Design Azure Compute and Storage Infrastructure

Hands-on lab

Windows Azure offers many choices for designing compute, storage, and other resources that provide an optimal fit for a particular workload or set of workloads. Designing resources for particular workloads requires an understanding, not only of the capabilities and cost associated with particular resources, but also the subscription and service limits, quotas, and constraints.

In this lab, you will learn about the relevant capabilities within Azure that will enable a cost-effective design that meets performance requirements.

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Before You Begin

In this lab, you will examine and analyze a number of quick start ARM templates that are available on GitHub. You will create a GitHub account, if you don't already have one, to host a GitHub repo for a quick start template that you will download and then modify and deploy. When you have completed the lab exercises, you will clean up the Azure resources that you created in the lab.

To as great extent as possible, the lab instructions assume the use the Azure Preview Portal, which is located at https://portal.azure.com. Some tasks are only available through the Azure Portal. There will be some need to switch back and forth between the two portals. Most of what you will be doing could also be done using the full portal. However, for the sake of consistency and clarity, lab instructions have only been written using the Preview Portal whenever possible. The full portal is located at https://manage.windowsazure.com.

For more information on the preview portal, please see http://channel9.msdn.com/Blogs/Windows-Azure/Azure-Preview-portal for a brief demonstration or http://azure.microsoft.com/en-us/documentation/preview-portal/ to read the current documentation for the preview portal.

Azure Subscriptions

This IT Camp lab requires a valid Azure subscription. While you may use an existing subscription such as a subscription associated MSDN account or existing corporate account, it would preferable to use an Azure Trial subscription for this IT camp. By using a trial subscription, you will avoid any charges against your MSDN or corporate subscription that would result from doing the exercises in this camp.

Your instructor may be able to provide you with a pre-provisioned Microsoft Account that already has an Azure subscription associated with it. Or, you may use a CLEAN and UNUSED Azure Trial account - details on how to set one up are detailed below.

To create a new Azure trail account perform the following steps.

1. Navigate to www.live.com and click **Sign up now**.
2. Follow the on-screen instructions to create a new Microsoft Account.
3. Navigate to www.azure.com and click **Free Trial**.
4. Follow the on-screen instructions to activate a new Windows Azure Trial.
5. Navigate to Manage.windowsazure.com and sign in.
6. In Microsoft Azure portal, in the upper left, click your user name, and then click **View my bill**.
7. Click your current trial subscription, and then click **Edit subscription details**.
8. Type a name you will recognize in SUBSCRIPTION NAME, such as ITCamps, and then click the **Done** icon.

Hosted Workstations

Labs in this camp are written to be completed on a pre-configured workstation. Additional labs require an on-premises environment consisting of multiple servers. A hosted virtual machine environment is provided for this purpose. Your instructor will provide a link to this environment.

If you are using the hosted workstation environment, use **Administrator** as the username and **Passw0rd!** as the password.

Use of Own System

You may complete lab instructions using your own workstation (either Windows 10 or Windows 8.1), providing you download the files used for the lab from GitHub and have the following software installed.

GitHub repository for Lab Files

If you are not using the hosted virtual machine and are using your own workstation, any custom files the lab instruction call out can be found in a GitHub repository. The repository is located here: https://github.com/AZITCAMP/Labfiles.

Required Software

1. Microsoft Azure PowerShell - http://go.microsoft.com/?linkid=9811175&clcid=0x409 (also installs the Web Platform Installer)
2. Visual Studio Code - https://code.visualstudio.com/
3. GitHub Desktop for Windows - https://desktop.github.com/
4. Windows Credential Store for Git (if VSCode won't authenticate with GitHub) - http://gitcredentialstore.codeplex.com/
5. Iometer - http://sourceforge.net/projects/iometer/

Optional Software

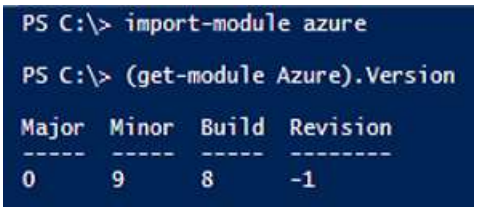
Any additional software that you require will be called out in the lab. The following software may be useful when working with Azure in general.

1. Remote Server Administration Tools - http://support.microsoft.com/kb/2693643 (Windows 8.1) or http://www.microsoft.com/en-ca/download/details.aspx?id=45520 (Windows 10)
2. AzCopy - http://aka.ms/downloadazcopy
3. Azure Storage Explorer - http://azurestorageexplorer.codeplex.com/downloads/get/891668
4. Microsoft Azure Cross-platform Command Line Tools (installed using the Web Platform Installer)
5. Visual Studio Community 2015 with Microsoft Azure SDK - 2.7.1 (installed using the Web Platform Installer)
6. Msysgit - http://msysgit.github.io
7. PuTTY and PuTTYgen - www.putty.org

8. Microsoft Online Services Sign-In Assistant for IT Professionals RTW - http://go.microsoft.com/fwlink/?LinkID=286152
9. Azure Active Directory Module for Windows PowerShell (64-bit version) - http://go.microsoft.com/fwlink/p/?linkid=236297

Please note that these lab exercises require a minimum version of 0.9.8 of the Microsoft Azure module for PowerShell. To determine the module version installed on your system, open a Windows PowerShell prompt, type the following commands, and then press ENTER.

```
↪ import-module Azure
↪ get-module Azure).version
```



Access the Lab Environment

For this lab you will be accessing a hosted environment that contains all the VMs and resources you require. Your instructor will provide a link to the hosted lab environment.

You should be able to connect with any recent web browser, including Microsoft Edge. Once you have connected to the lab environment, take a few minutes to familiarize yourself with Launchpad.

For this course there are four VMs that you will work in. If you look at the Machines tab on the right side of the lab environment you will find a listing of all the VMs. To switch to another VM, just click on the appropriate name in the Machines list. Below you will find a listing of the VMs for this course.

Virtual Machine	Role
AZRCamp-Admin	Windows 10. A member of the Contoso.com domain. Used for Azure management.
AZRCamp-Edge	A Stand-alone Windows Server 2012 R2 Server. Routing and Remote Access has been installed and it is acting as the default gateway for all outbound traffic.
AZRCamp-DC	Windows Server 2012 R2 domain controller and DNS server.
AZRCamp-Sync	Directory Sync for use in other Labs.

The password for all logons in these VMs is "Passw0rd!".

- You can type this in to the VM manually, or use the **Commands→Paste→Paste Password** sequence from the Launchpad.

Introduction and Scenario

Contoso, Inc. is still in the process of evaluating recently added new features to Azure, such as Azure Resource Manager. Contoso has a number of large applications that use significant amounts of disk space for both read and write operations. Consequently, Contoso is interested in investigating how recently added features, such as new virtual machine scale units and premium storage, can provide both performance and cost benefits. You have been asked to investigate these features and create a sample Azure Resource Manager template to deploy a relatively high performant application.

Prepare the Azure Infrastructure

In this exercise, you will use the Lab02Start.ps1 script to log on to your Azure subscription and create an Azure resource group that you will use for the remaining lab exercises. The script will also determine a globally unique name that you can use to create a storage account in subsequent lab exercises.

Additionally, you will also deploy a STANDARD_D2 virtual machine that has 4 striped data disks that use standard storage. You will use this virtual machine to compare and contrast disk performance with a STANDARD_DS2 virtual machine that uses premium storage.

Run the Lab02Start.ps1 script

To perform the subsequent lab exercises, you need to create two Azure Resource Groups and determine two globally unique names you can use to create your storage accounts.

- Perform the following tasks on **AZRCAMP-ADMIN**:

1. Open File Explorer and navigate to **C:\LabFiles\AZRITPROCamp\Lab02 – Design Azure compute and storage.**
2. Right-click **Lab02Start.ps1**, and click **Edit**.
   - The Windows PowerShell ISE console opens.
3. In Windows PowerShell ISE, on the upper Ribbon, click **Run Script** (green arrow).
4. When prompted, enter a lower-case string that represents your initial, and press ENTER.
   - The storage account name must contain only lower case letters and numbers and must be globally unique.
5. In the Sign in to Windows Azure PowerShell dialog box, enter the email address of the account associated with your Azure subscription, and click **Continue**.
6. On the sign in page, enter your password, and click **Sign in**.
   - The script starts running and then pauses to display the two names verified as unique for use the storage account names in your lab.
7. Record the unique storage account names, and press ENTER to continue.
   - You will need to know the unique name for the storage account in a subsequent lab exercise.
8. Leave the Windows PowerShell ISE console open for subsequent lab exercises.

Deploy D2 VM with standard storage

In this task, you will deploy a D2 virtual machine from a pre-configured template. You will subsequently use this virtual machine to compare with a DS2 virtual machine that uses premium storage.

- Perform the following tasks on **AZRCAMP-ADMIN**:

1. Open Microsoft Edge, and browse to https://github.com/AZITCAMP/Labfiles/tree/master/lab02.
   - The lab02 repository contains all files you need to complete the lab.
2. In the Readme.md section, click **Deploy to Azure**.
3. If prompted, log on to the Azure portal.
   - The Parameters tab for the virtual machine custom deployment appears.
4. In NEWSTORAGEACCOUNTNAME, enter the unique name of the standard storage account that you determined in the previous task.
   - The name will look something like this: **[abc]stdstore#**, where [abc] represents your initials and # is an integer.
5. In DNSNAMEFORPUBLICIP, enter your initials plus 4 random digits to ensure uniqueness.
6. In ADMINPASSWORD, enter **Passw0rd!**.
   - Note the account and password for use in future tasks
7. Leave the remaining parameters at their default value, and click **OK**.
8. On the custom deployment blade, in the Resource group section, click **Select a resource group**, and select **RG-AZITCAMP-STD**.
9. Click **Legal terms**.
10. In the Buy blade, click **Buy**.
11. On the Custom deployment tab, click **Create**.
    - You may see errors regarding the deployment of Desired State Configuration Extensions. Wait a few minutes and the problem will resolve itself.
12. Leave the Microsoft Edge browser open for subsequent steps, and proceed to the next exercise without waiting for the deployment to complete.

Design for appropriate workloads

Designing for appropriate workloads requires that performance benefits are relevant to the workloads and are cost-effective. Different applications will have different workloads. Some will be write-intensive, while others may be more read-intensive. And, the data that comprises the workloads can be vary from small to large. Within an Azure subscription, there is a cost associated with storage, compute, and other resources. Furthermore, software licensing models may be directly related to resources. For example, some database applications are licensed on a per CPU basis; the greater the number of CPUs, the greater the cost.

Windows Azure offers many choices for designing compute, storage, and other resources to provide an optimal fit for a particular workload or set of workloads. Designing resources for particular workloads requires an understanding, not only of the capabilities and cost associated with particular resources, but also the subscription and service limits, quotas, and constraints.

In this lab exercise, you will learn about some of the more relevant capabilities within Azure and considerations that will allow you to design for cost-effective performance that matches desired requirements.

Summary overview of Azure Storage and Compute Resource Capabilities

Microsoft recently added Premium Storage and two new series of virtual machines (D and G series) to provide additional, high performance capacity for your workloads and applications.

Virtual machine sizes are categorized by tier (basic or standard) and series (A, D, DS, G, and GS).

Basic tier

The basic pricing tier provides only A series virtual machines. The basic tier is adequate for small to medium applications or workloads that do not require advanced features, such as load-balancing or auto-scaling. Alternatively, basic tier virtual machines may be a cost-effective way for test/dev cycle. However, consideration would have to be given to the ease of scaling up or out of applications or workloads. Basic tier virtual machines belong to a scale unit that includes only A0-A4 virtual machines. If you need to scale up to a larger virtual machine, such as an A5, you will not be able to do so directly in the UI; you must do a more time-consuming manual migration.

The basic tier A series virtual machines represent the smallest virtual machines you can deploy. The smallest virtual machine is Basic_A0, which provides 1 CPU core and 768 MB ram; for storage, the Basic_A0 provide up to 1 1023 GB OS disk, 1 1068 GB data disk, and 300 Input/output operations (IOPS) per disk. The largest basic tier virtual machine is Basic_A4, which provides 8 CPU cores, 14 GB of RAM, 1 1023 GB OS disk (max size), and up to 16 1023 GB data disks. The maximum IOPS for each data disk is 300 IOPS. So, if the data disks are striped in a storage pool on a Basic_A4 virtual machine, it is possible to achieve a theoretical maximum of 16x300= 4800 IOPS.

Standard pricing tier

Standard tier offers more capabilities, such as load balancing and auto-scaling. Additionally, it offers a wide range of virtual machine sizes and performance capabilities. The standard tier includes A series virtual machines, as well as the D and G series. Like basic tier virtual machines, these virtual machines are also grouped into scale units (also known as stamps). The scale unit groupings are as follows:

- **SU 2:** A0-A7
- **SU 3:** A8 - A11 (HPC virtual machines)
- **SU 4:** A0 - A7 and D1 - D14
- **SU 5:** G1 - G5

Scale units have consequences if you are using cloud services and need to ensure you can scale up. For example, to ensure that you can scale from an A series virtual machine to a D series virtual machine directly in the UI, you need to create your first virtual machine in the cloud service as a D series virtual machine. This will ensure that any subsequent A series virtual machines you can create can be upgraded to D series virtual machines.

Within a series, the greater the numerical value, the more resources, such as CPU cores, RAM, disks, and IOPS the virtual machines can have. For the A0-A4 series of virtual machines, the capabilities of the virtual machines for the standard pricing tier are similar to those of the basic pricing tier, except that virtual machines in the standard tier have larger temporary drives and have higher maximum IOPS (500) per disk. An A4\extra large VM could theoretically have a maximum IOPS of 16 striped data disks x 500 IOPS = 8,000 total IOPS.

D and G Series virtual machines

The D and G series of virtual machines offer more memory and faster processing power than the A series machines, with the possible exception of A8-A11 virtual machines. Both the D and G series virtual machines offer local SSD storage for the temporary D: drive that is created by default when you provision a virtual machine in Azure. At the extreme upper end of the G series (G5), a virtual machine can have up to 32 vCPUs, 448 MB of memory, and 6.59 TB of Solid State Drive (SSD) space for the temporary drive. Additionally, the G5 series can have up to 64 persistent drives, each supporting a maximum of 500 IOPS.

Because not all datacenters are have the same hardware capacity, not all Azure datacenters can support G series virtual machines. For example, at the time of this writing, G series virtual machines could be created only in East US 2, West US, and West Europe. Other considerations for deciding whether to use D or G series virtual machines is whether you want to be able to resize and whether other types of virtual machines can exist in the same cloud service. For example, it is not possible to resize to a G series virtual machine from any other series and G series virtual machines cannot be in the same cloud service as other series.

Premium storage (DS and GS series)

Premium storage is available for DS and GS series of virtual machines. Premium storage provides durable data storage on SSD drives. Using SSD drives for durable storage allows Azure to support I/O intensive workloads. Using premium storage, applications can have up to 64 TB of storage per virtual machine and, depending on the configuration, achieve >80,000 IOPS per VM and 2000 MB per second disk throughput.

The following two tables show the virtual machine and disk sizes and limits for DS and GS series of virtual machines and the P10, P20, and P30 storage disk types.

VM Size	CPU cores	Max. Disk IOPS (per VM)	Max. Disk Bandwidth (per VM)	CACHE SIZE (GB)
STANDARD_DS1	1	3,200	32 MB per second	43
STANDARD_DS2	2	6,400	64 MB per second	86
STANDARD_DS3	4	12,800	128 MB per second	172
STANDARD_DS4	8	25,600	256 MB per second	344
STANDARD_DS11	2	6,400	64 MB per second	72
STANDARD_DS12	4	12,800	128 MB per second	144
STANDARD_DS13	8	25,600	256 MB per second	288
STANDARD_DS14	16	50,000	512 MB per second	576
STANDARD_GS1	2	5000	125 MB per second	264
STANDARD_GS2	4	10,000	250 MB per second	528
STANDARD_GS3	8	20,000	500 MB per second	1056
STANDARD_GS4	16	40,000	1,000 MB per second	2112
STANDARD_GS5	32	80,000	2,000 MB per second	4224

Storage Disk Type	P10	P20	P30
Disk size	128 GiB	512 GiB	1024 GiB (1 TB)
IOPS per disk	500	2300	5000
Throughput per disk	100 MB per second	150 MB per second	200 MB per second

Planning considerations for using premium (or standard) storage

- Premium storage is more expensive than standard storage and requires that you have a premium storage account. However, because of the performance gains offered by the storage subsystem, premium storage may be more cost effective than virtual machines that are using standard storage. For example, a database application that is licensed per CPU core may have a lower cost overall if it can run on DS virtual machine that has fewer cores than a D or A series virtual machine.

- Premium storage is locally redundant (LRS). Three copies are kept within the local region.

- You can use both Standard and Premium storage in DS or GS series virtual machines. This can provide cost benefits in that you can place the high performance storage where you need it. For example, if the OS disk is used only for booting, you can use a standard disk for the OS disk. An SSD disk will not provide a significant benefit in this case.

- By default, when you create Premium data disks, the caching policy is "Read-only"; for operating system disks, the caching policy is "Read-Write". If you use the data disks for write-intensive applications (e.g., SQL logs), you should disable disk caching to ensure writes are flushed to the disk to mitigate risk to data integrity.

- Premium storage is subject to bandwidth and IOP limits and constraints that differ according to the Premium Storage disk type. There are 3 disk types that you can choose from, each with their own cost profile: P10, P20, and P30. A P10 disk is 128 GB in size, provides a maximum of 500 IOPS per disk, and 100 MB throughput per disk. A P30 disk is 1 TB in size, provides a maximum of 5000 IOPS per disk, and 200 MB throughput per disk.

- The limits for Premium disks are for the disk traffic alone and do not include Cache hits or network traffic, which is measured separately. For example, cache hits from disk configured as read only are not subject to the Premium storage disk limitations, but are subject to a separate IOPS/throughput limit based on the VM size. A DS series VM provide approximately 4000 IOPS and 33 MB/sec per core for cache and local SSD IOs. If you have disks configured to use ReadOnly caching and you are mainly performing reads, you can achieve higher IOPS than the maximum limits indicated for the premium storage disks.

- To achieve maximum throughput and IOPS with multiple data disks, you can stripe the disks using Storage Spaces. It is recommended that you use 1 column for each disk. If you have more than 8 disks, you must use the NumberOfColumns parameter in the New-VirtualDisk cmdlet to specify more than 8 columns. By default, the UI creates a maximum of 8 columns, even if there are more than 8 disks. The total IOPS and throughput are a product of the number of disks in a stripe set:

  number of disks in a strip set x IOPS per disk = total IOPS.

- Be aware of the different throttling limits in your design choices. For example, both the DS1 and DS2 virtual machine series limit disk bandwidth to 32 and 64 MB per second respectively. This means that a P10 disk will not reach it maximum throughput limit of 100 MB per second if it is used in these virtual machines. A GS5 series of virtual machine can provide up to 2000 MB per second throughput across all disks. In some cases, the limiting factor will be the disk. For example, a DS4 VM provides up to 256 MB per second for disk throughput; however, a single P30 disk provides only 200 MB per second and is the limiting factor.

- The maximum number of IOPS for a storage account is 20,000. Your IOPS will be throttled if the sum of the IOPS for the disks in the same storage account exceed 20,000. For example, if you have a single GS5 VM with 5 striped P30 disks that belong to the same storage account, your IOPS will be throttled at 20,000. To achieve the maximum possible IOPS (25,000) in this scenario, you need to place the disks across 2 storage accounts. For each storage account, use the following formula to determine the number of storage accounts you require, where x = the number of standard or P10 disks, y = the number of P20 disks, and z = the number of P30 disks. If the result is greater than 1, you need 2 or more storage accounts.

(x * 500 IOPS) + (y * 2,300 IOPS) + (z * 5,000 IOPS)/20,000

- IOPS and Throughput are related, but the limits for each are applied separately. The relationship between IOPS and Throughput is described by this formula: IOPS x I/O size = Throughput. For example, 1000 IOPs x 8 KB = 8 MBs per second.

- I/O size is configurable and has implications for throughput and IOPS. If your applications uses larger files, increase the I/O size to increase throughput. If you require more IOPS, reduce the I/O size.

- Outstanding I/O requests are also known as Queue Depth (QD) and are related to performance as follows: IOPS x Latency = QD. For example, if you 5000 IOPS with a latency of 1 ms, your QD = 5 (5 is an optimal QD). Give this example, if your QD is more than 5, the IOPS is a limiting factor and your disk is a bottleneck. Likewise, if your QD is consistently lower than the 5, you are not taking advantage of the full capacity of the disk subsystem.

- Be aware of account and other scale limits. For example, the maximum allowable disk capacity for Premium Storage Accounts is 35 TB. Therefore, you would need to get an additional storage account to accommodate the 64 1 TB disks allowed for a G5 virtual machine.

For more information, please see the following:

- **Premium Storage: High-Performance Storage for Azure Virtual Machine Workloads** at https://azure.microsoft.com/en-us/documentation/articles/storage-premium-storage-preview-portal/
- **Azure Subscription and Service Limits, Quotas, and Constraints** at https://azure.microsoft.com/en-us/documentation/articles/azure-subscription-service-limits/
- **Azure Storage Scalability and Performance Targets** at https://azure.microsoft.com/en-us/documentation/articles/storage-scalability-targets/
- **Sizes for virtual machines** at https://azure.microsoft.com/en-us/documentation/articles/virtual-machines-size-specs/
- **New D-Series Virtual Machine Sizes** at https://azure.microsoft.com/en-us/blog/new-d-series-virtual-machine-sizes/
- **Largest VM in the Cloud** at https://azure.microsoft.com/en-us/blog/largest-vm-in-the-cloud/

Review Questions

The following provides a number of questions to reinforce your understanding of throttling limits and capacity.

1. You configure a DS1 VM with 2 striped P10 data disks. Excluding read-only cache, what is the maximum theoretical disk throughput? What is the maximum throughput for the virtual machine? What is the limiting factor, the disk or the virtual machine?
2. Your application is capable of writing 128 KB blocks to a P10 disk on a DS2 virtual machine. What is the maximum throughput that your design is capable of achieving?

3. You need to design a solution that can theoretically achieve the highest possible disk throughput of 2,000 MB per second using the minimum number of striped disks. Your application reads and writes data in 64 KB blocks. Specify the VM series, the disk type, and the IOPS needed achieve the maximum throughput.

4. Using the same design as provided in the answer to question 3 above, if your application uses data in 32 KB blocks, would you be able to achieve the 2000 MB per second throughput?

5. Given a latency of 1 ms, what is the Queue depth needed to achieve 2300 IOPS?

6. You have 5 DS3 VMs, each with 4 striped P20 disks that belong to a single storage account. What limit is going to affect disk performance? What can you do achieve optimal performance?
   Configure Git repository and Visual Studio Code

Deploy virtual machine with Premium Storage

In a previous task, you deployed a D2 virtual machine from a template. In this task, you will customize the template used to deploy the D2 virtual machine to deploy a DS2 virtual machine that uses premium storage. In a subsequent lab exercise, you will compare the performance of the 2 virtual machines.

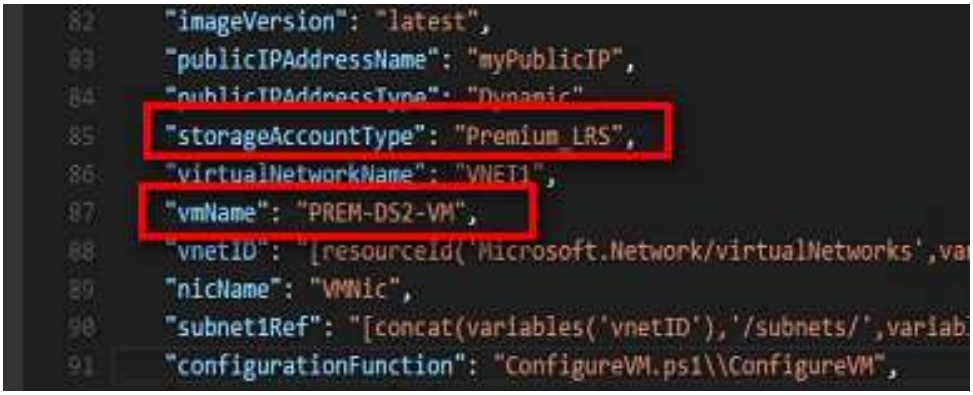
Modify azuredeploy.json template file

In this task you will download an azuredeploy.json file from GitHub and then modify it to deploy a virtual machine that uses premium storage, rather than standard storage.

- Perform the following tasks on AZRCAMP-ADMIN logged on as **Contoso\Administrator** using **Passw0rd!** as the password:

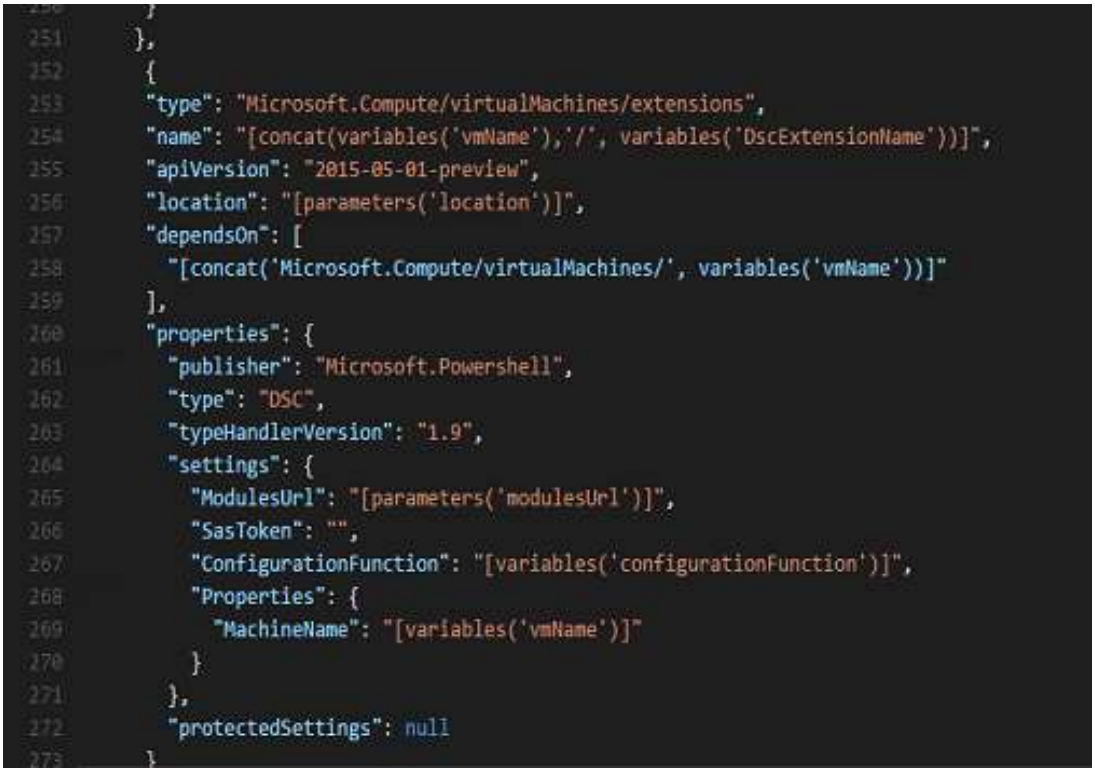
1. If not already open, open the Microsoft Edge browser and navigate to https://github.com/AZITCAMP/Labfiles/tree/master/lab02.
2. Click **azuredeploy.json**.
3. On the azuredeploy.json page, click **Raw**.
4. Press CTRL+A to select all the text in the window, and then press CTRL+C to copy the text to the clipboard.
5. From the taskbar, open **Visual Studio Code**.
6. In Visual Studio Code, place the cursor in the blank window and then press CTRL+V to copy the text.
7. Click **File**, and then click **Save As**.
8. In the Save As dialog box, browse to **C:\LabFiles\AZITPROCAMP\Lab02**.
9. In File name, type **azuredeploy-premstorage.json**, and click **Save**.
10. Locate the **"vmSize"** parameter at around line 30.
11. Change all the instances for Standard_D# to **Standard_DS#**, where # is an integer.
    - To use premium storage you must deploy a virtual machine that belongs to either the DS or the GS tiers.

12. Scroll down to the variables section, and locate the **"storageAccountType"** key/value pair at around line 85.
13. Change Standard_LRS to **Premium_LRS**.
14. A couple of lines below storageAccountType, locate the **"vmName"** key/value pair.
15. Change STD-D2-VM to **PREM-DS2-VM**.



16. Scroll down the resources section, and locate the dataDisks section that starts at around line 192.
    - Note that ReadOnly disk caching is configured here, along with other aspects of the disk, such as the LUN.
17. Scroll down to the end of the file and note the extension section that begins at around line 253.
    - In the extension section, we can specify the Desired State Configuration (DSC) properties. DSC allows us, among other things, to automate the post-deployment configuration of the virtual machines. In this case, the PowerShell script used by the DSC extension initializes the 4 data disks, creates a storage pool,

creates a striped volume from the disks in the pool, and then copies some files to the VM for later use in the lab.



```
    },
    {
      "type": "Microsoft.Compute/virtualMachines/extensions",
      "name": "[concat(variables('vmName'),'/', variables('DscExtensionName'))]",
      "apiVersion": "2015-05-01-preview",
      "location": "[parameters('location')]",
      "dependsOn": [
        "[concat('Microsoft.Compute/virtualMachines/', variables('vmName'))]"
      ],
      "properties": {
        "publisher": "Microsoft.Powershell",
        "type": "DSC",
        "typeHandlerVersion": "1.9",
        "settings": {
          "ModulesUrl": "[parameters('modulesUrl')]",
          "SasToken": "",
          "ConfigurationFunction": "[variables('configurationFunction')]",
          "Properties": {
            "MachineName": "[variables('vmName')]"
          }
        },
        "protectedSettings": null
      }
```

18. Click **File** and then click **Save**.
19. Leave file open for the next task.

Deploy virtual machine from template

In this task you will deploy a virtual machine that uses premium storage, rather than standard storage.

- Perform the following tasks on AZRCAMP-ADMIN logged on as **Contoso\Administrator** using **Passw0rd!** as the password:

1. Switch to the Microsoft Edge browser.
2. If not already logged on to the Azure portal, navigate to https://portal.azure.com and log in with the account associated with your subscription.
3. In the Azure portal, in the left pane, click **New**.
4. In the New blade, click **Template deployment**.
   - If you do not see this item for selection, you will need to search for it in the Marketplace. Please see the first lab for instructions on how to do this.

5. In the Custom deployment blade, click **Edit template**.
6. In the Edit template blade, select all the text and then delete it.
7. Place the cursor in the Edit template blade, and then press CTRL+V to paste the code you copied to the clipboard earlier.
8. Click **Save**.
9. In the Custom deployment blade, click **Parameters**.
10. In NEWSTORAGEACCOUNTNAME, enter the unique name of the Premium storage account that you determined in the previous task.
    - The name will look something like this: [abc]premstore#, where [abc] represents your initials and # is an integer.
11. In DNSNAMEFORPUBLICIP, enter your initials plus 4 random digits to ensure uniqueness.
12. In ADMINPASSWORD, type **Passw0rd!**
13. Leave the remaining parameters at their default value, and click **OK**.
14. On the custom deployment blade, in the Resource group section, click **Select a resource group**, and select **RG-AZITCAMP-PREM**.
15. Click **Legal terms**.
16. In the Buy blade, click **Buy**.
17. On the Custom deployment tab, click **Create**.
18. Leave the Microsoft Edge browser open for subsequent steps, and proceed to the next exercise without waiting for the deployment to complete.

Compare standard and premium storage

In the previous task, you deployed both a D2 virtual machine that uses standard storage and a DS2 virtual machine that uses premium storage. In this exercise, you connect to the virtual machines, install IOMETER software to measure disk IOPS and throughput, and then perform a basic benchmark test to compare the performance of the virtual machines.

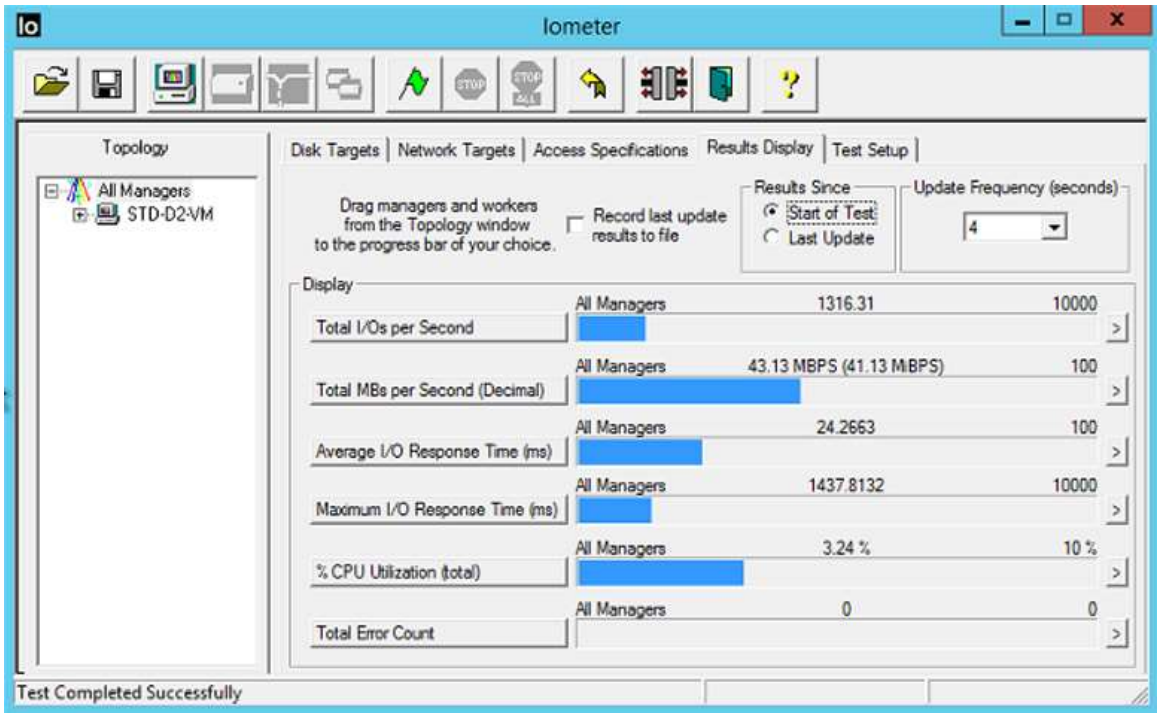
Connect to STD-D2-VM and run disk performance test

In this task, you will first connect to STD-D2-VM and install and configure IOMETER, and then run a bench mark test.

- Perform the following tasks on AZRCAMP-ADMIN logged on as **Contoso\Administrator** using **Passw0rd!** as the password:

1. In the Azure, in the left navigation, click **All resources**, and then click **STD-D2-VM**.
2. In the STD-D2-VM blade, click **Connect**.
3. When prompted, click **Open**.
4. In the Remote Desktop Connection dialog box, click **Connect**.
5. In the Windows Security dialog box, click Use another account.
6. In Username, type **itcampadmin**, in Password, type **Passw0rd!**, and then click **OK**.
7. In the Remote Desktop connection dialog box, click **Yes**.
8. If prompted to choose network preferences, click **No**.
9. Open **File Explorer**, and navigate to **C:\Source**.
10. Right-click **iometer.zip**, click **Extract all**, and then click **Extract**.
11. In C:\Source\iometer, double-click **iometer-setup.exe**.
12. In the Welcome to Iometer 1.1 Setup Wizard page, click **Next**.
13. On the License Agreement page, click **I Agree**.
14. On the Choose Components page, click **Next**.
15. On the Choose Install Location page, click **Install**.
16. Click **Finish**.
17. Click **Start**.
18. On the Start page, type **Iometer**, and then click **Iometer**.
19. Click **I Agree**.
20. Click **Open Test Configuration File** (the folder icon in the upper left).

21. In the Open Test Configuration File dialog box, navigate to **C:\Source\Iometer**, select **iometer.icf** and click **Open**.
    - The iomter.icf file was configured earlier as part of this lab setup.
22. Click **Start Tests** (the green flag).
    - At the bottom right of the dialog box, you see a message, "Preparing Drives". This is expected and can continue for some time.
23. Wait a few minutes and then close the Iometer application.
    - Iometer is preparing a test file. We are aborting the test file creation process.
24. Launch Iometer again and repeat steps **20-23**.
25. Click **Start Tests** (green flag).
26. When the test completes, take note of the metrics, which should be similar to those you see below.



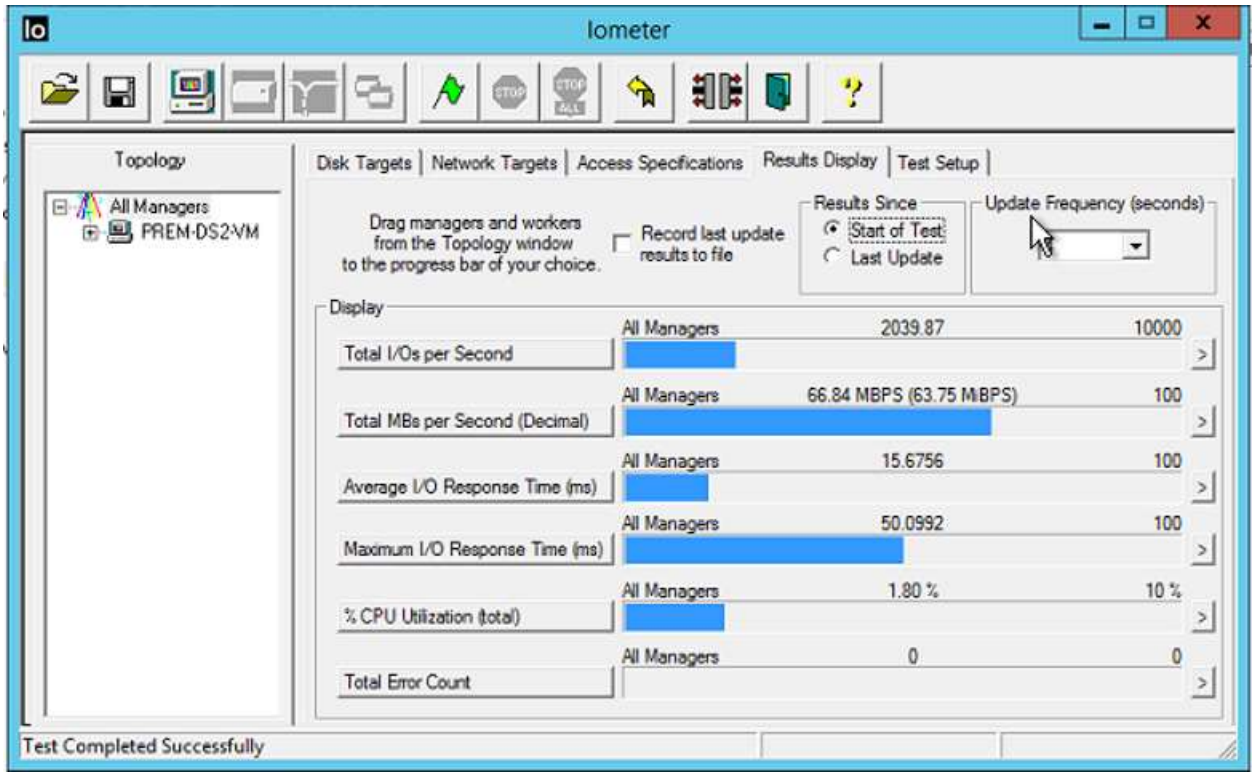
Connect to STD-D2-VM and run disk performance test

In this task, you will first connect to PREM-DS2-VM and install and configure IOMETER, and then run a bench mark test.

- Perform the following tasks on AZRCAMP-ADMIN logged on as **Contoso\Administrator** using **Passw0rd!** as the password:

1. In the Azure, in the left navigation, click **All resources**, and then click **PREM-DS2-VM**.
2. In the STD-D2-VM blade, click **Connect**.
3. When prompted, click **Open**.
4. In the Remote Desktop Connection dialog box, click **Connect**.
5. In the Windows Security dialog box, click **Use another account**.
6. In Username, type **itcampadmin**, in Password, type **Passw0rd!**, and then click **OK**.
7. In the Remote Desktop connection dialog box, click **Yes**.
8. If prompted to choose network preferences, click **No**.
9. Open **File Explorer**, and navigate to **C:\Source**.
10. Right-click **iometer.zip**, click **Extract all**, and then click **Extract**.
11. In C:\Source\iometer, double-click **iometer-setup.exe**.
12. In the Welcome to Iometer 1.1 Setup Wizard page, click **Next**.
13. On the License agreement page, click **I Agree**.
14. On the Choose Components page, click **Next**.
15. On the Choose Install Location page, click **Install**.
16. Click **Finish**.
17. Click **Start**.
18. On the Start page, type **Iometer**, and then click **Iometer**.
19. Click **I Agree**.
20. Click **Open Test Configuration File** (the folder icon in the upper left).
21. In the Open Test Configuration File dialog box, navigate to **C:\Source\Iometer**, select **iometer.icf** and click **Open**.
    - The iometer.icf file was configured earlier as part of this lab setup.
22. Click **Run** (the green flag).
    - At the bottom right of the dialog box, you see a message, "Preparing Drives". This is expected and can continue for some time.
23. Wait a few minutes and then close the Iometer application.
    - Iometer is preparing a test file. We are aborting the test file creation process.
24. Launch Iometer again and repeat steps **20-23**.
25. Click **Start Tests** (green flag).

26. When the test completes, take note of the metrics, which should be similar to those you see below.



27. Note that the total IOPS and throughput are significantly higher than STD-D2-VM. Aside from the storage account type, the virtual machines have an identical configuration.

Remove resource group used for lab

Because each lab in this series begins with an empty resource and because Azure resources are potentially billable, it is necessary to remove the resource group you created and used in this lab. Also, because Azure trial accounts are limited to 4 compute cores, it is important that you remove the resource group to ensure you do not run out of resources, if you have an Azure trial account.

Remove Azure resource group

In this task you will run a Windows PowerShell script to remove the resource group you created and used in this lab.

- Perform the following tasks on AZRCAMP-ADMIN logged on as **Contoso\Administrator** using **Passw0rd!** as the password:

1. If not already open, open Windows PowerShell ISE.
2. Click **File**, click **Open**, browse to **C:\LabFiles\AZITPROCamp\Scripts**, select **RGCleanup.ps1**, and click **Open**.
3. On the menu, click **Run**.
4. When prompted, log into your Azure subscription.
5. When prompted to delete **RG-AZITCAMP-PREM** and **RG-AZITCAMP-STD**, click **Yes**.
6. If you used a different resource groups for the lab, you can modify the PowerShell script to delete those resource groups.

Appendix: Review Question Answers

1. You configure a DS1 VM with 2 striped P10 data disks. Excluding read-only cache, what is the maximum theoretical disk throughput? What is the maximum throughput for the virtual machine? What is the limiting factor, the disk or the virtual machine?

   Answer: 32 MBs per second. The virtual machine limit will cause the throughput to be throttled. Each virtual disk is capable of 100 MBs per second throughput to provide a maximum of 200 MB per second when striped. However, a DS1 virtual machine has a maximum disk capacity throughput of 32 MB per second.

2. Your application is capable of writing 128 KB blocks to a P10 disk on a DS2 virtual machine. What is the maximum throughput that your design is capable of achieving?

   Answer: (500 IOPS * 128 KB)/1024 = 62.5 MB / second. A DS2 is capable of a disk throughput of 64 MBs per second, so the disk is (just barely), the limiting factor.

3. You need to design a solution that can theoretically achieve the highest possible disk throughput of 2,000 MB per second using the minimum number of striped disks. Your application reads and writes data in 64 KB blocks. Specify the VM series, the disk type, and the IOPS needed achieve the maximum throughput.

   Answer: At 200 MB / second, a P 30 disk provides the highest throughput. To achieve 2000 MBs / second, you need 10 striped P30 disks. Given a block size of 64 KB, you would need to achieve 3200 IOPS per second per disk to achieve the goal of 2000 MBs: (3200 IOPS * 64 KB)/1024 = 200 MBs per second per disk.

4. Using the same design as provided in the answer to question 3 above, if your application uses data in 32 KB blocks, would you be able to achieve the 2000 MB per second throughput?

   Answer: No. To achieve the desired throughput of 200 MBs per disk you need 6400 IOPs.

5. Given a latency of 1 ms, what is the Queue depth needed to achieve 2300 IOPS?

   Answer: IOPS x Latency = QD = 2300 x .001 = 2.3

6. You have 5 DS3 VMs, each with 4 striped P20 disks that belong to a single storage account. What limit is going to affect disk performance? What can you do achieve optimal performance?

   Answer: Each storage account is limited to 20,000 IOPS. Each of the DS3 VMs is capable of using 9,200 IOPS (4 x 2300 = 9200) for a combined total of 46,000 IOPS (9,200 x 5 = 46,000). To achieve the maximum performance target of 46,000 IOPS, you need to spread the disks across 3 separate storage accounts (46,000/20,000 = 2.3).