“Without networking, there is no cloud.”

Cloud IPv6
Innovation

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Agenda

Cloud Migrate to IPv6
- Underlay B2/B4/Jupiter/Andromeda
- IPv6 ULA and VPC Design

IPv6 Cloud Products
- DNS, Interconnect, LB,
- IPv6 K8S and Hybrid Cloud

Summary
- Many Cloud IPv6 Innovations
Global IPv6 adoption

United States
IPv6 Adoption: 44.63%
Latency / impact: -10ms / -0.01%

Nepal
IPv6 adoption 30.97%

India
IPv6 adoption 60.8%


<table>
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<tr>
<th>RANK</th>
<th>IPV6%</th>
<th>COUNTRY / REGION</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>60.8%</td>
<td>India</td>
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<tr>
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<td>United States</td>
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<tr>
<td>33</td>
<td>20.6%</td>
<td>China</td>
</tr>
</tbody>
</table>
Why IPv6? IoT+5G

By 2025, over 4.5 billion IoT connections, of which majority will be 5G

IPv4
$2^{32} = 4.2B(10^9)$

IPv6
$2^{128} = 3.4 \times 10^{38}$

Sources: Omdia, Gartner, Ericsson
A snapshot for IPv6 Innovation

Google innovations in networking

- 2006: Google Global Cache
- 2008: Watchtower
- 2010: Onix
- 2012: BwE, Jupiter
- 2014: Andromeda, Software Defined Network Virtualization
- 2015: QUIC
- 2016: gRPC
- 2017: Espresso, Software Defined Edge
- 2018: B4
- 2019: Maglev, Software Defined Load Balancer
- 2020: SWIFT, Cloud RDMA
- 2021: Orion, Software Defined Network Control Plane
- 2022: Aquila, A unified, low-latency fabric

Google Cloud
Cloud Global Network IPv6 Transformation

- SD-WAN/Interconnect: IPSec BGP IPv6
- Edge Pop/LB/CDN/DNS: MPLSoGRE IPv6
- Global Backbone, B2/B4: MPLS/SR/6to4/Dual Stack
- Data Center Cluster: IPv6-only
- K8S/Storage/GPU Overlay Services: IPv6 Only, 6to4 IPinIP, RoCEv2
- Applications, Search/Gmail/Youtube etc: IPv4/IPv6

GPU Direct
Cloud RDMA
TensorFlow

Google Edge POP
Google Edge POP
Google Edge POP

Cloud CDN
Cloud Load Balancing

Edge Fabric Espresso

Global Backbone Network

B4 DCI
B2 WAN
Key IPv6 Benefit: No NAT, no Performance downgrade

- **NAT44**
  - Common VPC design

- **NAT64/46**
  - IPv6 to IPv4 translation

- **NAT66**
  - No NAT for IPv6 VPC

- No more NAT (Network Address Translation)
- Auto-configuration
- No more private address collisions
- Better multicast routing
- Simpler header format
- Simplified, more efficient routing
- True quality of service (QoS), also called "flow labeling"
- Built-in authentication and privacy support
- Flexible options and extensions

No NAT
Cloud IPv6 Network Products

- Cloud CDN
- Cloud Load Balancing
- Cloud DNS
- Cloud VPN
- Cloud Interconnect
- Cloud Armor
- Firewall
- Private Cloud
- On-Premise
- Cloud Storage
- Internet Access
- Private Only
- User
- Admin
IPv6 VPC Still need Private Address(ULA)!

- **Frontend:** Only less 1% (around 100 VMs) need **public IPv6 GUA** (global unicast Address) address.

- **Backend:** 99% VM (few 15K+) only ask for **Internal/ULA address**, include Database, Storage. Customer don’t want to expose those applications to internet. Prefer ULA address, can leverage BYOIP GUA for now.

- All VM on GCP and On-premise may need to talk to each other. Private cloud already use ULA address, can allocate ULA block for GCP.
IPv6 Addressing, GUA/ULA
Global unicast Address/Unique Local Addressing

GUA IP block

2600:1900::/28 /48 /64 /96
VPC
VM

ULA IP block

fd20::/20 /48 /64 /96
VPC (working in Progress)
VM

Subnet
IPv6 NAT66? (Other Cloud Provider Solution)

- All VM only have single internal IP address (possible ULA)
- Ingress: User to Cloud traffic use Anycast LB, already address translation (similar with NAT)
- Egress: VM use ULA as Src IP, and Andromeda replace Src address with GUA, 1:1 NAT, **GUA not visible to VM.**
- Easier to connect to On-Premise Private Cloud ULA via Private BGP peering.
- IPv4 public cloud providers first use Public IPv4, then they facing security and shortage of IPv4, later all cloud provider changed to only allocate RFC1918 to VM, and NAT on vRouter.
- Only provide ULA on VM, **NAT on virtual Router**
Dual NIC solution with VPN and Internet Access

- **EA**: external Address, GUA
- **IA**: internal Address, ULA or GUA
Global LB for **IPv6** and **IPv4** clients

IPv6 Forwarding rules (FRs) i.e. VIPs are free, customers only pay for IPv4 FRs. Rest of the pricing is same.
Cloud GW IPv6 Support

Now support IPv4 BGP session with IPv6 AF. Later can support IPv6 BGP session with IPv6 AF.
Scalable & Dynamic

**Scalable IP addressing**
IPv6 support and flexible IP address management through multi-Pod CIDR allows you to run more apps with less IPs.

**Advanced Traffic Management**
Scale from 0 to N with traffic-based autoscaling. Distribute global traffic based on Service capacity and health, allowing you to serve traffic.

**15,000 Node Clusters**
GKE supports the highest scale clusters through networking innovations such as EndpointSlices, container-native load balancing, and scalable IP addressing.

**Global Service Discovery**
GKE supports the highest scale clusters through networking innovations such as EndpointSlices, container-native load balancing, and scalable IP addressing.
GKE Private Addresses

```
gcloud compute networks subnets update SUBNET_NAME \
  --stack-type=IPv4_IPv6 \
  --ipv6-access-type=EXTERNAL

gcloud compute networks subnets create SUBNET_NAME \
  --network=NETWORK \
  --range=IPV4_RANGE \
  --stack-type=IPV4_IPV6 \
  --ipv6-access-type=INTERNAL \
  --region=REGION
```
# Valid IP family policies:
# - SingleStack
# - PreferDualStack
# - RequireDualStack

```yaml
ipFamilyPolicy: PreferDualStack
ipFamilies:
- IPv6
- IPv4

clusterIP: 198.51.100.2
clusterIPs:
- 198.51.100.2
- 2001:D88:1::2
```

```yaml
podIP: 192.0.2.2
podIPs:
- ip: 192.0.2.2
- ip: 2001:D88:2::2
```

```yaml
podCIDR: 192.0.2.0/24
podCIDRs:
- ip: 192.0.2.2/24
- ip: 2001:D88:2::2/36
```
Dual Stack IPv4/IPv6 Hybrid Cloud

1. Flat Network - Service Mesh, Multi-Cluster Connectivity without NAT or Proxy
2. Migration from on-premises IPv6 deployment to GCP
3. IPv6 standardization - Telcos and SPs
IPv6 Enable GDC for Applications and Network Functions

Telco Solutions  Smart Retail  Smart Factory  Smart City  Healthcare  Smart Venue

- Network Services
  - 5G Core & Network Functions
  - Private Cellular
  - IoT & SD-WAN
  - Security

- Enterprise Services
  - Computer Vision
  - Business Process
  - Asset Intelligence
  - Caching & Media

- Edge Services
  - AI/ML Inferencing
    - Vision, Video, NLP, Translation,
    - Retail, Healthcare, Care, (custom)
  - Immersive AR/VR
    - Search, Ads, Training,
    - Collaboration, Gaming, other

Google Distributed Cloud
Managed Platform

GCP Services
- Google Marketplace
- Centralized Control(s)
- AI/ML Training
- Operations Management
- RAN Network Planner & SAS

Closed Loop
29 Regions
146+ POP