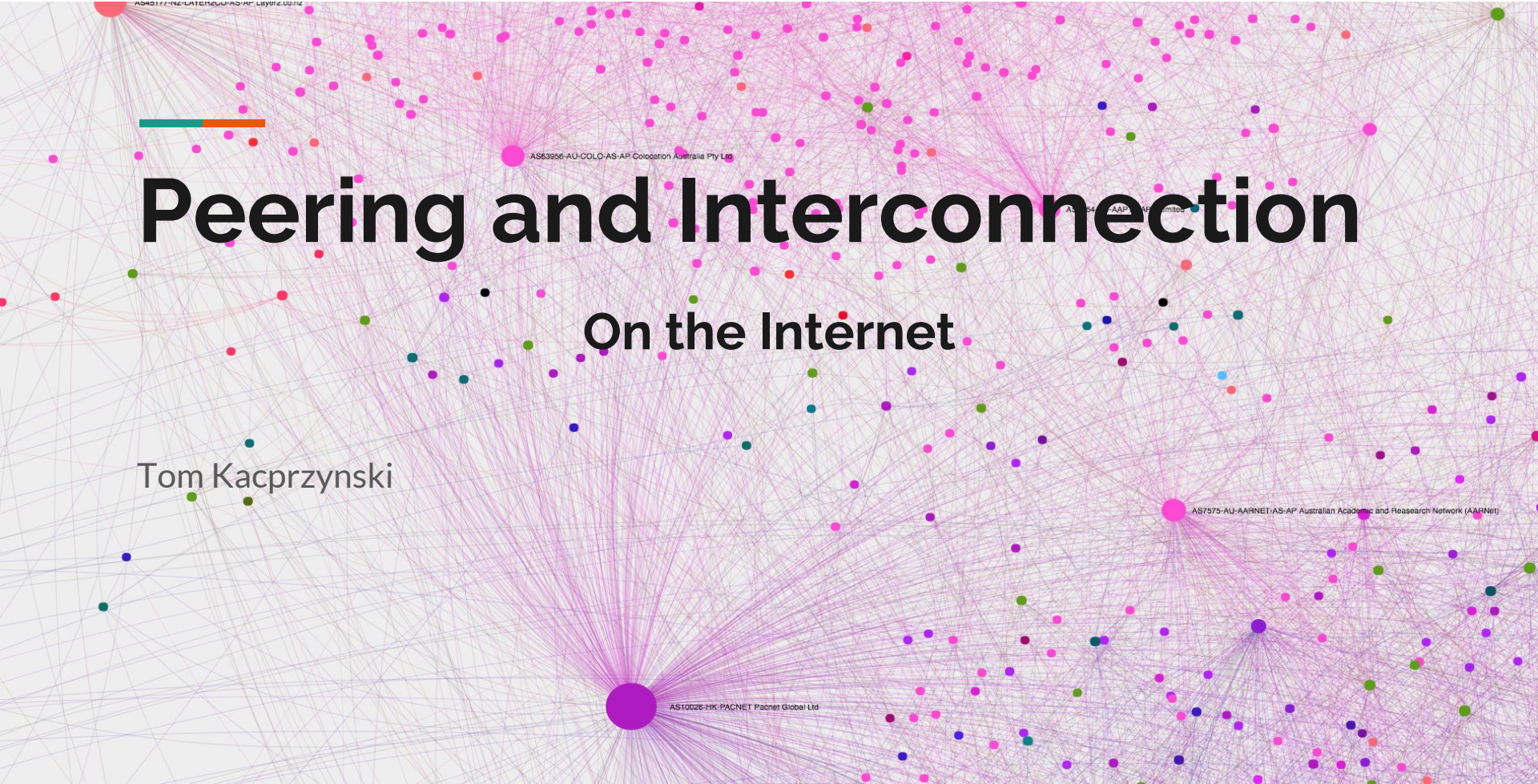


Peering and Interconnection

On the Internet

Tom Kacprzynski

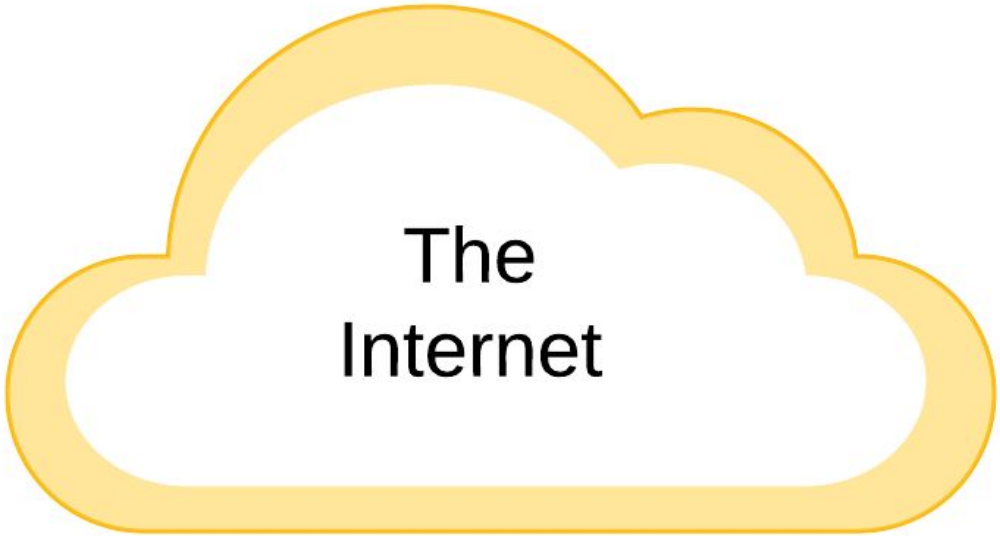
Introduction

- DePaul alumni, started when DePaul introduced their Network Technology program in fall of 2000
- CS Degree with minor in Network Technologies
- CCIE in RS#36159
- Worked on enterprise networks, datacenter, cloud and now at a CDN company called VidScale as a manager of network engineering and core deployment (internships)
- Peering coordination for Rackspace and VidScale (currently for AS47254)
- Organizer of CHI-NOG, a local community for network engineers with annual conferences

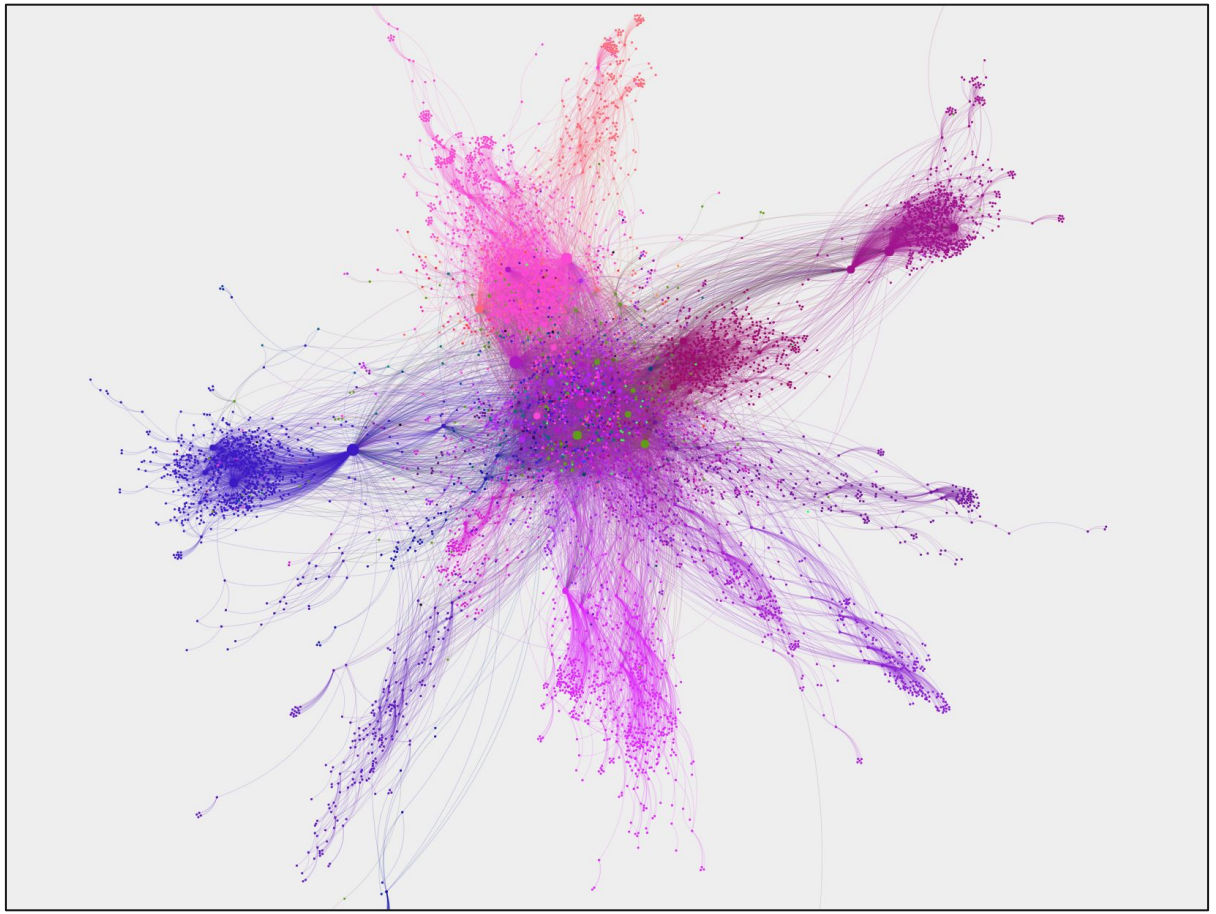
Overview

- The Peering Ecosystem
- Interconnection Types
- Peering Policy
- Benefits of Peering
- Peering Strategy

What we think is the Internet

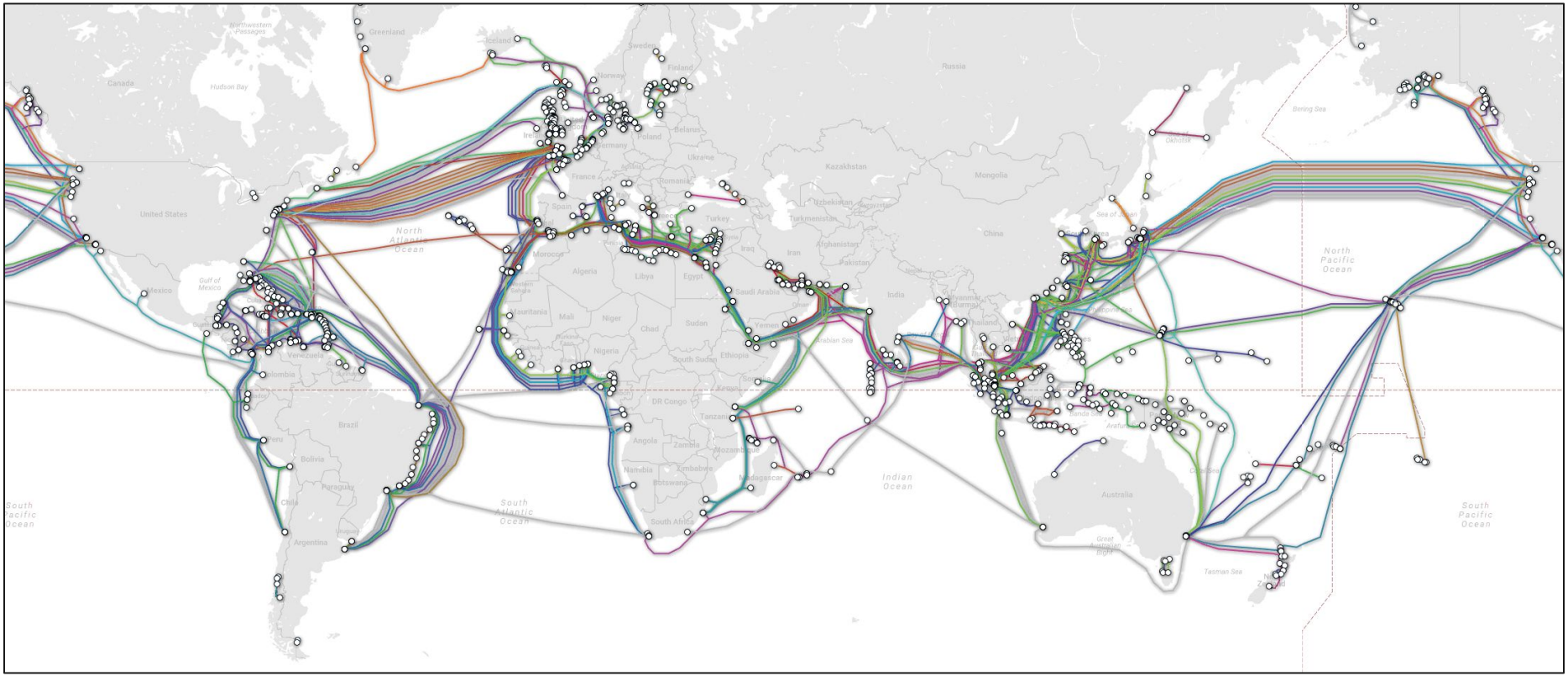


What it actually looks like - Asia



*Source: The Internet In the APNIC Region (http://thyme.apnic.net/network/#)

Submarine Cables Carrying the Internet



*Source: TeleGeography - Submarine Cable Maps (https://www.submarinecablemap.com/#/)

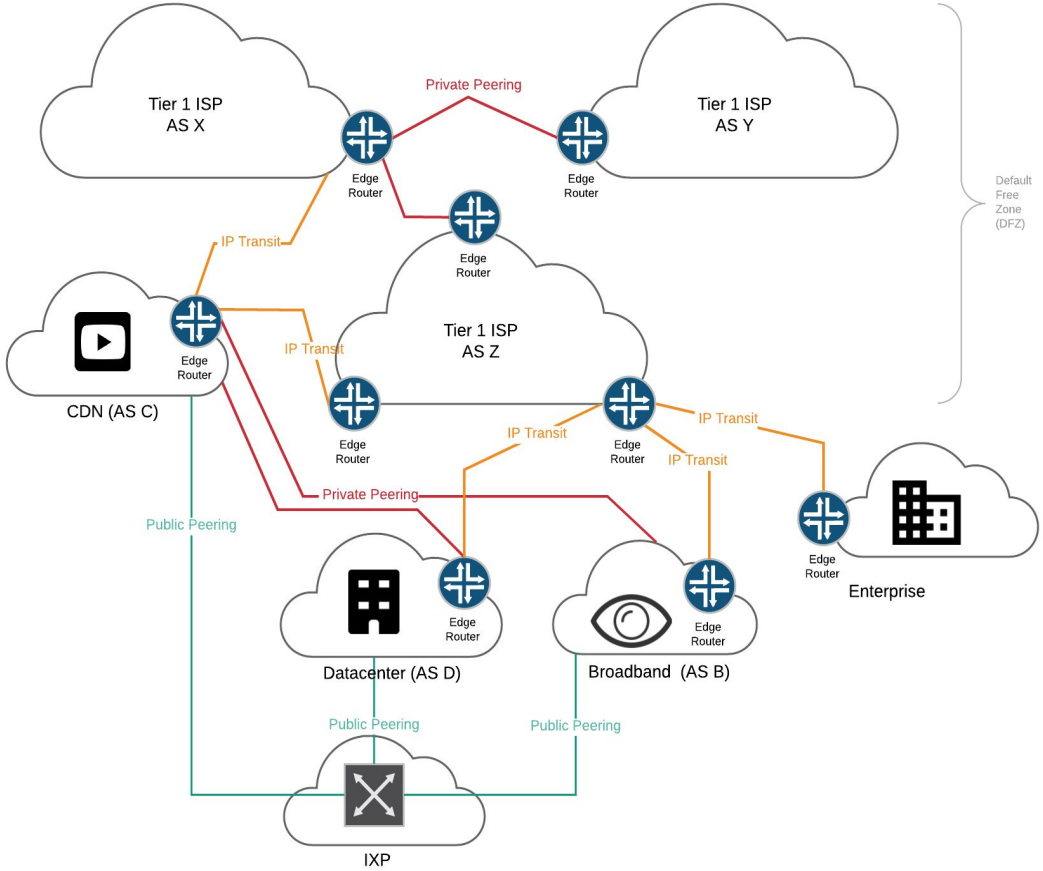
Peering Ecosystem - Networks

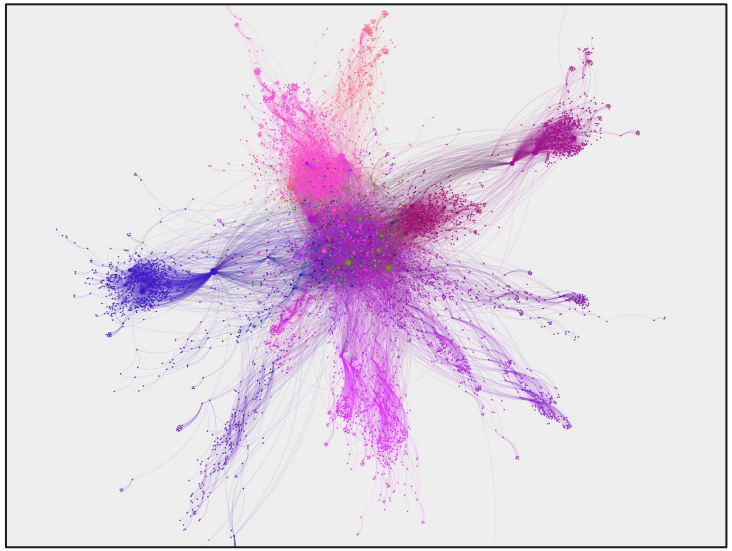
Internet is made up of autonomous networks. These network can be categorized into:

1. Broadband Networks (DSL/Cable/etc - eyeballs)
2. Enterprise Networks
3. Datacenter/Cloud Provider Networks
4. Content Delivery Networks (CDNs)
5. Internet Service Providers (Tier 1 ISPs)
6. Internet Exchange Point Networks (IXPs)

- Each network typically has their specific characteristics within the Internet.
    1. Geographic scope
        a. Local within Metro
        b. Regional
        c. Country Specific
        d. Continental
        e. Global
    2. Traffic Patterns
        a. Mostly Inbound
        b. Mostly Outbound
        c. Balanced
    3. Peering Policy
        a. Open
        b. Selective
        c. Restrictive
        d. Closed | No Peering

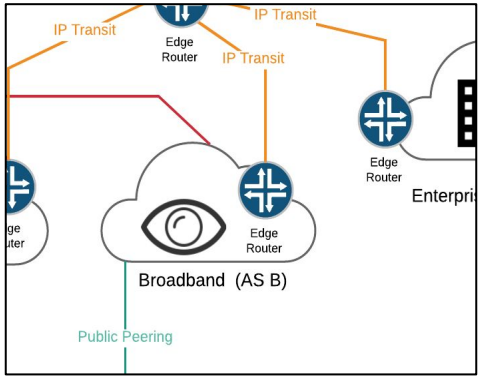
Peering Ecosystem - Networks

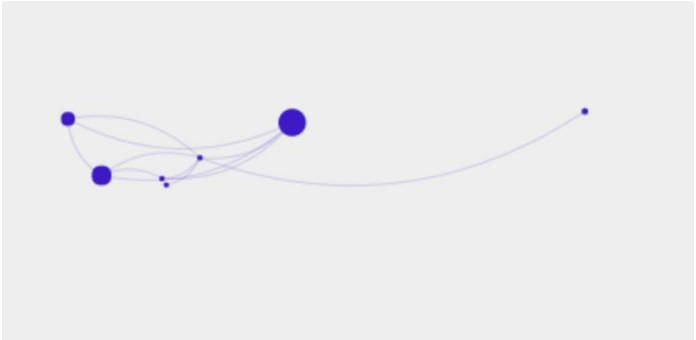




Broadband Networks

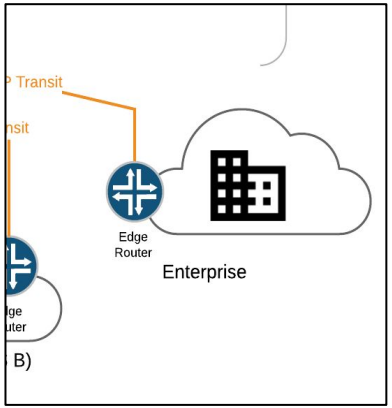
- **Traffic Pattern:** Inbound
- **Geographic scope:** Regional or Metro
- **Peering:** Select/Restrictive
- These networks are on the edge of the Internet
- They service a large number of customers with small bandwidth requirements (3Mbps-1Gbps)
- They are considered the Eyeball networks as they consume content vs originating the content
- Some of the largest broadband network consider themselves as the gatekeepers and would like to control access





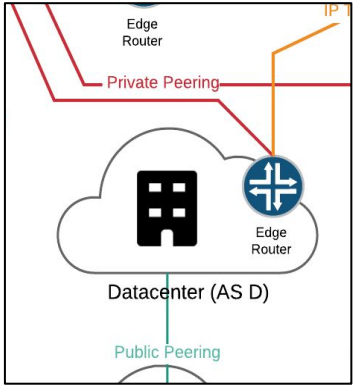
Enterprise Networks

- **Traffic Pattern:** Balanced
- **Geographic scope:** Regional or Global
- **Peering:** Usually don't peer
- These networks are on the edge of the Internet
- They service businesses access to the Internet and external access



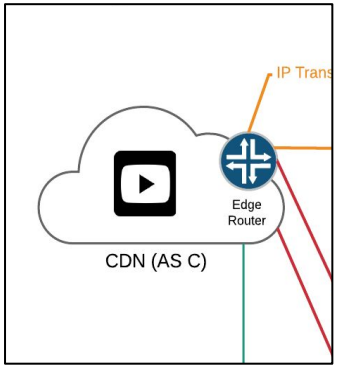
Datacenter/Cloud Providers

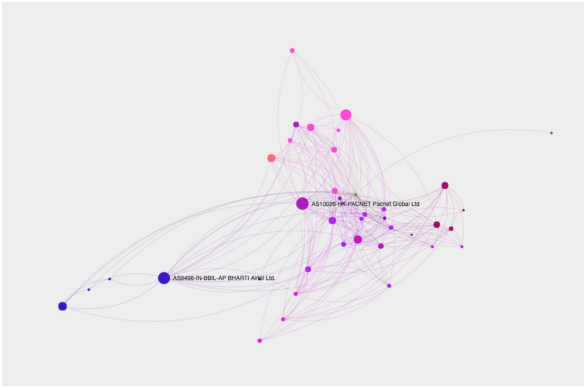
- **Traffic Pattern:** Outbound
- **Geographic scope:** Various
- **Peering:** Open
- These networks are on the edge of the Internet but connected close to the core
- Host website and cloud instances
- Origin and storage of majority of the applications and content



Content Delivery Networks

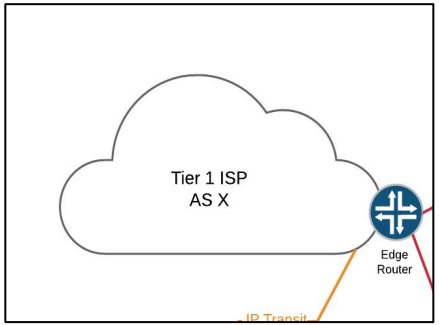
- **Traffic Pattern:** Outbound
- **Geographic scope:** Global
- **Peering:** Open
- These networks are globally distributed connected closely to the core
- Very large capacity to the Internet and peering
- Distribute video and other content such as live stream, large file download and cloud at the edge

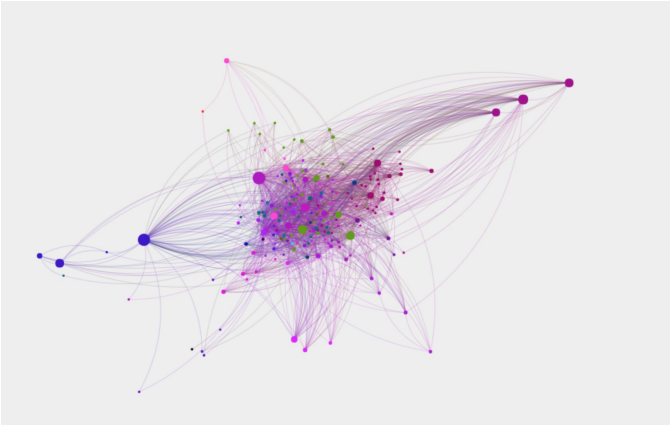




ISPs Tier 1

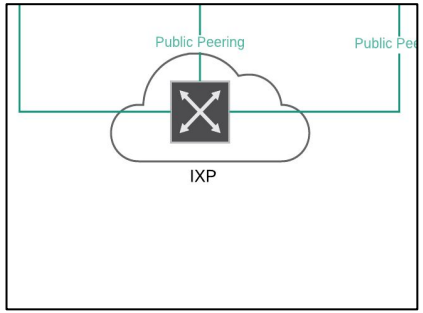
- **Traffic Pattern:** Balanced
- **Geographic scope:** Global
- **Peering:** Restrictive
- These networks make up the core of the internet in the default free zone
- Main goal is to transit traffic from point a to z and not origianate or terminate traffic
- Very restrictive in terms of peering especially in their dominant markets
- Mostly privately peer and don’t peer publicly





Internet Exchange Points

- **Traffic Pattern:** Balanced
- **Geographic scope:** Metro
- **Peering:** N/A - don't peer directly with IXP
- IXPs are the bridge of all networks, they are a layer 2 fabric with a metro with main purpose to facilitate peering of networks



Internet Exchange Points

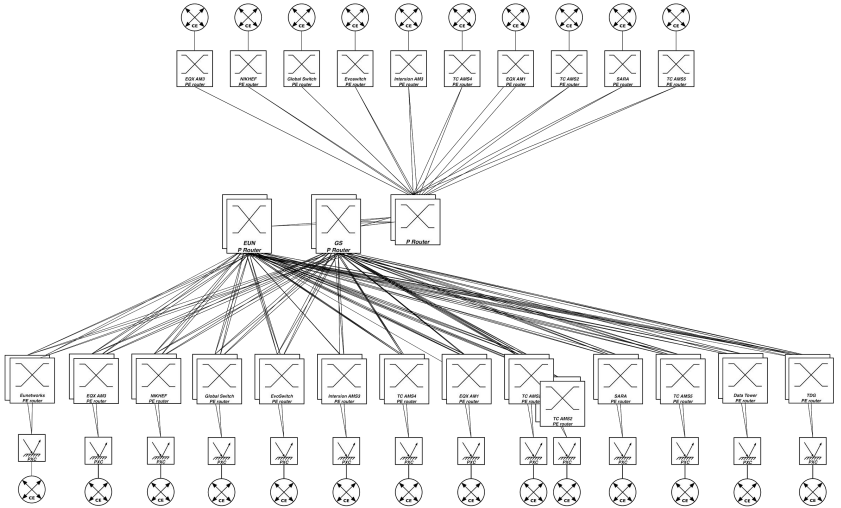
Unique requirements:

- /24, /23, or even /22, a large broadcast that domain require protection
- MAC Filters to member MAC addresses assigned to ports
- No broadcast services such as DHCP, CDP, IP Redirects, LLDP, STP, PIM
- Increase ARP timeout value
- Quarantine VLAN to check for compliance

Internet Exchange Points

Could be a simple as a single switch

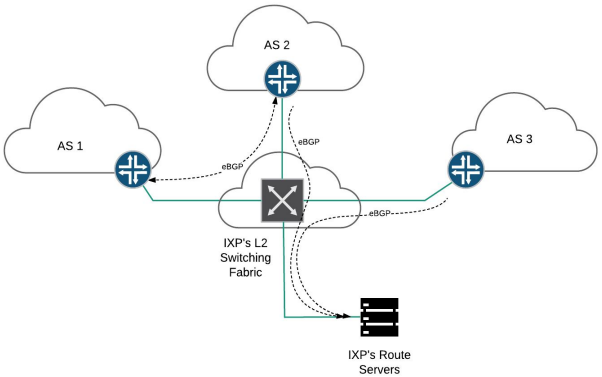
Complex as a full VPLS network

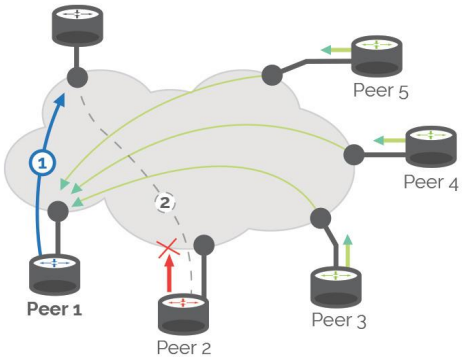


Internet Exchange Points

Route Servers

- Majority of IXP have Route Servers deployed on their network
- Route servers are BGP daemons (usually redundant) to aggregate BGP peers and advertise all learned prefixes back to connected routers
- Not part of forwarding path, BGP next_hops are maintained
- Does not insert its own ASN in advertised paths
- Filtering of prefixes is more involved
  - BGP communities advertised prefixes
    - `0:peer-as = Don't send route to this peer as`
      `10:peer-as = Send route to this peer as`
      `0:10 = Don't send route to any peer`
      `10:10 = Send route to all peers`
  - IRRdb
  - Route Origin Authorizations (ROA) and BGP Origin Validation Filtering
    - ROA states {VALID, INVALID, UNKNOWN} of prefixes tagged with special BGP community, networks can use in policy or ignore
- Supports Blackholing - DDoS Mitigation
  - Uses BGP standard blackholing community `65535:666 (RFC7999)`
  - Sets NEXT_HOP to blackholing server or discard interface





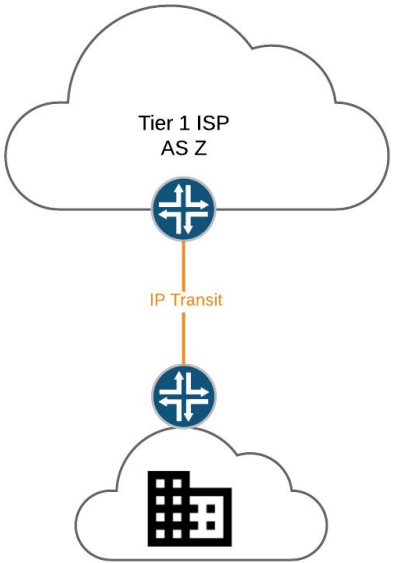
Interconnection Types

Networks can connect to each other in the following ways:

1. IP Transit Services
2. Public Peering at IXPs
3. Private Peering
4. Remote Peering
5. Cloud Interconnection
6. Paid Peering

Interconnection Types - IP Transit

- Provides access to rest of the internet
- AS Z transits traffic for the downstream network
- IP Transit is a type of service purchased from an ISP
- Paid a flat full rate fee or using metered 95% billing
- Customer network doesn't need BGP or a public ASN
- It can be an eBGP session using a private ASN or a public ASN, or no BGP with a static route (common)
- When using BGP, the ISP can provide a combination of routes:
    - Default only
    - Full Internet routing table
    - Default and full routes
- Outside of Tier 1 ISP, all network will need IP Transit to access the full Internet

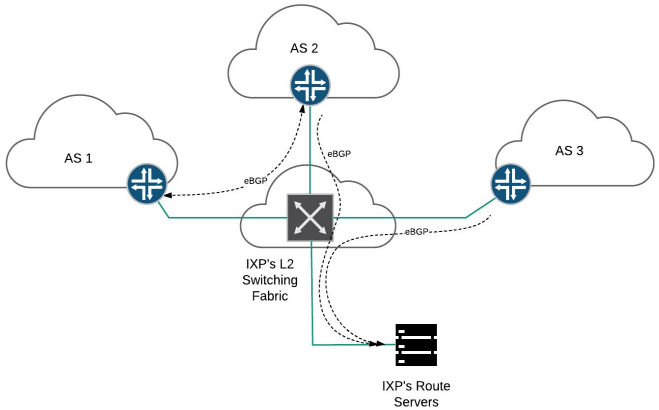


What's required for Peering

- Public BGP ASN assigned from ARIN, RIPE, APNIC, AfNIC, LACNIC
- Minimum of a /24 address of a public block for IPv4
- Minimum of a /48 address of a public block for IPv6
- Convincing the other network to peer with your network

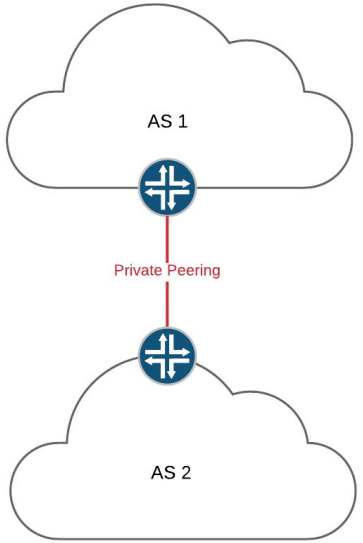
Interconnection Types - Public Peering at IXPs

- Direction connection to other networks using the IXPs switching fabric
- Provides access to peer's routes and their customers only, no transit to others (AS2 prefixes -> AS1, but not AS3s ->AS1)
- Requires an eBGP session only using a public ASNs
- Before eBGP can be establish, both network need to agree to peer
- IXP Route Servers provide a scalable way to receive routes without establishing direct 1-to-1 peering agreements
- Route Servers advertise all connected network's routes to each other
- IXPs just providing Layer 2 switching fabric and IP addressing for members
- Most network types publicly peer, outside of enterprises and tier 1 ISPs in their major markets
- Flat fee to connect to IXP or one time fee



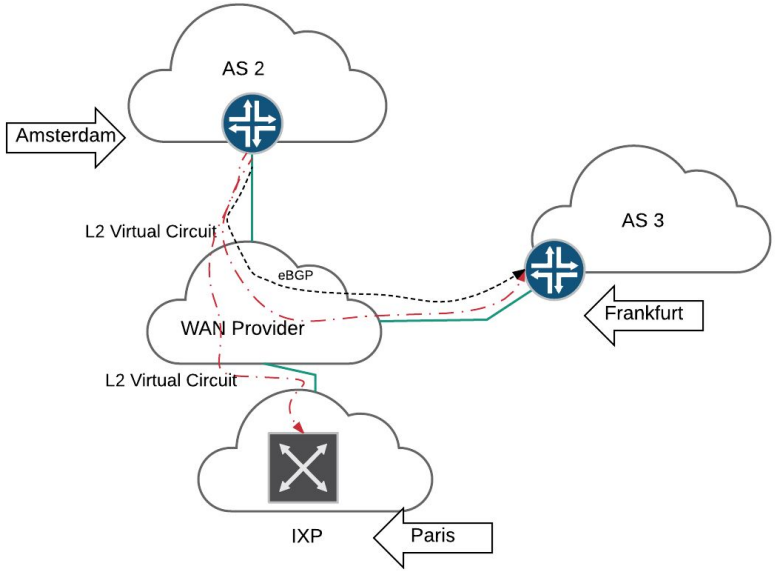
Interconnection Types - Private Peering

- Direction connection to other networks using dedicated port per peer and a cross connect (fiber connection)
- Provides access to peer's routes and their customers only, no transit to others
- Requires an eBGP session only using a public ASNs
- Before eBGP can be establish, both network need to agree to peer, agreements are more formal as cost and router resources are a factor
- Need to agree on who provides IPs, pays for cross connects, how many locations and where
- Most networks require >1G of traffic to privately peer
- Additional requirements are in documented peering policy requirements
- All networks types except enterprise privately peer



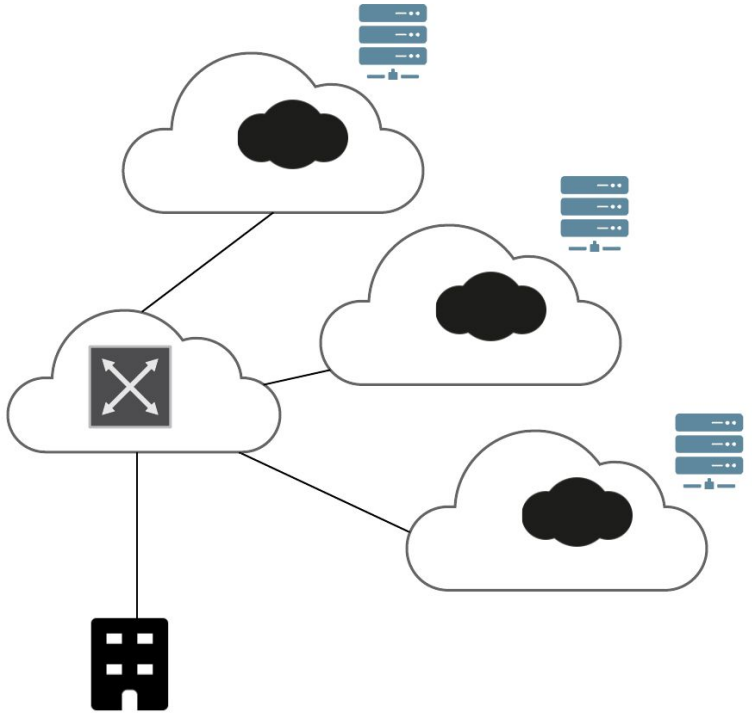
Interconnection Types - Remote Peering

- Remote Peering addresses the issue of not being in the same metro or facility to interconnect
- Utilizes a WAN provider with layer 2 virtual circuit to connect to peers
- Certain WAN provider partner with IXP to appear as if their customers are directly connected on the IXP
- Cost model is paying to physical connection to the WAN provider, then per virtual circuit (VLAN) depending on distance



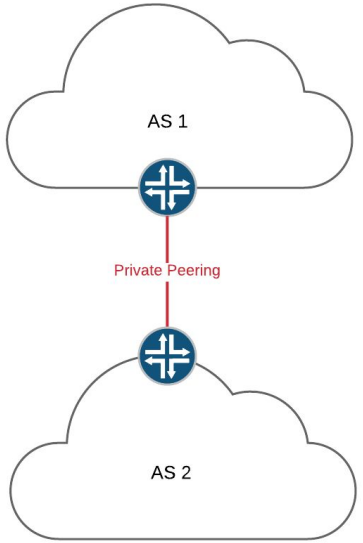
Interconnection Types - Cloud Interconnection

- All previous peering types required a public ASN, which many enterprise networks don't have
- Cloud interconnection has the capability of networks without public ASNs to connect to select cloud provider networks
- Connects networks to their private cloud/public cloud instances at the cloud provider
- Paid service, part of a hybrid enterprise model
- Cloud exchange is a layer 2 with custom integratior of each cloud network



Interconnection Types - Paid Peering

- Paid peering is a form of private peering
- The major exception is that it is **not settlement free peering**, but one party pays the other to connect to their network
- Usually done with major broadband networks or tier 1 ISPs



Peering Policy

Definition: “A Peering Inclination is a predisposition towards or against peering as demonstrated by Peering behavior in a Peering Ecosystem.” *

Four Types:

- **Open** - little requirements or any, will peer as long as in the same facility (CDNs/Cloud)
- **Selective** - stated requirements which have to be met, once met generally open to peering (Broadband)
- **Restrictive** - extremely high bar to peer with in terms of requirement (Tier 1 ISPs, Broadband)
- **No Peering** - not interested or doesn’t support peering, mostly using IP transit

Example of requirements:

- Locations and minimal number of peering points (3 in one continent or 3 globally)
- Traffic ratio - balanced traffic ratio (inbound/outbound)
- Minimal bandwidth requirements such as 10G or 1G peak or 95th percentile (different for NA & EU vs AP)
- Consistent set of routes (closest entry)
- Dedicated 24x7 NOC
- No default route pointing at the peer
- Peer must meet a minimum number ASN transiting it (customers)
- Maintain enough capacity at peering point and upgrade as requested
- PeeringDB entry

*Source: DrPeering - Peering Policy (http://drpeering.net/AskDrPeering/blog/articles/Internet_Service_Providers_and_Peering___Peering_Policy.html)

Routing Policy Based on Interconnection

Which route is the best path?
It's not the shortest
AS_PATH?

Why is it the best one?

	Status	Destination Network	Next Hop	Metric	LocPrf	Weight	Path	Origin
Private Peer	Best eBGP	159.117.206.0/24	216.66.88.58	0	140	0	15412, 47254	IGP
	iBGP	159.117.206.0/24	72.52.72.118	1420	140	0	15412, 47254	IGP
Transit/Backup	eBGP	159.117.206.0/24	80.239.161.221	0	70	0	1299, 47254	IGP
Public Peer	eBGP	159.117.206.0/24	195.66.227.94	0	100	0	47254	IGP
	eBGP	159.117.206.0/24	195.66.227.94	0	100	0	47254	IGP

Based on the interconnection type, networks have different policies which dictates how packets get routed

Routing Policy Based on Interconnection

Depending on interconnection type, networks have different preferences set, which influence traffic.

Understanding the interconnection relationship helps traffic engineering.

Local Preference Value	Prefix Type	Description
100	IP Transit	IP Transit path from ISPs. Default Local preference.
150	Route Server Peer	Routes received from an IXP route server.
200	Public Peer	Routes received from public peers over IXPs.
300	Private Peer	Routes received from private peers over dedicated connections.
400	Customer	Routes received from a customer type relationship.

Benefits of Peering

Why do networks Peer vs using IP Transit?

1. Cost Reduction
2. Increase redundancy
3. Improve Performance
4. Increase Routing Control
5. Marketing and perception of network's status
6. Improve security

Benefits of Peering

Cost Reduction

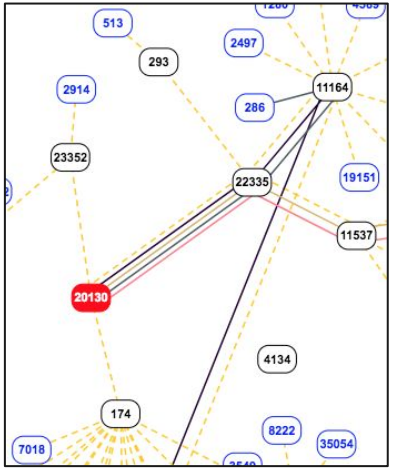
- IP Transit in EU and NA using 10G interfaces at 40% utilization
  - With Mbps costs anywhere from $0.40 to $1.00 would equate to $1600 or $4000 per month
- Compared to peering in EU and NA based on http://peering.exposed
  - average is $0.14
  - which would equate to $560.
- Using 100G interfaces (if using 40%)
  - IP Transit of ~$16,000 - $40,000
  - Peering in EU and NA of $4,000
- Major CDNs and Datacenter have capacity in 5-50 Tbps (not Gbps)

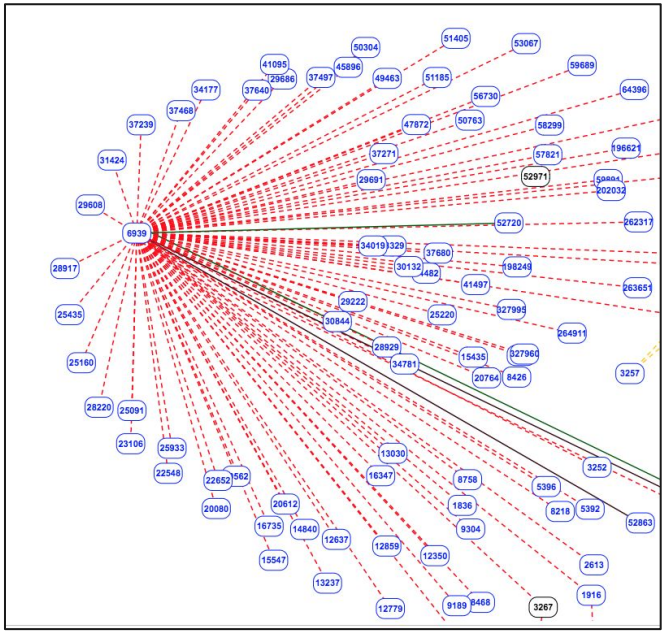
*Source: IXP megabit/sec cost & comparison (http://peering.exposed/)

Benefits of Peering

Increase Redundancy

- Spreading the number of connection and diversifying from few main ISPs to multiple networks
- AS 20130 has three connections to ASNs
- AS 6939 has a very large number of peering ASNs
- In the first case if one of the three experience outage or routing problems that could affect 33% of traffic to it
- In the second case because of the number of peers any one ASNs wouldn't cause as much problems





Benefits of Peering

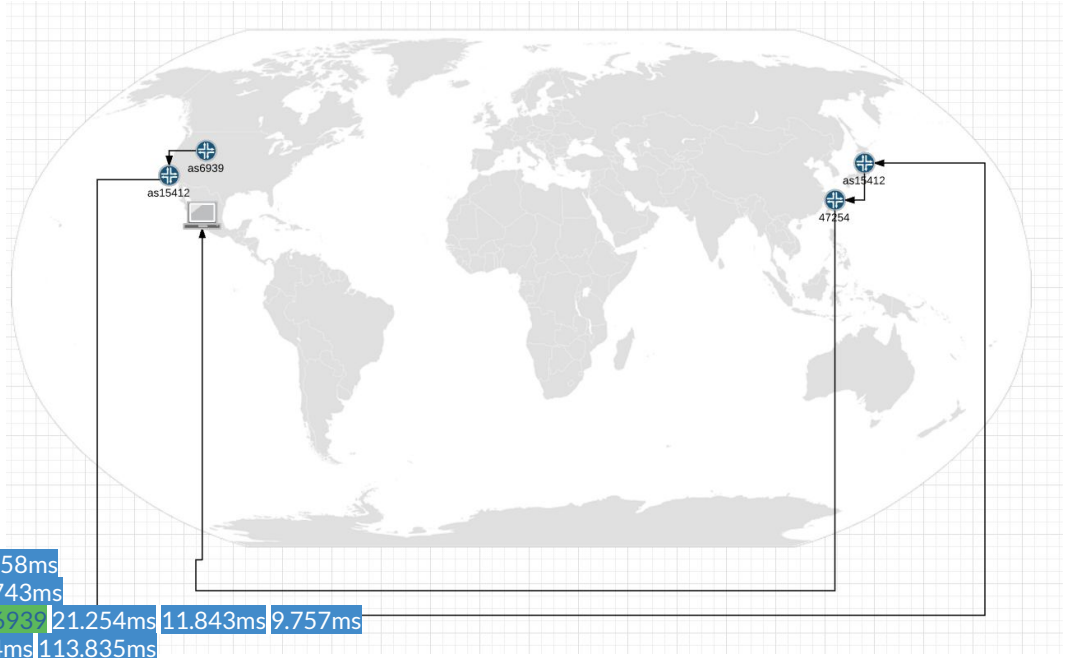
Improve Performance

- Bypass bottlenecks
- Reduce the number of hops and latency which improves overall round trip time and hop count for applications
- Peering directly reduces the tromboning effect of peering
- Example San Jose traffic going to Tokyo to come back to San Jose (next slide example)

Benefits of Peering

Improve Performance

- Improvement of ~200 ms



Pre Peering

Traceroute to 159.117.206.64 (159.117.206.64), 48 byte packets

1 72.52.66.17 v1127.core3.fmt2.he.net AS6939 7.397ms 1.217ms 1.171ms
2 184.105.222.90 10ge14-8.core1.pao1.he.net AS6939 1.906ms 1.879ms 7.858ms
3 184.105.81.238 100ge8-1.core1.lax2.he.net AS6939 9.648ms 9.487ms 13.743ms
4 72.52.72.118 flag-as-as15412.10gigabitethernet11.switch2.lax2.he.net AS6939 21.254ms 11.843ms 9.757ms
5 85.95.26.2 so-3-0-0.0.pjr01.wad001.flagtel.com AS15412 114.2ms 113.134ms 113.835ms
6 85.95.26.114 xe-0-2-0.0.eji01.tok007.flagtel.com AS15412 112.805ms 112.773ms 112.844ms
7 80.81.74.194 AS15412 113.255ms 133.97ms 113.432ms
8 10.130.1.7 131.491ms * *
9 159.117.206.64 AS47254 222.593ms 225.08ms 213.083ms

- How can you improve performance with peering?

Post Peering

Traceroute to 159.117.206.64 (159.117.206.64), 48 byte packets

1 72.52.66.17 - v1127.core3.fmt2.he.net AS6939 7.577ms 1.426ms 4.252ms
2 184.105.222.14 - 10ge7-9.core1.sjc2.he.net AS6939 2.412ms 1.697ms 1.694ms
3 206.223.116.5 - eqix-ix-sv5.e-1.com 1.839ms 1.714ms 1.778ms
4 10.2.1.3 - 2.18ms 1.962ms 1.996ms
5 159.117.206.64 - AS47254 1.899ms 1.733ms 1.743ms

Benefits of Peering

Improve Routing Control

- Provide more options for traffic engineering
  - Route server example
  - Individual ASNs policies
- Which prefixes to advertise to whom?
  - Blackholing/DDoS

Benefits of Peering

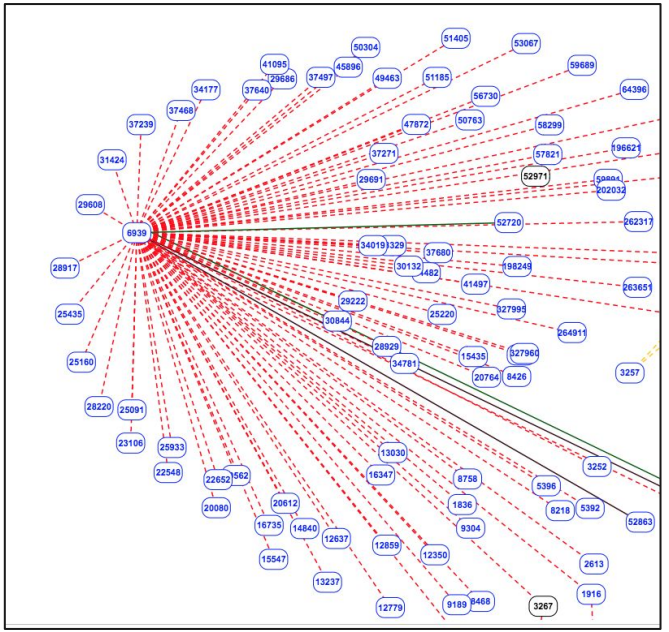
Marketing and perception of network's status

- More networks and peering capacity is a marketing advantage to CDNs/Cloud and ISPs
- Better application performance

Benefits of Peering

Improve security

- DDoS attacks may not have a big of an effect when networks peer with a lot of other ASNs
- Blackholing at IXPs with route servers



Peering Strategy

- How do networks know who to peer with?
- Why not peer with everyone?
- Why not peer with ASNs that at least advertise more than a single prefix?
- How many configured eBGP sessions will that require?
- Answering to this questions is very specific to each network and requires a peering strategy
- Peering strategy is the optimization of who to peer with for the greatest benefit

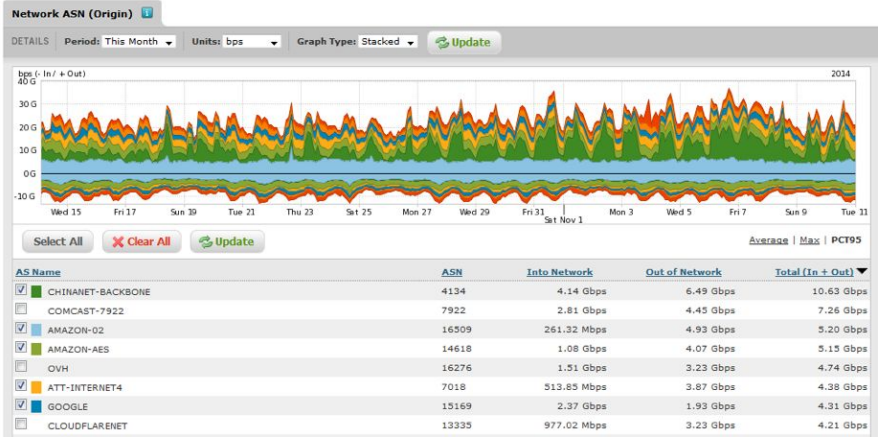
Active ASNs*	59,611
Originating Single Prefix ASNs*	22,122 (37%)
Originating Non Single Prefix ASNs	37,489 (63%)

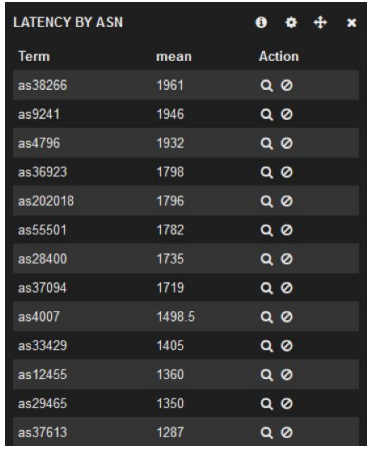
* Source: https://bgp.potaroo.net/as6447/

Peering Strategy

Strategy Ideas (select networks based on):

1. Networks with most volume of traffic exchanged
   a. Netflow statistics
2. Highest Latency
   a. Application specific logs
   b. RUM data collected
   c. TCP Setup latency map IP to ASN and /24
3. All networks with Open policy
   a. Easy and fast to peer with (check peeringdb.com)
4. Only eyeball networks
   a. Content networks to sent to eyeball networks bypass paid transit
5. Only content networks
   a. Eyeball networks to sent to content networks and bypass paid transit





Peering Strategy

Overall process:

1. Get ASN and public IP addressing
2. Connect to IXPs or colocate in internet hubs
3. Set peering strategy
4. Create a target peering list
5. Go to conferences or email peering coordinators to establish peering agreements
6. Select peering type
7. Configure routers
8. Thanks for peering

Links

- Content peeringDB entries
  - facebook https://www.peeringdb.com/net/979
  - akamai https://www.peeringdb.com/net/2
- Exchanges peeringDB entry
  - Equinix IXP Chicago https://www.peeringdb.com/ix/2
  - AMS-IX Chicago https://www.peeringdb.com/ix/944
- Eyeball peeringDB entry
  - WOW https://www.peeringdb.com/net/473
  - COX Comm https://www.peeringdb.com/net/6
- Peering Policy
  - Policy life cycle - http://drpeering.net/white-papers/Peering-Policies/Peering-Policy-Lifecycle.html
- Peering Agreement
  - http://drpeering.net/white-papers/Art-Of-Peering-The-Peering-Playbook.html
- Galaxy from NTT :http://as2914.net/#/?_k=1vge4a
- APNIC Internet View: http://thyme.apnic.net/network/#
- Cable systems: http://www.cablemap.info

Networking Community

Where a lot of the peering discussion occurs

- CHI-NOG http://www.chinog.org
- NANOG http://www.nanog.org
- Global Peering Forum https://www.peeringforum.com
- EURO-IX https://www.euro-ix.net
- Internship Opportunities http://www.vidscale.com

Questions/Comments

tom@chinog.org