

Google Certified Associate Cloud Engineer

Getting Started

In 28
Minutes



Compute Engine



Cloud Functions



Cloud Run



Cloud SQL



App Engine



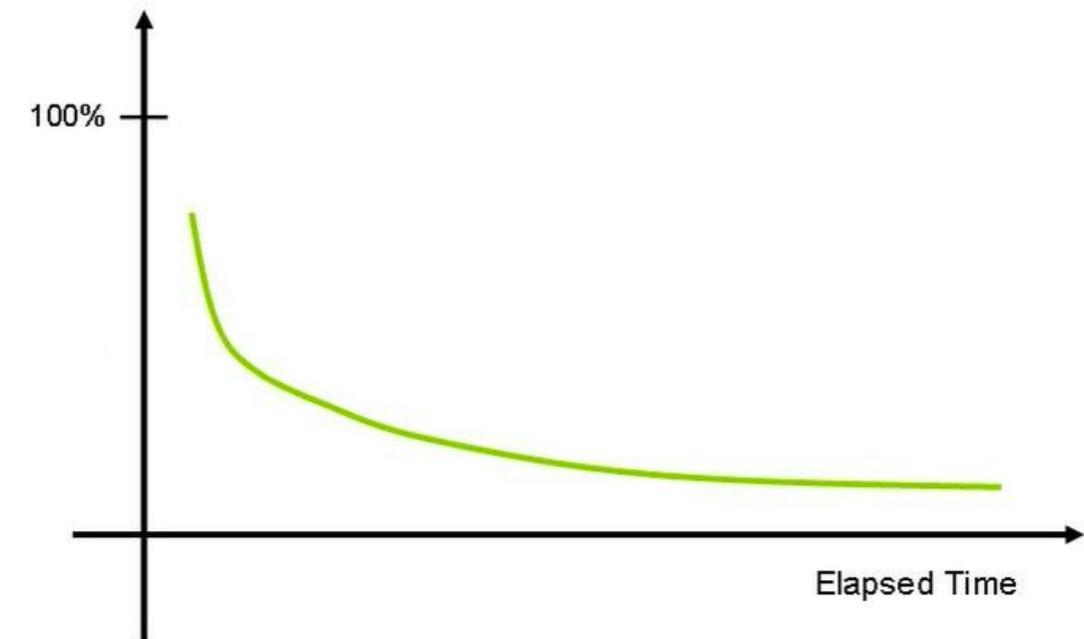
Kubernetes Engine

- GCP has 200+ services. This exam expects knowledge of 40+ Services.
- Exam expects **in-depth knowledge** about these services
- Exam *tests your decision making abilities:*
 - Which service do you choose in which situation?
- This course is **designed** to give you *in-depth* knowledge & *make tough choices*
- **Our Goal :** Enable you to understand and use GCP in your real world projects!

How do you put your best foot forward?

In 28
Minutes

- Challenging certification - Expects you to understand and **REMEMBER** a number of services
- As time passes, humans forget things.
- How do you improve your chances of remembering things?
 - Active learning - think and take notes
 - Review the presentation every once in a while



Our Approach

In 28
Minutes

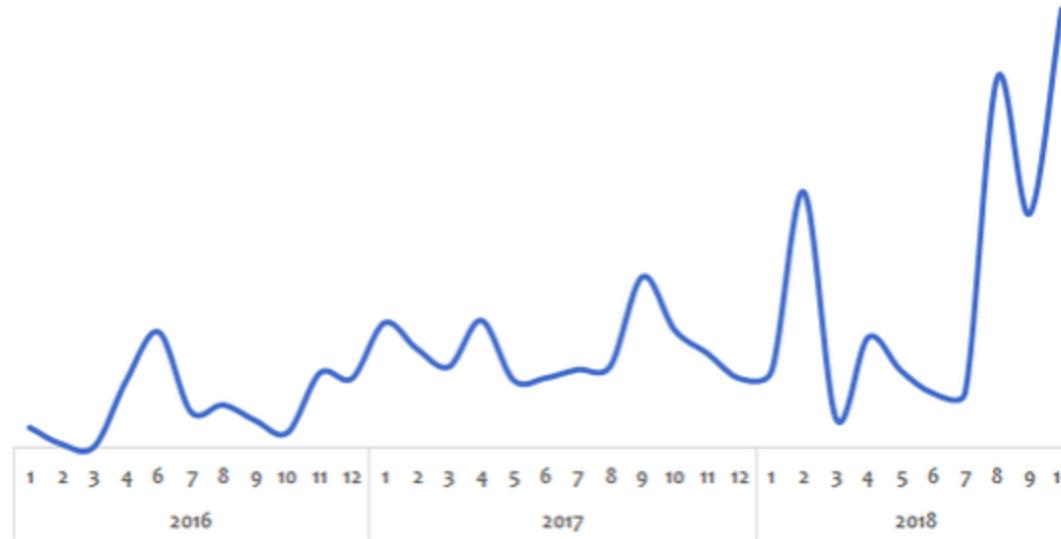
- Three-pronged approach to reinforce concepts:
 - Presentations (Video)
 - Demos (Video)
 - **Two kinds of quizzes:**
 - Text quizzes
 - Video quizzes
- (Recommended) Take your time. Do not hesitate to replay videos!
- (Recommended) Have Fun!



GCP - Getting started

Before the Cloud - Example 1 - Online Shopping App

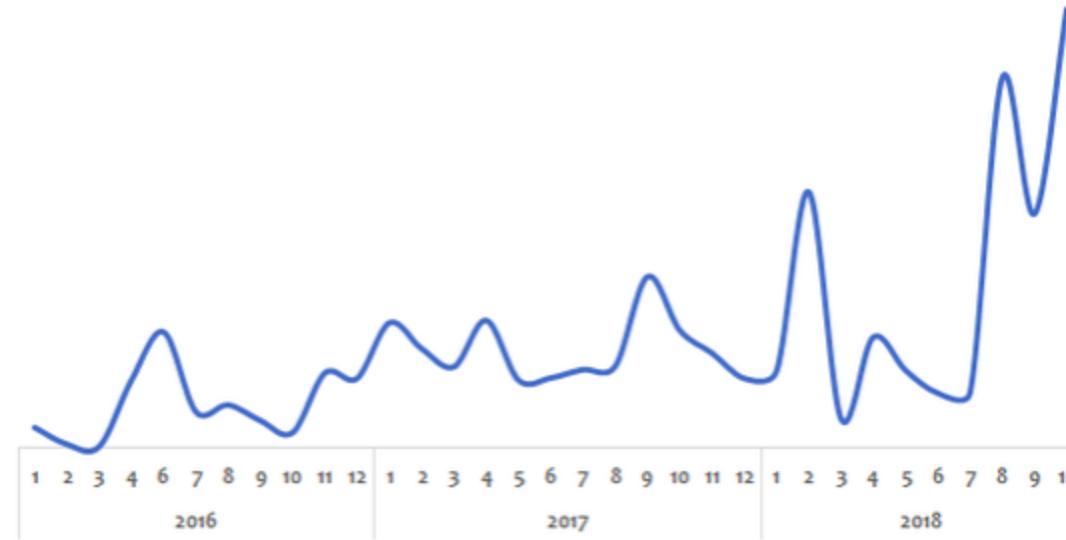
In 28
Minutes



- Challenge:
 - Peak usage during holidays and weekends
 - Less load during rest of the time
- Solution (before the Cloud):
 - **PEAK LOAD provisioning : Procure (Buy) infrastructure for peak load**
 - What would the infrastructure be doing during periods of low loads?

Before the Cloud - Example 2 - Startup

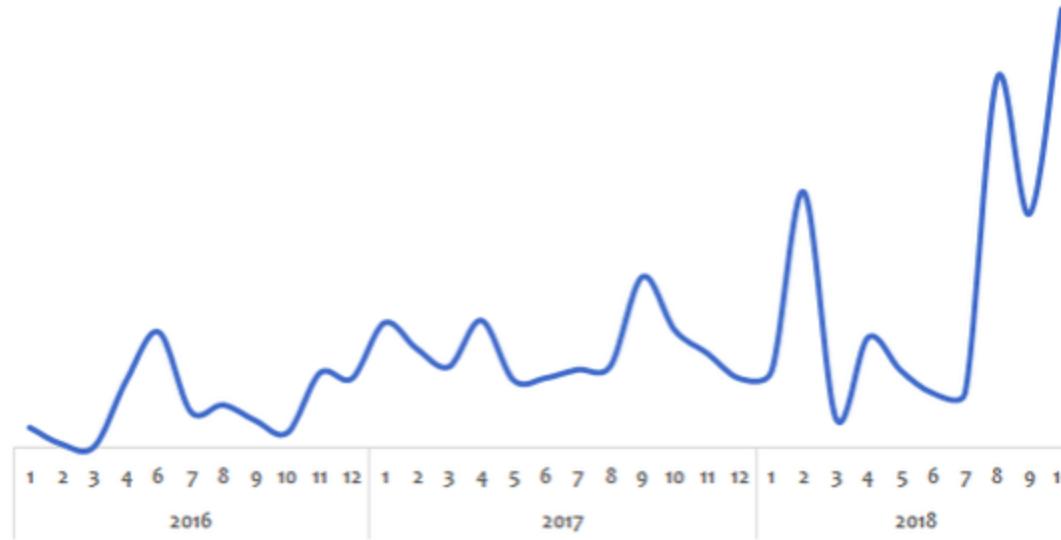
In 28
Minutes



- Challenge:
 - Startup suddenly becomes popular
 - How to handle the **sudden increase** in load?
- Solution (before the Cloud):
 - **Procure** (Buy) infrastructure assuming they would be successful
 - What if they are not successful?

Before the Cloud - Challenges

In 28
Minutes



- High cost of procuring infrastructure
- Needs ahead of time planning (**Can you guess the future?**)
- Low infrastructure utilization (**PEAK LOAD** provisioning)
- Dedicated infrastructure maintenance team (**Can a startup afford it?**)

Silver Lining in the Cloud

In 28
Minutes

- How about **provisioning** (renting) resources when you want them and releasing them back when you do not need them?
 - On-demand resource provisioning
 - Also called **Elasticity**



Cloud - Advantages

In 28
Minutes

- Trade "capital expense" for "variable expense"
- Benefit from massive economies of scale
- Stop guessing capacity
- Stop spending money running and maintaining data centers
- "**Go global**" in minutes



Google Cloud Platform (GCP)

In 28
Minutes

- One of the Top 3 cloud service providers
- Provides a number of services (200+)
- Reliable, secure and highly-performant:
 - Infrastructure that powers 8 services with over 1 Billion Users: Gmail, Google Search, YouTube etc
- One thing I love : "**cleanest cloud**"
 - Net carbon-neutral cloud (electricity used matched 100% with renewable energy)
- The entire course is all about GCP. You will learn it as we go further.



Google Cloud

Best path to learn GCP!

In 28
Minutes



Compute Engine



App Engine



Cloud Functions



Cloud Run



Kubernetes Engine



Cloud SQL



Datastore

- Cloud applications make use of multiple GCP services
- There is **no single path** to learn these services independently
- **HOWEVER**, we've worked out a simple path!

Setting up GCP Account

In 28
Minutes

- Create GCP Account

Regions and Zones

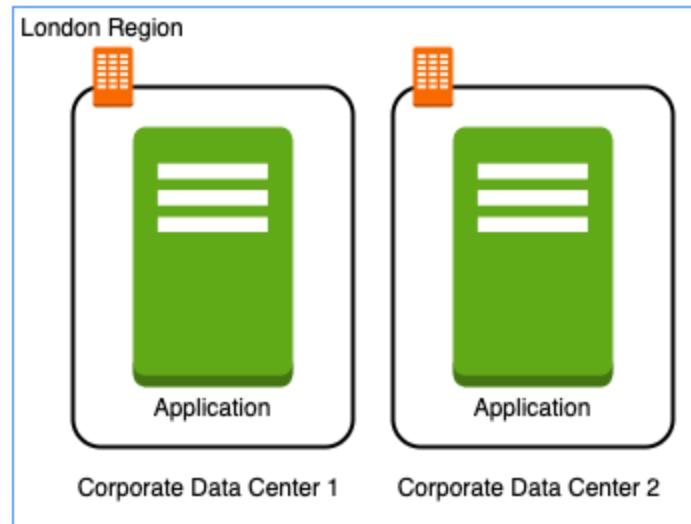
Regions and Zones

In 28
Minutes



- Imagine that your application is deployed in a data center in London
- What would be the challenges?
 - Challenge 1 : Slow access for users from other parts of the world (**high latency**)
 - Challenge 2 : What if the data center crashes?
 - Your application goes down (**low availability**)

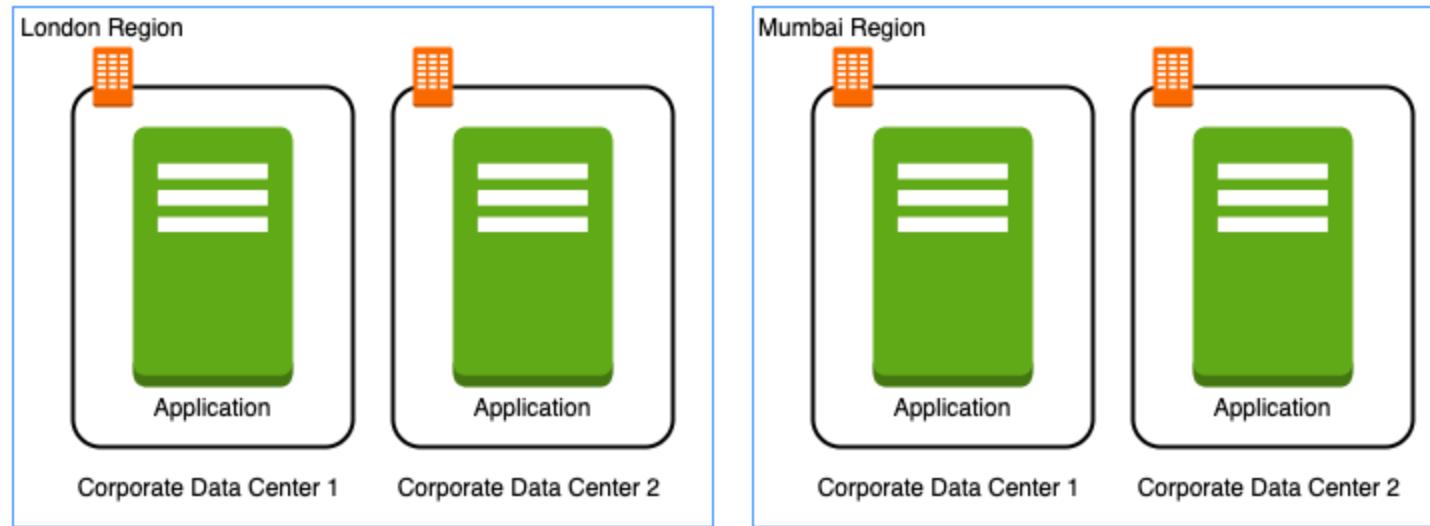
Multiple data centers



- Let's add in one more data center in London
- What would be the challenges?
 - Challenge 1 : Slow access for users from other parts of the world
 - Challenge 2 (**SOLVED**) : What if one data center crashes?
 - Your application is **still available** from the other data center
 - Challenge 3 : What if **entire region** of London is unavailable?
 - Your application goes down

Multiple regions

In 28
Minutes



- Let's add a new region : Mumbai
- What would be the challenges?
 - Challenge 1 (**PARTLY SOLVED**) : Slow access for users from other parts of the world
 - You can solve this by adding deployments for your applications in other regions
 - Challenge 2 (**SOLVED**) : What if one data center crashes?
 - Your application is still live from the other data centers
 - Challenge 3 (**SOLVED**) : What if entire region of London is unavailable?
 - Your application is served from Mumbai

Regions

In 28
Minutes

- Imagine setting up data centers in different regions around the world
 - Would that be easy?
- (Solution) Google provides **20+ regions** around the world
 - Expanding every year
- **Region** : Specific geographical location to host your resources
- **Advantages:**
 - High Availability
 - Low Latency
 - Global Footprint
 - Adhere to government regulations



Zones

In 28
Minutes

- How to achieve high availability in the same region (or geographic location)?
 - Enter Zones
- Each Region has three or more **zones**
- (Advantage) **Increased availability and fault tolerance** within same region
- (Remember) Each Zone has **one or more discrete clusters**
 - Cluster : distinct physical infrastructure that is housed in a data center
- (Remember) Zones in a region are connected through **low-latency** links



Regions and Zones examples

In 28
Minutes

New Regions and Zones are constantly added

Region Code	Region	Zones	Zones List
us-west1	The Dalles, Oregon, North America	3	us-west1-a us-west1-b us-west1-c
europe-north1	Hamina, Finland, Europe	3	europe-north1-a, europe-north1-b europe-north1-c
asia-south1	Mumbai, India APAC	3	asia-south1-a, asia-south1-b asia-south1-c

Compute

Compute Engine Fundamentals

Google Compute Engine (GCE)

In 28
Minutes

- In corporate data centers, applications are deployed to physical servers
- Where do you deploy applications in the cloud?
 - Rent virtual servers
 - **Virtual Machines** - Virtual servers in GCP
 - **Google Compute Engine (GCE)** - Provision & Manage Virtual Machines



Compute Engine

Compute Engine - Features

In 28
Minutes



- Create and manage lifecycle of Virtual Machine (VM) instances
- **Load balancing and auto scaling** for multiple VM instances
- **Attach storage** (& network storage) to your VM instances
- Manage network connectivity and configuration for your VM instances
- **Our Goal:**
 - Setup VM instances as HTTP (Web) Server
 - Distribute load with Load Balancers

Compute Engine Hands-on

In 28
Minutes

- Let's create a few VM instances and play with them
- Let's check out the lifecycle of VM instances
- Let's use SSH to connect to VM instances



Compute Engine

Compute Engine Machine Family

In 28
Minutes

- What type of hardware do you want to run your workloads on?
- Different Machine Families for Different Workloads:
 - **General Purpose (E2, N2, N2D, N1)** : Best price-performance ratio
 - Web and application servers, Small-medium databases, Dev environments
 - **Memory Optimized (M2, M1)**: Ultra high memory workloads
 - Large in-memory databases and In-memory analytics
 - **Compute Optimized (C2)**: Compute intensive workloads
 - Gaming applications



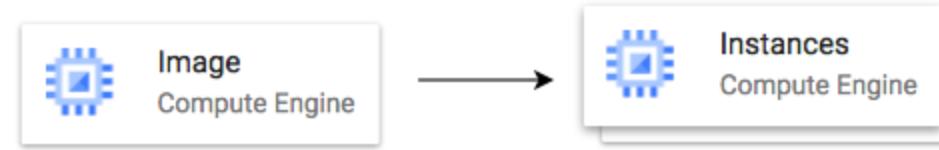
Compute Engine

Compute Engine Machine Types

In 28
Minutes

Machine name	vCPUs ¹	Memory (GB)	Max number of persistent disks (PDs) ²	Max total PD size (TB)	Local SSD	Maximum egress bandwidth (Gbps) ³
e2-standard-2	2	8	128	257	No	4
e2-standard-4	4	16	128	257	No	8
e2-standard-8	8	32	128	257	No	16
e2-standard-16	16	64	128	257	No	16
e2-standard-32	32	128	128	257	No	16

- How much CPU, memory or disk do you want?
 - Variety of machine types are available for each machine family
 - Let's take an example : **e2-standard-2**:
 - e2 - Machine Type Family
 - standard - Type of workload
 - 2 - Number of CPUs
- Memory, disk and networking capabilities increase along with vCPUs



- What operating system and what software do you want on the instance?
- Type of Images:
 - **Public Images:** Provided & maintained by Google or Open source communities or third party vendors
 - **Custom Images:** Created by you for your projects

Compute Engine Hands-on : Setting up a HTTP server

In 28
Minutes

```
#!/bin/bash
sudo su
apt update
apt -y install apache2
sudo service apache2 start
sudo update-rc.d apache2 enable
echo "Hello World" > /var/www/html/index.html
echo "Hello world from $(hostname) $(hostname -I)" > /var/www/html/index.html
```

- Commands:

- sudo su - execute commands as a root user
- apt update - Update package index - pull the latest changes from the APT repositories
- apt -y install apache2 - Install apache 2 web server
- sudo service apache2 start - Start apache 2 web server
- echo "Hello World" > /var/www/html/index.html - Write to index.html
- \$(hostname) - Get host name
- \$(hostname -I) - Get host internal IP address

Internal and External IP Addresses

In 28
Minutes

- External (Public) IP addresses are **Internet addressable**.
- Internal (Private) IP addresses are **internal** to a corporate network
- You CANNOT have two resources with same public (External) IP address.
 - HOWEVER, two different corporate networks CAN have resources with same Internal (private) IP address
- All **VM instances** are assigned at least one Internal IP address
- Creation of External IP addresses can be enabled for VM instances
 - (Remember) When you stop an VM instance, External IP address is lost
- **DEMO:** VM instances - Internal and External IPs



Compute Engine

Static IP Addresses

In 28
Minutes

- Scenario : How do you get a constant External IP address for a VM instance?
 - Quick and dirty way is to assign an Static IP Address to the VM!
- **DEMO:** Using Static IP Address with an VM instance



Compute Engine

Static IP Addresses - Remember

In 28
Minutes

- Static IP can be switched to another VM instance in same project
- Static IP **remains attached** even if you stop the instance. You have to manually detach it.
- Remember : You are **billed for** an Static IP when **you are NOT using it!**
 - Make sure that you explicitly release an Static IP when you are not using it.



Compute Engine

Simplify VM HTTP server setup

In 28
Minutes

- How do we reduce the number of steps in creating an VM instance and setting up a HTTP Server?
- Let's explore a few options:
 - Startup script
 - Instance Template
 - Custom Image



Compute Engine

Bootstrapping with Startup script

In 28
Minutes

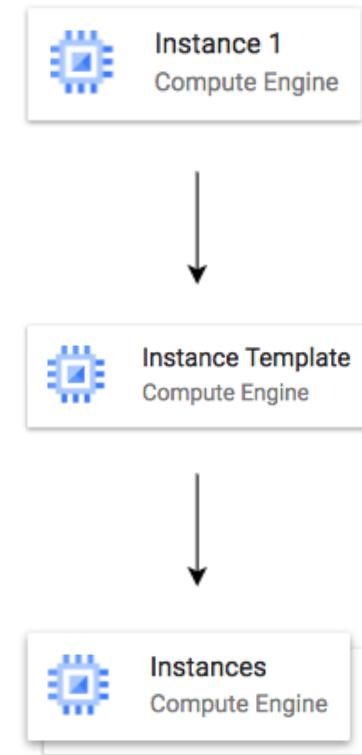
```
#!/bin/bash
apt update
apt -y install apache2
echo "Hello world from $(hostname) $(hostname -I)" > /var/www/html/index.html
```

- **Bootstrapping:** Install OS patches or software when an VM instance is launched.
- In VM, you can configure **Startup script** to bootstrap
- **DEMO** - Using Startup script

Instance templates

In 28
Minutes

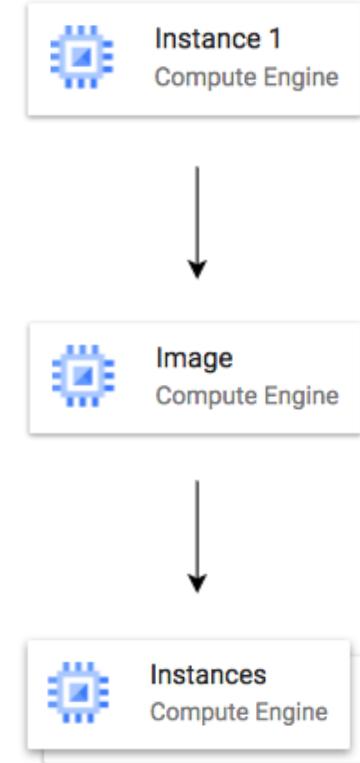
- Why do you need to specify all the VM instance details (Image, instance type etc) **every time** you launch an instance?
 - How about creating a **Instance template**?
 - Define **machine type, image, labels, startup script** and other properties
- Used to create **VM instances and managed instance groups**
 - Provides a **convenient way** to create similar instances
- **CANNOT** be updated
 - To make a change, copy an existing template and modify it
- (Optional) Image family can be specified (example - debian-9):
 - Latest non-deprecated version of the family is used
- **DEMO** - Launch VM instances using Instance templates



Reducing Launch Time with Custom Image

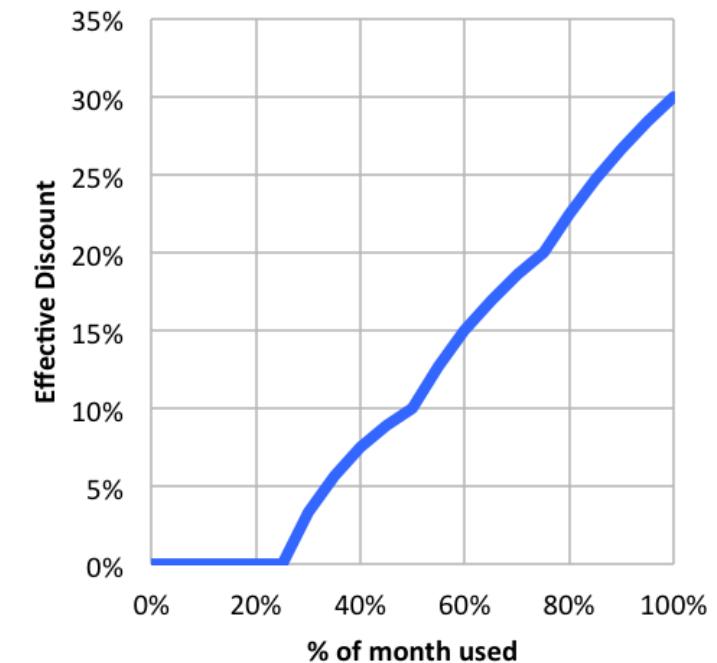
In 28
Minutes

- Installing OS patches and software at launch of VM instances **increases boot up time**
- How about creating a custom image with OS patches and software **pre-installed?**
 - Can be created from an instance, a persistent disk, a snapshot, another image, or a file in Cloud Storage
 - Can be shared across projects
 - (Recommendation) Deprecate old images (& specify replacement image)
 - (Recommendation) **Hardening an Image** - Customize images to your corporate security standards
- Prefer using **Custom Image** to **Startup script**
- **DEMO** : Create a Custom Image and using it in an Instance Template



Sustained use discounts

- Automatic discounts for running VM instances for significant portion of the billing month
 - Example: If you use N1, N2 machine types for more than 25% of a month, you get a 20% to 50% discount on every incremental minute.
 - Discount increases with usage (graph)
 - No action required on your part!
- Applicable for instances created by Google Kubernetes Engine and Compute Engine
- RESTRICTION: Does NOT apply on certain machine types (example: E2 and A2)
- RESTRICTION: Does NOT apply to VMs created by App Engine flexible and Dataflow



Source: <https://cloud.google.com>

Committed use discounts

In 28
Minutes

- For workloads with **predictable resource needs**
- **Commit** for 1 year or 3 years
- Up to 70% **discount** based on machine type and GPUs
- Applicable for instances created by **Google Kubernetes Engine** and **Compute Engine**
- **RESTRICTION:** Does NOT apply to VMs created by App Engine flexible and Dataflow



Compute Engine

Preemptible VM

In 28
Minutes

- **Short-lived cheaper** (upto 80%) compute instances
 - Can be stopped by GCP any time (preempted) within 24 hours
 - Instances get 30 second warning (to save anything they want to save)
- **Use Preempt VM's if:**
 - Your applications are **fault tolerant**
 - You are very **cost sensitive**
 - Your workload is **NOT immediate**
 - Example: Non immediate batch processing jobs
- **RESTRICTIONS:**
 - NOT always available
 - NO SLA and CANNOT be migrated to regular VMs
 - NO Automatic Restarts
 - Free Tier credits not applicable



Compute Engine

Google Compute Engine - Billing

In 28
Minutes

- You are **billed by the second** (after a minimum of 1 minute)
- You are NOT billed for compute when a compute instance is stopped
 - However, you will be billed for any storage attached with it!
- (RECOMMENDATION) **Always create Budget alerts** and make use of Budget exports to stay on top of billing!
- What are the ways you can save money?
 - Choose the right machine type and image for your workload
 - Be aware of the discounts available:
 - Sustained use discounts
 - Committed use discounts
 - Discounts for preemptible VM instances



Compute Engine

Compute Engine : Live Migration & Availability Policy

In 28
Minutes

- How do you keep your VM instances running when a host system needs to be updated (a software or a hardware update needs to be performed)?
- **Live Migration**
 - Your running instance is migrated to another host in the same zone
 - Does NOT change any attributes or properties of the VM
 - SUPPORTED for instances with local SSDs
 - NOT SUPPORTED for GPUs and preemptible instances
- **Important Configuration - Availability Policy:**
 - **On host maintenance:** What should happen during periodic infrastructure maintenance?
 - Migrate (default): Migrate VM instance to other hardware
 - Terminate: Stop the VM instance
 - **Automatic restart** - Restart VM instances if they are terminated due to non-user-initiated reasons (maintenance event, hardware failure etc.)

Compute Engine Features: Custom Machine Types

In 28
Minutes

- What do you do when predefined VM options are NOT appropriate for your workload?
 - Create a machine type customized to your needs (a **Custom Machine Type**)
- **Custom Machine Type: Adjust vCPUs, memory and GPUs**
 - Choose between E2, N2, or N1 machine types
 - Supports a wide variety of Operating Systems: CentOS, CoreOS, Debian, Red Hat, Ubuntu, Windows etc
 - **Billed per vCPUs, memory provisioned to each instance**
 - Example Hourly Price: \$0.033174 / vCPU + \$0.004446 / GB



Compute Engine

Compute Engine Features: GPUs

In 28
Minutes

- How do you accelerate math intensive and graphics-intensive workloads for AI/ML etc?
- Add a **GPU** to your virtual machine:
 - High performance for math intensive and graphics-intensive workloads
 - Higher Cost
 - (REMEMBER) Use **images with GPU libraries** (Deep Learning) installed
 - OTHERWISE, GPU will not be used
 - **GPU restrictions:**
 - NOT supported on all machine types (For example, not supported on shared-core or memory-optimized machine types)
 - On host maintenance can only have the value "Terminate VM instance"
- Recommended Availability policy for GPUs
 - Automatic restart - on



GPU

Virtual Machine - Remember

In 28
Minutes

- Associated with a project
- Machine type **availability can vary** from region to regions
- You can only change the machine type (adjust the number of vCPUs and memory) of a stopped instance
 - You CANNOT change the machine type of a running instance
- VM's **can be filtered** by various properties
 - Name, Zone, Machine Type, Internal/External IP, Network, Labels etc
- Instances are Zonal (Run in a **specific zone** (in a specific region))
 - Images are global (You can provide access to other projects - if needed)
 - Instance templates are global (Unless you use zonal resources in your templates)
- **Automatic Basic Monitoring** is enabled
 - Default Metrics: CPU utilization, Network Bytes (in/out), Disk Throughput/IOPS
 - For Memory Utilization & Disk Space Utilization - Cloud Monitoring agent is needed



Compute Engine

Virtual Machine - Best Practices

In 28
Minutes

- Choose **Zone and Region** based on:
 - Cost, Regulations, Availability Needs, Latency and Specific Hardware needs
 - Distribute instances in multiple zones and regions for high availability
- Choose **right machine type** for you needs:
 - Play with them to find out the right machine type
 - Use **GPUs** for Math and Graphic intensive applications
- Reserve for "**committed use discounts**" for constant workloads
- Use preemptible instances for fault-tolerant, NON time critical workloads
- Use **labels** to indicate environment, team, business unit etc



Compute Engine

Compute Engine Scenarios

In 28
Minutes

Scenario

What are the pre-requisites to be able to create a VM instance?

Solution

1. Project
2. Billing Account
3. Compute Engines APIs should be enabled

You want dedicated hardware for your compliance, licensing, and management needs

Sole-tenant nodes

I have 1000s of VM and I want to automate OS patch management, OS inventory management and OS configuration management (manage software installed)

Use "VM Manager"

You want to login to your VM instance to install software

You can SSH into it

You do not want to expose a VM to internet

Do NOT assign an external IP Address

You want to allow HTTP traffic to your VM

Configure Firewall Rules

Image

- What **operating system** and what **software** do you want on the VM instance?
- Reduce boot time and improve security by creating custom **hardened Images**.
- You can share an **Image** with other projects

Machine Types

- Optimized combination of compute(CPU, GPU), memory, disk (storage) and networking for specific workloads.
- You can **create your own Custom Machine Types** when existing ones don't fit your needs

Quick Review

In 28
Minutes

- **Static IP Addresses:** Get a constant IP addresses for VM instances
- **Instance Templates:** Pre-configured templates simplifying the creation of VM instances
- **Sustained use discounts:** Automatic discounts for running VM instances for significant portion of the billing month
- **Committed use discounts:** 1 year or 3 year reservations for workloads with predictable resource needs
- **Preemptible VM:** Short-lived cheaper (upto 80%) compute instances for non-time-critical fault-tolerant workloads

Gcloud

- **Command line interface** to interact with Google Cloud Resources
- Most GCP services can be managed from CLI using Gcloud:
 - Compute Engine Virtual Machines
 - Managed Instance Groups
 - Databases
 - and ... many more
- You can create/delete/update/read existing resources and perform actions like deployments as well!
- (REMEMBER) SOME GCP services have specific CLI tools:
 - Cloud Storage - gsutil
 - Cloud BigQuery - bq
 - Cloud Bigtable - cbt
 - Kubernetes - kubectl (in addition to Gcloud which is used to manage clusters)



Cloud Shell

Installation

- Gcloud is part of Google Cloud SDK
 - Cloud SDK requires Python
 - Instructions to install Cloud SDK (and Gcloud) => <https://cloud.google.com/sdk/docs/install>
- You can also use Gcloud on Cloud Shell

Connecting to GCP

- **gcloud init** - initialize or reinitialize gcloud
 - Authorize gcloud to use your user account credentials
 - Setup configuration
 - Includes current project, default zone etc
- **gcloud config list** - lists all properties of the active configuration

gcloud config set

In 28
Minutes

- Sets the specified property in your active configuration
 - `gcloud config set core/project VALUE`
 - `gcloud config set compute/region VALUE`
 - `gcloud config set compute/zone VALUE`
 - `gcloud config set core/verbosity VALUE(debug)`
- Syntax - **`gcloud config set SECTION/PROPERTY VALUE`**
 - **core, compute** - SECTIONS
 - **project, region, zone** - PROPERTIES
 - Specifying **core** is optional as it is the default SECTION!
 - `gcloud config set project VALUE`
 - `gcloud config set verbosity VALUE(debug)`
 - Get more details with **`gcloud config set --help`**
 - Look for AVAILABLE PROPERTIES in the content
- Opposite - **`gcloud config unset`**



Cloud Shell

Playing with gcloud config set

- gcloud config set compute/region us-east2
- gcloud config set compute/zone us-east1-b
- gcloud config list

```
testing@cloudshell:~ (useful-device-303710)$ gcloud config list
[component_manager]
disable_update_check = True
[compute]
gce_metadata_read_timeout_sec = 30
region = us-east1
zone = us-east1-b
[core]
account = testing@gmail.com
disable_usage_reporting = True
project = useful-device-303710
verbosity = info
[metrics]
environment = devshell
```

Gcloud - Managing Multiple Configurations

In 28
Minutes

- Scenario: You are working on multiple projects from the same machine. You would want to be able to execute commands using different configurations.

- How do you simplify this?

- **gcloud config configurations create/delete/describe/activate/list**
 - Create new configuration: **gcloud config configurations create NAME (dev)**
 - Activate specific configuration: **gcloud config configurations activate NAME (dev)**
 - List Configurations: **gcloud config configurations list**



Cloud Shell

gcloud command structure - Playing with Services

In 28
Minutes

- **gcloud GROUP SUBGROUP ACTION ...**
 - GROUP - config or compute or container or dataflow or functions or iam or ..
 - Which service group are you playing with?
 - SUBGROUP - instances or images or instance-templates or machine-types or regions or zones
 - Which sub group of the service do you want to play with?
 - ACTION - create or list or start or stop or describe or ...
 - What do you want to do?
- **Examples:**
 - gcloud compute instances list
 - gcloud compute zones list
 - gcloud compute regions list
 - gcloud compute machine-types list
 - gcloud compute machine-types list --filter="zone:us-central1-b"
 - gcloud compute machine-types list --filter="zone:(us-central1-b europe-west1-d)"

gcloud compute instances create

In 28
Minutes

- Creating Compute Instances

- **gcloud compute instances create [NAME]**

- Options:

- --machine-type (default type is n1-standard-1 - gcloud compute machine-types list)
 - --custom-cpu --custom-memory --custom-vm-type(n1/n2) (Custom Machine)
 - --custom-cpu 6 --custom-memory 3072MB --custom-vm-type n2
 - --image or --image-family or --source-snapshot or --source-instance-template or --source-machine-image (beta)
 - --service-account or --no-service-account
 - --zone=us-central1-b
 - --tags (List of tags - Allow network firewall rules and routes to be applied to VM instances)
 - --preemptible
 - --restart-on-failure(default) --no-restart-on-failure --maintenance-policy(MIGRATE(default)/TERMINATE)
 - --boot-disk-size, --boot-disk-type --boot-disk-auto-delete(default) --no-boot-disk-auto-delete
 - --deletion-protection --no-deletion-protection(default)
 - --metadata/metadata-from-file startup-script/startup-script-url
 - --metadata-from-file startup-script=/local/path/to/script/startup OR --metadata startup-script="echo 'hello world'"
 - shutdown-script
 - --network --subnet --network-tier (PREMIUM (default), STANDARD)
 - --accelerator="type=nvidia-tesla-v100,count=8" --metadata="install-nvidia-driver=True" (GPU)

Compute Instances - Default Region and Zone

In 28
Minutes

- Three Options:
 - Option 1 (Centralized Configuration): `gcloud compute project-info add-metadata --metadata=[google-compute-default-region=REGION | google-compute-default-zone=ZONE]`
 - Option 2 (Local gcloud configuration): `gcloud config set compute/region REGION`
 - Option 3 (Command Specific): `--zone` or `--region` in the command
- Priority: Option 3 (if exists) overrides Option 2 (if exists) overrides Option 1



Cloud Shell

List and Describe commands

In 28
Minutes

- Typically list commands are used to list a set of resources
 - `gcloud compute RESOURCES list`
 - `gcloud compute images/regions/zones/disk-types list`
 - `gcloud compute instances/disks/snapshots list`
 - Most list commands support a few common options
 - `--filter="zone:VALUE"`
 - `--sort-by (NAME, ~NAME)`
 - `--uri` (<https://www.googleapis.com/compute/v1/projects/windows-sql-cloud/global/images/sql-2019-web-windows-2019-dc-v20210112>)
 - `gcloud compute images list --sort-by NAME --filter "PROJECT:(windows-cloud ubuntu-os-cloud)"`
- Typically describe commands are used to describe a specific resource
 - `gcloud compute images describe ubuntu-1604-xenial- v20210203 --project ubuntu-os-cloud`
 - `gcloud compute regions describe us-central1`



Cloud Shell

Playing with Compute Instances - gcloud

In 28
Minutes

- Playing with compute instances

- `gcloud compute instances list/start/stop/delete/reset/describe/move`
 - `gcloud compute instances start example-instance`
 - `gcloud compute instances stop example-instance-1 example-instance-2`
 - `gcloud compute instances delete example-instance`
 - `--delete-disks=VALUE` (all or data or boot)
 - `--keep-disks=VALUE` (all or data or boot)
 - `gcloud compute instances move example-instance-1 --zone us-central1-b --destination-zone us-central1-f`
 - Move a VM from one zone to another



Cloud Shell

Playing with Instance Templates

In 28
Minutes

- `gcloud compute instance-templates create/delete/describe/list`
 - `gcloud compute instance-templates create INSTANCE-TEMPLATE`
 - `--source-instance=SOURCE_INSTANCE --source-instance-zone` (Which instance to create a template from?)
 - Supports almost all options supported by **`gcloud compute instances create [NAME]`**
 - `--image` or `--image-family` or `--source-snapshot` or `--source-instance-template`
 - `--service-account` or `--no-service-account`
 - `--tags`
 - `--preemptible`
 - `--restart-on-failure(default)` `--no-restart-on-failure` `--maintenance-policy(MIGRATE(default)/TERMINATE)`
 - `--boot-disk-size`, `--boot-disk-type` `--boot-disk-auto-delete(default)` `--no-boot-disk-auto-delete`
 - `--deletion-protection` `--no-deletion-protection(default)`
 - `--metadata/metadata-from-file` `startup-script/startup-script-url`
 - `--network` `--subnet` `--network-tier (PREMIUM (default), STANDARD)`
 - `--accelerator="type=nvidia-tesla-v100,count=8"` `--metadata="install-nvidia-driver=True"` (GPU)
 - Using Instance Tempate to create an instance
 - `gcloud compute instances create my-test-vm --sourc e-instance-template=my-instance-template-with-custom-image`



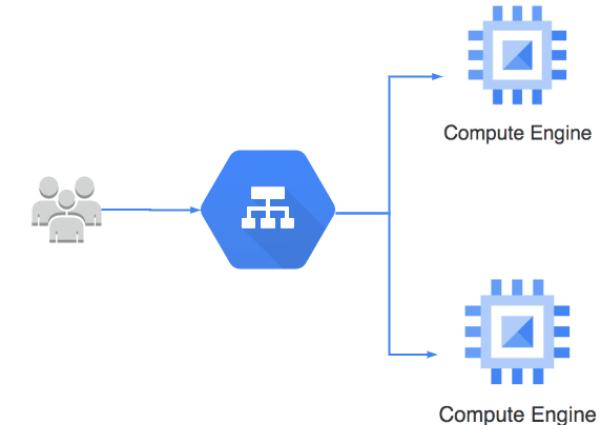
Cloud Shell

Instance Groups

Instance Groups

In 28
Minutes

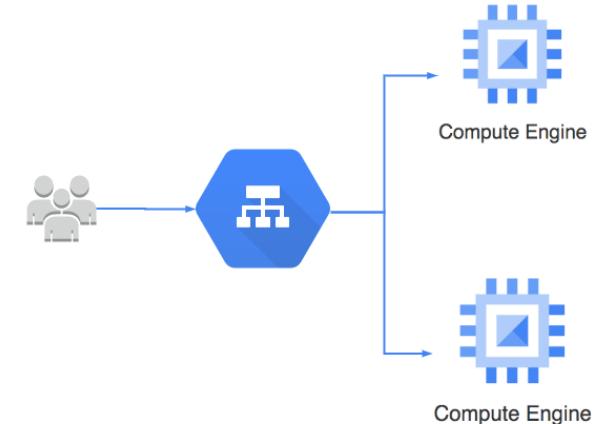
- How do you create a group of VM instances?
 - **Instance Group** - Group of VM instances managed as a single entity
 - Manage group of similar VMs having similar lifecycle as **ONE UNIT**
- **Two Types of Instance Groups:**
 - **Managed** : Identical VMs created using a template:
 - Features: Auto scaling, auto healing and managed releases
 - **Unmanaged** : Different configuration for VMs in same group:
 - Does NOT offer auto scaling, auto healing & other services
 - NOT Recommended unless you need different kinds of VMs
- **Location can be Zonal or Regional**
 - Regional gives you higher availability (**RECOMMENDED**)



Managed Instance Groups (MIG)

In 28
Minutes

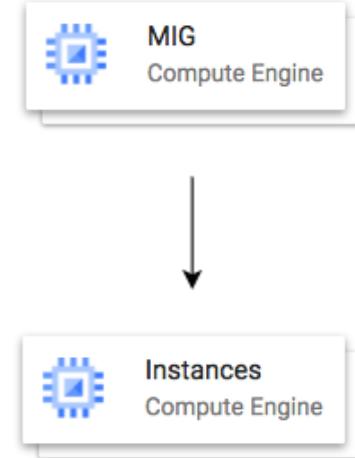
- Managed Instance Group - Identical VMs created using an **instance template**
- Important Features:
 - **Maintain** certain number of instances
 - If an instance crashes, MIG launches another instance
 - **Detect application failures** using health checks (**Self Healing**)
 - Increase and decrease instances based on load (**Auto Scaling**)
 - Add **Load Balancer** to distribute load
 - Create instances in multiple zones (regional MIGs)
 - Regional MIGs provide higher availability compared to zonal MIGs
 - **Release new application versions without downtime**
 - **Rolling updates:** Release new version step by step (gradually). Update a percentage of instances to the new version at a time.
 - **Canary Deployment:** Test new version with a group of instances before releasing it across all instances.



Creating Managed Instance Group (MIG)

In 28
Minutes

- Instance template is mandatory
- Configure auto-scaling to automatically adjust number of instances based on load:
 - Minimum number of instances
 - Maximum number of instances
 - Autoscaling metrics: CPU Utilization target or Load Balancer Utilization target or Any other metric from Stack Driver
 - Cool-down period: How long to wait before looking at auto scaling metrics again?
 - Scale In Controls: Prevent a sudden drop in no of VM instances
 - Example: Don't scale in by more than 10% or 3 instances in 5 minutes
 - Autohealing: Configure a Health check with Initial delay (How long should you wait for your app to initialize before running a health check?)
- Time for a Demo



Updating a Managed Instance Group (MIG)

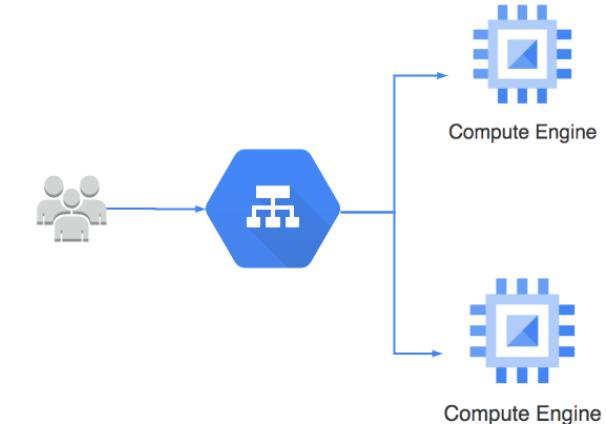
In 28
Minutes

- **Rolling update** - Gradual update of instances in an instance group to the new instance template

- Specify new template:
 - (OPTIONAL) Specify a template for canary testing
- Specify how you want the update to be done:
 - When should the update happen?
 - Start the update immediately (Proactive) or when instance group is resized later(Opportunistic)
 - How should the update happen?
 - Maximum surge: How many instances are added at any point in time?
 - Maximum unavailable: How many instances can be offline during the update?

- **Rolling Restart/replace:** Gradual restart or replace of all instances in the group

- No change in template BUT replace/restart existing VMs
- Configure Maximum surge, Maximum unavailable and What you want to do? (Restart/Replace)



Playing with Managed Instance Groups - Command Line

In 28
Minutes

- `gcloud compute instance-groups managed`

- **Create instance group:** `create`

- `gcloud compute instance-groups managed create my-mig --zone us-central1-a --template my-instance-template --size 1`

- `--health-check=HEALTH_CHECK`: How do you decide if an instance is healthy?
 - `--initial-delay`: How much time should you give to an instance to start?

- Other similar commands - `gcloud compute instance-groups managed delete/describe/list`

- **Setup Autoscaling:** `set-autoscaling/stop-autoscaling`

- `gcloud compute instance-groups managed set-autoscaling my-mig --max-num-replicas=10`

- `--cool-down-period` (default - 60s): How much time should Auto Scaler wait after initiating an autoscaling action?
 - `--scale-based-on-cpu` `--target-cpu-utilization` `--scale-based-on-load-balancing` `--target-load-balancing-utilization`
 - `--min-num-replicas` `--mode` (off/on/default)/only-scale-out)

- `gcloud compute instance-groups managed stop-autoscaling my-mig`

- **Update existing MIG policies** (ex: auto healing policies):

- `gcloud compute instance-groups managed update my-mig`

- `--initial-delay`: How much time should you give to the instance to start before marking it as unhealthy?
 - `--health-check`: How do you decide if an instance is healthy?



Cloud Shell

Managed Instance Group - Command Line - Making Updates

28
Minutes

- **Resize the group:**
 - *gcloud compute instance-groups managed resize my-mig --size=5*
- **Recreate one or more instances** (delete and recreate instances):
 - *gcloud compute instance-groups managed recreate-instances my-mig --instances=my-instance-1,my-instance-2*
- **Update specific instances:**
 - *gcloud compute instance-groups managed update-instances my-mig --instances=my-instance-3,my-instance-4 (Update specific instances from the group)*
 - *--minimal-action=none(default)/refresh/replace/restart*
 - *--most-disruptive-allowed-action=none(default)/refresh/replace/restart*
- **Update instance template:**
 - *gcloud compute instance-groups managed set-instance-template my-mig --template=v2-template*
 - After updating instance template, you can trigger roll out of the new template using update-instances, recreate-instances or rolling-action start-update commands

Managed Instance Groups - Command Line - Rolling Actions

28
Minutes

- **Scenario:** You want to manage your new release - v1 to v2 - without downtime
- *gcloud compute instance-groups managed rolling-action*
 - **Restart(stop & start)-** *gcloud compute instance-groups managed rolling-action restart my-mig*
 - --max-surge=5 or 10% (Max no of instances updated at a time)
 - **Replace(delete & recreate)-** *gcloud compute instance-groups managed rolling-action replace my-mig*
 - --max-surge=5 or 10% (Max no of instances updated at a time)
 - --max-unavailable=5 or 10% (Max no of instances that can be down for the update)
 - --replacement-method=recreate/substitute (recreate creates instances with new names. substitute reuses names)
 - **Updates instances to a new template:**
 - **Basic Version** (Update all instances slowly step by step) - *gcloud compute instance-groups managed rolling-action start-update my-mig --version=template=v1-template*
 - **Canary Version** (Update a subset of instances to v2) - *gcloud compute instance-groups managed rolling-action start-update my-mig --version=template=v1-template --canary-version=template=v2-template,target-size=10%*
 - Options: --max-surge, --max-unavailable, --replacement-method

Playing with Managed Instance Groups - Scenarios

In 28
Minutes

- I want to ensure that I have one healthy instance running all the time:
 - `gcloud compute instance-groups managed set-autoscaling my-group --max-num-replicas=1 --min-num-replicas=1`
- I want to make a new release with no reduction in available number of instances. I want to update one instance at a time:
 - `gcloud compute instance-groups managed rolling-action start-update my-group --version=template=my-v1-template --max-surge 1 --max-unavailable 0`



Cloud Shell

Instance Group Scenarios

In 28
Minutes

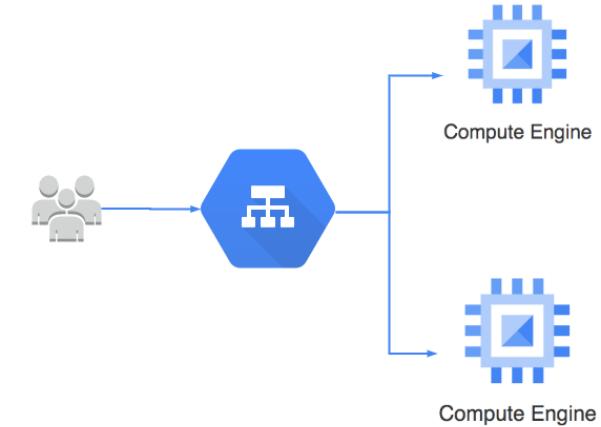
Scenario	Solution
You want MIG managed application to survive Zonal Failures	Create multiple zone MIG (or regional MIG)
You want to create VMs of different configurations in the same group	Create Un-managed Instance Group
You want to preserve VM state in an MIG	Stateful MIG - Preserve VM state (Instance name, attached Persistent disks and Metadata). Recommended for stateful workloads (database, data processing apps)
You want high availability in an MIG even when there are hardware/software updates	Use an instance template with availability policy automatic restart: enabled & on-host maintenance: migrate Ensures live migration and automatic restarts
You want unhealthy instances to be automatically replaced	Configure health check on the MIG (self healing)
Avoid frequent scale up & downs	Cool-down period/Initial delay

Cloud Load Balancing

Cloud Load Balancing

In 28
Minutes

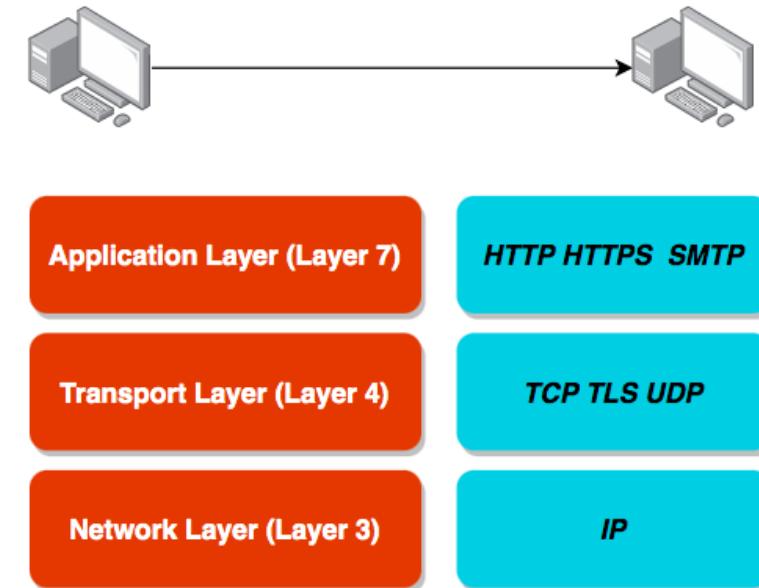
- Distributes user traffic across instances of an application in single region or multiple regions
 - Fully distributed, software defined managed service
 - Important Features:
 - Health check - Route to healthy instances
 - Recover from failures
 - Auto Scaling
 - Global load balancing with single anycast IP
 - Also supports internal load balancing
- Enables:
 - High Availability
 - Auto Scaling
 - Resiliency



HTTP vs HTTPS vs TCP vs TLS vs UDP

In 28
Minutes

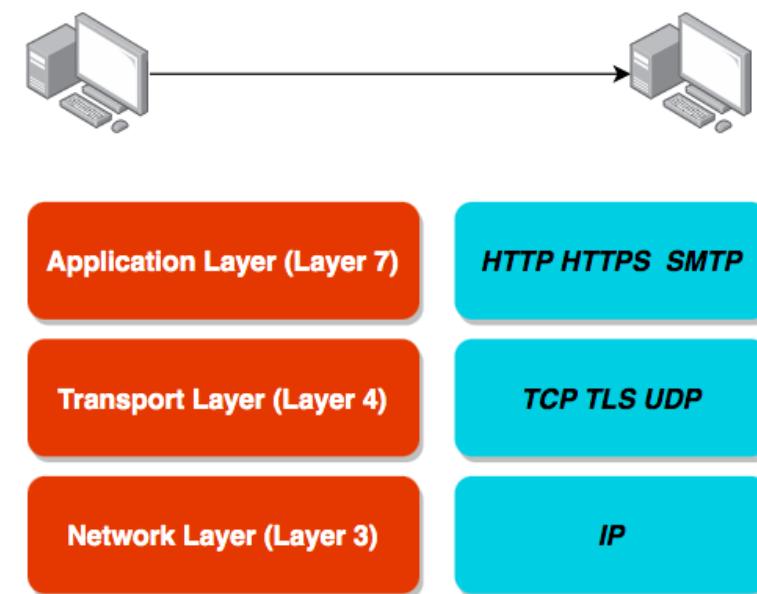
- Computers use protocols to communicate
- Multiple layers and multiple protocols
- **Network Layer** - Transfer bits and bytes
- **Transport Layer** - Are the bits and bytes transferred properly?
- **Application Layer** - Make REST API calls and Send Emails
- (Remember) Each layer makes use of the layers beneath it
- (Remember) Most applications talk at application layer. BUT some applications talk at transport layer directly(high performance).



HTTP vs HTTPS vs TCP vs TLS vs UDP

In 28
Minutes

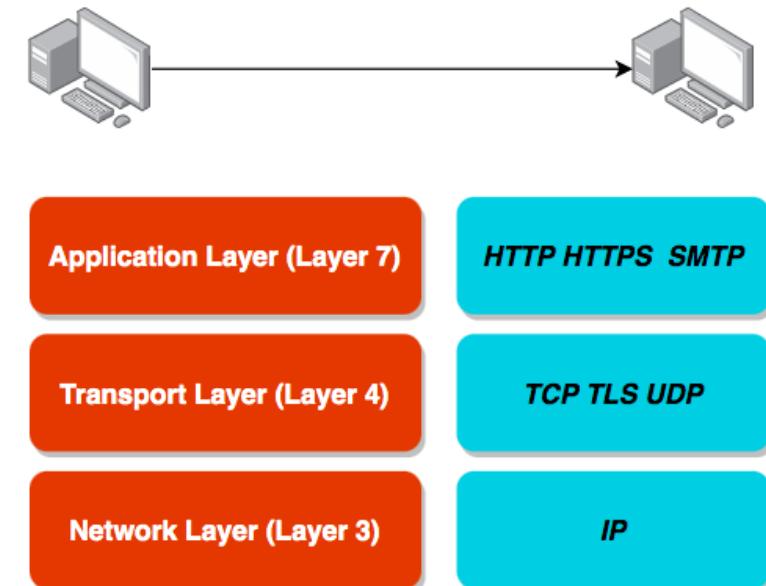
- Network Layer:
 - IP (Internet Protocol): Transfer bytes. Unreliable.
- Transport Layer:
 - TCP (Transmission Control): Reliability > Performance
 - TLS (Transport Layer Security): Secure TCP
 - UDP (User Datagram Protocol): Performance > Reliability
- Application Layer:
 - HTTP(Hypertext Transfer Protocol): Stateless Request Response Cycle
 - HTTPS: Secure HTTP
 - SMTP: Email Transfer Protocol
 - and a lot of others...



HTTP vs HTTPS vs TCP vs TLS vs UDP

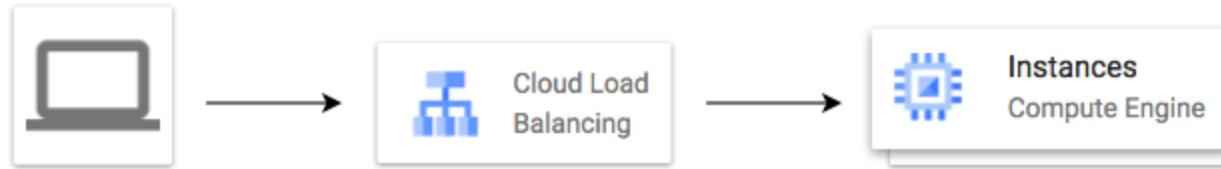
In 28
Minutes

- Most applications typically communicate at application layer
 - Web apps/REST API(HTTP/HTTPS), Email Servers(SMTP), File Transfers(FTP)
 - All these applications use TCP/TLS at network layer(for reliability)
- **HOWEVER** applications needing high performance directly communicate at transport layer:
 - Gaming applications and live video streaming use UDP (sacrifice reliability for performance)
- **Objective:** Understand Big Picture. Its OK if you do not understand all details.



Cloud Load Balancing - Terminology

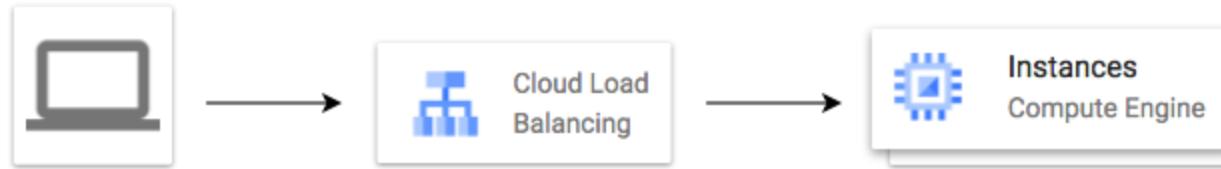
In 28
Minutes



- **Backend** - Group of endpoints that receive traffic from a Google Cloud load balancer (example: instance groups)
- **Frontend** - Specify an IP address, port and protocol. This IP address is the frontend IP for your clients requests.
 - For SSL, a certificate must also be assigned.
- **Host and path rules** (For HTTP(S) Load Balancing) - Define rules redirecting the traffic to different backends:
 - Based on **path** - in28minutes.com/a vs in28minutes.com/b
 - Based on **Host** - a.in28minutes.com vs b.in28minutes.com
 - Based on **HTTP headers** (Authorization header) and methods (POST, GET, etc)
 - etc..

Load Balancing - SSL/TLS Termination/Offloading

In 28
Minutes

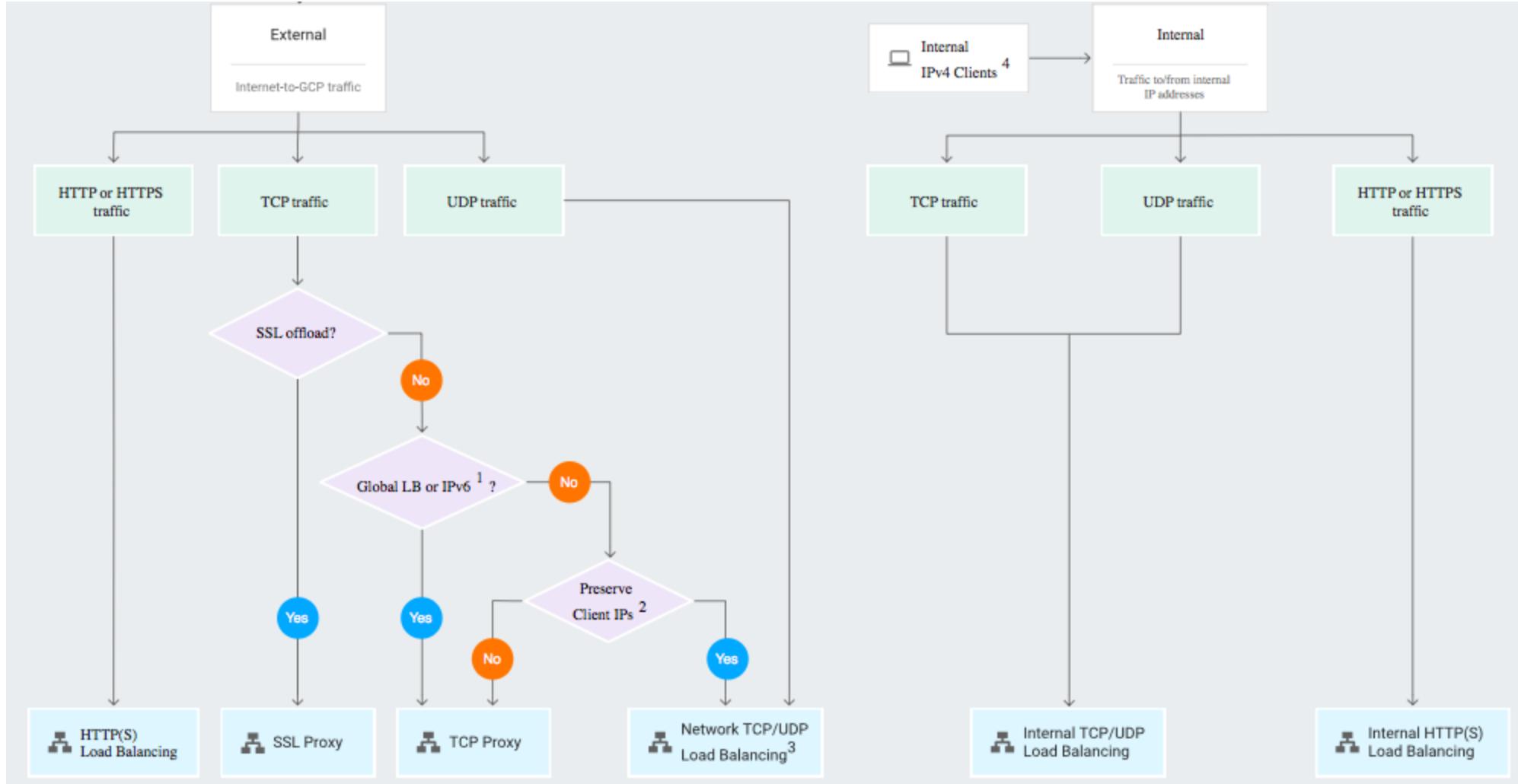


- Client to Load Balancer: Over internet
 - HTTPS recommended
- Load Balancer to VM instance: Through Google internal network
 - HTTP is ok. HTTPS is preferred.
- SSL/TLS Termination/Offloading
 - Client to Load Balancer: HTTPS/TLS
 - Load Balancer to VM instance: HTTP/TCP

Cloud Load Balancing - Choosing Load Balancer

In 28
Minutes

<https://cloud.google.com/load-balancing/images/choose-lb.svg>



Cloud Load Balancing - Features

In 28
Minutes

Load Balancer	Type of Traffic	Proxy or pass-through	Destination Ports
External HTTP(S)	Global, External, HTTP or HTTPS	Proxy	HTTP on 80 or 8080 HTTPS on 443
Internal HTTP(S)	Regional, Internal, HTTP or HTTPS	Proxy	HTTP on 80 or 8080 HTTPS on 443
SSL Proxy	Global, External, TCP with SSL offload	Proxy	A big list
TCP Proxy	Global, External, TCP without SSL offload	Proxy	A big list
External Network TCP/UDP	Regional, External, TCP or UDP	Pass-through	any
Internal TCP/UDP	Regional, Internal, TCP or UDP	Pass-through	any

Load Balancer Scenarios

In 28
Minutes

Scenario	Solution
You want only healthy instances to receive traffic	Configure health check
You want high availability for your VM instances	Create Multiple MIGs for your VM instances in multiple regions. Load balance using a Load Balancer.
You want to route requests to multiple microservices using the same load balancer	Create individual MIGs and backends for each microservice. Create Host and path rules to redirect to specific microservice backend based on the path (/microservice-a, /microservice-b etc). You can route to a backend Cloud Storage bucket as well.
You want to load balance Global external HTTPS traffic across backend instances, across multiple regions	Choose External HTTP(S) Load Balancer
You want SSL termination for Global non-HTTPS traffic with load balancing	Choose SSL Proxy Load Balancer

Managed Services

Managed Services

In 28
Minutes

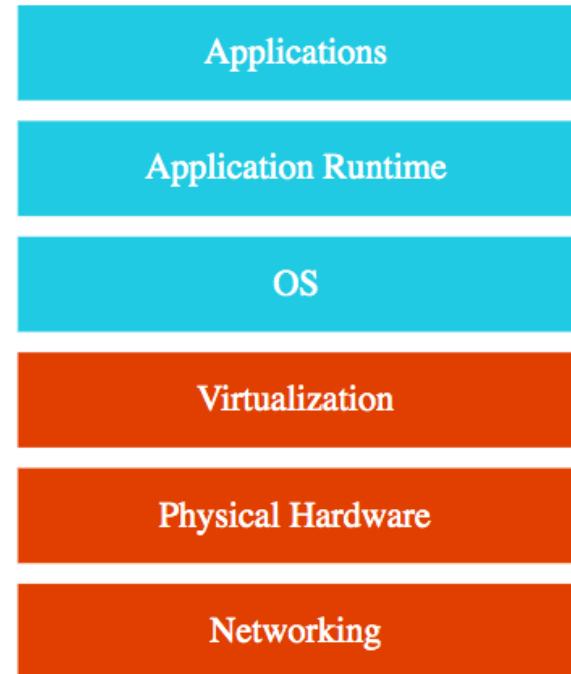
- Do you want to continue running applications in the cloud, the **same way you run them** in your data center?
- OR are there **OTHER** approaches?
- You should **understand some terminology** used with cloud services:
 - IaaS (Infrastructure as a Service)
 - PaaS (Platform as a Service)
 - FaaS (Function as a Service)
 - CaaS (Container as a Service)
 - Serverless
- Let's get on a quick journey to understand these!



IAAS (Infrastructure as a Service)

In 28
Minutes

- Use **only infrastructure** from cloud provider
- **Example:** Using VM to deploy your applications or databases
- You are responsible for:
 - Application Code and Runtime
 - Configuring load balancing
 - Auto scaling
 - OS upgrades and patches
 - Availability
 - etc.. (and a lot of things!)



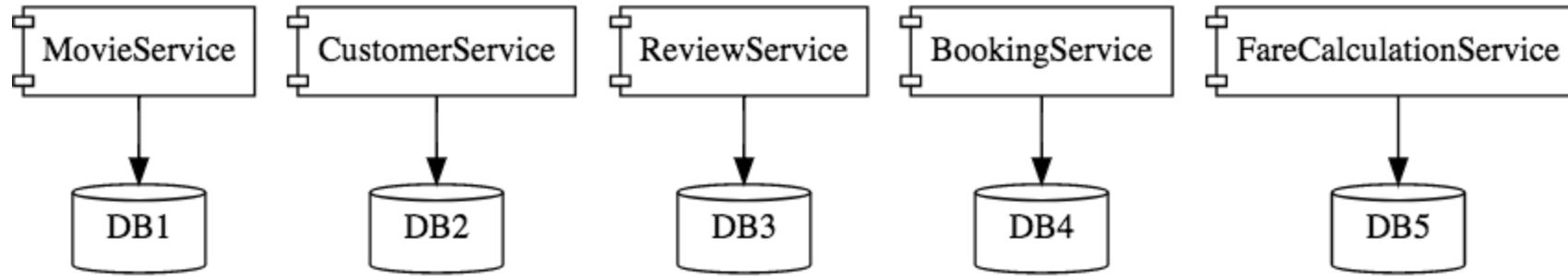
PAAS (Platform as a Service)

- Use a platform provided by cloud
- **Cloud provider** is responsible for:
 - OS (incl. upgrades and patches)
 - Application Runtime
 - Auto scaling, Availability & Load balancing etc..
- **You** are responsible for:
 - Configuration (of Application and Services)
 - Application code (if needed)
- Varieties:
 - **CAAS (Container as a Service)**: Containers instead of Apps
 - **FAAS (Function as a Service)**: Functions instead of Apps
 - Databases - Relational & NoSQL (Amazon RDS, Google Cloud SQL, Azure SQL Database etc), Queues, AI, ML, Operations etc!



Microservices

In 28
Minutes

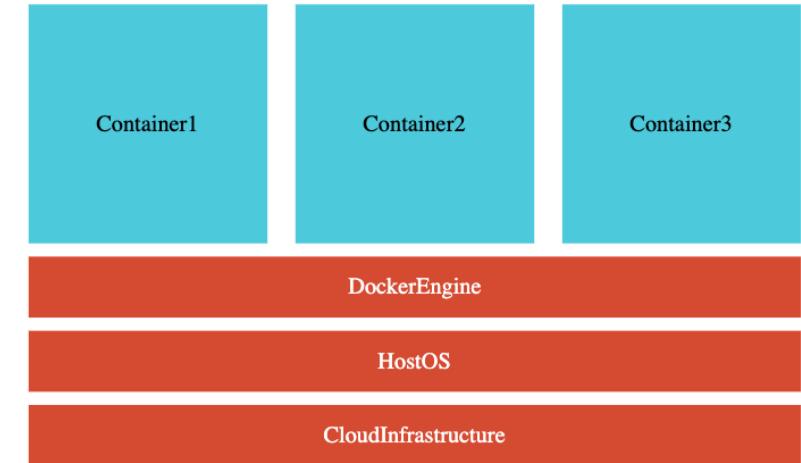


- Enterprises are heading towards microservices architectures
 - Build small focused microservices
 - **Flexibility to innovate** and build applications in different programming languages (Go, Java, Python, JavaScript, etc)
- **BUT deployments become complex!**
- How can we have **one way of deploying** Go, Java, Python or JavaScript .. microservices?
 - Enter **containers!**

Containers - Docker

In 28
Minutes

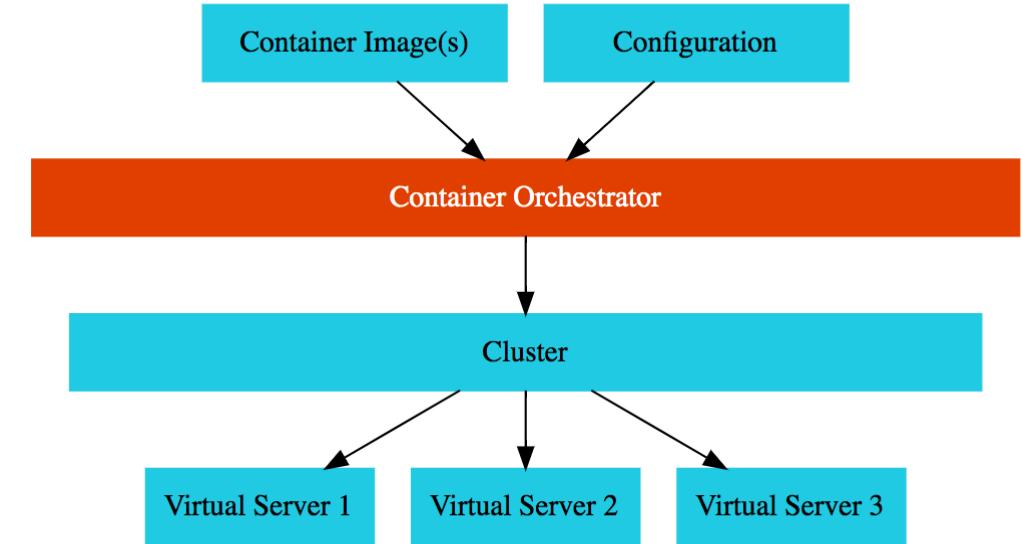
- Create Docker images for each microservice
- Docker image has all needs of a microservice:
 - Application Runtime (JDK or Python or NodeJS)
 - Application code and Dependencies
- Runs the same way on any infrastructure:
 - Your local machine
 - Corporate data center
 - Cloud
- Advantages
 - Docker containers are light weight
 - Compared to Virtual Machines as they do not have a Guest OS
 - Docker provides isolation for containers
 - Docker is cloud neutral



Container Orchestration

In 28
Minutes

- **Requirement :** I want 10 instances of Microservice A container, 15 instances of Microservice B container and
- **Typical Features:**
 - **Auto Scaling** - Scale containers based on demand
 - **Service Discovery** - Help microservices find one another
 - **Load Balancer** - Distribute load among multiple instances of a microservice
 - **Self Healing** - Do health checks and replace failing instances
 - **Zero Downtime Deployments** - Release new versions without downtime



- What do we think about when we develop an application?
 - Where to deploy? What kind of server? What OS?
 - How do we take care of scaling and availability of the application?
- **What if you don't need to worry about servers and focus on your code?**
 - Enter Serverless
 - Remember: Serverless does NOT mean "No Servers"
- **Serverless for me:**
 - You don't worry about infrastructure (ZERO visibility into infrastructure)
 - Flexible scaling and automated high availability
 - Most Important: Pay for use
 - Ideally ZERO REQUESTS => ZERO COST
- **You focus on code** and the cloud managed service takes care of all that is needed to scale your code to serve millions of requests!
 - And you pay for requests and NOT servers!

Serverless - My Perspective!

In 28
Minutes

- Serverless - Important Features:
 - 1: Zero worry about infrastructure, scaling and availability
 - 2: Zero invocations => Zero Cost (Can you scale down to ZERO instances?)
 - 3: Pay for invocations and NOT for instances (or nodes or servers)
 - Serverless **Level 1**: Features (1 + 2)
 - Serverless **Level 2**: Features (1 + 2 + 3)
- When I refer to Serverless, I'm referring to Level 2
- HOWEVER cloud providers include managed services at Level 1 and Level 2:
 - **Level 1: Google App Engine** (Google Calls it "App Engine is a fully managed, serverless platform"), **AWS Fargate** (AWS calls it "serverless compute engine for containers")
 - Scale down to ZERO instances when there is no load, BUT you pay for number (and type) of instances running!
 - **Level 2: Google Functions, AWS Lambda, Azure Functions etc**
 - You pay for invocations

GCP Managed Services for Compute

In 28
Minutes

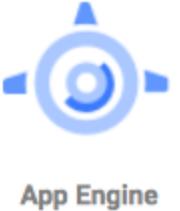
Service	Details	Category	
Compute Engine	High-performance and general purpose VMs that scale globally	IaaS	 Compute Engine
Google Kubernetes Engine	Orchestrate containerized microservices on Kubernetes Needs advanced cluster configuration and monitoring	CaaS	
App Engine	Build highly scalable applications on a fully managed platform using open and familiar languages and tools	PaaS (CaaS, Serverless)	 Cloud Run
Cloud Functions	Build event driven applications using simple, single-purpose functions	FaaS, Serverless	
Cloud Run	Develop and deploy highly scalable containerized applications. Does NOT need a cluster!	CaaS (Serverless)	 Cloud Functions

App Engine

App Engine

In 28
Minutes

- **Simplest way** to deploy and scale your applications in GCP
 - Provides end-to-end application management
- **Supports:**
 - Go, Java, .NET, Node.js, PHP, Python, Ruby using pre-configured runtimes
 - Use custom run-time and write code in any language
 - Connect to variety of Google Cloud storage products (Cloud SQL etc)
- **No usage charges** - Pay for resources provisioned
- **Features:**
 - Automatic load balancing & Auto scaling
 - Managed platform updates & Application health monitoring
 - Application versioning
 - Traffic splitting



Compute Engine vs App Engine

In 28
Minutes

- **Compute Engine**

- IAAS
- MORE Flexibility
- MORE Responsibility
 - Choosing Image
 - Installing Software
 - Choosing Hardware
 - Fine grained Access/Permissions (Certificates/Firewalls)
 - Availability etc



App Engine



Compute Engine

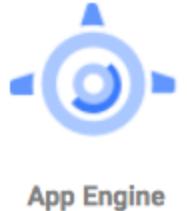
- **App Engine**

- PaaS
- Serverless
- LESSER Responsibility
- LOWER Flexibility

App Engine environments

In 28
Minutes

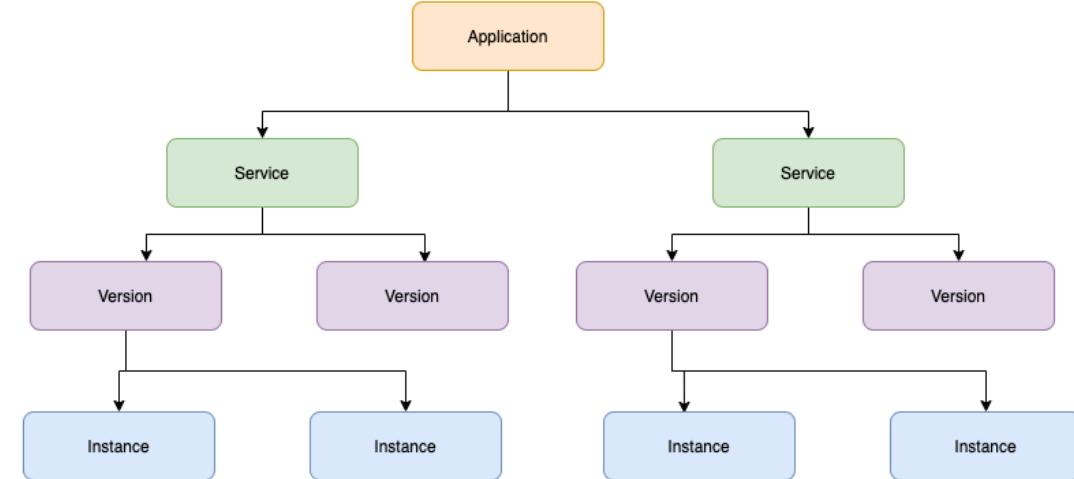
- **Standard:** Applications run in language specific sandboxes
 - Complete isolation from OS/Disk/Other Apps
 - **V1:** Java, Python, PHP, Go (OLD Versions)
 - ONLY for Python and PHP runtimes:
 - Restricted network Access
 - Only white-listed extensions and libraries are allowed
 - No Restrictions for Java and Go runtimes
 - **V2:** Java, Python, PHP, Node.js, Ruby, Go (NEWER Versions)
 - Full Network Access and No restrictions on Language Extensions
- **Flexible** - Application instances run within Docker containers
 - Makes use of Compute Engine virtual machines
 - Support ANY runtime (with built-in support for Python, Java, Node.js, Go, Ruby, PHP, or .NET)
 - Provides access to background processes and local disks



App Engine - Application Component Hierarchy

In 28
Minutes

- **Application:** One App per Project
- **Service(s):** Multiple Microservices or App components
 - You can have multiple services in a single application
 - Each **Service** can have different settings
 - Earlier called Modules
- **Version(s):** Each version associated with code and configuration
 - Each **Version** can run in one or more instances
 - Multiple versions can co-exist
 - Options to rollback and split traffic



App Engine - Comparison

Feature	Standard	Flexible
Pricing Factors	Instance hours	vCPU, Memory & Persistent Disks
Scaling	Manual, Basic, Automatic	Manual, Automatic
Scaling to zero	Yes	No. Minimum one instance
Instance startup time	Seconds	Minutes
Rapid Scaling	Yes	No
Max. request timeout	1 to 10 minutes	60 minutes
Local disk	Mostly(except for Python, PHP). Can write to /tmp.	Yes. Ephemeral. New Disk on startup.
SSH for debugging	No	Yes

App Engine - Scaling Instances

In 28
Minutes

- **Automatic** - Automatically scale instances based on the load:

- Recommended for Continuously Running Workloads
 - Auto scale based on:
 - Target CPU Utilization - Configure a CPU usage threshold.
 - Target Throughput Utilization - Configure a throughput threshold
 - Max Concurrent Requests - Configure max concurrent requests an instance can receive
 - Configure **Max Instances** and **Min Instances**



App Engine

- **Basic** - Instances are created as and when requests are received:

- Recommended for Adhoc Workloads
 - Instances are shutdown if ZERO requests
 - Tries to keep costs low
 - High latency is possible
 - NOT supported by App Engine Flexible Environment
 - Configure **Max Instances** and **Idle Timeout**

- **Manual** - Configure specific number of instances to run:

- Adjust number of instances manually over time

AppEngine Demo

In 28
Minutes

- Deploy an application to cloud using App Engine

app.yaml Reference

```
runtime: python28 #The name of the runtime environment that is used by your app
api_version: 1  #RECOMMENDED - Specify here - gcloud app deploy -v [YOUR_VERSION_ID]
instance_class: F1
service: service-name
#env: flex

inbound_services:
- warmup

env_variables:
  ENV_VARIABLE: "value"

handlers:
- url: /
  script: home.app

automatic_scaling:
  target_cpu_utilization: 0.65
  min_instances: 5
  max_instances: 100
  max_concurrent_requests: 50
#basic_scaling:
#  max_instances: 11
#  idle_timeout: 10m
#manual_scaling:
#  instances: 5
```

AppEngine - Request Routing

In 28
Minutes

- You can use a **combination** of three approaches:
 - Routing with URLs:
 - `https://PROJECT_ID.REGION_ID.r.appspot.com` (default service called)
 - `https://SERVICE-dot-PROJECT_ID.REGION_ID.r.appspot.com` (specific service)
 - `https://VERSION-dot-SERVICE-dot-PROJECT_ID.REGION_ID.r.appspot.com` (specific version of service)
 - Replace -dot- with . if using custom domain
 - Routing with a **dispatch file**:
 - Configure `dispatch.yaml` with routes
 - `gcloud app deploy dispatch.yaml`
 - Routing with **Cloud Load Balancing**:
 - Configure routes on Load Balancing instance



App Engine

AppEngine - Deploying new versions without downtime

In 28
Minutes

- How do I go from V1 to V2 without downtime?
- **Option 1:** I'm very confident - Deploy & shift all traffic at once:
 - Deploy and shift all traffic at once from v1 to v2: *gcloud app deploy*
- **Option 2:** I want to manage the migration from v1 to v2
 - **STEP 1:** Deploy v2 without shifting traffic (`--no-promote`)
 - *gcloud app deploy --no-promote*
 - **STEP 2:** Shift traffic to V2:
 - **Option 1 (All at once Migration):** Migrate all at once to v2
 - *gcloud app services set-traffic s1 --splits V2=1*
 - **Option 2 (Gradual Migration):** Gradually shift traffic to v2. Add `--migrate` option.
 - Gradual migration is not supported by App Engine Flexible Environment
 - **Option 3 (Splitting):** Control the pace of migration
 - *gcloud app services set-traffic s1 --splits=v2=.5,v1=.5*
 - Useful to perform A/B testing
 - Ensure that new instances are warmed up before they receive traffic (app.yaml - `inbound_services > warmup`)



App Engine

How do you split traffic between multiple versions?

In 28
Minutes

- How do you decide which version receives which traffic?
 - **IP Splitting** - Based on request IP address
 - IP addresses can change causing accuracy issues! (I go from my house to a coffee shop)
 - If all requests originate from a corporate vpn with single IP, this can cause all requests to go to the same version
 - **Cookie Splitting** - Based on a cookie (**GOOGAPPUID**)
 - Cookies can be controlled from your application
 - Cookie splitting accurately assign users to versions
 - **Random** - Do it randomly
- How to do it?
 - Include `--split-by` option in `gcloud app services set-traffic` command
 - Value must be one of: cookie, ip, random
 - `gcloud app services set-traffic s1 --splits=v2=.5,v1=.5 --split-by=cookie`



App Engine

Playing with App Engine

In 28
Minutes

- ***gcloud app browse/create/deploy/describe/open-console***
 - *gcloud app create --region=us-central*
 - *gcloud app deploy app.yaml*
 - --image-url: Only for flexible environments. Deploy docker image.
 - *gcloud app deploy --image-url gcr.io/PROJECT-ID/hello-world-rest-api:0.0.1.RELEASE*
 - --promote --no-promote (Should new version receive traffic?)
 - --stop-previous-version --no-stop-previous-version (Should old version be stopped after new version receives all traffic?)
 - --version (Assign a version. Otherwise, a version number is generated.)
 - *gcloud app browse --service="myService" --version="v1"* (open in a web browser)
 - *gcloud app open-console --service="myService" --version="v1"*
 - *gcloud app open-console --logs*
- Other Commands
 - *gcloud app logs tail*
 - *gcloud app regions list*



App Engine

Playing with App Engine Instances



- ***gcloud app instances delete/describe/list/scp/ssh***
 - *gcloud app instances delete i1 --service=s1 --version=v1*
 - *gcloud app instances describe --service=s1 --version=v1 i1*
 - *gcloud app instances list*
 - *gcloud app instances scp --service=s1 --version=v1 --recurse local_dir i1:remote_dir*
(Copy files to/from App Engine Flexible instances)
 - *gcloud app instances ssh --service=s1 --version=v1 i1* (SSH into the VM of an App Engine Flexible instance)

Playing with App Engine Services and Versions

In 28
Minutes

- **gcloud app services browse/delete/describe/list/set-traffic**
 - *gcloud app services list*
 - *gcloud app services browse myService --version="v1"*
 - *gcloud app services delete service1 service2*
 - *gcloud app services describe service1*
 - *gcloud app services set-traffic APP1 --splits v1=0.9,v2=0.1*
 - --split_by (ip, cookie, random)
- **gcloud app versions browse/delete/describe/list/migrate/start/stop**
 - *gcloud app versions list*
 - --hide-no-traffic (Only show versions that are receiving traffic)
 - *gcloud app versions browse/delete/describe v1 --service="myService"*
 - *gcloud app versions migrate v2 --service="myService"* (migrate all traffic to new version)
 - *gcloud app versions start/stop v1*
 - --service=my-service Only start v1 of service my-service

App Engine - Cron Job

In 28
Minutes

```
cron:  
- description: "daily summary job"  
  url: /tasks/summary  
  schedule: every 24 hours
```

- Allows to run **scheduled jobs** at pre-defined intervals
- **Use cases:**
 - Send a report by email every day
 - Refresh cache data every 30 minutes
- Configured using **cron.yaml**
- Run this command - ***gcloud app deploy cron.yaml***
 - Performs a **HTTP GET** request to the configured URL on schedule

Others Important App Engine yaml files

In 28
Minutes

- **dispatch.yaml** - override routing rules

```
dispatch:  
  - url: "/mobile/*"  
    service: mobile-frontend  
  - url: "/work/*"  
    service: static-backend
```

- **queue.yaml** - manage task queues

```
queue:  
  - name: fooqueue  
    rate: 1/s  
    retry_parameters:  
      task_retry_limit: 7  
      task_age_limit: 2d
```

App Engine - Remember

In 28
Minutes

- AppEngine is **Regional** (services deployed across zones)
 - You CANNOT change an Application's region
- Good option for simple **microservices** (multiple services)
 - Use **Standard v2** when you are using supported languages
 - Use **Flexible** if you are building containerized apps
- Be aware - **ATLEAST one container** is always running when using **Flexible**:
 - Go for **Standard** if you want to be able to scale down the number of instances to zero when there is NO load
- Use a **combination of resident and dynamic instances**
 - Resident Instances: Run continuously
 - Dynamic Instances: Added based on load
 - Use all dynamic instances if you are cost sensitive
 - If you are not very cost sensitive, keep a set of resident instances running always



App Engine

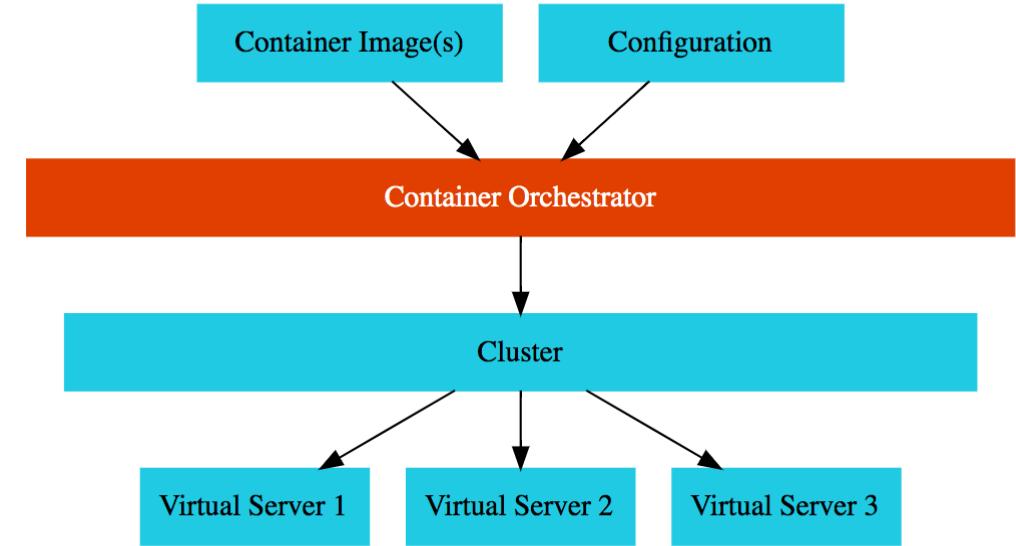
App Engine - Scenarios

In 28
Minutes

Scenario	Solution
I want to create two Google App Engine Apps in the same project	Not possible. You can only have one App Engine App per project. However you can have multiple services and multiple version for each service.
I want to create two Google App Engine Services inside the same App	Yup. You can create multiple services under the same app. Each service can have multiple versions as well.
I want to move my Google App Engine App to a different region	App Engine App is region specific. You CANNOT move it to different region. Create a new project and create new app engine app in the new region.
Perform Canary deployments	Deploy v2 without shifting traffic (<code>gcloud app deploy --no-promote</code>) Shift some traffic to V2 (<code>gcloud app services set-traffic s1 --splits v1=0.9,v2=0.1</code>)

Google Kubernetes Engine (GKE)

- Most popular open source container orchestration solution
- Provides Cluster Management (including upgrades)
 - Each cluster can have different types of virtual machines
- Provides all important container orchestration features:
 - Auto Scaling
 - Service Discovery
 - Load Balancer
 - Self Healing
 - Zero Downtime Deployments



Google Kubernetes Engine (GKE)

In 28
Minutes

- Managed Kubernetes service
- Minimize operations with **auto-repair** (repair failed nodes) and **auto-upgrade** (use latest version of K8S always) features
- Provides Pod and Cluster Autoscaling
- Enable Cloud Logging and Cloud Monitoring with simple configuration
- Uses Container-Optimized OS, a hardened OS built by Google
- Provides support for Persistent disks and Local SSD



Kubernetes Engine

Kubernetes - A Microservice Journey - Getting Started

In 28
Minutes

- **Let's Have Some Fun:** Let's get on a journey with Kubernetes:
 - Let's create a cluster, deploy a microservice and play with it in **13 steps!**
- **1:** Create a Kubernetes cluster with the default node pool
 - *gcloud container clusters create* or use cloud console
- **2:** Login to Cloud Shell
- **3:** Connect to the Kubernetes Cluster
 - *gcloud container clusters get-credentials my-cluster --zone us-central1-a --project solid-course-258105*



Kubernetes Engine

Kubernetes - A Microservice Journey - Deploy Microservice

28
Minutes

- 4: Deploy Microservice to Kubernetes:
 - Create deployment & service using kubectl commands
 - *kubectl create deployment hello-world-rest-api --image=in28min/hello-world-rest-api:0.0.1.RELEASE*
 - *kubectl expose deployment hello-world-rest-api --type=LoadBalancer --port=8080*
- 5: Increase number of instances of your microservice:
 - *kubectl scale deployment hello-world-rest-api --replicas=2*
- 6: Increase number of nodes in your Kubernetes cluster:
 - *gcloud container clusters resize my-cluster --node-pool my-node-pool --num-nodes 5*
 - You are NOT happy about manually increasing number of instances and nodes!



Kubernetes Engine

Kubernetes - A Microservice Journey - Auto Scaling and ..

In 28
Minutes

- 7: Setup auto scaling for your microservice:
 - `kubectl autoscale deployment hello-world-rest-api --max=10 --cpu-percent=70`
 - Also called horizontal pod autoscaling - HPA - `kubectl get hpa`
- 8: Setup auto scaling for your Kubernetes Cluster
 - `gcloud container clusters update cluster-name --enable-autoscaling --min-nodes=1 --max-nodes=10`
- 9: Add some application configuration for your microservice
 - Config Map - `kubectl create configmap todo-web-application-config --from-literal=RDS_DB_NAME=todos`
- 10: Add password configuration for your microservice
 - Kubernetes Secrets - `kubectl create secret generic todo-web-application-secrets-1 --from-literal=RDS_PASSWORD=dummytodos`



Kubernetes Engine

Kubernetes Deployment YAML - Deployment

In 28
Minutes

```
apiVersion: apps/v1
kind: Deployment
metadata:
  labels:
    app: hello-world-rest-api
  name: hello-world-rest-api
  namespace: default
spec:
  replicas: 3
  selector:
    matchLabels:
      app: hello-world-rest-api
  template:
    metadata:
      labels:
        app: hello-world-rest-api
    spec:
      containers:
        - image: in28min/hello-world-rest-api:0.0.3.RELEASE
          name: hello-world-rest-api
```

Kubernetes Deployment YAML - Service

In 28
Minutes

```
apiVersion: v1
kind: Service
metadata:
  labels:
    app: hello-world-rest-api
  name: hello-world-rest-api
  namespace: default
spec:
  ports:
  - port: 8080
    protocol: TCP
    targetPort: 8080
  selector:
    app: hello-world-rest-api
  sessionAffinity: None
  type: LoadBalancer
```

Kubernetes - A Microservice Journey - The End!

In 28
Minutes

- 11: Deploy a new microservice which needs nodes with a GPU attached
 - Attach a new node pool with GPU instances to your cluster
 - `gcloud container node-pools create POOL_NAME --cluster CLUSTER_NAME`
 - `gcloud container node-pools list --cluster CLUSTER_NAME`
 - Deploy the new microservice to the new pool by setting up `nodeSelector` in the `deployment.yaml`
 - `nodeSelector: cloud.google.com/gke-nodepool: POOL_NAME`
- 12: Delete the Microservices
 - Delete service - `kubectl delete service`
 - Delete deployment - `kubectl delete deployment`
- 13: Delete the Cluster
 - `gcloud container clusters delete`

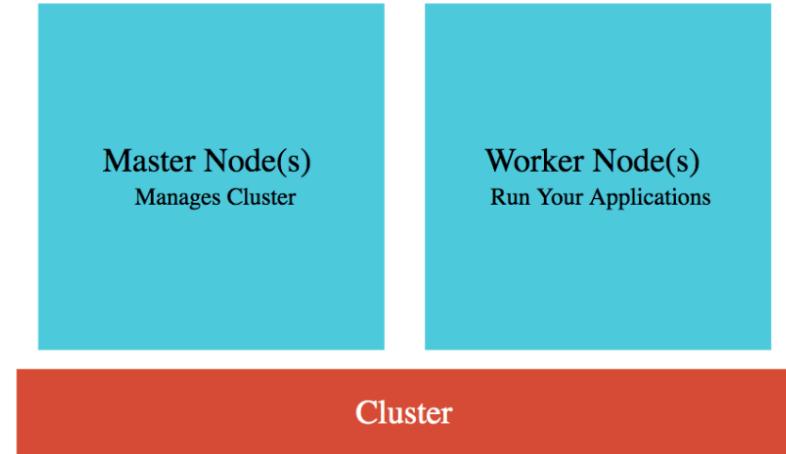


Kubernetes Engine

Google Kubernetes Engine (GKE) Cluster

In 28
Minutes

- **Cluster** : Group of Compute Engine instances:
 - **Master Node(s)** - Manages the cluster
 - **Worker Node(s)** - Run your workloads (pods)
- **Master Node (Control plane) components:**
 - **API Server** - Handles all communication for a K8S cluster (from nodes and outside)
 - **Scheduler** - Decides placement of pods
 - **Control Manager** - Manages deployments & replicaset
 - **etcd** - Distributed database storing the cluster state
- **Worker Node components:**
 - Runs your pods
 - **Kubelet** - Manages communication with master node(s)



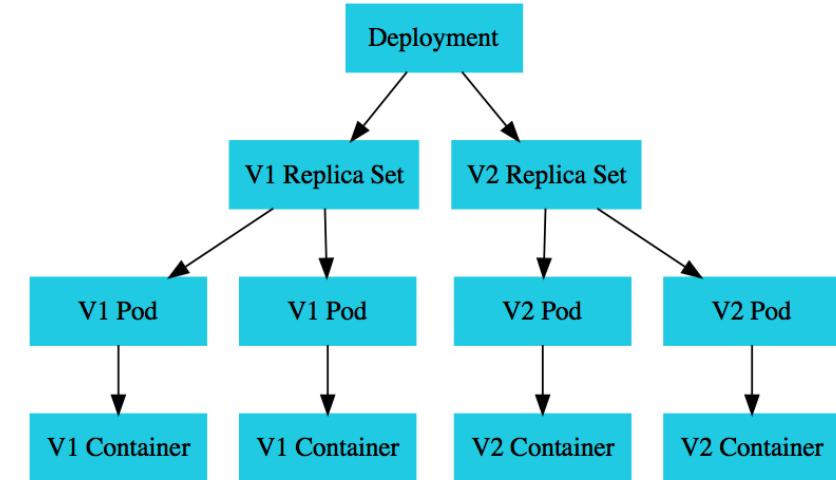
GKE Cluster Types

In 28
Minutes

Type	Description	
Zonal Cluster	Single Zone - Single Control plane. Nodes running in the same zone.	
	Multi-zonal - Single Control plane but nodes running in multiple zones	Kubernetes Engine
Regional cluster	Replicas of the control plane runs in multiple zones of a given region. Nodes also run in same zones where control plane runs.	
Private cluster	VPC-native cluster. Nodes only have internal IP addresses.	
Alpha cluster	Clusters with alpha APIs - early feature API's. Used to test new K8S features.	

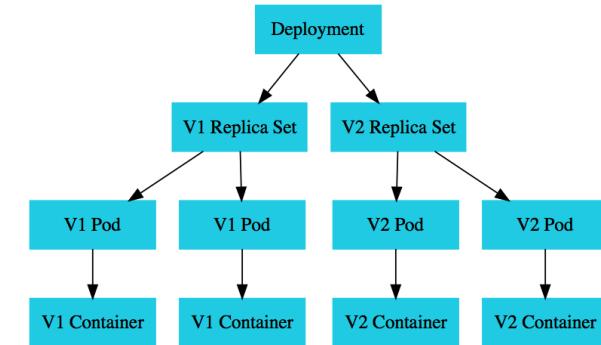
Kubernetes - Pods

- Smallest deployable unit in Kubernetes
- A Pod contains **one or more containers**
- Each Pod is assigned an ephemeral IP address
- All containers in a pod share:
 - Network
 - Storage
 - IP Address
 - Ports and
 - Volumes (Shared persistent disks)
- POD statuses : Running /Pending /Succeeded /Failed /Unknown



Kubernetes - Deployment vs Replica Set

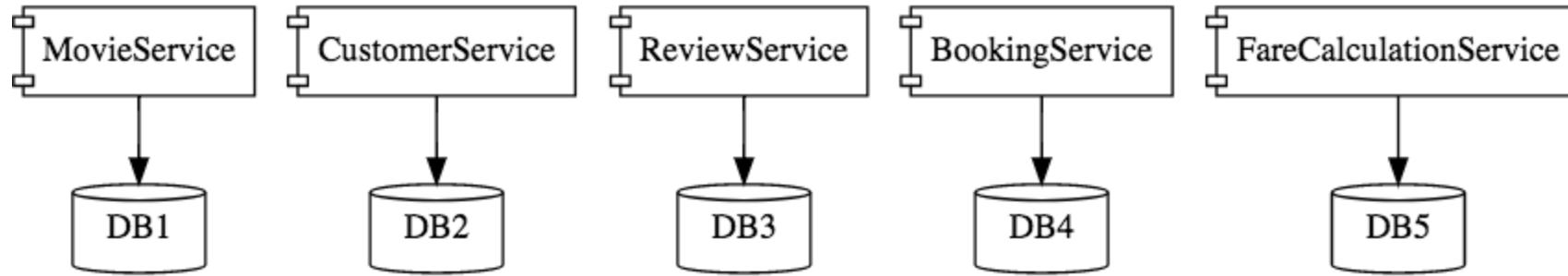
- A **deployment** is created for each microservice:
 - `kubectl create deployment m1 --image=m1:v1`
 - Deployment represents a microservice (with all its releases)
 - Deployment manages new releases ensuring zero downtime
- **Replica set** ensures that a specific number of pods are running for a specific microservice version
 - `kubectl scale deployment m2 --replicas=2`
 - Even if one of the pods is killed, replica set will launch a new one
- Deploy V2 of microservice - Creates a new replica set
 - `kubectl set image deployment m1 m1=m1:v2`
 - V2 Replica Set is created
 - Deployment updates V1 Replica Set and V2 Replica Set based on the release strategies



- Each Pod has its own IP address:
 - How do you ensure that external users are not impacted when:
 - A pod fails and is replaced by replica set
 - A new release happens and all existing pods of old release are replaced by ones of new release
- Create Service
 - *kubectl expose deployment name --type=LoadBalancer --port=80*
 - Expose PODs to outside world using a stable IP Address
 - Ensures that the external world does not get impacted as pods go down and come up
- Three Types:
 - **ClusterIP:** Exposes Service on a cluster-internal IP
 - Use case: You want your microservice only to be available inside the cluster (Intra cluster communication)
 - **LoadBalancer:** Exposes Service externally using a cloud provider's load balancer
 - Use case: You want to create individual Load Balancer's for each microservice
 - **NodePort:** Exposes Service on each Node's IP at a static port (the NodePort)
 - Use case: You DO not want to create an external Load Balancer for each microservice (You can create one Ingress component to load balance multiple microservices)

Container Registry - Image Repository

In 28
Minutes



- You've created docker images for your microservices:
 - Where do you store them?
- **Container Registry** - fully-managed container registry provided by GCP
- (Alternative) Docker Hub
- Can be integrated to CI/CD tools to publish images to registry
- You can secure your container images. Analyze for vulnerabilities and enforce deployment policies.
- Naming: HostName/ProjectID/Image:Tag - gcr.io/projectname/helloworld:1

- Replicate master nodes across multiple zones for high availability
- (REMEMBER) Some CPU on the nodes is reserved by Control Plane:
 - 1st core - 6%, 2nd core - 1%, 3rd/4th - 0.5, Rest - 0.25
- Creating Docker Image for your microservices(Dockerfile):
 - Build Image: `docker build -t in28min/hello-world-rest-api:0.0.1.RELEASE`.
 - Test it Locally: `docker run -d -p 8080:8080 in28min/hello-world-rest-api:0.0.1.RELEASE`
 - Push it to Container Repository: `docker push in28min/hello-world-rest-api:0.0.1.RELEASE`
- Kubernetes supports **Stateful** deployments like Kafka, Redis, ZooKeeper:
 - **StatefulSet** - Set of Pods with unique, persistent identities and stable hostnames
- How do we run services on nodes for **log collection or monitoring**?
 - **DaemonSet** - One pod on every node! (for background services)
- (Enabled by default) Integrates with Cloud Monitoring and Cloud Logging
 - Cloud Logging System and Application Logs can be exported to Big Query or Pub/Sub

GKE - Cluster Management - Command Line

In 28
Minutes

Description	Command
Create Cluster	gcloud container clusters create my-cluster --zone us-central1-a --node-locations us-central1-c,us-central1-b
Resize Cluster	gcloud container clusters resize my-cluster --node-pool my-node-pool --num-nodes 10
Autoscale Cluster	gcloud container clusters update cluster-name --enable-autoscaling --min-nodes=1 --max-nodes=10
Delete Cluster	gcloud container clusters delete my-cluster
Adding Node Pool	gcloud container node-pools create new-node-pool-name --cluster my-cluster
List Images	gcloud container images list

GKE - Workload Management - Command Line

In 28
Minutes

Description	Command
List Pods/Service/Replica Sets	<code>kubectl get pods/services/replicasets</code>
Create Deployment	<code>kubectl apply -f deployment.yaml</code> or <code>kubectl create deployment</code>
Create Service	<code>kubectl expose deployment hello-world-rest-api --type=LoadBalancer --port=8080</code>
Scale Deployment	<code>kubectl scale deployment hello-world --replicas 5</code>
Autoscale Deployment	<code>kubectl autoscale deployment --max --min --cpu-percent</code>
Delete Deployment	<code>kubectl delete deployment hello-world</code>
Update Deployment	<code>kubectl apply -f deployment.yaml</code>
Rollback Deployment	<code>kubectl rollout undo deployment hello-world --to-revision=1</code>

Google Kubernetes Engine - Scenarios - 1

In 28
Minutes

Scenario

You want to keep your costs low and optimize your GKE implementation

Solution

Consider Preemptible VMs, Appropriate region, Committed-use discounts.
E2 machine types are cheaper than N1.
Choose right environment to fit your workload type (Use multiple node pools if needed).

You want an efficient, completely auto scaling GKE solution

Configure Horizontal Pod Autoscaler for deployments and Cluster Autoscaler for node pools

You want to execute untrusted third-party code in Kubernetes Cluster

Create a new node pool with GKE Sandbox. Deploy untrusted code to Sandbox node pool.

Google Kubernetes Engine - Scenarios - 2

In 28
Minutes

Scenario	Solution
You want enable ONLY internal communication between your microservice deployments in a Kubernetes Cluster	Create Service of type ClusterIP
My pod stays pending	Most probably Pod cannot be scheduled onto a node(insufficient resources)
My pod stays waiting	Most probably failure to pull the image

Google Cloud Functions

Cloud Functions

In 28
Minutes

- Imagine you want to **execute some code when an event happens?**
 - A file is uploaded in Cloud Storage
 - An error log is written to Cloud Logging
 - A message arrives to Cloud Pub/Sub
- Enter **Cloud Functions**
 - **Run code in response to events**
 - Write your business logic in Node.js, Python, Go, Java, .NET, and Ruby
 - Don't worry about servers or scaling or availability (only worry about your code)
 - **Pay only for what you use**
 - Number of invocations
 - Compute Time of the invocations
 - Amount of memory and CPU provisioned
 - **Time Bound** - Default 1 min and MAX 9 minutes(540 seconds)
 - **Each execution runs in a separate instance**
 - No direct sharing between invocations



Cloud Functions

Cloud Functions - Concepts

In 28
Minutes

- **Event** : Upload object to cloud storage
- **Trigger**: Respond to event with a Function call
 - **Trigger** - Which function to trigger when an event happens?
 - **Functions** - Take event data and perform action?
- Events are **triggered from**
 - Cloud Storage
 - Cloud Pub/Sub
 - HTTP POST/GET/DELETE/PUT/OPTIONS
 - Firebase
 - Cloud Firestore
 - Stack driver logging



Cloud Functions

Example Cloud Function - HTTP - Node.js

In 28
Minutes

```
const escapeHtml = require('escape-html');

/**
 * HTTP Cloud Function.
 *
 * @param {Object} req Cloud Function request context.
 *                      More info: https://expressjs.com/en/api.html#req
 * @param {Object} res Cloud Function response context.
 *                      More info: https://expressjs.com/en/api.html#res
 */
exports.helloHttp = (req, res) => {
  res.send(`Hello ${escapeHtml(req.query.name || req.body.name || 'World')}`);
};
```

Example Cloud Function - Pub/Sub - Node.js

In 28
Minutes

```
/**  
 * Background Cloud Function to be triggered by Pub/Sub.  
 * This function is exported by index.js, and executed when  
 * the trigger topic receives a message.  
 *  
 * @param {object} message The Pub/Sub message.  
 * @param {object} context The event metadata.  
 */  
exports.helloPubSub = (message, context) => {  
  const name = message.data  
    ? Buffer.from(message.data, 'base64').toString()  
    : 'World';  
  
  console.log(`Hello, ${name}!`);  
};
```

Cloud Functions - Remember

In 28
Minutes

- No Server Management: You dont need to worry about scaling or availability of your function
- Cloud Functions automatically spin up and back down in response to events
 - They scale horizontally!
- Cloud Functions are recommended for responding to events:
 - Cloud Functions are NOT ideal for long running processes
 - Time Bound - Default 1 min and MAX 9 minutes(540 seconds)



Cloud Functions

Cloud Run & Cloud Run for Anthos

In 28
Minutes

- **Cloud Run - "Container to Production in Seconds"**
 - Built on top of an open standard - **Knative**
 - **Fully managed** serverless platform for containerized applications
 - ZERO infrastructure management
 - Pay-per-use (For used CPU, Memory, Requests and Networking)
- **Fully integrated end-to-end developer experience:**
 - **No limitations** in languages, binaries and dependencies
 - Easily portable because of **container** based architecture
 - Cloud Code, Cloud Build, Cloud Monitoring & Cloud Logging Integrations
- **Anthos** - Run Kubernetes clusters anywhere
 - Cloud, Multi Cloud and On-Premise
- **Cloud Run for Anthos:** Deploy your workloads to Anthos clusters running on-premises or on Google Cloud
 - Leverage your existing Kubernetes investment to quickly run serverless workloads



Cloud Run

Cloud Run - From the Command Line

In 28
Minutes

Description	Command
Deploy a new container	<code>gcloud run deploy SERVICE_NAME --image IMAGE_URL --revision-suffix v1</code> First deployment creates a service and first revision Next deployments for the same service create new revisions
List available revisions	<code>gcloud run revisions list</code>
Adjust traffic assignments	<code>gcloud run services update-traffic myservice --to-revisions=v2=10,v1=90</code>

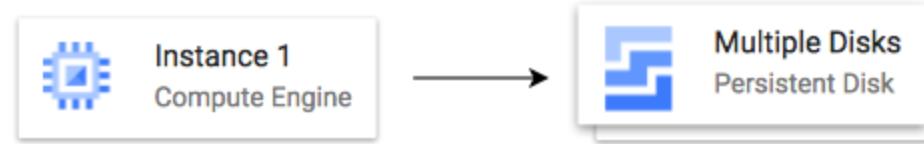
Encryption



- **Data at rest:** Stored on a device or a backup
 - Examples : data on a hard disk, in a database, backups and archives
- **Data in motion:** Being transferred across a network
 - Also called Data in transit
 - **Examples :**
 - Data copied from on-premise to cloud storage
 - An application talking to a database
 - **Two Types:**
 - In and out of cloud (from internet)
 - Within cloud
- **Data in use:** Active data processed in a non-persistent state
 - Example: Data in your RAM

Encryption

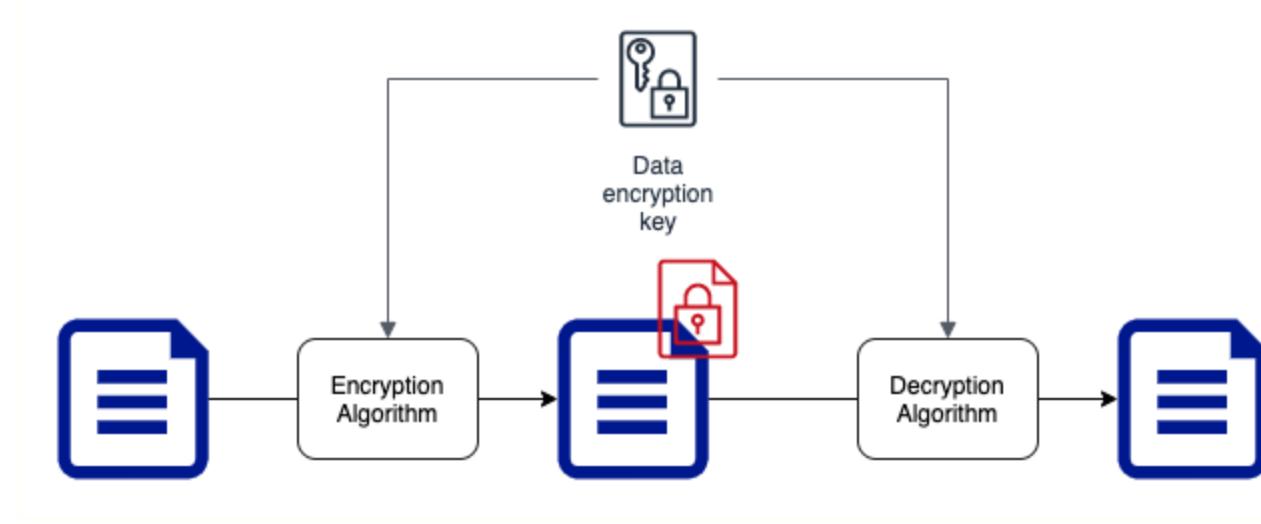
In 28
Minutes



- If you store data as is, what would happen if an **unauthorized entity** gets access to it?
 - Imagine losing an unencrypted hard disk
- **First law of security** : Defense in Depth
- Typically, enterprises encrypt all data
 - Data on your hard disks
 - Data in your databases
 - Data on your file servers
- Is it sufficient if you encrypt data at rest?
 - **No.** Encrypt data in transit - between application to database as well.

Symmetric Key Encryption

In 28
Minutes

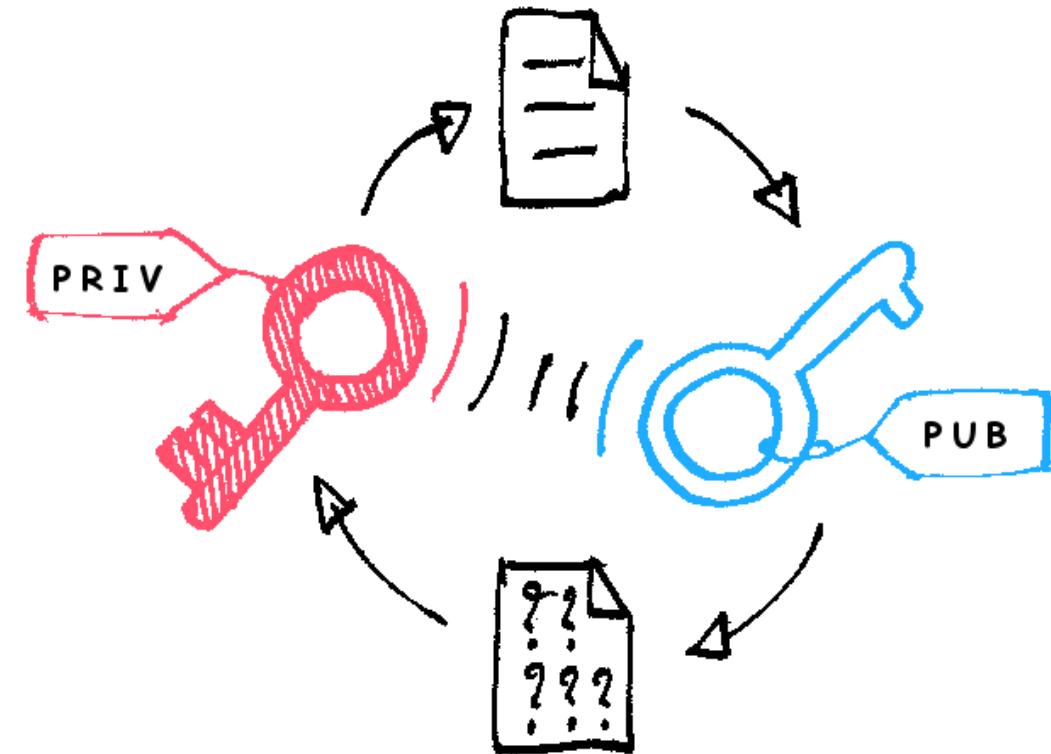


- Symmetric encryption algorithms use the **same key for encryption and decryption**
- Key Factor 1: Choose the **right encryption algorithm**
- Key Factor 2: How do we **secure the encryption key?**
- Key Factor 3: How do we **share the encryption key?**

Asymmetric Key Encryption

In 28
Minutes

- Two Keys : Public Key and Private Key
- Also called **Public Key Cryptography**
- Encrypt data with Public Key and decrypt with Private Key
- Share Public Key with everybody and keep the Private Key with you(YEAH, ITS PRIVATE!)
- No crazy questions:
 - Will somebody not figure out private key using the public key?
- How do you create Asymmetric Keys?



https://commons.wikimedia.org/wiki/File:Asymmetric_encry

Cloud KMS

In 28
Minutes

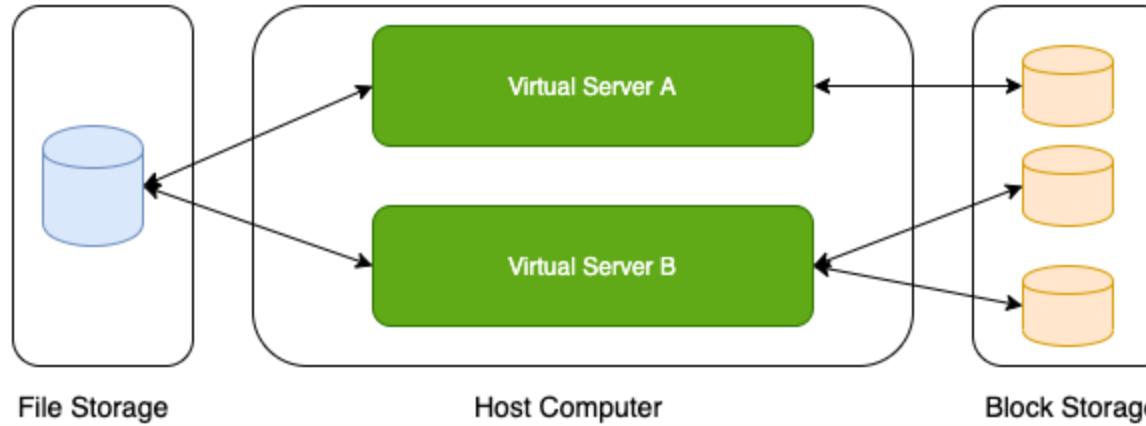
- Create and manage **cryptographic keys** (symmetric and asymmetric)
- **Control their use** in your applications and GCP Services
- Provides an API to encrypt, decrypt, or sign data
- Use existing cryptographic keys created on premises
- **Integrates with almost all GCP services** that need data encryption:
 - Google-managed key: No configuration required
 - Customer-managed key: Use key from KMS
 - Customer-supplied key: Provide your own key



Storage

Storage Types - Block Storage and File Storage

In 28
Minutes

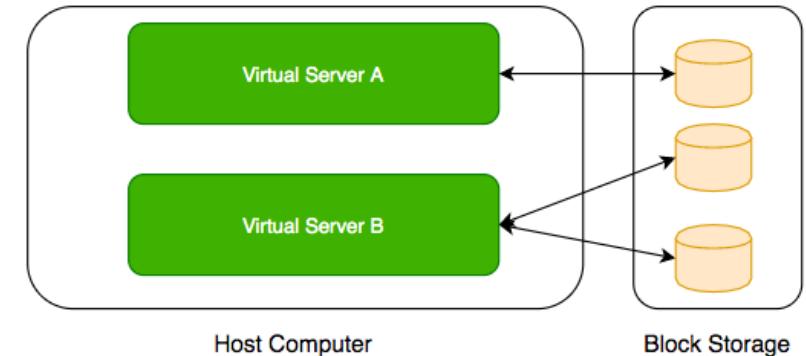


- What is the type of storage of your hard disk?
 - Block Storage
- You've created a file share to share a set of files with your colleagues in a enterprise. What type of storage are you using?
 - File Storage

Block Storage

In 28
Minutes

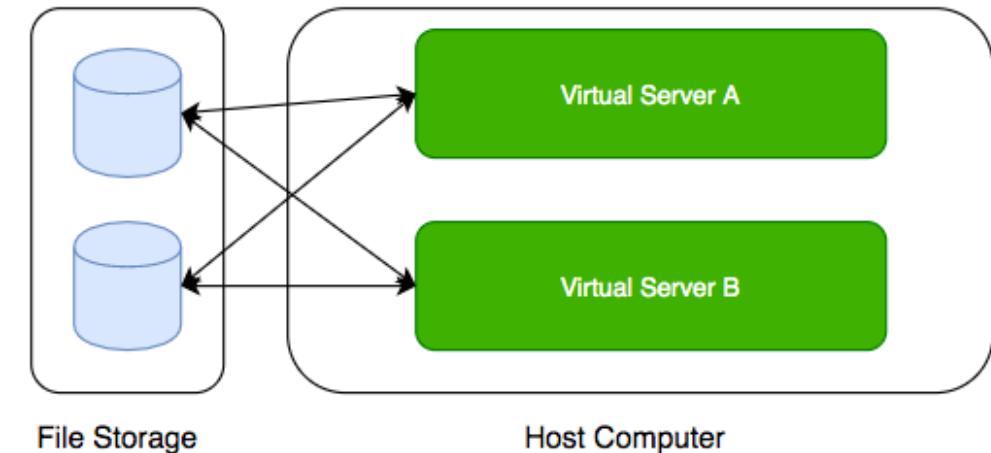
- Use case: Harddisks attached to your computers
- Typically, ONE Block Storage device can be connected to ONE virtual server
 - (EXCEPTIONS) You can attach read only block devices with multiple virtual servers and certain cloud providers are exploring multi-writer disks as well!
- HOWEVER, you can connect multiple different block storage devices to one virtual server
- Used as:
 - Direct-attached storage (DAS) - Similar to a hard disk
 - Storage Area Network (SAN) - High-speed network connecting a pool of storage devices
 - Used by Databases - Oracle and Microsoft SQL Server



File Storage

In 28
Minutes

- Media workflows need huge shared storage for supporting processes like video editing
- Enterprise users need a quick way to share files in a secure and organized way
- These file shares are shared by several virtual servers



GCP - Block Storage and File Storage

In 28
Minutes



Persistent Disk



Filestore

- **Block Storage:**
 - **Persistent Disks:** Network Block Storage
 - Zonal: Data replicated in one zone
 - Regional: Data replicated in multiple zone
 - **Local SSDs:** Local Block Storage
- **File Storage:**
 - **Filestore:** High performance file storage

GCP - Block Storage

In 28
Minutes

- Two popular types of block storage can be attached to VM instances:
 - Local SSDs
 - Persistent Disks
- **Local SSDs** are physically attached to the host of the VM instance
 - Temporary data
 - Lifecycle tied to VM instance
- **Persistent Disks** are network storage
 - More durable
 - Lifecycle NOT tied to VM instance

Local SSDs

In 28
Minutes

- **Physically attached** to the host of VM instance:
 - Provide very high (IOPS) and very low latency
 - (**BUT**) **Ephemeral storage** - Temporary data (Data persists only until instance is running)
 - Enable live migration for data to survive maintenance events
 - Data automatically encrypted
 - HOWEVER, you CANNOT configure encryption keys!
 - Lifecycle tied to VM instance
 - ONLY some machine types support Local SSDs
 - Supports SCSI and NVMe interfaces
- Remember:
 - Choose NVMe-enabled and multi-queue SCSI images for best performance
 - Larger Local SSDs (more storage), More vCPUs (attached to VM) => Even Better Performance

Local SSDs - Advantages and Disadvantages

In 28
Minutes

- **Advantages**

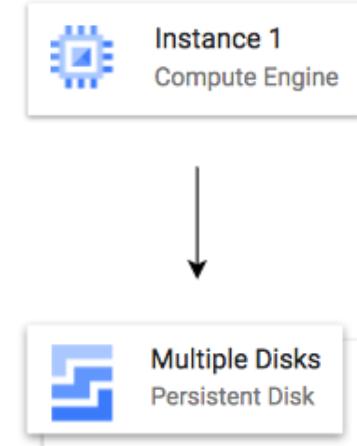
- Very Fast I/O (~ 10-100X compared to PDs)
 - Higher throughput and lower latency
- Ideal for use cases needing high IOPs while storing **temporary information**
 - Examples: Caches, temporary data, scratch files etc

- **Disadvantages**

- **Ephemeral storage**
 - Lower durability, lower availability, lower flexibility compared to PDs
- You **CANNOT** detach and attach it to another VM instance

Persistent Disks (PD)

- Network block storage attached to your VM instance
- Provisioned capacity
- Very Flexible:
 - Increase size when you need it - when attached to VM instance
 - Performance scales with size
 - For higher performance, resize or add more PDs
- Independent lifecycle from VM instance
 - Attach/Detach from one VM instance to another
- Options: Regional and Zonal
 - Zonal PDs replicated in single zone. Regional PDs replicated in 2 zones in same Region.
 - Typically Regional PDs are 2X the cost of Zonal PDs
- Use case : Run your custom database



Persistent Disks vs Local SSDs

In 28
Minutes

Feature	Persistent Disks	Local SSDs
Attachment to VM instance	As a network drive	Physically attached
Lifecycle	Separate from VM instance	Tied with VM instance
I/O Speed	Lower (network latency)	10-100X of PDs
Snapshots	Supported	Not Supported
Use case	Permanent storage	Ephemeral storage

Persistent Disks - Standard vs Balanced vs SSD

In 28
Minutes

Feature	Standard	Balanced	SSD
Underlying Storage	Hard Disk Drive	Solid State Drive	Solid State Drive
Referred to as	pd-standard	pd-balanced	pd-ssd
Performance - Sequential IOPS (Big Data/Batch)	Good	Good	Very Good
Performance - Random IOPS (Transactional Apps)	Bad	Good	Very Good
Cost	Cheapest	In Between	Expensive
Use cases	Big Data (cost efficient)	Balance between cost and performance	High Performance

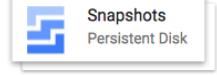
Persistent Disks - Snapshots

In 28
Minutes

- Take **point-in-time snapshots** of your Persistent Disks
- You can also schedule snapshots (configure a schedule):
 - You can also auto-delete snapshots after X days
- Snapshots can be Multi-regional and Regional
- You can share snapshots across projects
- You can create new disks and instances from snapshots
- Snapshots are **incremental**:
 - Deleting a snapshot **only deletes data which is NOT needed** by other snapshots
- Keep similar data together on a Persistent Disk:
 - Separate your operating system, volatile data and permanent data
 - Attach multiple disks if needed
 - This helps to better organize your snapshots and images



Persistent
Disk



Snapshots
Persistent Disk

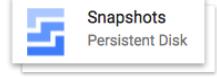
Persistent Disks - Snapshots - Recommendations

In 28
Minutes

- Avoid taking snapshots more often than once an hour
- Disk volume is available for use **but Snapshots reduce performance**
 - (RECOMMENDED) Schedule snapshots during off-peak hours
- Creating snapshots from disk is faster than creating from images:
 - But creating disks from image is faster than creating from snapshots
 - (RECOMMENDED) If you are repeatedly creating disks from a snapshot:
 - Create an image from snapshot and use the image to create disks
- Snapshots are **incremental**:
 - BUT you don't lose data by deleting older snapshots
 - Deleting a snapshot **only deletes data which is NOT needed** by other snapshots
 - (RECOMMENDED) Do not hesitate to delete unnecessary snapshots



Persistent
Disk

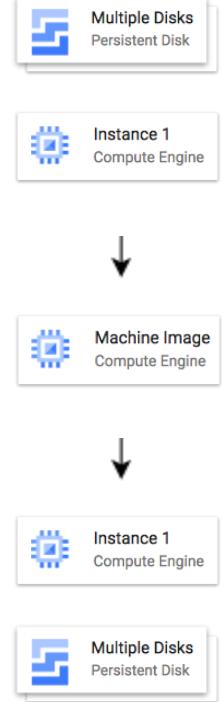


Snapshots
Persistent Disk

Playing with Machine Images

In 28
Minutes

- (Remember) Machine Image is different from Image
- **Multiple disks can be attached** with a VM:
 - One Boot Disk (Your OS runs from Boot Disk)
 - Multiple Data Disks
- An image is created from the boot Persistent Disk
- **HOWEVER**, a Machine Image is created from a VM instance:
 - Machine Image **contains everything you need** to create a VM instance:
 - Configuration
 - Metadata
 - Permissions
 - Data from one or more disks
- **Recommended for** disk backups, instance cloning and replication



Let's Compare

In 28
Minutes

Scenarios	Machine image	Persistent disk snapshot	Custom image	Instance template
Single disk backup	Yes	Yes	Yes	No
Multiple disk backup	Yes	No	No	No
Differential backup	Yes	Yes	No	No
Instance cloning and replication	Yes	No	Yes	Yes
VM instance configuration	Yes	No	No	Yes

<https://cloud.google.com/compute/docs/machine-images>

Playing with Disks - Command Line

In 28
Minutes

- ***gcloud compute disks list/create/delete/resize/snapshot***

- ***gcloud compute disks create my-disk-1 --zone=us-east1-a***

- What should be the size and type?

- `--size=SIZE` (1GB or 2TB)

- `--type=TYPE` (default - pd-standard) (*gcloud compute disk-types list*)

- What should be on the disk?

- `--image --image-family --source-disk --source-snapshot`

- How should data on disk be encrypted?

- `--kms-key --kms-project`

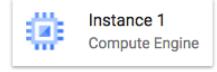
- ***gcloud compute disks resize example-disk-1 --size=6TB***

- Only increasing disk size is supported

- ***gcloud compute disks snapshot test --zone=us-central1-a --snapshot-names=snapshot-test***

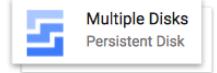
- You can also play with the snapshots which are created:

- *gcloud compute snapshots list/describe/delete*



Instance 1

Compute Engine



Multiple Disks

Persistent Disk

Playing with Images - Command Line

In 28
Minutes

- *gcloud compute images*
- Actions: *create/delete/deprecate/describe/export/import/list/update*
 - Creating Images
 - *gcloud compute images create my-image*
 - From a Disk - --source-disk=my-disk --source-disk-zone=us-east1-a
 - From a Snapshot - --source-snapshot=source-snapshot
 - From another image - --source-image=source-image --source-image-project=source-image-project
 - From latest non deprecated image from a family - --source-image-family=source-image-family --source-image-project=source-image-project
 - Deprecate Image
 - *gcloud compute images deprecate IMAGE --state=DEPRECATED*
 - Exports virtual disk images
 - *gcloud compute images export --image=my-image --destination-uri=gs://my-bucket/my-image.vmdk --export-format=vmdk --project=my-project*
 - Other Examples:
 - *gcloud compute images delete my-image1 my-image2*
 - *gcloud compute images list --format="value(NAME)"*



Persistent
Disk

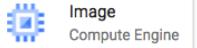


Image
Compute Engine

Playing with Machine Images - Command Line

In 28
Minutes

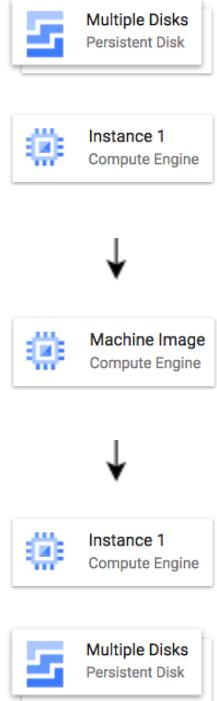
- (Remember) gcloud commands for machine images are IN BETA
- Commands:

- Create Machine Image:

- `gcloud beta compute machine-images create MACHINE_IMAGE_NAME --source-instance SOURCE_INSTANCE_NAME`

- Create an Instance from the Machine Image:

- `gcloud beta compute instances create VM_NAME --zone ZONE --source-machine-image SOURCE_MACHINE_IMAGE_NAME`



Storage - Scenarios - Persistent Disks

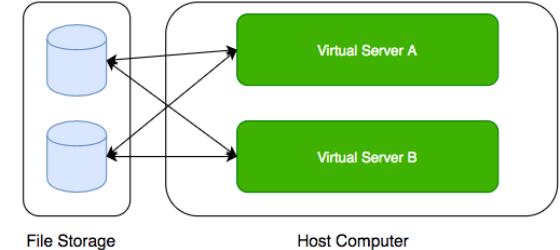
In 28
Minutes

Scenario	Solution
You want to improve performance of Persistent Disks (PD)	Increase size of PD or Add more PDs. Increase vCPUs in your VM.
You want to increase durability of Persistent Disks (PD)	Go for Regional PDs (2X cost but replicated in 2 zones)
You want to take hourly backup of Persistent Disks (PD) for disaster recovery	Schedule hourly snapshots!
You want to delete old snapshots created by scheduled snapshots	Configure it as part of your snapshot scheduling!

Cloud Filestore

In 28
Minutes

- **Shared cloud file storage:**
 - Supports NFSv3 protocol
 - Provisioned Capacity
- Suitable for **high performance** workloads:
 - Up to 320 TB with throughput of 16 GB/s and 480K IOPS
- Supports HDD (general purpose) and SSD (performance-critical workloads)
- **Use cases :** file share, media workflows and content management



Review - Global, Regional and Zonal Resources

In 28
Minutes

- **Global**
 - Images
 - Snapshots
 - Instance templates (Unless you use zonal resources in your templates)
- **Regional**
 - Regional managed instance groups
 - Regional persistent disks
- **Zonal**
 - Zonal managed instance groups
 - Instances
 - Persistent disks
 - You can attach a disk only to instances in the same zone as the disk

Storage - Scenarios

In 28
Minutes

Scenario	Solution
You want Very High IOPS but your data can be lost without a problem	Local SSDs
You want to create a high performance file sharing system in GCP which can be attached with multiple VMs	Filestore
You want to backup your VM configuration along with all its attached Persistent Disks	Create a Machine Image
You want to make it easy to launch VMs with hardened OS and customized software	Create a Custom Image

Object Storage - Cloud Storage

Cloud Storage

In 28
Minutes

- **Most popular, very flexible & inexpensive storage service**
 - Serverless: Autoscaling and infinite scale
- **Store large objects using a key-value approach:**
 - Treats entire object as a unit (Partial updates not allowed)
 - Recommended when you operate on entire object most of the time
 - Access Control at Object level
 - Also called **Object Storage**
- Provides REST API to access and modify objects
 - Also provides CLI (gsutil) & Client Libraries (C++, C#, Java, Node.js, PHP, Python & Ruby)
- **Store all file types - text, binary, backup & archives:**
 - Media files and archives, Application packages and logs
 - Backups of your databases or storage devices
 - Staging data during on-premise to cloud database migration



Cloud Storage

Cloud Storage - Objects and Buckets

In 28
Minutes

- Objects are stored in buckets
 - Bucket names are **globally unique**
 - Bucket names are used as part of object URLs => Can contain ONLY lower case letters, numbers, hyphens, underscores and periods.
 - 3-63 characters max. Can't start with **goog prefix** or should not contain **google (even misspelled)**
 - Unlimited objects in a bucket
 - Each bucket is associated with a project
- Each object is identified by a **unique key**
 - Key is **unique** in a bucket
- Max object size is **5 TB**
 - BUT you can store unlimited number of such objects



Cloud Storage

Cloud Storage - Storage Classes - Introduction

In 28
Minutes

- Different kinds of data can be stored in Cloud Storage
 - Media files and archives
 - Application packages and logs
 - Backups of your databases or storage devices
 - Long term archives
- Huge variations in access patterns
- Can I pay a cheaper price for objects I access less frequently?
- Storage classes help to optimize your costs based on your access needs
 - Designed for durability of 99.999999999%(11 9's)



Cloud Storage

Cloud Storage - Storage Classes - Comparison

In 28
Minutes

Storage Class	Name	Minimum Storage duration	Typical Monthly availability	Use case
Standard	STANDARD	None	> 99.99% in multi region and dual region, 99.99% in regions	Frequently used data/Short period of time
Nearline storage	NEARLINE	30 days	99.95% in multi region and dual region, 99.9% in regions	Read or modify once a month on average
Coldline storage	COLDLINE	90 days	99.95% in multi region and dual region, 99.9% in regions	Read or modify at most once a quarter
Archive storage	ARCHIVE	365 days	99.95% in multi region and dual region, 99.9% in regions	Less than once a year

Features across Storage Classes

In 28
Minutes

- High durability (99.99999999% annual durability)
- Low latency (first byte typically in tens of milliseconds)
- **Unlimited storage**
 - Autoscaling (No configuration needed)
 - NO minimum object size
- Same APIs across storage classes
- **Committed SLA** is 99.95% for multi region and 99.9% for single region for Standard, Nearline and Coldline storage classes
 - No committed SLA for Archive storage



Cloud Storage

Cloud Storage - Uploading and Downloading Objects

In 28
Minutes

Option	Recommended for Scenarios
Simple Upload	Small files (that can be re uploaded in case of failures) + NO object metadata
Multipart upload	Small files (that can be re uploaded in case of failures) + object metadata
Resumable upload	Larger files. RECOMMENDED for most usecases (even for small files - costs one additional HTTP request)
Streaming transfers	Upload an object of unknown size
Parallel composite uploads	File divided up to 32 chunks and uploaded in parallel. Significantly faster if network and disk speed are not limiting factors.
Simple download	Downloading objects to a destination
Streaming download	Downloading data to a process
Sliced object download	Slice and download large objects

Object Versioning

In 28
Minutes

- Prevents accidental deletion & provides history
 - Enabled at bucket level
 - Can be turned on/off at any time
 - **Live version** is the latest version
 - If you delete live object, it becomes noncurrent object version
 - If you delete noncurrent object version, it is deleted
 - Older versions are uniquely identified by (object key + a generation number)
 - Reduce costs by deleting older (noncurrent) versions!



Cloud Storage

Object Lifecycle Management

In 28
Minutes

- Files are frequently accessed when they are created
 - Generally usage reduces with time
 - How do you save costs by **moving files automatically between storage classes?**
 - Solution: Object Lifecycle Management
- Identify objects using conditions based on:
 - Age, CreatedBefore, IsLive, MatchesStorageClass, NumberOfNewerVersions etc
 - Set multiple conditions: all conditions must be satisfied for action to happen
- Two kinds of actions:
 - **SetStorageClass** actions (change from one storage class to another)
 - **Deletion** actions (delete objects)
- Allowed Transitions:
 - (Standard or Multi-Regional or Regional) to (Nearline or Coldline or Archive)
 - Nearline to (Coldline or Archive)
 - Coldline to Archive



Cloud Storage

Object Lifecycle Management - Example Rule

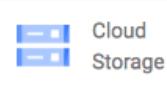
In 28
Minutes

```
{  
  "lifecycle": {  
    "rule": [  
      {  
        "action": {"type": "Delete"},  
        "condition": {  
          "age": 30,  
          "isLive": true  
        }  
      },  
      {  
        "action": {  
          "type": "SetStorageClass",  
          "storageClass": "NEARLINE"  
        },  
        "condition": {  
          "age": 365,  
          "matchesStorageClass": [ "STANDARD" ]  
        }  
      }  
    ]  
  }  
}
```

Cloud Storage - Encryption

In 28
Minutes

- Cloud Storage always encrypts data on the server side!
- Configure **Server-side** encryption: Encryption performed by Cloud Storage
 - Google-managed encryption key - Default (No configuration required)
 - Customer-managed encryption keys - Created using **Cloud Key Management Service (KMS)**. Managed by customer in KMS.
 - Cloud Storage Service Account should have access to keys in KMS for encrypting and decrypting using the Customer-Managed encryption key
- (OPTIONAL) **Client-side** encryption - Encryption performed by customer before upload
 - GCP does NOT know about the keys used



Cloud Storage - Scenarios

In 28
Minutes

Scenario	Description
How do you speed up large uploads (example: 100 GB) to Cloud Storage?	Use Parallel composite uploads (File is broken in to small chunks and uploaded)
You want to permanently store application logs for regulatory reasons. You don't expect to access them at all.	Cloud storage - Archive
Log files stored in Cloud storage. You expect to access them once in quarter.	Cold Line
How do you change storage class of an existing bucket in Cloud Storage?	Step 1: Change Default Storage Class of the bucket. Step 2: Update the Storage Class of the objects in the bucket.

Cloud Storage - Command Line - gsutil - 1

In 28
Minutes

- (REMEMBER) **gsutil** is the CLI for Cloud Storage (NOT gcloud)
- Cloud Storage (**gsutil**)
 - *gsutil mb gs://BKT_NAME* (Create Cloud Storage bucket)
 - *gsutil ls -a gs://BKT_NAME* (List current and non-current object versions)
 - *gsutil cp gs://SRC_BKT/SRC_OBJ gs://DESTN_BKT/NAME_COPY* (Copy objects)
 - -o 'GSUtil:encryption_key=ENCRYPTION_KEY' - Encrypt Object
 - *gsutil mv* (Rename/Move objects)
 - *gsutil mv gs://BKT_NAME/OLD_OBJ_NAME gs://BKT_NAME/NEW_OBJ_NAME*
 - *gsutil mv gs://OLD_BUCKET_NAME/OLD_OBJECT_NAME gs://NEW_BKT_NAME/NEW_OBJ_NAME*
 - *gsutil rewrite -s STORAGE_CLASS gs://BKT_NAME/OBJ_PATH* (Ex: Change Storage Class for objects)
 - *gsutil cp* : Upload and Download Objects
 - *gsutil cp LOCAL_LOCATION gs://DESTINATION_BKT_NAME/* (Upload)
 - *gsutil cp gs://BKT_NAME/OBJ_PATH LOCAL_LOCATION* (Download)



Cloud Storage

Cloud Storage - Command Line - gsutil - 2

In 28
Minutes

- Cloud Storage (gsutil)

- *gsutil versioning set on/off gs://BKT_NAME* (Enable/Disable Versioning)

- *gsutil uniformbucketlevelaccess set on/off gs://BKT_NAME*

- *gsutil acl ch* (Set Access Permissions for Specific Objects)

- *gsutil acl ch -u AllUsers:R gs://BKT_NAME/OBJ_PATH* (Make specific object public)

- *gsutil acl ch -u john.doe@example.com:WRITE gs://BKT_NAME/OBJ_PATH*

- Permissions - READ (R), WRITE (W), OWNER (O)

- Scope - User, allAuthenticatedUsers, allUsers(-u), Group (-g), Project (-p) etc

- *gsutil acl set JSON_FILE gs://BKT_NAME*

- *gsutil iam ch MBR_TYPE:MBR_NAME:IAM_ROLE gs://BKT_NAME* (Setup IAM role)

- *gsutil iam ch user:me@myemail.com:objectCreator gs://BKT_NAME*

- *gsutil iam ch allUsers:objectViewer gs://BKT_NAME* (make the entire bucket readable)

- *gsutil signurl -d 10m YOUR_KEY gs://BUCKET_NAME/OBJECT_PATH* (Signed URL for temporary access)



Cloud Storage

IAM

Typical identity management in the cloud

In 28
Minutes

- You have **resources** in the cloud (examples - a virtual server, a database etc)
- You have **identities (human and non-human)** that need to access those resources and perform actions
 - For example: launch (stop, start or terminate) a virtual server
- How do you **identify users** in the cloud?
 - How do you configure resources they can access?
 - How can you configure what actions to allow?
- In GCP: *Identity and Access Management (Cloud IAM)* provides this service



Cloud IAM

Cloud Identity and Access Management (IAM)

In 28
Minutes

- **Authentication** (is it the right user?) and
- **Authorization** (do they have the right access?)
- **Identities** can be
 - A GCP User (Google Account or Externally Authenticated User)
 - A Group of GCP Users
 - An Application running in GCP
 - An Application running in your data center
 - Unauthenticated users
- Provides very **granular** control
 - Limit a single user:
 - to perform single action
 - on a specific cloud resource
 - from a specific IP address
 - during a specific time window



Cloud IAM

Cloud IAM Example

In 28
Minutes

- I want to provide access to manage a specific cloud storage bucket to a colleague of mine:
 - Important Generic Concepts:
 - Member: My colleague
 - Resource: Specific cloud storage bucket
 - Action: Upload/Delete Objects
 - In Google Cloud IAM:
 - Roles: A set of permissions (to perform specific actions on specific resources)
 - Roles do NOT know about members. It is all about permissions!
 - How do you assign permissions to a member?
 - Policy: You assign (or bind) a role to a member
- 1: Choose a Role with right permissions (Ex: Storage Object Admin)
- 2: Create Policy binding member (your friend) with role (permissions)
- IAM in AWS is very different from GCP (Forget AWS IAM & Start FRESH!)
 - Example: Role in AWS is NOT the same as Role in GCP



Cloud Storage

- **Roles are Permissions:**
 - Perform some set of actions on some set of resources
- **Three Types:**
 - **Basic Roles (or Primitive roles)** - Owner/Editor/Viewer
 - **Viewer(roles.viewer)** - Read-only actions
 - **Editor(roles.editor)** - Viewer + Edit actions
 - **Owner(roles.owner)** - Editor + Manage Roles and Permissions + Billing
 - EARLIEST VERSION: Created before IAM
 - NOT RECOMMENDED: **Don't use in production**
 - **Predefined Roles** - Fine grained roles predefined and managed by Google
 - Different roles for different purposes
 - Examples: Storage Admin, Storage Object Admin, Storage Object Viewer, Storage Object Creator
 - **Custom Roles** - When predefined roles are NOT sufficient, you can create your own custom roles



Cloud IAM

IAM - Predefined Roles - Example Permissions

In 28
Minutes

- Important Cloud Storage Roles:
 - **Storage Admin (roles/storage.admin)**
 - storage.buckets.*
 - storage.objects.*
 - **Storage Object Admin (roles/storage.objectAdmin)**
 - storage.objects.*
 - **Storage Object Creator (roles/storage.objectCreator)**
 - storage.objects.create
 - **Storage Object Viewer (roles/storage.objectViewer)**
 - storage.objects.get
 - storage.objects.list
- All four roles have these permissions:
 - resourcemanager.projects.get
 - resourcemanager.projects.list

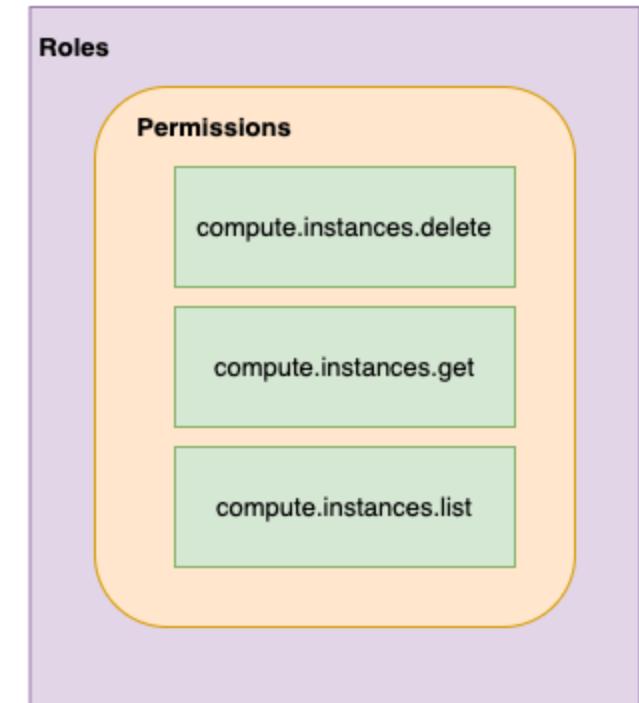


Cloud IAM

IAM - Most Important Concepts - A Review

In 28
Minutes

- Member : Who?
- Roles : Permissions (What Actions? What Resources?)
- Policy : Assign Permissions to Members
 - Map Roles (What?) , Members (Who?) and Conditions (Which Resources?, When?, From Where?)
 - Remember: Permissions are NOT directly assigned to Member
 - Permissions are represented by a Role
 - Member gets permissions through Role!
- A Role can have multiple permissions
- You can assign multiple roles to a Member



IAM policy

In 28
Minutes

- Roles are assigned to users through **IAM Policy** documents
- Represented by a **policy object**
 - Policy object has list of bindings
 - A binding, binds a role to list of members
- Member type is identified by **prefix:**
 - Example: user, serviceaccount, group or domain



Cloud IAM

IAM policy - Example

```
{  
  "bindings": [  
    {  
      "role": "roles/storage.objectAdmin",  
      "members": [  
        "user:you@in28minutes.com",  
        "serviceAccount:myAppName@appspot.gserviceaccount.com",  
        "group:administrators@in28minutes.com",  
        "domain:google.com"  
      ]  
    },  
    {  
      "role": "roles/storage.objectViewer",  
      "members": [  
        "user:you@in28minutes.com"  
      ],  
      "condition": {  
        "title": "Limited time access",  
        "description": "Only upto Feb 2022",  
        "expression": "request.time < timestamp('2022-02-01T00:00:00.000Z')"  
      }  
    }  
  ]  
}
```

Playing With IAM

In 28
Minutes

- **gcloud:** Playing with IAM

- **gcloud compute project-info describe** - Describe current project
- **gcloud auth login** - Access the Cloud Platform with Google user credentials
- **gcloud auth revoke** - Revoke access credentials for an account
- **gcloud auth list** - List active accounts
- **gcloud projects**
 - **gcloud projects add-iam-policy-binding** - Add IAM policy binding
 - **gcloud projects get-iam-policy** - Get IAM policy for a project
 - **gcloud projects remove-iam-policy-binding** - Remove IAM policy binding
 - **gcloud projects set-iam-policy** - Set the IAM policy
 - **gcloud projects delete** - Delete a project
- **gcloud iam**
 - **gcloud iam roles describe** - Describe an IAM role
 - **gcloud iam roles create** - create an iam role(--project, --permissions, --stage)
 - **gcloud iam roles copy** - Copy IAM Roles

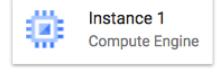


Cloud Shell

Service Accounts

In 28
Minutes

- Scenario: An Application on a VM needs access to cloud storage
 - You DONT want to use personal credentials to allow access
- (RECOMMENDED) Use Service Accounts
 - Identified by an email address (Ex: id-compute@developer.gserviceaccount.com)
 - Does NOT have password
 - Has a private/public RSA key-pairs
 - Can't login via browsers or cookies
- Service account types:
 - Default service account - Automatically created when some services are used
 - (NOT RECOMMENDED) Has Editor role by default
 - User Managed - User created
 - (RECOMMENDED) Provides fine grained access control
 - Google-managed service accounts - Created and managed by Google
 - Used by GCP to perform operations on user's behalf
 - In general, we DO NOT need to worry about them



Use case 1 : VM <-> Cloud Storage

In 28
Minutes

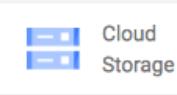


- 1: Create a Service Account Role with the right permissions
- 2: Assign Service Account role to VM instance
- **Uses Google Cloud-managed keys:**
 - Key generation and use are automatically handled by IAM when we assign a service account to the instance
 - Automatically rotated
 - No need to store credentials in config files
- **Do NOT delete service accounts used by running instances:**
 - Applications running on those instances will lose access!

Use case 2 : On Prem <-> Cloud Storage (Long Lived)

In 28
Minutes

- You CANNOT assign Service Account directly to an On Prem App
- 1: Create a Service Account with right permissions
- 2: Create a Service Account User Managed Key
 - *gcloud iam service-accounts keys create*
 - Download the service account key file
 - Keep it secure (It can be used to impersonate service account)!
- 3: Make the service account key file accessible to your application
 - Set environment variable GOOGLE_APPLICATION_CREDENTIALS
 - *export GOOGLE_APPLICATION_CREDENTIALS="/PATH_TO_KEY_FILE"*
- 4: Use Google Cloud Client Libraries
 - Google Cloud Client Libraries use a library - Application Default Credentials (ADC)
 - ADC uses the service account key file if env var GOOGLE_APPLICATION_CREDENTIALS exists!



Use case 3 : On Prem <-> Google Cloud APIs (Short Lived)

In 28
Minutes

- Make calls from outside GCP to Google Cloud APIs with short lived permissions
 - Few hours or shorter
 - Less risk compared to sharing service account keys!
- Credential Types:
 - OAuth 2.0 access tokens
 - OpenID Connect ID tokens
 - Self-signed JSON Web Tokens (JWTs)
- Examples:
 - When a member needs elevated permissions, he can assume the service account role (Create OAuth 2.0 access token for service account)
 - OpenID Connect ID tokens is recommended for service to service authentications:
 - A service in GCP needs to authenticate itself to a service in other cloud



Cloud IAM

Service Account Use case Scenarios

In 28
Minutes

Scenario	Solution
Application on a VM wants to talk to a Cloud Storage bucket	Configure the VM to use a Service Account with right permissions
Application on a VM wants to put a message on a Pub Sub Topic	Configure the VM to use a Service Account with right permissions
Is Service Account an identity or a resource?	It is both. You can attach roles with Service Account (identity). You can let other members access a SA by granting them a role on the Service Account (resource).
VM instance with default service account in Project A needs to access Cloud Storage bucket in Project B	In project B, add the service account from Project A and assign Storage Object Viewer Permission on the bucket

ACL (Access Control Lists)



- **ACL:** Define **who** has access to your buckets and objects, as well as **what level** of access they have
- **How is this different from IAM?**
 - IAM permissions apply to all objects within a bucket
 - ACLs can be used to customized specific accesses to different objects
- User gets access if he is allowed by either IAM or ACL!
- (Remember) **Use IAM for common permissions to all objects in a bucket**
- (Remember) **Use ACLs if you need to customize access to individual objects**

Access Control - Overview

In 28
Minutes

- How do you control access to objects in a Cloud Storage bucket?
- Two types of access controls:
 - **Uniform** (Recommended) - Uniform bucket level access using IAM
 - **Fine-grained** - Use IAM and ACLs to control access:
 - Both bucket level and individual object level permissions
- Use Uniform access when all users have same level of access across all objects in a bucket
- Fine grained access with ACLs can be used when you need to customize the access at an object level
 - Give a user specific access to edit specific objects in a bucket



Cloud IAM

Cloud Storage - Signed URL

In 28
Minutes

- You would want to allow a user limited time access to your objects:
 - Users do NOT need Google accounts
- Use **Signed URL** functionality
 - A URL that gives permissions for limited time duration to perform specific actions
- To create a **Signed URL**:
 - 1: Create a key (YOUR_KEY) for the Service Account/User with the desired permissions
 - 2: Create Signed URL with the key:
 - `gsutil signurl -d 10m YOUR_KEY gs://BUCKET_NAME/OBJECT_PATH`



Cloud Storage

Cloud Storage - Static website

In 28
Minutes



- 1: Create a bucket with the **same name** as website name (Name of bucket should match DNS name of the website)
 - Verify that the domain is owned by you
- 2: Copy the files to the bucket
 - Add index and error html files for better user experience
- 3: Add member **allUsers** and grant **Storage Object Viewer** option
 - Select Allow Public Access

Database Fundamentals

Databases Primer

In 28
Minutes

- Databases provide **organized** and **persistent** storage for your data
- To **choose between different database types**, we would need to understand:
 - Availability
 - Durability
 - RTO
 - RPO
 - Consistency
 - Transactions etc
- Let's get started on a **simple journey** to understand these

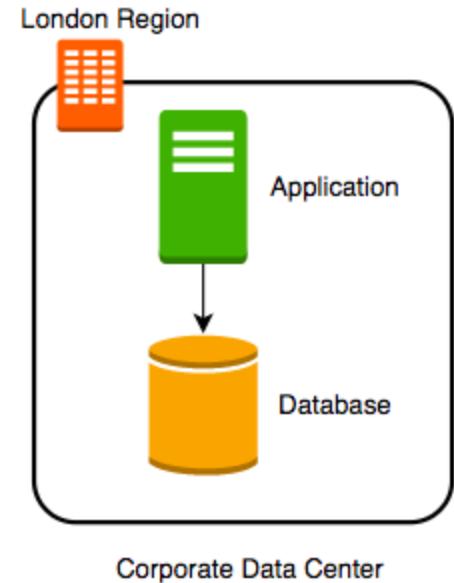


Database

Database - Getting Started

In 28
Minutes

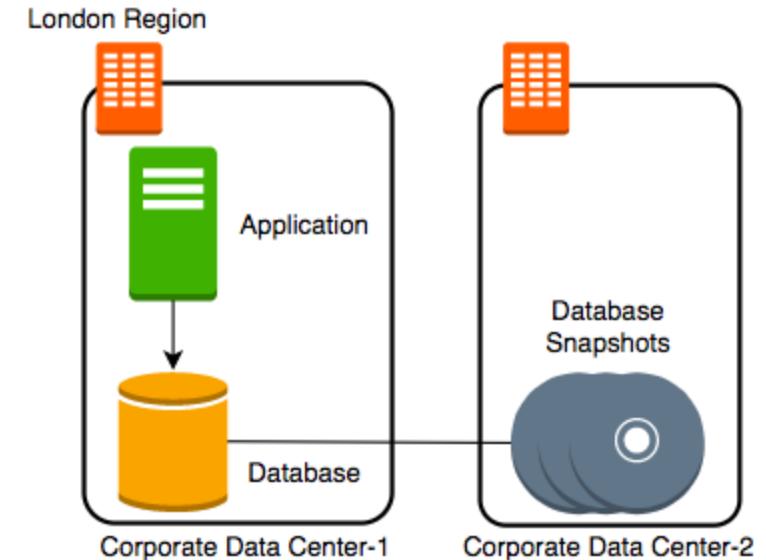
- Imagine a database deployed in a data center in London
- Let's consider some challenges:
 - Challenge 1: Your database will go down if the data center crashes or the server storage fails
 - Challenge 2: You will lose data if the database crashes



Database - Snapshots

In 28
Minutes

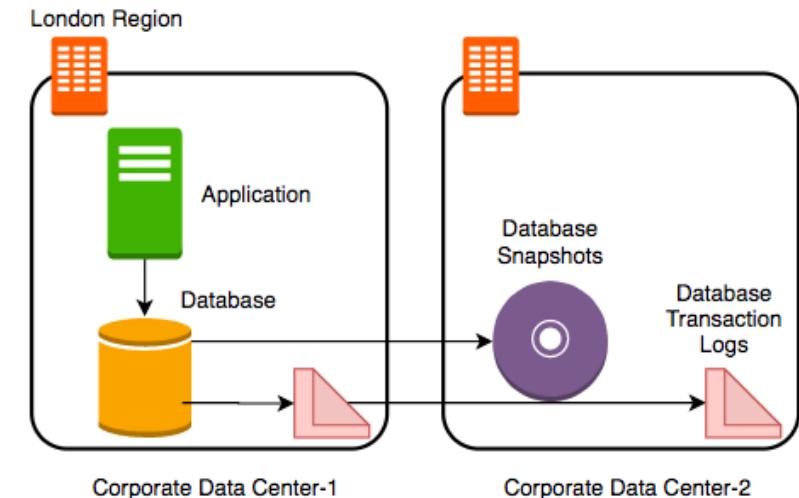
- Let's automate taking copy of the database (**take a snapshot**) every hour to another data center in London
- Let's consider some challenges:
 - **Challenge 1:** Your database will go down if the data center crashes
 - **Challenge 2 (PARTIALLY SOLVED):** You will lose data if the database crashes
 - You can setup database from latest snapshot. But depending on when failure occurs you can lose up to an hour of data
 - **Challenge 3(NEW):** Database will be slow when you take snapshots



Database - Transaction Logs

In 28
Minutes

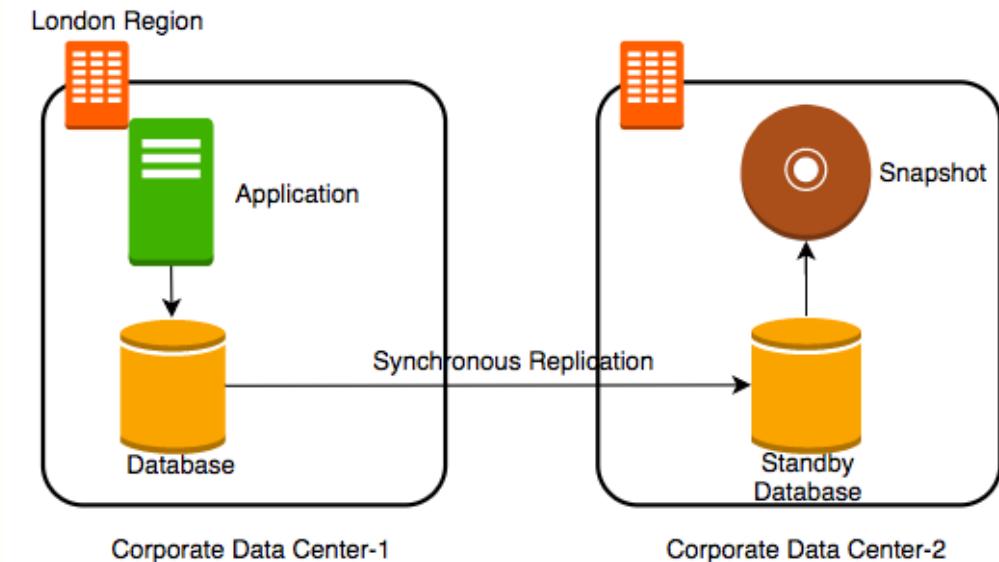
- Let's add transaction logs to database and create a process to copy it over to the second data center
- Let's consider some challenges:
 - **Challenge 1:** Your database will go down if the data center crashes
 - **Challenge 2 (SOLVED):** You will lose data if the database crashes
 - You can setup database from latest snapshot and apply transaction logs
 - **Challenge 3:** Database will be slow when you take snapshots



Database - Add a Standby

In 28
Minutes

- Let's add a **standby database** in the second data center with replication
- Let's consider some challenges:
 - **Challenge 1 (SOLVED):** Your database will go down if the data center crashes
 - You can switch to the standby database
 - **Challenge 2 (SOLVED):** You will lose data if the database crashes
 - **Challenge 3 (SOLVED):** Database will be slow when you take snapshots
 - Take snapshots from standby.
 - Applications connecting to master will get good performance always



Availability and Durability

In 28
Minutes

- **Availability**
 - Will I be able to access my data now and when I need it?
 - Percentage of time an application provides the operations expected of it
- **Durability**
 - Will my data be available after 10 or 100 or 1000 years?
- Examples of measuring availability and durability:
 - 4 9's - 99.99
 - 11 9's - 99.999999999
- Typically, an **availability of four 9's** is considered very good
- Typically, a **durability of eleven 9's** is considered very good

Availability

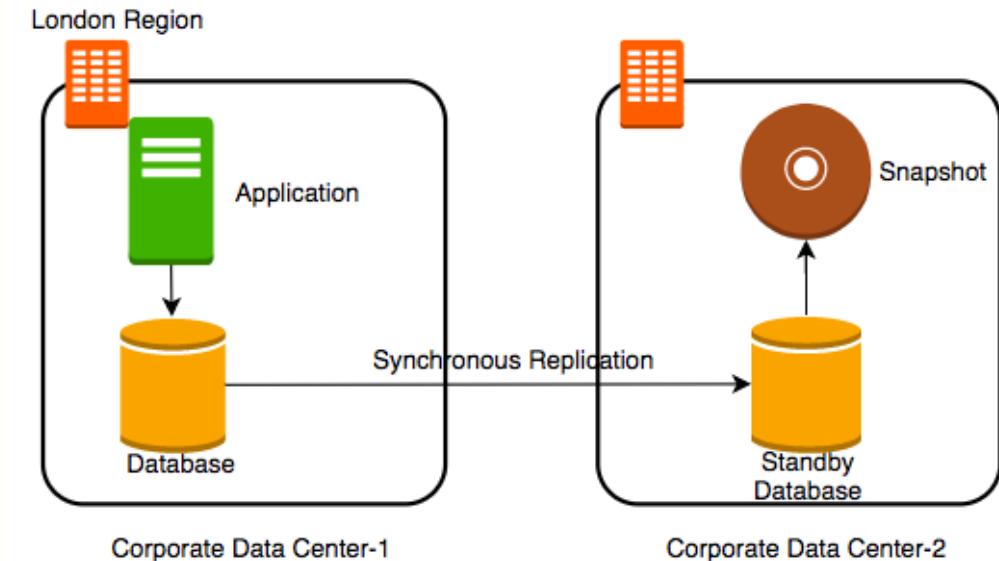
In 28
Minutes

Availability	Downtime (in a month)	Comment
99.95%	22 minutes	
99.99% (4 9's)	4 and 1/2 minutes	Typically online apps aim for 99.99% (4 9's) availability
99.999% (5 9's)	26 seconds	Achieving 5 9's availability is tough

Durability

In 28
Minutes

- What does a durability of 11 9's mean?
 - If you **store one million files for ten million years**, you would expect to **lose one file**
- Why should durability be high?
 - Because we hate losing data
 - Once we lose data, it is gone



Increasing Availability and Durability of Databases

In 28
Minutes

- **Increasing Availability:**

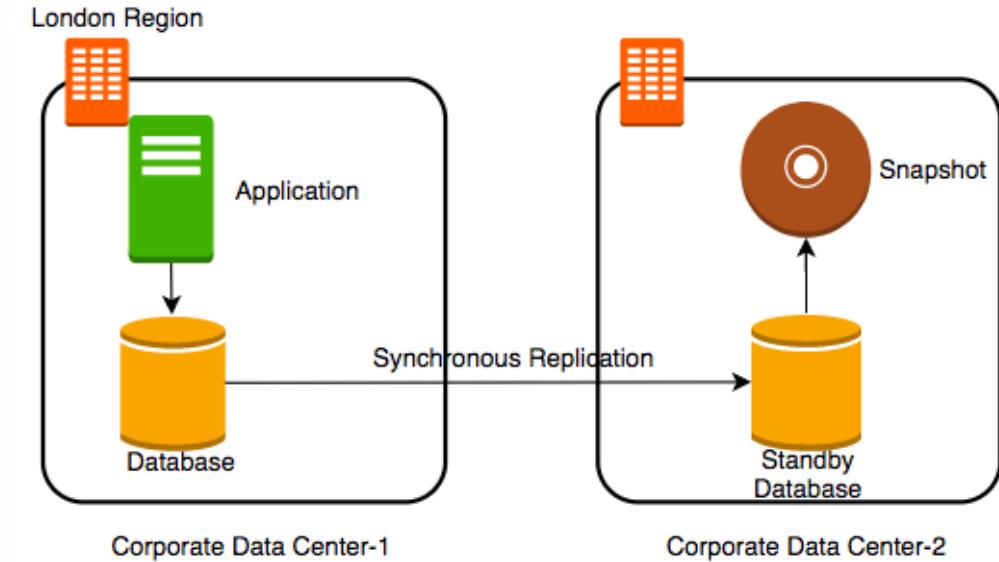
- Have multiple standbys available OR distribute the database
 - in multiple Zones
 - in multiple Regions

- **Increasing Durability:**

- Multiple copies of data (standbys, snapshots, transaction logs and replicas)
 - in multiple Zones
 - in multiple Regions

- **Replicating data comes with its own challenges!**

- We will talk about them a little later



Database Terminology : RTO and RPO

In 28
Minutes

- Imagine a financial transaction being lost
- Imagine a trade being lost
- Imagine a stock exchange going down for an hour
- Typically businesses are fine with some downtime but they hate losing data
- Availability and Durability are technical measures
- How do we measure how quickly we can recover from failure?
 - RPO (Recovery Point Objective): Maximum acceptable period of data loss
 - RTO (Recovery Time Objective): Maximum acceptable downtime
- Achieving minimum RTO and RPO is expensive
- Trade-off based on the criticality of the data



Database

Question - RTO and RPO

In 28
Minutes

- You are running an application in VM instance storing its data on a persistent data storage. You are taking snapshots every 48 hours. If the VM instance crashes, you can manually bring it back up in 45 minutes from the snapshot. What is your RTO and RPO?
 - RTO - 45 minutes
 - RPO - 48 hours

Achieving RTO and RPO - Failover Examples

In 28
Minutes

Scenario

Very small data loss (RPO - 1 minute)

Very small downtime (RTO - 5 minutes)

Very small data loss (RPO - 1 minute)

BUT I can tolerate some downtimes (RTO - 15 minutes)

Data is critical (RPO - 1 minute) but I can tolerate downtime of a few hours (RTO - few hours)

Data can be lost without a problem (for example: cached data)

Solution

Hot standby - Automatically synchronize data

Have a standby ready to pick up load

Use automatic failover from master to standby

Warm standby - Automatically synchronize data

Have a standby with minimum infrastructure

Scale it up when a failure happens

Create regular data **snapshots and transaction logs**

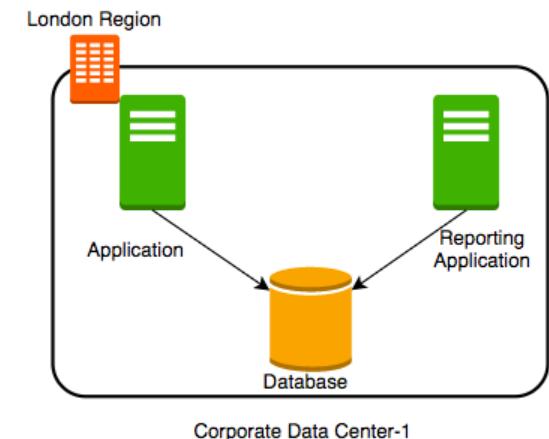
Create database from snapshots and transactions logs when a failure happens

Failover to a completely new server

(New Scenario) Reporting and Analytics Applications

In 28
Minutes

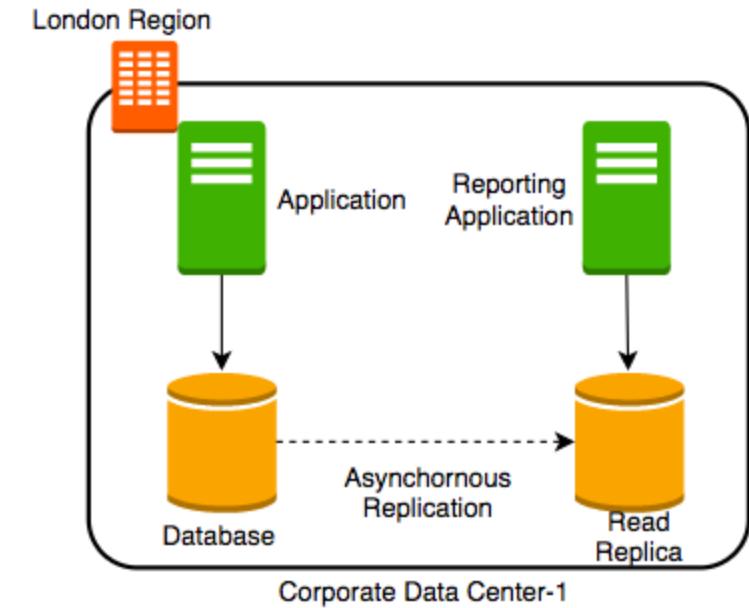
- New reporting and analytics applications are being launched using the same database
 - These applications will ONLY read data
- Within a few days you see that the database performance is impacted
- How can we fix the problem?
 - Vertically scale the database - increase CPU and memory
 - Create a database cluster (Distribute the database) - Typically database clusters are expensive to setup
 - Create read replicas - Run read only applications against read replicas



Database - Read Replicas

In 28
Minutes

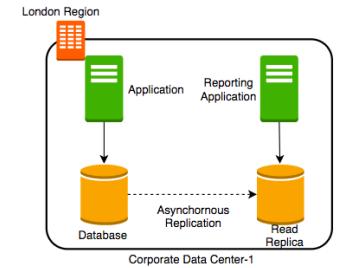
- Add read replica
- Connect reporting and analytics applications to read replica
- Reduces load on the master databases
- Upgrade read replica to master database (supported by some databases)
- Create read replicas in multiple regions
- Take snapshots from read replicas



Consistency

In 28
Minutes

- How do you ensure that data in multiple database instances (standbys and replicas) is updated simultaneously?
- **Strong consistency** - Synchronous replication to all replicas
 - Will be slow if you have multiple replicas or standbys
- **Eventual consistency** - Asynchronous replication. A little lag - few seconds - before the change is available in all replicas
 - In the intermediate period, different replicas might return different values
 - Used when scalability is more important than data integrity
 - Examples : Social Media Posts - Facebook status messages, Twitter tweets, LinkedIn posts etc
- **Read-after-Write consistency** - Inserts are immediately available
 - However, updates would have eventual consistency



Database Categories

In 28
Minutes

- There are **several categories** of databases:
 - Relational (OLTP and OLAP), Document, Key Value, Graph, In Memory among others
- **Choosing type of database** for your use case is not easy. A few factors:
 - Do you want a **fixed schema**?
 - Do you want flexibility in defining and changing your schema? (schemaless)
 - What level of **transaction properties** do you need? (atomicity and consistency)
 - What kind of **latency** do you want? (seconds, milliseconds or microseconds)
 - **How many transactions** do you expect? (hundreds or thousands or millions of transactions per second)
 - **How much data** will be stored? (MBs or GBs or TBs or PBs)
 - and a lot more...



Cloud SQL



Cloud Spanner



Datastore

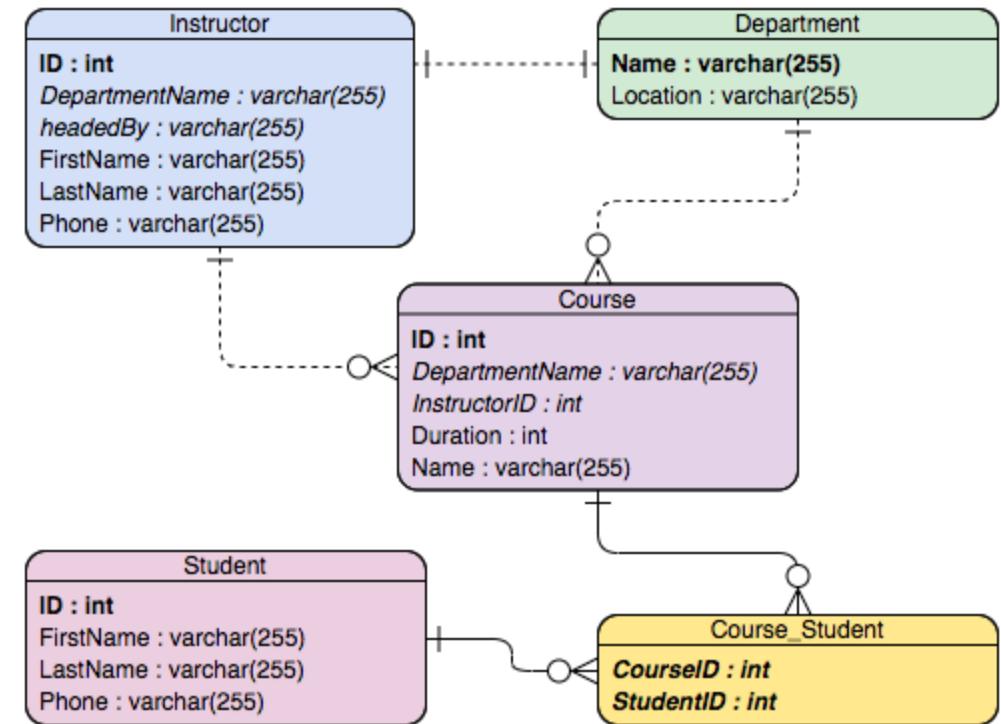


BigQuery

Relational Databases

In 28
Minutes

- This was the **only** option until a decade back!
- Most **popular** (or unpopular) type of databases
- **Predefined schema** with tables and relationships
- Very **strong transactional** capabilities
- Used for
 - OLTP (Online Transaction Processing) use cases and
 - OLAP (Online Analytics Processing) use cases



Relational Database - OLTP (Online Transaction Processing)

08
Minutes

- Applications where **large number of users make large number of small transactions**
 - small data reads, updates and deletes
- **Use cases:**
 - Most traditional applications, ERP, CRM, e-commerce, banking applications
- **Popular databases:**
 - MySQL, Oracle, SQL Server etc
- Recommended Google Managed Services:
 - **Cloud SQL** : Supports PostgreSQL, MySQL, and SQL Server for regional relational databases (upto a few TBs)
 - **Cloud Spanner**: Unlimited scale (multiple PBs) and 99.999% availability for global applications with horizontal scaling



Cloud SQL



Cloud Spanner

Relational Database - OLAP (Online Analytics Processing)

In 28 Minutes

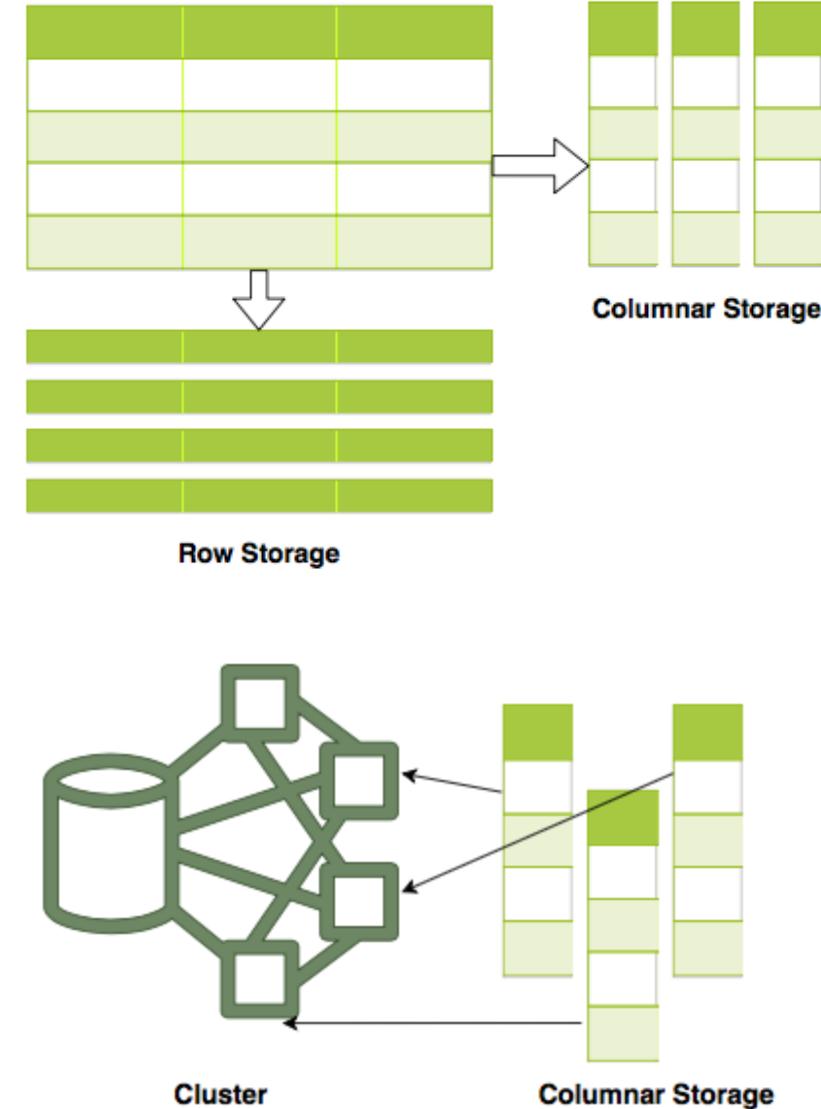
- Applications allowing users to **analyze petabytes of data**
 - Examples : Reporting applications, Data ware houses, Business intelligence applications, Analytics systems
 - Sample application : Decide insurance premiums analyzing data from last hundred years
 - Data is consolidated from multiple (transactional) databases
- Recommended GCP Managed Service
 - BigQuery: Petabyte-scale distributed data ware house



Relational Databases - OLAP vs OLTP

In 28
Minutes

- OLAP and OLTP use **similar data structures**
- BUT **very different approach in how data is stored**
- **OLTP databases use row storage**
 - Each table row is stored together
 - Efficient for processing small transactions
- **OLAP databases use columnar storage**
 - Each table column is stored together
 - **High compression** - store petabytes of data efficiently
 - **Distribute data** - one table in multiple cluster nodes
 - **Execute single query across multiple nodes** - Complex queries can be executed efficiently



NoSQL Databases

In 28
Minutes

- **New approach** (actually NOT so new!) to building your databases
 - NoSQL = not only SQL
 - Flexible schema
 - Structure data **the way your application needs it**
 - Let the schema evolve with time
 - Horizontally scale to petabytes of data with millions of TPS
- **NOT a 100% accurate generalization** but a great starting point:
 - Typical NoSQL databases trade-off "Strong consistency and SQL features" to achieve "scalability and high-performance"
- **Google Managed Services:**
 - Cloud Firestore (Datastore)
 - Cloud BigTable



Datastore



BigQuery

Cloud Firestore (Datastore) vs Cloud BigTable

In 28
Minutes

- **Cloud Datastore** - Managed serverless NoSQL document database

- Provides ACID transactions, SQL-like queries, indexes
 - Designed for transactional mobile and web applications
- Firestore (next version of Datastore) adds:
 - Strong consistency
 - Mobile and Web client libraries
- Recommended for small to medium databases (0 to a few Terabytes)



Datastore

- **Cloud BigTable** - Managed, scalable NoSQL wide column database

- NOT serverless (You need to create instances)
- Recommend for data size > 10 Terabytes to several Petabytes
- Recommended for large analytical and operational workloads:
 - NOT recommended for transactional workloads (Does NOT support multi row transactions - supports ONLY Single-row transactions)



BigQuery

In-memory Databases

In 28
Minutes

- Retrieving data from memory is much faster than retrieving data from disk
- In-memory databases like Redis deliver microsecond latency by storing **persistent data in memory**
- Recommended GCP Managed Service
 - Memory Store
- **Use cases** : Caching, session management, gaming leader boards, geospatial applications



Memorystore

Databases - Summary

In 28
Minutes

Database Type	GCP Services	Description
Relational OLTP databases	Cloud SQL, Cloud Spanner	<p>Transactional usecases needing predefined schema and very strong transactional capabilities (Row storage)</p> <p>Cloud SQL: MySQL, PostgreSQL, SQL server DBs</p> <p>Cloud Spanner: Unlimited scale and 99.999% availability for global applications with horizontal scaling</p>
Relational OLAP databases	BigQuery	Columnar storage with predefined schema. Datawarehousing & BigData workloads
NoSQL Databases	Cloud Firestore (Datastore) , Cloud BigTable	<p>Apps needing quickly evolving structure (schema-less)</p> <p>Cloud Firestore - Serverless transactional document DB supporting mobile & web apps. Small to medium DBs (0 - few TBs)</p> <p>Cloud BigTable - Large databases(10 TB - PBs). Streaming (IOT), analytical & operational workloads. NOT serverless.</p>
In memory databases/caches	Cloud Memorystore	Applications needing microsecond responses

Databases - Scenarios

In 28
Minutes

Scenario	Solution
A start up with quickly evolving schema (table structure)	Cloud Datastore/Firebase
Non relational db with less storage (10 GB)	Cloud Datastore
Transactional global database with predefined schema needing to process million of transactions per second	CloudSpanner
Transactional local database processing thousands of transactions per second	Cloud SQL
Cache data (from database) for a web application	MemoryStore
Database for analytics processing of petabytes of data	BigQuery
Database for storing huge volumes stream data from IOT devices	BigTable
Database for storing huge streams of time series data	BigTable

- **Fully Managed Relational Database service**
 - Configure your needs and do NOT worry about managing the database
 - Supports MySQL, PostgreSQL, and SQL Server
 - Regional Service providing High Availability (99.95%)
 - Use SSDs or HDDs (For best performance: use SSDs)
 - Up to 416 GB of RAM and 30 TB of data storage
- **Use Cloud SQL for simple relational use cases:**
 - To migrate local MySQL, PostgreSQL, and SQL Server databases
 - To reduce your maintenance cost for a simple relational database
 - (REMEMBER) Use Cloud Spanner(Expensive\$\$\$\$) instead of Cloud SQL if:
 - You have huge volumes of relational data (TBs) OR
 - You need infinite scaling for a growing application (to TBs) OR
 - You need a Global (distributed across multiple regions) Database OR
 - You need higher availability (99.999%)



Cloud SQL

Cloud SQL - Features

In 28
Minutes

- **Important Cloud SQL Features:**

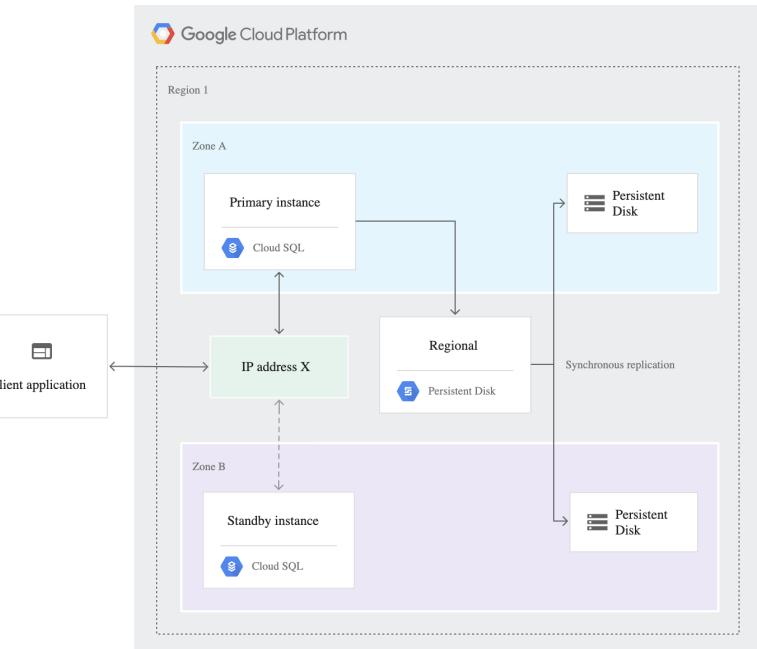
- Automatic encryption (tables/backups), maintenance and updates
- High availability and failover:
 - Create a Standby with automatic failover
 - Pre requisites: Automated backups and Binary logging
- Read replicas for read workloads:
 - Options: Cross-zone, Cross-region and External (NON Cloud SQL DB)
 - Pre requisites: Automated backups and Binary logging
- Automatic storage increase without downtime (for newer versions)
- Point-in-time recovery: Enable binary logging
- Backups (Automated and on-demand backups)
- Supports migration from other sources
 - Use Database Migration Service (DMS)
- You can export data from UI (console) or gcloud with formats:
 - SQL (Recommended if you import data into other databases) and CSV



Cloud SQL

Cloud SQL - High Availability

- Create a High Availability (HA) Configuration
 - Choose Primary and Secondary zones within a region
 - You will have two instances : Primary and Secondary instances
- Changes from primary are replicated synchronously to secondary
- In case of Zonal failure, automatic failover to secondary instance:
 - If Primary zone becomes available, failover does not revert automatically
- (Remember) High Availability setup CANNOT be used as a Read Replica



source:cloud.google.com

Cloud Spanner

In 28
Minutes

- Fully managed, mission critical, relational(SQL), globally distributed database with VERY high availability (99.999%)
 - Strong transactional consistency at global scale
 - Scales to PBs of data with automatic sharding
- Cloud Spanner scales horizontally for reads and writes
 - Configure no of nodes
 - (REMEMBER) In comparison, Cloud SQL provides read replicas:
 - BUT you cannot horizontally scale write operations with Cloud SQL!
- Regional and Multi-Regional configurations
- Expensive (compared to Cloud SQL): Pay for nodes & storage
- Data Export: Use Cloud Console to export data
 - Other option is to use Data flow to automate export
 - No gcloud export option



Cloud Spanner

Cloud Datastore and Firestore

In 28
Minutes

- **Datastore** - Highly scalable NoSQL Document Database

- Automatically scales and partitions data as it grows
- Recommended for upto a few TBs of data
 - For bigger volumes, BigTable is recommended
- Supports Transactions, Indexes and SQL like queries (GQL)
 - Does NOT support Joins or Aggregate (sum or count) operations
- For use cases needing flexible schema with transactions
 - Examples: User Profile and Product Catalogs
- Structure: Kind > Entity (Use namespaces to group entities)
- You can export data ONLY from gcloud (NOT from cloud console)
 - Export contains a metadata file and a folder with the data



Datastore

- **Firestore** = Datastore++ : Optimized for multi device access

- Offline mode and data synchronization across multiple devices - mobile, IOT etc
- Provides client side libraries - Web, iOS, Android and more
- Offers Datastore and Native modes

Cloud BigTable

In 28
Minutes

- **Petabyte scale, wide column NoSQL DB (HBase API compatible)**
 - Designed for huge volumes of analytical and operational data
 - IOT Streams, Analytics, Time Series Data etc
 - Handle millions of read/write TPS at very low latency
 - Single row transactions (multi row transactions NOT supported)
- **NOT serverless:** You need to create a server instance (Use SSD or HDD)
 - Scale horizontally with multiple nodes (No downtime for cluster resizing)
- **CANNOT export data using cloud console or gcloud:**
 - Either use a Java application (java -jar JAR export\import) OR
 - Use HBase commands
- Use cbt command line tool to work with BigTable (NOT gcloud)
 - Ex: `cbt createtable my-table`



Cloud Bigtable

Cloud BigTable - Wide Column Database

In 28
Minutes

Rowid	Column Family 1			Column Family 2			Column Family 3		
	col1	col2	col3	col1	col2	col3	col1	col2	col3
1									
2									
3									

- At the most basic level, each table is a sorted key/value map
 - Each value in a row is indexed using a key - **row key**
 - Related columns are grouped into column families
 - Each column is identified by using column-family:column-qualifier(or name)
- This structure supports high read and write throughput at low latency
 - Advantages : Scalable to petabytes of data with millisecond responses upto millions of TPS
- Use cases : IOT streams, graph data and real time analytics (time-series data, financial data - transaction histories, stock prices etc)
- **Cloud Dataflow** : Used to export data from BigTable to CloudStorage
 - For ex: Cloud Bigtable to Cloud Storage Avro, Cloud Bigtable to Cloud Storage Parquet

Memorystore

In 28
Minutes

- **In-memory datastore service:** Reduce access times
- **Fully managed (Provisioning, Replication, Failover and Patching)**
 - Highly available with 99.9% availability SLA
 - Monitoring can be easily setup using Cloud Monitoring
- **Support for Redis and Memcached:**
 - Use Memcached for Caching
 - Reference data, database query caching, session store etc
 - Use Redis for low latency access with persistence and high availability
 - Gaming Leader Boards, Player Profiles, In memory Stream Processing etc



Memorystore

BigQuery - Datawarehouse

In 28
Minutes

- **Exabyte scale modern Datawarehousing solution from GCP**
 - Relational database (SQL, schema, consistency etc)
 - Use SQL-like commands to query massive datasets
 - Traditional (Storage + Compute) + Modern (Realtime + Serverless)
- When we are talking about a Datawarehouse, **importing and exporting data (and formats) becomes very important:**
 - Load data from a variety of sources, incl. streaming data
 - Variety of import formats - CSV/JSON/Avro/Parquet/ORC/Datastore backup
 - Export to Cloud Storage (long term storage) & Data Studio (visualization)
 - Formats - CSV/JSON (with Gzip compression), Avro (with deflate or snappy compression)
- Automatically expire data (**Configurable Table Expiration**)
- Query **external data sources** without storing data in BigQuery
 - Cloud Storage, Cloud SQL, BigTable, Google Drive
 - Use Permanent or Temporary external tables



BigQuery - Accessing and Querying Data

In 28
Minutes

- Access databases using:
 - Cloud Console
 - bq command-line tool (NOT gcloud)
 - BigQuery Rest API OR
 - HBase API based libraries (Java, .NET & Python)
- (Remember) BigQuery queries **can be expensive** as you are running them on large data sets!
- (BEST PRACTICE) **Estimate BigQuery queries before running:**
 - 1: Use UI(console)/bq(--dry-run) - Get scanned data volume (estimate)
 - 2: Use Pricing Calculator: Find price for scanning 1 MB data. Calculate cost.



Relational Database - Import and Export

In 28
Minutes

- **Cloud SQL** : to/from Cloud Storage (*gcloud sql export/import csv/sql*)
 - From Console/gcloud/REST API
 - SQL and CSV formats
 - For large databases, use serverless mode
 - Reduces performance impact of export on the live database
- **Cloud Spanner**: to/from Cloud Storage
 - From Console (uses Cloud Data Flow)
- **BigQuery**: to/from Cloud Storage and Others (*bq extract/load*)
 - From Console/bq
 - Formats - CSV/JSON (with Gzip compression), Avro (with deflate or snappy compression)
 - Variety of options to import data:
 - Load data from Cloud Storage
 - Example Use Case: Data Store > Cloud Storage > Big Query
 - Batch Loading with BigQuery Data Transfer Service
 - Use Dataflow to setup streaming pipeline



Cloud SQL



Cloud Spanner



BigQuery

NoSQL Databases - Import and Export

In 28
Minutes

- Cloud Datastore/Firestore: to/from Cloud Storage
 - From Console/gcloud/REST API
 - *gcloud datastore/firestore export/import --kinds --namespaces*
- Cloud BigTable: to/from Cloud Storage
 - Create Dataflow jobs
 - Formats: Avro/Parquet/SequenceFiles
- (REMEMBER) Ensure that service accounts have access to Cloud Storage Buckets
 - ACL (*gsutil acl ch -U SERVICE_ACCOUNT:W BUCKET*) OR
 - Roles Storage Admin or Storage Object Admin or Storage Object Creator



Datastore



Firestore



Cloud Bigtable

Cloud SQL - CommandLine

In 28
Minutes

- ***gcloud sql***
 - ***gcloud sql instances create/clone/delete/describe/patch***
 - *gcloud sql instances create INSTANCE*
 - *gcloud sql instances patch --backup-start-time*
 - ***gcloud sql databases create/delete/describe/list/patch***
 - *gcloud sql databases create DATABASE --instance=INSTANCE*
 - ***gcloud sql connect INSTANCE [--database=DATABASE --user=root]***
 - ***gcloud sql backups create/describe/list***
 - *gcloud sql backups create --async --instance [INSTANCE]* (one time backup)



Cloud SQL

BigQuery - Command Line

In 28
Minutes

- BigQuery (**bq**)
 - *bq show bqpublicdata:samples.shakespeare*
 - *bq query 'QUERY-STRING'*
 - **--dry-run** - To estimate the bytes scanned by a query
 - *bq extract* (export data)
 - *bq load* (load data)
- (Remember) Use the standard way to set the project
 - *gcloud config set project my-project*



BigQuery

cbt tool - Cloud Bigtable - CommandLine

In 28
Minutes

- cbt - CLI for Cloud Bigtable (NOT gcloud)
 - Installing - *gcloud components install cbt*
 - Verify Installation - *cbt listinstances*
 - Create **.cbtrc file** with the configuration
 - *echo project = project-id > ~/.cbtrc*
 - *echo instance = quickstart-instance >> ~/.cbtrc*
 - Commands (**cbt**):
 - **cbt createinstance** - Create an instance
 - **cbt createcluster** - Create a cluster within configured instance!
 - **cbt createtable/deleteinstance/deletecluster/deletetable**
 - **cbt listinstances/listclusters**
 - **cbt ls** - list tables and column families
- (Remember) You can **configure your project** with cbt in **.cbtrc** file



Cloud Bigtable

Databases - Remember

In 28
Minutes

- (Remember) BigQuery, Datastore, Firebase does NOT need VM configuration
 - whereas Cloud SQL and BigTable need VM configuration
- **Relational Databases**
 - Small Local Databases - Cloud SQL
 - Highly scalable global databases - Cloud Spanner
 - Datawarehouse - BigQuery
- **NoSQL Databases**
 - Transactional database for a few Terabytes of data - Cloud Datastore
 - Huge volumes of IOT or streaming analytics data - Cloud BigTable

Decoupling Applications with Pub/Sub

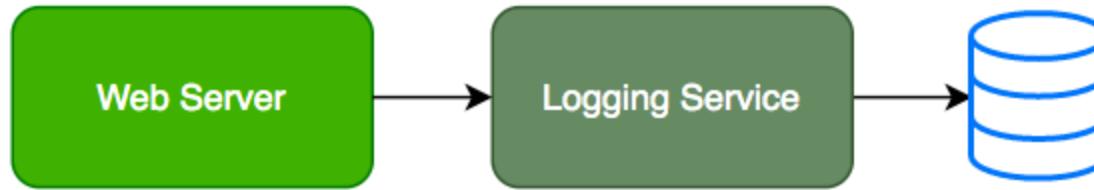
Need for Asynchronous Communication

In 28
Minutes

- Why do we need asynchronous communication?

Synchronous Communication

In 28
Minutes



- Applications on your web server make synchronous calls to the logging service
- What if your logging service goes down?
 - Will your applications go down too?
- What if all of sudden, there is high load and there are lots of logs coming in?
 - Log Service is not able to handle the load and goes down very often

Asynchronous Communication - Decoupled

In 28
Minutes



- Create a topic and have your applications put log messages on the topic
- Logging service picks them up for processing when ready
- Advantages:
 - Decoupling: Publisher (Apps) don't care about who is listening
 - Availability: Publisher (Apps) up even if a subscriber (Logging Service) is down
 - Scalability: Scale consumer instances (Logging Service) under high load
 - Durability: Message is not lost even if subscriber (Logging Service) is down

Pub/Sub

In 28
Minutes

- Reliable, scalable, fully-managed asynchronous messaging service
- Backbone for **Highly Available and Highly Scalable Solutions**
 - Auto scale to process billions of messages per day
 - Low cost (Pay for use)
- Use cases: Event ingestion and delivery for streaming analytics pipelines
- Supports push and pull message deliveries

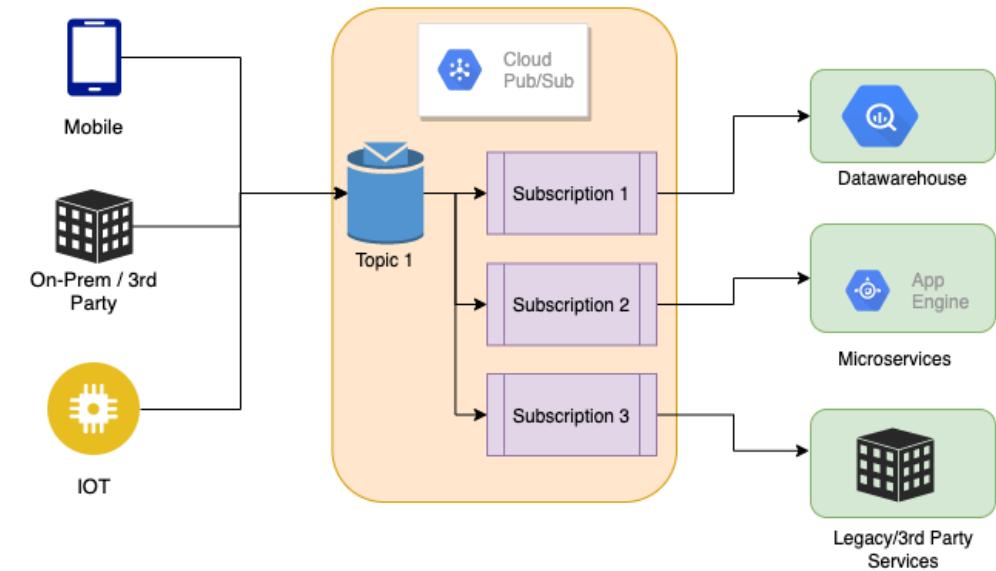


Pub/Sub

Pub/Sub - How does it work?

In 28
Minutes

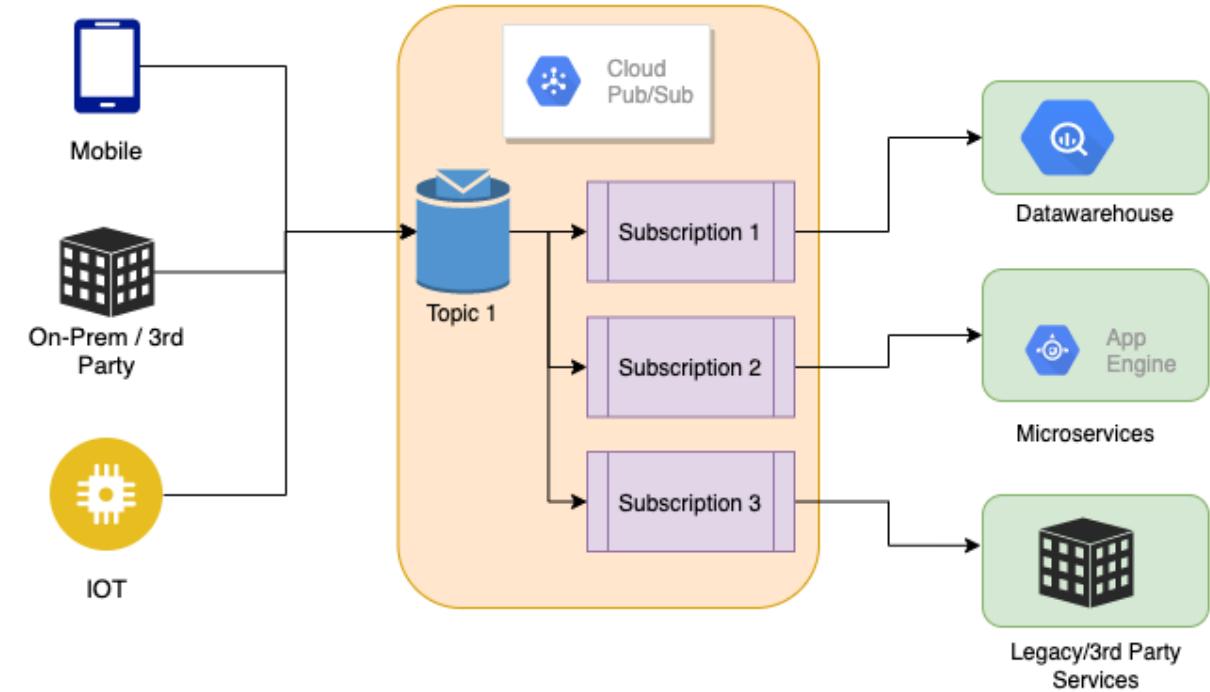
- **Publisher** - Sender of a message
 - Publishers send messages by making HTTPS requests to pubsub.googleapis.com
- **Subscriber** - Receiver of the message
 - **Pull** - Subscriber pulls messages when ready
 - Subscriber makes HTTPS requests to pubsub.googleapis.com
 - **Push** - Messages are sent to subscribers
 - Subscribers provide a web hook endpoint at the time of registration
 - When a message is received on the topic, A HTTPS POST request is sent to the web hook endpoints
- **Very Flexible** Publisher(s) and Subscriber(s) Relationships: One to Many, Many to One, Many to Many



Pub/Sub - Getting Ready with Topic and Subscriptions

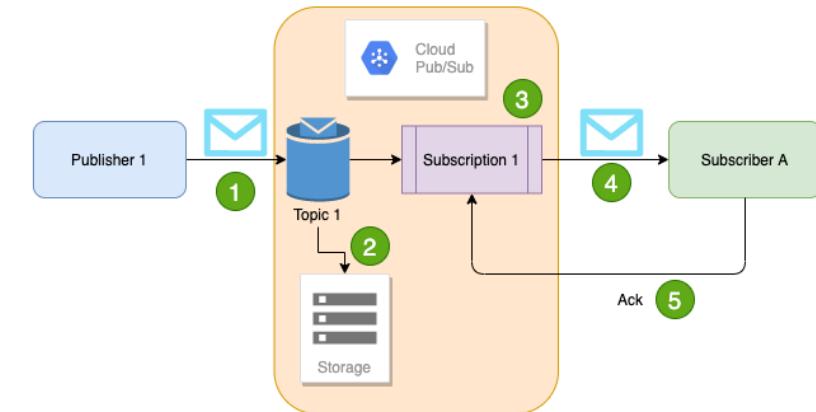
In 28
Minutes

- Step 1 : Topic is created
- Step 2 : Subscription(s) are created
 - Subscribers register to the topic
 - Each Subscription represents discrete pull of messages from a topic:
 - Multiple clients pull same subscription => messages split between clients
 - Multiple clients create a subscription each => each client will get every message



Pub/Sub - Sending and Receiving a Message

- Publisher sends a message to Topic
- Message **individually** delivered to each and every subscription
 - Subscribers can receive message either by:
 - Push: Pub/Sub sends the message to Subscriber
 - Pull: Subscribers poll for messages
- Subscribers send acknowledgement(s)
- Message(s) are removed from subscriptions message queue
 - Pub/Sub ensures the message is retained per subscription until it is acknowledged



Managing Pub/Sub

In 28
Minutes

- Pub/Sub **pubsub**
 - *gcloud pubsub topics create my-topic*
 - *gcloud pubsub subscriptions create my-subscription --topic=my-topic*
 - **--enable-message-ordering** - ordered message delivery
 - **--ack-deadline** - how long to wait for acknowledgment?
 - **--message-filter** - criteria to filter messages
 - *gcloud pubsub subscriptions pull my-subscription*
 - **--auto-ack** **--limit**
 - *gcloud pubsub subscriptions ack my-subscription --ack-ids=[ACK_ID,...]*
 - Topic: *gcloud pubsub topics*
 - *gcloud pubsub topics delete my-topic*
 - *gcloud pubsub topics list*
 - *gcloud pubsub topics list-subscriptions my-topic*



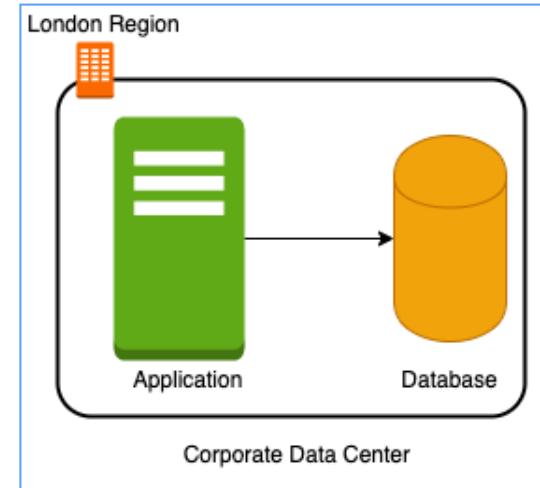
Pub/Sub

Networking

Need for Google Cloud VPC

In 28
Minutes

- In a corporate network or an on-premises data center:
 - Can anyone on the internet see the data exchange between the application and the database?
 - No
 - Can anyone from internet directly connect to your database?
 - Typically NO.
 - You need to connect to your corporate network and then access your applications or databases.
- Corporate network provides a **secure internal network** protecting your resources, data and communication from external users
- How do you do create **your own private network** in the cloud?
 - Enter **Virtual Private Cloud (VPC)**



Google Cloud VPC (Virtual Private Cloud)

In 28
Minutes

- Your own **isolated network** in GCP cloud
 - Network traffic within a VPC is isolated (not visible) from all other Google Cloud VPCs
- You **control all the traffic** coming in and going outside a VPC
- **(Best Practice)** Create all your GCP resources (compute, storage, databases etc) **within a VPC**
 - Secure resources from unauthorized access AND
 - Enable secure communication between your cloud resources
- VPC is a **global resource** & contains subnets in one or more region
 - **(REMEMBER)** NOT tied to a region or a zone. VPC resources can be in any region or zone!



Virtual Private
Cloud

Need for VPC Subnets

In 28
Minutes

- Different types of resources are created on cloud - databases, compute etc
 - Each type of resource has **its own access needs**
 - Load Balancers are accessible from internet (**public** resources)
 - Databases or VM instances should NOT be accessible from internet
 - ONLY applications within your network (VPC) should be able to access them(**private** resources)
- How do you **separate public resources from private resources** inside a VPC?
 - Create separate Subnets!
- (Additional Reason) You want to distribute resources across multiple regions for high availability



User



Cloud Load
Balancing



Compute Engine

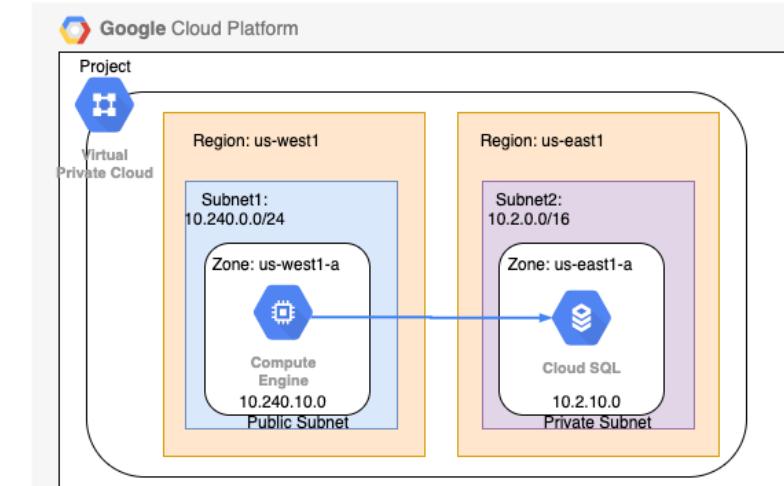


Database

VPC Subnets

In 28
Minutes

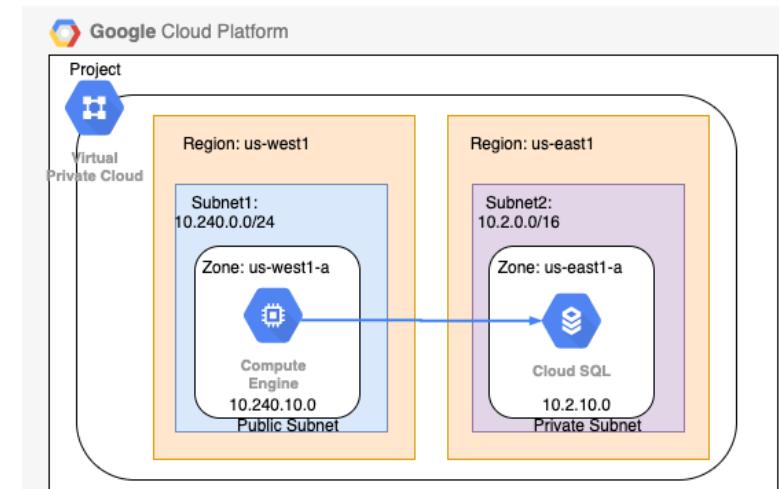
- (Solution) Create different subnets for public and private resources
 - Resources in a public subnet **CAN** be accessed from internet
 - Resources in a private subnet **CANNOT** be accessed from internet
 - BUT resources in public subnet can talk to resources in private subnet
- Each Subnet is created in a region
- Example : VPC - demo-vpc => Subnets - region us-central1, europe-west1 or us-west1 or ..



Creating VPCs and Subnets

In 28
Minutes

- By default, every project has a default VPC
- You can create YOUR own VPCs:
 - **OPTION 1:** Auto mode VPC network:
 - Subnets are automatically created in each region
 - Default VPC created automatically in the project uses auto mode!
 - **OPTION 2:** Custom mode VPC network:
 - No subnets are automatically created
 - You have complete control over subnets and their IP ranges
 - Recommended for Production
- Options when you create a subnet:
 - **Enable Private Google Access** - Allows VM's to connect to Google API's using private IP's
 - **Enable FlowLogs** - To troubleshoot any VPC related network issues



CIDR (Classless Inter-Domain Routing) Blocks

In 28
Minutes

- Resources in a network use continuous IP addresses to make routing easy:
 - Example: Resources inside a specific network can use IP addresses from 69.208.0.0 to 69.208.0.15
- How do you express a **range of addresses** that resources in a network can have?
 - CIDR block
- A **CIDR block** consists of a **starting IP address(69.208.0.0)** and a **range(/28)**
 - Example: CIDR block 69.208.0.0/28 represents addresses from 69.208.0.0 to 69.208.0.15 - a total of 16 addresses
- **Quick Tip:** 69.208.0.0/28 indicates that the first 28 bits (out of 32) are fixed.
 - Last 4 bits can change => 2^{28} = 16 addresses

CIDR Exercises

CIDR	Start Range	End Range	Total addresses	Bits selected in IP address
69.208.0.0/24	69.208.0.0	69.208.0.255	256	01000101.11010000.00000000.*****
69.208.0.0/25	69.208.0.0	69.208.0.127	128	01000101.11010000.00000000.0*****
69.208.0.0/26	69.208.0.0	69.208.0.63	64	01000101.11010000.00000000.00*****
69.208.0.0/27	69.208.0.0	69.208.0.31	32	01000101.11010000.00000000.000****
69.208.0.0/28	69.208.0.0	69.208.0.15	16	01000101.11010000.00000000.0000***
69.208.0.0/29	69.208.0.0	69.208.0.7	8	01000101.11010000.00000000.00000**
69.208.0.0/30	69.208.0.0	69.208.0.3	4	01000101.11010000.00000000.000000*
69.208.0.0/31	69.208.0.0	69.208.0.1	2	01000101.11010000.00000000.000000*
69.208.0.0/32	69.208.0.0	69.208.0.0	1	01000101.11010000.00000000.0000000

- Exercise : How many addresses does **69.208.0.0/26** represent?
 - $2 \text{ to the power } (32-26 = 6) = 64$ addresses from 69.208.0.0 to 69.208.0.63
- Exercise : How many addresses does **69.208.0.0/30** represent?
 - $2 \text{ to the power } (32-30 = 2) = 4$ addresses from 69.208.0.0 to 69.208.0.3
- Exercise : What is the difference between **0.0.0.0/0** and **0.0.0.0/32**?
 - 0.0.0.0/0 represent all IP addresses. 0.0.0.0/32 represents just one IP address 0.0.0.0.

Examples of Recommended CIDR Blocks - VPC Subnets

In 28
Minutes

- **Recommended CIDR Blocks**
 - Private IP addresses RFC 1918: 10.0.0.0/8, 172.16.0.0/12, 192.168.0.0/16
 - Shared address space RFC 6598: 100.64.0.0/10
 - IETF protocol assignments RFC 6890: 192.0.0.0/24
- **Restricted Range Examples**
 - You CANNOT use these as CIDR for VPC Subnets
 - Private Google Access-specific virtual IP addresses: 199.36.153.4/30, 199.36.153.8/30
 - Current (local) network RFC 1122: 0.0.0.0/8
 - Local host RFC 1122: 127.0.0.0/8
- **(REMEMBER)** You CAN EXTEND the CIDR Block Range of a Subnet (Secondary CIDR Block)



Virtual Private
Cloud

Firewall Rules

In 28
Minutes

- Configure Firewall Rules to control traffic going in or out of the network:
 - Stateful
 - Each firewall rule has priority (0-65535) assigned to it
 - 0 has highest priority. 65535 has least priority
 - Default implied rule with lowest priority (65535)
 - Allow all egress
 - Deny all ingress
 - Default rules can't be deleted
 - You can override default rules by defining new rules with priority 0-65534
 - Default VPC has 4 additional rules with priority 65534
 - Allow incoming traffic from VM instances in same network (**default-allow-internal**)
 - Allow Incoming TCP traffic on port 22 (SSH) **default-allow-ssh**
 - Allow Incoming TCP traffic on port 3389 (RDP) **default-allow-rdp**
 - Allow Incoming ICMP from any source on the network **default-allow-icmp**



Virtual Private
Cloud

Firewall Rules - Ingress and Egress Rules

In 28
Minutes

- **Ingress Rules:** Incoming traffic from outside to GCP targets
 - Target (defines the destination): All instances or instances with TAG/SA
 - Source (defines where the traffic is coming from): CIDR or All instances or instances with TAG/SA
- **Egress Rules:** Outgoing traffic to destination from GCP targets
 - Target (defines the source): All instances or instances with TAG/SA
 - Destination: CIDR Block
- **Along with each rule, you can also define:**
 - Priority - Lower the number, higher the priority
 - Action on match - Allow or Deny traffic
 - Protocol - ex. TCP or UDP or ICMP
 - Port - Which port?
 - Enforcement status - Enable or Disable the rule



Virtual Private
Cloud

Shared VPC

In 28
Minutes

- Scenario: Your organization has multiple projects. You want resources in different projects to talk to each other?
 - How to allow resources in different projects to talk with internal IPs securely and efficiently?
- Enter **Shared VPC**
 - Created at organization or shared folder level (Access Needed: Shared VPC Admin)
 - Allows VPC network to be shared between projects in same organization
 - Shared VPC contains one host project and multiple service projects:
 - **Host Project** - Contains shared VPC network
 - **Service Projects** - Attached to host projects
- Helps you achieve **separation of concerns**:
 - Network administrators responsible for Host projects and Resource users use Service Project



Virtual Private
Cloud

VPC Peering

In 28
Minutes

- Scenario: How to connect VPC networks across different organizations?
- Enter **VPC Peering**
 - Networks in same project, different projects and across projects in different organizations can be peered
 - All communication happens using internal IP addresses
 - Highly efficient because all communication happens **inside Google network**
 - Highly secure because **not accessible from Internet**
 - **No data transfer charges** for data transfer between services
 - **(REMEMBER)** Network administration is NOT changed:
 - Admin of one VPC do not get the role automatically in a peered network



Virtual Private
Cloud

Hybrid Cloud

Cloud VPN

In 28
Minutes

- Cloud VPN - Connect on-premise network to the GCP network
 - Implemented using **IPSec VPN Tunnel**
 - Traffic through internet (public)
 - Traffic encrypted using **Internet Key Exchange** protocol
- Two types of Cloud VPN solutions:
 - HA VPN (SLA of 99.99% service availability with two external IP addresses)
 - Only dynamic routing (BGP) supported
 - Classic VPN (SLA of 99.9% service availability, a single external IP address)
 - Supports Static routing (policy-based, route-based) and dynamic routing using BGP



Cloud VPN

Cloud Interconnect

In 28
Minutes

- High speed physical connection between on-premise and VPC networks:
 - Highly available and high throughput
 - Two types of connections possible
 - Dedicated Interconnect - 10 Gbps or 100 Gbps configurations
 - Partner Interconnect - 50 Mbps to 10 Gbps configurations
- Data exchange happens through a private network:
 - Communicate using VPC network's internal IP addresses from on-premise network
 - Reduces egress costs
 - As public internet is NOT used
- (Feature) Supported Google API's and services can be privately accessed from on-premise
- Use only for high bandwidth needs:
 - For low bandwidth, Cloud VPN is recommended



Cloud Interconnect

Direct Peering

In 28
Minutes

- Connect customer network to google network using network peering
 - Direct path from on-premises network to Google services
- **Not a GCP Service**
 - Lower level network connection outside of GCP
- **NOT RECOMMENDED:**
 - Use Cloud Interconnect and Cloud VPN

Cloud Operations

Cloud Monitoring

In 28
Minutes

- To operate cloud applications effectively, you should know:
 - Is my application healthy?
 - Are the users experiencing any issues?
 - Does my database has enough space?
 - Are my servers running in an optimum capacity?
- **Cloud Monitoring** - Tools to monitor your infrastructure
 - Measures key aspects of services (Metrics)
 - Create visualizations (Graphs and Dashboard)
 - Configure Alerts (when metrics are NOT healthy)
 - Define Alerting Policies:
 - Condition
 - Notifications - Multiple channels
 - Documentation



Cloud Monitoring

Cloud Monitoring - Workspace

In 28
Minutes

- You can use Cloud Monitoring to monitor one or more GCP projects and one or more AWS accounts
- How do you group all the information from multiple GCP projects or AWS Accounts?
- **Create a Workspace**
- Workspaces are needed to organize monitoring information
 - A workspace allows you to see monitoring information from multiple projects
 - Step I: Create workspace in a specific project (Host Project)
 - Step II: Add other GCP projects (or AWS accounts) to the workspace



Cloud Monitoring

Cloud Monitoring - Virtual Machines

In 28
Minutes



- **Default metrics monitored include:**
 - CPU utilization
 - Some disk traffic metrics
 - Network traffic, and
 - Uptime information
- Install **Cloud Monitoring agent** on the VM to get more disk, CPU, network, and process metrics:
 - collectd-based daemon
 - Gathers metrics from VM and sends them to Cloud Monitoring

Cloud Logging

In 28
Minutes

- Real time log management and analysis tool
- Allows to store, search, analyze and alert on massive volume of data
- Exabyte scale, fully managed service
 - No server provisioning, patching etc
- Ingest Log data from any source
- Key Features:
 - Logs Explorer - Search, sort & analyze using flexible queries
 - Logs Dashboard - Rich visualization
 - Logs Metrics - Capture metrics from logs (using queries/matching strings)
 - Logs Router - Route different log entries to different destinations



Cloud Logging

Cloud Logging - Collection

In 28
Minutes



- Most GCP Managed services automatically send logs to Cloud Logging:
 - GKE
 - App Engine
 - Cloud Run
- Ingest logs from GCE VMs:
 - Install **Logging Agent** (based on fluentd)
 - (Recommended) Run Logging Agent on all VM instances
- Ingest logs from on-premises:
 - (Recommended) Use the BindPlane tool from Blue Medora
 - Use the Cloud Logging API

Cloud Logging - Audit and Security Logs

In 28
Minutes

- **Access Transparency Log:** Captures Actions performed by GCP team on your content (NOT supported by all services):
 - ONLY for organizations with Gold support level & above
- **Cloud Audit Logs:** Answers who did what, when and where:
 - Admin activity Logs
 - Data Access Logs
 - System Event Audit Logs
 - Policy Denied Audit Logs



Cloud Logging

Cloud Logging - Audit Logs

In 28
Minutes

- Which service?
 - `protoPayload.serviceName`
- Which operation?
 - `protoPayload.methodName`
- What resource is audited?
 - `resource.Type`
- Who is making the call?
 - `authenticationInfo.principalEmail`

```
{
  protoPayload: {
    @type: "type.googleapis.com/google.cloud.audit.AuditLog",
    status: {},
    authenticationInfo: {
      principalEmail: "user@example.com"
    },
    serviceName: "appengine.googleapis.com",
    methodName: "SetIamPolicy",
    authorizationInfo: [...],
    serviceData: {
      @type: "type.googleapis.com/google.appengine.legacy.AuditData",
      policyDelta: { bindingDeltas: [
        action: "ADD",
        role: "roles/logging.privateLogViewer",
        member: "user:user@example.com"
      ], },
      request: {
        resource: "my-gcp-project-id",
        policy: { bindings: [...] }
      },
      response: {
        bindings: [
          {
            role: "roles/logging.privateLogViewer",
            members: [ "user:user@example.com" ]
          }
        ],
        ...
      },
      insertId: "53179D9A9B559.AD6ACC7.B40604EF",
      resource: {
        type: "gae_app",
        labels: { project_id: "my-gcp-project-id" }
      },
      timestamp: "2019-05-27T16:24:56.135Z",
      severity: "NOTICE",
      logName: "projects/my-gcp-project-id/logs/cloudaudit.googleapis.com%2Factivity",
    }
  }
}
```

Cloud Audit Logs

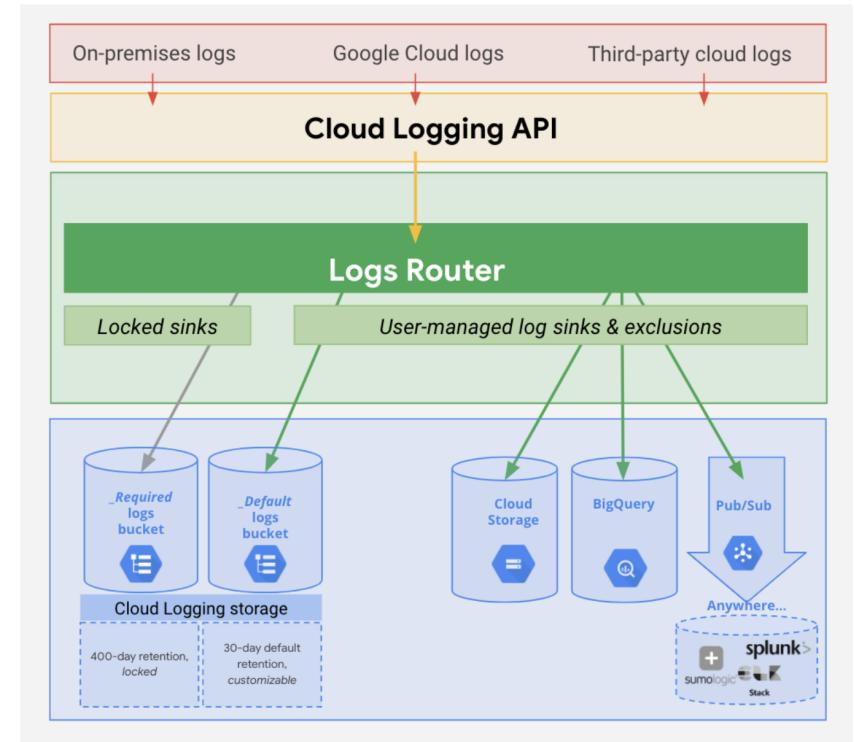
In 28
Minutes

Feature	Admin Activity Logs	Data Access Logs	System Event Logs	Policy Denied Logs
Logs for	API calls or other actions that modify the configuration of resources	Reading configuration of resources	Google Cloud administrative actions	When user or service account is denied access
Default Enabled	✓	X	✓	✓
VM Examples	VM Creation, Patching resources, Change in IAM permissions	Listing resources (vms, images etc)	On host maintenance, Instance preemption, Automatic restart	Security policy violation logs
Cloud Storage	Modify bucket or object	Modify/Read bucket or object		
Recommended Roles	Logging/Logs Viewer or Project/Viewer	Logging/Private Logs Viewer or Project/Owner	Logging/Logs Viewer or Project/Viewer	Logging/Logs Viewer or Project/Viewer

Cloud Logging - Controlling & Routing

In 28
Minutes

- How do you manage your logs?
 - Logs from various sources reaches **Log Router**
 - Log Router checks against configured rules
 - What to ingest? what to discard?
 - Where to route?
- Two types of Logs buckets:
 - **_Required:** Holds Admin activity, System Events & Access Transparency Logs (retained for 400 days)
 - ZERO charge
 - You cannot delete the bucket
 - You cannot change retention period
 - **_Default:** All other logs (retained for 30 days)
 - You are billed based on Cloud Logging pricing
 - You cannot delete the bucket:
 - But you can disable the **_Default** log sink route to disable ingestion!
 - You can edit retention settings (1 to 3650 days (10 years))



source: (<https://cloud.google.com>)

Cloud Logging - Export

In 28
Minutes

- Logs are ideally stored in Cloud Logging for limited period
 - For long term retention (Compliance, Audit) logs can be exported to:
 - Cloud Storage bucket (ex: bucket/syslog/2025/05/05)
 - Big Query dataset (ex: tables syslog_20250505 > columns timestamp, log)
 - Cloud Pub/Sub topic (base64 encoded log entries)
- How do you export logs?
 - Create **sinks** to these destinations using Log Router:
 - You can create **include** or **exclude** filters to limit the logs



Cloud Logging

Cloud Logging - Export - Use Cases

In 28
Minutes

- Use Case 1: Troubleshoot using VM Logs:
 - Install Cloud logging agent in all VM's and send logs to Cloud Logging
 - Search for logs in Cloud Logging
- Use Case 2: Export VM logs to BigQuery for querying using SQL like queries:
 - Install Cloud logging agent in all VM's and send logs to Cloud Logging
 - Create a BigQuery dataset for storing the logs
 - Create an export sink in Cloud Logging with BigQuery dataset as sink destination
- Use Case 3: You want to retain audit logs for external auditors at minimum cost
 - Create an export sink in Cloud Logging with Cloud Storage bucket as sink destination
 - Provide auditors with Storage Object Viewer role on the bucket
 - You can use Google Data Studio also (for visualization)

Cloud Trace

In 28
Minutes

- Distributed tracing system for GCP: Collect latency data from:
 - Supported Google Cloud Services
 - Instrumented applications (using tracing libraries) using **Cloud Trace API**
- Find out:
 - How long does a service take to handle requests?
 - What is the average latency of requests?
 - How are we doing over time? (increasing/decreasing trend)
- Supported for:
 - Compute Engine, GKE, App Engine (Flexible/Standard) etc
- Trace client libraries available for:
 - C#, Go, Java, Node.js, PHP, Python & Ruby



Cloud Debugger

In 28
Minutes

- How to debug issues that are happening only in test or production environments?
- **Cloud Debugger:** Capture state of a running application
 - Inspect the state of the application directly in the GCP environment
 - Take snapshots of variables and call stack
 - No need to add logging statements
 - No need to redeploy
 - Very lightweight => Very little impact to users
 - Can be used in any environment: Test, Acceptance, Production



Cloud Profiler

In 28
Minutes

- How do you identify performance bottlenecks in production?
- **Cloud Profiler** - Statistical, low-overhead profiler
 - Continuously gathers CPU and Memory usage from production systems
 - Connect profiling data with application source code
 - Easily identify performance bottlenecks
 - Two major components:
 - Profiling agent (collects profiling information)
 - Profiler interface (visualization)



Profiler

Error Reporting

In 28
Minutes

- How do you identify production problems in real time?
- Real-time exception monitoring:
 - Aggregates and displays errors reported from cloud services (using stack traces)
 - **Centralized Error Management console:**
 - Identify & manage top errors or recent errors
 - Use **Firebase Crash Reporting** for errors from Android & iOS client applications
 - Supported for Go, Java, .NET, Node.js, PHP, Python, and Ruby
- Errors can be reported by:
 - Sending them to Cloud Logging OR
 - By calling Error Reporting API
- Error Reporting can be accessed from desktop
 - Also available in the Cloud Console mobile app for iOS and Android



Error Reporting

Cloud Operations Scenarios

In 28
Minutes

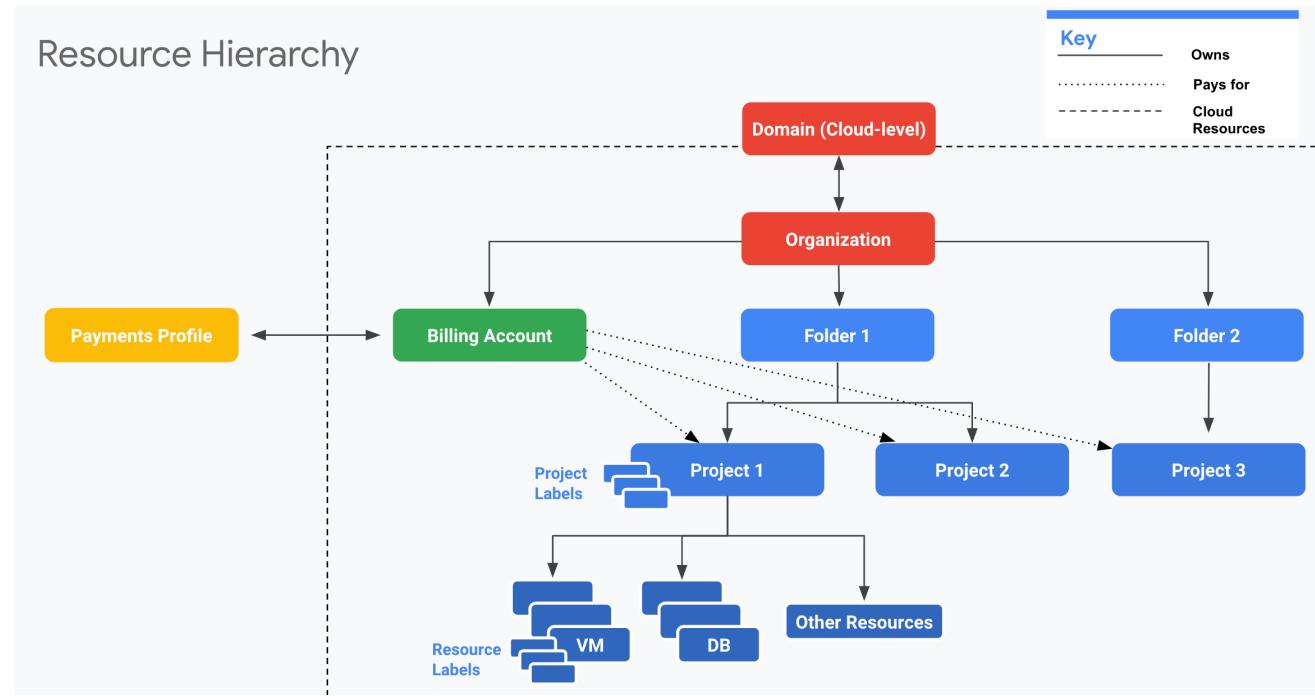
Scenario	Solution
You would like to record all operations/requests on all objects in a bucket (for auditing)	Turn on data access audit logging for the bucket
You want to trace a request across multiple microservices	Cloud Trace
You want to identify prominent exceptions (or errors) for a specific microservice	Error Reporting
You want to debug a problem in production by executing step by step	Cloud Debugger
You want to look at the logs for a specific request	Cloud Logging

Organizing GCP Resources

Resource Hierarchy in GCP

In 28
Minutes

- Well defined hierarchy:
 - Organization > Folder > Project > Resources
- Resources are created in projects
- A Folder can contain multiple projects
- Organization can contain multiple Folders



source: (<https://cloud.google.com>)

Resource Hierarchy - Recommendations for Enterprises

In 28
Minutes

- Create **separate projects for different environments**:
 - Complete isolation between test and production environments
- Create **separate folders for each department**:
 - Isolate production applications of one department from another
 - We can create a shared folder for shared resources
- **One project per application per environment**:
 - Let's consider two apps: "A1" and "A2"
 - Let's assume we need two environments: "DEV" and "PROD"
 - In the ideal world you will create four projects: A1-DEV, A1-PROD, A2-DEV, A2-PROD:
 - Isolates environments from each other
 - DEV changes will NOT break PROD
 - Grant all developers complete access (create, delete, deploy) to DEV Projects
 - Provide production access to operations teams only!

Billing Accounts

In 28
Minutes

- **Billing Account** is mandatory for creating resources in a project:
 - Billing Account contains the payment details
 - Every Project with active resources should be associated with a Billing Account
- Billing Account can be associated with one or more projects
- You can have multiple billing accounts in an Organization
- (RECOMMENDATION) Create Billing Accounts representing your organization structure:
 - A startup can have just one Billing account
 - A large enterprise can have a separate billing account for each department
- Two Types:
 - **Self Serve** : Billed directly to Credit Card or Bank Account
 - **Invoiced** : Generate invoices (Used by large enterprises)

Managing Billing - Budget, Alerts and Exports

In 28
Minutes

- Setup a **Cloud Billing Budget** to avoid surprises:
 - (RECOMMENDED) Configure Alerts
 - Default alert thresholds set at 50%, 90% & 100%
 - Send alerts to Pub Sub (Optional)
 - Billing admins and Billing Account users are alerted by e-mail
- Billing data can be **exported (on a schedule)** to:
 - Big Query (if you want to query information or visualize it)
 - Cloud Storage (for history/archiving)

- **Principle of Least Privilege** - Give least possible privilege needed for a role!
 - Basic Roles are NOT recommended
 - Prefer predefined roles when possible
 - Use Service Accounts with minimum privileges
 - Use different Service Accounts for different apps/purposes
- **Separation of Duties** - Involve atleast 2 people in sensitive tasks:
 - Example: Have separate deployer and traffic migrator roles
 - AppEngine provides App Engine Deployer and App Engine Service Admin roles
 - App Engine Deployer can deploy new version but cannot shift traffic
 - App Engine Service Admin can shift traffic but cannot deploy new version!
- **Constant Monitoring:** Review Cloud Audit Logs to audit changes to IAM policies and access to Service Account keys
 - Archive Cloud Audit Logs in Cloud Storage buckets for long term retention
- **Use Groups when possible**
 - Makes it easy to manage users and permissions

User Identity Management in Google Cloud

In 28
Minutes

- Email used to create free trial account => "**Super Admin**"
 - Access to everything in your GCP organization, folders and projects
 - Manage access to other users using their Gmail accounts
- However, this is **NOT recommended** for enterprises
- **Option 1:** Your Enterprise is using **Google Workspace**
 - Use Google Workspace to manage users (groups etc)
 - Link Google Cloud Organization with Google Workspace
- **Option 2:** Your Enterprise uses an Identity Provider of its own
 - **Federate** Google Cloud with your Identity Provider



Cloud IAM

Corporate Directory Federation

In 28
Minutes

- Federate Cloud Identity or Google Workspace with your external identity provider (IdP) such as Active Directory or Azure Active Directory.
- **Enable Single Sign On:**
 - 1: Users are redirected to an external IdP to authenticate
 - 2: When users are authenticated, SAML assertion is sent to Google Sign-In
- **Examples:**
 - Federate Active Directory with Cloud Identity by using Google Cloud Directory Sync (GCDS) and Active Directory Federation Services (AD FS)
 - Federating Azure AD with Cloud Identity



Cloud IAM

IAM Members/Identities

In 28
Minutes



Cloud IAM

- **Google Account** - Represents a person (an email address)
- **Service account** - Represents an application account (Not person)
- **Google group** - Collection - Google & Service Accounts
 - Has an unique email address
 - Helps to apply access policy to a group
- **Google Workspace domain:** Google Workspace (formerly G Suite) provides collaboration services for enterprises:
 - Tools like Gmail, Calendar, Meet, Chat, Drive, Docs etc are included
 - If your enterprise is using Google Workspace, you can manage permissions using your Google Workspace domain
- **Cloud Identity domain** - Cloud Identity is an Identity as a Service (IDaaS) solution that centrally manages users and groups.
 - You can use IAM to manage access to resources for each Cloud Identity account

IAM Members/Identities - Use Cases

In 28
Minutes

Scenario

All members in your team have G Suite accounts. You are creating a new production project and would want to provide access to your operations team

All members in your team have G Suite accounts. You are setting up a new project. You want to provide a one time quick access to a team member.

You want to provide an external auditor access to view all resources in your project BUT he should NOT be able to make any changes

Your application deployed on a GCE VM (Project A) needs to access cloud storage bucket from a different project (Project B)

Solution

Create a Group with all your operations team. Provide access to production project to the Group.

Assign the necessary role directly to G Suite email address of your team member
If it is not a one time quick access, the recommended approach would be to create a Group

Give them roles/viewer role (Generally basic roles are NOT recommended BUT it is the simplest way to provide view only access to all resources!)

In Project B, assign the right role to GCE VM service account from Project A

Organization Policy Service

In 28
Minutes

- How to enable centralized constraints on all resources created in an Organization?
 - Configure Organization Policy
 - Example: Disable creation of Service Accounts
 - Example: Allow/Deny creation of resources in specific regions
- Needs a Role - Organization Policy Administrator
- (Remember) IAM focuses on Who
 - Who can take specific actions on resources?
- (Remember) Organization Policy focuses on What
 - What can be done on specific resources?

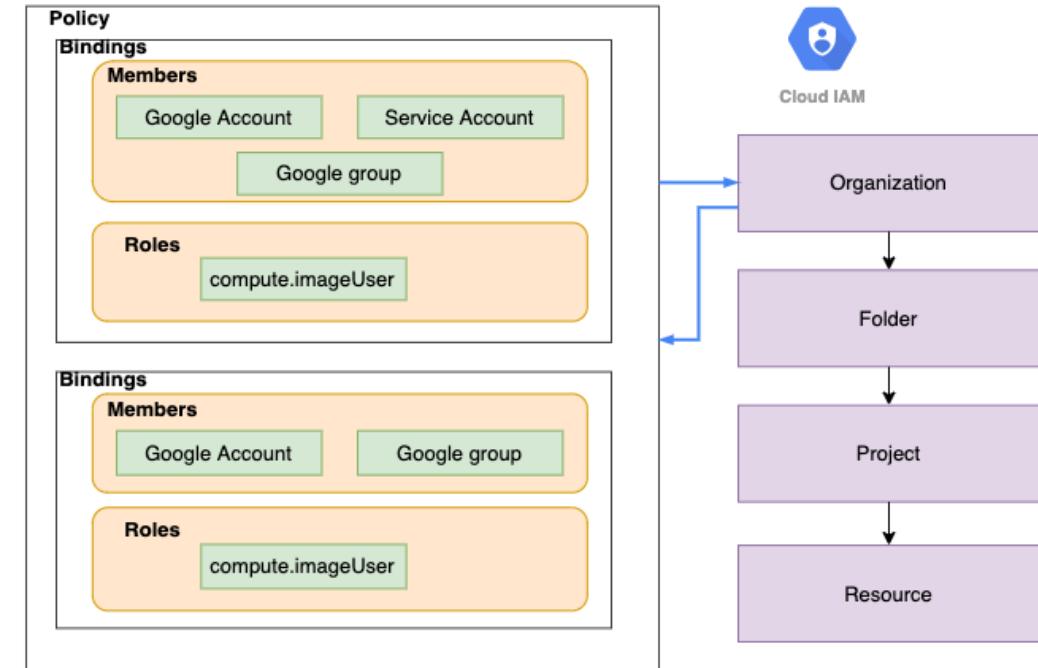


Cloud IAM

Resource Hierarchy & IAM Policy

In 28
Minutes

- IAM Policy can be set at any level of the hierarchy
- Resources inherit the policies of All parents
- The effective policy for a resource is the union of the policy on that resource and its parents
- Policy inheritance is transitive:
 - For example: Organization policies are applied at resource level
- You can't restrict policy at lower level if permission is given at an higher level



Organization, Billing and Project Roles

In 28
Minutes

- **Organization Administrator**
 - Define Resource Hierarchy
 - Define Access Management Policies
 - Manage other users and roles
- **Billing Account Creator** - Create Billing Accounts
- **Billing Account Administrator** - Manage Billing Accounts (payment instruments, billing exports, link and unlink projects, manage roles on billing account)
 - CANNOT create a Billing Account
- **Billing Account User** - Associate Projects with Billing Accounts
 - Typically used in combination with **Project Creator**
 - These two roles allow user to create new project and link it with billing account
- **Billing Account Viewer** - See all Billing Account details

Billing Roles - Quick Review

In 28
Minutes

Roles	Description	Use Case
Billing Account Creator	Permissions to create new billing accounts	Finance Team
Billing Account Administrator	Manages billing account but can't create them	Finance Team
Billing Account User	Assigns projects to billing accounts	Project Owner
Billing Account Viewer	View only access to billing account	Auditor

Organization, Billing and Project Roles - Scenarios

In 28
Minutes

- **Scenario 1:** I'm creating a project and I want to associate an existing billing account with the project
 - Roles needed : Project Creator and Billing Account User (link project to billing account)
- **Scenario 2:** I'm a billing auditor
 - Roles needed : Billing Account Viewer role

Compute Engine Roles

In 28
Minutes

- Compute Engine IAM Roles
 - **Compute Engine Admin** - Complete control of compute - Instances, Images, Load Balancers, Network, Firewalls etc...
 - **Compute Instance Admin** - Create, modify, and delete virtual machine instances and disks
 - **Compute Engine Network Admin** - Complete access to networking resources (routes, networks, health checks, VPN, Gateways etc) and READ ONLY access to (firewall rules and SSL certificates)
 - **Compute Engine Security Admin** - Complete access to firewall rules and SSL certificates
 - **Compute Storage Admin** - Complete access to disks, images, snapshots
 - **Compute Engine Viewer** - Read ONLY access to everything in compute
 - **Compute OS Admin Login** - Log in to a Compute Engine instance as an administrator user
 - **Compute OS Login** - Log in to a Compute Engine instance as a standard user

App Engine Roles

In 28
Minutes

- App Engine Roles (CRUD - Create, Read (get/list), Update, Delete)
 - **App Engine Creator** - applications(CD) (Responsible for creating an application)
 - **App Engine Admin** - applications(RU), services/instances/versions(CRUD), operations
 - **App Engine Viewer** - applications/services/instances/versions(R), operations
 - **App Engine Code Viewer** - appengine.versions.getFileContents (ONLY role that can view code)
 - **App Engine Deployer** - versions(CRD), applications/services/versions(R)
 - Deploy a new version of an app (if you also grant the Service Account User role)
 - **App Engine Service Admin** - versions(RUD), applications(R), services/instances(CRUD), operations: Split or migrate traffic, Start and stop a version
- App Engine Roles DO NOT allow you to
 - View and download application logs
 - View Monitoring charts in the Cloud Console
 - Enable and Disable billing
 - Access configuration or data stored in other services

Compute Engine and App Engine Roles - Few Scenarios

In 28
Minutes

- **Scenario 1:** What is the difference between Compute Engine Admin vs Compute Instance Admin?
 - Compute Instance Admin can do everything with instances and disks ONLY. Compute Engine Admin is admin for everything in compute - instances, disks, images, network, firewalls etc.
- **Scenario 2:** What is a secure way of setting up application deployment?
 - **Application Deployer** - Roles: App Engine Deployer + Service Account User
 - Limited to deploying new versions and deleting old versions that are not serving traffic
 - Will NOT be able to configure traffic
 - **Operations** - Role: App Engine Service Admin
 - CANNOT deploy a new version of an app
 - Change traffic between versions

Google Kubernetes Engine (GKE) IAM Roles

In 28
Minutes

- **Kubernetes Engine Admin (roles/container.admin)** - Complete Access to Clusters and Kubernetes API objects
- **Kubernetes Engine Cluster Admin** - Provides access to management of clusters (Cannot access Kubernetes API objects - Deployments, Pods etc)
- **Kubernetes Engine Developer** - Manage Kubernetes API objects (and read cluster info)
- **Kubernetes Engine Viewer** - get/list cluster and kubernetes api objects

Cloud Storage - Roles

In 28
Minutes

- **Storage Admin** - storage.buckets.* , storage.objects.*
- **Storage Object Admin** - storage.objects.* (DOES NOT HAVE storage.buckets.*)
- **Storage Object Creator** - storage.objects.create
- **Storage Object Viewer** - storage.objects.get, storage.objects.list
- (REMEMBER) Container Registry stores container images in Cloud Storage buckets
 - Control access to images in Container Registry using Cloud Storage permissions!
- (REMEMBER) **Storage Admin vs Storage Object Admin**
 - Storage Admin can create buckets and play with objects
 - Storage Object Admin CANNOT create buckets but can play with objects in a bucket!

Cloud BigQuery Roles

In 28
Minutes

- Cloud BigQuery IAM Roles
 - **BigQuery Admin** - `bigquery.*`
 - **BigQuery Data Owner** - `bigquery.datasets.*`, `bigquery.models.*`, `bigquery.routines.*`, `bigquery.tables.*` (**Does NOT have access to Jobs!**)
 - **BigQuery Data Editor** - `bigquery.tables.(create/delete/export/get/getData/getIamPolicy/list/update/updateData/updateTag)`, `bigquery.models.*`, `bigquery.routines.*`, `bigquery.datasets.(create/get/getIamPolicy/updateTag)`
 - **BigQuery Data Viewer** - `get/list bigquery.(datasets/models/routines/tables)`
 - **BigQuery Job User** - `bigquery.jobs.create`
 - **BigQuery User** - BigQuery Data Viewer + `get/list (jobs, capacityCommitments, reservations etc)`
- To see data, you need either **BigQuery User** or **BigQuery Data Viewer** roles
 - You CANNOT see data with **BigQuery Job User** roles
- **BigQuery Data Owner** or **Data Viewer** roles do NOT have access to jobs!

Logging IAM Roles and Service Account Roles

In 28
Minutes

- Logging and Audit Logging:
 - **roles/logging.viewer (Logs Viewer)**: Read all Logs except Access Transparency logs and Data Access audit logs.
 - **roles/logging.privateLogViewer (Private Logs Viewer)**: Logs Viewer + Read Access Transparency logs and Data Access audit logs
 - **roles/logging.admin (Logging Admin)**: All permissions related to Logging
- Service Accounts:
 - **roles/iam.serviceAccountAdmin**: Create and manage service accounts
 - **roles/iam.serviceAccountUser**: Run operations as the service account
 - **roles/iam.serviceAccountUser** => create and manage instances that use a service account. This needs to be added to Admin roles if you want them to attach service accounts with instances.
 - **roles/iam.serviceAccountTokenCreator** - Impersonate service accounts (create OAuth2 access tokens, sign blobs or JWTs, etc).
 - **roles/iam.serviceAccountKeyAdmin** - Create and manage (and rotate) service account keys.

Other Important IAM Roles

In 28
Minutes

- **roles/iam.securityAdmin** - Get and set any IAM policy
- **roles/iam.securityReviewer** - List all resources & IAM policies
- **roles/iam.organizationRoleAdmin** - Administer all custom roles in the organization and the projects below it
- **roles/iam.organizationRoleViewer** - Read all custom roles in the organization and the projects below it
- **roles/iam.roleAdmin** - Provides access to all custom roles in the project
- **roles/iam.roleViewer** - Provides read access to all custom roles in the project
- **roles/browser** - Read access to browse the hierarchy for a project, including the folder, organization, and IAM policy
 - This role doesn't include permission to view resources in the project

SSHing into Linux VMs - Options

In 28
Minutes

- Compute Engine Linux VMs uses **key-based SSH** authentication
- Two Options:
 - **Metadata managed:** Manually create and configure individual SSH keys
 - **OS Login:** Manage SSH access without managing **individual** SSH keys!
 - Recommended for managing multiple users across instances or projects
 - Your Linux user account is linked to your Google identity
 - To enable: Set enable-oslogin to true in metadata
 - *gcloud compute project-info/instances add-metadata --metadata enable-oslogin=TRUE*
 - (Advantage) Ability to import existing Linux accounts from on premises AD and LDAP
 - Users need to have roles : roles/compute.osLogin or roles/compute.osAdminLogin
- (Windows) **Windows** instances use **password**
authentication(username and password)
 - Generate using console or gcloud (*gcloud compute reset-windows-password*)



Compute Engine

SSHing into Linux VMs - Details

In 28
Minutes

- **Option 1: Console - SSH Button**
 - Ephemeral SSH key pair is created by Compute Engine
- **Option 2: Gcloud - *gcloud compute ssh***
 - A username and persistent SSH key pair are created by Compute Engine
 - SSH key pair reused for future interactions
- **Option 3: Use customized SSH keys**
 - (Metadata managed): Upload the public key to project metadata OR
 - (OS Login): Upload your public SSH key to your OS Login profile
 - *gcloud compute os-login ssh-keys add* OR
 - Use OS Login API : POST https://oslogin.googleapis.com/v1/users/ACCOUNT_EMAIL:importSshPublicKey
- You can disable Project wide SSH keys on a specific compute instance
 - *gcloud compute instances add-metadata [INSTANCE_NAME] --metadata block-project-ssh-keys=TRUE*



Compute Engine

Scenario	Description
You want to give permanent access to a sub set of objects in a Cloud Storage bucket	Use ACLs
You want to give permanent access to the entire bucket in a Cloud Storage bucket	Use IAM
You want to provide time limited access to a specific object in a Cloud Storage bucket	Create a Signed URL
You want to give access to a set of resources to your development team	Create a Group with your development team as member. Bind the right Predefined Roles to your Group.
Which Role? Upload objects to Cloud Storage	Storage Object Creator
Which Role? Manage Kubernetes API objects	Kubernetes Engine Developer
Which Role? Manage service accounts	Service Account Admin
Which Role? View Data in BigQuery	BigQuery Data Viewer

Other Google Cloud Platform Services

Pricing Calculator

In 28
Minutes

- Estimating the cost of a Google Cloud solution is NOT easy
- You would need to take a number of factors into account
- How do you estimate the cost of your GCP solution?
 - Use Google Cloud Pricing Calculator
- Estimates for 40+ Services:
 - Compute Engine
 - Google Kubernetes Engine
 - Cloud Run
 - App Engine
 - Cloud Storage
 - etc
- (REMEMBER) These are Estimates! (NOT binding on GCP)

Google Cloud Deployment Manager - Introduction

In 28
Minutes

- Lets consider an example:
 - I would want to create a new VPC and a subnet
 - I want to provision a Load balancer, Instance groups with 5 Compute Engine instances and an Cloud SQL database in the subnet
 - I would want to setup the right Firewall
- AND I would want to create 4 environments
 - Dev, QA, Stage and Production!
- Deployment Manager can help you do all these with a simple (actually NOT so simple) script!



Cloud Deployment
Manager

Google Cloud Deployment Manager - Advantages

In 28
Minutes

- Automate deployment and modification of Google Cloud resources in a controlled, predictable way
 - Deploy in multiple environments easily!
- Avoid configuration drift
- Avoid mistakes with manual configuration
- Think of it as version control for your environments
- **Important Note** - Always modify the resources created by Deployment Manager using Deployment Manager



Cloud Deployment Manager

Google Cloud Deployment Manager

In 28
Minutes

- All configuration is defined in a simple text file - YAML
 - I want a VPC, a subnet, a database and ...
- Deployment Manager understands dependencies
 - Creates VPCs first, then subnets and then the database
- (Default) Automatic rollbacks on errors (Easier to retry)
 - If creation of database fails, it would automatically delete the subnet and VPC
- Version control your configuration file and make changes to it over time
- Free to use - Pay only for the resources provisioned
 - Get an automated estimate for your configuration



Cloud Deployment
Manager

Cloud Deployment Manager - Example

In 28
Minutes

```
- type: compute.v1.instance
  name: my-first-vm
  properties:
    zone: us-central1-a
    machineType: <<MACHINE_TYPE>>
    disks:
      - deviceName: boot
        type: PERSISTENT
        boot: true
        autoDelete: true
        initializeParams:
          sourceImage: <<SOURCE_IMAGE>>
    networkInterfaces:
      - network: <<NETWORK>>
        # Give instance a public IP Address
        accessConfigs:
          - name: External NAT
            type: ONE_TO_ONE_NAT
```

Cloud Deployment Manager - Terminology

In 28
Minutes

- **Configuration file:** YAML file with resource definitions for a single deployment
- **Templates:** Reusable resource definitions that can be used in multiple configuration files
 - Can be defined using:
 - Python (preferred) OR
 - JinJa2 (recommended only for very simple scripts)
- **Deployment:** Collection of resources that are deployed and managed together
- **Manifests:** Read-only object containing original deployment configuration (including imported templates)
 - Generated by Deployment Manager
 - Includes fully-expanded resource list
 - Helpful for troubleshooting

Cloud Marketplace (Cloud Launcher)

In 28
Minutes

- Installing custom software might involve setting up multiple resources:
 - Example: Installing WordPress needs set up of compute engine and a relational database
- How do you simplify the set up of custom software solutions like Wordpress or even more complex things like SAP HANA suite on GCP?
- **Cloud Marketplace:** Central repo of easily deployable apps & datasets
 - Similar to App Store/Play Store for mobile applications
 - You can search and install a complete stack
 - Commercial solutions - SAP HANA etc
 - Open Source Packages - LAMP, WordPress, Cassandra, Jenkins etc
 - OS Licenses: BYOL, Free, Paid
 - Categories: Datasets/Developer tools/OS etc
 - When selecting a solution, you can see:
 - Components - Software, infrastructure needed etc
 - Approximate price

- What would be the **steps in setting up a website** with a domain name (for example, in28minutes.com)?
 - Step I : Buy the domain name in28minutes.com (Domain Registrar)
 - Step II : Setup your website content (Website Hosting)
 - Step III : Route requests to in28minutes.com to the my website host server (DNS)
- **Cloud DNS = Global Domain Name System (Step III)**
 - Setup your DNS routing for your website (in28minutes.com)
 - Route api.in28minutes.com to the IP address of api server
 - Route static.in28minutes.com to the IP address of http server
 - Route email (ranga@in28minutes.com) to the mail server(mail.in28minutes.com)
 - Public and private managed DNS zones (container for records)



Cloud DNS

Cloud DNS - CLI

In 28
Minutes

- ***gcloud dns managed-zones create ZONE_NAME***
 - --description (REQUIRED - Short description for the managed-zone)
 - --dns-name (REQUIRED - DNS name suffix that will be managed with the created zone)
 - --visibility (private/public)
 - --networks (List of networks that the zone should be visible in if the zone visibility is [private])
- Three Steps to add records to a managed zone:
 - Start Transaction for Zone
 - ***gcloud dns record-sets transaction start --zone***
 - Make Changes
 - ***gcloud dns record-sets transaction add --name=REC_NAME --ttl --type A/CNAME --zone=ZONE_NAME***
 - End Transaction for Zone
 - ***gcloud dns record-sets transaction execute --zone***



Cloud DNS

Cloud Dataflow

In 28
Minutes

- Cloud Dataflow is a difficult service to describe:
 - Let's look at a few example pipelines you can build:
 - Pub/Sub > Dataflow > BigQuery (Streaming)
 - Pub/Sub > Dataflow > Cloud Storage (Streaming - files)
 - Cloud Storage > Dataflow > Bigtable/CloudSpanner/Datastore/BigQuery (Batch - Load data into databases)
 - Bulk compress files in Cloud Storage (Batch)
 - Convert file formats between Avro, Parquet & csv (Batch)
- Streaming and Batch Usecases
 - Realtime Fraud Detection, Sensor Data Processing, Log Data Processing, Batch Processing (Load data, convert formats etc)
- Use pre-built templates
- Based on Apache Beam (supports Java, Python, Go ...)
- Serverless (and Autoscaling)



Dataflow

Cloud Dataproc

In 28
Minutes

- Managed Spark and Hadoop service:
 - Variety of jobs are supported:
 - Spark, PySpark, SparkR, Hive, SparkSQL, Pig, Hadoop
 - Perform complex batch processing
- Multiple Cluster Modes:
 - Single Node / Standard/ High Availability (3 masters)
 - Use regular/preemptible VMs
- Use case: Move your Hadoop and Spark clusters to the cloud
 - Perform your machine learning and AI development using open source frameworks
- (REMEMBER) Cloud Dataproc is a data analysis platform
 - You can export cluster configuration but NOT data
- (ALTERNATIVE) BigQuery - When you run SQL queries on Petabytes
 - Go for Cloud Dataproc when you need more than queries (Example: Complex batch processing Machine Learning and AI workloads)



Dataproc

Get Ready

Certification Resources

In 28
Minutes

Title	Link
Home Page	https://cloud.google.com/certification/cloud-engineer
Exam Guide	https://cloud.google.com/certification/guides/cloud-engineer
Sample Questions	https://cloud.google.com/certification/sample-questions/cloud-engineer
Registering For Exam	https://support.google.com/cloud-certification/#topic=9433215

Certification Exam

In 28
Minutes

- **50 questions and Two hours**
- **No penalty for wrong answers**
- **Questions:**
 - Type 1 : Multiple Choice - 4 options and 1 right answer
 - Type 2 : Multiple Select - 5 options and 2 right answers
- Result immediately shown after exam completion
- Email (a couple of days later)
- **My Recommendations:**
 - **Read the entire question**
 - Identify and write down the **key parts of the question**
 - **Read all answers** at least once
 - If you do NOT know the answer, **eliminate wrong answers first**
 - **Flag questions** for future consideration and review them before final submission

You are all set!

Let's clap for you!

In 28
Minutes

- You have a lot of patience! **Congratulations**
- You have put your best foot forward to be an Google Cloud Certified Associate Cloud Engineer
- Make sure you prepare well
- Good Luck!

Do Not Forget!

In 28
Minutes

- Recommend the course to your friends!
 - Do not forget to review!
- **Your Success = My Success**
 - Share your success story with me on LinkedIn (Ranga Karanam)
 - Share your success story and lessons learnt in Q&A with other learners!

What next?

In 28
Minutes

- Go Deeper into AWS!
 - Three things I would recommend
 - Serverless (Lambda, API Gateway, DynamoDB)
 - Elastic Beanstalk
 - ECS
- Learn other Cloud Platforms:
 - Gartner predicts a multi cloud world soon
 - Get certified on AWS, Azure and Google Cloud
- Learn DevOps (Containers and Container Orchestration)
- Learn Full Stack Development



Cloud SQL



Cloud Spanner



BigQuery

