NNENIX

NORTHERN NEW ENGLAND
NEUTRAL INTERNET EXCHANGE

MTUG Webinar

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Purpose of Today's Presentation

- Primer and vocabulary on Internet infrastructure
- some Internet History and Cartography lesson
- Share some Internet statistics and trends
- Explain the role of Internet Exchanges
- Details about NNENIX and how to join
- Answer your questions

What is The Internet?

- A global telecommunications system that is seemingly essential to modern life
- “an internet” is a collection of computer networks
- “The Internet” is a “network of networks”
- refers to the global collection of networks as a whole
- This collection of networks all use a common protocol suite to interoperate.

Getting on the Internet

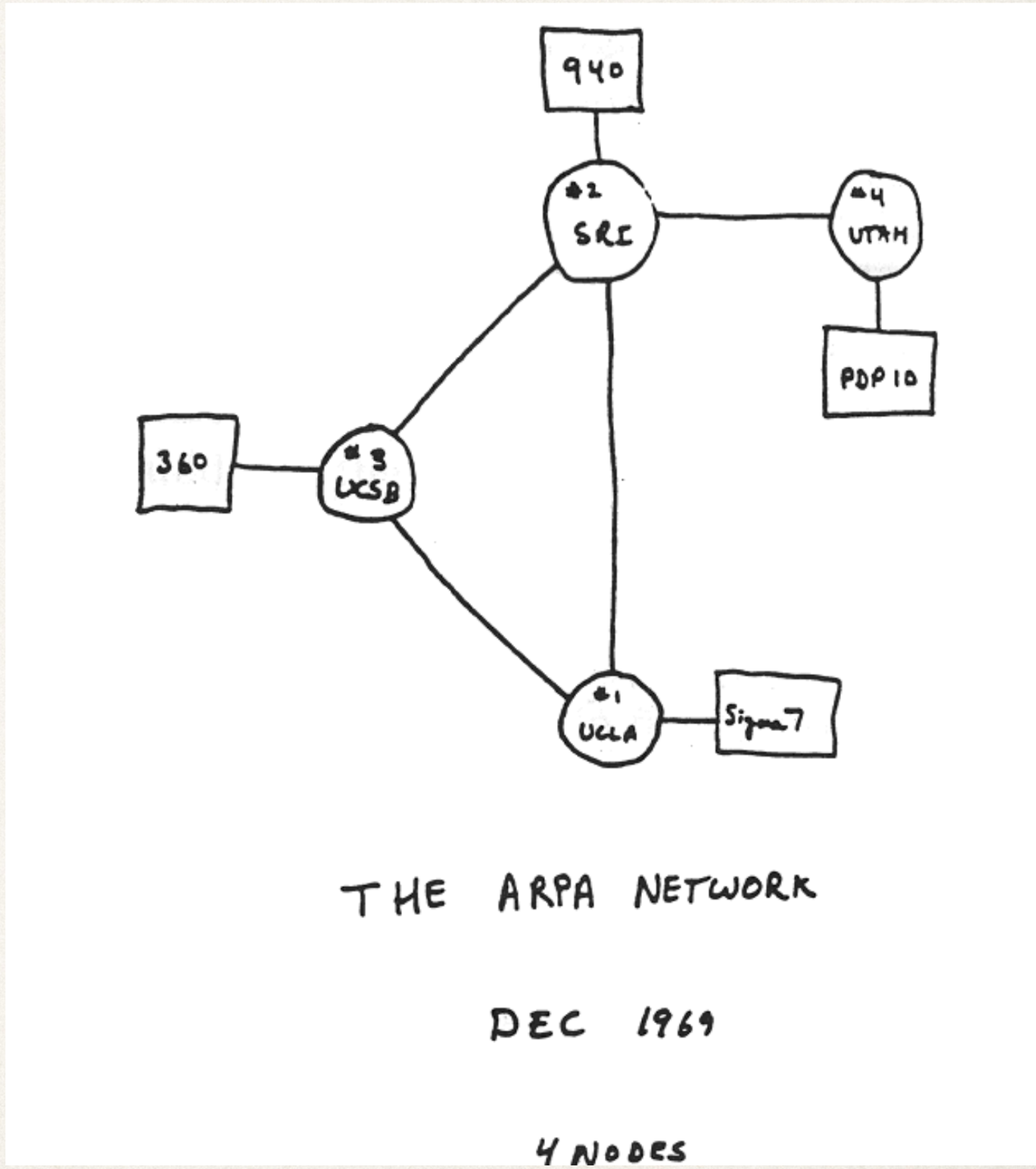
- Most organizations and all home users get connected to the Internet by purchasing services from an Internet Service Provider (ISP) of some sort.
- An ISP is often your phone company, cable company, cellular provider, fixed wireless, satellite company, and others
- By definition, an ISP sells access to the Internet (and also to their own network)
- Internet Service Providers must connect to the Internet
- But how? And where?

First, back to the beginning

- Before the Internet, we had the Advanced Research Projects Agency Network - ARPANET
- Funded by the United States Department of Defense
- Operated from 1969 - 1990, used Network Control Program (NCP) at the common protocol

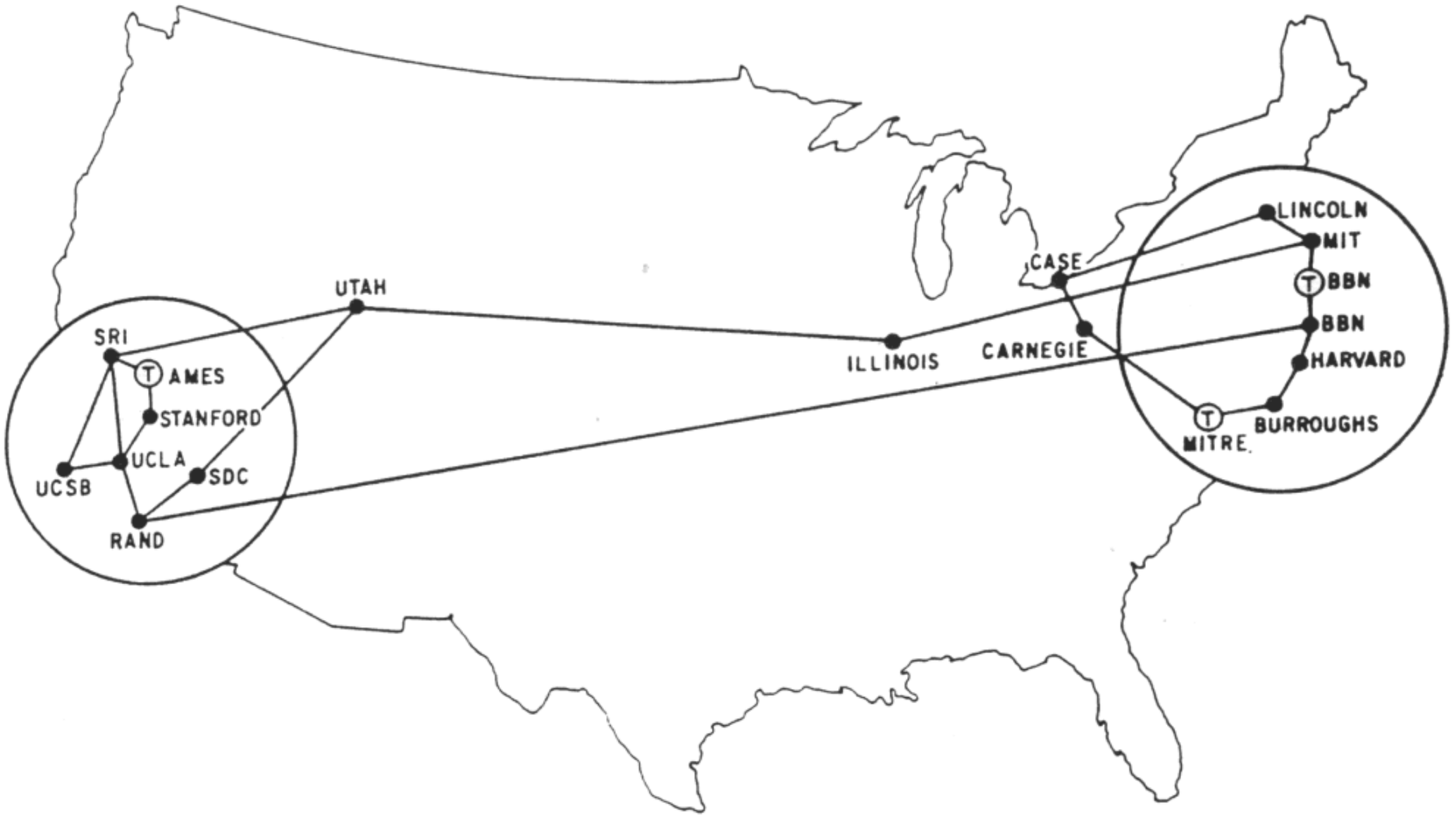
ARPANET

- primarily for higher education, government & research sites
- Initial speeds of 2.4 kilobits per second, later 50 kbps



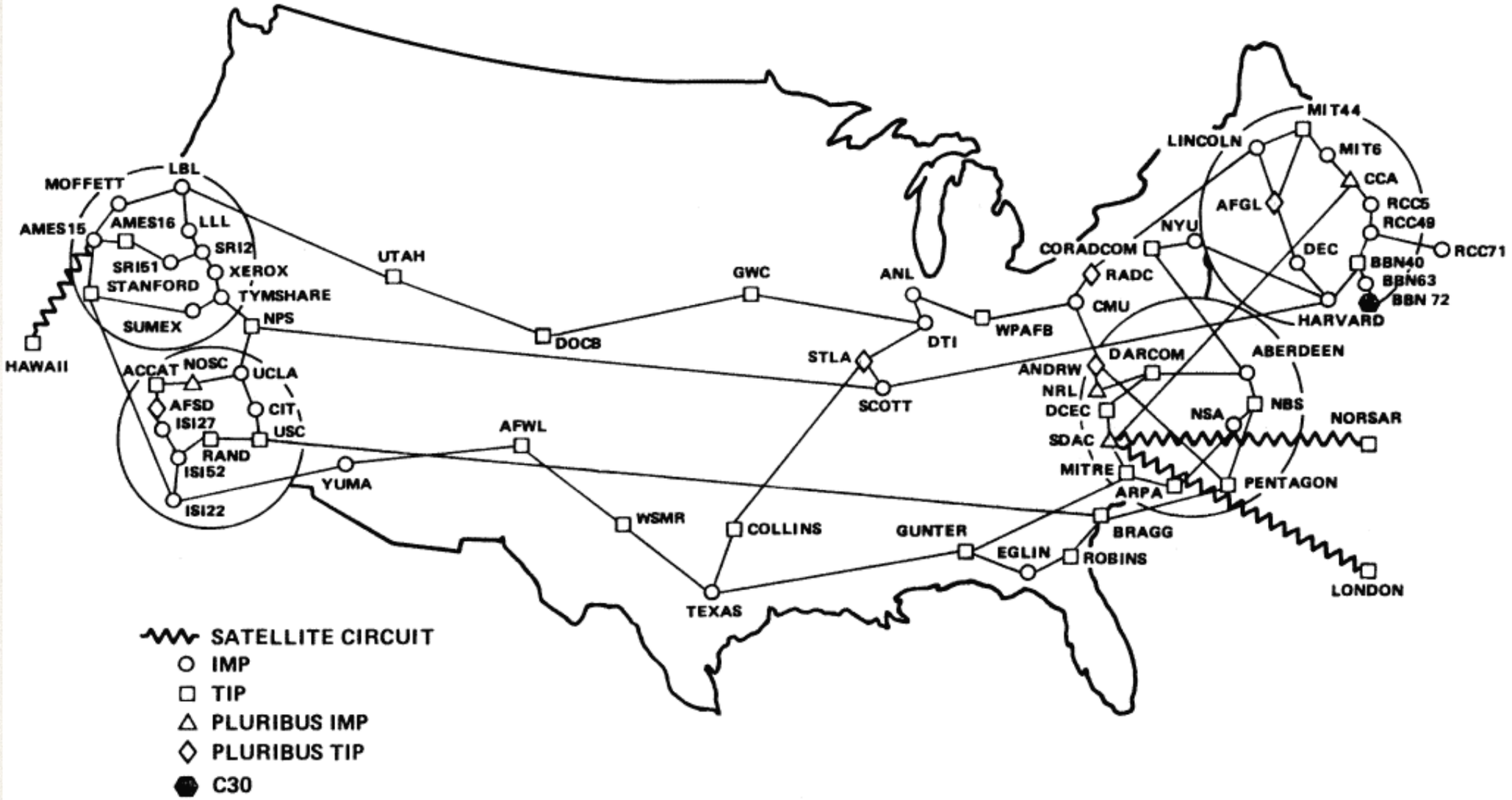
Thumbnail of Early ARPANET & Internet Growth

- 1969, October: 2 nodes
- 1969, December: 4 nodes
- 1971: 40 nodes
- 1984: 1000 nodes
- 1986: 5000 nodes
- 1987: 28,000 nodes
- 1989: 80,000 in January, 160,000 by end of year.



MAP 4 September 1971

ARPANET in 1971



ARPANET in 1980

Transmission Control Protocol / Internet Protocol (TCP/IP)

- Used for today's Internet
- initial protocol development started in 1973, implemented globally by 1983
- Replaced previous ARPANET NCP
- currently two separate versions of TCP/IP in operation worldwide

Milestones in Commercial Internet Service

- 1987 - the first commercial ISP, UUNET was founded
- 1988 - NSFnet backbone was upgraded to T1 lines (1.544Mbit)
- 1989 - Dawn of commercial email (MCI Mail, compuserve) to Internet
- 1990 - ARPANET officially shutdown
- 1991 - Restrictions on commercial content removed from the NSFnet
- 1992 - NSFnet backbone upgraded to T3 lines (45Mbit)

Internet Protocol version 4 (IPv4)

- Internet Protocol version 4 (IPv4) - 1983
- 32 bit addressing - 4,294,967,296 total IPs
- “dotted quad” address format
  - 172.16.254.1

Internet Protocol version 4 (IPv4)

- IPv4 address space is “exhausted” globally, due to the rise in number of homes and devices connected
- Technologies like Network Address Translation (NAT) and Port Address Translation (PAT) have helped keep the v4 Internet functional far longer than expected

Internet Protocol version 6 (IPv6)

- Internet Protocol version 6 (IPv6) - 1998
- 128 bit addressing - extremely large, ~3.4 x 10^{38} IPs
- Hexadecimal address format:
  2001:0db8:0000:0000:0000:ff00:0042:8329
- Needed for the future of the “Internet of Things”

Yes, there really are two separate Internets

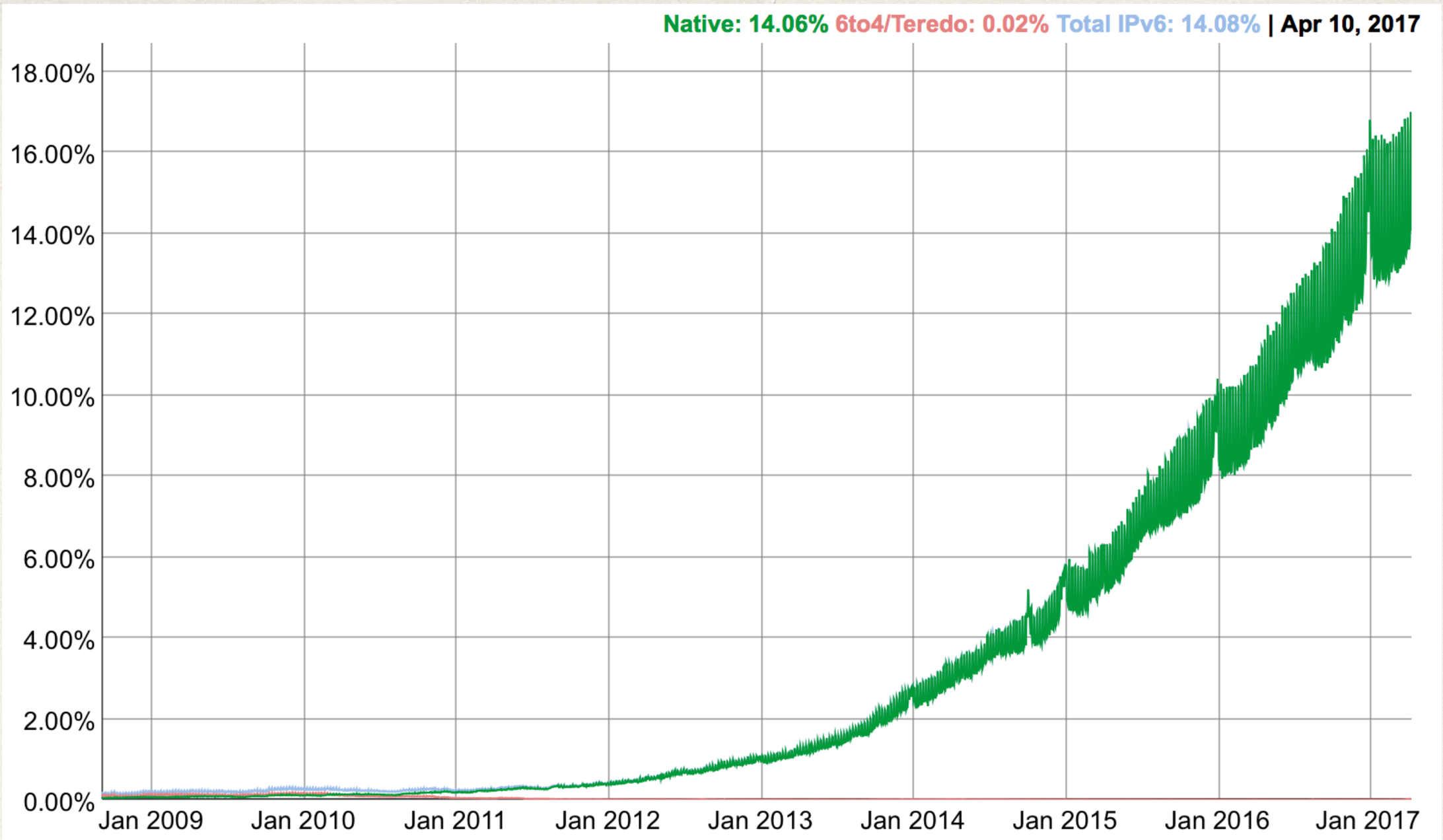
- The IPv4 Internet is what most people think of as the normal Internet
  - not much wrong with it, but limited address space and end-to-end reachability issues due to widespread use of NAT/PAT (to help with address space issues)
- IPv6 adoption has been slow (19 years!)

Internet Protocol version 6 (IPv6) Adoption

- Your smartphone is most likely using IPv6 only when connected to your cellular carrier's network

- Translation mechanisms such as NAT64 allow you to seamlessly reach the v4 Internet.

- IPv6 on by default since Windows Vista & Server 2008 (optional since XP and Server 2003)



IPv6 Adoption per Google

14.08% of Google's traffic as of April 10, 2017

Internet Service Vocabulary: IP Address

- An “IP Address” is one or more unique identifiers for your network devices to use to communicate to other network devices on the Internet

- IPv4 addresses look like 172.16.254.1

- IPv6 addresses look like 2001:0db8:0000:0000:0000:ff00:0042:8329

- You need large numbers of IP addresses (called a subnet, or IP block) if you have a lot of devices to connect.

Internet Service Vocabulary: IP Address

- You can obtain IP addresses from your Internet Service Provider, up to certain amount (depends on the ISP). Single up to about 255 addresses, usually.

- For larger needs, you have to apply for your own IP address blocks to be assigned.

- IPv4 subnets come in various sizes from 2 addresses up to many thousands.

- The minimum address block commonly accepted for routing on the Internet is a /24, or 255 IP addresses.

Internet Service Vocabulary: IP Address fees

- IP Address blocks have an annual fee associated with them, based on size, ranging from $250/year for a IPv4 /24 (IPv6 /40) up to $256,000/year for a IPv4 /6 or larger.

- IPv4 address space is now “exhausted” and difficult to come by easily. Plenty of IPv6 available easily, indefinitely.

- Address blocks can be legally “owned” and bought and sold in a special marketplace, after you prove justification.

- The one-time cost of a /24 on the marketplace is about $5000, currently.

Internet Service Vocabulary: Routing & Routers

- Routing is the act of connecting different IP networks (subnets) together to form a larger network, or an internet.

- Routers are devices that perform the routing function

- usually specialized hardware devices from companies like Cisco, Juniper, Brocade and others.

- routers for a business can cost between $500 to $500,000 depending on your needs (the speed, capacity and number of connection ports)

Internet Service Vocabulary: Firewall

- A firewall is a specialized network device that controls access between two or more separate IP networks, sometimes with routing functions.
  - A firewall can implement administrative policies (such as no access to FaceBook at work) and otherwise block undesirable traffic.
  - often performs Network Address Translation (NAT) and Port Address Translation (PAT) in IPv4 networks, due to limited Internet addresses and security concerns.
  - Firewall vendors include Cisco, Juniper, Fortinet, Watchguard, Netgear
  - For a business, can cost between $500 to $50,000 depending on your needs (the speed, capacity and number of connection ports)

Internet Services Vocabulary: IP Transit

- Internet Protocol (IP) Transit is Internet connectivity you purchase from another (presumably larger) network operator, and they agree to “route you traffic” to everywhere on the Internet, and back to your IP address.

- This is what most people think of as “Internet access”, or sometimes called “Dedicated Internet Access” (DIA) by some ISP vendors.

- Most organizations and all residential customers are buying IP Transit service.

- Often, you can obtain IP addresses as part of your service contract for IP Transit.

Internet Services Vocabulary: Autonomous System Number

- An Autonomous System Number (ASN) is a unique identifier for your organization's network on the Internet, under a common control and management policy.

- Every network operator on the Internet must have an ASN to route between each others networks.

- an ASN can be obtained by filling out some paperwork with ARIN, and paying $550 one time fee, and a $250 annual fee.

- If you don't have an ASN of your own, you are using your ISP's

A Sample of Autonomous System Numbers

- UMaine & Networkmaine AS557
- Oxford Networks AS21547
- Bangor Savings Bank AS22270
- Fairpoint AS13977
- Great Works Internet AS5760
- Coastal Telco Services (LincolnVille/Tidewater) AS33247
- Google AS15169

Internet Services Vocabulary: Border Gateway Protocol

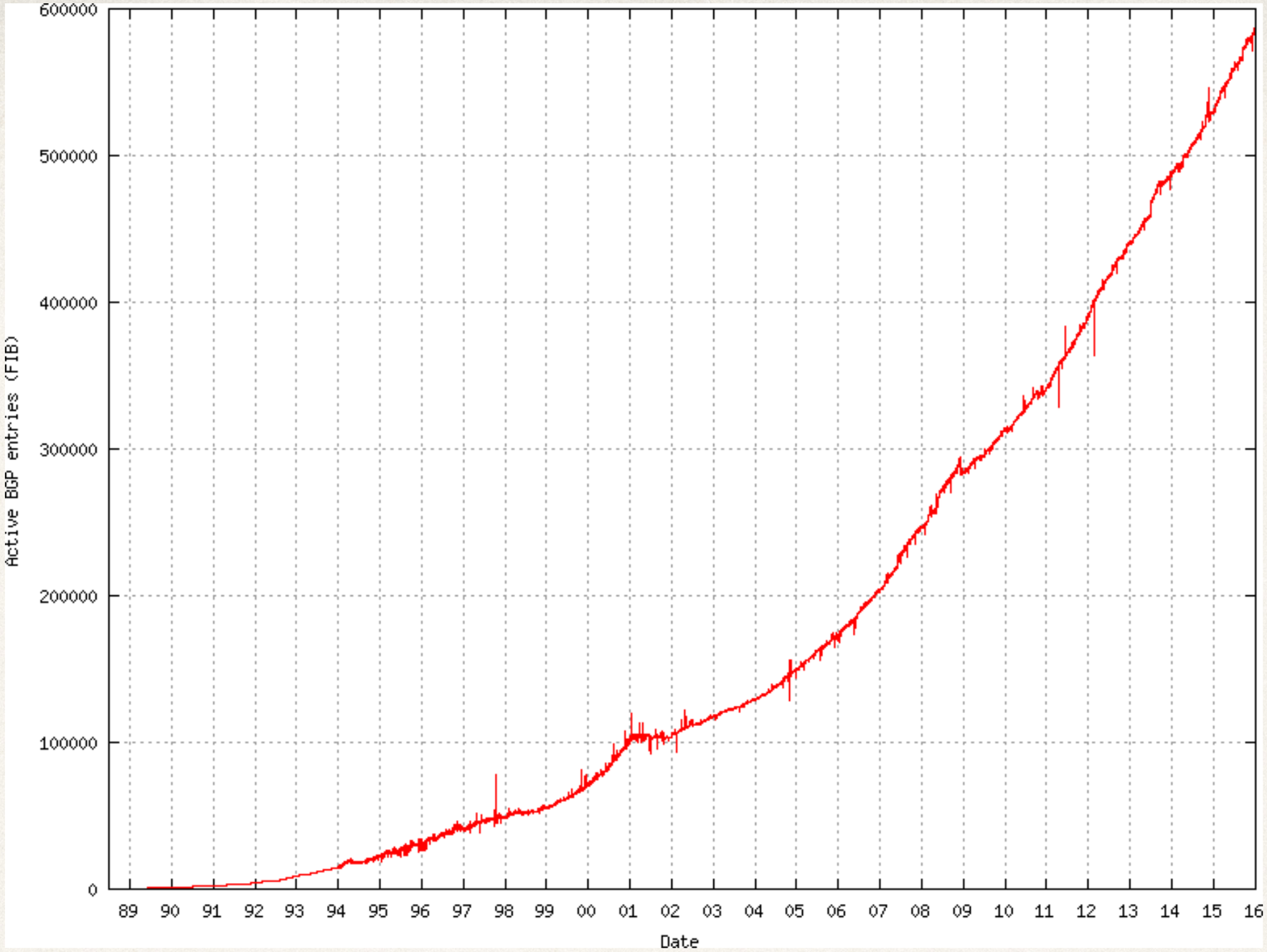
- Border Gateway Protocol (BGP) is the standard for how Internet Service Providers (who operate Autonomous Systems, using ASNs) exchange information with each other about network “routes” or which network numbers (IP Addresses blocks or subnets) are part of their network, and where.

Internet Services Vocabulary: Border Gateway Protocol

- If you are not running the BGP routing protocol using routers on your network, you are not actually a network operator, in Internet terms.

- Entities that do not run BGP are generally called customers or end-users.

- It is common for larger enterprises and institutions to run BGP and establish multiple Internet and peering connections for redundancy, performance, and lowest cost.



BGP Routing Table Growth

Total number of IPv4 subnets globally, past 28 years

Internet Services Vocabulary: Peering

- Peering is when two Autonomous Systems (ASs) agree to connect at a mutually agreeable place, with a mutually agreeable technology and speed, for the purpose of exchanging BGP routes with each other.

- Nearly always done on a “settlement free” basis, shared cost.

- Peering means your ASNs can reach each other (and each other’s downstream customers, if any), but NOT the Internet as a whole.

- Peering can done on private facilities, or more often done via a public Internet Exchange facility (like NNENIX)

Internet Services Vocabulary: Server Provider Tiers

- Historically, various ISPs have often represented themselves as being a “Tier X” carrier or provider.
- The Tiers are 1 to 3 (some argue for 4),
  - supposed to represent network operator size, connectivity, and somehow be a proxy for network quality and performance,
  - mostly marketing

Internet Services Vocabulary: Tier 1 ISP

- Tier 1 Internet Providers are the national and international backbone operators that do not pay anyone else for “IP Transit”
  - they ARE “the Internet”, essentially
- This is due to their overall size, or for mostly historical reasons.
- They have customers, and peers (generally only other Tier 1s)
- Examples: AT&T, Century Link (former Qwest & Savvis), Cogent (former PSInet), GTT (formerly Tinet & nLayer & Hibernia), Level 3 (former Global Crossing), NTT (former Verio), Orange, Sprint, Tata, Telecom Italia, Telefonica, Verizon Enterprise (former UUNET), XO Communications, Zayo (former AboveNet).

Internet Services Vocabulary: Tier 1 ISP

- The Tier 1s work hard to create many barriers to entry for anyone else to become a Tier 1.

- This includes requirements such as peers must operate on 5 continents, connect in a dozen locations, meet traffic volumes, etc.

- A connection to a Tier 1 provider does not necessarily guarantee you good connectivity to everywhere on the Internet.

Internet Services Vocabulary: Tier 2 ISP

- Tier 2 Internet Providers are ISPs that have multiple peering connections to multiple other ASNs, but they still have to buy IP Transit from a few Tier 1 ISPs and in quantity, to reach the rest of the global Internet that they do not peer with directly.

- Some Tier 1 network operators are actually far smaller in terms of total customers, routes, and service locations than other network operators that are considered Tier 2.

- Hurricane Electric and PCCW are two examples of Tier 2s that are far bigger than some of the Tier 1s.

- Tier 2s often have better connectivity than Tier 1s!

Internet Services Vocabulary: Tier 3 ISP

- Tier 3 Service Providers are ISPs that have their own IP space and do BGP routing, but only they buy IP Transit connections, and do not do any peering with other ASNs.
- Some Tier 3 providers only have a single IP Transit vendor, but most have two for redundancy purposes.
- Prior to 2016, nearly all network operators in Maine were Tier 3.

Internet Services Vocabulary: Tier 3 ISP

- In the past, a Tier 3 would select two Tier 1 vendors, order circuits to be delivered from a far away city (at great expense and time), and setup BGP routing.
- If you were diligent, the two upstream circuits would not be in the same cable going across the same bridge.
- Or at least, that is what they told you.

How to connect a network to the Internet - Basic

- To connect any network (from large to small business) to the Internet in the basic way, there are just a few requirements:

1. At least one circuit or network path to an Internet Service Provider, at an appropriate speed for your network's needs (50Mbit, 100Mbit, 10 GigE, etc.) - can be delivered via a variety of media types (copper, coax, fiber, etc.)

2. IPv4 (and ideally also IPv6) address space for your external and internal network devices

3. Some sort of device (a firewall performing NAT/PAT, or a router) connecting between your network and the ISP.

How to connect a network to the Internet - Advanced

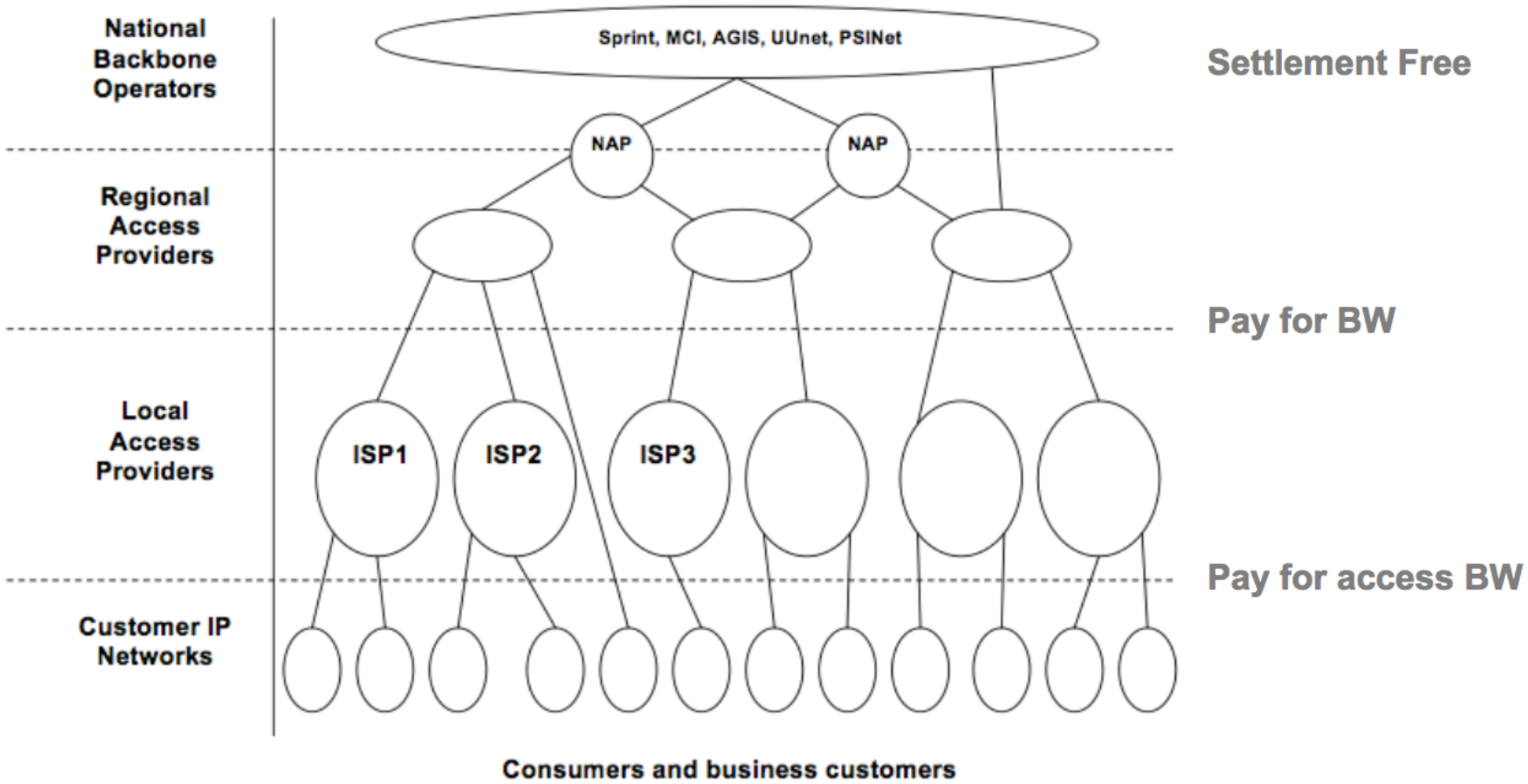
1. at least one IP Transit circuit with an ISP (more is better)

2. IPv4 (and ideally also IPv6) address space - from your ISP, or obtained from ARIN or marketplace purchase.

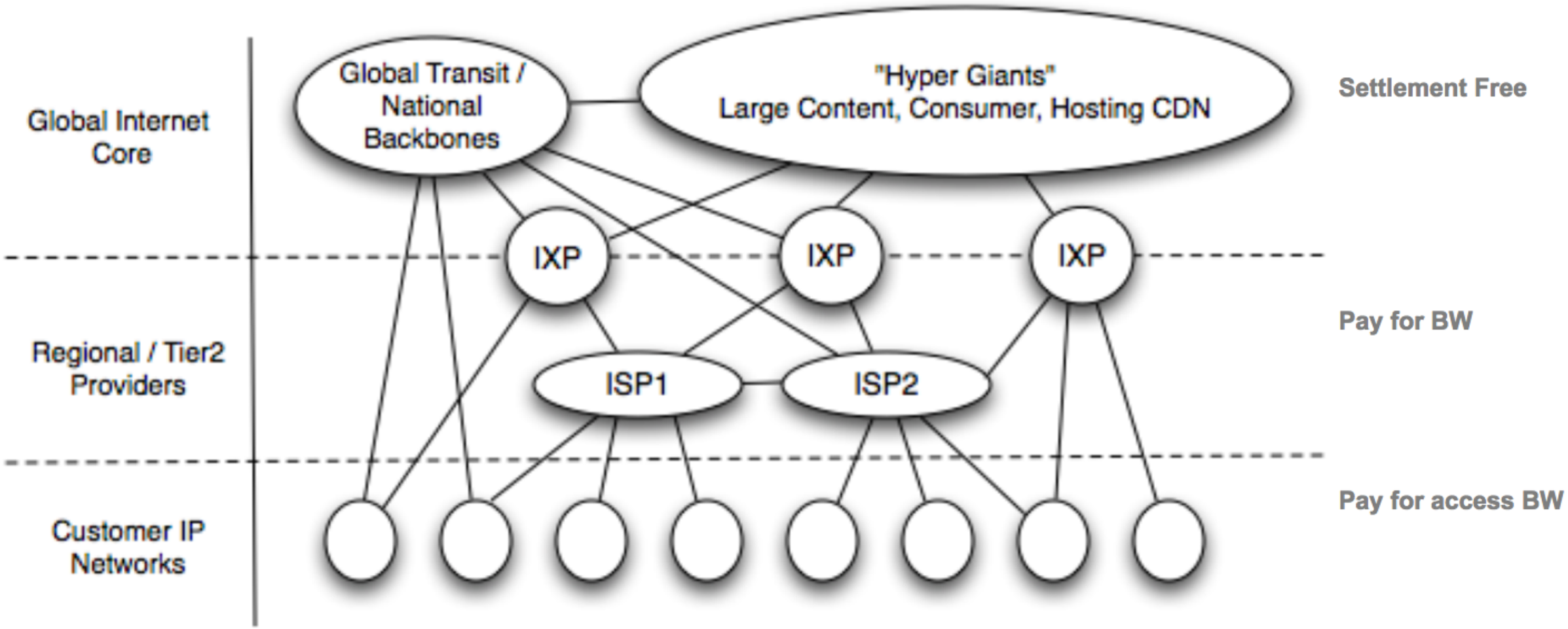
3. Autonomous System Number (ASN) from ARIN

4. Device running BGP protocol on your network, routing your subnets to your ISP vendors and peers

Connecting to the Internet: The Old Way



Connecting to the Internet: Modern Architecture



The rise of the Internet Exchange

- An Internet Exchange Point (IXP or IX) is a network facility that enables the interconnection of more than two independent Autonomous Systems, primarily for the purpose of facilitating the exchange of Internet traffic.

- An IXP provides interconnection only for Autonomous Systems (not any end-users)

- Content Delivery Networks (CDNs) like to place physical hardware in IXs to serve up traffic to networks with increased performance and at lower total cost.

- large web destinations (Apple, Microsoft, Yahoo, Google, etc.) connect their networks to IXs to also reduce their costs and increase performance.

The rise of the Internet Exchange

- PeeringDB lists 542 public IXPs worldwide

- IXPs are one of the primary ways that network operators exchange IP traffic today, in addition to private peering connections

- Many exchanges are carrying more than 1000 Gigabits (1 Terabit) per second of peak traffic. Some carry more than 5 Terabits/sec.

The rise of the Internet Exchange

- Peering often gets political on the Internet
- Some providers refuse to peer with each other for various business or sometimes personal reasons.
- Cogent currently refuses to peer with Hurricane Electric for IPv6 — you have to connect to both (or someone that peers with both) if you want access to the entire IPv6 Internet
- Some Maine network operators are not in favor of NNENIX

NNENIX - an IXP for Maine and Northern New England

- Non-profit organization (501c3 applied for), volunteer based
  - Educational mission (educational meetings, training sessions)
- Initial support from Maine Fiber Company - Thank you!
  - MFC donating space and power for 1st year
  - Loan to cover startup expenses
- Donation of Cisco Nexus 9396 and 3524 switches from Packet Clearing House, a non-profit dedicated to fostering IXPs around the world

NNENIX - an IXP for Maine and Northern New England

- NNENIX is open to membership by any organization that runs BGP routing with an ASN, including ISPs, educational institutions, healthcare, enterprise businesses.

- Organizations with access to dark fiber in Portland can easily connect at low cost - NOW!

- Bangor region presence is next, within 60 days.

- Hope to work out ways for carriers like Fairpoint, Spectrum, or FirstLight to provide ELINE transport circuits to NNENIX and wavelength services at reasonable costs, if you cannot reach NNENIX via dark fiber.

NNENIX - the IXP for Maine and Northern New England

- Costs for membership (not including your transport)
- $250/month for 1 GigE
- $750/month for 10 GigE
- $500 one time cost, plus you provide us optics
- invoiced quarterly

NNENIX - the IXP for Maine and Northern New England

- Benefits of joining are many - latency, cost, capacity, resiliency
- Avoid “boomerang effect” - local traffic stays in Maine
- Access to content caches - Netflix, Akamai, Google on day 1
- 30-50% of a residential ISP peak traffic can come from the exchange instead of from IP Transit connections.

NNENIX - the IXP for Maine and Northern New England

- Access to multiple IP Transit providers through the IX
- New IP Transit providers will be coming to Portland, directly attributable to NNENIX
- More competition means lower costs for IP Transit, and lower backhaul costs to get it to your network

NNENIX - the IXP for Maine and Northern New England

- NNENIX will be hosting several global root DNS and GTLD server instances
  - increases resiliency of DNS
  - lower latency for DNS requests for the root and things like .com/.net

NNENIX - the IXP for Maine and Northern New England

- NNENIX future plans include physical presence in Bangor region, and expansion to New Hampshire (Manchester, Hanover) and Vermont (Burlington)
  - University of Vermont wants to host us in Burlington
  - More locations are possible with demand and donations.
- Additional support in the form of donations of switch equipment, transport waves, colo space, cash, and volunteer technical operations all gratefully accepted

Maine is last in US Internet speeds

- “In the third quarter, Maine held the spot for lowest average peak connection speed in the country at 47.4 Mbps, up 1.6% from the previous quarter. Arkansas, which held the bottom spot in the second quarter, just beat out Maine with a 47.6 Mbps average peak connection speed, up 2.9% quarter over quarter.”

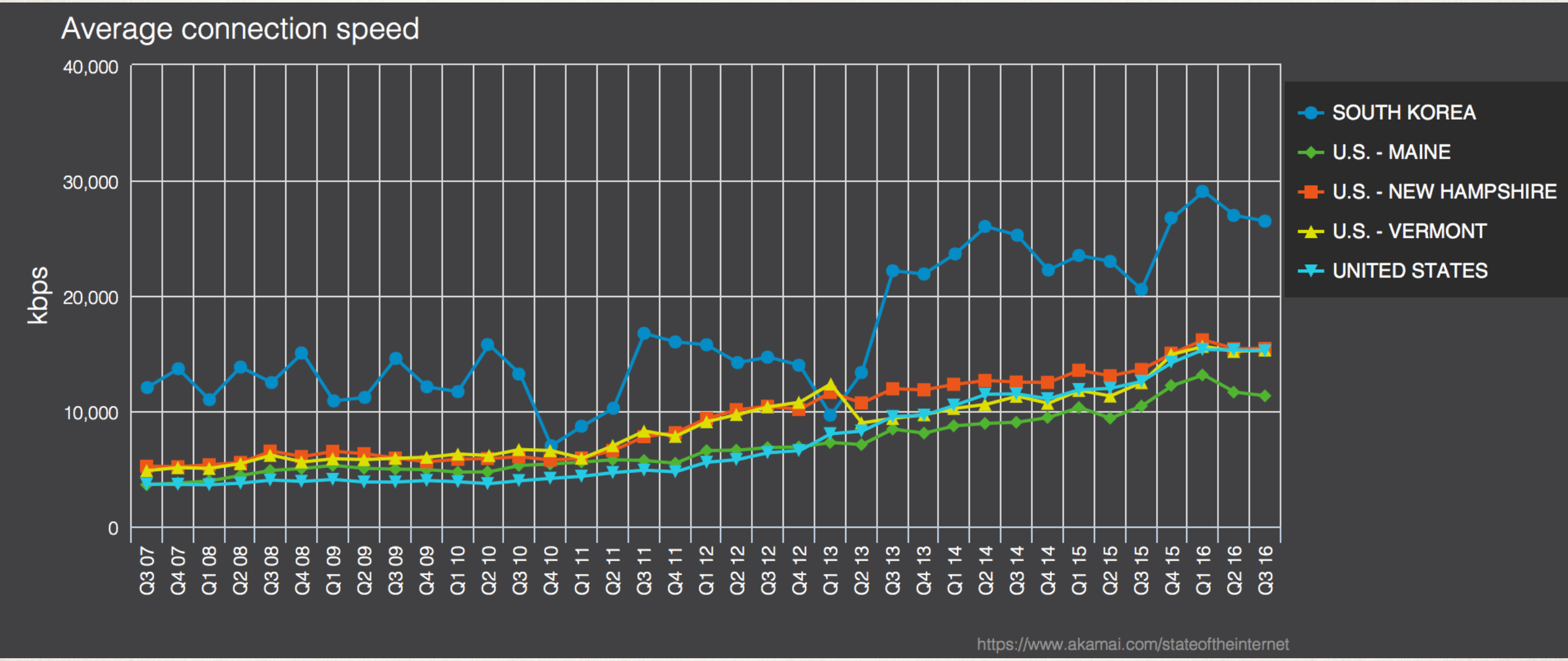
- Actual measurements of trillions of connections, not a survey

- https://www.akamai.com/us/en/multimedia/documents/state-of-the-internet/q3-2016-state-of-the-internet-connectivity-report.pdf

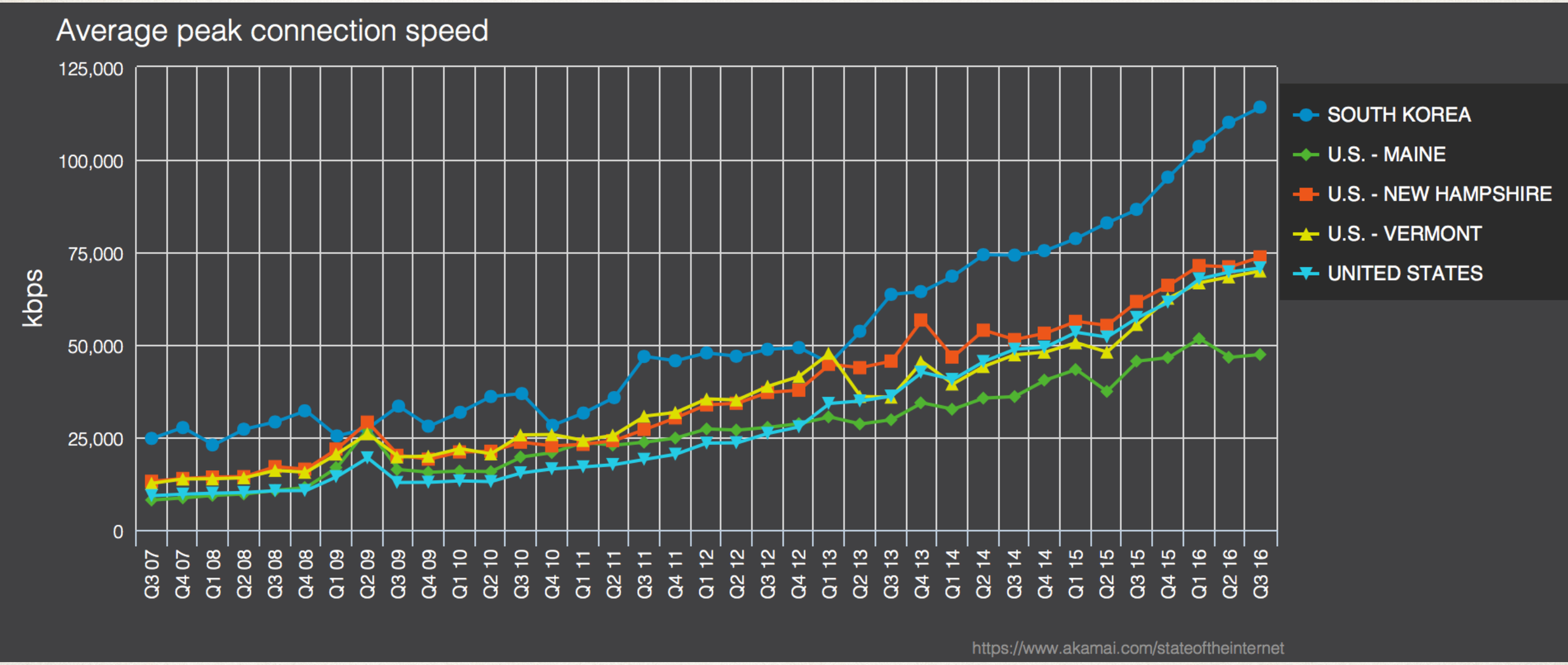
Maine is last in US Internet speeds - why?

- Limited access to high capacity Internet connections due to high costs of backhaul to Maine
- No local access to content providers
- Higher latency to reach content networks in the south and west coast
- NNENIX will help change this, but indirectly
- Last mile is biggest issue

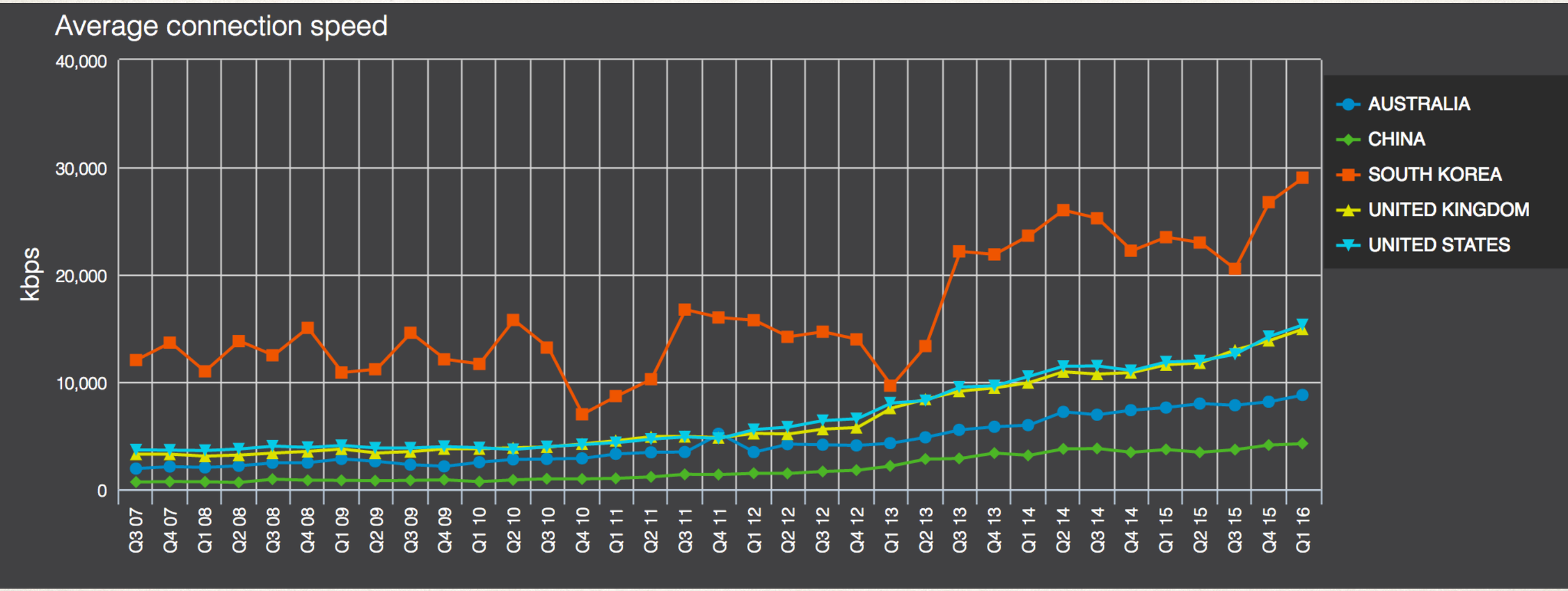
Average Internet Speeds



Peak Internet Speeds



Global Internet Speeds



Internet Traffic Volume over Time

Year	Global Internet Traffic
1992	100 GB per day
1997	100 GB per hour
2002	100 GB per second
2007	2,000 GB per second
2015	20,235 GB per second
2020	61,386 GB per second estimated

Internet Metric Snapshot

Q3 2016

- ASNs - 55,725 IPv4
- ASNs - 12,652 IPv6
- IPv4 Prefixes total observed - 705,526
- IPv6 prefixes - 40,446
- Domain names globally - 193,267,131
- 1525 Top Level Domains now (TLDs)
- Website Hosting Companies - 18,594

Cisco Global Internet VNI Forecast

- By 2020, there will be nearly 4.1 billion global Internet users (more than 52 percent of the world's population), up from 3.0 billion in 2015.
- By 2020, there will be 26.3 billion networked devices and connections globally, up from 16.3 billion in 2015.
- Globally, the average fixed broadband connection speed will increase 1.9-fold, from 24.7 Mbps in 2015 to 47.7 Mbps by 2020.
- Globally, IP video will represent 82 percent of all traffic by 2020, up from 70 percent in 2015.

IP Transit Pricing 1998-2015 from drpeering.net

1998	$1200	per Mbps	00%
1999	$800	per Mbps	33%
2000	$675	per Mbps	16%
2001	$400	per Mbps	40%
2002	$200	per Mbps	50%
2003	$120	per Mbps	40%
2004	$90	per Mbps	25%
2005	$75	per Mbps	17%
2006	$50	per Mbps	33%
2007	$25	per Mbps	50%
2008	$12	per Mbps	52%
2009	$9.00	per Mbps	25%
2010	$5.00	per Mbps	44%
2011	$3.25	per Mbps	35%
2012	$2.34	per Mbps	28%
2013	$1.57	per Mbps	33%
2014	$0.94	per Mbps	40%
2015	$0.63	per Mbps	33%

NNENIX
NORTHERN NEW ENGLAND
NEUTRAL INTERNET EXCHANGE

New England Peering Forum & Boston Network Operators Group (BOSNOG) Meeting

June 2nd, 2017 in Cambridge, MA

Full day event with both non-technical and technical content all about Internet peering & making the Internet better everywhere

Folks from Mass IX, Boston IX, NNENIX, Halifax IX and various content provider networks & more.

http://www.bosnog.org for detailed announcement