

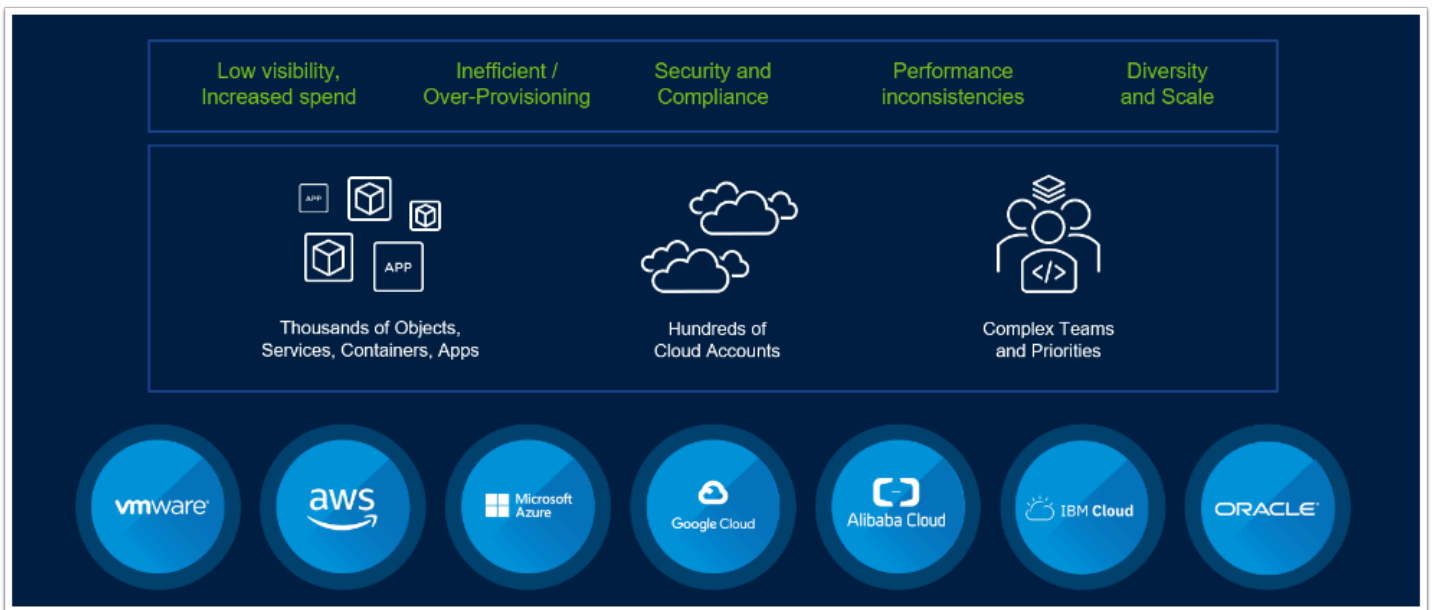
# Lab 02 - Cloud Operations Automation (PowerCLI, APIs)

## Introduction

With diverse applications deployed across multiple clouds, your IT portfolio is becoming increasingly complicated. Simplify your multi-cloud operations with VMware.

The VMware Cloud Operating Model is a framework that binds your business, application, and cloud strategies together to accelerate agility, optimize performance, and control your multi-cloud environment. It brings people, process, and technology together for consistent service delivery, operations, and governance wherever workloads reside, for today and the future by:

- Transforming IT Ops by delivering self-service clouds, with rapid elasticity and a full set of consumable APIs.
- Align to CloudOps and embrace your existing clouds to optimize your investments, strengthen security and governance, and deliver a framework for accountability and clarity.
- Efficiently extend cloud management processes and capabilities to new public cloud services and environments through a repeatable on boarding process.



With the emergence of Multi-Cloud adoption for a myriad of reasons by organizations of all sizes, we can see even clearer the challenges that abound when managing workloads in multiple environments, by different teams attempting to ensure governance and organization policy adherence, while using different tools, each dedicated to a given environment. With the VMware Cloud Operating Model you use traditional VMware On-Premises Operations Management tools which have now been optimized for Cloud Management as well, to manage your On-Premises environment, VMware assets, running in one or more Hyper-Scalers (AWS, AZURE, Google Cloud, IBM Cloud, etc...), as well as Native Cloud workloads and services

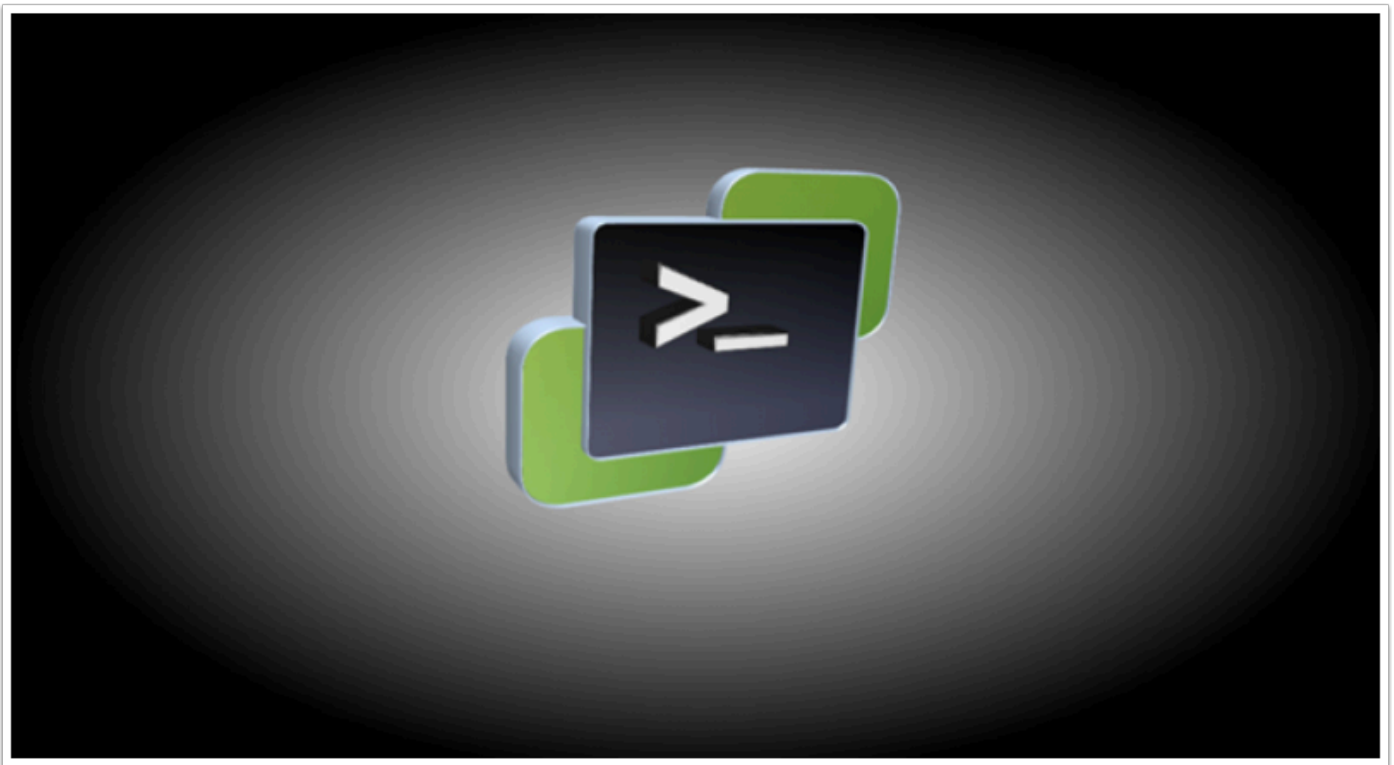
## TASKS

### Task 1 - Gather Cloud vCenter Information

- i** PowerCLI is a PowerShell-based command-line interface for managing VMware vSphere. VMware describes PowerCLI as "a powerful command-line tool that lets you automate all aspects of vSphere management, including network, storage, VM, guest. PowerCLI can also be used to manage and automate other VMware Technologies such as:

- HCX
- VMC on AWS
- NSX-T
- etc...

In Multi-Cloud scenarios PowerCLI is a compelling tool that can be used for Day-0 through Day-2 operations. Everything from Creating a new SDDC, to adding adding Clusters, and even deploying and managing workloads.



**i** In this lab task we will use PowerCLI to:

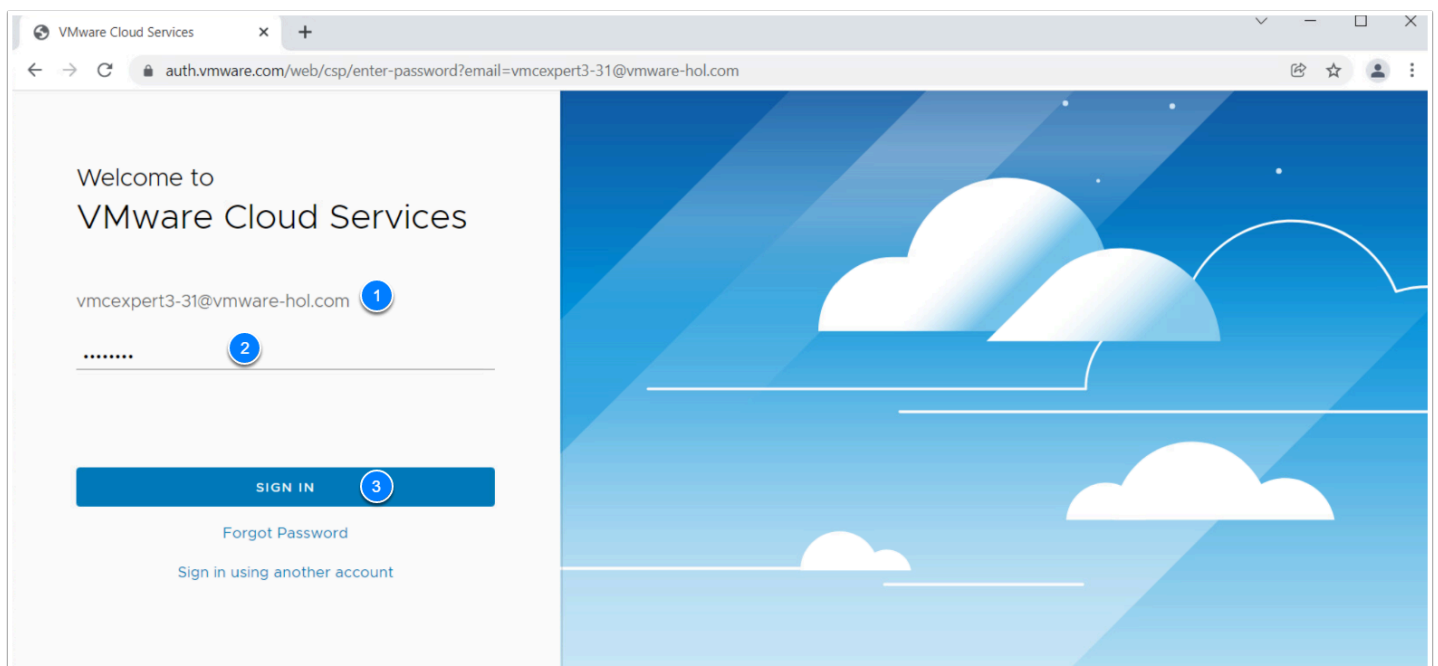
- Create a Content Library
- Upload an OVF to the content library
- Deploy a Virtual Machine

1. From your Virtual Desktop, launch the Web Browser (Google Chrome Preferred) and go <https://vmc.vmware.com/console/sddcs>

💡 NOTE: For instructions on accessing your Virtual Desktop please see "**Lab 1 - Accessing the Environment**"

2. Login with your VMC on AWS console credentials provided by your instructor.
3. Type <**Your Assigned login Credentials**> in the email address field i.e. **vmcexpert#-XX@vmware-hol.com** (where **#** is your Environment ID, and **XX** is your assigned student number)
4. Click **NEXT**
5. Type **VMware1!** in the Password field
6. Click **SIGN IN**

💡 If you didn't do so in Lab 1, bookmark this page so you can access it quicker in subsequent steps



⚠️ NOTE: Upon signing in you'll notice there are two or more SDDCs named VMCExpert#-XX (Where XX indicates your student number). Unless instructed to, only use the SDDC that matches your assigned Student number

SDDCs

SDDC Groups

VMCEXPERT3-31

Ready

Expires in 46 days

Region	US West (Oregon)	Clusters	1
Type	VMC on AWS SDDC	Hosts	1
Availability Zones	us-west-2a	Cores	36

CPU

Memory

Storage

82.8 GHz

512 GiB

10.37 TiB

VIEW DETAILS

OPEN VCENTER

ACTIONS

VMCEXPERT3-I32

Ready

Expires in 46 days

Region	US West (Oregon)	Clusters	1
Type	VMC on AWS SDDC	Hosts	1
Availability Zones	us-west-2a	Cores	36

CPU

Memory

Storage

82.8 GHz

512 GiB

10.37 TiB

VIEW DETAILS

OPEN VCENTER

ACTIONS

💡 Identify your SDDC, (VMCexpert#-XX, where XX is your Student Number). At the top left of the SDDC tile (i.e. **VMCExpert3-31**).

- Click **VIEW DETAILS** on your SDDC Tile. **WARNING: Never click on the SCALE UP button.**
- Click the **Settings** Tab
- Under **vCenter Client** information, identify and record the Cloud **vCenter FQDN** and/or **Public IP** (I.E. **vcenter.sddc-xx-xx-xx-xx.vmwarevmc.com**)
- Under **Default vCenter User Account**, identify and record the User name and Password

📘 **NOTE:** You will use this FQDN and credential with PowerCLI in the next task

The screenshot shows the 'Settings' tab in the vCenter SDDC interface. The 'vCenter Information' section is expanded, showing the 'Default vCenter User Account'. The 'User name' field (4) contains 'cloudadmin@vmc.local'. The 'Password' field (5) contains a masked password. The 'vSphere Client (HTML5)' field shows 'https://vcenter.sddc-...3.vmwarevmc.com/ui'. The 'vCenter Server API Explorer' field shows 'https://vcenter.sddc-...3.vmwarevmc.com/apiexplorer/'. The 'PowerCLI Connect' field shows 'Connect-VIServer -Server vcenter.sddc-...3.vmwarevmc.com -Protocol https -User cloudadmin@vmc.local -Password '<password>'''. The 'vCenter FQDN' field shows 'FQDN: https://vcenter.sddc-...3.vmwarevmc.com' (2), 'Resolution Address: Public IP' (3), and 'Public IP: 52.3...' (3). The 'Private IP: 10.231.14.4' is also visible.

## Task 2 - Infrastructure Management with PowerCLI

1. From your Virtual Desktop, launch **PowerShell 7**. Note: Do NOT use "powershell" nor the powershellise as these will launch powershell 5.
2. Type the following commands to confirm the PowerCLI Configuration and PowerShell Execution Policy

```
<p>Connect-VIServer {Your_Cloud_vCenter_FQDN or IP} -Username cloudadmin@vmc.local -
Password {Your_Default_vCenter_User_Password}

Get-PowerCLIConfiguration

Get-ExecutionPolicy </p>
```

Click to copy

**If the Connect-VIServer command returns an error message**, the vSphere PowerCLI modules need to be installed.

**Install-Module -Name VMware.PowerCLI -AllowClobber**

Answer **Y** to the prompt. Once the installation completes, re-run the **Connect-VIServer** command.


```
PS C:\Users\vmcexpert3-student01> Get-PowerCLIConfiguration
```

Scope	ProxyPolicy	DefaultVIMServerMode	InvalidCertificateAction	DisplayDeprecationWarnings	WebOperationTimeout Seconds
Session	UseSystemProxy	Multiple	Ignore	False	300
User					
AllUsers			Ignore	False	

```
PS C:\Users\vmcexpert3-student01>
PS C:\Users\vmcexpert3-student01> Get-ExecutionPolicy
RemoteSigned
PS C:\Users\vmcexpert3-student01>
```

3. In PowerShell or Windows Terminal type the following command to create a Content Library and Upload an Ubuntu Desktop Virtual Appliance

```
<p>New-ContentLibrary -Name {YourStudentName}_CL -Published -Datastore  
'WorkloadDatastore'
New-ContentLibraryItem -ContentLibrary {Your_Content_Library} -Name 'Ubuntu-22_Desktop'  
-Files @("E:\Lab_Files\OVAs\Ubuntu-22-OVF\Ubuntu-22_DT.mf", "E:\Lab_Files\OVAs\Ubuntu-  
22-OVF\Ubuntu-22_DT.ovf", "E:\Lab_Files\OVAs\Ubuntu-22-OVF\Ubuntu-22_DT-1.vmdk",  
"E:\Lab_Files\OVAs\Ubuntu-22-OVF\Ubuntu-22_DT-2.nvram") -ItemType 'ovf'</p>
```

 Click to copy

**Note:** Should the New-ContentLibraryItem task fail, it can be corrected in one of two ways. Log into your vCenter server and delete the Content Library Item, or execute the command **remove-ContentLibraryItem -ContentLibraryItem 'Ubuntu-22\_Desktop'** then rerun the New-ContentLibraryItem command above.

```
PS C:\Users\vmcexpert3-student31>
PS C:\Users\vmcexpert3-student31> New-ContentLibrary -Name vmcexpert2-31_CL -Published -Datastore 'WorkloadDatastore'
```

Name	Type	Published	Password Protected
vmcexpert2-31_CL	Local	True	False

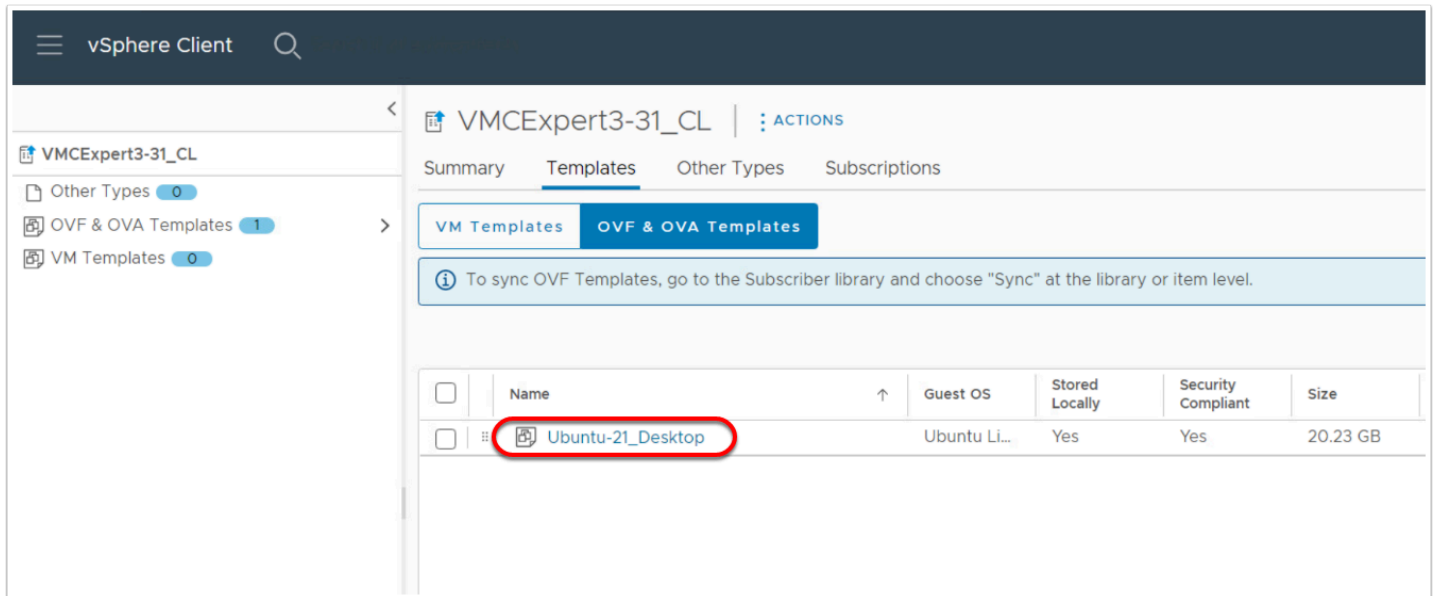
```
PS C:\Users\vmcexpert3-student31>
>> New-ContentLibraryItem -ContentLibrary vmcexpert2-31_CL -Name 'Ubuntu-22_Desktop' -Files @("E:\Lab_Files\OVAs\Ubuntu-  
22-OVF\Ubuntu-22_DT.mf", "E:\Lab_Files\OVAs\Ubuntu-22-OVF\Ubuntu-22_DT.ovf", "E:\Lab_Files\OVAs\Ubuntu-22-OVF\Ubuntu-22_  
DT-1.vmdk", "E:\Lab_Files\OVAs\Ubuntu-22-OVF\Ubuntu-22_DT-2.nvram") -ItemType 'ovf'
```

Name	ContentLibrary	ItemType	SizeGB
Ubuntu-22_Desktop	vmcexpert2-31_CL	ovf	18.895

```
PS C:\Users\vmcexpert3-student31>
```

4. Access your SDDC Console Browser tab, and log into your SDDC
5. Click **OPEN VCENTER**
6. Click **SHOW CREDENTIALS**
7. Copy and Record the Default vCenter Credentials Password
8. Click **OPEN VCENTER**
9. Log into vCenter as:
  - **cloudadmin@vmc.local**

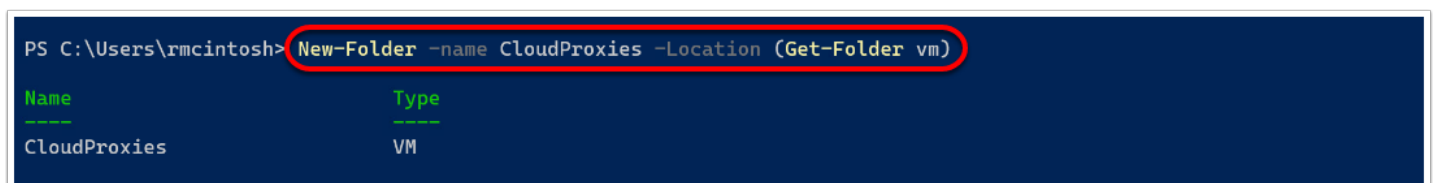
- {**Default\_vCenter\_User\_Password**} (Copied from step 7)
- Bookmark this page and save the cloudadmin **username** and **password** for quicker access to vCenter
  - In the upper left-hand corner Click the **Hamburger Menu** (3 vertical lines)
  - Click **Content Libraries**
  - Click **{Your Content Library}** to inspect it
  - Click **Templates**, then **OVF & OVA Templates**. Your Ubuntu Virtual Appliance should be present and the size should be larger than zero



- Type the following command to create a Virtual Machine Folder in the vCenter Inventory

```
<p>New-Folder -name CloudProxies -Location (Get-Folder vm)</p>
```

Click to copy



- Back in the browser window for vCenter, go to the **VMs and Templates view** to confirm that the folder appears. Note: You will need to select the hamberger in the top left corner and select inventory.

**i** We will now create a virtual machine from the Content Library

- Return to or launch PowerShell or Windows Terminal



## 18. Type the following commands, first to create the Virtual Machine, then to Power it



Please wait for the 1st command to complete before running the 2nd command (Start-VM). Also, when prompted to confirm the VM power-on operation type Y

```
<p>Get-ContentLibraryItem -Name Ubuntu-22_Desktop | New-VM -name Ubuntu-DT -Location  
'Workloads' -ResourcePool 'Compute-ResourcePool'  
  
Start-VM -VM 'Ubuntu-DT' -Confirm -RunAsync</p>
```

Click to copy

```
PS C:\Users\student32> get-contentLibraryItem -Name Ubuntu-22_Desktop | New-VM -name Ubuntu-DT -Location 'Workloads' -ResourcePool 'Compute-ResourcePool'
WARNING: com.vmware.vcenter.ovf.ovf_warning { category : 'warning', 'issues' : , 'name' : , 'value' : , 'message' : com.vmware.vapi.std.localizable_message { id : com.vmware.ovfs.o
vfs-main.ovfs.vmm_extra_config_accept_others, 'default_message' : The following extra configurations in the OVF package might pose security risks, and will be deployed to th
e target virtual machine: [vmotion.checkpointSVGAPrimarySize, pciBridge0.present, pciBridge6.functions, sata0.pciSlotNumber, sched.swap.derivedName, pciBridge5.virtualDev,
pciBridge4.present, pciBridge5.present, vmotion.svga.mobMaxSize, pciBridge6.pciSlotNumber, pciBridge7.present, pciBridge6.present, pciBridge4.pciSlotNumber, pciBridge6.virt
ualDev, hpet0.present, migrate.hostLog, guestInfo.detailed.data, numa.autosize.cookie, pciBridge5.functions, vmotion.svga.graphicsMemoryKB, monitor.phys_bits_used, svga.pre
sent, pciBridge7.pciSlotNumber, pciBridge0.pciSlotNumber, ethernet0.pciSlotNumber, pciBridge7.functions, scsi0.pciSlotNumber, pciBridge7.virtualDev, pciBridge5.pciSlotNumbe
r, softPowerOff, svga.guestBackedPrimaryAware, viv.moid, scsi0:0.redo, numa.autosize.vcpu.maxPerVirtualNode, pciBridge4.virtualDev, sched.cpu.latencySensitivity, pciBridge4
.functions, vmotion.checkpointFBSzSize], 'args' : [[vmotion.checkpointSVGAPrimarySize, pciBridge0.present, pciBridge6.functions, sata0.pciSlotNumber, sched.swap.derivedName, p
ciBridge5.virtualDev, pciBridge4.present, pciBridge5.present, vmotion.svga.mobMaxSize, pciBridge6.pciSlotNumber, pciBridge7.present, pciBridge6.present, pciBridge4.pciSlotN
umber, pciBridge6.virtualDev, hpet0.present, migrate.hostLog, guestInfo.detailed.data, numa.autosize.cookie, pciBridge5.functions, vmotion.svga.graphicsMemoryKB, monitor.ph
ys_bits_used, svga.present, pciBridge7.pciSlotNumber, pciBridge0.pciSlotNumber, ethernet0.pciSlotNumber, pciBridge7.functions, scsi0.pciSlotNumber, pciBridge7.virtualDev, p
ciBridge5.pciSlotNumber, softPowerOff, svga.guestBackedPrimaryAware, viv.moid, scsi0:0.redo, numa.autosize.vcpu.maxPerVirtualNode, pciBridge4.virtualDev, sched.cpu.latencyS
ensitivity, pciBridge4.functions, vmotion.checkpointFBSzSize]], 'params' : , 'localized' : {}, 'error' : {}

Name                               PowerState Num CPUs MemoryGB
--
Ubuntu-DT                          PoweredOff 2         4.000

PS C:\Users\student32> Start-VM -VM 'Ubuntu-DT' -Confirm -RunAsync
Confirm
Are you sure you want to perform this action?
Performing the operation "Start-VM" on target "VM 'Ubuntu-DT'".
[Y] Yes [A] Yes to All [N] No [L] No to All [S] Suspend [?] Help (default is "Y"): Y

Name                               State      % Complete Start Time Finish Time
--
Running                             0 05:03:25 PM
```

## 19. Back in the browser window for vCenter, confirm that the "Ubuntu-DT" VM deployed successfully and is powered-on

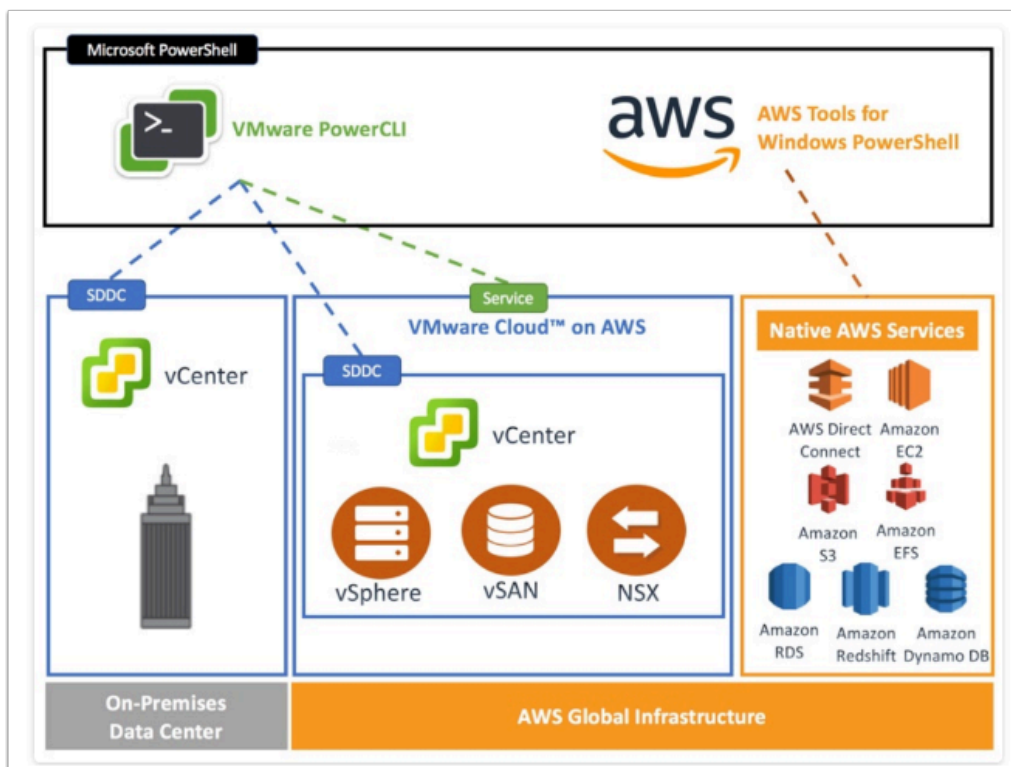


In Multi-Cloud scenarios, it is not uncommon to have multiple SDDC and Multiple vSphere clusters running across VMC on AWS, Azure VMware Solution, Google Cloud VMware Engine, IBM Cloud, just to name a few. The challenge however is to ensure each environment has a standardized inventory hierarchy, the required golden templates and virtual appliances needed to deploy workloads, customization specifications, and even the appropriate RBAC to control user access. In all these cases, standard PowerCLI commands (the same as those used on-premises) can be used to standardize these cloud-based vSphere environments.

## Task 3 - Using the VMware.VMC PowerShell Module

VMware.VMC is a PowerShell Module for Managing VMware Cloud on AWS. Using this module you can do the following:

1. Retrieve your AWS Account & VPC Information
2. Connect to VMware Cloud
3. Retrieve your VMC on AWS Organization Information
4. Create and Manage SDDCs
5. Create & Manage SDDC Clusters
6. etc...



- i** To use this module you must 1st generate an API Key. API Tokens are used to authenticate when authorized API connections are instantiated. Previously called an OAuth Refresh token, an API token is exchanged for an access token and authorizes access per organization. API tokens are generated from the account page in Cloud Services Console or through the VMware Cloud Services.

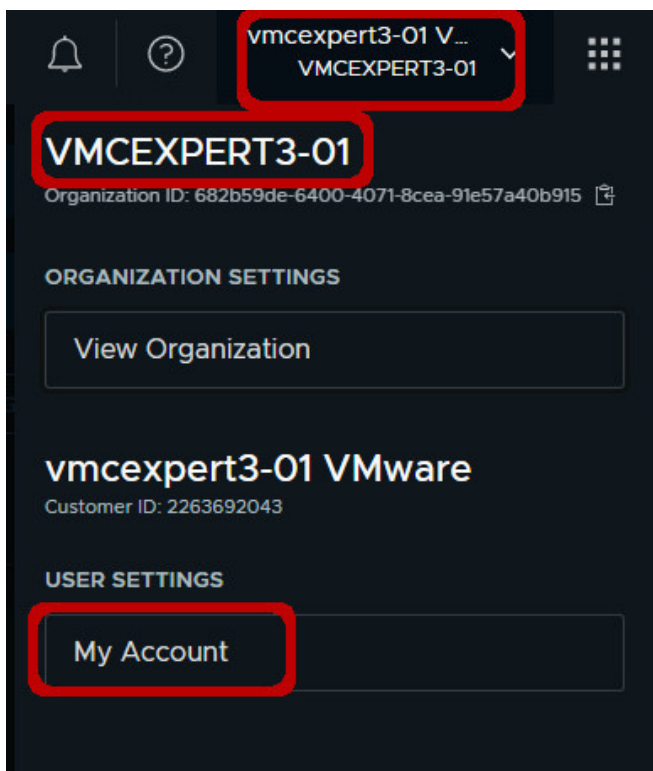
In this lab task you will do the following:

1. Generate an API Token
2. Retrieve your VMC on AWS Organization, SDDC and Cluster Information

1. From your Virtual Desktop, go to your SDDC Console <https://vmc.vmware.com/console/sddcs> and Login if required.

 **NOTE:** Login steps can be found in steps 2 through 6 of Task 1

2. In the Upper right-hand corner Click the {Username/Org} Dropdown
3. Record your Organization name.
4. Click **My Account**



5. Click the **API Tokens** Tab
6. Click **GENERATE A NEW API TOKEN**
7. Select the following Options and Value(s):
  - Token Name: {**Your\_Student\_Acct**}\_API\_Token (I.E. **VMCExpert3-31\_API\_Token**)
  - Define Scopes: Select checkbox for **All Roles**
8. Click **GENERATE**

9. Click **COPY**
10. Open Notepad, Paste in the API Key and save the file on the desktop
11. Click **CONTINUE**

Profile Preferences Security My Roles **API Tokens**

API Tokens

MFA

### Generate a New API Token

Token Name

Token TTL  months

#### Define Scopes

Scopes provide a way to implement granular access control.

☒ All Roles ⓘ

#### Organization Roles

☒ All Organization Roles

- ☒ Access Log Auditor
- ☒ Billing Read-only
- ☒ Developer
- ☒ Organization Member
- ☒ Organization Owner
- ☒ Project Admin
- ☒ Software Installer
- ☒ Support User

#### Service Roles

☒ CloudHealth Platform

The OpenID scope requests and receives information about authenticated sessions and users of your app.

☒ OpenID

#### Email preferences

☐ Send me email reminders when this token is about to expire in

**GENERATE** **CANCEL**

**i** Make sure to save this refresh token in a safe place to be used in the next section when using API's in Postman.

Now let's attach to the VMC server, input the command below and append the refresh token after the -refreshtoken parameter

12. From the Virtual desktop Launch **Powershell 7**, if it is no longer open
13. Type the following command in the PowerShell Window

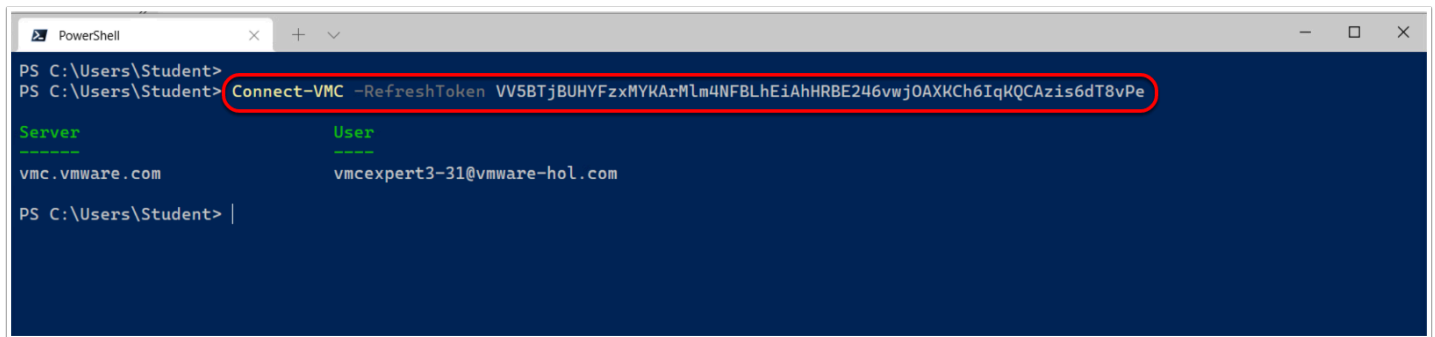
```
<p>Connect-VMC -RefreshToken {"Your_API_Token_From_Step_7"}</p>
```

Click to copy

**If the command returns an error message**, the PowerCLI VMC modules need to be installed.  
Type the following command:

**Install-Module -Name VMware.VMC -AllowClobber**

Answer **Y** to install. Once updated, rerun the **Connect-VMC** command.



```
PS C:\Users\Student> Connect-VMC -RefreshToken VV5BTjBUHYFzxMYKAzMLm4NFBLeEiAhHRBE246vwj0AXKCh6IqKQCAzis6dT8vPe
Server                               User
-----                               -
vmc.vmware.com                       vmcexpert3-31@vmware-hol.com
PS C:\Users\Student> |
```

14. Type the following commands in the PowerShell 7 Window. If the Get-VMCOrg command fails, then run the Install-Module command mentioned previously and rerun the Get-VMCOrg command.

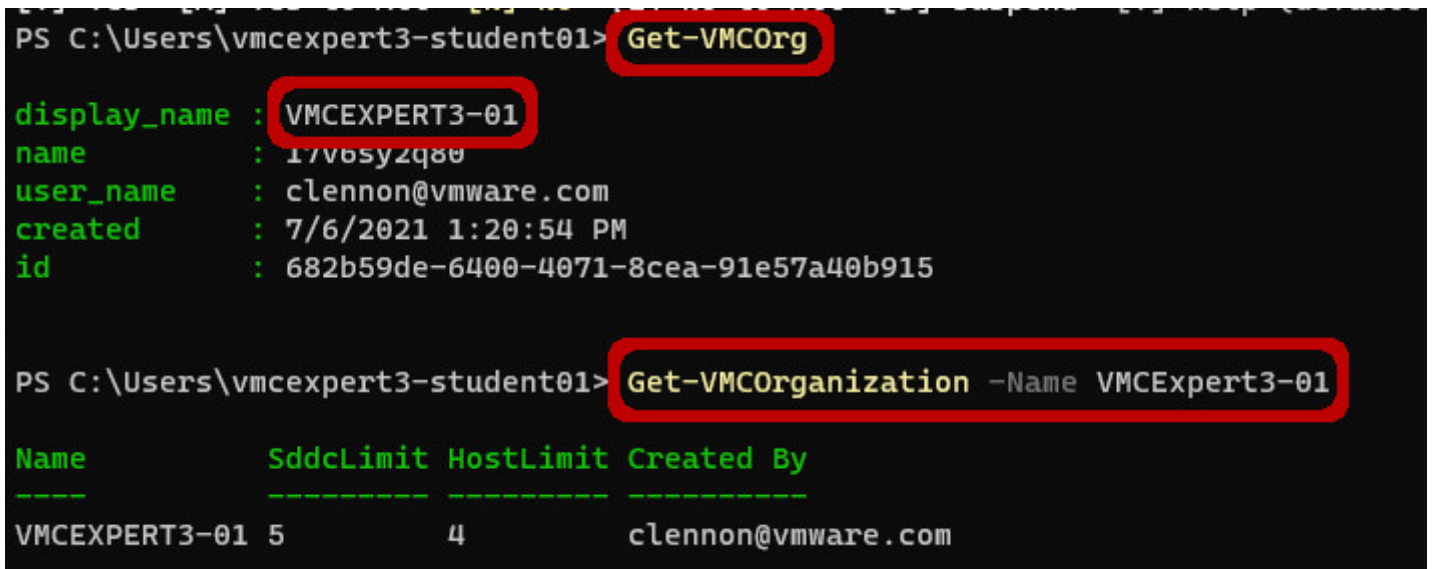
```
<p>Get-VMCOrg

Get-VMCOrganization -Name {Your_VMC_Organization_Name}

Get-VMCSDDCcluster

Get-VMCSDDCDefaultCredential -Org {Your_VMC_Organization}</p>
```

 Click to copy



```
PS C:\Users\vmcexpert3-student01> Get-VMCOrg

display_name : VMCEXP3-01
name         : 17v6sy2q80
user_name    : clennon@vmware.com
created      : 7/6/2021 1:20:54 PM
id           : 682b59de-6400-4071-8cea-91e57a40b915

PS C:\Users\vmcexpert3-student01> Get-VMCOrganization -Name VMCExpert3-01

Name          SddcLimit HostLimit Created By
-----
VMCEXP3-01    5          4          clennon@vmware.com
```

```
PS C:\Users\vmcexpert3-student01> Get-VMCSDDCCluster
```

Name	State	Sddc	HostCount
Cluster-1	READY	VMCEXP3-01	1
Cluster-1	READY	VMCEXP3-02	1

```
PS C:\Users\vmcexpert3-student01> Get-VMCSDDCDefaultCredential -Org VMCExpert3-01
```

```
vc_url           : https://vcenter.sddc-44-227-65-28.vmwarevmc.com/
vc_management_ip : 10.201.14.4
vc_public_ip     : 44.227.65.28
cloud_username   : cloudadmin@vmc.local
cloud_password   : n+5*AsOWpvk8FCH

vc_url           : https://vcenter.sddc-54-203-166-45.vmwarevmc.com/
vc_management_ip : 10.202.14.4
vc_public_ip     : 54.203.166.45
cloud_username   : cloudadmin@vmc.local
cloud_password   : Y*T9j2xKMejL-gM
```

## Task 4 - Work with the VMC on AWS REST APIs

The VMC on AWS APIs allows you to Build, Automate and Manage your Software Defined Data Centers (SDDCs) running on VMware Cloud on Amazon Web Services

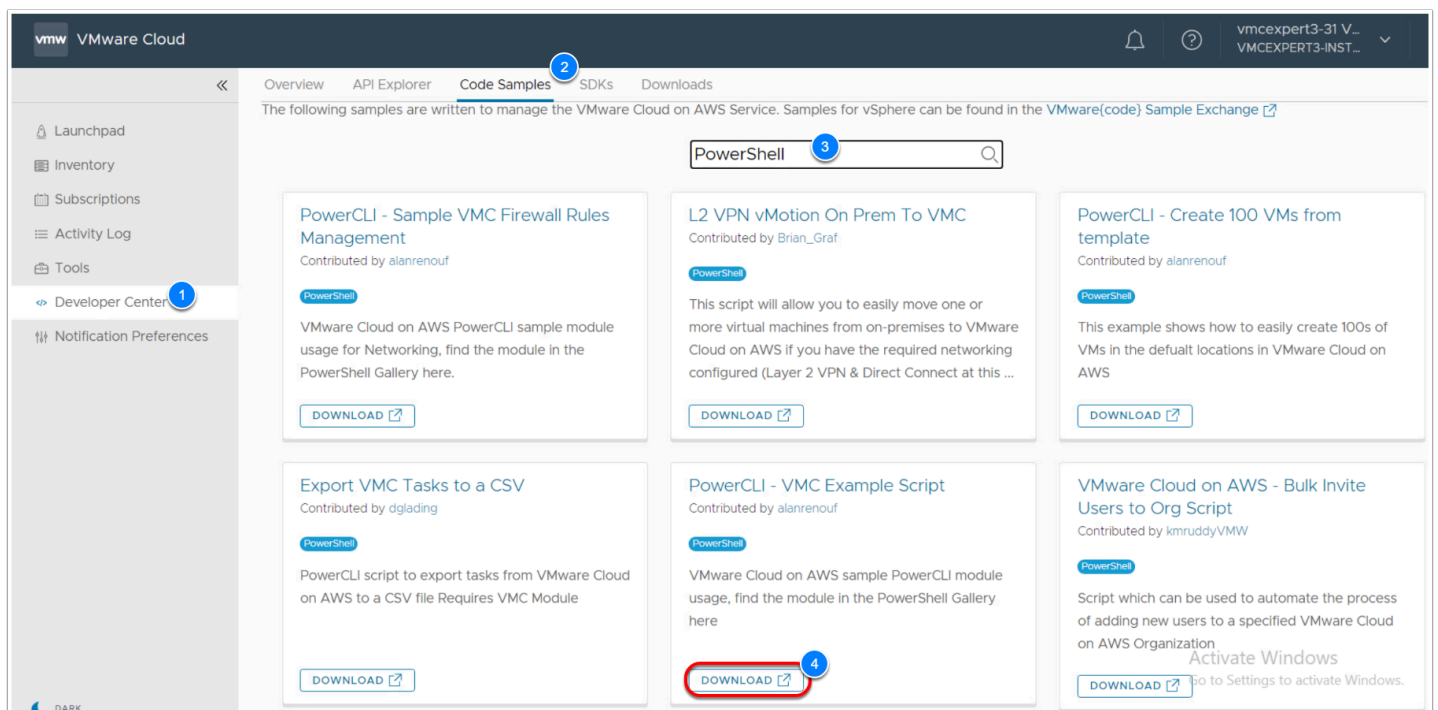
The VMware Cloud on AWS APIs are organized around [REST](#) ("Representational State Transfer") operations for performing create, retrieve, update and delete operations on VMware Cloud on AWS resources. For ease of use and security, REST builds on the standard web protocols HTTP and HTTPS, using the normal network ports 80 and 443, which are both open in most data centers, and uses standard HTTP response codes and verbs.

As a Cloud Service VMware Cloud on AWS APIs are not publicly available and require an API Token for programmatic use. You will need a [VMware Cloud Services account](#) to generate an API Token which you will use to programmatically call APIs from your programming language of choice.

In this task we will be using the VMware Cloud on AWS REST API to get some basic information about your VMware Cloud on AWS Organization and SDDC deployment. To do this we will be using the new Developer Center feature in VMware Cloud on AWS. This was

built specifically to focus on using APIs and scripts to create SDDCs, add and remove hosts, plus connect to and use the full vCenter API set. To get started, let go back to your VMC environment.

1. From your Virtual Desktop, launch the Web Browser (Google Chrome Preferred) and go <https://vmc.vmware.com/console/sddcs> if prompted
2. If your Browser window is still logged in from Task 3, click **Services**, then **VMware Cloud on AWS**. If not, you can skip this step
3. Click **Developer Center**
4. Click **Code Samples**
5. Type **Powershell** in the **Filter Samples** Textbox
6. Click on **Download** in the "PowerCLI - VMC Example Script" Tile

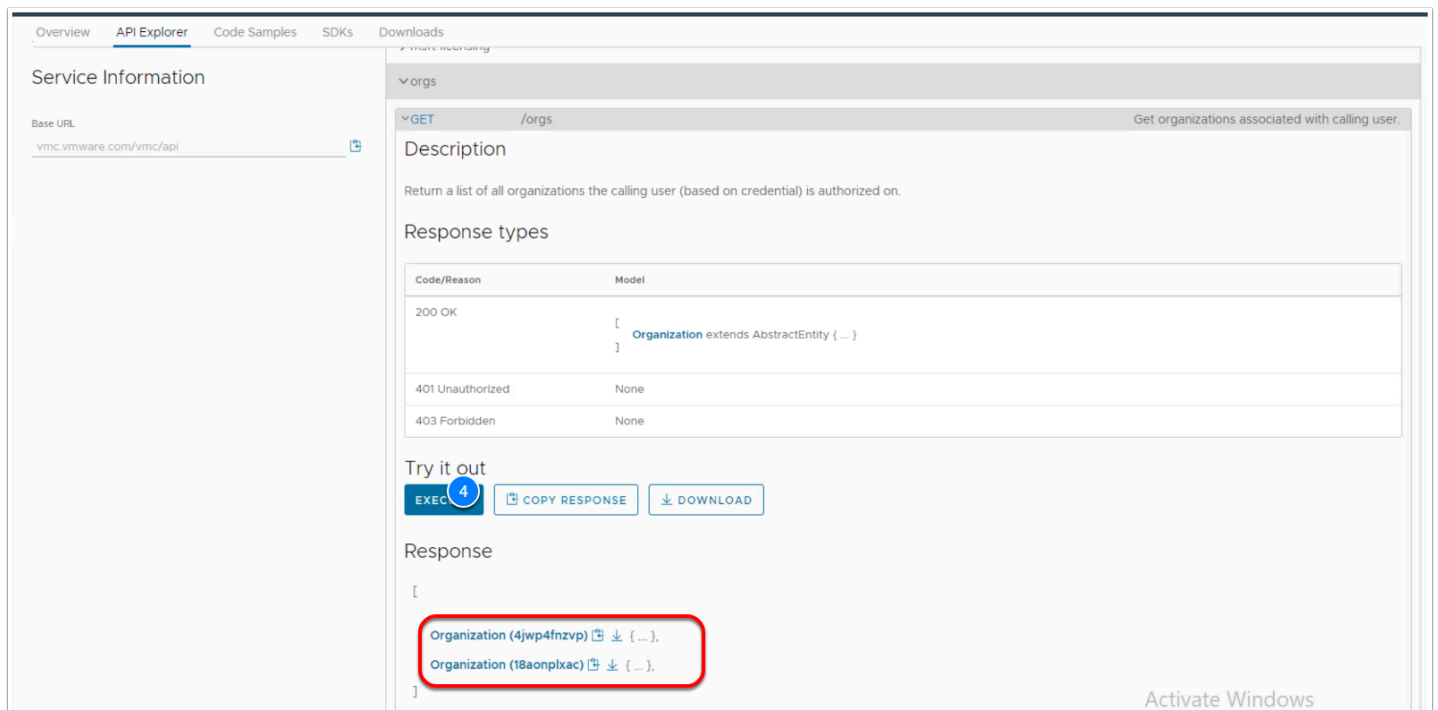
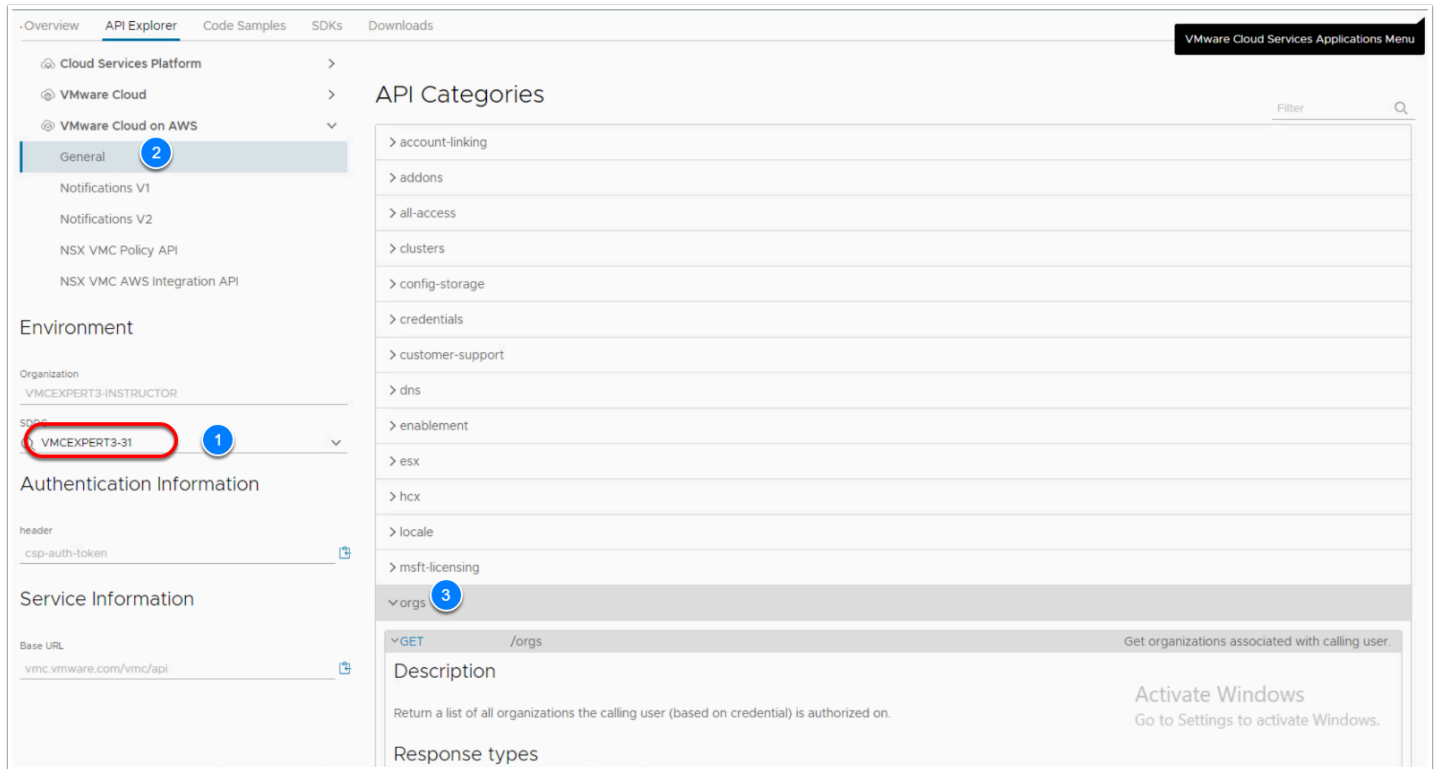


7. After the Download Completes, Click on the **File** and **Extract its Content**
8. In the extracted folder navigate to **PowerCLI-Example-Scripts-master\Scripts\VMware\_Cloud\_on\_AWS**
9. Right-Click the **VMC Example Script** File and Click **Open**

**i** Now you can see the PowerShell commands you used in the previous task as well as other commands you can use with your SDDC. Review the commands and close the Notepad window



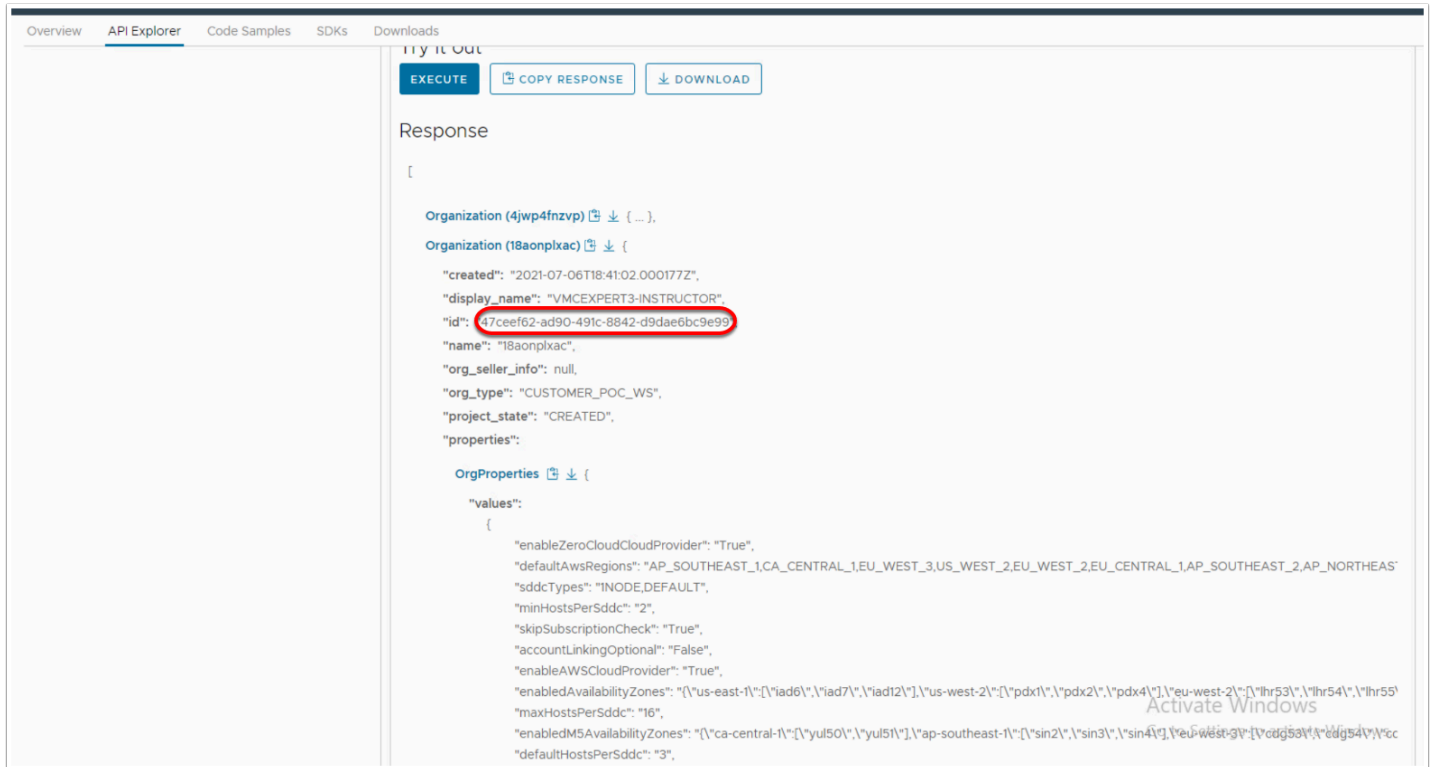
10. In the SDDC Console browser window, click on the **API Explorer** tab, under **Developer Center**
11. In the SDDC Drop-Down, Select **your SDDC** (I.E. **VMCExpert3-31**)
12. Expand the **VMware Cloud on AWS** Menu, Click **General**
13. Under API Category expand orgs, then expand the GET section for **/orgs**
14. Click Execute, your VMC Organization(s) will be displayed



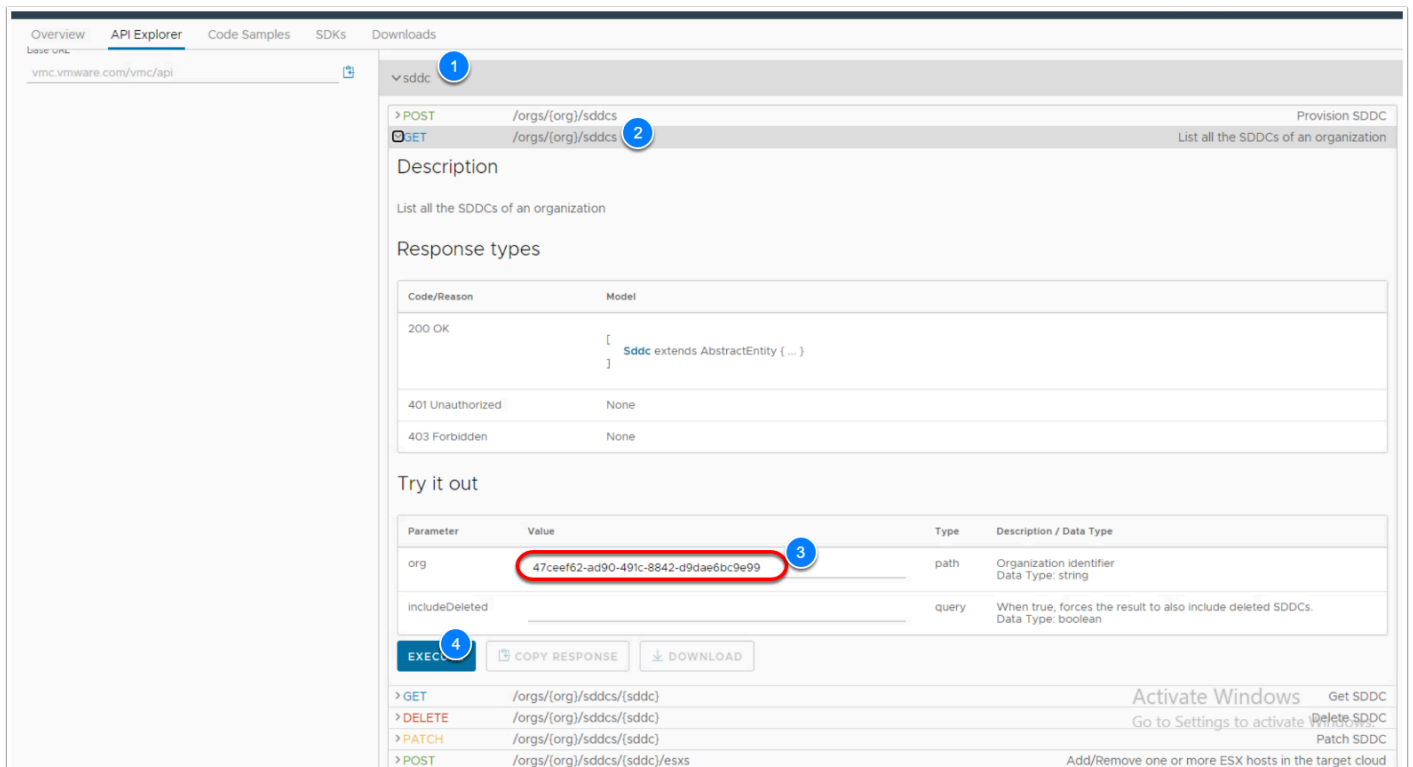
15. Expand the Response for your Organization and Inspect the output



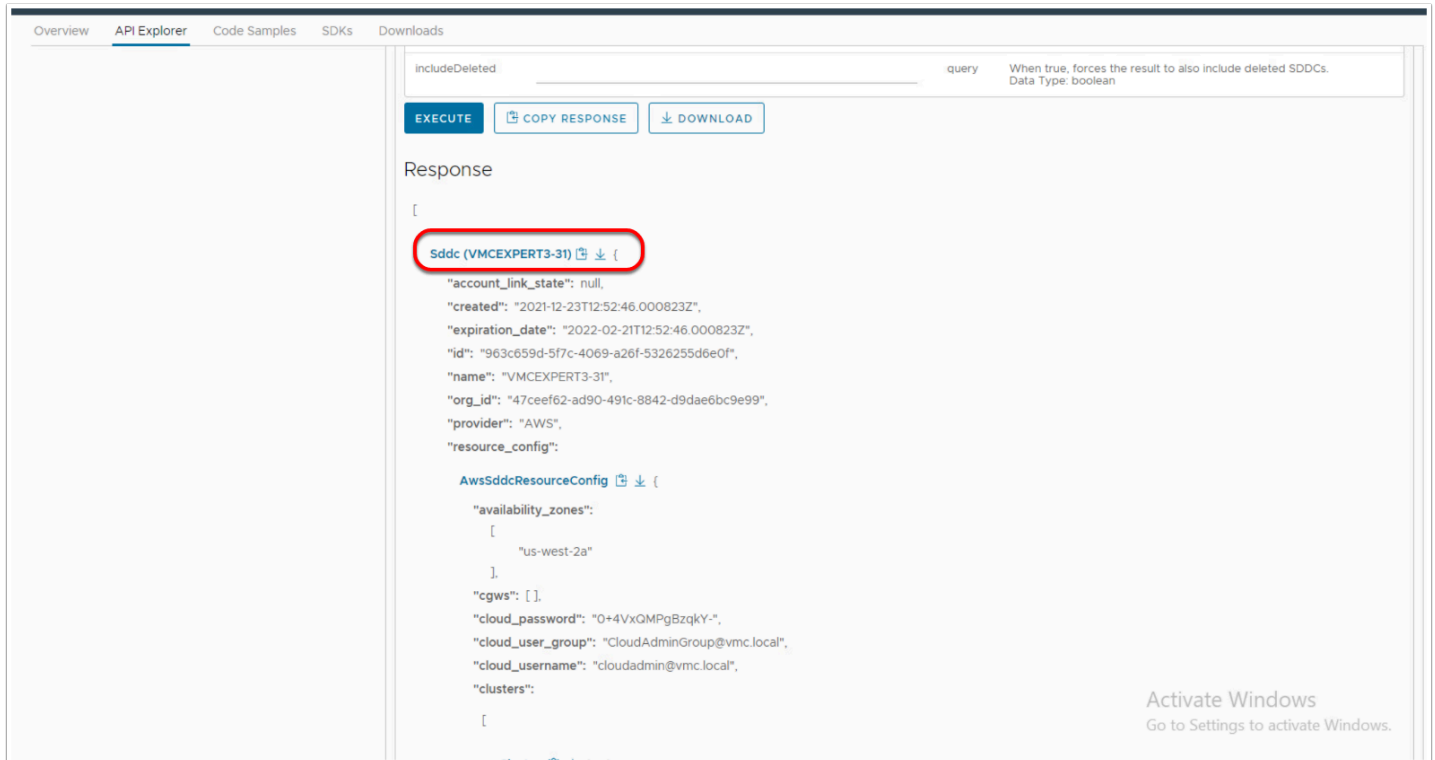
16. Take note of and save the organization ID



17. Scroll down and expand **sddc**
18. Expand **GET /orgs/{org}/sddcs**
19. Confirm that the correct org id is displayed in the org field, if not, please input the correct ID
20. Click **Execute**



## 21. Review the Response Output



The screenshot shows the API Explorer interface with the 'API Explorer' tab selected. The 'IncludeDeleted' checkbox is checked, and the 'query' parameter is set to 'When true, forces the result to also include deleted SDDCs. Data Type: boolean'. The 'EXECUTE' button is highlighted. The response output is displayed as a JSON object:

```
[
  {
    "name": "VMCEXP3-31",
    "org_id": "47ceef62-ad90-491c-8842-d9dae6bc9e99",
    "provider": "AWS",
    "resource_config": {
      "availability_zones": [
        "us-west-2a"
      ],
      "cgws": [
      ],
      "cloud_password": "0+4VxQMPgBzqkY-",
      "cloud_user_group": "CloudAdminGroup@vmc.local",
      "cloud_username": "cloudadmin@vmc.local",
      "clusters": [
      ]
    }
  }
]
```

## Conclusion

Organizations must decide on a cloud strategy that meets the needs of their business, whether that is hybrid cloud and/or multi-cloud. Hybrid cloud is defined as the use of private cloud, and public cloud platforms to provide a flexible mix of cloud computing services, allowing for consistent infrastructure, simplified workload migration and placement. Multi-cloud, by comparison, is defined as the use of two or more public cloud providers with or without any existing private cloud infrastructure. Multi-cloud is an emerging strategy employed by organizations that need to meet specific technical requirements and business outcomes by leveraging services across multiple cloud providers simultaneously. Organizations adopt this approach when faced with a scenario where no one cloud platform is able to meet all their technical requirements or deliver all the necessary outcomes for the business. This often occurs through mergers and acquisitions (M&A), where businesses find themselves with application, operational and financial ownership across clouds that may not align with their initial cloud strategy. This model affords organizations the flexibility, choice, and unique opportunity to be intentional about their approach to infrastructure and application modernization (e.g., refactor/build, replatform, rehost/migrate, retain, or retire)

- Refactor / Build involves changing the application at the source code level. Typically, applications are re-written to take advantage of cloud micro-services architecture and to incorporate new services such as IoT, machine learning, and others.
- Replatform involves changing the operating system, such as going from Windows to Linux, modifying the application middleware, such as going from a self-managed database to a cloud provider managed database or from a virtual machine to a container image.
- Rehost / Migrate involves either changing the hypervisor. (e.g., migrate applications from one virtualized environment to another) which is known as Rehost or moving an application without changing the underlying hypervisor or application at a source code level (e.g., migrate VMs from one virtualized environment to another without requiring changes) which is known as Relocate.
- Retain means leaving workloads in a private cloud environment
- Retire means decommissioning workloads and/or converting to SaaS

For most organizations, the need for a multi-cloud strategy is rapidly becoming an inevitability. Considerations for multi-cloud are not limited to just technical decisions. Service level agreements (SLAs) and service level objectives (SLOs), instance types or node specifications, region/availability zone (AZ) placement, storage, and network performance characteristics are important factors, but do not stand alone. Business considerations such as existing commercial agreements, regulatory compliance requirements, organizational culture and cloud perception, skills availability, and many others are also critical concepts to weigh in when building out a complete multi-cloud strategy. The VMware Multi-Cloud Management Framework provides cross-cloud/cross platform tools for system-wide management.