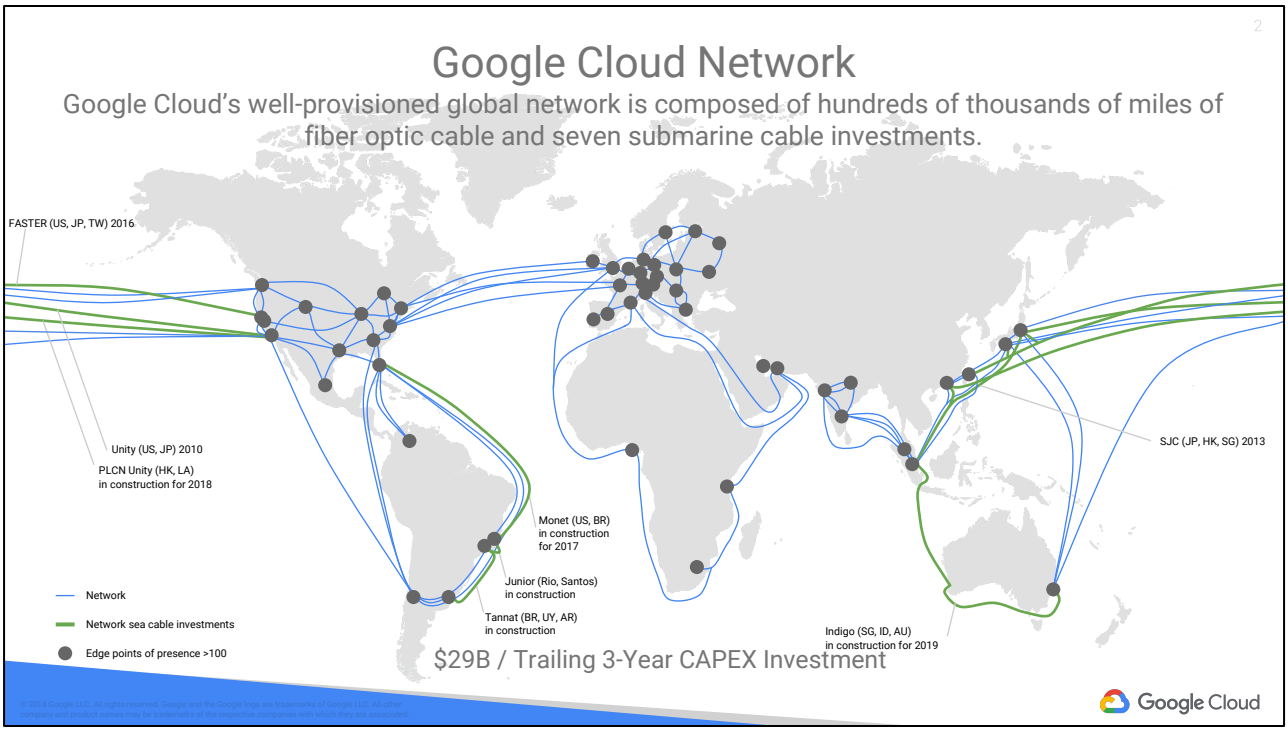
Interconnecting Networks

Elastic Cloud Infrastructure: Scaling and Automation

CLOUD VPN, CLOUD ROUTER, CLOUD INTERCONNECT, DIRECT PEERING, CLOUD DNS

VIRTUAL PRIVATE NETWORKS (VPN)

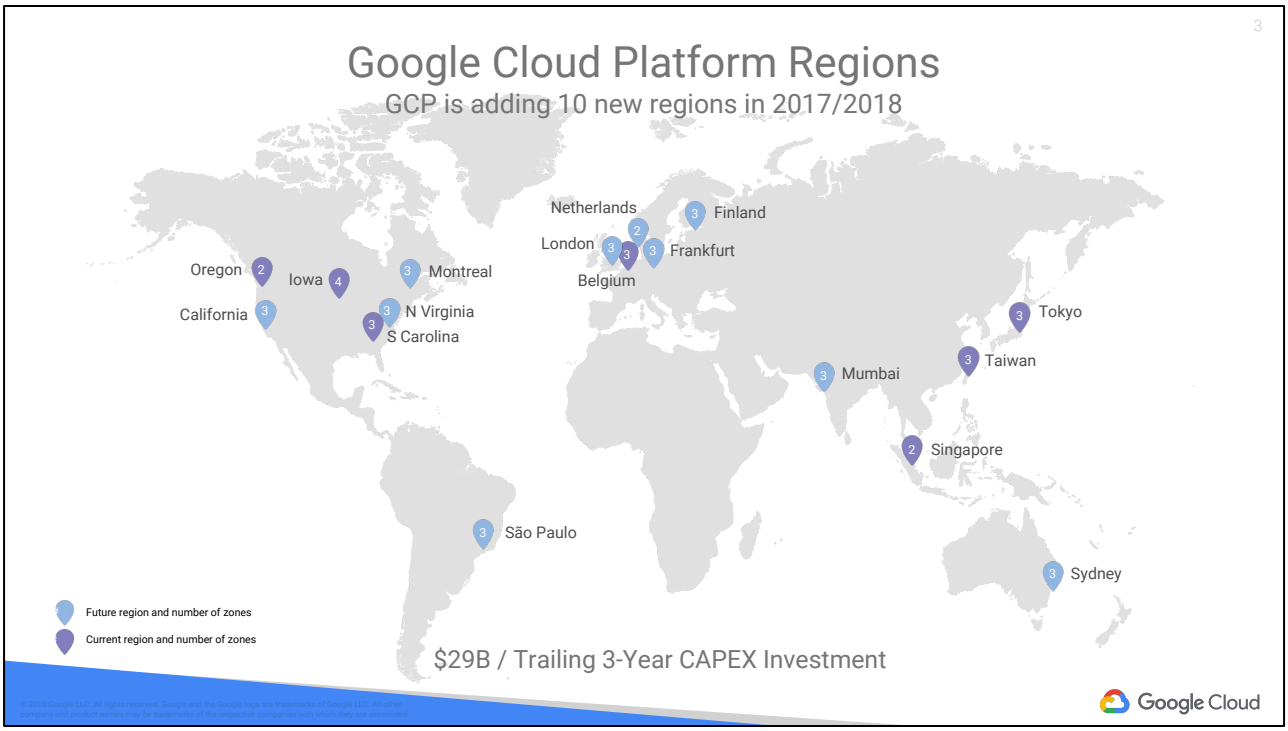
Last modified 2018-01-29



A global network in 14 regions and 39 zones in 2017. Not only for performance, but also to meet customer regulatory or policy requirements.

Thousands of miles of fiber.
Four owned undersea cables.

Google's networking infrastructure:
https://techcrunch.com/2015/08/18/how-googles-networking-infrastructure-has-evolved-over-the-last-10-years/

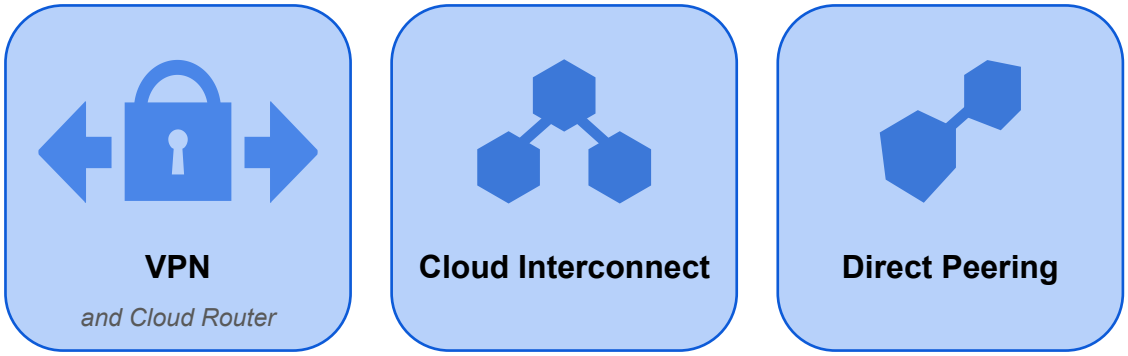


For more information, see:
https://cloud.google.com/compute/docs/regions-zones/regions-zones

Google Cloud networking

Global Scale	Application delivery at scale globally or regionally	HTTPS, TCP, UDP Load Balancing Cloud CDN Cloud DNS
Virtual Network	Global private space, regional segmentation	SDN network virtualization Global Networks Granular Subnetworks
Hybrid Cloud	Connection to on-premises	Cloud VPN Cloud Router Cloud Interconnect
Control	User control Security policies Visibility/diagnostics	Network IAM roles Firewalls

Interconnection options



Google Cloud

Direct Peering
Private enterprise-grade connection for hybrid cloud workloads

Carrier Interconnect
Enterprise-grade connection through service provider partners

VPN
Secure multi-Gbps connection over VPN tunnels

Agenda

- **Cloud Virtual Private Networks (VPN)**
- Lab
- Cloud Router
- Cloud Interconnect
- External Peering
- Cloud DNS
- Quiz

Google Cloud

Google Cloud VPN

- Securely connects your on-premises network to your GCP VPC network
- Traffic traveling between the two networks is protected as it travels over the internet:
  - Encrypted by one VPN gateway
  - Decrypted by the other VPN gateway
- SLA of 99.9% service availability
- Supports site-to-site VPN
- Supports:
  - Static routes
  - Dynamic routes (Cloud Router)
- Supports IKEv1 and IKEv2 using a shared secret
- Uses ESP in tunnel mode with authentication

Google Cloud

Google Cloud VPN securely connects your on-premises network to your Google Cloud Platform (GCP) Virtual Private Cloud (VPC) network through an IPsec VPN connection. Traffic traveling between the two networks is encrypted by one VPN gateway, then decrypted by the other VPN gateway. This protects your data as it travels over the internet.

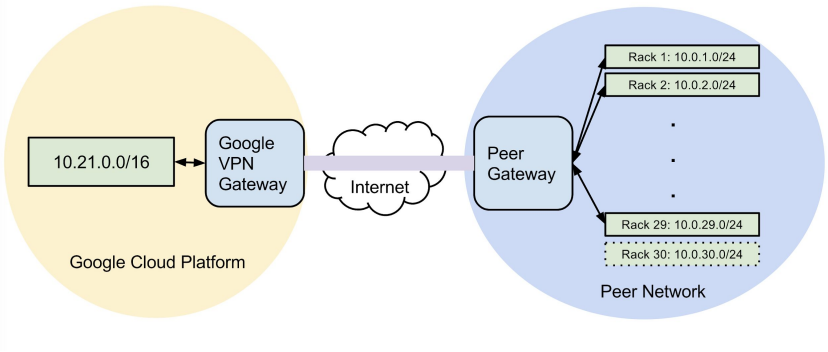
- Cloud VPN provides an SLA of 99.9% service availability.
- Cloud VPN supports site-to-site VPN. You can have multiple tunnels to a single VPN gateway.
- Cloud VPN supports both static routes and dynamic routes (via Cloud Router) for managing traffic between your instances and your existing infrastructure.
- Cloud VPN supports both IKEv1 and IKEv2 using a shared secret (IKE pre-shared key).
- Cloud VPN uses ESP in Tunnel mode with authentication. Cloud VPN does not support AH or ESP in Transport mode.

For more information, see:
Cloud VPC: https://cloud.google.com/vpc/docs
IPsec: https://wikipedia.org/wiki/IPsec
VPN: https://wikipedia.org/wiki/Virtual_private_network
Cloud VPN: https://cloud.google.com/vpn/docs/concepts/overview

VPN with static routes

With static routing, updating the tunnel requires:

- The addition of static routes to GCP.
- Restarting the VPN tunnel to include the new subnet.



Google Cloud

The diagram shows the example topology using a VPN tunnel to connect a Google Cloud network and 29 subnets (one per rack) in the on-premises network. In the diagram, a new subnet is being added (10.0.30.0/24).

For more information, see:
https://cloud.google.com/vpn/docs/how-to/creating-vpns

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Google Cloud

Lab: Virtual private networks (VPN)

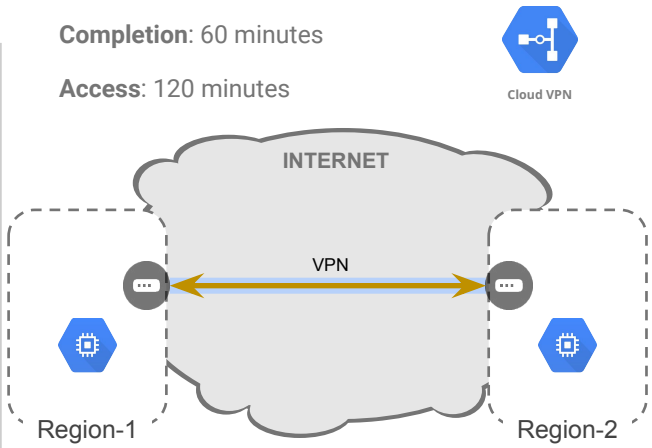
Objectives

In this lab, you learn how to perform the following tasks:

- Create two custom networks and associated subnetwork
- Create VPN gateways in each network
- Establish static routes to enable the gateways to pass traffic
- Configure static routes to pass traffic to the VPN gateway
- Establish firewall rules to enable ICMP and SSH traffic

Completion: 60 minutes

Access: 120 minutes



Lab review

In this lab you learned how to:

- Set up virtual private networking (VPN) between two subnets in different regions.
- Perform most of the configuration from the command line.
- Configure VPN using the GCP Console; many of the steps are automated.

One purpose of this lab is to show you how to configure VPN manually, so that you will better understand what the GCP Console does automatically. This can help in troubleshooting a configuration.

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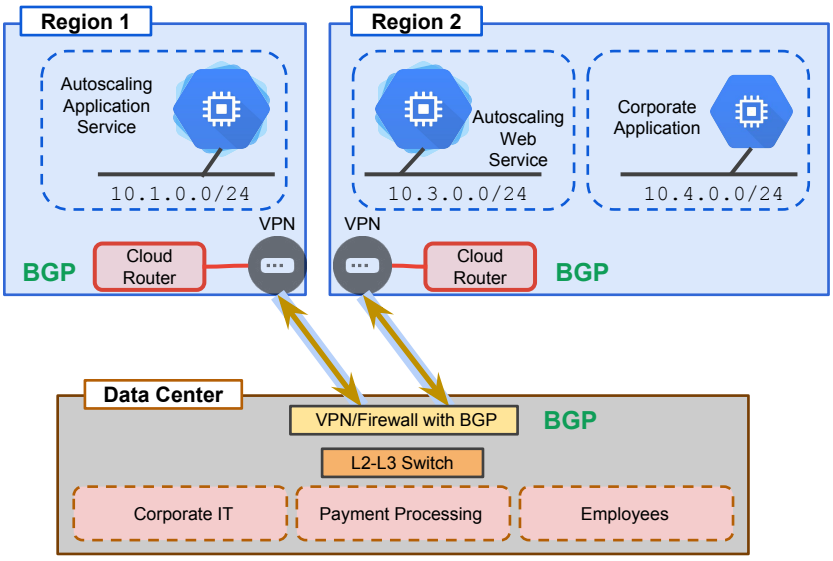
Cloud Router

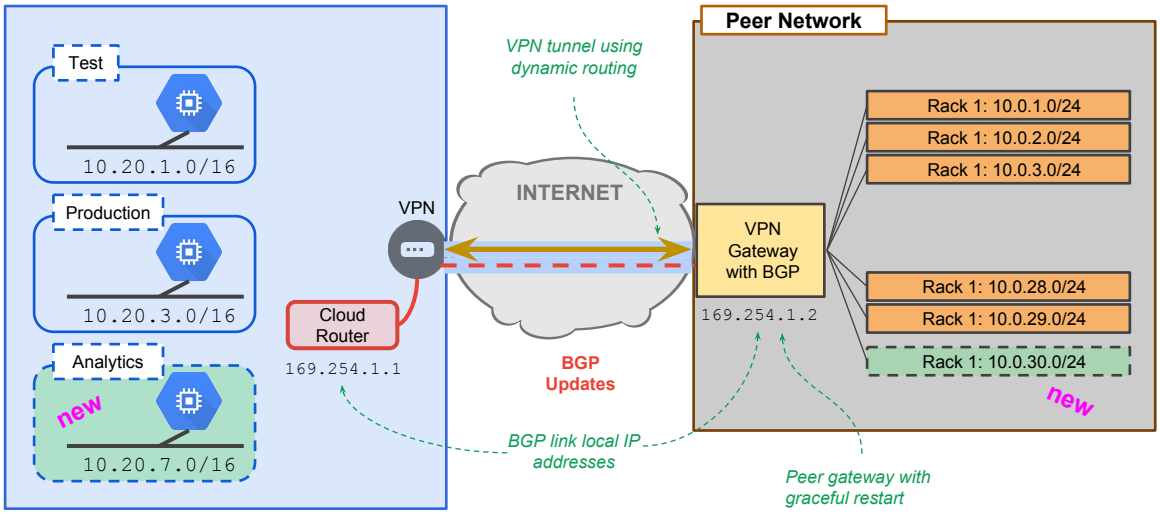
- Provides BGP routing
  - Dynamically discovers and advertises routes
- Supports graceful restart
- Supports ECMP
- Primary/Backup tunnels for failover
  - MED
  - AS Path length
  - AS Prepend

Dynamic routing with Cloud Router

- One Cloud Router in each region
- Peers with BGP router on-premises
- Advertise all subnets of the region
- Link-local IPs for BGP
- Private ASN on GCP
- Private or Public ASN on-premises



Cloud Router with subnetworks



Google Cloud

BGP peers establish adjacency on private network 169.254.1.0.
New subnets in GCP or in Peer network are discovered and shared, enabling connectivity between the two peers for both entire networks.

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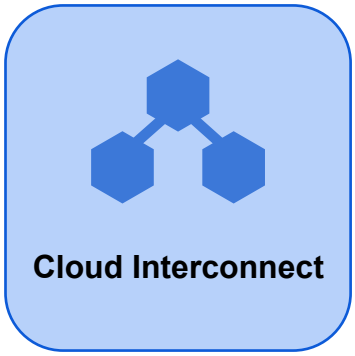
Cloud Interconnect

- Enterprise-grade connection to GCP
- Provides access to private (e.g., RFC1918) network addresses
- Enables easy hybrid cloud deployment
- Does not require the use of and management of hardware VPN devices



- Connect through a service providers network
- Provides dedicated bandwidth (50Mbps – 10Gbps)

- Connect to Google Cloud through Google POPs
- Provides N X 10G transport circuits for private cloud traffic

Google Cloud

For more information, see: https://cloud.google.com/interconnect/docs

- Arranged through Cloud Interconnect Service Providers
  - https://cloud.google.com/interconnect/docs
  - No Google SLA; SLA only through service provider
  - Service Provider network security (not Google end-to-end)
- Benefits of Cloud Interconnect
  - Higher availability
  - Lower latency
  - Lower cost for data-intensive applications

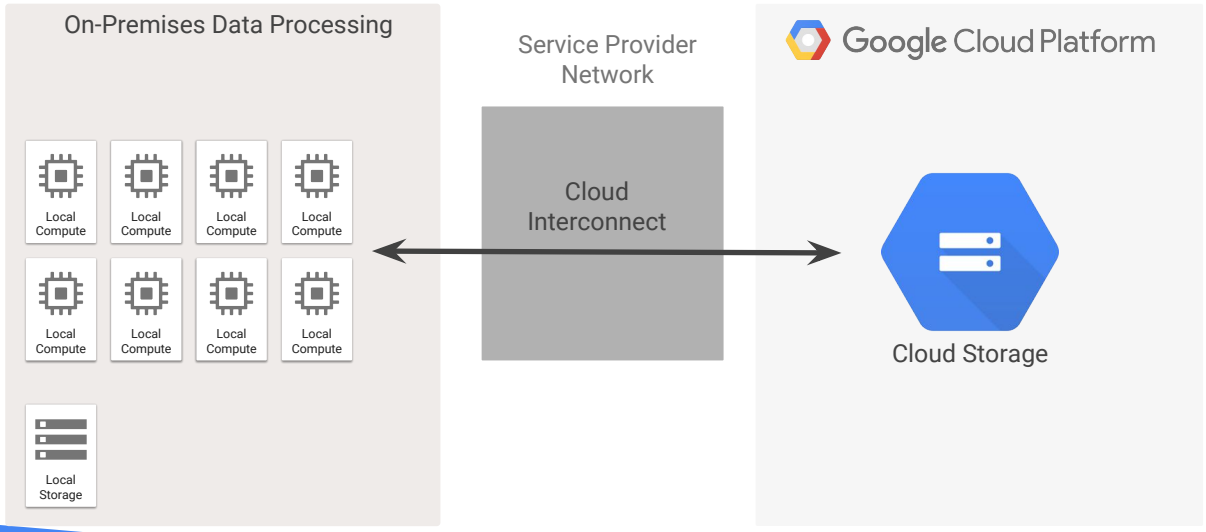
Dedicated interconnect considerations

- Must have a common point of presence with Google
- Your router must:
  - Be a single-mode fiber, 10GBASE-LR, 1310 nm
  - Must support:
    - LACP for bonding multiple links from 10 GB to 80 GB and more
    - Link local addressing
    - 802.1q VLANs
    - BGP-4 with multihop
    - Support IPv4 link local addressing
    - EBGP-4

Google Cloud

For more information, see:
https://cloud.google.com/interconnect/docs/details/dedicated#benefits

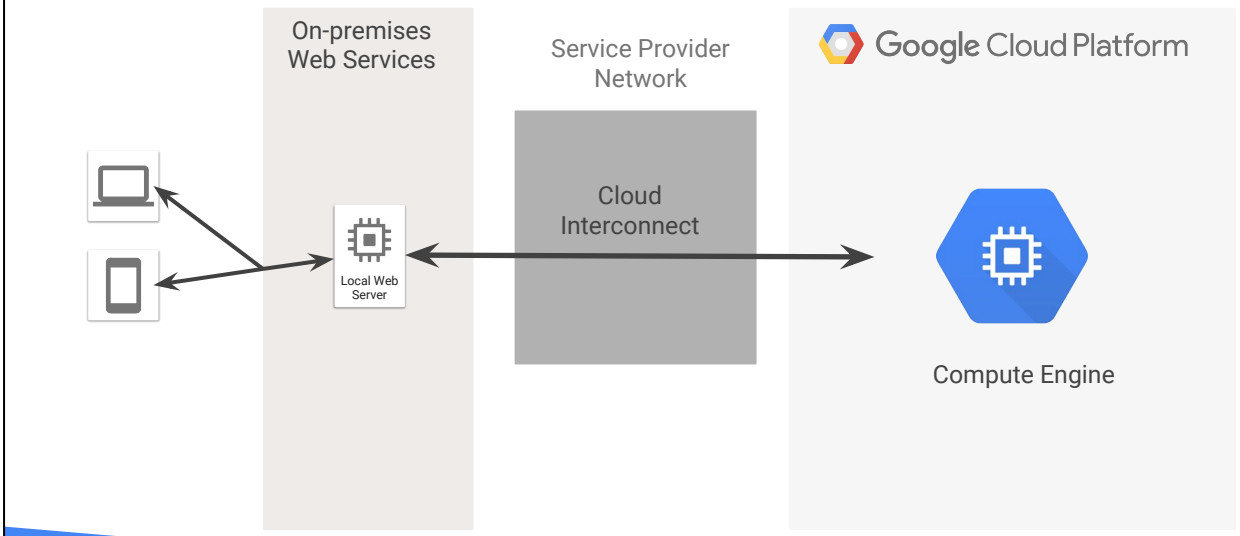
Data-intensive application



Google Cloud

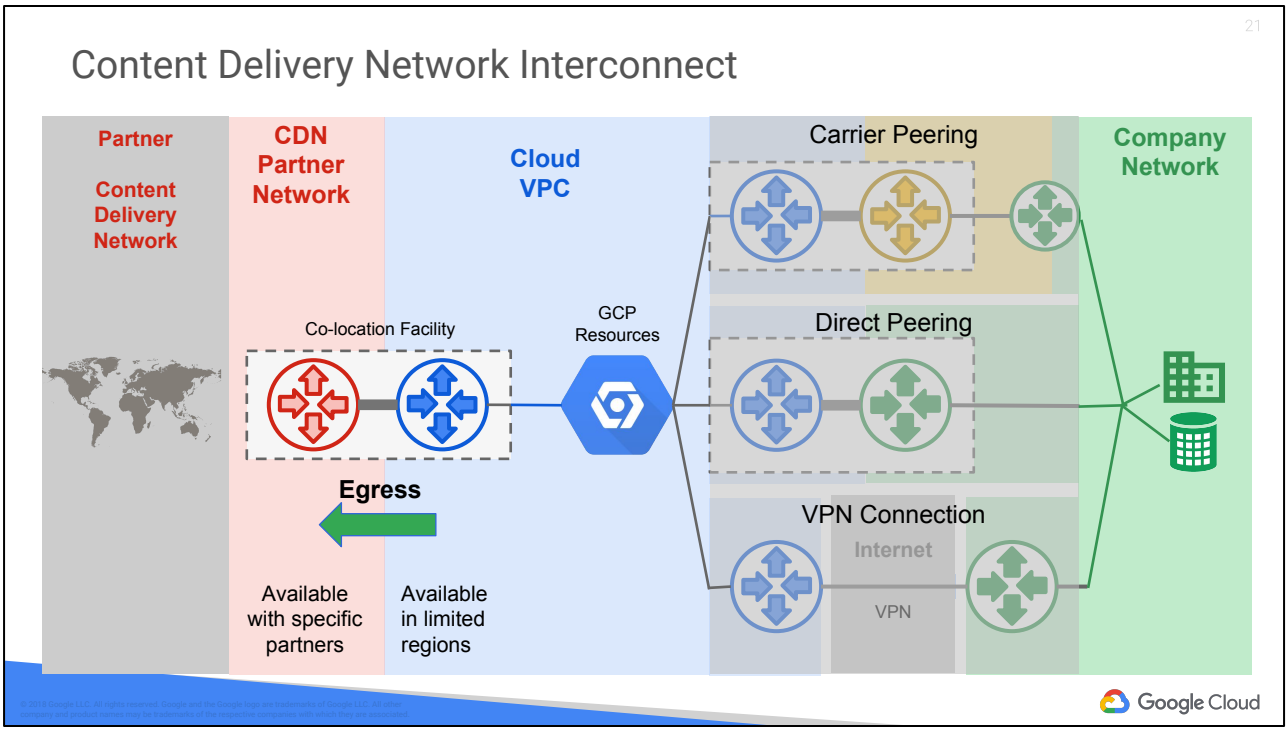
Massive data in cloud storage is being pulled/pushed to the on-premises computers for data processing. In this case, Cloud Interconnect provides lower latency, lower costs for some transfers, and higher reliability (depending on the service provider's SLAs).

Latency-sensitive application



Google Cloud

User uploads video that is transmitted to Compute Engine for flexible compute capacity. The video is processed and returned to the web server and to the user. In this case, Cloud Interconnect is used primarily to reduce the round-trip latency.



- Use case: data stored or processed in GCP, and hosted on the provider's CDN service, that is frequently updated from GCP
- Cloud Interconnect egress region-to-region pricing

CDN Interconnect is about egress from the VPC. Select CDN Partner Providers have direct egress capability to access their global Content Delivery Network. Note that Google has its own Content Delivery Network service. However, if you use a different CDN provider, Google has a partnering relationship with some with which an egress interconnect has been established. You may benefit by lower rates or lower latency to the CDN partner's services.

- Specific CDN Partners
- Specific limited regions and/or locations

For more information, see: https://cloud.google.com/interconnect/cdn-interconnect

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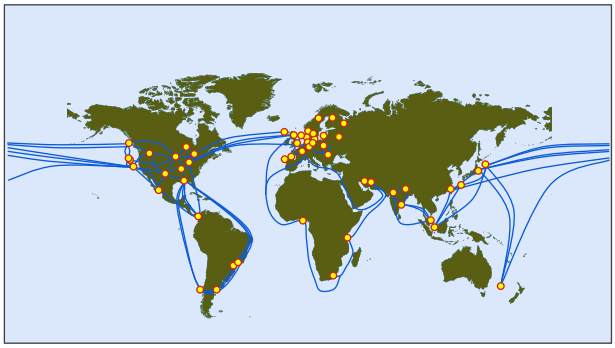
Google Cloud

Direct peering

- BGP direct connect between your network and Google's network at Edge Network locations
- Autonomous System numbers (AS) are exchanged via IXPs and some private facilities
- Technical, commercial, and legal requirements

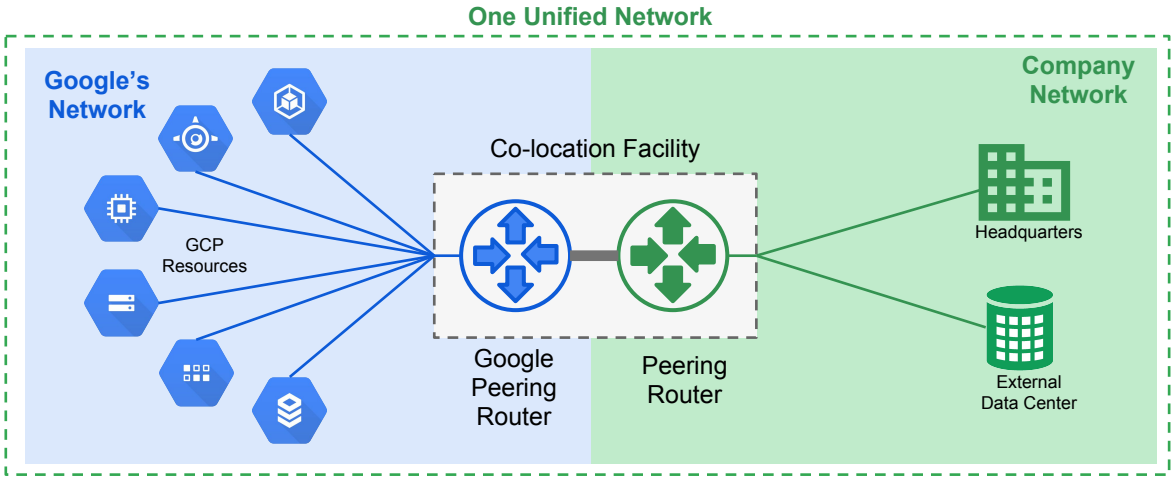
Points of Presence



Google Cloud

Google edge points of presence (PoPs) are where Google's network is connected to the rest of the internet via peering. Google is present on over 90 internet exchanges and at over 100 interconnection facilities around the world. LB and CDN at 80+ of these POPs. 42ms latency (median) and 140ms 90p.

Direct peering



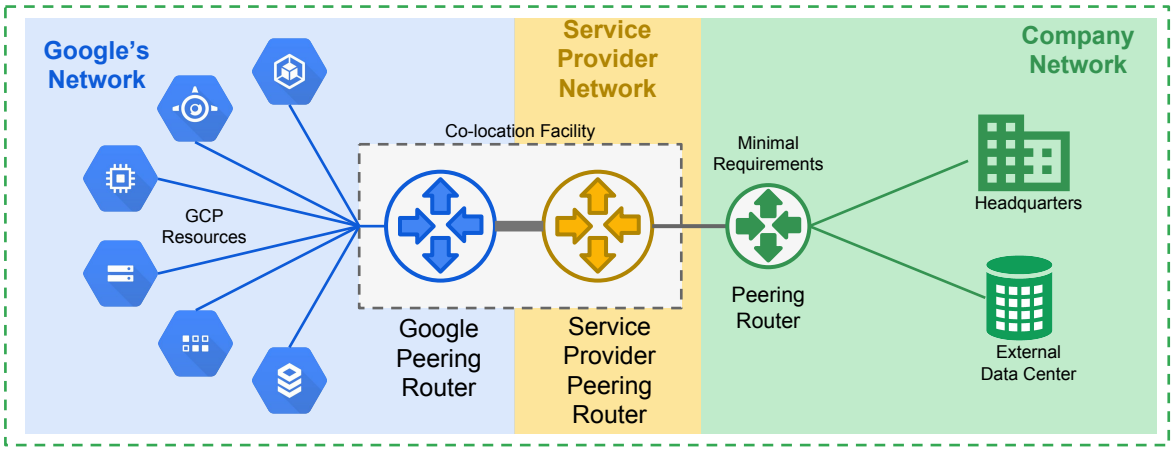
- Direct physical connection between an on-premise network and Google's network at any of 70+ locations in 33 countries around the world.
- Extends your private network into your cloud network.

Google Cloud

Google allows you to establish a direct peering connection between your business network and Google's. With this connection you can exchange internet traffic between your network and Google's at one of their broad-reaching edge network locations. Direct peering with Google is done by exchanging BGP routes between Google and the peering entity. After a direct peering connection is in place, you can use it to reach all of Google's services, including the full suite of Google Cloud Platform products.

For more information, see:
https://cloud.google.com/interconnect/docs/how-to/direct-peering

Carrier peering



- You can obtain enterprise-grade network services that connect your infrastructure to Google by using a service provider
- You can get connections with higher availability and lower latency, using one or more links.

Google Cloud

For more information, see:
https://cloud.google.com/interconnect/docs/how-to/carrier-peering

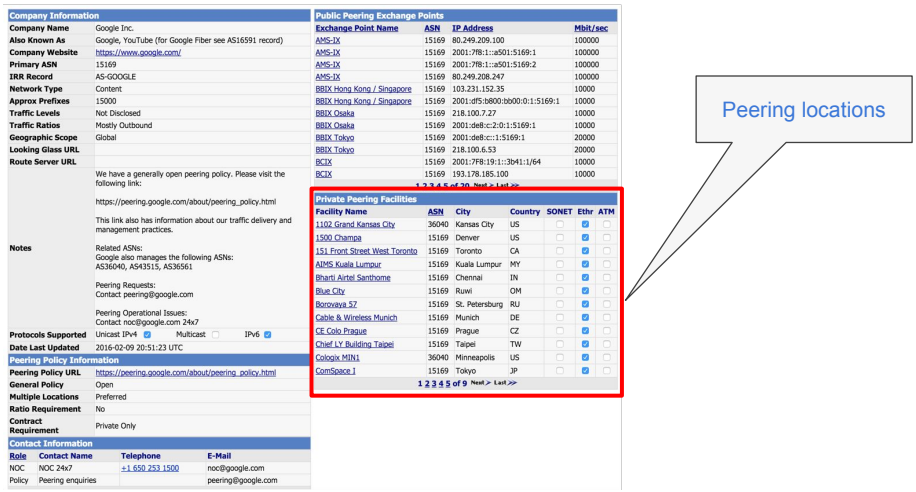
Autonomous System (AS)

- AS represents a collection of Internet Protocol (IP) routing prefixes under the control of an administrative entity representing one or more network operators
- ASN refers to AS number, which is allocated by Internet Assigned Numbers Authority (IANA)
- A business entity with an assigned ASN generally implies that that entity owns one or more blocks of IP addresses
- Google's ASN is 15169

Key concepts

- Border Gateway Protocol (BGP)
  - BGP is used to route traffic among internet service providers (ISP) or any entities who are assigned their own ASNs
- Private Network Interconnect (PNI)
  - Means "private peering"
- PeeringDB
  - A freely available web-based database of networks that are interested in peering
  - A resource for identifying candidates for peering

Peering locations for ASN=15169



Company Information

Company Name	Google Inc.
Also Known As	Google, YouTube (for Google Fiber see AS16591 record)
Company Website	https://www.google.com/
Primary ASN	15169
IRR Record	AS-GOOGLE
Network Type	Content
Approx Prefixes	15000
Traffic Levels	Not Disclosed
Traffic Ratios	Mostly Outbound
Geographic Scope	Global
Looking Glass URL	
Route Server URL	
Notes	We have a generally open peering policy. Please visit the following link: https://peering.google.com/about/peering_policy.html This link also has information about our traffic delivery and management practices. Related ASNs: Google also manages the following ASNs: AS36040, AS43515, AS36561 Peering Requests: Contact peering@google.com Peering Operational Issues: Contact noc@google.com 24x7
Protocols Supported	Unicast IPv4 ☑ Multicast ☐ IPv6 ☑
Date Last Updated	2016-02-09 20:51:23 UTC

Peering Policy Information

Peering Policy URL	https://peering.google.com/about/peering_policy.html
General Policy	Open
Multiple Locations	Preferred
Ratio Requirement	No
Contract Requirement	Private Only

Contact Information

Role	Contact Name	Telephone	E-Mail
NOC	NOC 24x7	+1 650 253 1500	noc@google.com
Policy	Peering enquiries		peering@google.com

Public Peering Exchange Points

Exchange Point Name	ASN	IP Address	Mbit/sec
AMS-IX	15169	80.249.209.100	100000
AMS-IX	15169	2001:7f8:1::a501:5169:1	100000
AMS-IX	15169	2001:7f8:1::a501:5169:2	100000
AMS-IX	15169	80.249.208.247	100000
BBIX Hong Kong / Singapore	15169	103.231.152.35	10000
BBIX Hong Kong / Singapore	15169	2001:df5:b800:bb00:0:1:5169:1	10000
BBIX Osaka	15169	218.100.7.27	10000
BBIX Osaka	15169	2001:de8:c:2:0:1:5169:1	10000
BBIX Tokyo	15169	2001:de8:c::1:5169:1	20000
BBIX Tokyo	15169	218.100.6.53	20000
BCIX	15169	2001:7F8:19:1::3b41:1/64	10000
BCIX	15169	193.178.185.100	10000

1 2 3 4 5 of 20 Next > Last >>

Private Peering Facilities

Facility Name	ASN	City	Country	SONET	Ethr	ATM
1102 Grand Kansas City	36040	Kansas City	US	☐	☑	☐
1500 Champa	15169	Denver	US	☐	☑	☐
151 Front Street West Toronto	15169	Toronto	CA	☐	☑	☐
AIMS Kuala Lumpur	15169	Kuala Lumpur	MY	☐	☑	☐
Bharti Airtel Santhome	15169	Chennai	IN	☐	☑	☐
Blue City	15169	Ruwi	OM	☐	☑	☐
Borovaya 57	15169	St. Petersburg	RU	☐	☑	☐
Cable & Wireless Munich	15169	Munich	DE	☐	☑	☐
CE Colo Prague	15169	Prague	CZ	☐	☑	☐
Chief LY Building Taipei	15169	Taipei	TW	☐	☑	☐
Cologix MIN1	36040	Minneapolis	US	☐	☑	☐
ComSpace 1	15169	Tokyo	JP	☐	☑	☐

1 2 3 4 5 of 9 Next > Last >>

Peering locations

https://www.peeringdb.com/view.php?asn=15169

Google Cloud

For more information, see: https://www.peeringdb.com/view.php?asn=15169

Details about direct peering

- Via edge point of presence (PoP)
- Uses the existing peering infrastructure Google uses for internet service providers (ISP)
- ***Not*** a private MPLS line into Google data centers where GCP services are located
- For all Google-bound traffic, not limited to GCP
- For public internet traffic via BGP with dedicated bandwidth but not necessarily private data exchange
- Discounted egress charges only apply to traffic flowing through the direct peering cross-connect, which requires a pre-defined BGP advertisement of its respective IP range
  - The IP range for the announcement must be of /24 at the minimum
- Direct peering set up with Google NetOps Content Distribution (NCD) team *(outside of GCP team)*

Share GCP VPC networks across projects in your cloud organization using Shared VPC

Shared VPC allows:

- Creation of a VPC network of RFC1918 IP spaces that associated projects can use
- Project admins to create VMs in the shared VPC network spaces
- Network and security admins to create VPNs and firewall rules usable by the projects in the VPC network
- Policies to be applied and enforced easily across a cloud organization

Google Cloud

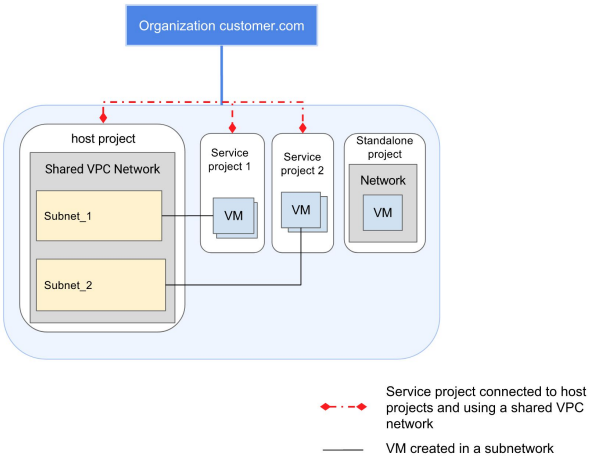
In large organizations, you may need to put different departments or different applications into different projects for purposes of separating budgeting, access control, and so on. With Shared VPC, cloud organization administrators can give multiple projects permission to use a single, shared VPC network and corresponding networking resources.

Shared VPC allows for the creation of a VPC network of RFC1918 IP spaces that associated projects can use. With Shared VPC, you can allow project admins to create VMs in the shared VPC network spaces and allow network and security admins to create VPNs and firewall rules that are usable by the projects in the VPC network. Shared VPC makes it easy to apply and enforce consistent policies across a cloud organization.

For more information, see:
Shared VPC Concepts:
https://cloud.google.com/vpc/docs/shared-vpc#concepts_and_terminology
Shared VPC: https://cloud.google.com/vpc/docs/shared-vpc
RFC1918: https://tools.ietf.org/html/rfc1918

Shared VPC overview

- Make a VPC network shareable across several projects in your cloud organization
- Host the VPC network in a shared VPC host project



Google Cloud

The diagram shows a host project sharing its VPC network with two service projects. It is sharing Subnet_1 with one project and Subnet_2 with another project. The Standalone project has not been designated a service project, so it can't share resources with the host project.

For more information, see: https://cloud.google.com/vpc/docs/shared-vpc#shared_vpc_host_project_and_service_project_associations

Connect two VPC networks regardless of shared projects/organizations using VPC Network Peering

VPC Network Peering allows you to:

- Build SaaS ecosystems in GCP
  - Make services available privately across different VPC networks in and across organizations
  - Have workloads communicate in private RFC1918 space

VPC Network Peering is useful for organizations:

- With several network administrative domains
- That want to peer with other organizations

VPC Network Peering advantages

VPC Network Peering provides the following advantages over using external IP addresses or VPNs to connect networks:

- Network latency
- Network security
- Network cost

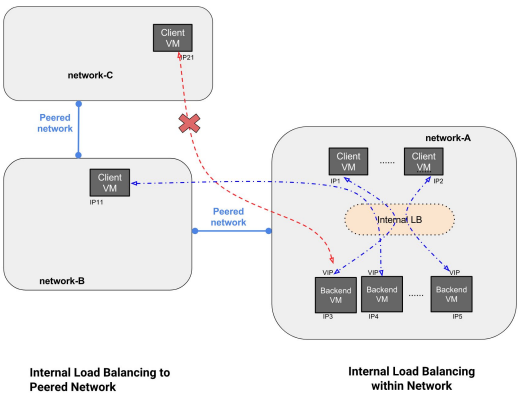
Google Cloud

VPC Network Peering gives you several advantages over using external IP addresses or VPNs to connect networks, including:

- Network latency: Public IP networking suffers higher latency than private networking.
- Network security: Service owners do not need to have their services exposed to the public internet and deal with its associated risks.
- Network cost: GCP charges egress bandwidth pricing for networks that use external IPs to communicate, even if the traffic is within the same zone. However, if the networks are peered, they can use internal IPs to communicate and save on those egress costs. Regular network pricing still applies to all traffic.

VPC Network Peering scenarios

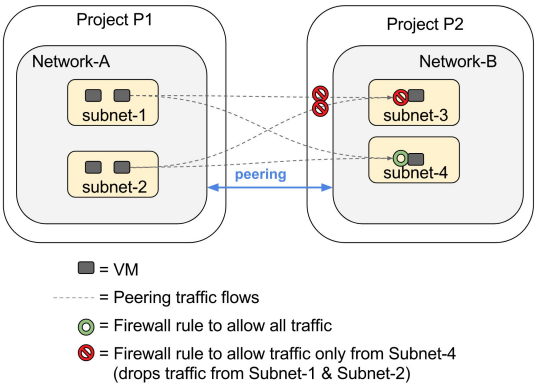
Internal Load Balancing



Internal Load Balancing to Peered Network

Internal Load Balancing within Network

Firewall



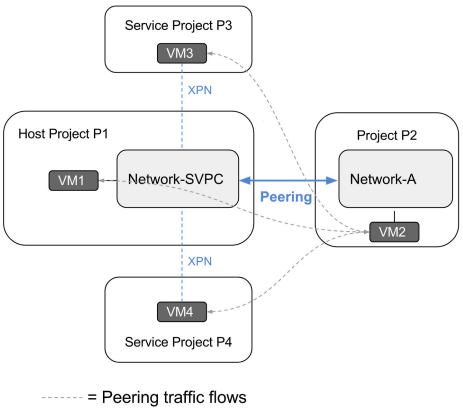
Google Cloud

The Internal Load Balancing diagram shows how VM instances in network-B access the load balanced backends in network-A. The Internal Load Balancing configuration from network-A is automatically applied to network-B in this case. Internal Load Balancing services are available to clients in directly peered networks only. That is, in the case that network-B peers with network-C, the Internal load-balanced backends in network-A will not be reachable from clients in network-C.

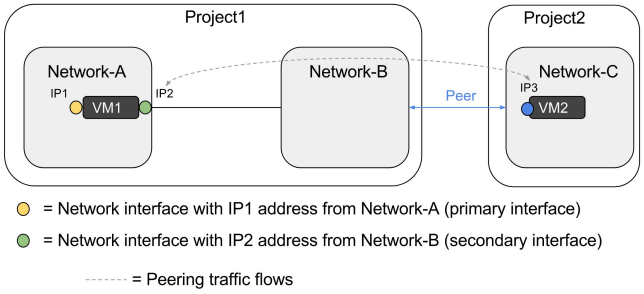
If you have peering between your VPC network and another VPC network, you may want to block traffic to a given set of VM instances or Internal Load Balancing endpoints. You must use firewall rules to do this because there is no way to exclude certain VM instances or Internal load balancers from the peering. If you want to disallow communication with certain VM instances or Internal load balancers, you can install ingress firewall rules on the network you want to block the communication to. The diagram shows how you could create a firewall rule to allow all traffic from subnets 1 and 2 in Network-A to subnet 4 in Network-B and deny traffic from subnets 1 and 2 in Network-A to subnet 3 in Network-B.

VPC Network Peering scenarios

Shared VPC



Multiple Network Interfaces per instance



Google Cloud

VPC Network Peering allows peering with a Shared VPC. As discussed earlier, a shared VPC host project allows other projects to use one of its networks. In the Shared VPC diagram, Network-SVPC is in a shared VPC network in host project P1. Service projects P3 and P4 are able to attach VM instances to Network-SVPC peers with Network-A. This results in the following:

- VM instances in shared VPC service projects that are using the Network-SVPC (VM3 and VM4) have private, internal IP connectivity with any endpoints associated to Network-A.
- VM instances associated to network-A will have private, internal IP connectivity with any endpoints associated to Network-SVPC, regardless of whether they live in the host project or a service project.

You can set up VPC Network Peering between two shared VPC networks.

An instance can have multiple network interfaces, one each in different VPC networks, which is shown in the Multiple Network Interfaces per instance diagram. In the diagram, VM1 has a network interface in both network-A and network-B. Network-B is peered with another Network-C. IP3 can send traffic to IP2 because IP2 is in Network-B, and Network-B routes are automatically propagated to Network-C when the two networks are peered. For IP2 to send traffic to IP3, you'd have to configure policy routing for the IP2 interface. Flows for IP1 are not installed in Network-C, so Network-C cannot access IP1.

For more information, see:
Multiple Network Interfaces:
https://cloud.google.com/vpc/docs/multiple-interfaces-concepts
Configure Policy Routing:
https://cloud.google.com/vpc/docs/create-use-multiple-interfaces#configuring_policy_routing
Using VPC Network Peering: https://cloud.google.com/vpc/docs/using-vpc-peering

Private Google access

- Enables virtual machine instances on a subnetwork to reach Google APIs and services using an internal IP address instead of an external IP address
- Allows VMs without internet access to reach Google services

Google Cloud

Private Google access enables virtual machine (VM) instances on a subnetwork to reach Google APIs and services using an internal IP address instead of an external IP address. External IP addresses are routable and reachable over the internet. Internal (private) IP addresses are internal to Google Cloud Platform and are not routable or reachable over the internet. You can use Private Google access to allow VMs without internet access to reach Google services.

The services that can be reached include, but are not limited to, the following:

- Cloud Spanner
- Google Cloud BigQuery
- Google Cloud Bigtable
- Google Cloud Dataproc
- Google Cloud Datastore
- Google Cloud Pub/Sub
- Google Cloud Storage

Private Google access does not apply to Google Cloud SQL. You do not get private connectivity to Cloud SQL when you use Private Google access.

For more information, see:
Private Google Access: https://cloud.google.com/vpc/docs/private-google-access
Google Cloud and Developer APIs: https://developers.google.com/apis-explorer/#p/

Configure Private Google Access:
https://cloud.google.com/compute/docs/private-google-access/configure-private-google-access
Configuring IP Addresses:
https://cloud.google.com/compute/docs/ip-addresses/reserve-static-external-ip-address

Agenda

- Cloud Virtual Private Networks (VPN)
- Lab
- Cloud Router
- Cloud Interconnect
- External Peering
- **Cloud DNS**
- Quiz

Google Cloud

Cloud DNS

- Google's DNS service
  - Lookup that translates symbolic names to IP addresses
  - High-performance DNS lookup for your users
  - Cost-effective for massive updates (millions of records)
- Manage DNS records through API or web UI
- Request routed to the nearest location, reducing latency
- Use cases
  - DNS resolver for your company's users w/o managing your own servers
  - DNS propagation of company DNS records

Google Cloud

Requests are automatically routed to the nearest location, reducing latency and improving authoritative name lookup performance for your users.

For more information, see: https://cloud.google.com/dns/overview

Cloud DNS managed zones

- An abstraction that manages all DNS records for a single domain name
- One project may have multiple managed zones
- Must enable the Cloud DNS API in GCP Console first
  - `gcloud dns managed-zones …`
- Managed zones
  - Permission controls at project level
  - Monitor propagation of changes to DNS name servers

Google Cloud

For more information, see: https://cloud.google.com/dns/zones/

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More resources

Cloud VPN
https://cloud.google.com/compute/docs/vpn/overview

Cloud Router
https://cloud.google.com/compute/docs/cloudrouter

Cloud Interconnect
https://cloud.google.com/interconnect/docs

Direct Peering
https://cloud.google.com/interconnect/direct-peering

Cloud DNS
https://cloud.google.com/dns/docs/

Google Cloud