

DISTRIBUTED AND CLOUD COMPUTING

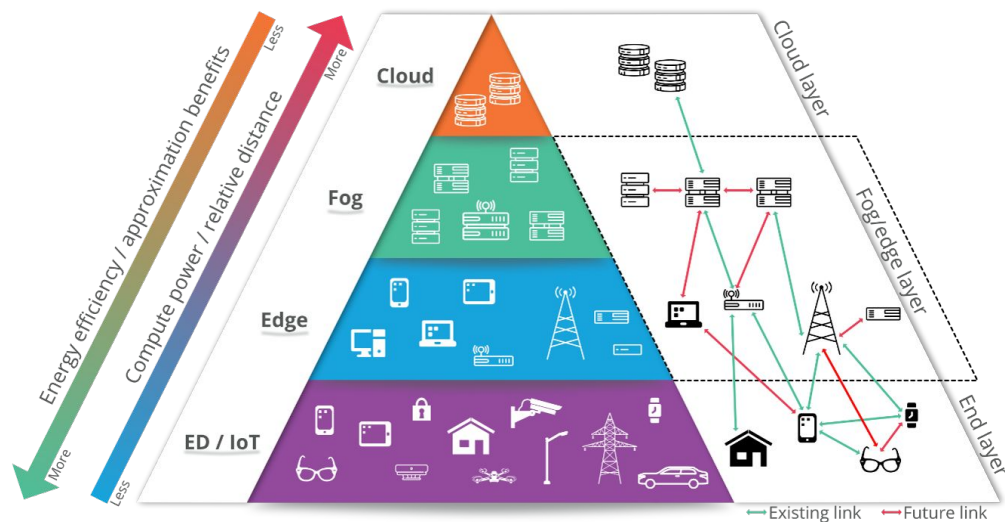
LAB 14: CLOUD BASICS + IAC

(Module: K8S & CLOUD BASICS)





Cloud Computing

- “A paradigm for enabling **network access** to a scalable and **elastic pool** of **shareable** physical or virtual resources with **self-service** provisioning and administration **on-demand**.”
- 5 Essential Characteristics (by INST):
 - On-demand self-service**
 - Provision as needed
 - Automatic provisioning
 - Broad network access**
 - Heterogeneous clients
 - Resource pooling**
 - Serve multiple clients
 - Rapid elasticity**
 - “Unlimited” resources
 - Measured service**
 - Monitoring for optimization
- Future: End-Edge-Cloud Hierarchy



Cloud Providers

- “A CSP (cloud service provider) is a third-party company that provides scalable computing resources that businesses can access on demand over a network, including cloud-based compute, storage, platform, and application services.”
- Common Providers:
 - [Amazon Web Services \(AWS\)](#) 
 - [Google Cloud Platform \(GCP\)](#)  Google Cloud
 - [Microsoft Azure \(AZR\)](#) 
 - In China:
 - [Alibaba Cloud](#)  Alibaba Cloud
 - [Tencent Cloud](#)  Tencent Cloud
 - [Huawei Cloud](#)  HUAWEI
 - ...



Cloud Service Models

- **Infrastructure as a Service (IaaS)**
 - “on-demand access to cloud-hosted physical and virtual servers, storage and networking”
- **Platform as a Service (PaaS)**
 - “on-demand access to a complete, ready-to-use, cloud-hosted platform for developing, running, maintaining and managing applications”
- **Software as a Service (SaaS)**
 - “on-demand access to ready-to-use, cloud-hosted application software”
- ... (FaaS, CaaS, KaaS, etc.)

Cloud Computing Models



Common Cloud Services

Identity & Access Management (IAM)

- “The user has a responsibility and is allowed to perform these operations on these resources.”
- General Concept

- **Principal/Identity**

- User accounts
- Service accounts
- [OIDC identity providers](#)
- ...

- **Role**

- collection of permissions

- Example

- [AWS IAM](#)
- [Google Cloud IAM](#)
- [Microsoft Entra ID](#)



AWSServiceRoleForEC2Spot info
Default EC2 Spot Service Linked Role

Summary

Creation date

Last activity

ARN
arn:aws:iam:::role/aws-service-role/ec2-spot.amazonaws.com/AWSServiceRoleForEC2Spot
Maximum session duration
1 hour

Permissions

Trust relationships

Tags

Last Accessed

Permissions policies (1) info

Search Filter by Type
All types

Policy name	Type	Attached entities
AWSEC2SpotServiceRolePolicy	AWS managed	1

AWSEC2SpotServiceRolePolicy
Allows EC2 Spot to launch and manage spot instances

```

1 {
2   "Version": "2012-10-17",
3   "Statement": [
4     {
5       "Effect": "Allow",
6       "Action": [
7         "ec2:DescribeInstances",
8         "ec2:StartInstances",
9         "ec2:StopInstances",
10        "ec2:RunInstances"
11      ],
12       "Resource": [
13        "*"
14      ]
15     },
16     {
17       "Effect": "Deny",
18       "Action": [
19        "ec2:RunInstances"
20      ]
21     }
22   ]
23 }
```

Copy JSON

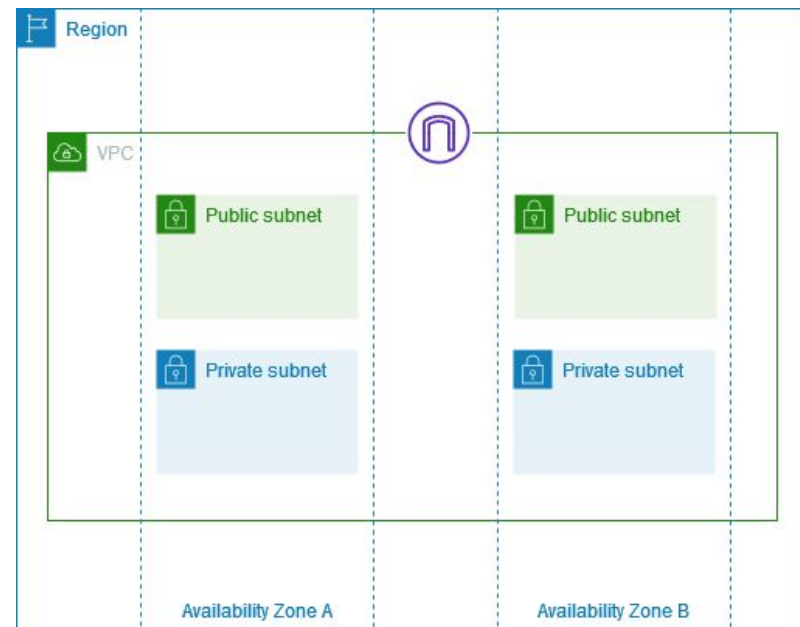
https://cloud.google.com/iam/docs/overview#how_cloud_iam_works

<https://k21academy.com/amazon-web-services/aws-identity-and-access-management-iam/>

Common Cloud Services

Networking

- Pre-requisites (configured by cloud providers)
 - **Region:** independent geographic areas that consist of zones.
 - **Availability Zone (AZ):** deployment area housed in physical data centers.
- **Virtual Private Cloud (VPC)**
 - A logically isolated virtual network.
 - **Subnet:** a range of IP addresses in a VPC.
 - **Public Subnet:** possesses a route to an internet gateway in a route table.
 - **Private Subnet**
 - Example
 - [AWS VPC](#)
 - [Google VPC](#)
 - [Azure Virtual Network](#)



VPC - required | Info

Tokyo **ap-northeast-1** (default) ▼

vpc-0 7b
172.31.0.0/16

Subnet | Info

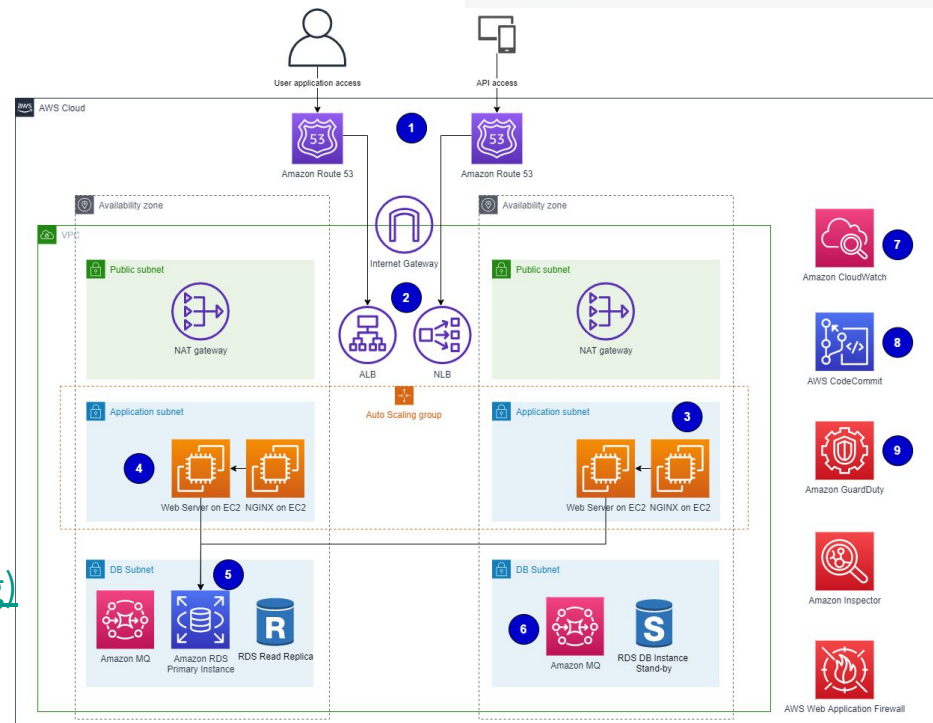
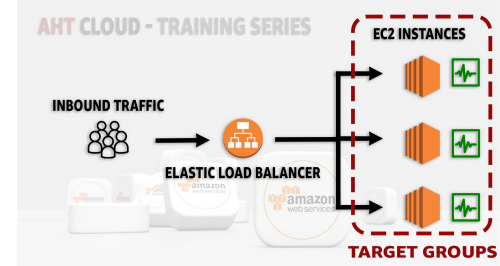
subnet-0 43
VPC: vpc-0 7b Owner:
Availability Zone: ap-northeast-1c Zone type: Availability Zone
IP addresses available: 4091 CIDR: 172.31.0.0/20

<https://cloud.google.com/compute/docs/regions-zones>
<https://docs.aws.amazon.com/vpc/latest/userguide/configure-subnets.html>
<https://docs.aws.amazon.com/vpc/latest/userguide/how-it-works.html#how-it-works-subnet>

Common Cloud Services

Networking

- Pre-requisites
 - **Region**
 - **Availability Zone (AZ)**
- **Virtual Private Cloud (VPC)**
- **DNS**
 - Example
 - [AWS Route 53](#)
 - [Google Cloud DNS](#)
 - [Azure DNS](#)
- **Load Balancing**
 - Example
 - [AWS ELB \(Elastic Load Balancing\)](#)
 - [Google Cloud Load Balancing](#)
 - [Azure Load Balancer](#)



<https://www.ahtcloud.com/what-is-elastic-load-balancing>

<https://aws.amazon.com/blogs/architecture/how-munich-re-automation-solutions-ltd-built-a-digital-insurance-platform-on-aws/>

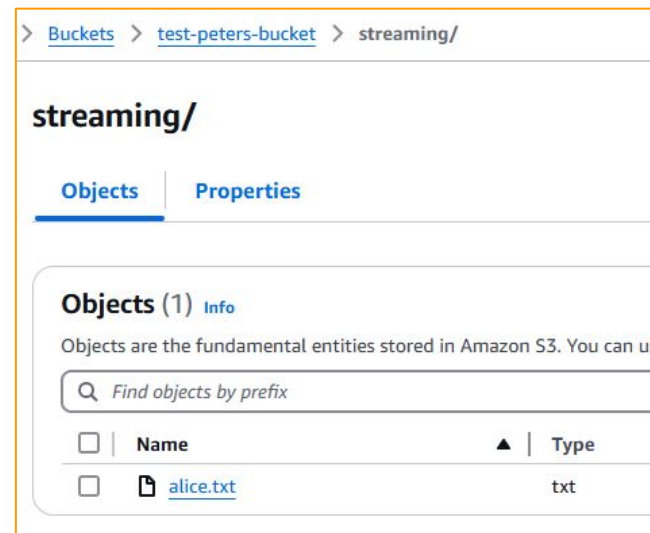
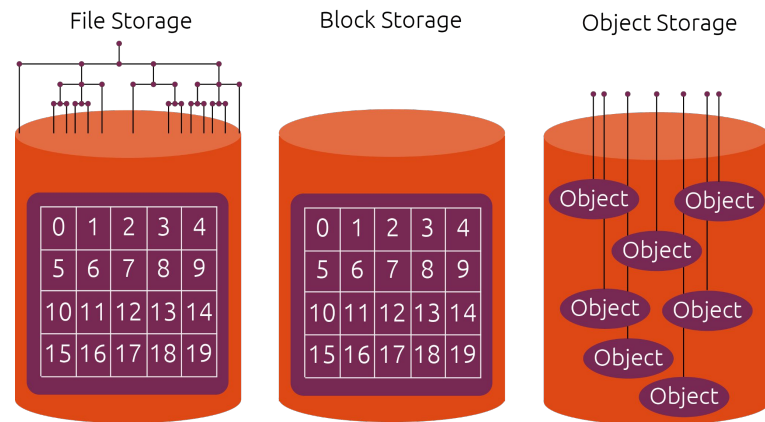
Common Cloud Services

Object Storage

- “[Object Storage](#) stores and manages data in an **unstructured** format called **objects**.”
- High throughput for large & durable data transfer.
- Example
 - [AWS S3 \(Simple Storage Service\)](#)
 - [GCS \(Google Cloud Storage\)](#)
 - [Azure Blob Storage](#)

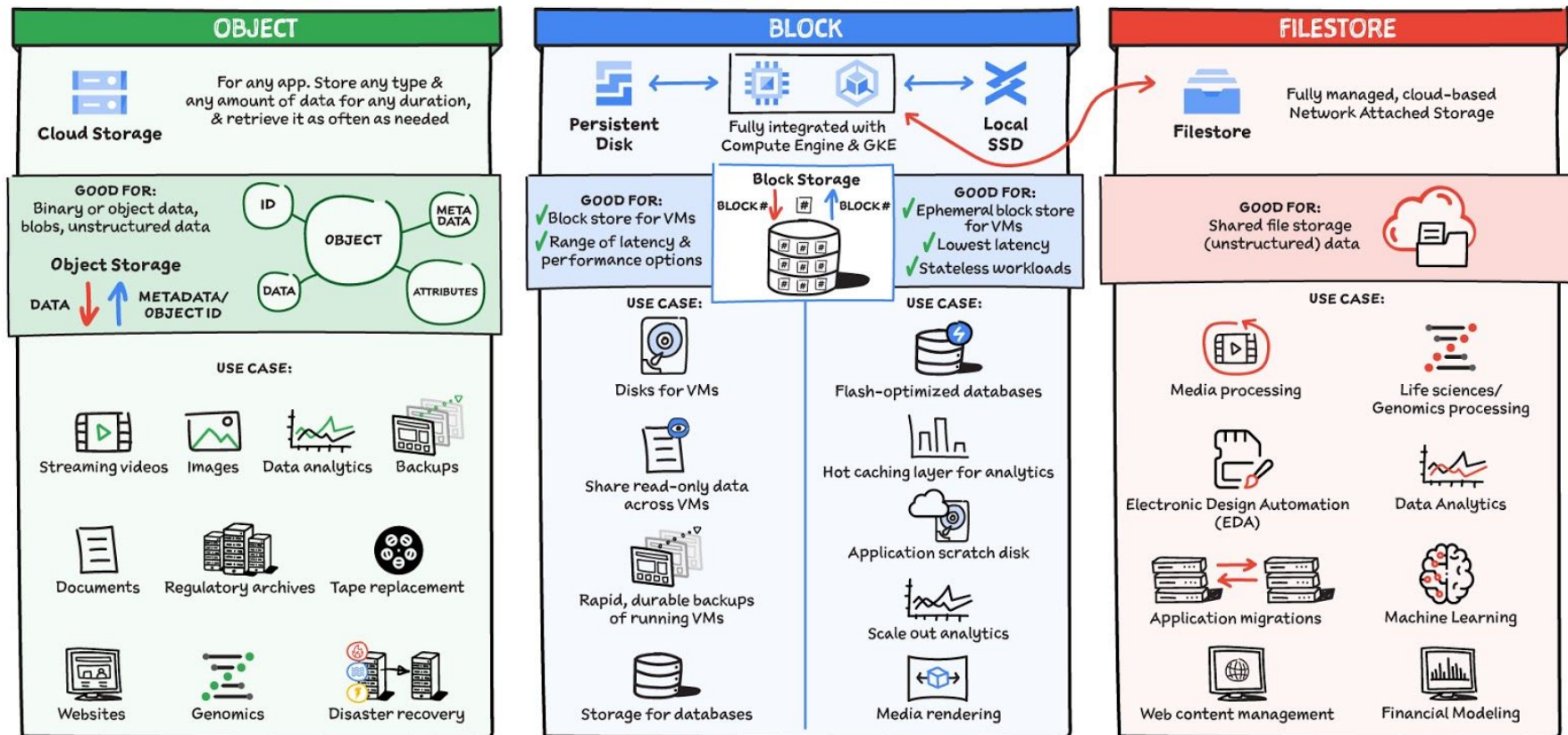
Block Storage

- “[Block Storage](#) stores data **blocks** in a manner that is optimized for fast access and retrieval.”
- High IOPS & low latency for transactions.
- Example
 - [AWS EBS \(Elastic Block Store\)](#)
 - [Google Persistent Disk](#)
 - [Azure Managed Disks](#)





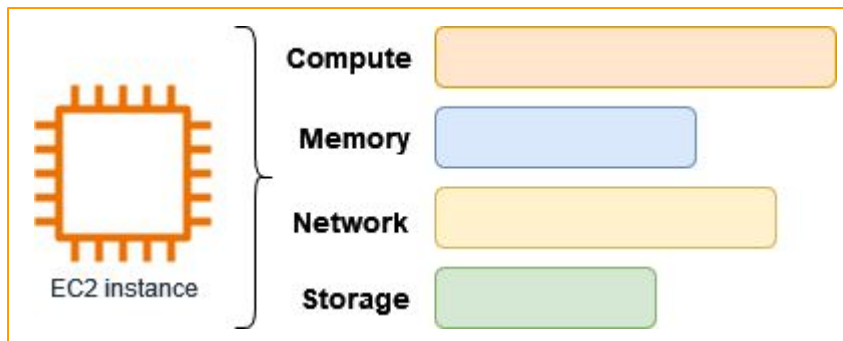
Which Storage Should I Use?



Common Cloud Services

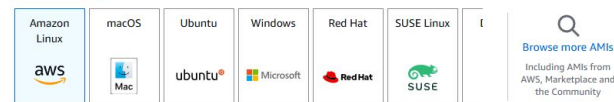
Compute

- A virtual machine (VM) as a compute instance.
- Uses **Block Storage** as “Volume”.
- Use **VPC** for networking.
- Example
 - [AWS EC2 \(Elastic Compute Cloud\)](#)
 - [GCE \(Google Compute Engine\)](#)
 - [Azure VMs](#)

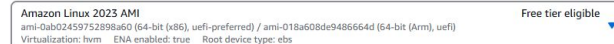


▼ Application and OS Images (Amazon Machine Image) [Info](#)

Quick Start

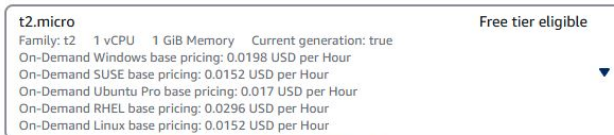


Amazon Machine Image (AMI)



▼ Instance type [Info](#) | [Get advice](#)

Instance type



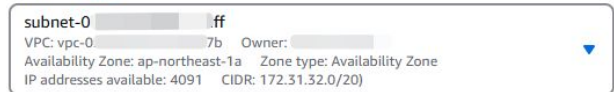
Additional costs apply for AMIs with pre-installed software

▼ Network settings [Info](#)

VPC - required [Info](#)



Subnet [Info](#)



▼ Configure storage [Info](#)

1x GiB Root volume (Not encrypted)

① Free tier eligible customers can get up to 30 GB of EBS General Purpose (SSD) or Magnetic storage

Common Cloud Services

Container Orchestration

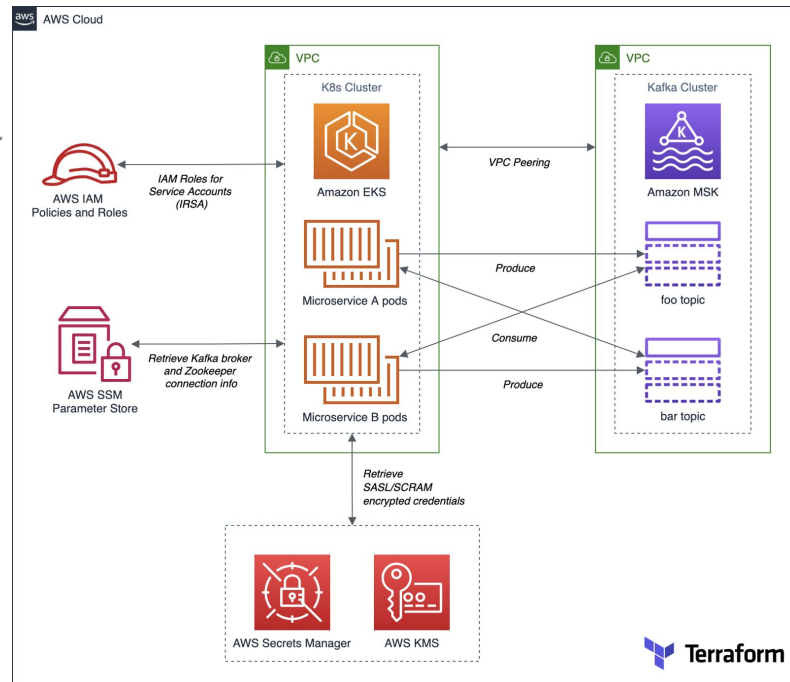
- **Kubernetes as a Service (KaaS)**

- Implements the Cloud Controller Manager component from Kubernetes control plane.
 - E.g., interact with EC2, ELB, EBS.
- Example
 - [AWS EKS \(Elastic Kubernetes Service\)](#)
 - [GKE \(Google Kubernetes Engine\)](#)
 - [AKS \(Azure Kubernetes Service\)](#)

Serverless Compute

- **Function as a Service (FaaS)**

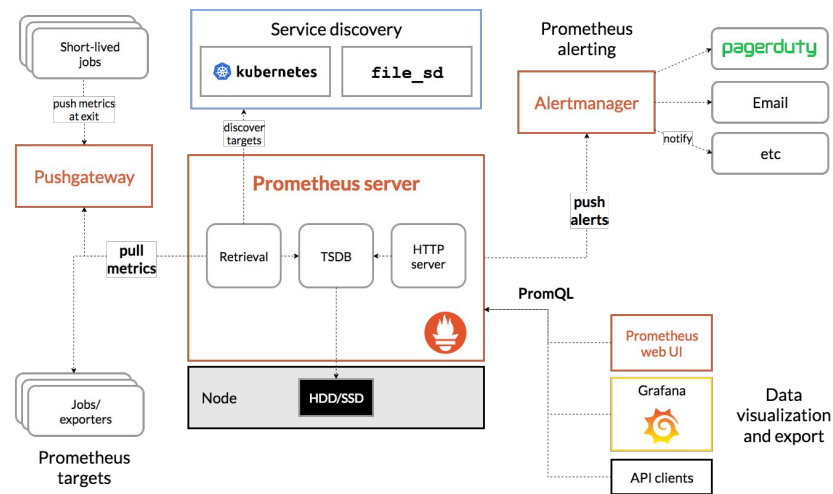
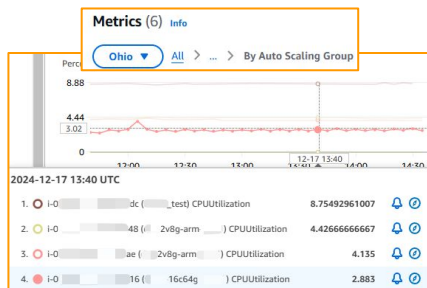
- Build & run apps without managing servers.
- Example
 - [AWS Lambda](#)
 - [Google Cloud Run Functions](#)
 - [Azure Functions](#)



Monitoring & Logging

- Remember the **Measured Service** characteristic of Cloud Computing?
 - Monitor resources for automated **optimizations**.
 - For Kubernetes, we have Prometheus.
 - In AWS → AMP (Managed Prometheus)
 - Cloud providers also have their own solutions.
 - Example
 - AWS CloudWatch
 - Google Cloud's Observability
 - Azure Monitor
- Log events

You can use the filter



You can use the filter bar below to search for and match terms, phrases, or values in your log events. [Learn more about filter patterns](#)

Q

Filter events - press enter to search

Clear

1m

30m

1h

12h

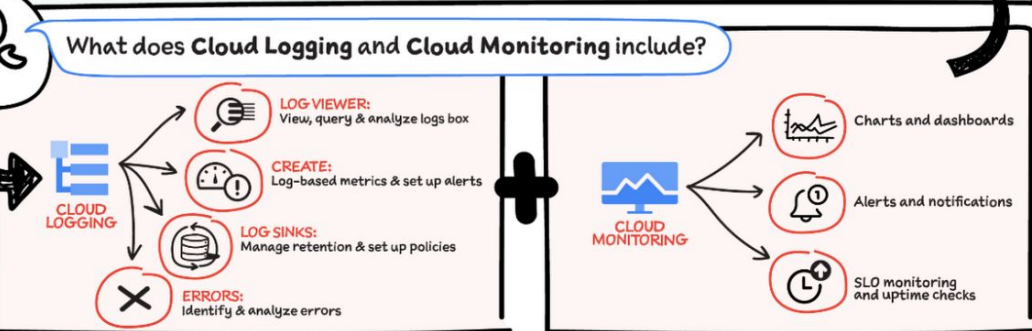
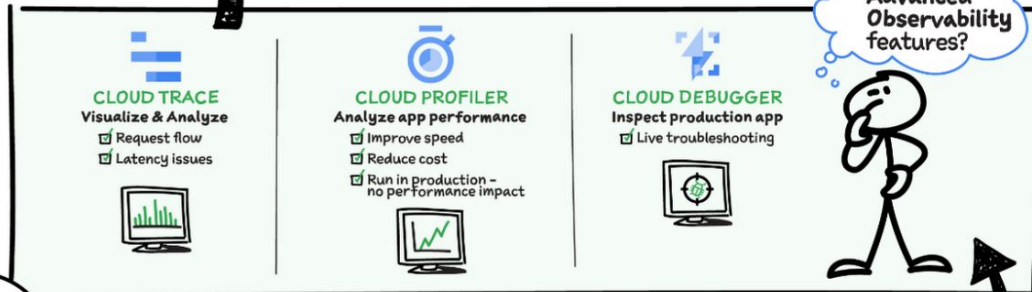
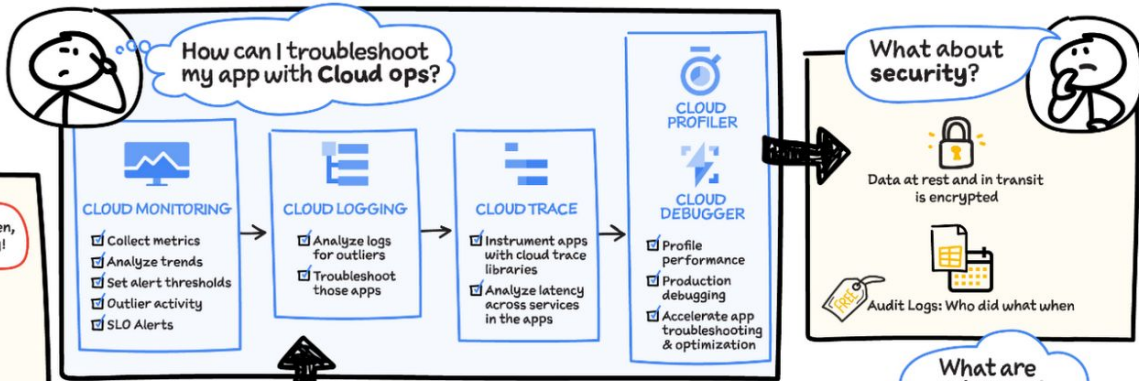
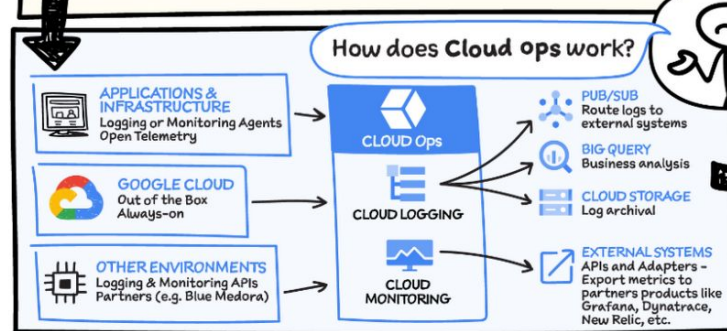
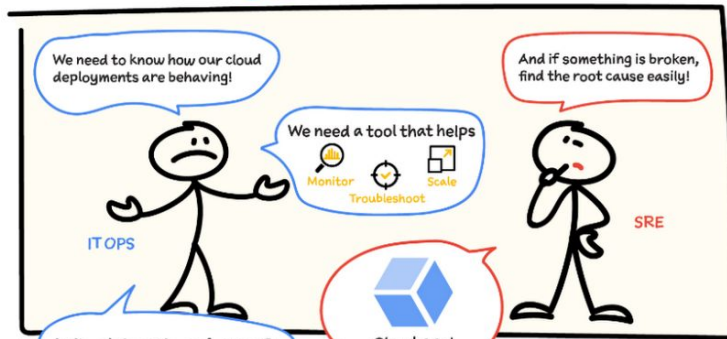
Custom

Local timezone

Display

▶	2023-08-31T06:00:19.492+08:00	INIT_START Runtime Version: python:3.10.v10 Runtime Version ARN: arn:aws:lambda:us-east-2::runtime:8	1
▶	2023-08-31T06:00:19.720+08:00	START RequestId: 0 f8 Version: \$LATEST	
▶	2023-08-31T06:00:19.898+08:00	[INFO] 2023-08-30T22:00:19.897Z 0 f8 Found credentials in environment variables.	
▶	2023-08-31T06:00:20.737+08:00	[INFO] 2023-08-30T22:00:20.737Z 0 f8 Handling region "us-east-1".	
▶	2023-08-31T06:00:22.296+08:00	[INFO] 2023-08-30T22:00:22.296Z 0 f8 [ROUND 1]	
▶	2023-08-31T06:00:22.296+08:00	[INFO] 2023-08-30T22:00:22.296Z 0 f8 Scanning for leaked volumes...	
▶	2023-08-31T06:00:23.599+08:00	[INFO] 2023-08-30T22:00:23.598Z 0 f8 Found 141 volumes: ["vol-0", "vol-16", "vol-17", "vol-18", "vol-19", "vol-20", "vol-21", "vol-22", "vol-23", "vol-24", "vol-25", "vol-26", "vol-27", "vol-28", "vol-29", "vol-30", "vol-31", "vol-32", "vol-33", "vol-34", "vol-35", "vol-36", "vol-37", "vol-38", "vol-39", "vol-40", "vol-41", "vol-42", "vol-43", "vol-44", "vol-45", "vol-46", "vol-47", "vol-48", "vol-49", "vol-50", "vol-51", "vol-52", "vol-53", "vol-54", "vol-55", "vol-56", "vol-57", "vol-58", "vol-59", "vol-60", "vol-61", "vol-62", "vol-63", "vol-64", "vol-65", "vol-66", "vol-67", "vol-68", "vol-69", "vol-70", "vol-71", "vol-72", "vol-73", "vol-74", "vol-75", "vol-76", "vol-77", "vol-78", "vol-79", "vol-80", "vol-81", "vol-82", "vol-83", "vol-84", "vol-85", "vol-86", "vol-87", "vol-88", "vol-89", "vol-90", "vol-91", "vol-92", "vol-93", "vol-94", "vol-95", "vol-96", "vol-97", "vol-98", "vol-99", "vol-100", "vol-101", "vol-102", "vol-103", "vol-104", 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<https://prometheus.io/docs/introduction/overview/#architecture>



Infrastructure as Code

- “**Infrastructure as Code (IaC)** is the managing and provisioning of infrastructure through code instead of through manual processes.”
- **Declarative (preferred)** vs. Imperative IaC
- Benefits
 - a. Reduced **cost**, **time**, and **risk** of deployments.
 - b. Eliminates configuration drift to ensure **infrastructure consistency**.
- Common IaC Tools
 - a. Helm: manages **K8s apps** using **Charts** as config/template
 - b. Terraform: for now one of the most popular IaC tools
 - c. OpenTofu: an **open-source** fork of Terraform
 - d. Cloud Solutions
 - AWS CloudFormation
 - Google Cloud Deployment Manager
 - Azure Resource Manager
 - e. ...

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: mychart-configmap
data:
  myvalue: "Hello World"
```



HashiCorp

Terraform



OpenTofu

Helm Chart

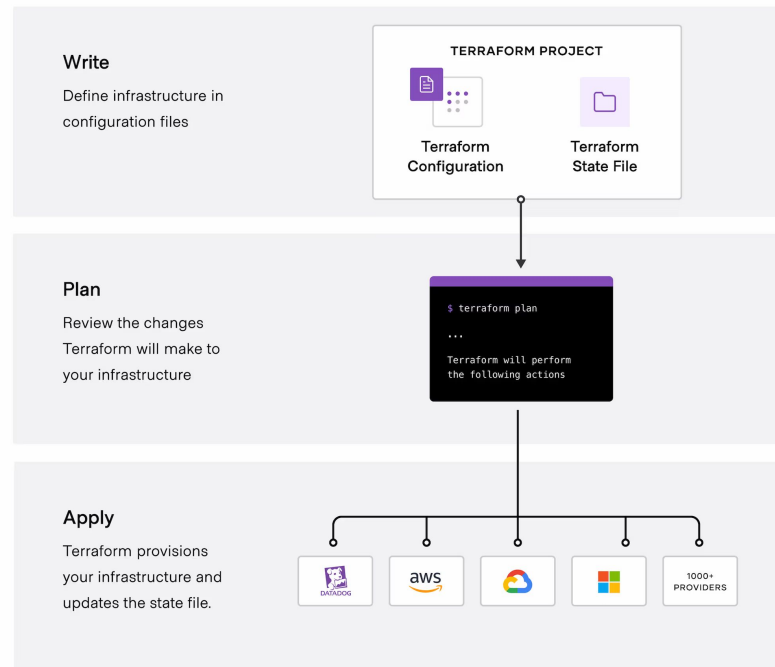
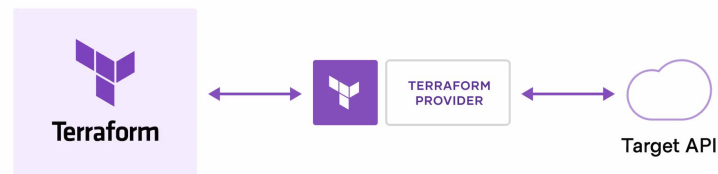


```
apiVersion: v1
kind: ConfigMap
metadata:
  name: {{ .Release.Name }}-configmap
data:
  myvalue: "Hello World"
```



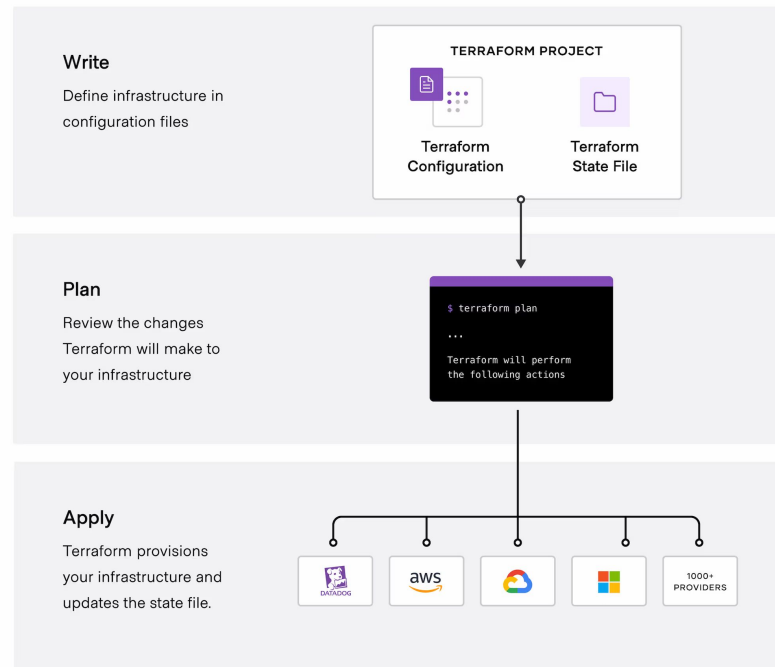
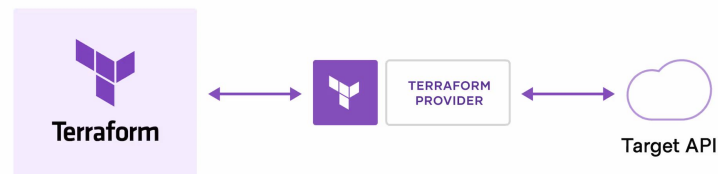
Terraform as an IaC Tool

- Developed by [HashiCorp](#).
- Workflow Stages: Write → Plan → Apply
- Features:
 1. **Manages any infrastructure**
 - a. Multi-cloud / hybrid cloud / on-premise
 - b. [Provider](#): plugins to interact with cloud providers, SaaS providers, etc.
 - c. [Terraform Registry](#): central repository for provider & module sharing.
 2. **Drift Detection & Management**
 - a. [Drift](#): difference between the real-world infrastructure state & the state defined in the configuration files.
 - b. [State](#): stores the current infrastructure state in a state file.



Terraform as an IaC Tool

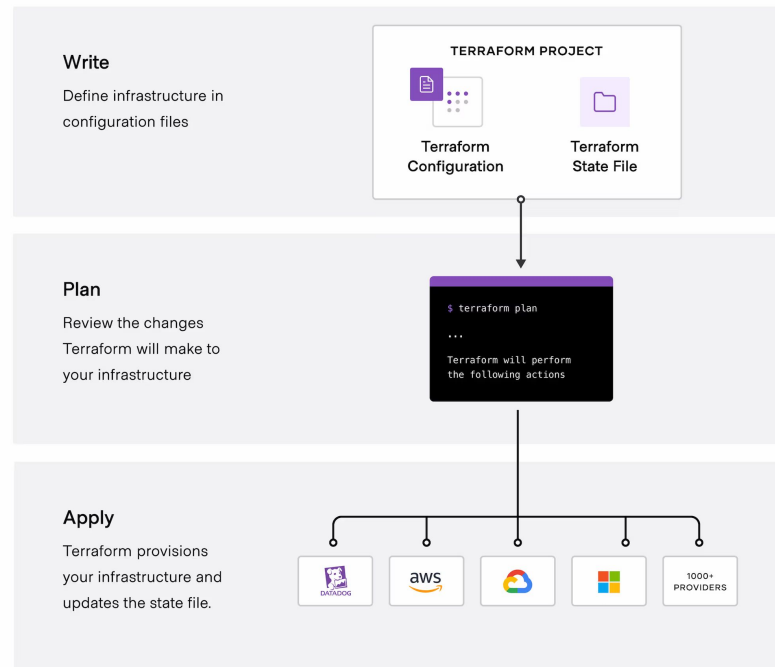
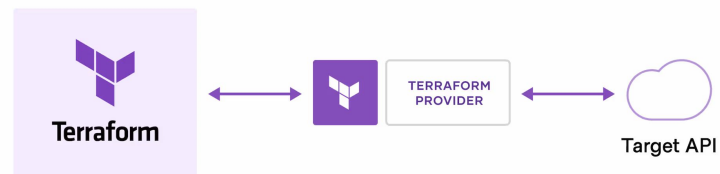
- Developed by [HashiCorp](#).
- Workflow Stages: Write → Plan → Apply
- Features:
 1. **Manages any infrastructure**
 2. **Drift detection & management**
 3. **Automated efficient changes**
 - a. Declarative `.tf` configuration files using the [Terraform Language](#).
 - b. [Resource graph](#) for resource dependency determination.
 - c. Handles independent resources [in parallel](#).
 4. **Standardizes configurations**
 - a. Declarative `.tf` configuration files using the [Terraform Language](#).
 - b. [Modules](#) as reusable components.



Terraform as an IaC Tool

- Developed by [HashiCorp](#).
- Workflow Stages: Write → Plan → Apply
- Features:
 1. Manages any infrastructure
 2. Drift detection & management
 3. Automated efficient changes
 4. Standardizes configurations
 5. Supports VCS & Collaboration
 - a. IaC: infrastructure config as code files
 - b. State - states are also stored in state files
 - c. [State Locking](#) - locks the state file to prevent concurrent writes

We currently have no money to play with the cloud providers, but we can try a local file demo to at least understand how Terraform works...



TASK: Terraform

Note how the states are maintained and how state locking is performed.

Use Terraform to manage a local file.

> Reference codebase: `iac_tf_local`

1. Install [Terraform CLI](#).
2. Check the `.tf` configuration files in the `dncc_file/` folder.
 - This folder is considered as a Terraform module.
 - All these `.tf` files (names do not matter) will be executed by Terraform.
 - It contains the provider specification, the local file configuration, as well as the input & output formats.
 - The `terraform.tfvars` file sets the values of the input variables specified in the configurations.
3. Initialize the Terraform module: `terraform init`
4. Apply the module and confirm changes: `terraform apply`
5. The file will be created at the expected path. Now manually modify the file and apply again to check drift detection.
6. Clean up the resources after testing: `terraform destroy`
7. (*) Try the [official tutorials](#) (e.g., AWS) if available.

```
Initializing the backend...
Initializing provider plugins...
- Finding hashicorp/local versions matching "2.5.2"...
- Installing hashicorp/local v2.5.2...
- Installed hashicorp/local v2.5.2 (signed by HashiCorp)
Terraform has created a lock file .terraform.lock.hcl to record the provider
selections it made above. Include this file in your version control repository
so that Terraform can guarantee to make the same selections by default when
you run "terraform init" in the future.
```

Terraform has been successfully initialized!

You may now begin working with Terraform. Try running "terraform plan" to see any changes that are required for your infrastructure. All Terraform commands should now work.

If you ever set or change modules or backend configuration for Terraform, rerun this command to reinitialize your working directory. If you forget, other commands will detect it and remind you to do so if necessary.

```
cd dncc_file/; terraform apply

Terraform used the selected providers to generate the following execution plan. Resource actions
+ create

Terraform will perform the following actions:

# local_file.my_file will be created
+ resource "local_file" "my_file" {
  + content      = "Hello dncc. This is Terraform!"
  + content_base64sha256 = (known after apply)
  + content_base64sha512 = (known after apply)
  + content_md5   = (known after apply)
  + content_sha1  = (known after apply)
  + content_sha256 = (known after apply)
  + content_sha512 = (known after apply)
  + directory_permission = "0777"
  + file_permission    = "0777"
  + filename          = "../dncc_folder/configured_dncc_file"
  + id                = (known after apply)
}

Plan: 1 to add, 0 to change, 0 to destroy.

Changes to Outputs:
+ path = "../dncc_folder/configured_dncc_file"

Do you want to perform these actions?
  Terraform will perform the actions described above.
  Only 'yes' will be accepted to approve.

  Enter a value: yes

local_file.my_file: Creating...
local_file.my_file: Creation complete after 0s [id=d5657c22e81212273b0e425892ca84c33487f046]

Apply complete! Resources: 1 added, 0 changed, 0 destroyed.

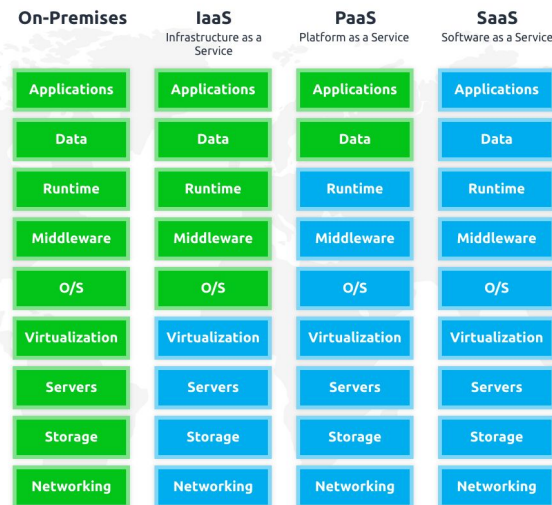
Outputs:
path = "../dncc_folder/configured_dncc_file"
```

Summary

- **5 Essential Cloud Computing Characteristics**
 - a. On-demand self-service
 - b. Broad network access
 - c. Resource pooling
 - d. Rapid elasticity
 - e. Measured service
- **Common Cloud Providers:** AWS, GCP, AZR, ...
- **Cloud Service Model:** IaaS vs. PaaS vs. SaaS
- **Common Cloud Services:**
 - a. IAM
 - b. Networking: VPC, DNS, Load Balancing
 - c. Object Storage vs. Block Storage
 - d. Compute & Serverless Compute
 - e. Container Orchestration
 - f. Monitoring & Logging
- **IaC:** Helm, Terraform, OpenTofu, ...

That's all for the K8s & Cloud Basics lab!

Cloud Computing Models



aws partner network

VEEAM
CSP PARTNER
Gold

VMWARE
CLOUD
VERIFIED

You Manage

Provider Manages