Virtual Machines and Networks in the Cloud

In this module, we're going to explore how Google Compute Engine works, with a focus on virtual networking.

Let's begin.

Virtual Machines and Networks in the Cloud

Many users start with Google Cloud by defining their own virtual private cloud inside their first Google Cloud project or by starting with the default virtual private cloud.

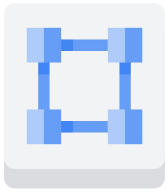
So, what *is* a virtual private cloud?

Virtual Private Cloud is your cloud within the Cloud

A virtual private cloud, or VPC, is a secure, individual, private cloud-computing model hosted within a public cloud

A virtual private cloud, or VPC, is a secure, individual, private cloud-computing model hosted within a public cloud – like Google Cloud!

On a VPC, customers can run code, store data, host websites, and do anything else they could do in an ordinary private cloud, but this private cloud is hosted remotely by a **public** cloud provider. This means that VPCs combine the scalability and convenience of public cloud computing with the data isolation of private cloud computing.



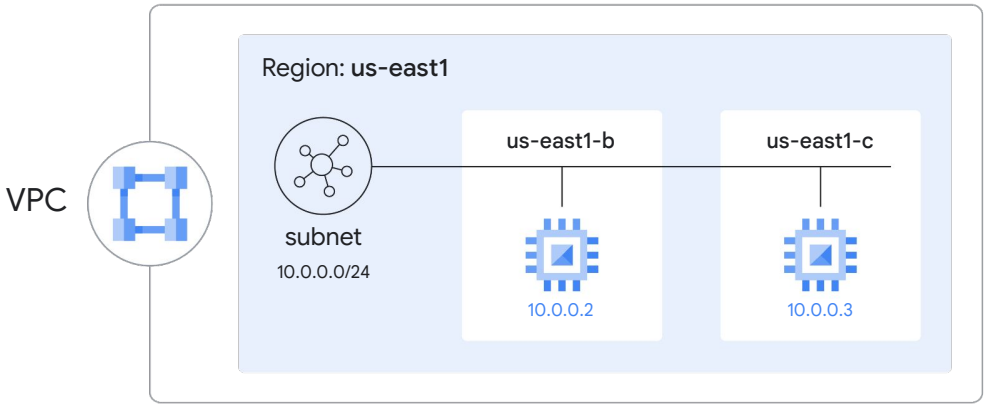
Virtual Private Cloud

- VPC networks connect Google Cloud resources to each other and to the internet
  - Segmenting networks
  - Using firewall rules to restrict access to instances
  - Creating static routes to forward traffic to specific destinations
- Google VPC networks are global and can have subnets in any Google Cloud region worldwide

VPC networks connect Google Cloud resources to each other and to the internet. This includes segmenting networks, using firewall rules to restrict access to instances, and creating static routes to forward traffic to specific destinations.

Here's something that tends to surprise a lot of new Google Cloud users: **Google VPC networks are global**. They can also have subnets, which is a segmented piece of the larger network, in any Google Cloud region worldwide. Subnets can span the zones that make up a region. This architecture makes it easy to define network layouts with global scope. Resources can even be in different zones on the same subnet.

VPC subnets connect resources in different zones



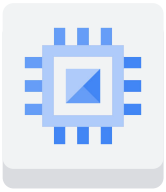
The size of a subnet can be increased by expanding the range of IP addresses allocated to it. And doing so won't affect already configured virtual machines.

For example, let's take a VPC with **one network** that currently has **one subnet** defined in Google Cloud's *us-east1* region. If the VPC has two Compute Engine VMs attached to it, it means they're neighbors on the same subnet even though they are in different zones! This capability can be used to build solutions that are resilient to disruptions, yet retain a simple network layout.

Virtual Machines and Networks in the Cloud

01	Virtual Private Cloud networking
02	**Compute Engine**
03	Scaling virtual machines
04	Important VPC compatibilities
05	Cloud Load Balancing
06	Cloud Domain Name Service
07	Cloud Content Delivery Network
08	Connecting Networks to Google VPC

Earlier in the course, we explored Infrastructure as a Service, or IaaS. Now let's explore Google Cloud's IaaS solution: Google Compute Engine.



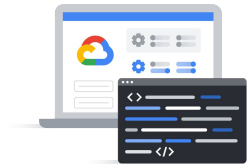
Compute Engine

- Compute Engine lets users can create and run virtual machines on Google infrastructure
- Each VM contains the power and functionality of a full-fledged operating system

With Compute Engine, users can create and run virtual machines on Google infrastructure. There are no upfront investments, and thousands of virtual CPUs can run on a system that is designed to be fast and offer consistent performance.

Each virtual machine contains the power and functionality of a full-fledged operating system. This means a virtual machine can be configured much like a physical server; by specifying the amount of CPU power and memory needed, the amount *and* type of storage needed, and the operating system.

Virtual machine instances are flexible resources



VM can be created via the Google Cloud Console the gcloud command-line tool

Linux Server images

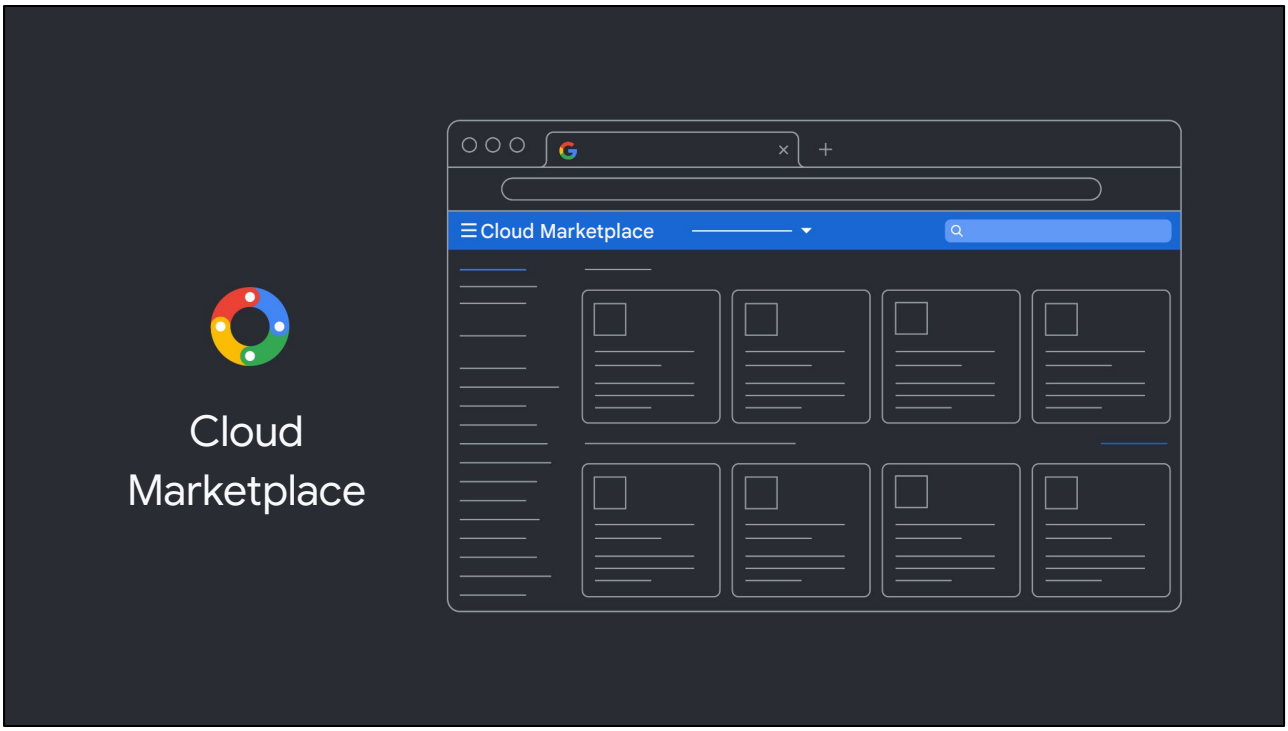
Windows Server images

provided by Google

VM can run Linux and Windows Server images or any customized versions of these images

You can build and run images of other operating systems and flexibly reconfigure virtual machines

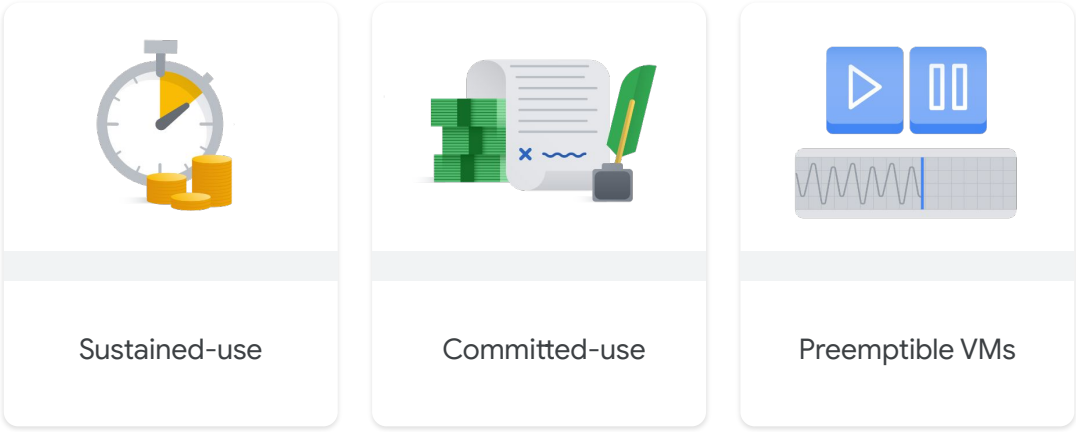
A virtual machine instance can be created via the Google Cloud Console, which is a web-based tool to manage Google Cloud projects and resources, or via the gcloud command-line tool. The instance can run Linux and Windows Server images provided by Google, or any customized versions of these images. You can also build and run images of other operating systems and flexibly reconfigure virtual machines.



A quick way to get started with Google Cloud is through the Cloud Marketplace, which offers solutions from both Google and third-party vendors. With these solutions, there's no need to manually configure the software, virtual machine instances, storage, or network settings, although many of them can be modified before launch if that's required.

Most software packages in Cloud Marketplace are available at no additional charge beyond the normal usage fees for Google Cloud resources. Some Cloud Marketplace images charge usage fees, particularly those published by third parties, with commercially licensed software, but they all show estimates of their monthly charges before they're launched.

Compute Engine pricing and billing offers discounts



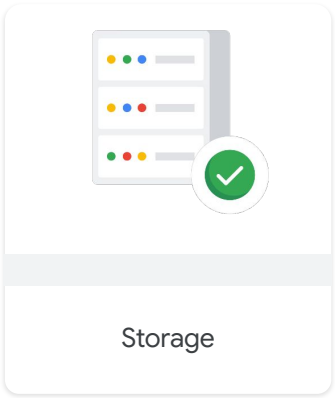
At this point, you might be wondering about pricing and billing related to Compute Engine.

For the use of virtual machines, Compute Engine bills by the second with a one-minute minimum, and **sustained-use discounts** start to apply automatically to virtual machines the longer they run. So, for each VM that runs for more than 25% of a month, Compute Engine automatically applies a discount for every additional minute.

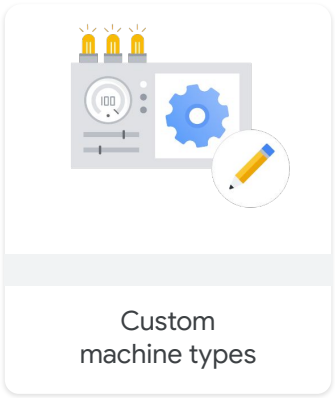
Compute Engine also offers **committed-use discounts**. This means that for stable and predictable workloads, a specific amount of vCPUs and memory can be purchased for up to a 57% discount off of normal prices in return for committing to a usage term of one year or three years.

And then there are **Preemptible VMs**. Let's say you have a workload that doesn't require a human to sit and wait for it to finish–like a batch job analyzing a large dataset, for example. You can save money, in some cases up to 90%, by choosing Preemptible VMs to run the job. A Preemptible VM is different from an ordinary Compute Engine VM in only one respect: Compute Engine has permission to terminate a job if its resources are needed elsewhere. While savings can be had with preemptible VMs, you'll need to ensure your job can be stopped and restarted.

Compute Engine pricing is “pay for only what you need”



Storage



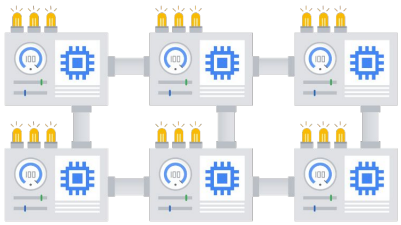
Custom machine types

In terms of storage, Compute Engine doesn’t require a particular option or machine type to get high throughput between processing and persistent disks. That’s the default, and it comes to you at no extra cost.

And finally, you’ll only pay for what you need with custom machine types. Compute Engine lets you choose the machine properties of your instances, like the number of virtual CPUs and the amount of memory, by using a set of predefined machine types or by creating your own custom machine types.

Virtual Machines and Networks in the Cloud

VMs can be auto-scaled to meet demand



Use Autoscaling for resilient, scalable applications

Use big VMs for memory- and compute-intensive applications

As we've just seen, with Compute Engine, you can choose the most appropriate machine properties for your instances, like the number of virtual CPUs and the amount of memory, by using a set of predefined machine types, or by creating custom machine types.

To do this, Compute Engine has a feature called Autoscaling, where VMs can be added to or subtracted from an application based on load metrics. The other part of making that work is balancing the incoming traffic among the VMs. Google's Virtual Private Cloud (VPC) supports several different kinds of load balancing, which we'll explore shortly.

With Compute Engine, you can in fact configure very large VMs, which are great for workloads such as in-memory databases and CPU-intensive analytics, but most Google Cloud customers start off with scaling *out*, not up. The maximum number of CPUs per VM is tied to its "machine family" and is also constrained by the quota available to the user, which is zone-dependent.

Specs for currently available VM machine types:

cloud.google.com/compute/docs/machine-types

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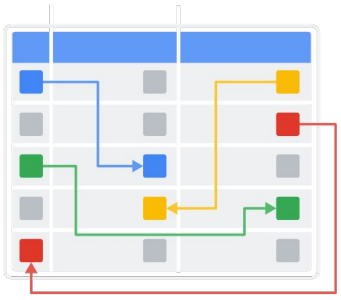
Virtual Machines and Networks in the Cloud

Now let's explore some of the most important Virtual Private Cloud compatibility features.

VPCs do not require a router to be provisioned



Routing tables

- Built-in so you don't have to provision or manage a router
- Used to forward traffic from one instance to another

Much like physical networks, VPCs have **routing tables**. VPC routing tables are built-in so you don't have to provision or manage a router. They are used to forward traffic from one instance to another within the same network, across subnetworks, or even between Google Cloud zones, without requiring an external IP address.

VPCs also do not require a firewall to be provisioned

Firewall

- Restricts access to instances through both incoming and outgoing traffic
- Rules can be defined through metadata tags on Compute Engine instances

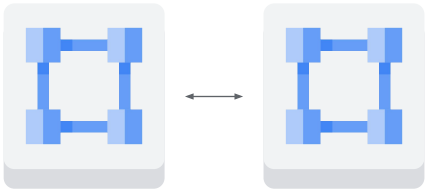
Another thing you don't have to provision or manage for Google Cloud is a **firewall**.

VPCs provide a global distributed firewall, which can be controlled to restrict access to instances through both incoming and outgoing traffic.

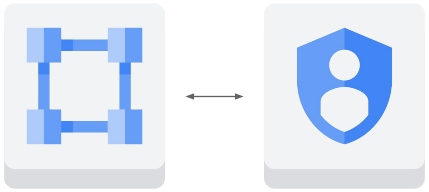
Firewall rules can be defined through metadata tags on Compute Engine instances, which is really convenient.

For example, you can tag all your web servers with, say, "WEB," and write a firewall rule saying that traffic on ports 80 or 443 is allowed into all VMs with the "WEB" tag, no matter what their IP address happens to be.

VPC peering and sharing allow projects to communicate



VPC peering



Shared VPC

You'll remember that VPCs belong to Google Cloud projects, but what if your company has several Google Cloud projects and the VPCs need to talk to each other?

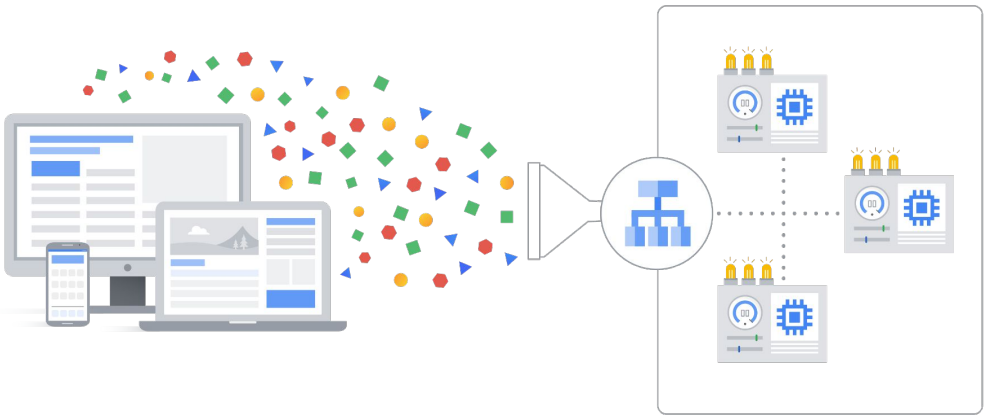
With **VPC Peering**, a relationship between two VPCs can be established to exchange traffic.

Alternatively, to use the full power of identity access management (IAM) to control who and what in one project can interact with a VPC in another, then you can configure a **Shared VPC**.

Virtual Machines and Networks in the Cloud

Previously, we explored how virtual machines can autoscale to respond to changing loads. But how do your customers get to your application when it might be provided by four VMs one moment, and by forty VMs at another? That's done through **Cloud Load Balancing**.

Load balancing distributes traffic across instances



The job of a load balancer is to distribute user traffic across multiple instances of an application. By spreading the load, load balancing reduces the risk that applications experience performance issues.

Cloud Load Balancing

- Fully distributed, software-defined, managed service
- You can put Cloud Load Balancing in front of all of your traffic:
  - HTTP(S)
  - TCP traffic
  - SSL traffic
  - UDP traffic

Cloud Load Balancing is a fully distributed, software-defined, managed service for all your traffic. And because the load balancers don't run in VMs that you have to manage, you don't have to worry about scaling or managing them. You can put Cloud Load Balancing in front of all of your traffic: HTTP(S), other TCP and SSL traffic, and UDP traffic too.

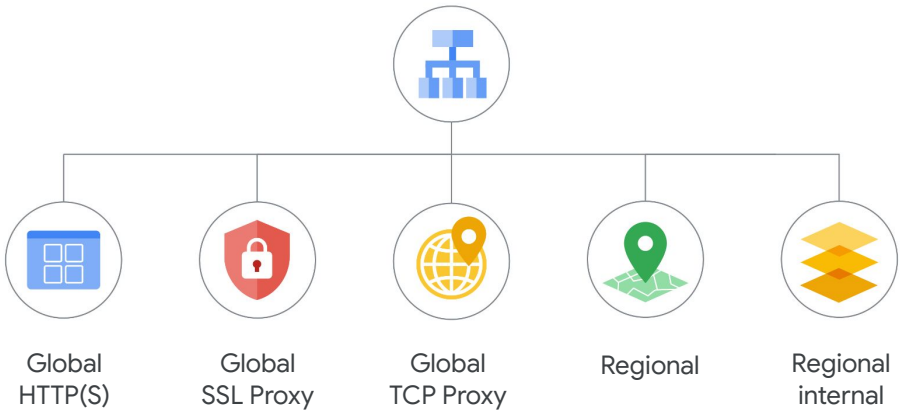
Cloud Load Balancing

- Provides single as well as cross-region load balancing, including automatic multi-region failover
- No “pre-warming” is required for anticipated spikes in traffic

Cloud Load Balancing provides cross-region load balancing, including automatic multi-region failover, which gently moves traffic in fractions if backends become unhealthy. Cloud Load Balancing reacts quickly to changes in users, traffic, network, backend health, and other related conditions.

And what if you anticipate a huge spike in demand? Say, your online game is already a hit; do you need to file a support ticket to warn Google of the incoming load? No. No so-called “pre-warming” is required.

There are several load balancing options



Google Cloud

VPC offers a suite of load-balancing options:

If you need cross-regional load balancing for a Web application, use **Global HTTP(S)** load balancing.

For Secure Sockets Layer traffic that is not HTTP, use the **Global SSL Proxy** load balancer.

If it's other TCP traffic that does not use Secure Sockets Layer, use the **Global TCP Proxy** load balancer.

Those two proxy services only work for specific port numbers, and they only work for TCP. If you want to load balance UDP traffic, or traffic on any port number, you can still load balance across a Google Cloud region with the **Regional** load balancer.

Finally, what all those services have in common is that they're intended for traffic coming into the Google network from the Internet. But what if you want to load balance traffic inside your project, say, between the presentation layer and the business layer of your application? For that, use the **Regional internal** load balancer. It accepts traffic on a Google Cloud internal IP address and load balances it across Compute Engine VMs.

Virtual Machines and Networks in the Cloud

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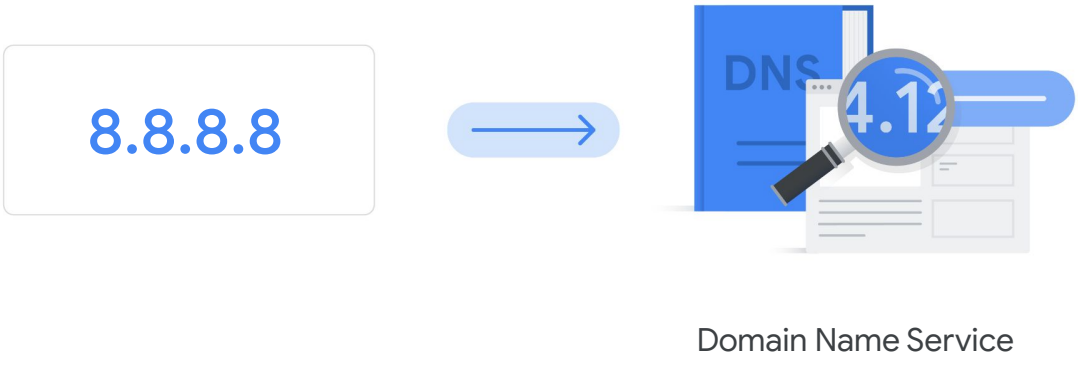
Google provides public DNS services



Domain Name Service

One of the most famous free Google services is 8.8.8.8, which provides a public **Domain Name Service** to the world. DNS is what translates Internet hostnames to addresses, and as you might imagine, Google has a highly developed DNS infrastructure. It makes 8.8.8.8 available so that everybody can take advantage of it.

Cloud DNS

- Managed DNS service that runs on the same infrastructure as Google
- Low latency, high availability, and cost-effective way to make applications and services available to users
- The DNS information you publish is served from redundant locations around the world.
- Cloud DNS is programmable. You can publish and manage millions of DNS zones and records using the Cloud Console, the command-line interface, or the API.

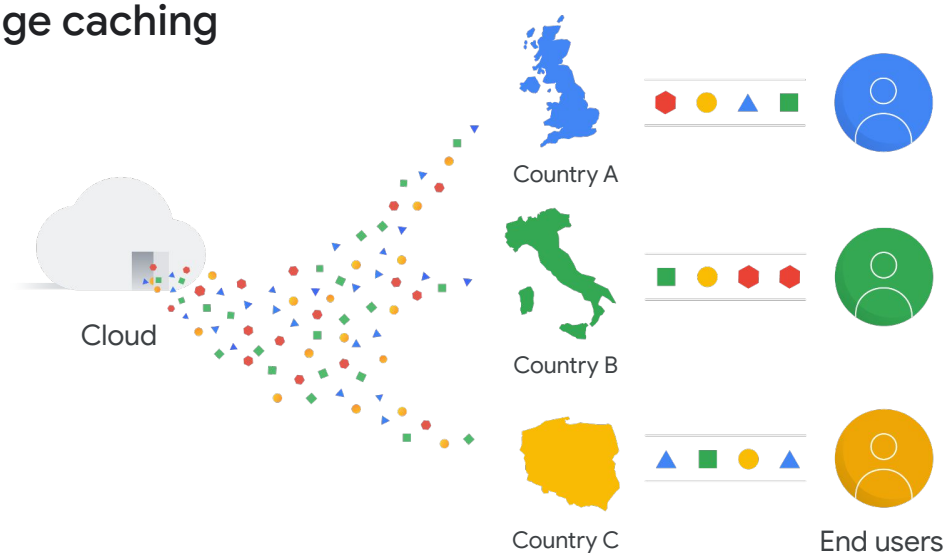
But what about the Internet hostnames and addresses of applications built in Google Cloud?

Google Cloud offers **Cloud DNS** to help the world find them. It's a managed DNS service that runs on the same infrastructure as Google. It has low latency and high availability, and it's a cost-effective way to make your applications and services available to your users. The DNS information you publish is served from redundant locations around the world.

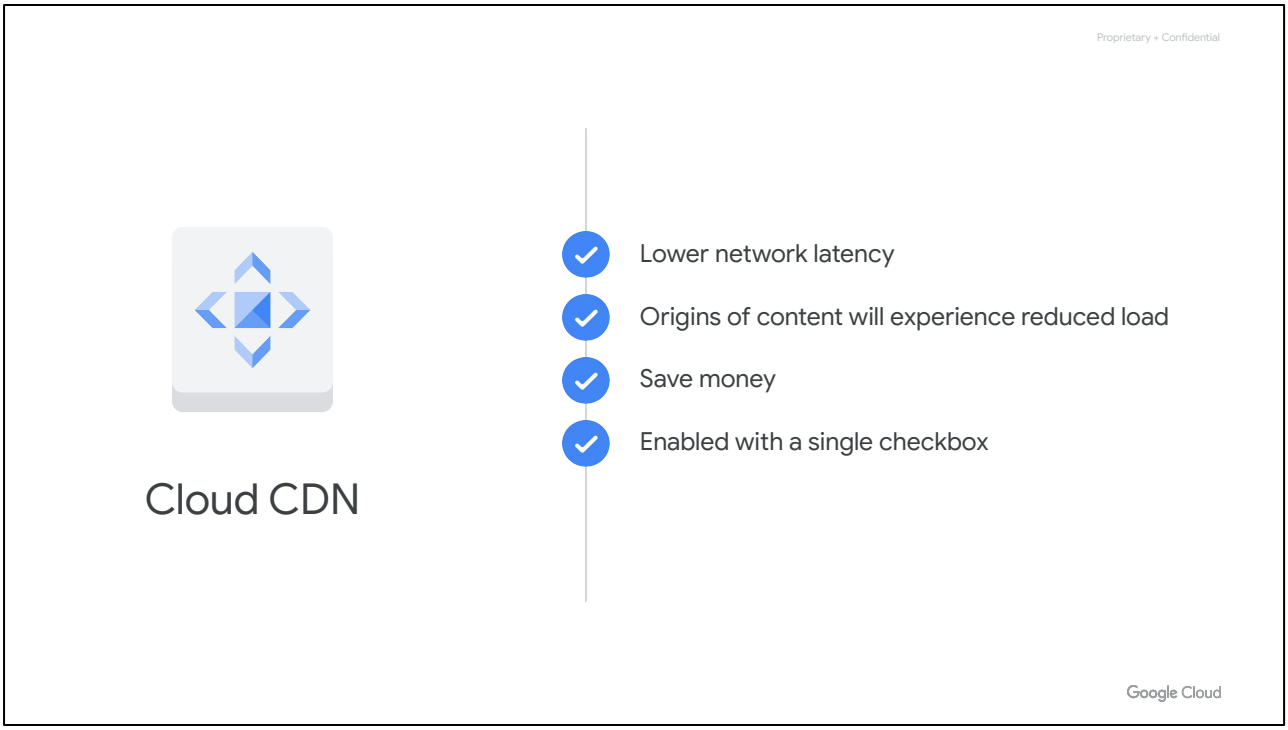
Cloud DNS is also programmable. You can publish and manage millions of DNS zones and records using the Cloud Console, the command-line interface, or the API.

Virtual Machines and Networks in the Cloud

Edge caching



Google has a global system of edge caches. Edge caching refers to the use of caching servers to store content closer to end users.

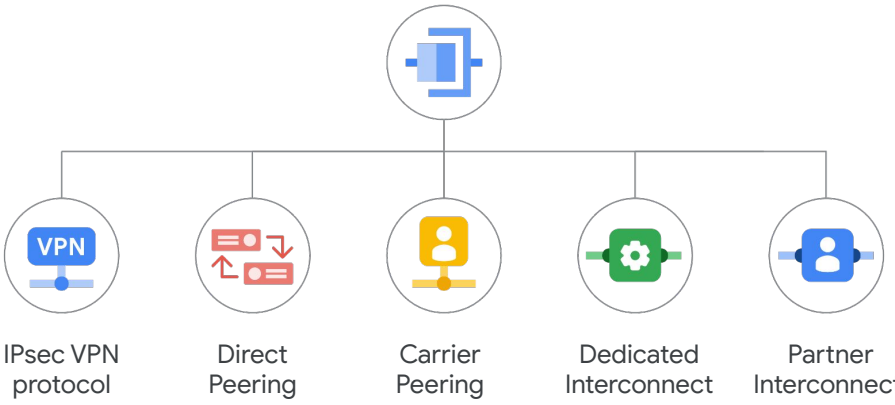


You can use this system to accelerate content delivery in your application using **Cloud CDN** - Content Delivery Network. This means your customers will experience lower network latency, the origins of your content will experience reduced load, and you can even save money. Once HTTP(S) Load Balancing is set up, Cloud CDN can be enabled with a single checkbox.

There are many other CDNs available out there, of course. If you are already using one, chances are, it's a part of Google Cloud's CDN Interconnect partner program, and you can continue to use it.

Virtual Machines and Networks in the Cloud

Google VPNs can connect to other networks



Many Google Cloud customers want to connect their Google Virtual Private Clouds to other networks in their system, such as on-premises networks or networks in other clouds. There are a number of effective ways to accomplish this.

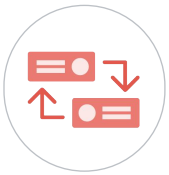
IPsec VPN creates dynamic connections

IPsec VPN protocol

- Creates a VPN “tunnel” connection
- Uses Cloud Router to make the connection dynamic
- Lets other networks and Google VPC exchange route information over the VPN using the Border Gateway Protocol
- Not always the best option because of security concerns or bandwidth reliability

One option is to start with a Virtual Private Network connection over the Internet and use the **IPsec VPN protocol** to create a “tunnel” connection. To make the connection dynamic, a Google Cloud feature called Cloud Router can be used. Cloud Router lets other networks and Google VPC exchange route information over the VPN using the Border Gateway Protocol. Using this method, if you add a new subnet to your Google VPC, your on-premises network will automatically get routes to it.

Direct peering routes traffic through a Google PoP



Direct Peering

- Puts a router in the same public datacenter as a Google point of presence (PoP)
- Uses a router to exchange traffic between networks
- Connects to more than 100 Google points of presence around the world

But using the Internet to connect networks isn't always the best option for everyone, either because of security concerns or because of bandwidth reliability.

A second option is to consider “peering” with Google using **Direct Peering**. Peering means putting a router in the same public datacenter as a Google point of presence and using it to exchange traffic between networks. Google has more than 100 points of presence (PoPs) around the world.

Carrier peering allows access to Google Workspace

Carrier Peering

- Uses a service provider's enterprise grade network to connect your infrastructure to Google
- Provides higher availability and lower latency
- VPC network traffic flows through either a default internet gateway or a VPN tunnel

Customers who aren't already in a point of presence can contract with a partner in the **Carrier Peering** program to get connected. Carrier peering gives you direct access from your on-premises network through a service provider's network to Google Workspace and to Google Cloud products that can be exposed through one or more public IP addresses. One downside of peering, though, is that it isn't covered by a Google Service Level Agreement.

Dedicated Interconnect is a direct connection to Google

Dedicated Interconnect

- Good solution for getting the highest uptimes for interconnection
- Allows for one or more direct, private connections to Google
- Can be covered by up to a 99.99% SLA if connections have topologies that meet Google's specifications
- Connections can be backed up by a VPN for even greater reliability

If getting the highest uptimes for interconnection is important, then using **Dedicated Interconnect** would be a good solution. This option allows for one or more direct, private connections to Google. If these connections have topologies that meet Google's specifications, they can be covered by up to a 99.99% SLA. Also, these connections can be backed up by a VPN for even greater reliability.

Partner Interconnect links your on-prem with your VPC

Partner Interconnect

- Provides connectivity between an on-premises network and a VPC network through a supported service provider
- Can be configured to support mission-critical services or applications that can tolerate some downtime
- Can be covered by up to a 99.99% SLA if connections have topologies that meet Google's specifications

And the final option we'll explore is **Partner Interconnect**, which provides connectivity between an on-premises network and a VPC network through a supported service provider. A Partner Interconnect connection is useful if a data center is in a physical location that can't reach a Dedicated Interconnect colocation facility, or if the data needs doesn't warrant an entire 10 Gbps connection.

Depending on availability needs, Partner Interconnect can be configured to support mission-critical services or applications that can tolerate some downtime. As with Dedicated Interconnect, if these connections have topologies that meet Google's specifications, they can be covered by up to a 99.99% SLA, but note that Google is not responsible for any aspects of Partner Interconnect provided by the third party service provider nor any issues outside of Google's network.

Module Review

Quiz Question 1

In Google Cloud VPCs, what scope do subnets have?

A: Zonal

B: Regional

C: Global

D: Multi-regional

Quiz Question 2

What is the main reason customers choose Preemptible VMs?

A: To improve performance.

B: To reduce cost.

C: To use custom machine types

D: To reduce cost on premium operating systems.

Quiz Question 3

For which of these interconnect options is a Service Level Agreement available?

A: Dedicated Interconnect

B: VPNs with Cloud Router

C: Direct Peering

D: Carrier Peering

Lab

Getting Started with VPC Networking and Google Compute Engine

[30 - 60 minutes]

In this lab, you create an auto mode VPC network with firewall rules and two VM instances. Then, you explore the connectivity for the VM instances.