resulted in the following billable transactions:

$$100\ \frac{transactions}{sec} * 60\ Seconds * 60\ \frac{Minutes}{Hour} = \mathbf{360,000\ Billable\ transactions\ per\ hour}$$

With the transaction cap, the hourly billed transaction **are now capped at 43,400**. Changing the monthly billed transaction amount to $6.33 per month

$$43{,}400\ billable\ transactions * \frac{\$0.002}{10{,}000\ Transactions} * 730\ \frac{hours}{month} = \mathbf{\$6.33\ per\ month}$$

Total uncapped Standard SSD TCO for a month:

$$\mathbf{Capacity\ Cost + Transactions\ cost =}$$
$$\mathbf{\$2.40 + \$6.33} \quad \mathbf{= \$8.73}$$

41% TCO savings over HDD!

Standard HDD

The 100 transactions/second would have resulted in the following billable transactions:

$$100\ \frac{transactions}{sec} * 60\ Seconds * 60\ \frac{Minutes}{Hour} = \mathbf{360,000\ Billable\ transactions\ per\ hour}$$

That would have resulted in the hourly cost shown below:

$$360{,}000\ billable\ transactions * \frac{\$0.0005}{10{,}000\ Transactions} * 730\ \frac{hours}{month} = \mathbf{\$13.14\ per\ month}$$

Total Standard HDD TCO for a month:

$$\mathbf{Capacity\ Cost + Transactions\ cost =}$$
$$\mathbf{\$1.54 + \$13.14} \quad \mathbf{= \$14.68}$$

Optimize performance and costs with the optimal option

	Credit-based bursting	On-demand bursting	Performance tiers	Performance plus
Performance scaling	Recommended for unplanned events	Recommended for unplanned events	Recommended for planned events	Recommended for planned events
Duration of higher performance	Short-term	Short-term	Longer duration - sustained higher performance	Longer duration – sustained higher performance
Cost	Free	Enablement fee and cost per transaction	Fixed cost, you pay for the current performance tier	Free
Disk type	Premium SSD and Standard SSD on sizes less than and equal to 512GB	Premium SSD on sizes bigger than 512GB	All Premium SSDs	Premium SSD, Standard SSD and Standard HDD Disks sized 513GB and larger
Latency	Low single digit ms	Low single digit ms	Low single digit ms	Depends on product SKU
Enablement	Enabled by default	Manual enablement required	Manual enablement required	Enabled by User

Knowledge check

Question 1

An administrator must select the disk type that provides the highest IOPS for a new VM. Which disk type should they use, assuming their region supports all disk types?

A. Ultra Disk Storage

B. Standard HDD

C. Premium SSD

Vote at https://aka.ms/polls

Question 2

You're running an application that requires 15,000 IOPS on an Azure VM. You've provisioned one VM with the Standard_D8s_v3 tier. It provides 12,800 IOPS, a P30 operating system disk with 5,000 IOPS, and two P30 data disks with 5,000 IOPS each. Which of the following statements is true?

A. You've met the application's demands.

B. VM I/O capping prevents the application from receiving the demanding IOPS.

C. Disk I/O capping prevents the application from receiving the demanding IOPS.

Vote at https://aka.ms/polls

Question 3

Vote at https://aka.ms/polls

An administrator is creating an Azure VM by using Premium SSD disks to run a marketing application. You've scheduled a planned marketing event, for which you require a sustained increase in disk performance. Which of the performance-scaling options should the administrator choose to meet the application requirements?

A. Use disk bursting.

B. Change the performance tiers.

C. Use read/write caching on the disk.

Summary

- The disk types that are available in Azure
- How disk performance works
- Performance-scaling options

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