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Homomorphic Encryption hands-on lab

Hands-on lab setup

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Abstract and learning objectives

Homomorphic Encryption refers to a [new type of encryption technology](#) that allows computation to be directly on encrypted data, without requiring any decryption in the process.

In this hands-on lab, you will better understand how to:

- Use Homomorphic Encryption to secure your data in public cloud services while being able to leverage them appropriately to sustain the intended treatments and processing.
- Leverage the [Microsoft SEAL open source library](#) for your projects.
- And more importantly use this API correctly and securely, with all the relevant explanation and any necessary background material.

Overview

The **Homomorphic Encryption hands-on lab** is a series of exercises that will walkthrough you to the main considerations, the encryption's schemes, etc. that pertain to Homomorphic Encryption, at least through the lens of the Microsoft SEAL library and other open source projects that lie on top of it. A such, and as you will, Microsoft SEAL provides a simple and convenient API with state-of-the-art performance.

To accommodate different backgrounds, in terms of development languages (namely C/C++ vs. Python) and roles (developers/architects vs. data scientist), this hands-on lab is mainly split into two tracks:

- A track devoted to C/C++ developers,
- And another one that more specifically "targets" data scientists.

Please note that, besides common grounded objectives, these tracks are not necessarily meant to be equivalent since they are intended to be adapted for their respective audience.

Regardless of the chosen track, the related hands-on lab's exercises can be implemented on your own. Please note that they do not contain for a vast majority of them a complete set of step-by-step instructions, but rather, to achieve this, refer to:

- A series of pre-baked Jupyter notebooks.
- Specific commented code samples.
- Specific GitHub repos and theirs (Mark Down) readme and quick starts.
- Specific Web pages.

Hands-on lab requirements

- A [Microsoft account](#).
- An Azure subscription. If you don't have an Azure subscription, create a [free account](#) before you begin.
- A local machine running Windows 10 1809 and above.
- A Windows-based and a Linux-based development VMs configured with (**complete the day before the lab!**):

- A code editor, such as either [Visual Studio Community 2019](#) or [Visual Studio Code](#) installed.
- A terminal console which allows you to both:
 - Execute Git commands, such as [Git for Windows](#) (2.10 or later).
 - Remotely connect to a VM in SSH, such as [OpenSSH](#), [PuTTY](#).

As such, you will have to create and prepare two VMs, namely:

Name of the VM	OS of the VM	Type of the VM
HE-HOL-WDEV-01	Windows (Windows Server 2016)	Standard D2_v3
HE-HOL-LDEV-01	Linux (Ubuntu 18.04 LTS)	Standard D2_v3

Deploy the lab environment pre-build

This section will guide you throughout the setup of the environment for use in the hands-on lab. You should follow all steps provided.

IMPORTANT: Most Azure resources require unique names. Throughout this lab you will see the word "**HE-HOL-**" as a PREFIX of all the resource names.

Task 1: Provision a resource group

In this task, you will create an Azure resource group for the resources used throughout this lab.

1. In the [Azure Portal](#), select **Resource groups**, select **+Add**, then enter the following in the **Create a resource group** blade:

The screenshot shows the 'Create a resource group' blade in the Azure Portal. The 'Basics' tab is selected. The 'Project details' section has a 'Subscription' dropdown set to 'Souscription NTO-France Microsoft Azure' and a 'Resource group' text input field. The 'Resource details' section has a 'Region' dropdown set to '(Europe) West Europe'.

- a. **Subscription:** Select the subscription you are using for this hands-on lab.
 - b. **Resource group:** Enter **HE-HOL-RG**
 - a. **Region:** Select a nearby location. Remember this location for other resources in this hands-on lab.
2. Select **Review + create**.
 3. Once the validation passed, click **Create**.
 4. When invited, click **Go to resource group**.

You can now instantiate the development environment after creating a VM.

To do so, you will need to create:

1. A Windows-based development VM. Please follow the instructions as per **Task 2: Create a Windows-based development VM**.
2. A Linux-based development VM. Please follow instead the instructions as per **Task 4: Create a Linux-based development VM**.

Task 2: Create a Windows-based development VM

In this task, you will provision an Azure virtual machine (VM) using the Visual Studio Community 2017 and the Visual Studio Code on Windows Server 2016 (x64) image. This will be used as a Windows-based development machine throughout the lab.

Note It is recommended you use a Standard DS2 or Standard D2 instance size for this VM.

1. Launch a browser and navigate to <https://portal.azure.com>. Once prompted, login with your Microsoft Azure credentials. If prompted, choose whether your account is an organization account or just a Microsoft Account.
2. In the [Azure Portal](#), select **+Create a resource**, enter "Visual Studio" into the Search the Marketplace box, and select **Visual Studio 2019** from the results.
3. On the blade that comes up, under Select a software plan, ensure **Visual Studio 2019 Enterprise on Windows Server 2019 (x64)** is selected, and click **Create**.
4. Set the following configuration on the Basics tab.
 - a. **Subscription:** Select the subscription you are using for this hands-on lab
 - b. **Resource Group:** Choose Use existing and select the **HE-HOL-RG** resource group
 - c. **Virtual machine name:** Enter **HE-HOL-WDEV-01**
 - d. **Region:** Select the location you are using to setup this hands-on-lab. For example, West Europe
 - e. **Availability options:** Leave No infrastructure redundancy required selected
 - f. **Image:** Leave Visual Studio 2019 Enterprise on Windows Server 2019 (x64) selected
 - g. **Azure Spot instance:** Leave No selected
 - h. **Size:** leave **Standard D2 v3** selected
 - i. **Username:** Enter *demouser*
 - j. **Password:** Enter *Password.1!!*
 - k. **Public inbound ports:** Leave Allow selected ports selected
 - l. **Select inbound ports:** Select RDP (3389)
 - m. **Already have a Windows license:** Leave No selected
5. Select **Review + create** to move to the last step of the configuration.
6. Once validated, Click **Create** provision the virtual machine.
7. It may take 10+ minutes for the virtual machine to complete provisioning.



Your deployment is complete



Deployment name: CreateVm-MicrosoftVisualStudio.VisualStudio-...
Subscription: [Subscription NTO-France Microsoft Azure](#)
Resource group: [RGLabVM](#)

Start time: 4/22/2020, 10:10:38 AM
Correlation ID: 471e0f9a-60ae-4ba8-900a-aaaa25fd8636

▼ Deployment details [\(Download\)](#)

^ Next steps

[Setup auto-shutdown](#) Recommended

[Monitor VM health, performance and network dependencies](#) Recommended

[Run a script inside the virtual machine](#) Recommended

[Go to resource](#)

[Create another VM](#)

8. Click **Go to resource**.

Let's now create the second to-be provided development VM. You will need for that purpose a RSA key pair.

Task 3: Generate an SSH key pair with OpenSSH

If you already have an SSH key pair, you can skip this task.

In this task, you will start by installing OpenSSH on your local machine – We assume here that your local machine is running Windows 10 1809 and above -. The OpenSSH Client and OpenSSH Server are separately installable components in Windows 10 1809 and above.

Note For information about the OpenSSH availability on Windows 10, see [here](#).

OpenSSH includes different tools and more specifically the `ssh-keygen` command for generating secure SSH key pairs, that can be in turn used for key authentication with SSH. SSH key pairs refer to the public and private key files that are used by certain authentication protocols.

1. On your local machine, open an elevated PowerShell console.
2. Run the following command:

```
PS C:\> Add-WindowsCapability -Online -Name OpenSSH.Client~~~~0.0.1.0
```

Once the installation completes, you can use the OpenSSH client from PowerShell or the Windows 10 command shell.

3. Generate your SSH key pair for the lab:

```
PS C:\> ssh-keygen
```

You can just hit ENTER to generate them, but you can also specify your own filename if you want. At this point, you'll be prompted to use a passphrase to encrypt your private key files. The passphrase works with the key file to provide 2-factor authentication. For this example, we are leaving the passphrase empty.

```

Administrator: Windows PowerShell
PS C:\WINDOWS\system32> ssh-keygen
Generating public/private rsa key pair.
Enter file in which to save the key (C:\Users\philber\.ssh\id_rsa):
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in C:\Users\philber\.ssh\id_rsa.
Your public key has been saved in C:\Users\philber\.ssh\id_rsa.pub.
The key fingerprint is:
SHA256:zHdApZpi0+mzKynqCvEzJxWgdmSkiaTffqQi9SLiuCQ europe\philber@PHILBER001
The key's randomart image is:
+---[RSA 3072]-----+
| .o=o.   .   |
| +.=.   .   |
| ++=.   o   |
| .o.* . + + .|
| . . o + S . .|
| . . . + . . |
| E.o   .o   |
| X=.o. o o   |
| ++o.. .o.   |
+---[SHA256]-----+
PS C:\WINDOWS\system32>

```

Note SSH public-key authentication uses asymmetric cryptographic algorithms to generate two key files – one "private" and the other "public". The **private key** file is the equivalent of a password and should be protected under all circumstances. If someone acquires your private key, they can log in as you to any SSH server you have access to. The **public key** is what is placed on the SSH server and may be shared without compromising the private key.

When using key authentication with an SSH server, the SSH server and client compare the public key for username provided against the private key. If the public key cannot be validated against the client-side private key, authentication fails.

By default, the files are saved in the following folder `%USERPROFILE%\.ssh`:

File	Description
<code>%USERPROFILE%\.ssh\id_rsa</code>	Contains the RSA private key
<code>%USERPROFILE%\.ssh\id_rsa.pub</code>	Contains the RSA public key.

Task 4: Create a Linux-based development VM

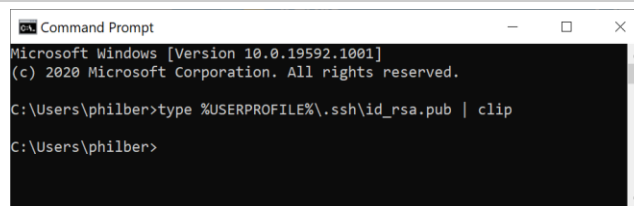
Conversely, in this task, you will provision an Azure virtual machine (VM) using an Ubuntu Pro 20.04 LTS image provided by Canonical. This will be used as a Linux-based development machine throughout this lab.

Important note It is recommended you use a DS2 or D2 instance size for this VM.

1. Launch a browser and navigate to <https://portal.azure.com>. Once prompted, login with your Microsoft Azure credentials. If prompted, choose whether your account is an organization account or just a Microsoft Account.
2. In the [Azure Portal](#), select **+ Create a resource**, enter "Ubuntu" into the Search the Marketplace box, and select **Ubuntu Server 20.04 LTS** from the results.

3. On the blade that comes up, click **Create**.
4. Set the following configuration on the **Basics** tab.
 - a. **Subscription:** Select the subscription you are using for this hands-on lab
 - b. **Resource Group:** Choose Use existing and select the **HE-HOL-RG** resource group
 - c. **Virtual machine name:** Enter **HE-HOL-LDEV-01**
 - d. **Region:** Select the location you are using to setup this hands-on-lab. For example, West Europe
 - e. **Availability options:** Leave No infrastructure redundancy required selected
 - f. **Image:** Leave Ubuntu Pro 20.04 LTS selected
 - g. **Azure Spot instance:** Leave No selected
 - h. **Size:** leave **Standard D2 v2** selected
 - i. **Authentication type:** Leave SSH public key selected
 - j. **SSH public key source:** Select **Upload existing public key**
 - k. **Username:** Enter **azureadmin**
 - l. **SSH public key;** Specify your RSA key pair.
 - i. On a Windows command prompt, run the following command to retrieve the content of your SSH public key and copy it to the clipboard.

```
C:\> type %USERPROFILE%\ssh\id_rsa.pub | clip
```



```
Command Prompt
Microsoft Windows [Version 10.0.19592.1001]
(c) 2020 Microsoft Corporation. All rights reserved.

C:\Users\philber>type %USERPROFILE%\ssh\id_rsa.pub | clip

C:\Users\philber>
```

- ii. Paste the content in this field.

SSH public key * ⓘ

```
mGdgr7Zq4wGcny5m0q6BkR0ZmK0gdm0ge0m0a0GCEV/mK0ZmK0
NhtDR33t1sZ+x9UCuGe3rLdaDHn78TUzOTVCrvNSOP+XnARQ8iBbhgJ
YcTZGiQeNIAjXlf//jpBq1tNzekPcoP08nB+qh
europe\philber@PHILBER001
```

- m. **Public inbound ports:** Leave Allow selected ports selected
 - n. **Select inbound ports:** Select SSH (22)
5. Select **Review + create** to move to the last step of the configuration.
 6. Once validated, Click **Create** provision the virtual machine.
 7. It may take 10+ minutes for the virtual machine to complete provisioning.

You are now ready to further prepare the above created VMs.

Prepare the Windows-based development VM

You will now prepare the Windows-based development VM, i.e. the **HE-HOL-WDEV-01** lab VM.

Task 1: Connect to the Windows-based development VM

In this task, you will open an RDP connection to the Windows-based development VM you created and disable Internet Explorer Enhanced Security Configuration.

1. On the **HE-HOL-WDEV-01** lab VM's blade, click **Connect** from the top menu, and then select **RDP**.

The screenshot shows the 'Connect with RDP' interface. At the top, there are three tabs: 'RDP' (selected), 'SSH', and 'BASTION'. Below the tabs, the text reads 'Connect with RDP' followed by 'To connect to your virtual machine via RDP, select an IP address, optionally change the port number, and download the RDP file.' There are two input fields: 'IP address *' with a dropdown menu showing 'Public IP address (52.166.88.167)' and 'Port number *' with the value '3389'. A blue button labeled 'Download RDP File' is below the port number field. At the bottom, there is a section 'Can't connect?' with two links: 'Test your connection' and 'Troubleshoot RDP connectivity issues'.

2. Select **Download RDP file**, then open the downloaded RDP file.
3. Click **Connect** on the Remote Desktop Connection dialog.
4. A warning dialog opens up about the publisher. You can ignore the warning. Click **Connect** to continue.
5. Enter the following credentials when prompted.
 - a. User name: HE-HOL-WDEV-01\demouser
 - b. Password: Password.1!!(Do not use your organizational account or your Microsoft Account one.)
6. Click **Yes** to connect, if prompted that the identity of the remote computer cannot be verified.
7. Once logged in, launch the Server Manager. This should start automatically, but you can access it via the Start menu if it does not start.
8. Select Local Server, then select **Off** next to IE Enhanced Security Configuration.
9. In the Internet Explorer Enhanced Security Configuration dialog, select Off under Administrators and Users.
10. Select **OK**.
11. Close the Server Manager.

At the stage, you should be connected on the Windows desktop of the **HE-HOL-WDEV-01** lab VM.

Task 2: Update Visual Studio

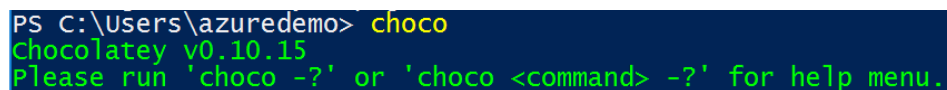
In this task, you will add update to the Visual Studio Community 2019 installation on the Windows development VM.

1. Connect to the **HE-HOL-WDEV-01** lab VM as per **Task 1: Connect to the Windows-based development VM**.
2. On your Windows-based development VM, launch **Visual Studio Installer**.
3. Select **More** and **Modify** for the Visual Studio Community 2019 installation. Note: If updates are available, select the Update button first, and install the updates before moving on to installing the additional components. Once the updates are installed, the Update button will be replaced with the Modify button.

Task 3: Install the Chocolatey package manager

In this task, you will add the Chocolatey package manager on your **CC-HOL-WDEV-01** lab VM for convenience purpose during the lab.

1. Navigate to <https://chocolatey.org/install>
2. Follow the installation method, opening a PowerShell prompt with **administrative privileges**
3. Execute **choco** to verify the installation. Output should look like the image below



```
PS C:\Users\azuredemo> choco
Chocolatey v0.10.15
Please run 'choco -?' or 'choco <command> -?' for help menu.
```

Task 4: Install Docker EE

In this task, you will install Docker onto Windows Server 2019 1809. To run both Linux container on Windows Server, you will need nested virtualization, that is enabled by default on Ds2_v3 Azure virtual machines. The Linux containers feature has then just to be enabled.

1. Open a PowerShell console
2. Run the following command:

```
Install-WindowsFeature -Name Hyper-V -IncludeManagementTools -Restart
```

3. Restart the VM and reopen a PowerShell console
4. Run the following command:

```
Install-Module "DockerMsftProvider" -Force
```

5. Restart the VM and reopen a PowerShell console
6. Run the following commands:

```
Update-Module "DockerMsftProvider"  
Install-Package Docker -ProviderName "DockerMsftProvider" -Update -Force  
Install-WindowsFeature Containers
```

7. Restart the VM and reopen a PowerShell console
8. Run the following command:

```
Set-Content -Value "`{"experimental":true`}" -Path C:\ProgramData\docker\config\daemon.json
```

9. Restart Docker service:

```
Restart-Service docker
```

10. Create a directory for Linux containers:

```
mkdir "C:\Program Files\Linux Containers"
```

11. Navigate into this directory:

```
cd "C:\Program Files\Linux Containers"
```

12. Get LCOW archive:

```
curl -OutFile release.zip https://github.com/linuxkit/lcow/releases/download/v4.14.35-v0.3.9/release.zip
```

13. Extract LCOW:

```
Expand-Archive -DestinationPath . .\release.zip
```

14. Clean up the archive:

```
rm release.zip
```

15. Test a Linux container:

```
docker run -it ubuntu /bin/bash
```

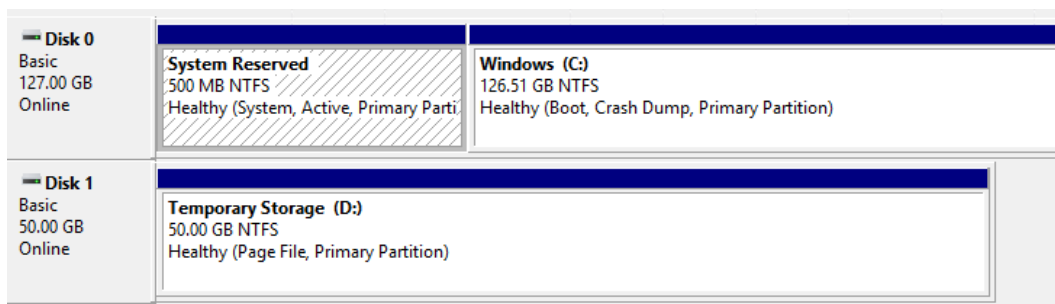
16. Connect to the containers' repository used in the lab:

```
docker login -u pull-access -p TZByz=v=BjshL4DDJ9UzW9zpujHQ0YBW devlabs.azurecr.io
```

Task 5: Shrink the main partition (optional)

To reduce the final .vhd image size, the main Windows partition must be reduced accordingly. This step isn't mandatory and only allows the resulting disk snapshot to be smaller.

1. Press the Windows + R, this should open a Windows command prompt with the **Run command**.
2. Type *diskmgmt.msc* into the prompt and press ENTER.



3. Two disks should be available. Only Disk 0 will be exported into the .vhd file. Right click on Windows (C:) and select **Shrink Volume**.
4. On the next screen, select the amount of space to shrink. Remember to let at least a small amount of remaining space to use during the lab.
5. Click on **Shrink**.

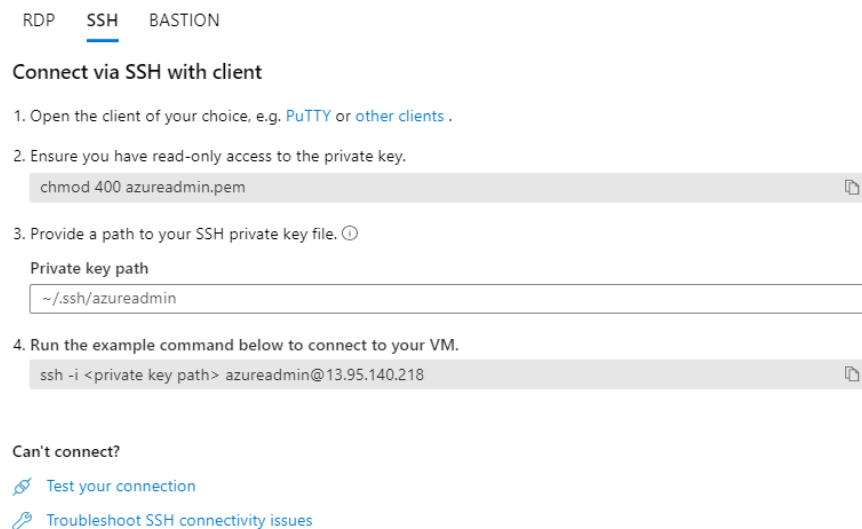
Prepare the Linux-based development VM

You will now prepare the Windows-based development VM, i.e. the **HE-HOL-LDEV-01** lab VM.

Task 1: Connect to the VM

In this task, you will open an SSH connection to the Linux-based development VM you created

1. In the **HE-HOL-LDEV-01** lab VM's blade, click **Connect**, and then select **SSH**. An SSH connection string will be displayed.



RDP **SSH** BASTION

Connect via SSH with client

1. Open the client of your choice, e.g. [PuTTY](#) or [other clients](#).
2. Ensure you have read-only access to the private key.

```
chmod 400 azureadmin.pem
```
3. Provide a path to your SSH private key file. ⓘ
Private key path
4. Run the example command below to connect to your VM.

```
ssh -i <private key path> azureadmin@13.95.140.218
```

Can't connect?

- [Test your connection](#)
- [Troubleshoot SSH connectivity issues](#)

2. Now open on your local machine a prompt command line and enter the provided SSH connection string.

```
C:\> ssh azureadmin@13.95.140.218
```

3. When prompted, type "yes". Optionally specify your passphrase if any for your private key to unlock it.

At the stage, you should be connected on the Linux **HE-HOL-LDEV-01** lab VM with a Bash shell.

Task 2: Install build dependencies

On the Linux, required dependencies to build SEAL should be added, plus Docker. After a logout, you should be able to execute a docker command without super user privileges.

```
sudo apt update && sudo apt -y install git curl build-essential cmake docker.io && sudo systemctl enable --now docker && sudo usermod -aG docker $USER
```

Note The build-essential meta-package contains g++ but not clang. To use clang, you must install it separately.

Task 3: Shrink the main partition (Optional, strongly not recommended)

CAUTION: Shrinking a live EXT4 partition is a difficult and dangerous process. These manipulations may result in the VM being unusable. Thus, following these steps is strongly not recommended.

The default OS disk size for an Ubuntu-Server image is 30GB. However, the actual Disk usage sits around 2GB. By reducing the Ubuntu main partition size, it should be possible to reduce amount of space required to store the Disk image.

However, reducing the size of a live partition is not a well-supported process, and would typically be done by using a live CD containing a partitioning utility like Gparted. This can't obviously be done with premade VMs.

The workaround used consists of pivoting the root onto a ramdisk while the modification to the root partition are done. Once again, this process is very likely to make the VM unusable.

The first step is to stop all running services allowed to write onto the root partition (**sda1**).

```
sudo service <service_name> stop
```

By default, on the chosen VM, no such services should be running. However, your mileage may vary.

Next, unmount all unused filesystems, and check if the root partition has been unmounted.

```
sudo umount -a  
sudo mount # check if /dev/sda1 has been unmounted
```

If the root partition is still mounted, it means that a running process is holding onto it. This can be asserted using this command

```
sudo fuser -vm /dev/sda1
```

Stop any service still using the partition before proceeding. Next, the root will be *pivoted* onto a temporary file system.

```
mkdir /tmp/tmproot  
mount -t tmpfs none /tmp/tmproot  
mkdir /tmp/tmproot/{proc,sys,dev,run,usr,var,tmp,oldroot}  
cp -ax /{bin,etc,mnt,sbin,lib} /tmp/tmproot/  
cp -ax /usr/{bin,sbin,lib} /tmp/tmproot/usr/  
cp -ax /var/{account,empty,lib,local,lock,nis,opt,preserve,run,spool,tmp,yp} /tmp/tmproot/var/  
mount --make-rprivate /  
pivot_root /tmp/tmproot /tmp/tmproot/oldroot
```

Ensure you can still connect via SSH in another terminal. This most likely won't be the case. You will then need to copy the `authorized_hosts` file in the old root `.ssh` directory into the new temp root. Once you can connect again via SSH, kill every process still user the old root using

```
sudo fuser -vm /oldroot
```

Finally, close the first terminal to release the final resource holding onto the old root. In the second terminal, you should be able to unmount the old root.

```
sudo umount /oldroot
```

Now that the old root is unmounted, it can be resized at will. For example:

```
resize2fs /dev/sda1 3G
```

Let's now revert all the changes back, pivot the root back and remove the temporary root created.

```
mount /dev/sda1 /oldroot
mount --make-rprivate /
pivot_root /oldroot /oldroot/tmp/tmproot
for i in dev proc sys run; do mount --move /tmp/tmproot/$i /$i; done
umount /tmp/tmproot
rmdir /tmp/tmproot
mount -a
mount --make-rshared /
systemctl isolate default.target
```

Log out and back in again, the resized root should be up and running.

Having followed these directions, you will then be able to reduce the size of the VHD file down to the same size at the main partition later in section **Shrink the resulting VHD images** below.

You should follow all steps provided *before* exporting the VHD image of the VMs.

You are now ready to start exporting the disk images.

Understanding the lab workflow

A Dev & Test Lab is a powerful learning structure, allowing anyone to leverage a reusable Cloud playground for any technology. At the end of this guide, VHDs images and JSON descriptions are located on a Storage Account. From this point on, every step is automated. This part will detail whole creation process.

From model VMs to Storage Account [This guide]

Throughout this guide, you have created VMs from pre-existing templates already having an operating system and tailored them to your needs. Azure VMs have a main managed disk, called an **OS_Disk**, and a temporary storage disk. Parts "[Prepare the Windows-based development VM](#)" and "[Prepare the Linux-based testing VM](#)" are dedicated to edit the content of the Os_Disk to suit the lab goal.

Next, in part "[Export the VMs'Disks](#)" This Disk is then dissociated from the VMs and expose as its own entity, before being saved as a VHD file. During this process, VM is generalized, meaning that the Operating system is prepared to be used as a template to create other VMs. User specific information are changed to system-wide modification. Thus, any new user will have the same specific environment as the one created during this lab.

This VHD file however, doesn't contains any information on the VM runtime environment itself, as it's a disk image. In part "[Describing the lab through JSON](#)", a JSON file containing these specific runtime information is created, and the two file are stored together.

From Storage Account to reusable Image Definitions

Once both the VHD file and the JSON file are located on a storage account, the lab creation process continues with an automated process creating an [Azure Stored Image Gallery](#). This gallery is what is used internally to store image to be used in the [Azure Marketplace](#), it's an highly available VM template registry that combines both the VHD file JSON file information.

Within this gallery, multiple Image Definitions are contained, one for each VM. These Image definitions contains Image Versions. Similar to a version-control software, such as git, these versions are auto-labeled using [semantic versioning](#). Specific evolution is the image can thus be easily monitored, and breaking changes won't disturb any production setup. A new Image Version is created by making a snapshot of the current VHD file and freezing this snapshot into a reusable component.

This entire process is fully automated and available with the "[Import-VHDsToSharedImageGallery](#)" script is the [Lab script repository, using the branch "HyperVGen2"](#).

From Image Definitions to user VMs

The last step is simply using these Images Versions to create brand new VMs, this process is also fully automated using the "Create-Vms" script int the lab repository.

As these images are generalized, they need to be created with a new user account. That's precisely the point of the `credentials.csv` file accompanying the Lab script repository.

image Name	Username	Credential Type	Credential Value
CC-HOL-LTEST-01	azureadmin	SSHKey	ssh-rsa AAAAB3NzaC1yc2EAAA...
CC-HOL-LTEST-02	azureadmin	SSHKey	ssh-rsa AAAAB3NzaC1yc2EAAA...
CC-HOL-WDEV-01	CamfYEQD	Password	QHvBcReAw1u0dXWv8kg
HE-HOL-LDEV-01	NvVKrhfj	Password	pB2CZybXRHGJSmnclL7

Using `Create-Vms.csv`, the VMs are created and exposed to be connected to. The lab can be either set to "Private", "Public", "Shared".

Dev Test Lab Name	Resource Group Name	Ip Config	Shared Image Gallery Name	Shut Down Time	Timezone Id	Lab Region	Lab Owners	Lab Users
testLabOfDespair	COMPASS-HOL-RG	public	compassholsig	1900	"W. Europe Standard Time"	westeurope		

A "Public" lab will assign a different IP address to all VM, a "Shared" lab will use one IP address, shared between all VMs. On these labs, the destination port of any incoming connection will be used to differentiate VMs. A "Private" lab is not exposing any VMs to the public. It can be regarded as "owners only".

Export the VMs' disks

You will export the disk of the VMs you created and prepared before, i.e. the **HE-HOL-WDEV-01** and **HE-HOL-LDEV-01** lab VMs.

Task 1: Create a storage account

Using the Azure CLI, you can create a new storage account easily.

```
$storageAccountName="<your-storage-account-name>"
$storageAccountRG="<your-storage-account-resource-group>"
$storageContainerName="<your-storage-container-name>"
#Create the storage account
az storage account create --name $storageAccountName --resource-group $storageAccountRG
#Retrieves its credentials
$storageCredentials = az storage account keys list -n $storageAccountName --resource-group
$storageAccountRG | ConvertFrom-Json
#Creates a container within the storage account
az storage container create --account-name $storageAccountName --account-key
$storageCredentials[0].value --name $storageContainerName
```

To create an azure storage account using the Azure Portal, please refer to section **Prepare your environment for the hands-on labs** of the document entitled **Available hands-on labs: Hands-on lab deployment instructions**.

Task 2: Prepare the Virtual Machines for the export

In this task, you will separate the managed disk from the created VMs to download an image of it. First, you must stop the Azure agent in both Linux and Windows machines.

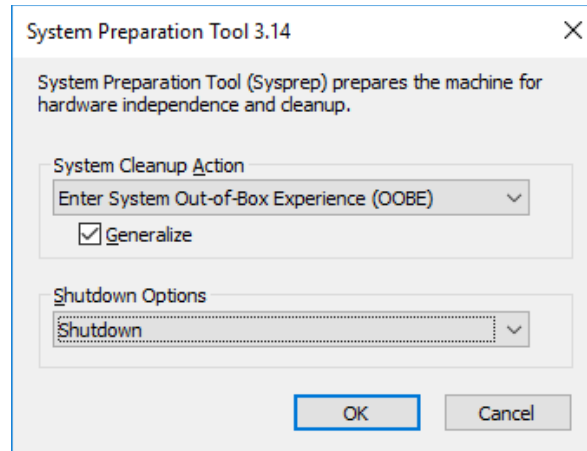
Preparing a Linux-based Virtual Machine for generalization

The Az Agent must be stopped to properly generalize the VM. Be careful, this process will render the VM

```
# Connect to the Linux machines and execute this command
sudo waagent -deprovision+user
# For Windows VMs : Follow these instructions
# https://docs.microsoft.com/fr-fr/azure/virtual-machines/windows/capture-image-resource
```

Preparing a Windows-based Virtual Machine for generalization

1. Press **Windows + R**
2. Type "%windir%\system32\sysprep\sysprep.exe"
3. In the following GUI, make sure the **"Generalize"** box is ticked and select Shutdown in **"Shutdown Options"**.



4. Click **OK**.

Generalize the Virtual Machines

Both Windows and Linux machines require to be deallocated and generalized before copying their virtual disk,

```
az vm deallocate --resource-group HE-HOL-RG --name <machineName>
az vm generalize --resource-group HE-HOL-RG --name <machineName>
```

Task 3: Export the disk images on the storage account

This step purpose will be to copy over the VMs disk images to the storage account. This step requires both [Az-Copy 10](#) and [Azure PowerShell](#) to be installed.

Then change the variable to fit your needs and execute the script below. To create a storage account, a container and get the storage access key, please refer to section **Prepare your environment for the hands-on labs** of the document entitled **Available hands-on labs: Hands-on lab deployment instructions**.

```
#Provide the subscription Id of the subscription where managed disk is created
$subscriptionId = "<your-subscription-id>"

#Provide the name of your resource group where managed is created
$resourceGroupName = "HE-HOL-RG"

#Machines within the resource group you want to save an image of, the three created machines here
$machineNames = @("HE-HOL-LDEV-01", "HE-HOL-WDEV-01")

#Provide storage account name where you want to copy the underlying VHD of the managed disk.
$storageAccountName = "<your-storage-account-name>"

#Name of the storage container where the downloaded VHD will be stored
$storageContainerName = "<your-storage-container-name>"

#Provide the key of the storage account where you want to copy the VHD of the managed disk.
$storageAccountKey = '<your-storage-container-key>'
```

```

#Provide Shared Access Signature (SAS) expiry duration in seconds e.g. 3600.
#An Azure to Azure transfer should take way less than 1 hour, only consider changing this value
#on Azure to premise tranfer
$sasExpiryDuration = "3600"

function getDiskName($machineName){
    return az disk list `
        --resource-group $resourceGroupName `
        -o tsv `
        --query " [?contains(name,'$machineName')].{Name:name} "
}

function copyDiskImage($machineName){

    $diskName = getDiskName $machineName
    # Set the context to the subscription Id where managed disk is created
    Select-AzSubscription -SubscriptionId $SubscriptionId

    #Generate the SAS for the managed disk
    $sas = Grant-AzDiskAccess -ResourceGroupName $ResourceGroupName -DiskName $diskName -
DurationInSeconds $sasExpiryDuration -Access Read



    #Create the context of the storage account where the underlying VHD of the managed disk will be
    copied
    $destinationContext = New-AzStorageContext -StorageAccountName $storageAccountName -
StorageAccountKey $storageAccountKey

    $containerSASURI = New-AzStorageContainerSASToken -Context $destinationContext -ExpiryTime(get-
date).AddSeconds($sasExpiryDuration) -FullUri -Name $storageContainerName -Permission rw
    $containername, $sastokenkey = $containerSASURI -split "\"
    $containerSASURI = "$containername/$machineName`?$sastokenkey"
    azcopy copy $sas.AccessSAS $containerSASURI --s2s-preserve-access-tier=false
}

foreach ($machineName in $machineNames) {
    copyDiskImage $machineName
}

```

The extracted image should now be visible in the storage account.

NAME	ACCESS TIER	ACCESS TIER LAST MODIFIED	LAST MODIFIED	BLOB TYPE	CONTENT TYPE	SIZE	STATUS
 HE-HOL-WDEV-01			04/05/2020 à 20:01:07	Page Blob	application/octet-stream	127.0 GB	Active
 HE-HOL-LDEV-01			04/05/2020 à 19:36:51	Page Blob	application/octet-stream	30.0 GB	Active

Shrink the resulting VHD images

Note This step requires to have completed in section **Task 5: Shrink the main partition (optional)** above for Windows-based development VM, conversely in section **Prepare the Linux-based development VM** above for Linux-based development VM.

By default, a VHD file has the same size as the whole disk. However, unpartitioned space can be omitted. Thus, by reducing the main partition size in the earlier steps, the size of the VHDs images can be reduced.

1. Download the [disk resizer utility](#) (Windows only) and extract it
2. Go to the storage account page on the Azure portal. For example, **compasswshols** in our illustration.
3. Click on the blob container containing the VHDs images. For example, **hol-vhds** in our illustration:
<https://compasswshols.blob.core.windows.net/hol-vhds>
4. Right click on the VHD image to be resized
5. In the context menu, select **Get Shared Access Signature** (SAS)
6. In the **Permissions** Box, tick Read, List, Write and Create
7. Click on **Create** to generate the SAS
8. In a command prompt, execute the **WindowsAzureDiskResizer** utility with 2 arguments. The first being the new size of the VHD in Gigabytes (must be an integer), the second being the generated SAS.

```
.\WindowsAzureDiskResizer.exe <new_size_in_GB> "<windows_SAS>"
```


Describing the lab through JSON

Task 1: Creating a JSON file for each machine

Each disk image must be accompanied by a JSON description file. This description file will be used to rebuild the machine from the disk.

```
{
  "timestamp": "2020-05-13T18:27:35",
  "description": "CC - Lab",
  "osType": "Windows",
  "imageName": "CC-HOL-WDEV-01",
  "vhdFileName": "CC-HOL-WDEV-01",
  "size": "Standard_D2_v3",
  "storageType": "Standard",
  "dnsServer": ""
}
```

Each attribute is a straightforward way to represent an aspect of the machine:

Timestamp: JSON creation timestamp

Description: Description of the machine to build

osType: Either *"Windows"* or *"Linux"*. The OS is stored on the disk itself, and this attribute is used to open either SSH or RDP.

imageName: Name of the machine to create

vhdFileName: VHD file to used to build the machine

size: VM size to deploy the Disk image on. All available sizes are available of the [Microsoft Website](#).

storageType: SSD type to use. Either *"Premium"* or *"Standard"*. Comparison is available on the [Microsoft website](#).

dnsServer: Machine to use as a DNS server. This is an optional parameter; the value can be set to an empty string to use the default configuration. In the default configuration, every machine has access to the internet, and can query each other via ICMP.

The **Appendix B. JSON files for the virtual machines** provides sample JSON file for the CC-HOL-WDEV-01, and HE-HOL-LDEV-01 lab environment VMs.

Task 2: Upload the files to the blob containers

The final step is to upload the JSON files on the same storage container than the VHD files. These files will be later picked up by the lab building script.

1. In the Azure portal, go to the storage account (**compasshols** in the example) page.

2. On the left panel, select **Storage Explorer (preview)**
3. On the middle panel, click on **BLOB CONTAINERS** and select your container (**vhds-2020-04** in the example)
4. Click on **Upload** and select all the json files to upload

Share the VHD images

In this the, you will be learning how to find and make a link to the previously exported images.

Task 1: Get a link to an exported image

1. On your Storage account, click on **Storage Explorer (preview)**
2. Under **BLOB CONTAINERS** in the middle panel, click on your created container
3. You should now be able to see all previously exported images
4. Click on the image you want to export and then click on **Copy URL**
5. Share the copied link with whom it may concern

Delete the lab environment pre-build

Lastly, you will deprovision any Azure resources that were created in support of the lab.

Task 1: Delete the Resource group in which you placed your Azure resources

1. From the Portal, navigate to the blade of your **HE-HOL-RG** resource group and select **Delete** in the command bar at the top.
2. Confirm the deletion by re-typing the resource group name and selecting **Delete**.

You should follow all steps provided *after* preparing the hands-on lab's environment.

If so, this concludes the setup of the hands-on lab.

Appendix A: Partial automation with Docker

The confidential computing lab setup process can be partially automated. Using the ARM templates, a reusable deploy script can be created. Likewise, saving VMs images to a storage account can be automated. A Docker container, usable on any platform, has been prepared to allow any interested user to setup this lab easily. This procedure assumes the user understand the manual method described above, and thus will be more concise

First, pull the lab docker image:

```
docker pull devlabs.azurecr.io/helab
```

Next, create a `config.ps1` file on the host system. Although this is a PowerShell script, the file won't be executed on the host system. Thus, PowerShell doesn't need to be installed. The file content should be the following

```
# Resource Group name to create
$resGroupName = "CC-HOL-RG"

# Resource group region (non-correlated to physical machine regions)
$resGroupLocation = "westeurope"

# Name of the Azure subscription to use in the deployment
# Use "az account list" to find out
$subName = "<your-subscription-name>"

# SSH key Path to register in the Linux machines, for direct connection
# Please refer to the guide to create one
$sshPubKeyFilePath = "$HOME/.ssh/id_rsa.pub"

# Linux root username
$linuxUser = "azureadmin"

# Windows username and password
$windowsUser = "azuredemo"
$windowsPassword = "Password.1!!"

#Machine within the resource group you want to save an image of.
# If not set, all the VMs in the resource group are saved
$machineNames = @("CC-HOL-LTEST-01","CC-HOL-LTEST-02", "CC-HOL-WDEV-01" )

#Storage account resource group name and Location.
# Same resource group and location as the VMs by default.
$storageAccountResourceGroupName = $resGroupName
$storageAccountResourceGroupLocation = $resGroupLocation
#Provide storage account name where you want to copy the underlying VHD of the managed disk.
$storageAccountName = "compasshols"

#Name of the storage container where the downloaded VHD will be stored
$storageContainerName = "vhds-2020-04"

#Provide the key of the storage account where you want to copy the VHD of the managed disk.
$storageAccountKey = '<storage-key>'
```

Adapt these variables to your needs.

This file will then be share with the lab container, along with the directory where your SSH Public key is located.

```
docker run -it -v $PWD\config.ps1:/app/config.ps1 -v $HOME\.ssh\::/root/.ssh <image_name>
```

Note Docker volumes needs absolute path, using relative path could lead to unexpected behavior.

Once logged into the container, the entire lab can be deployed with a single command

```
./deploy.ps1
```

This process can take up to 20 minutes to complete. Once completed, login credentials for the lab VMs will be displayed as such:

```
All Done ! You can now connect to the Windows development Machine with RDP:
(ip : 13.94.143.143, user: azuredemo, password: Password.1!!)
--
Linux machine 1 is available via ssh azureadmin@13.81.251.159
```

You should be able to connect to any of the machines using SSH for Linux-based VMs and RDP for Windows-based VMs.

Steps **Prepare the Windows-based development VM**, **Prepare the second Linux-based testing VM** and the first two tasks of **Export the VMs' disks** can then be executed as normal, fine-tuning the machines for the lab. Executing these steps is mandatory and failing to complete them will lead to errors stating that the VM disk is in use.

If it doesn't exist yet, you can then create a storage account to receive the VM disk images. Be aware that the name of the storage account must be unique and must be less than 24 characters long.

```
./create-storage-account.ps1
```

Once these steps are finished, the export process can be executed with two commands:

```
Connect-AzAccount
./copy-disks.ps1
```

Your VMs images are now saved in the provided storage account.

The lab setup process is complete!

Appendix B. JSON files for the virtual machines

This section provides JSON files sample for the HE-HOL-WDEV-01, and HE-HOL-LDEV-01 lab environment VMs.

HE-HOL-WDEV-01.json

```
{
  "timestamp": "2020-05-13T18:27:35",
  "description": "HE - Lab",
  "osType": "Windows",
  "imageName": "HE-HOL-WDEV-01",
  "vhdFileName": "HE-HOL-WDEV-01",
  "size": "Standard_D2_v3",
  "storageType": "Standard",
  "dnsServer": ""
}
```

HE-HOL-LDEV-01.json

```
{
  "timestamp": "2020-05-13T18:27:35",
  "description": "HE - Lab",
  "osType": "Linux",
  "imageName": "HE-HOL-LDEV-01",
  "vhdFileName": "HE-HOL-LDEV-01",
  "size": "Standard_D2_v3",
  "storageType": "Standard",
  "dnsServer": ""
}
```