Cloud forensics

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Agenda

1. Cloud computing types (PaaS/SaaS/IaaS) - what data can be seized?
2. Sizing non-volatile data
    a. Cloud Logs
    b. Virtual machines including k8s nodes
    c. Encrypted disks
3. Forensic environment preparation
    a. Evidence protection
    b. Data integrity verification
    c. Microsoft Azure and Google Cloud Platform reference architectures
4. Common issues

Technical challenges

1. Data volatility and data retention
2. Data location and distributed storage
3. Limited access to data
4. Readiness of incident response teams to investigate cloud environments

Cloud computing types and forensics data types

	On Prem	IaaS	PaaS	SaaS
Application/services logs				
file system data				
logs of operating system				
Images				
physical drives				
Volatile memory*				

*Suspend (GCP) - currently not useful
*Hibernation (Azure) - require additional set up

Examples of cloud computing services

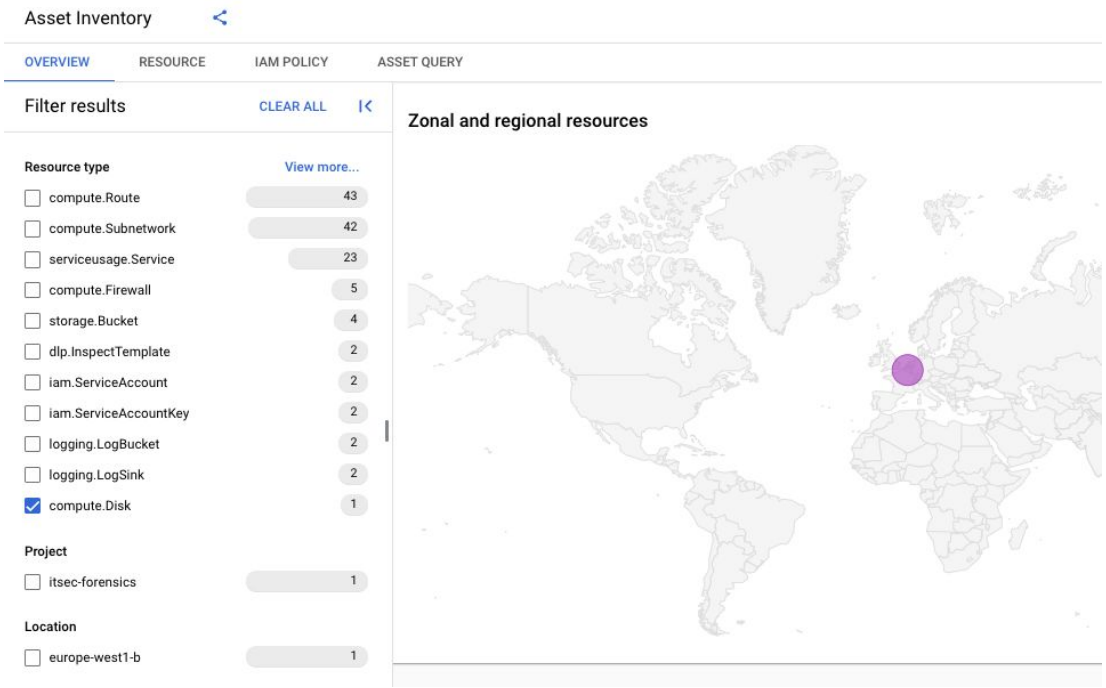
SaaS - GCP IAM, Entra ID, Office365, Google Workspace, GCP KMS, Key Vault, GCP Console, Azure Console

IaaS - GCP Compute Engine, Azure Virtual Machine

PaaS - Azure Web Apps, GCP App Engine

Where is the data?

Regions
Zones



Event logs

Audit Logs (Who What Where When)

Enabled audit logs and default retention period

Google GCP

- Admin Activity - 400 days
- Data Access (by default only BigQuery) - 30 days
- System Event - 400 days
- Policy Deny - 30 days

Google Workspace

- Audit logs (Admin, Login, OAuth Token, SAML, Group, Gmail, Drive, Chat, Drive, Device, etc) - 180 days

Microsoft Azure

- Activity Log - 90 days
- Entra ID logs - 30 days

Microsoft 365 / Office 365

- Audit Log (App administration, User administration, Entra administration, Directory administration, Exchange admin, Exchange mailbox, Defender for Endpoint, Teams, Sharing and access request, etc) - 90 days -> 180 days

GCP - Admin Activity

Data contained in audit logs:

- administrative actions that modify the configuration or metadata of GCP resources
- user or service account who modify roles

Examples:

- adding role to user for project, folder or organisation
- removing compute engine

GCP - Data Access

Data contained in audit logs:

- requests that read the configuration or metadata of GCP resources (ADMIN_READ)
- requests that create, modify, delete, read user-provided resource data

Examples:

- read, write, modify or delete user data in BigQuery dataset
- read a cloud storage object

GCP - System Event

Data contained in audit logs:

- actions that modify the configuration of resources (but changes are initialized by Google systems)

Examples:

- automatic backup event or scheduled snapshot
- automatic scaling events

GCP - Policy Deny

Data contained in audit logs:

- denied access to GCP services because of a security policy violation

Examples:

- attempt of adding service account to project
- creation of resource in prohibited region

Azure - Activity (subscription log)

Data contained in audit logs:

- activities related to modify (create/update/delete) all Azure resources
- activities related to RBAC

Examples:

- removing virtual machine
- creating network security group
- adding user to group

Azure - Directory (tenant logs)

Data contained in audit logs:

- records of access to system activity - changes in service configuration, activity related to Azure services, changes in groups and users.
- Sign in Logs - information about sign-ins into Azure, access to application and other resources by users, service principals and managed identities.

Examples:

- history of logins to services
- sign-in locations
- authentication methods used by users
- changes of permissions to service

Log management in GCP

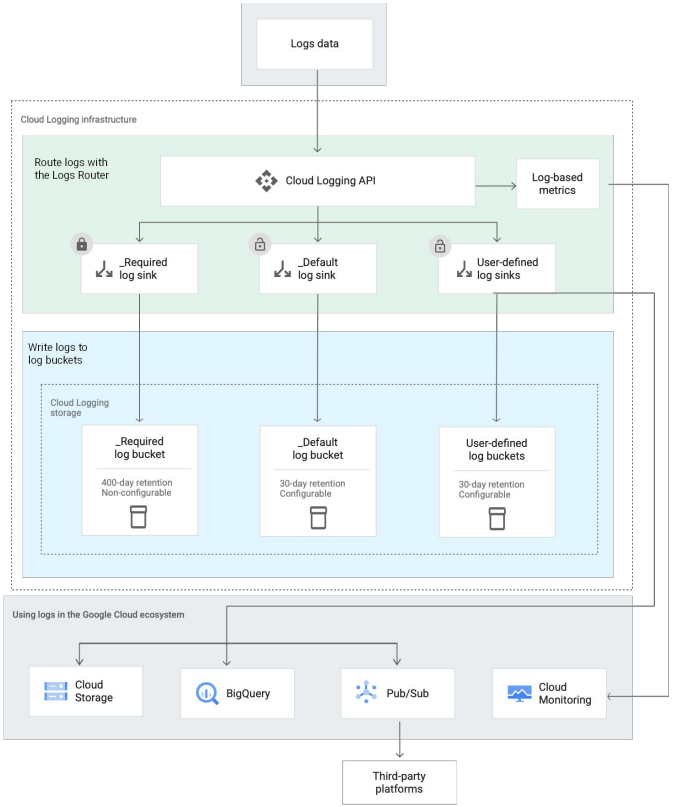
- Organizations, Folders and Projects
- Sinks
  - supported destinations
  - filters
- Configuration of additional logs

Data access audit logs configuration

The effective data access configuration below combines the configuration for the currently selected resource and the data access configurations set on all parent resources.

Filter | Identity and Access Management (IAM) API | Enter property name or value

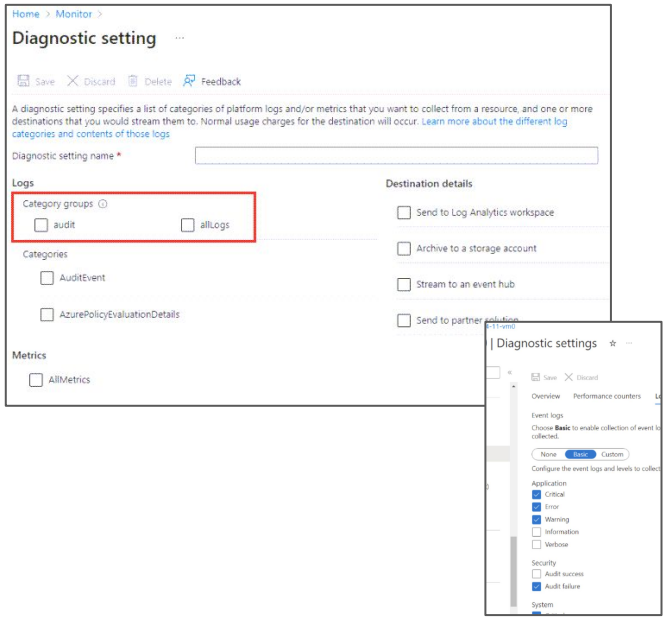
Service	Admin Read	Data Read	Data Write	Exempted principals	Inherited exempted principals
Identity and Access Management (IAM) API	✓	–	–	0	0

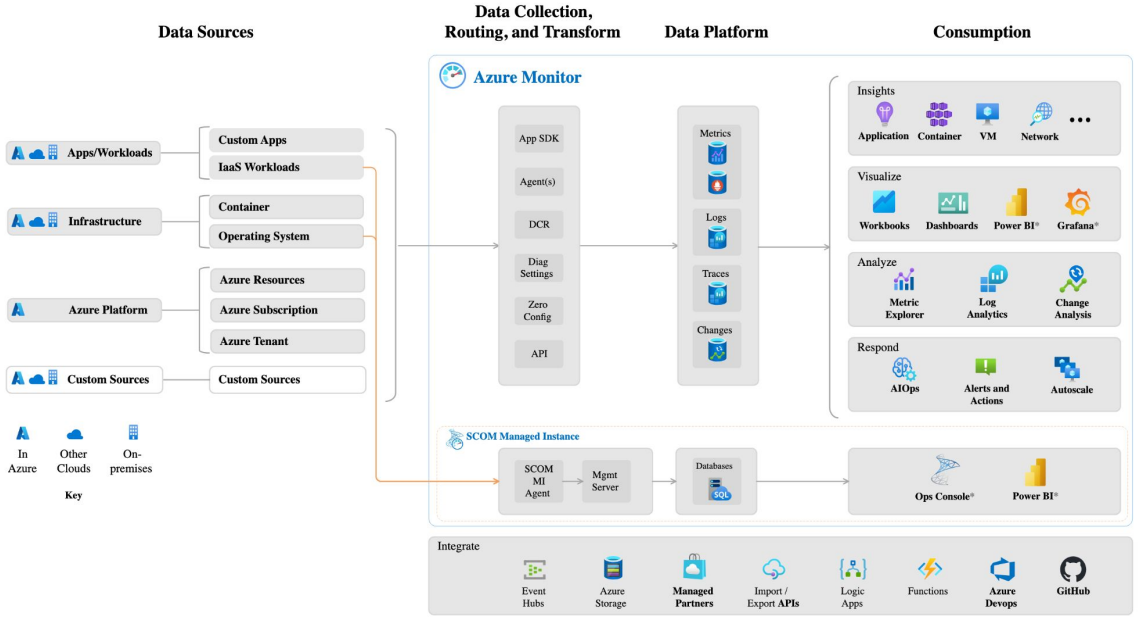


https://cloud.google.com/logging/docs/routing/overview

Log management in Azure

- Resources
- Diagnostics Settings
- Configuration





https://learn.microsoft.com/en-us/azure/azure-monitor/overview

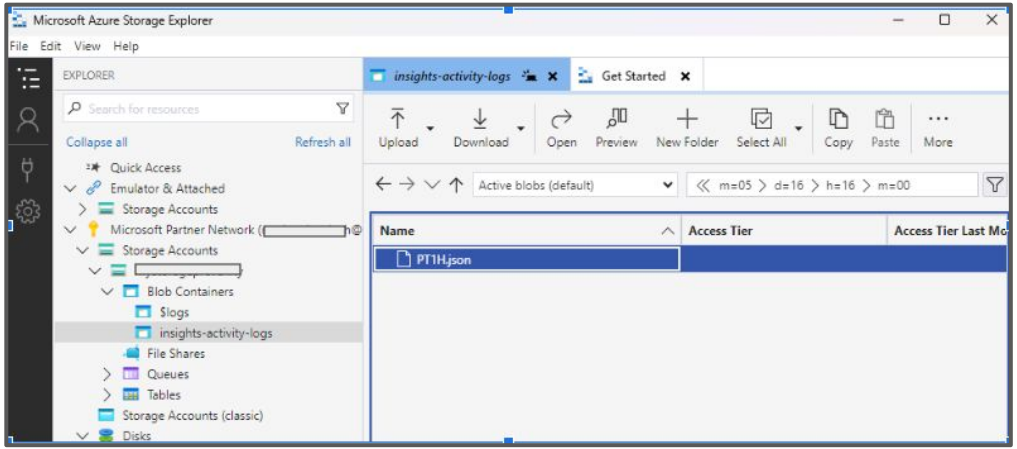
Export logs from Azure

Supported methods:

- Portal | Service
- Azure Monitor
- Export Data Settings
- REST API
  - GET https://auditservice.dev.azure.com/{organization}/_apis/audit/auditlog?api-version=7.1-preview.1
- PowerShell
  - Get-AzLog | Get-AzActivityLog
- Azure CLI
- Microsoft Extractor Suite

Destinations:

- Storage Accounts
- Log Analytics
- Event Hubs



PS - microsoft extractor suite

```
PS /home/mariusz> Get-ActivityLogs -StartDate 2024-02-22 -EndDate 2024-02-25 -OutputDir Evidence
[INFO] Custom directory set to: Evidence
[INFO] Retrieving all subscriptions linked to the logged-in user account
[INFO] Identified Subscription: [redacted]
[INFO] Activity logs found in subscription: [redacted]
[INFO] Retrieving all Activity Logs for [redacted]
[INFO] Connected to Subscription [redacted]
[INFO] No Activity Logs found on 2024-02-22. Moving on!
[INFO] No Activity Logs found on 2024-02-23. Moving on!
[INFO] Successfully retrieved 3 Activity logs for 2024-02-24. Moving on!
[INFO] Done all logs are collected for Microsoft Partner Network
PS /home/mariusz>
```


```
[
 {
  "EventTimestamp": "2/24/2024 4:06:16 AM",
  "EventName": "End request",
  "EventDataId": "***",
  "TenantId": null,
  "CorrelationId": "***",
  "SubStatus": "OK (HTTP Status Code: 200)",
  "SubscriptionId": "***",
  "SubmissionTimestamp": "2/24/2024 4:09:51 AM",
  "Status": "Succeeded",
  "ResourceType": null,
  "ResourceProviderName": "Microsoft.GuestConfiguration",
  "ResourceId": "/subscriptions/***/providers/Microsoft.GuestConfiguration",
  "ResourceGroupName": "",
  "OperationName": "Registers the feature for Microsoft.GuestConfiguration",
  "OperationId": "***",
  "Level": "Informational",
  "Id": "/subscriptions/***/providers/Microsoft.GuestConfiguration/events/***/ticks/***",
  "Description": "",
  "Category": "Administrative",
  "Caller": "***",
  "...
```

Export logs from GCP

Supported methods:

- GCP console
- Cloud Logging service
- API
  - `POST https://logging.googleapis.com/v2/entries:list`
    - `ProjectIDs`
    - `resourceNames`
- CLI
  - gcloud logging read –format=csv|json

Destinations:

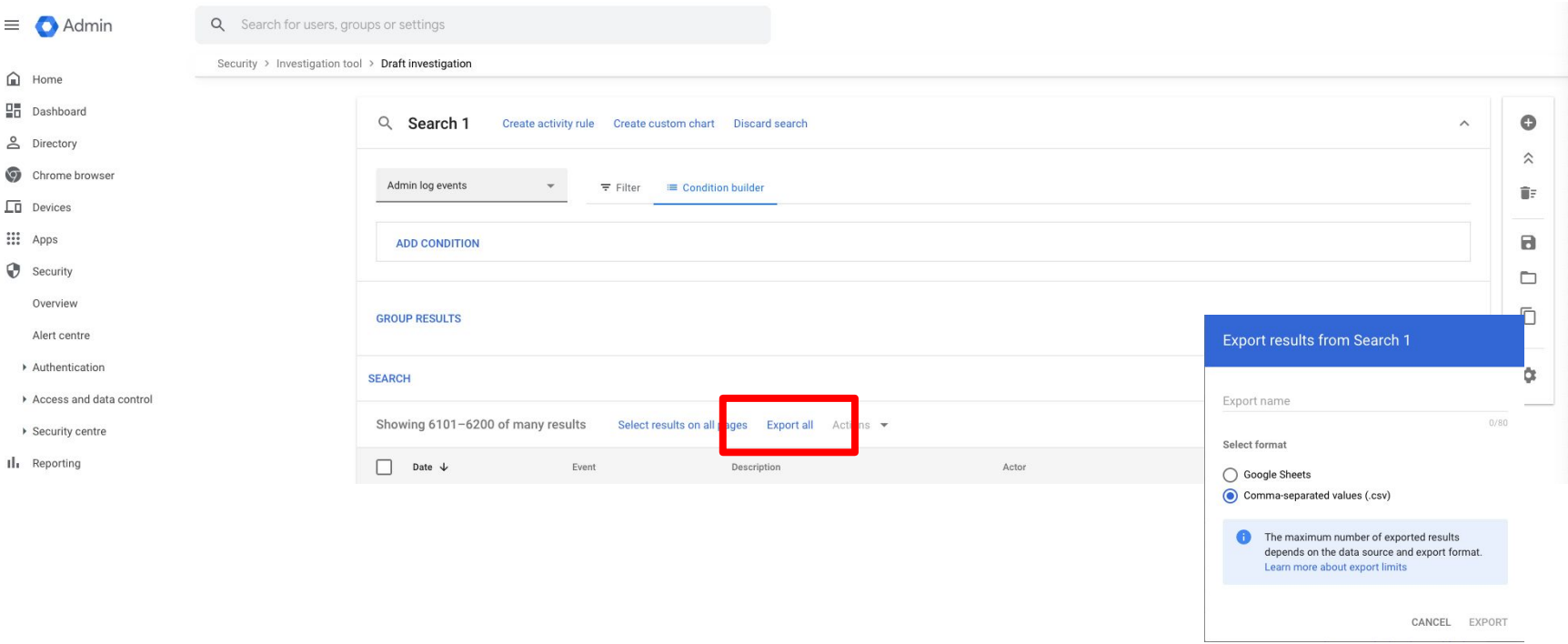
- Storage
  - _Default
  - _Required (Admin Activity i System Event)
- BigQuery
- Cloud Pub/Sub

CLI - gcloud

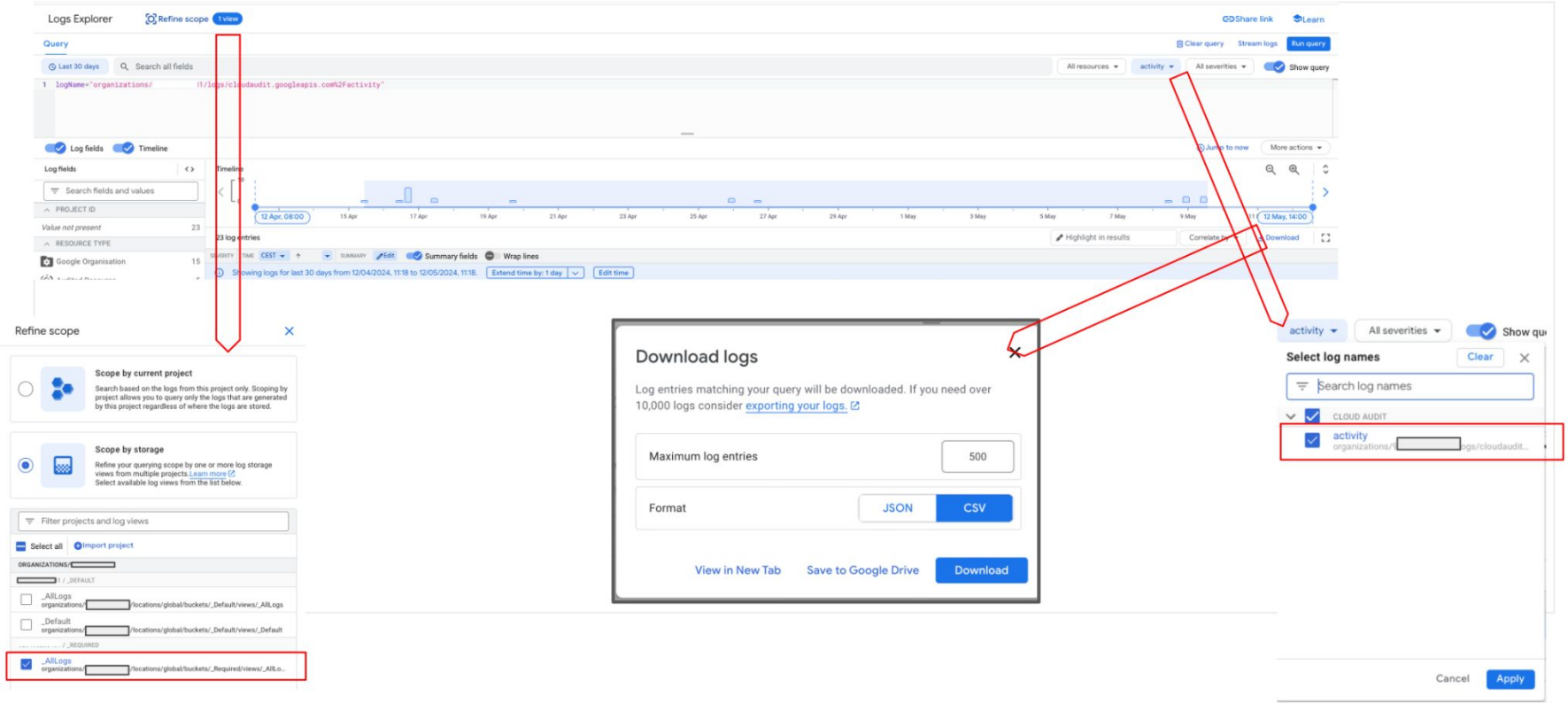
```
gcloud logging read 'timestamp >= "2024-04-09T00:00:00Z" AND timestamp < "2024-04-10T00:00:00Z"' --project=<project> --format=json > exported.log
```


```
[
 {
  "insertId": "-wgmuy5dobky",
  "logName": "projects/***/logs/cloudaudit.googleapis.com%2Factivity",
  "protoPayload": {
   "@type": "type.googleapis.com/google.cloud.audit.AuditLog",
   "authenticationInfo": {
    "principalEmail": "***@***.iam.gserviceaccount.com",
    "principalSubject": "serviceAccount:svc-gcp-permission@t***.iam.gserviceaccount.com",
    "serviceAccountKeyName": "//iam.googleapis.com/projects/***o/serviceAccounts/***@***.iam.gserviceaccount.com/keys/***"
   },
   "authorizationInfo": [
    {
     "permission": "resourcemanager.projects.setIamPolicy",
     "permissionType": "ADMIN_WRITE",
     "resource": "projects/***",
     "resourceAttributes": {
      "name": "projects/***",
      "service": "cloudresourcemanager.googleapis.com",
      "type": "cloudresourcemanager.googleapis.com/Project"
     }
    },
    {
     "permission": "resourcemanager.projects.setIamPolicy",
     "permissionType": "ADMIN_WRITE",
     "resource": "projects/***",
     "resourceAttributes": {
      "name": "projects/c***",
      "service": "cloudresourcemanager.googleapis.com",
      "type": "cloudresourcemanager.googleapis.com/Project"
     }
    }
   ],
…
```

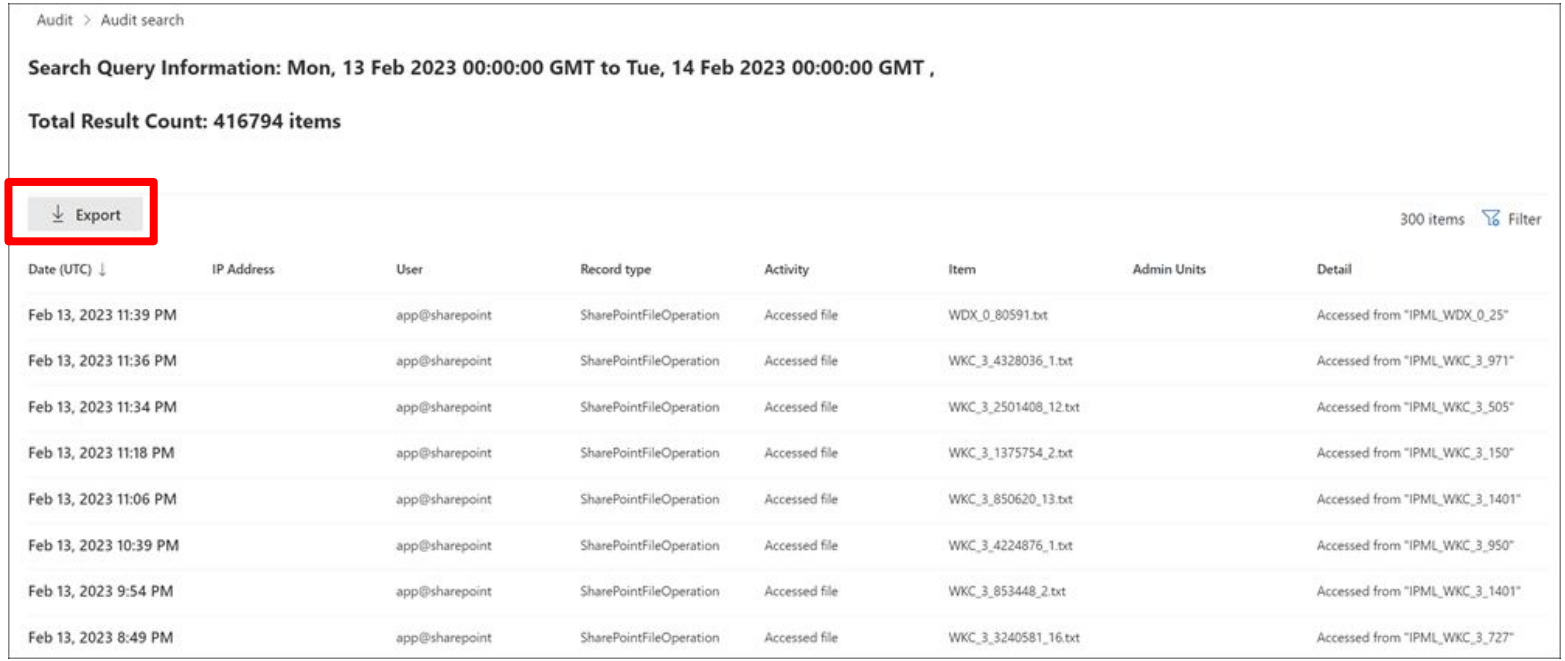
Google Workspace - Audit Log Collection



Google Cloud Platform - Cloud Audit Logs Collection



Microsoft 365/Office 365 - Audit Log Collection



Audit > Audit search

Search Query Information: Mon, 13 Feb 2023 00:00:00 GMT to Tue, 14 Feb 2023 00:00:00 GMT ,

Total Result Count: 416794 items

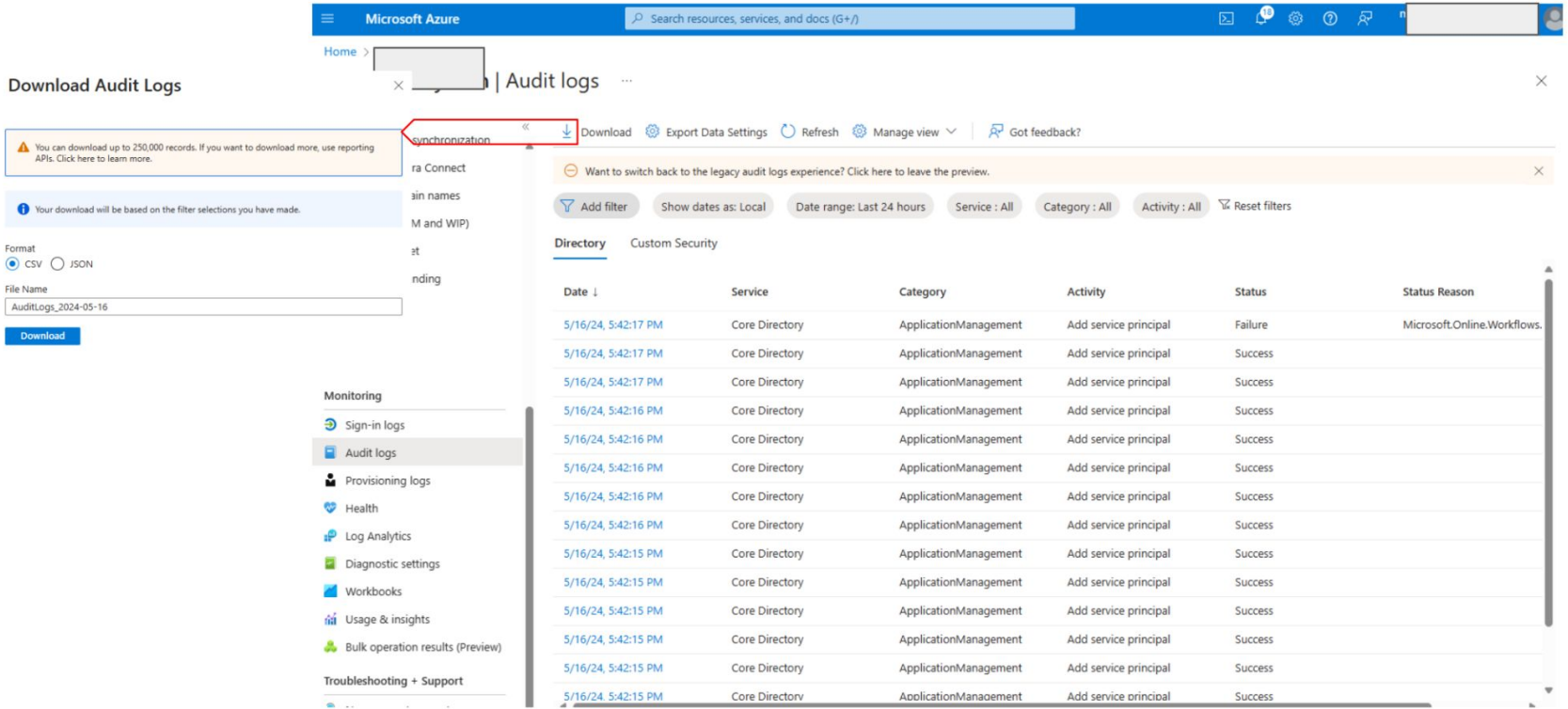
Export

300 items Filter

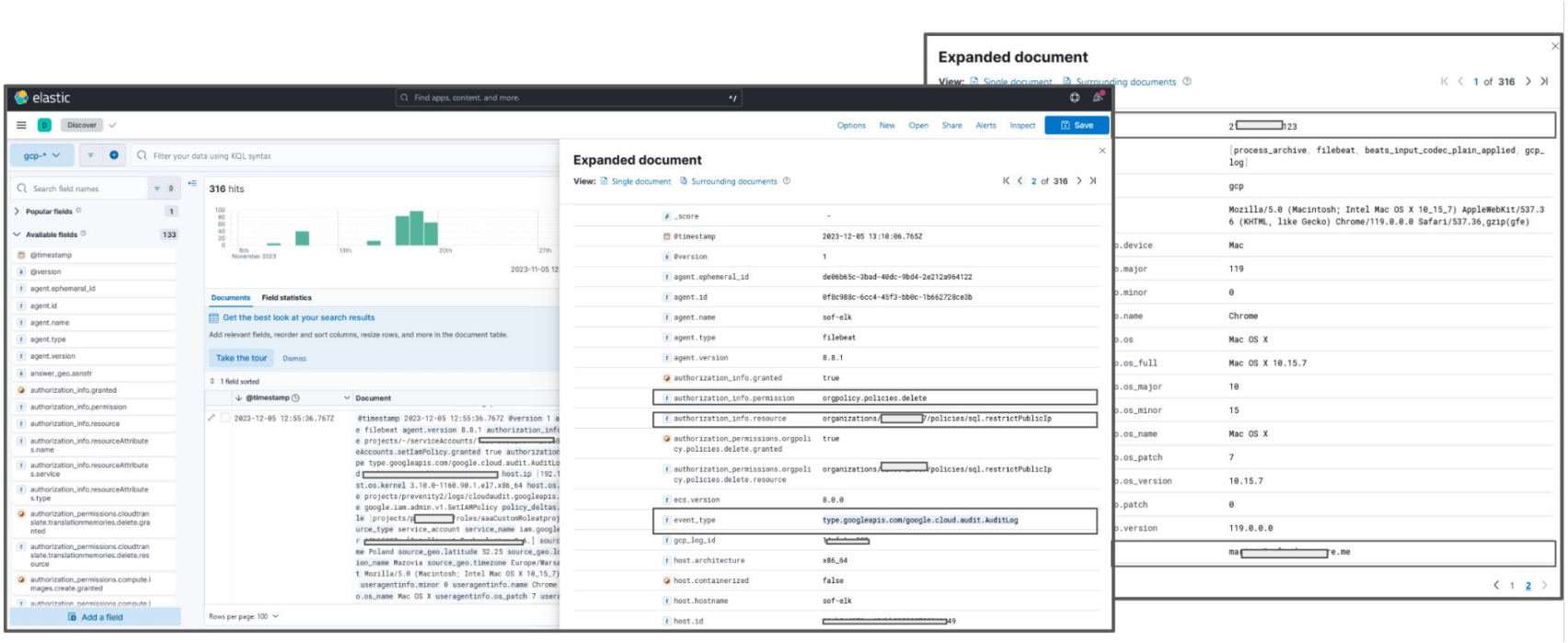
Date (UTC)	IP Address	User	Record type	Activity	Item	Admin Units	Detail
Feb 13, 2023 11:39 PM		app@sharepoint	SharePointFileOperation	Accessed file	WDX_0_80591.txt		Accessed from "IPML_WDX_0_25"
Feb 13, 2023 11:36 PM		app@sharepoint	SharePointFileOperation	Accessed file	WKC_3_4328036_1.txt		Accessed from "IPML_WKC_3_971"
Feb 13, 2023 11:34 PM		app@sharepoint	SharePointFileOperation	Accessed file	WKC_3_2501408_12.txt		Accessed from "IPML_WKC_3_505"
Feb 13, 2023 11:18 PM		app@sharepoint	SharePointFileOperation	Accessed file	WKC_3_1375754_2.txt		Accessed from "IPML_WKC_3_150"
Feb 13, 2023 11:06 PM		app@sharepoint	SharePointFileOperation	Accessed file	WKC_3_850620_13.txt		Accessed from "IPML_WKC_3_1401"
Feb 13, 2023 10:39 PM		app@sharepoint	SharePointFileOperation	Accessed file	WKC_3_4224876_1.txt		Accessed from "IPML_WKC_3_950"
Feb 13, 2023 9:54 PM		app@sharepoint	SharePointFileOperation	Accessed file	WKC_3_853448_2.txt		Accessed from "IPML_WKC_3_1401"
Feb 13, 2023 8:49 PM		app@sharepoint	SharePointFileOperation	Accessed file	WKC_3_3240581_16.txt		Accessed from "IPML_WKC_3_727"

CSV file contains AuditData

Azure - Entra Audit Logs Collection

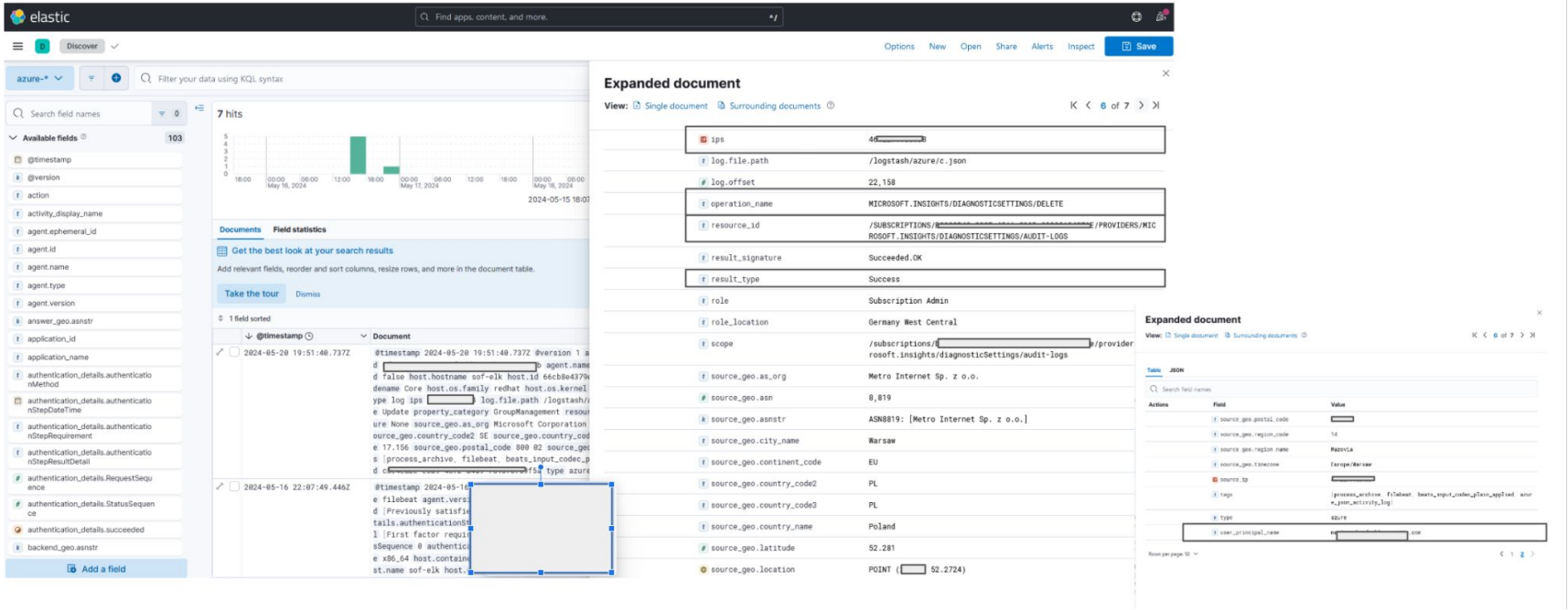


Analysis with SOF-ELK (GCP logs)

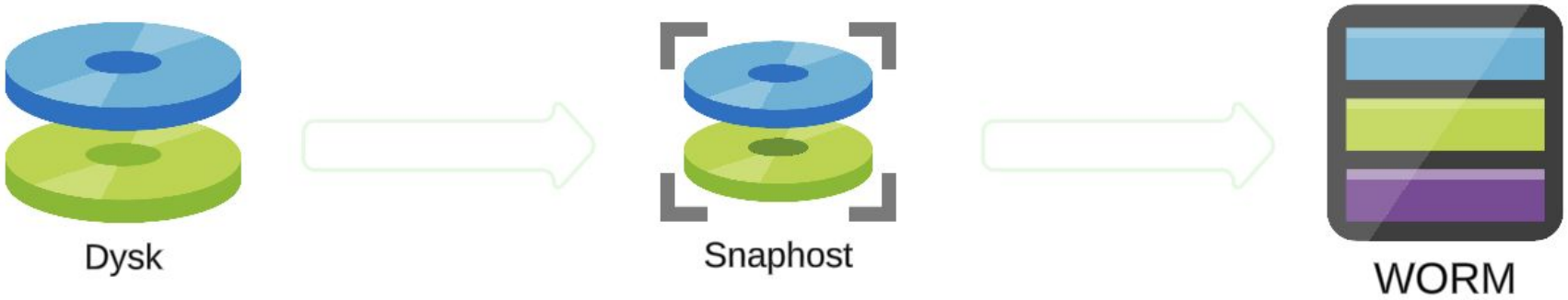


https://www.sans.org/tools/sof-elk/

Analysis with SOF-ELK (Azure logs)



VMs



Discussed scenario: Shutdown the VM and take a snapshot of each disk, but it is possible to take snapshot while the VM is running.

GCP - Compute Engine - image acquisition

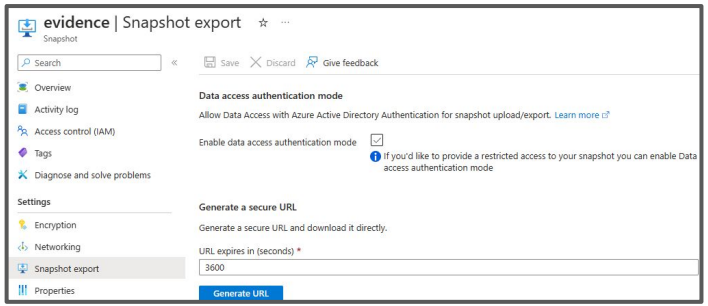
1. Enumerating all VM disks
    - gcloud compute instances describe <VM_NAME> –format=”table[disks](disks)”
2. Creating snapshot
    - gcloud compute disks snapshot <DISK_NAME> –snapshot-names=*evidence* –zone=<ZONE>
3. Creating image
    - gcloud compute images create *evidence-image* –source-snapshot=*evidence*
4. Exporting image to bucket
    - gcloud compute images export --destination-uri=gs://<BUCKET>/<NAME> --image=*evidence-image* --export-format=vmdk

GCP - Compute Engine - copy disk to bucket

1. Creating of temp disk (disk will be used to store evidence)
    - gcloud compute disks create temp-forensic-disk --size 40GB --zone=<ZONE>
2. Creating of new disk from original snapshot
    - gcloud compute disks create evidence-disk –source-snapshot=evidence –zone=<ZONE>
3. Setting up new (temporary) VM
    - gcloud compute instances create <VM_NAME> --scopes storage-ro --disk name=evidence-disk,device-name=evidence-disk--zone=<ZONE>
4. Adding disk from step 1(temp-forensic-disk) in RW mode
5. Configuration of temp disk and making copy of new disk
    - mkfs.ext4 -F /dev/disk/by-id/google-temp-forensic-disk
    - mount -o rw /dev/disk/by-id/google-temp-forensic-disk /mnt
    - dd if=/dev/<sdx> of=/mnt/<image> conv=sync,noerror
    - hash calculation (openssl sha256 <image>)
    - compression/conversion of evidence
6. Making copy of disk to bucket
    - gsutil cp <image> gs://<bucket-name>/<image>
7. Temporary sharing of image with sign-url feature of GCP
    - gcloud storage sign-url gs://<bucket-name/<image> –private-key-file=<privkey.json> –duration=20m

Azure - Virtual Machine - disk acquisition

1. Gathering metadata information about VM and disks (OsDisk and DataDisks)
    - $vm = Get-AzVM -ResourceGroupName <GROUP-NAME> -Name <VM-NAME>
    - $datadisk = Get-AzDisk -ResourceGroupName <GROUP-NAME> -DiskName $vm.StorageProfile.DataDisks.Name (in this example we will copy an additional data disk)
2. Snapshot configuration
    - $snapshotconfig = New-AzSnapshotConfig -SourceUri $datadisk.Id -CreateOption Copy -Location $vm.Location
3. Snapshot creation
    - New-AzSnapshot -ResourceGroupName <GROUP_NAME> -Snapshot $snapshotconfig -SnapshotName “evidence”
4. Export from Azure console



Azure - Virtual Machine - copy image to blob

Copying to Storage Account BLOB

1. Gathering Storage Account metadata
    - $targetstoragecontextblob = (Get-AzStorageAccount -ResourceGroupName <GROUP-NAME> -Name "<STORAGE-NAME>").Context
2. Gathering snapshot metadata
    - $snapshot = Get-AzSnapshot -ResourceGroupName <GROUP-NAME> -SnapshotName “evidence”
3. Temporary sharing of snapshot
    - $snapshotSasURL =Grant-AzSnapshotAccount -ResourceGroupName <GROUP-NAME> -SnapshotName $snapshot.Name -DurationInSecond 3600 -Access Read
4. Copying of snapshot to Storage Blob
    - Start-AzStorageBlobCopy -AbsoluteUri $snapshotSasUrl.AccessSAS -DestContainer <CONTAINER-NAME> -DestContext $targetstoragecontextblob -DestBlob "evidence-snapshot" -Force

Kubernetes forensics

- Creation of snapshot of disks attached to K8S nodes (as presented on previous slides)
- Mount node image (image contains containers but also logs from pods)
- Use Docker-explorer or Container-explorer (for GCP) in order to mount containers
- Docker-explorer shows image history:

```
de.py -r /mnt/root/var/lib/docker history
003fd5af7dcb0d8f84ecb49dbb5648a6e4626affa6c29417a2cf6cf7351bb2d6

{
   "sha256:7968321274dc6…": {
      "container_cmd": "/bin/sh -c #(nop)  CMD [\"sh\"]",
      "created_at : "2024-04-21T18:42:05.712133",
      "size" : 0
   }
   }
```

https://github.com/google/docker-explorer
https://github.com/google/container-explorer

Mounting container from GKE node - example

- Attach disk to VM in read only mode
- Identify disk
  - dmesg | grep sd
- Listing all partitions on disk
  - fdisk -l /dev/sdc

```
Device      Start      End  Sectors  Size Type
/dev/sdc1  8704000 104857566 96153567 45.9G Linux filesystem
…
```

- Mounting file system /dev/sdc1 as read only
  - mount -o ro,noload,noexec /dev/sdc1 /mnt
- Listing containers with use of container explorer
  - ./ce -i /mnt/part1/ --support-container-data supportcontainer.yaml list containers
- Mounting container
  - ./ce -i /mnt/part1 --support-container-data supportcontainer.yaml -n k8s.io mount 003fd5af7dcb0d8f84ecb49dbb5648a6e4626affa6c29417a2cf6cf7351bb2d6 /mnt/container/

Encrypted disks

GCP

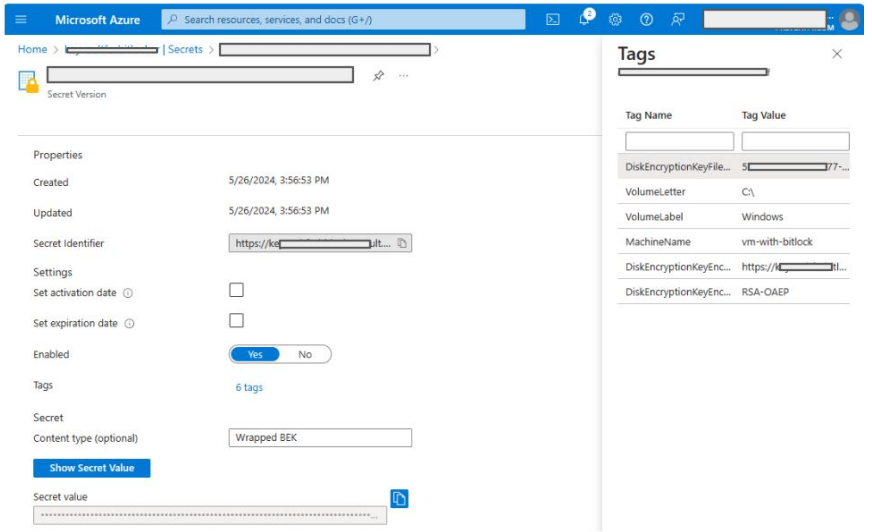
- Google managed encryption (at rest)
- Cloud KMS
  - KEK/DEK
  - CMEK
  - CSEK
- Snapshot points to KMS

Azure

- Azure Disk Storage Server-Side Encryption
  - Disk Encryption Set
- Encryption at host
- Azure Disk Encryption
  - Azure Key Vault stores Bitlocker encryption key (BEK) i DM-Crypt encryption key

BitLocker - decrypting disk

- **Check whether volumes are encrypted**
  - Get-AzVmDiskEncryptionStatus -ResourceGroupName <NAME> -VMName <NAME>
- **Collect metadata about encrypted disk**
  - $disk = Get-AzDisk -ResourceGroupName <GROUP-NAME> -DiskName <DISK-NAME>
- **Retrieve BitLocker Encryption Key URL**
  - $BEKurl = echo $disk.EncryptionSettingsCollection.EncryptionSettings.DiskEncryptionKey.SecretUrl
- **Retrieve Key Encryption Key URL**
  - $KEKurl = Get-AzKeyVaultKey -VaultName <NAME> -Name <KEYNAME>
- **Unwrap (decrypt) BitLocker Encryption Key**
  - *unwrapbek.ps1 $BEKurl $KEKurl $recoverykey (output)
- **Mount and unlock volume**
  - manage-bde -unlock <drive> -RecoveryKey <recoverykey>



*https://github.com/Prevenity/Azure-Cloud-Security

Preparation of forensic environment in cloud

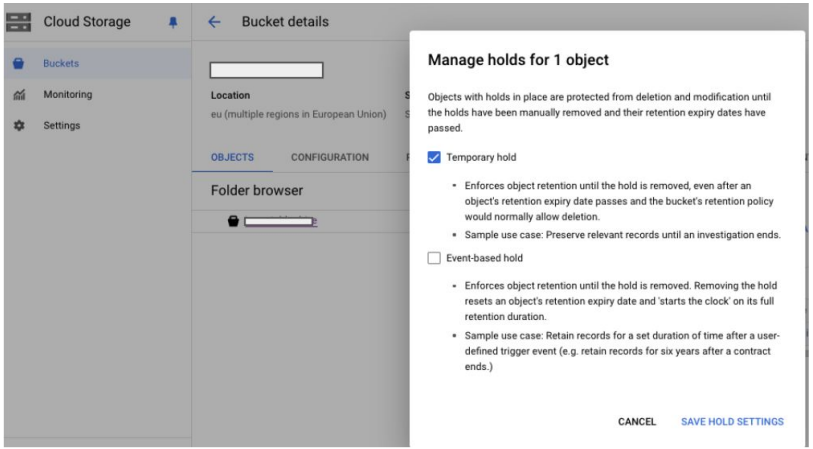
- Evidence protection
- Data integrity verification
- Microsoft Azure and Google Cloud Platform reference architectures

Immutable storage

GCP

Lifecycle Management

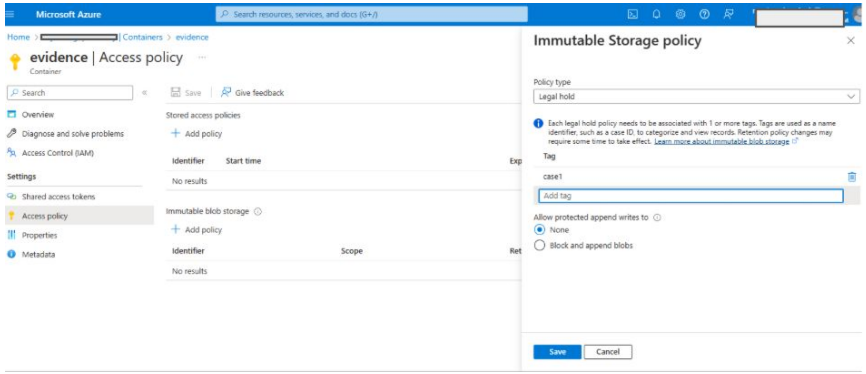
Manage Holds



Azure

Lifecycle Management

Legal Hold



Automation - handling images

Operations which can be performed remotely

- Compression (valuable due to image size)
- hash calculation
- conversion of images - e01, vmdk, vhd, EWF.

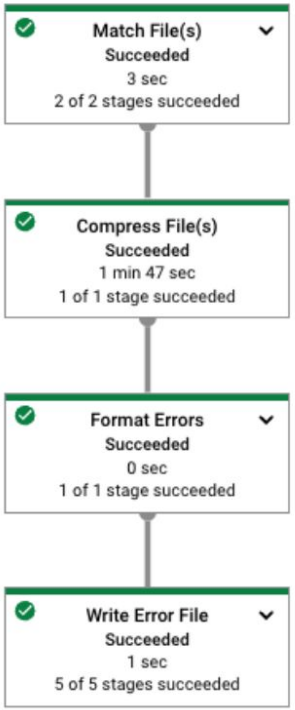
GCP

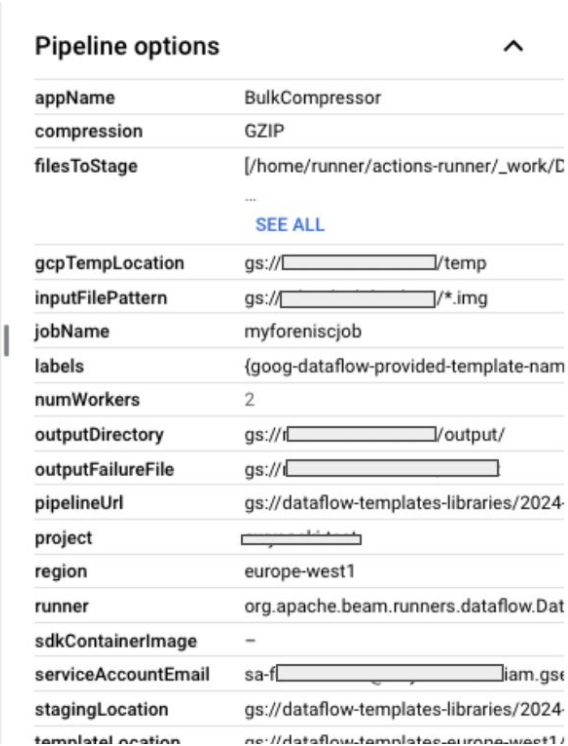
- Cloud Function
- Cloud Dataflow

Azure

- Azure Function
- Data Factory
- Azure Automation

Cloud Dataflow example - image compression





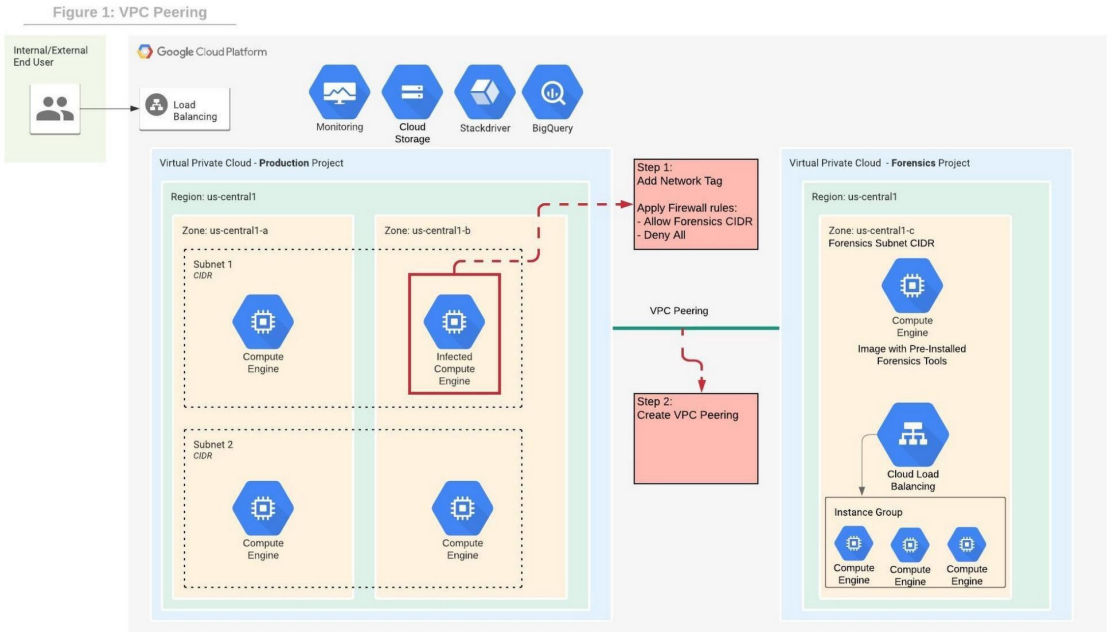
Reference Forensic Architecture for GCP

Incident response process:

Step 1: Isolation of MV

Step 2: enabling access between forensic VM and infected VM

Step 3: Manual seizing of disks and RAM (optional)



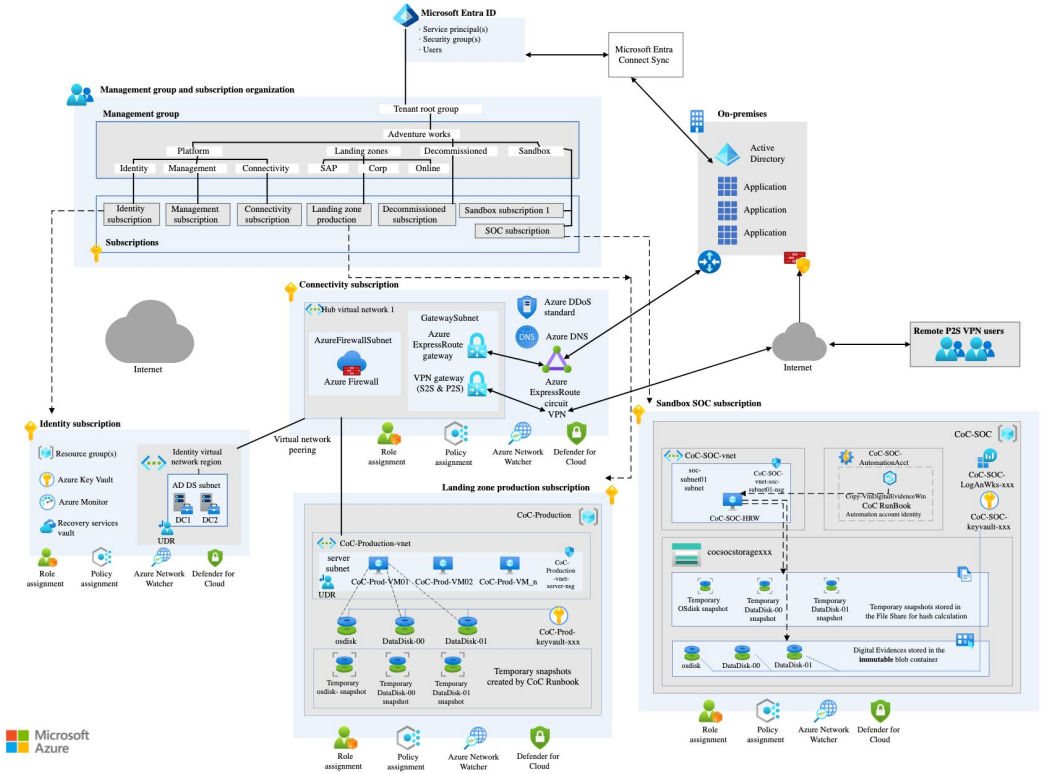
https://cloud.google.com/blog/products/identity-security/how-to-use-live-forensics-to-analyze-a-cyberattack

Reference Forensic Architecture for AZURE

Incident response process:

Step 1: Execution of Copy-VmDigitalEvidence runbook with use of Automation - runbook worker (VM). Script is copying BEK key.

Step 2: Manual seizing of RAM (optional)



https://learn.microsoft.com/en-us/azure/architecture/example-scenario/forensics

Cloud Forensics - common issues

- Insufficient permissions
  - GCP -> roles/logging.privateLogViewer
  - Azure -> Key Vault Secrets User
- Constraint Policies
  - GCP -> Organization policy constraints (for example trusted image projects)
- Images/snapshots/disks are stored in different locations
- Limitation related to some cloud features (for example azure functions limits related to size of processed files with powershell)
- Firewall rules blocking access to VMs

References

https://learn.microsoft.com/en-us/entra/identity/monitoring-health/

https://learn.microsoft.com/en-us/entra/identity/monitoring-health/concept-audit-logs

https://microsoft-365-extractor-suite.readthedocs.io/en/latest/

https://cloud.google.com/logging/docs/routing/overview

https://www.sans.org/tools/sof-elk/

https://github.com/google/docker-explorer

https://github.com/google/container-explorer

https://github.com/Prevenity/Azure-Cloud-Security

https://cloud.google.com/blog/products/identity-security/how-to-use-live-forensics-to-analyze-a-cyberattack

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Thank you.