



IPv6 Adoption over Internet Exchanges

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Hurricane Electric - Massive Peering!

Pro IPv6 Disclaimer

Hurricane Electric has worked to advance IPv6 deployments globally.

- HE received its first IPv6 allocation in 2001.
- Our network completed a native IPv6 conversion in 2007.
- HE peers with more ASNs over IPv6 than any other network.

IPv6 Adoption over Internet Exchanges

With IPv4 now depleted from two of the five RIRs, it is time to take a look at how the top Internet Exchanges have progressed in adoption of IPv6.

My assumptions are:

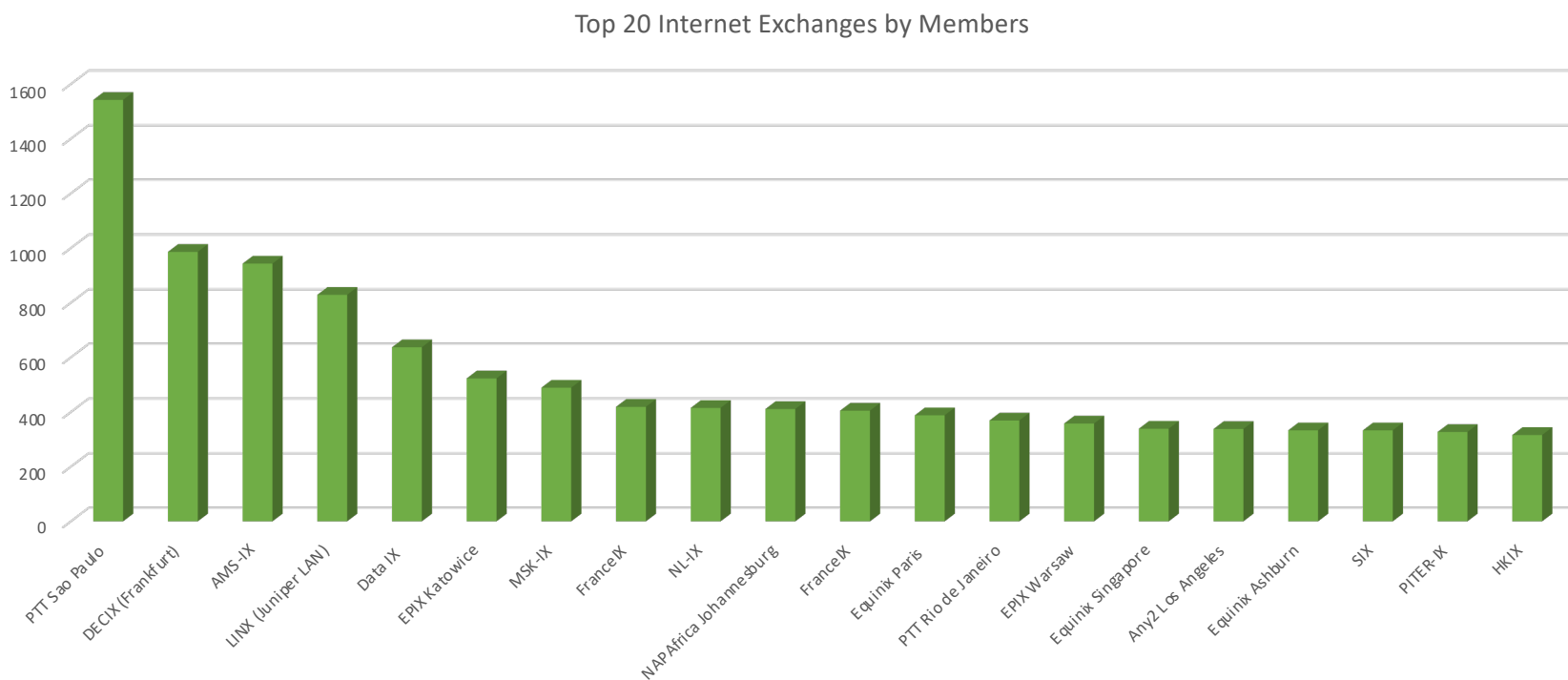
- Internet Exchanges historically are where we grow the Internet.
- Increasing IPv6 traffic across exchanges starts with increasing IPv6 peering.

IPv6 Adoption over Internet Exchanges

The development of Internet exchanges shaped the industry. Here are a few IPv6 and IX facts to keep in mind:

- 27.32 percent of all existing networks advertise IPv6 prefixes.
- Of the 688 Internet Exchanges worldwide, 20 new exchanges formed in 2019.
- Peers are more likely to route IPv6 if they participate in an exchange.

Top 20 Internet Exchanges by Members



Regional IPv6 Adoption at Internet Exchanges

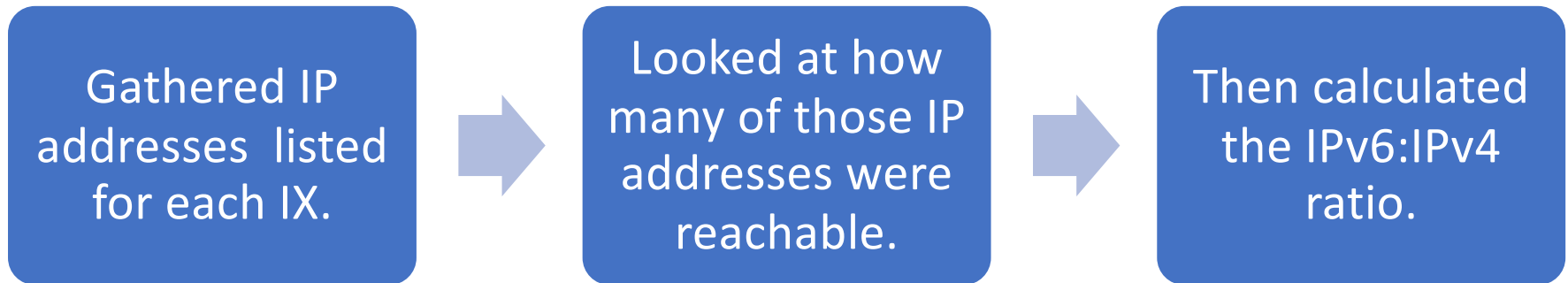
Global trends are a lot to absorb.

So let's take a look at Internet exchanges by region and see how we are doing in North America by comparison.

How I measured the progress:

- Took the number of listed addresses for each exchange.
- Looked at how many of those IP addresses were reachable.
- Then compared how many reachable IPv6 addresses against how many reachable IPv4 addresses on the exchange to determine who is available to peer over IPv6 on the exchange.

Regional IPv6 Adoption at Internet Exchanges

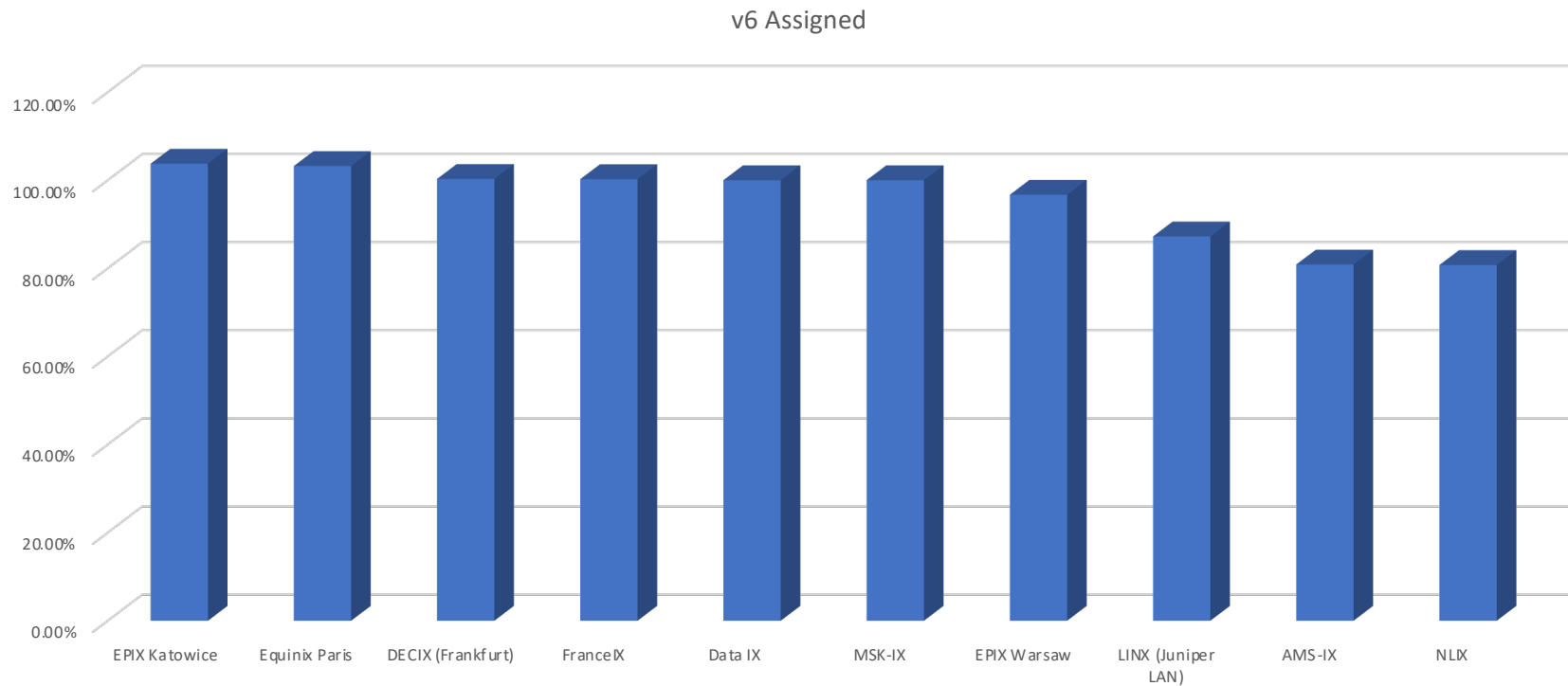


IPv6 Adoption in European Exchanges

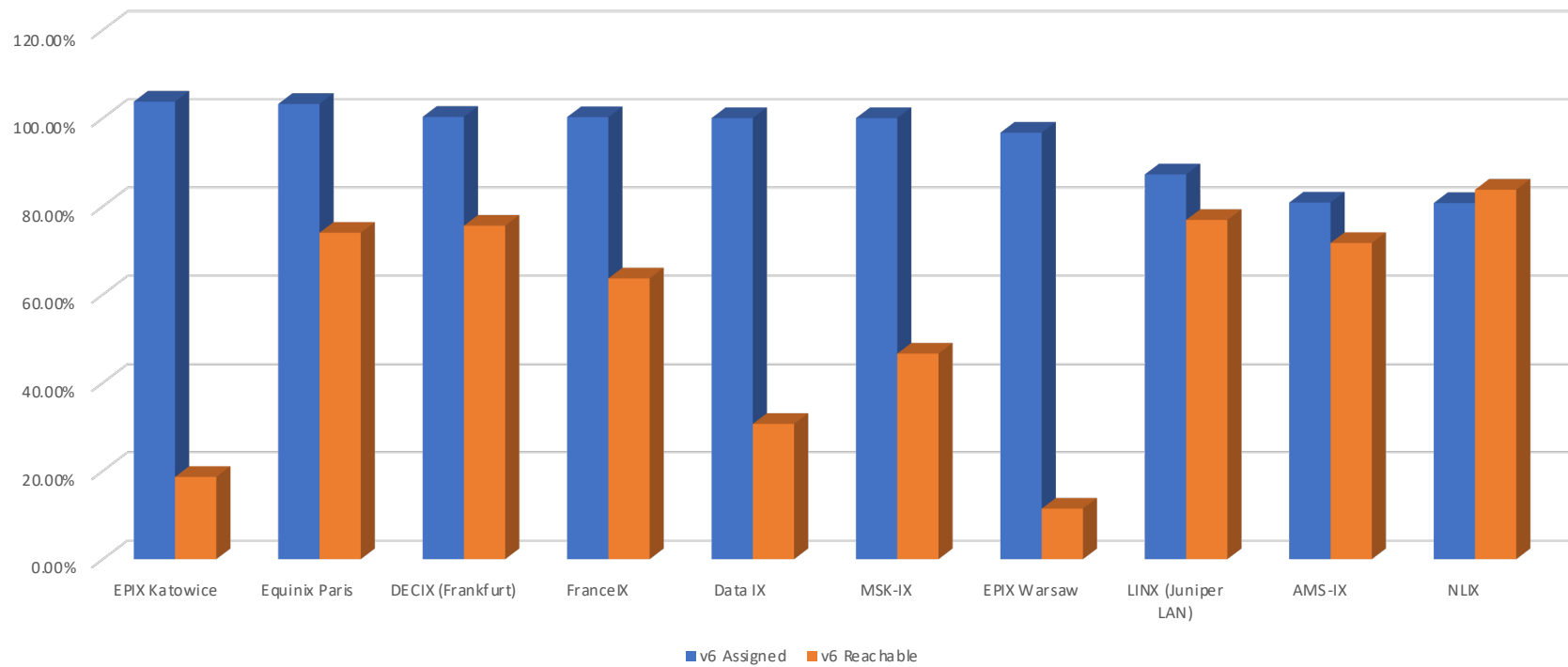
Europe literally has led the way in forming Internet exchanges. Some European IX trivia includes:

- Of the 688 Internet Exchanges worldwide, 261 are in Europe.
- The first Internet Exchanges in the world were established in Europe.
- Peers are more likely to have both an IPv4 and IPv6 peering session on a European exchange.

IPv6 Adoption at the top European IXs



IPv6 Adoption at European Exchanges

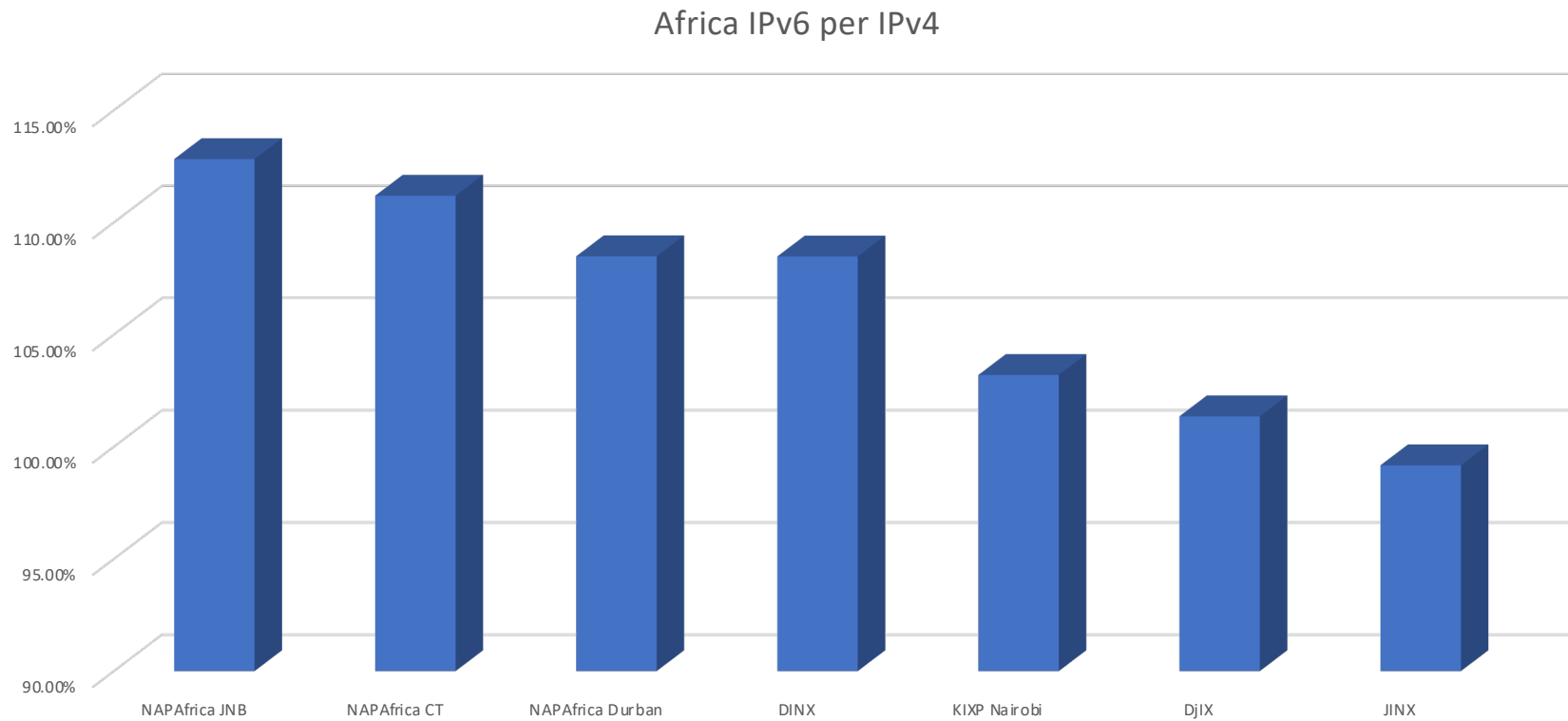


IPv6 Adoption in African Exchanges

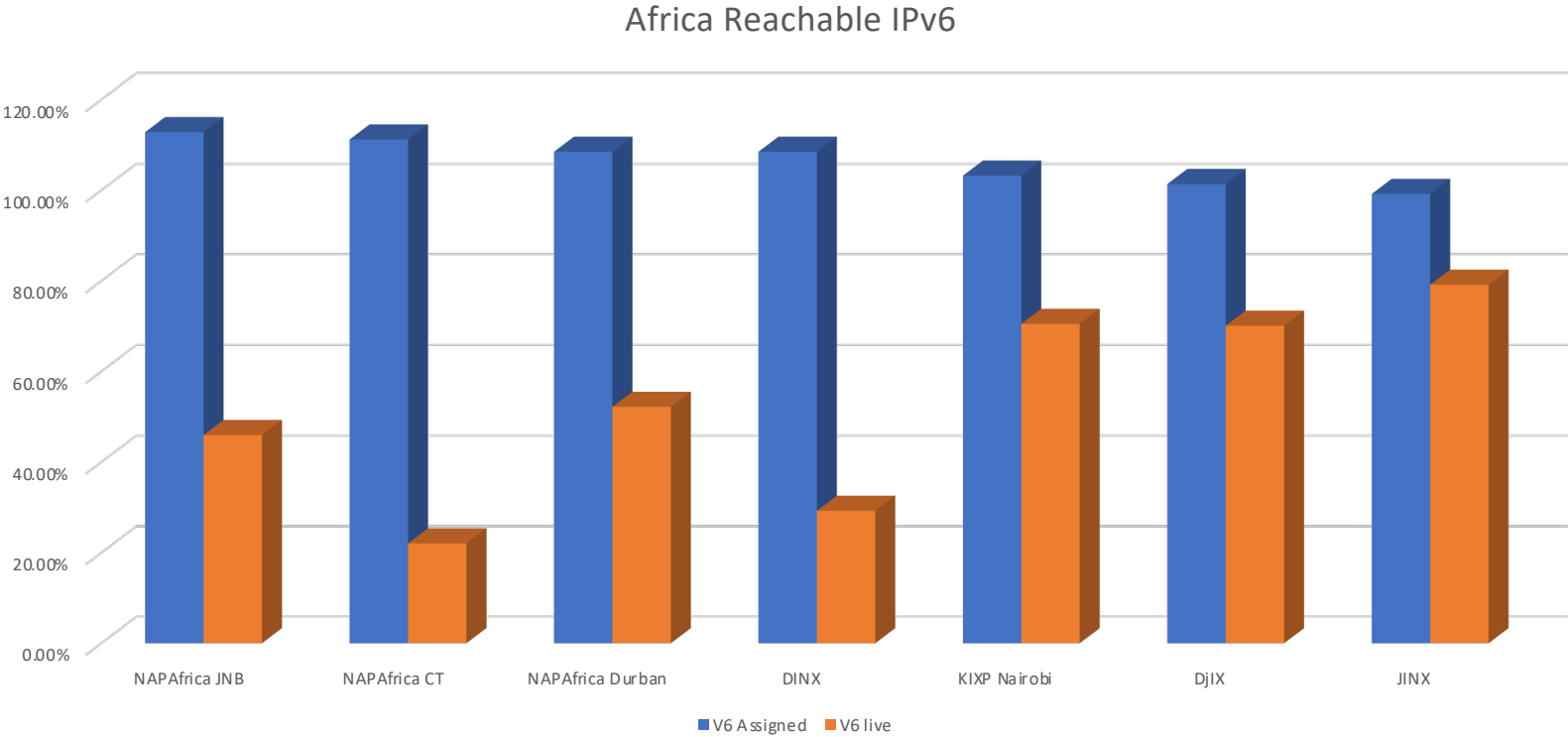
While Europe is the senior among IX's, Africa could be characterized as the fresh new faces. Africa is expanding rapidly, and new exchanges are helping develop better networks across the continent.

- NAPAfrica in Johannesburg just cracked the top 10 of the largest internet exchanges in the world.
- Africa's Internet infrastructure is diverse and developing rapidly in 54 countries.

IPv6 Adoption in Africa



Reachable IPv6 addresses in Africa

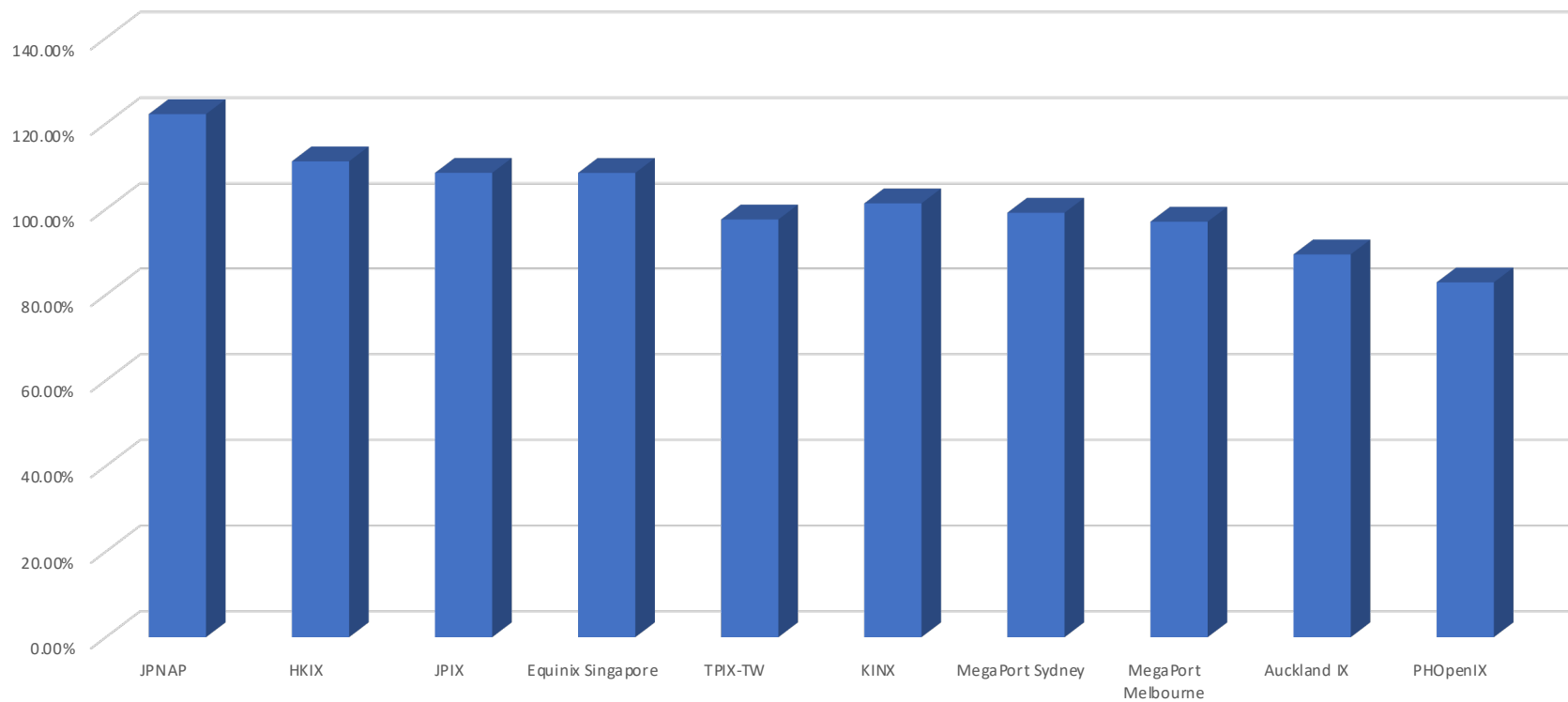


IPv6 Adoption in Asia Pacific

Asia Pacific is a broad region with unique challenges.

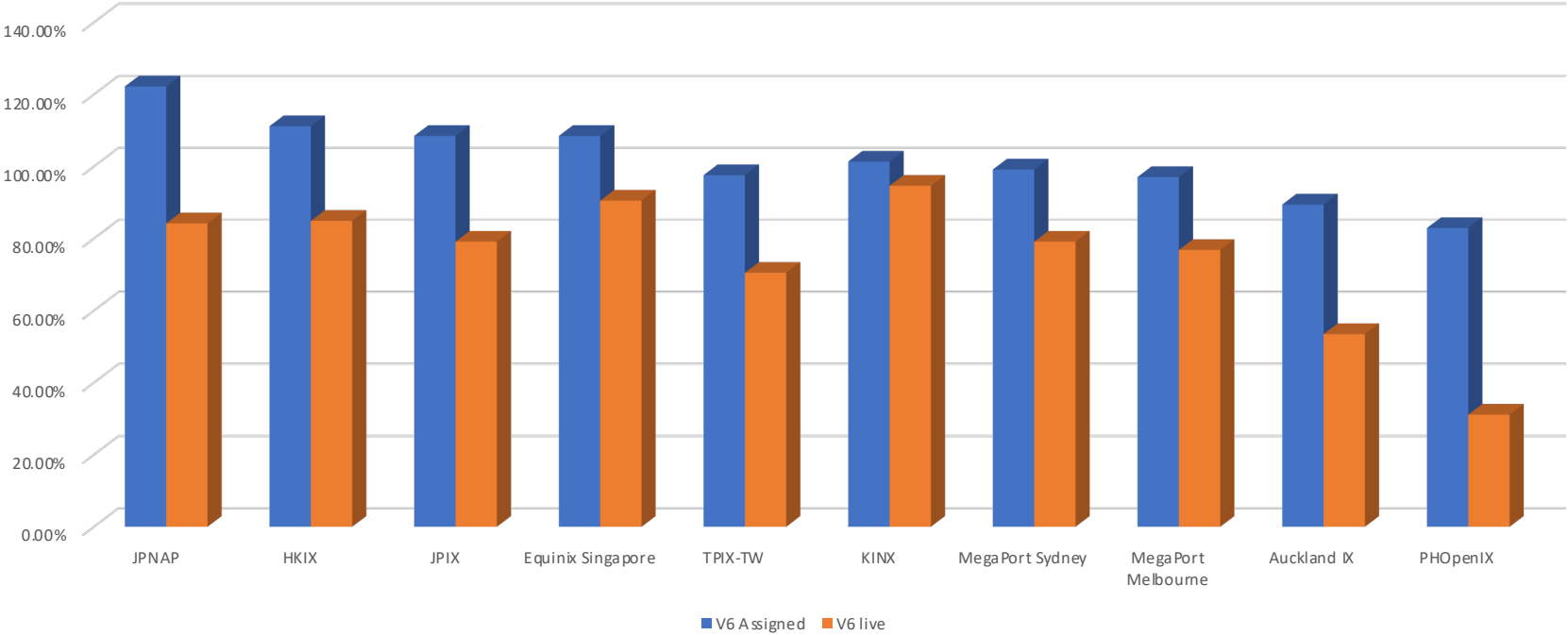
- A lot of the region is dispersed throughout the Pacific Ocean.
- Asian cities have very dense populations.
- Asian ISPs have embraced IPv6.

IPv6 Adoption in Asia Pacific



Reachable IPv6 addresses in Asia Pacific

Reachable IPv6 in Smaller IXs



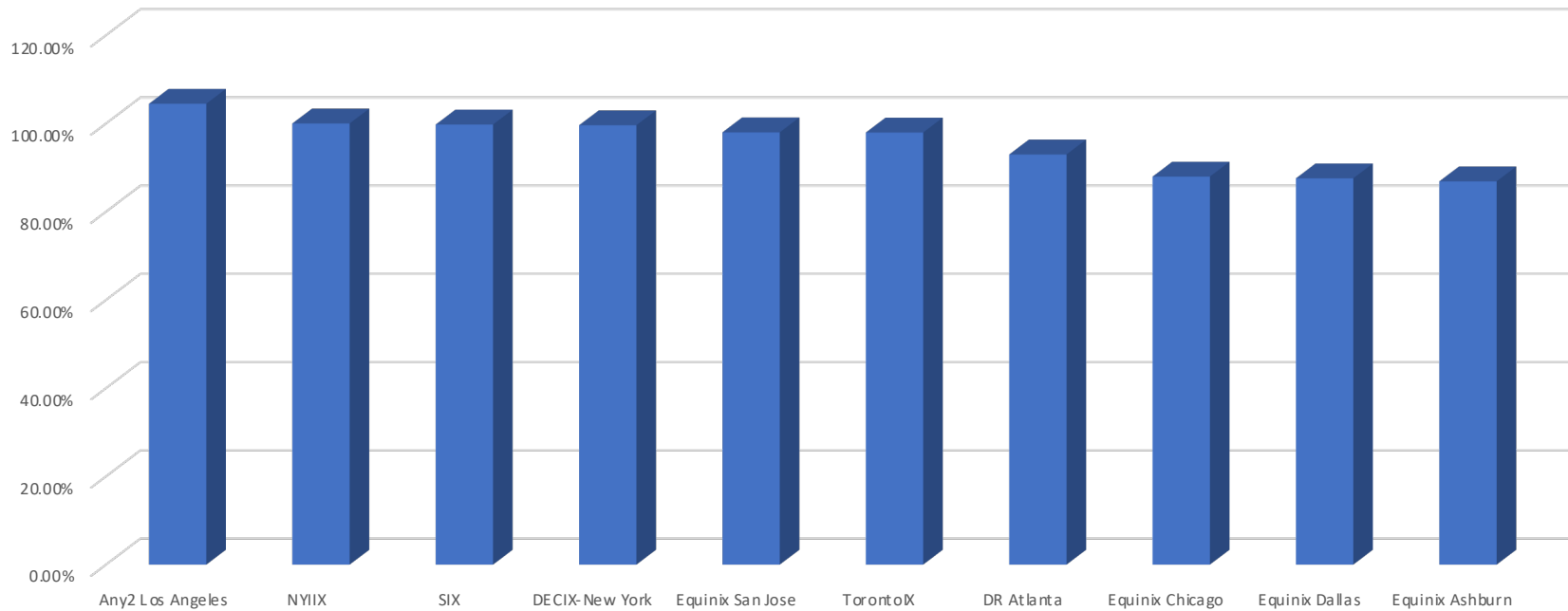
IPv6 Adoption at Exchanges in North America

And because this is NANOG, I saved the North American Internet Exchanges for the last.

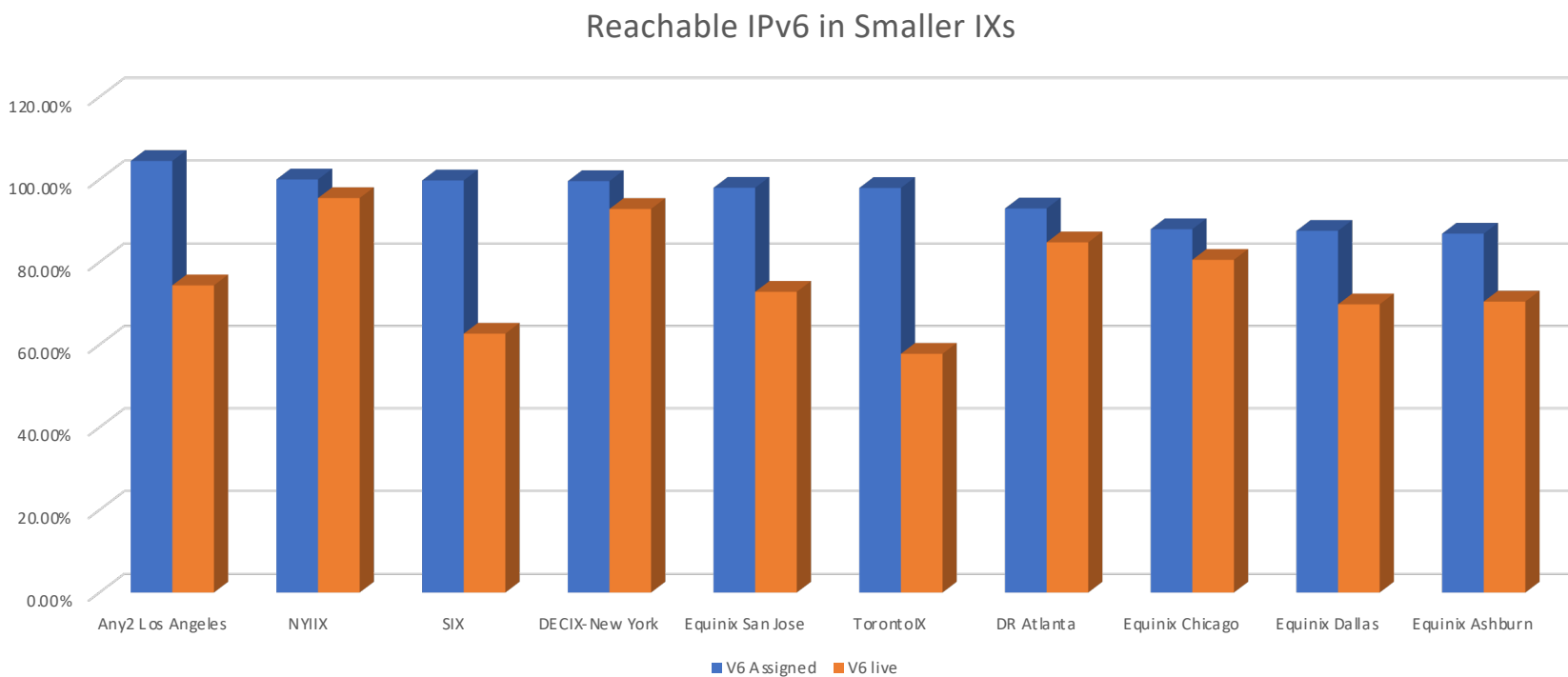
ARIN was the first RIR to exhaust its allocation, so let's look at the North American exchanges and see if that created a sense of urgency.

IPv6 Adoption in the Americas

Assigned IPv6 Address per IPv4

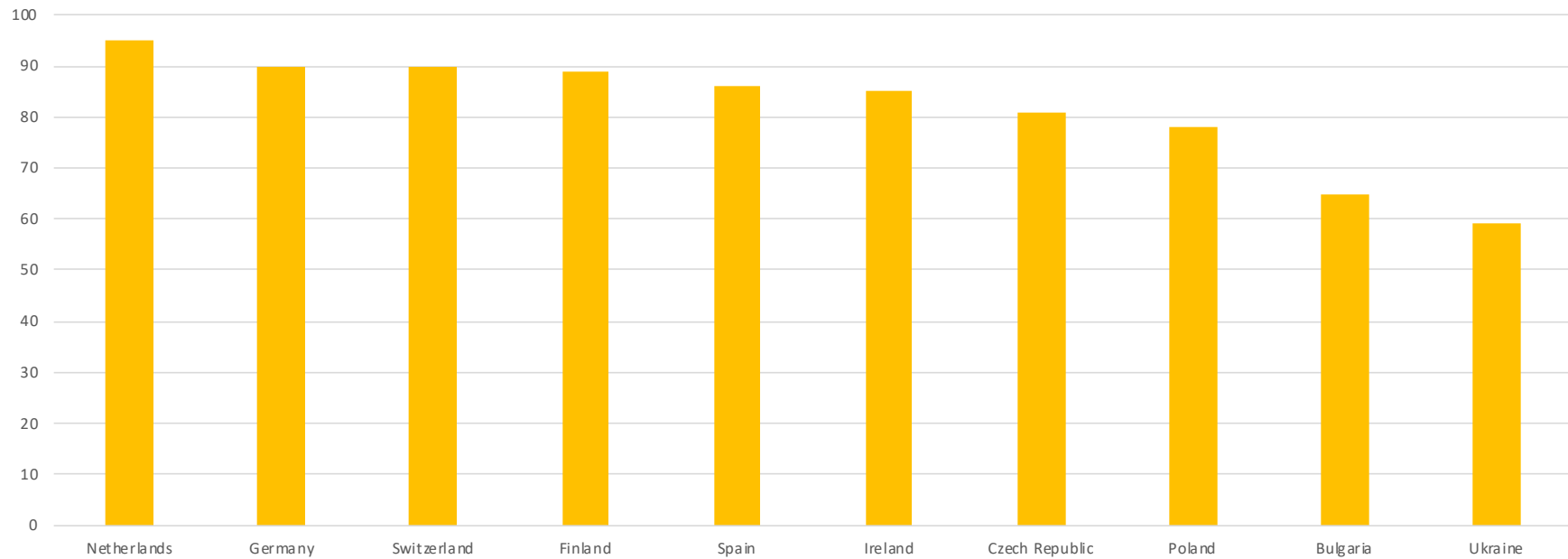


Reachable IPv6 addresses in the Americas



IPv6 Adoption over Internet Exchanges

Percentage of Population that are Internet Users



IPv6 Adoption over Internet Exchanges

Overall, these figures show that you can assign a network an IPv6 address, but you can't make them peer.

Based on what we just saw, a few assumptions seem reasonable:

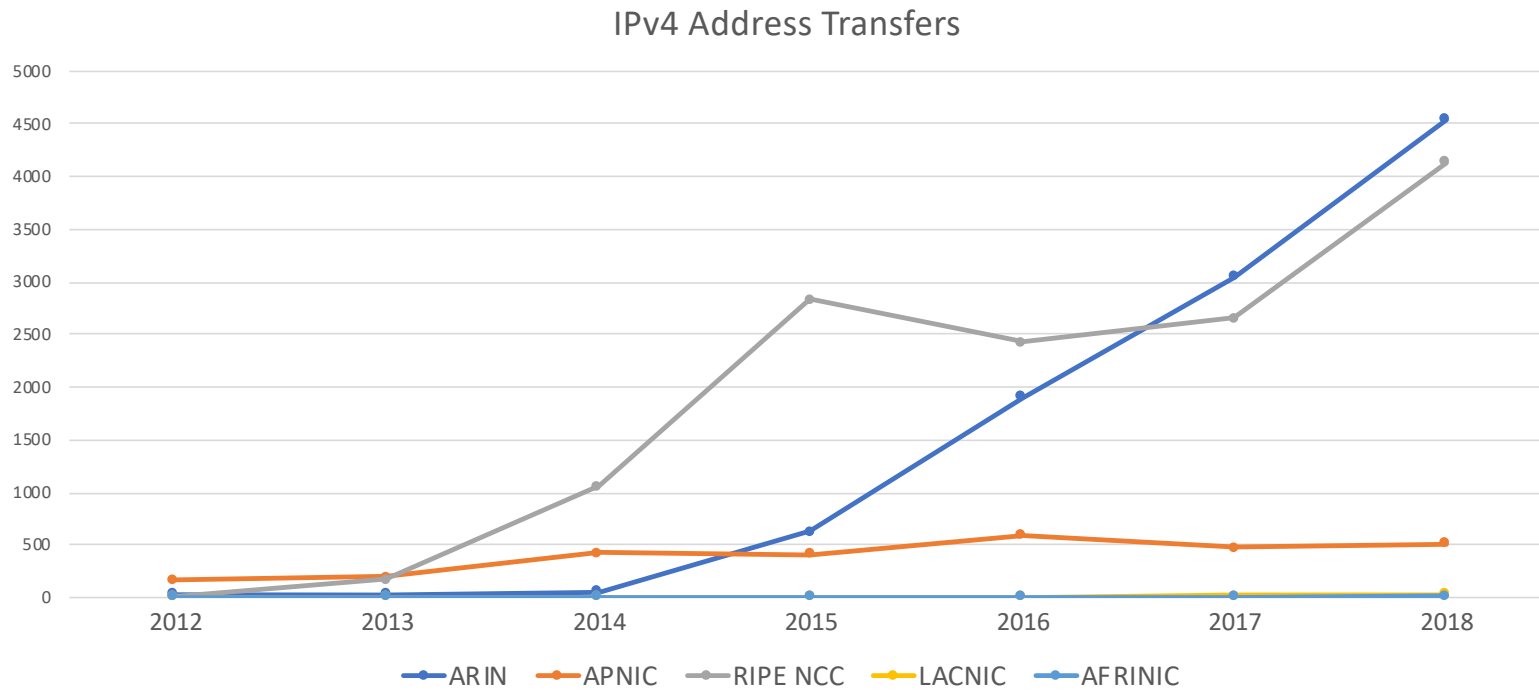
- IPv6 routing is actively encouraged on Internet exchanges.
- A large percentage of peering networks are routing IPv6, and on most exchanges, the number of networks is higher than the global average of 27.3 percent of all ASNs.
- If a network isn't peering over IPv6, it's probably because it has not deployed IPv6.

Why Internet Exchanges need more IPv6 peers

ARIN exhausted its IPv4 allocation in September 2015. RIPE just distributed its final /22 on November 25, 2019. The clock is ticking at the remaining RIRs.

- You can NAT, but CGN solutions still require additional IP space.
- Yes, you still can buy IPv4 addresses. Current pricing averages \$21 per IP for a /24, /23, or /22. Depending on who you believe, prices could double over the next two years.
- IPv4 transactions are increasing year over year as RIRs exhaust their allocations and networks .

Maximizing IPv6 Traffic Across Exchanges



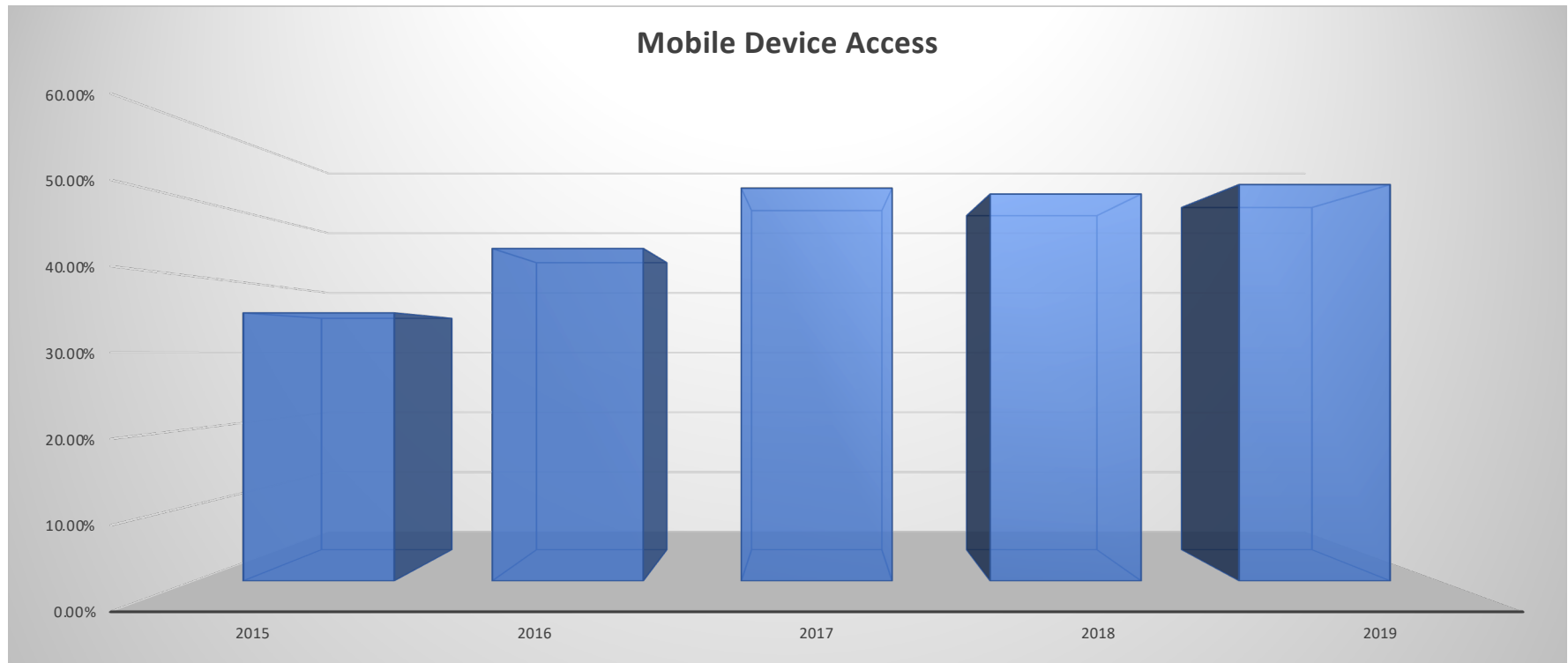
Why Internet Exchanges need more IPv6 peers

The increasing number of transactions is a reflection of demand, and the demand is increasing the price of IPv4 space.

The availability of IPv4 addresses soon will be through address brokers entirely.

As more users are added to the Internet, demand will rise. The marketing and transfer of legacy IPv4 blocks means most networks will be able to get IP space, but demand and speculation will put pressure on the price.

Maximizing IPv6 Traffic Across Exchanges



Why Internet Exchanges need more IPv6 peers

It's obvious that more peering on Internet exchanges will drive more IPv6 deployment.

What might not be as obvious is encouraging the growth of IPv6 networks works in favor of those who want to stay on IPv4.

When more traffic moves to IPv6, it lessens the demand for IPv4 resources.

When networks don't deploy IPv6, they put pressure on the IPv4 supply, which increases prices and the cost of operating networks.

Why Internet Exchanges need more IPv6 peers

If you think more networks need to route traffic over IPv6, you can do something about it.

- Whenever you peer, ask to turn up IPv6 sessions with the IPv4 sessions.
- Advertise your IPv6 prefixes and ask other networks to advertise theirs.
- Check back with your IPv4-only neighbors from time to time to see if they have added IPv6 peering.

Increasing IPv6 Traffic Across Exchanges

Summary

- IPv6 participation on Internet exchanges is better than the global rate of 27.32 percent.
- While IPv6 adoption continues to increase, IPv4 here to stay for the foreseeable future.
- No matter what your protocol politics, increasing peering over IPv6 will help you meet your objectives.

Thank you!

Questions?

Resources

- Internet Exchanges data
<https://bgp.he.net/report/exchanges>
- “BGP in 2019” by Geoff Huston, 30 Jan 2019
<https://www.potaroo.net/ispcol/2020-01/bgp2019.html>
- Individuals using the Internet (% of population)
<https://data.worldbank.org/indicator/IT.NET.USER.ZS>