Introduction

1 minute

You're the system architect for a law firm. The firm has asked you to migrate critical systems to Azure. Operations include the database of case histories, currently hosted by an on-premises SQL server and accessed from a desktop application. The SQL server also runs some custom in-house services to perform database maintenance. You've decided that a solution based on Azure virtual machines (VMs) will allow you to host your SQL server and continue using your custom services. You'll create an Azure virtual hard disk based on the contents of your existing on-premises server to ease migration.

In this module, you'll learn how to architect the optimal disk configuration for the VMs you create in Azure.

Learning objectives

In this module, you will:

- Create a virtual machine (VM)
- Configure and attach virtual hard drives (VHDs) to an existing VM
- Determine whether you need premium disks
- Resize disks for a VM

Prerequisites

None

Next unit: Understand storage options for virtual machines (VMs)

Continue

Understand storage options for virtual machines (VMs)

3 minutes

Just like any other computer, virtual machines in Azure use disks as a place to store an operating system, applications, and data. These disks are called virtual hard disks (VHDs).

Suppose you have created a virtual machine (VM) in Azure, which will host the database of case histories that your law firm relies on. A well-designed disk configuration is fundamental to good performance and resilience for SQL Server.

In this unit, you'll learn how to choose the right configuration values for your disks and how to attach those disks to a VM.

How disks are used by VMs

VMs use disks for three different purposes:

- **Operating system storage**. Every VM includes one disk that stores the operating system. This drive is registered as a SATA drive and labeled as the C: drive in Windows and mounted at "/" in Unix-like operating systems. It has a maximum capacity of 2048 gigabytes (GB), and its content is taken from the VM image you used to create the VM.
- **Temporary storage**. Every VM includes a temporary VHD that is used for page and swap files. Data on this drive may be lost during a maintenance event or redeployment. The drive is labeled as D: on a Windows VM by default. Do not use this drive to store important data that you do not want to lose.
- **Data storage**. A data disk is any other disk attached to a VM. You use data disks to store files, databases, and any other data that you need to persist across reboots. Some VM images include data disks by default. You can also add additional data

disks up to the maximum number specified by the size of the VM. Each data disk is registered as a SCSI drive and has a max capacity of 4095 GB. You can choose drive letters or mount points for your data drives.

Storing VHD files

In Azure, VHDs are stored in an Azure storage account as **page blobs**.

This table shows the various kinds of storage accounts and which objects can be used with each.

Storage account type	Services supported	Types of blobs supported
General-purpose standard	Azure Blob storage, Azure Files, Azure Queue storage	Block blobs, page blobs, and append blobs
General-purpose premium	Blob storage	Page blobs
Blob storage, hot and cool access tiers	Blob storage	Block blobs and append blobs

Both general-purpose standard and premium storage support page blobs. Choose a standard storage account if cost is your primary concern. Premium storage will cost more, but will also deliver much higher I/O operations per second, or IOPS. If data performance is a requirement for your VM, consider using premium storage.

Attach data disks to VMs

You can add data disks to a virtual machine at any time by attaching them to the VM. Attaching a disk associates the VHD file with the VM.

The VHD can't be deleted from storage while it's attached.

Attach an existing data disk to an Azure VM

You may already have a VHD that stores the data you want to use in your Azure VM. In our law firm scenario, for example, perhaps you've already converted your physical disks to VHDs locally. In this case, you can use the PowerShell `Add-AzVhd` cmdlet to upload it to the storage account. This cmdlet is optimized for transferring VHD files and may complete the upload faster than other methods. The transfer is completed by using multiple threads for best performance. Once the VHD has been uploaded, attach it to an existing VM as a data disk. This approach an excellent way to deploy data of all types to Azure VMs. The data is automatically present in the VM, and there's no need to partition or format the new disk.

Attach a new data disk to an Azure VM

You can use the Azure portal to add a new, empty data disk to a VM.

This process will create a **.vhd** file as a page blob in the storage account that you specify, and attach that .vhd file as a data disk to the VM.

Before you can use the new VHD to store data, you have to initialize, partition, and format the new disk. We'll practice these steps in the next exercise.

In physical on-premises servers, you store data on physical hard disks. You store data in an Azure virtual machine (VM) on virtual hard disks (VHDs). These VHDs are stored as page blobs in Azure storage accounts. For example, when you migrate your law firm's database of case histories to Azure, you must create VHDs where the database files will be saved.

Next unit: Exercise - Add a data disk to a VM

Continue >

Determine whether to use premium storage

7 minutes

Some applications place greater demands on data storage than others. Apps such as Dynamics CRM, Exchange Server, SAP Business Suite, SQL Server, Oracle, and SharePoint require constant high performance and low latency to run at their best.

When creating your VMs or adding new disks, you have a few choices which will have a dramatic impact on disk performance, starting with the *type* of storage you choose.

Types of disks

Azure Disks are designed for 99.999% availability.

There are four performance tiers for storage that you can choose from when creating your disks -- Ultra disks, Premium SSD Disks, Standard SSD, and Standard HDD storage. Depending on the VM size, you can mix and match these disk types.

Ultra disks

Azure ultra disks deliver high throughput, high IOPS, and consistent low latency disk storage for Azure IaaS VMs. Ultra disks include the ability to dynamically change the performance of the disk without the need to restart your virtual machines (VM). Ultra disks are suited for data-intensive workloads such as SAP HANA, top tier databases, and transaction-heavy workloads. Ultra disks can only be used as data disks. We recommend using premium SSDs as OS disks.

Premium SSD disks

Premium SSD disks are backed by solid-state drives (SSDs), and deliver high-performance, low-latency disk support for VMs running I/O-intensive workloads. These drives tend to be more reliable because they have no moving parts. A read or write head doesn't have to move to the correct location on a disk to find the data requested.

You can use Premium SSD disks with VM sizes that include an "s" in the series name. For example, there is the **Dv3-Series** and the **Dsv3-series**, the **Dsv3-series** can be used with Premium SSD disks.

Standard SSD

Premium storage is limited to specific VM sizes - so the VM type you create will impact the storage capabilities: size, max capacity, and storage type. What if you have a low-end VM, but you need SSD storage for I/O performance? That's what Standard SSDs are for. Standard SSDs are between standard HDDs and premium SSDs from a performance and cost perspective.

You can use standard SSDs with any VM size, including VM sizes that don't support premium storage. Using standard SSDs is the only way to use SSDs with those VMs. This disk type is only available in specific regions and only with *managed disks*.

Standard HDD storage

Standard HDD disks are backed by traditional hard disk drives (HDDs). Standard HDD disks are billed at a lower rate than the Premium disks. Standard HDD disks can be used with any VM size.

Unmanaged versus managed disks

When you create VMs or VHDs, you have the choice to use **unmanaged** or **managed** disks.

With unmanaged disks, you are responsible for the storage accounts that are used to hold the VHDs that correspond to your VM disks. You pay the storage account rates for the amount of space you use. A single storage account has a fixed rate limit of 20,000

I/O operations/sec. This means that a single storage account is capable of supporting 40 standard virtual hard disks at full throttle. If you need to scale out, then you need more than one storage account, which can get complicated.

Managed disks are the newer and **recommended disk storage model**. They elegantly solve this complexity by putting the burden of managing the storage accounts onto Azure. You specify the disk type, and the size of the disk and Azure creates and manages both the disk *and* the storage it uses. You don't have to worry about storage account limits, which makes them easier to scale out. Here are some of the benefits you get over the older unmanaged disks:

- **Increased reliability**: Azure ensures that VHDs associated with high-reliability VMs will be placed in different parts of Azure storage to provide similar levels of resilience.
- **Better security**: Managed disks are managed resources in the resource group. This means they can use role-based access control to restrict who can work with the VHD data.
- **Snapshot support**: Snapshots can be used to create a read-only copy of a VHD. You have to shut down the owning VM but creating the snapshot only takes a few seconds. Once it's done, you can power on the VM and use the snapshot to create a duplicate VM to troubleshoot a production issue or rollback the VM to the point in time that the snapshot was taken.
- **Backup support**: Managed disks can be automatically backed up to different regions for disaster recovery with Azure Backup all without affecting the service of the VM.

With all the additional benefits, including the guaranteed performance characteristics, you should always choose managed disks for new VMs.

Disk comparison

The following table provides a comparison of Ultra disk, Premium SSD, Standard SSD, and Standard HDD to help you decide what to use.

	Ultra disk	**Premium SSD**	**Standard SSD**	**Standard HDD**
Disk type	SSD	SSD	SSD	HDD

	Ultra disk	Premium SSD	Standard SSD	Standard HDD
Scenario	IO-intensive workloads such as SAP HANA, top tier databases (for example, SQL, Oracle), and other transaction-heavy workloads.	Production and performance sensitive workloads	Web servers, lightly used enterprise applications and dev/test	Backup, non-critical, infrequent access
Max disk size	65,536 gibibyte (GiB)	32,767 GiB	32,767 GiB	32,767 GiB
Max throughput	2,000 MiB/s	900 MiB/s	750 MiB/s	500 MiB/s
Max IOPS	160,000	20,000	6,000	2,000

There is more detail on disk performance below.

Data replication

The data in your Microsoft Azure storage account is automatically replicated to ensure durability and high availability. Azure Storage replication copies your data so that it's protected from planned and unplanned events like transient hardware failures, network or power outages, natural disasters, and so on. You can choose to replicate your data within the same data center, across zonal data centers within the same region, and even across regions.

There are four types of replication:

- **Locally redundant storage (LRS)** - Azure replicates the data within the same Azure data center. The data remains available if a node fails. However, if an entire data center fails, data may be unavailable.
- **Geo-redundant storage (GRS)** - Azure replicates your data to a second region that is hundreds of miles away from the primary region. If your storage account

has GRS enabled, then your data is durable even if there's a complete regional outage or a disaster in which the primary region isn't recoverable.

- **Read-access geo-redundant storage (RA-GRS)** - Azure provides read-only access to the data in the secondary location, and geo-replication across two regions. If a data center fails, the data remains readable but can't be modified.
- **Zone-redundant storage (ZRS)** - Azure replicates your data synchronously across three storage clusters in a single region. Each storage cluster is physically separated from the others and resides in its own availability zone (AZ). With this type of replication, you can still access and manage your data in the event that a zone becomes unavailable.

Standard storage accounts support all replication types, but premium storage accounts only support locally redundant storage (LRS). Since VMs themselves run in a single region, this restriction isn't usually an issue for VHD storage.

Disk performance

The performance of your disks depends on the type of disk you chose. Each disk is rated to a specific number of I/O operations per second, or IOPS (pronounced "eye-ops"). In addition, each drive has a throughput rating - this determines how much data you can read or write in a second. The combination of these two determines how fast the disk is.

For example, with standard storage, you get a maximum of **500 IOPS and 60 MB/second** throughput per disk (even on SSDs). With premium storage, the IOPS depends on the premium disks you choose and the VM size.

	P4	**P6**	**P10**	**P15**	**P20**	**P30**	**P40**
Disk Size	32 GiB	64 GiB	128 GiB	256 Gib	512 GiB	1 TiB	2 TiB
Max IOPS per disk	120	240	500	1,100	2300	5000	7500
Max Throughput per disk	25 MB/sec	50 MB/sec	100 MB/sec	125 MB/sec	150 MB/sec	200 MB/sec	250 MB/

As you can see, you can go from **25 MB/sec** and **120 IOPS** to **900 MB/sec** and **20,000 IOPS**.

Next unit: Resize virtual machine disks

Continue >

Resize virtual machine disks

5 minutes

Azure stores your VHD images as page blobs in an Azure Storage account. With managed disks, Azure takes care of managing the storage on your behalf - it's one of the best reasons to choose managed disks.

When you create the VM, it chooses a size for the OS disk. The specific size is based on the image you select. On Linux, it's often around 30 GB, and on Windows about 127 GB.

You can add data disks to provide for additional storage space, but you may also wish to expand an existing disk - perhaps a legacy application cannot split its data across drives, or you are migrating a physical PC's drive to Azure and need a larger OS drive.

> **Note**
>
> You can only resize a disk to a *larger* size. Shrinking managed disks is not supported.

Changing the size of the disk can also change the level of the disk (for example from P10 to P20). Keep this in mind - this can be beneficial for performance upgrades, but will also cost more as you move up the premium tiers.

VM size versus disk size

The VM size you choose when you create your VM determines how many resources it can allocate. For storage, the size controls the number of disks you can add to the VM and the maximum size of each disk.

As mentioned previously, some VM sizes support only Standard storage drives - limiting the I/O performance.

If you find that you need more storage than what your VM size allows for, you can change the VM size. We cover that topic in the Introduction to Azure Virtual Machines module.

Expanding a disk using the Azure CLI

> **⚠ Warning**
>
> Always make sure that you back up your data before performing disk resize operations!

Operations on VHDs cannot be performed with the VM running. The first step is to stop and deallocate the VM with `az vm deallocate`, supplying the VM name and resource group name.

Deallocating a VM, unlike just *stopping* a VM, releases the associated computing resources and allows Azure to make configuration changes to the virtualized hardware.

> **ⓘ Note**
>
> Don't run these commands just yet. You'll practice the process in the next part.

Azure CLI | Copy

```
az vm deallocate \
  --resource-group <resource-group-name> \
  --name <vm-name>
```

Next, to resize a disk, you use `az disk update`, passing the disk name, resource group name, and newly requested size. When you expand a managed disk, the specified size is mapped to the nearest managed disk size.

Azure CLI | Copy

```
az disk update \
  --resource-group <resource-group-name> \
```

```
  --name <disk-name> \
  --size-gb 200
```

Finally, you run `az vm start` to restart the VM.

Azure CLI | Copy

```
az vm start \
  --resource-group <resource-group-name> \
  --name <vm-name>
```

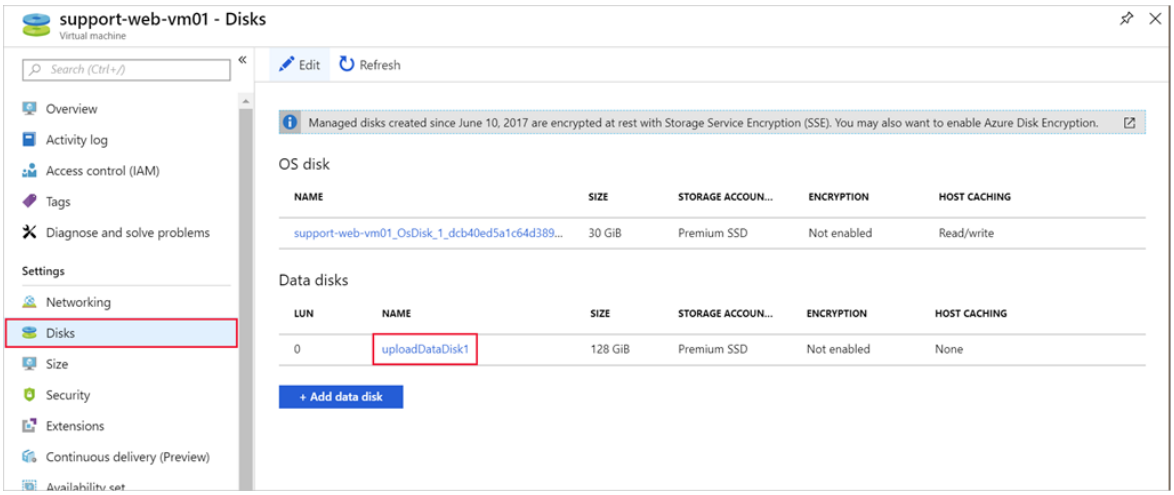
Expanding a disk using the Azure portal

You can also expand a disk through the Azure portal.

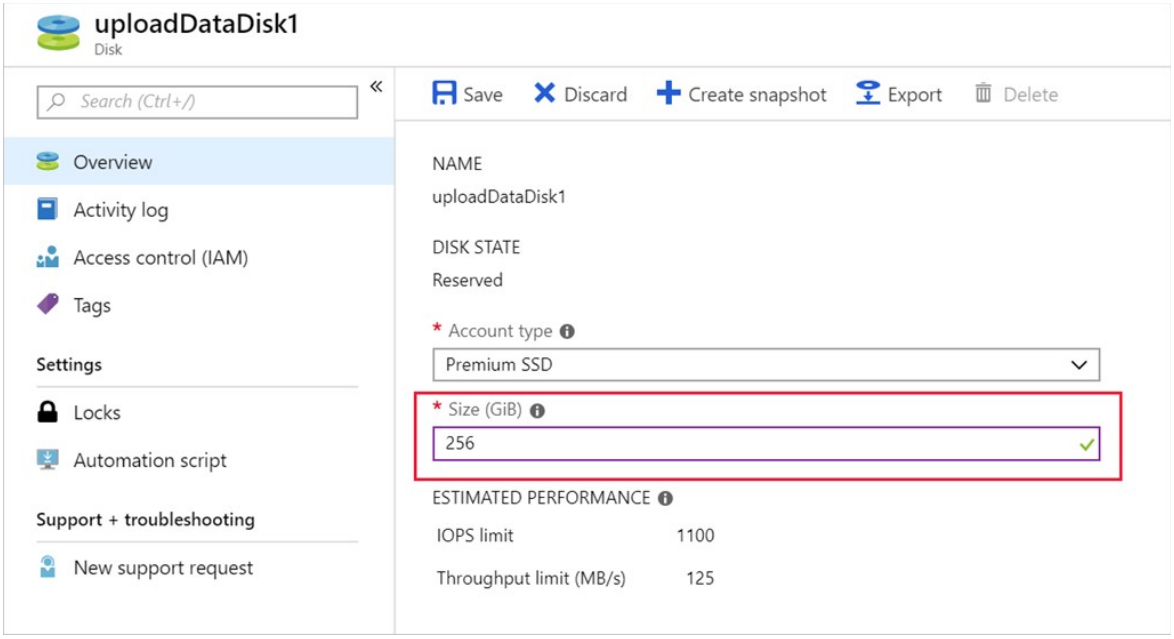
1. Stop the VM using the **Stop** button in the toolbar on the **Overview** page for the VM.

2. Click **Disks** in the **Settings** section.

3. Select the data disk you want to resize.



4. In the disk details, type a size *larger* than the current size. You can also change from Premium to Standard (or vice-versa) here. These settings will adjust your performance as shown in the predicted IOPS section.



5. Click **Save** to save the changes.

6. Restart the VM.

Expanding the partition

Just like adding a new data disk, an expanded disk won't add any usable space until you expand the partition and filesystem. This must be done using the OS tools available to the VM.

On Windows, you might use the Disk Manager tool or the `diskpart` command line tool.

On Linux, you might use `parted` and `resize2fs`. You'll do that in the next part.

Next unit: Exercise - Resize a VM disk

Continue >

Summary

3 minutes

In this module, you learned how to add new disks to your VMs to increase their storage. In addition, you explored the different disk types available, features of Standard versus Premium storage, and how to resize existing disks.

Clean up

The sandbox automatically cleans up your resources when you're finished with this module.

When you're working in your own subscription, it's a good idea at the end of a project to identify whether you still need the resources you created. Resources left running can cost you money. You can delete resources individually or delete the resource group to delete the entire set of resources.

Additional resources

- Frequently asked questions about Azure IaaS VM disks and managed and unmanaged premium disks
- Convert Azure managed disks storage from standard to premium, and vice versa
- Full list of VM sizes that support premium storage for Windows and Linux

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Module complete:

Unlock achievement