Tracking IPv6 evolution: Data We Have and Data We Need

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IPv6 Historical Data Points

- IANA allocated the first IPv6 address in 1999
- Today, estimates of IPv6 penetration span at least four orders of magnitude across different sources
    - 20% of IPv4 traffic (CERNET), 11% of ASNs... 0.01% on U.S. backbone link.
- U.S. Federal government is (again) requiring IPv6 deployment within .gov networks.
- Many attempts to evaluate penetration, e.g,

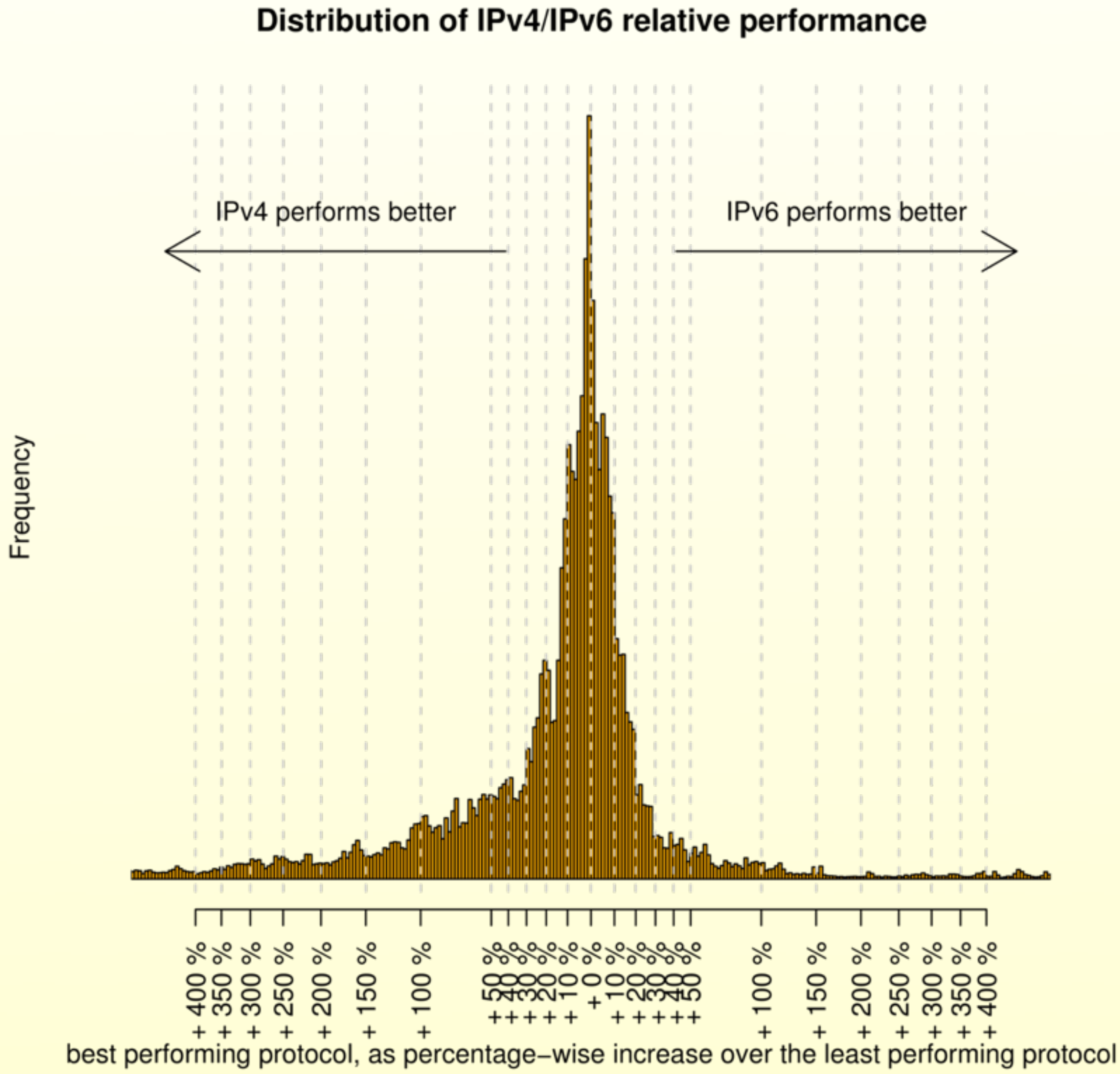
kc claffy, *Tracking IPv6 Evolution: Data we have and Data We Need,* ACM SIGCOMM CCR V. 41, p. 43-48, 2011.

IPv6 Observable Trends

- Current levels of observable IPv6 activity are well below 1%, although up to 11% of global Autonomous Systems announce at least one IPv6 prefix.
    - *Networks with IPv6 over Time," Nov 2010. http://labs.ripe.net/Members/emileaben/*
- Measurements on U.S. OC-192 commercial backbone link peaked at .27% IPv6 packets in Jan 2010. Most hourly samples show 0.003%-0.01% IPv6 packets.
- Most metrics show increase since 2006.
- Internet2: working on IPv6 measurement capability
- World IPv6 Day reviewed at IETF
    - http://www.ietf.org/proceedings/81/slides/plenaryt-9.pdf
    - Most graphs have no numbers...
    - Yahoo an exception: .1 to .229% traffic
    - "That was a lot of work for 0.229%!"

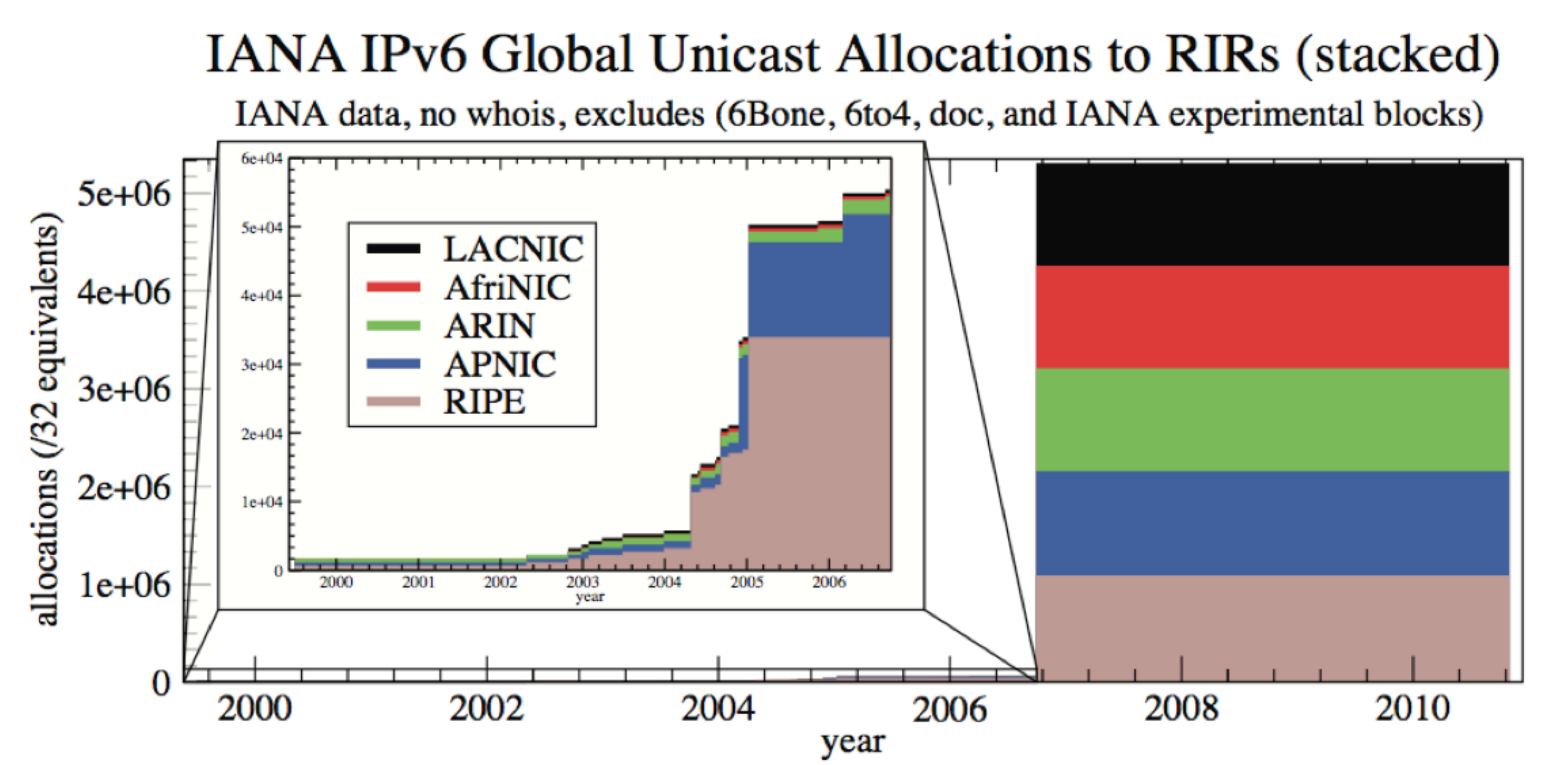
RIPE-NCC Labs IPv4 vs. IPv6 World IPv6 Day Performance

- "Measuring World IPv6 Day - Comparing IPv4 and IPv6 Performance" http://labs.ripe.net/Members/emileaben/measuring-world-ipv6-day-comparing-ipv4-and-ipv6-performance



Conclusion: "In the data we analysed we see IPv4 is still generally faster then IPv6, for a significant fraction of measurements IPv6 is the faster protocol."

IANA IPv6 Allocations

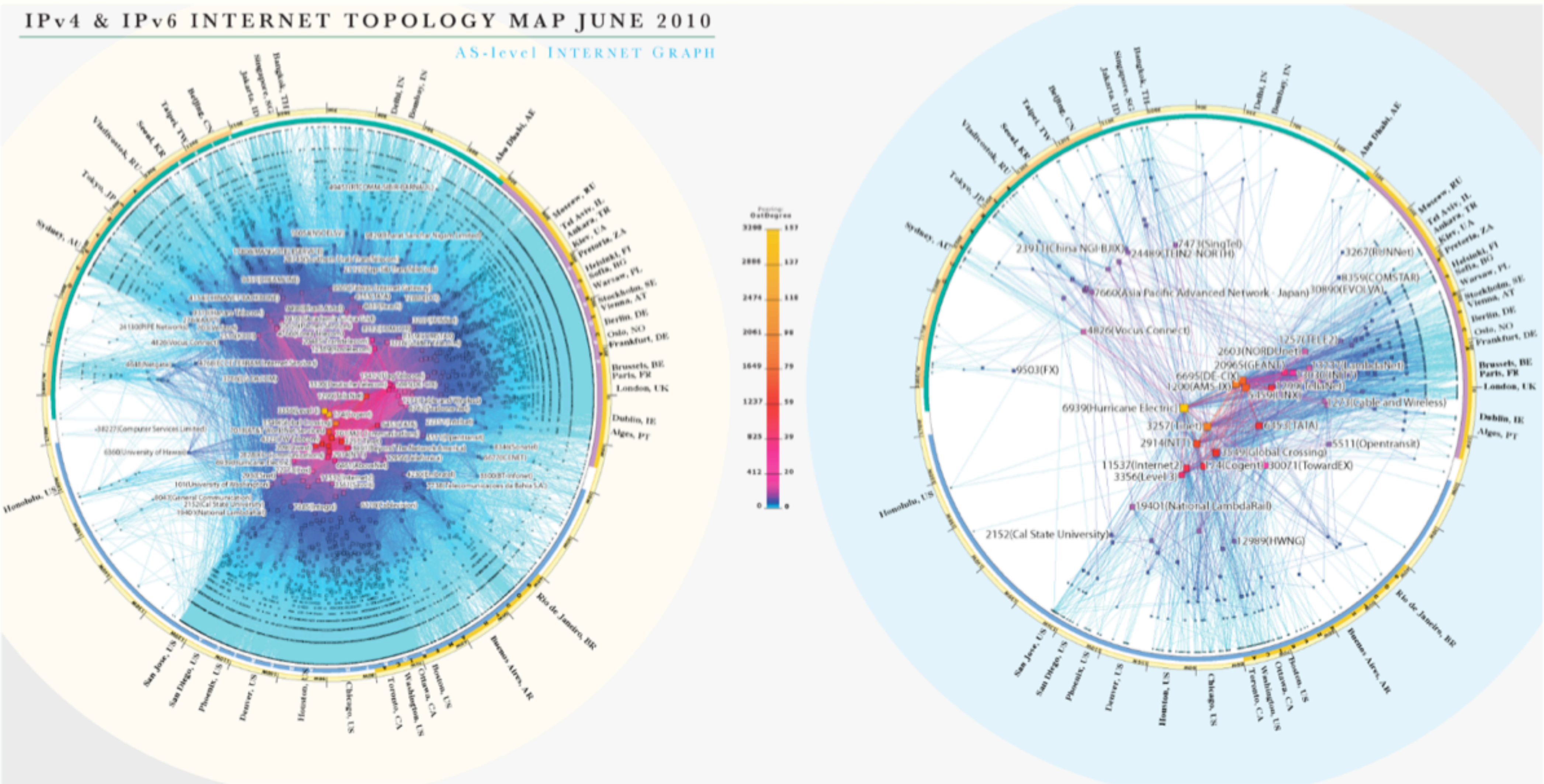


Left plot: IPv6 allocation until 2006. In Sept 2006, IANA changed policy: give RIRs "at least 18 months" worth of IPv6 addresses. No new requests to IANA since.

N.A. region (ARIN) has historically had lower interest in IPv6 than Europe and Asia, consistent with the U.S. holding the majority of IPv4 space today.

If we have to abandon allocation policies to get IPv6 deployed, do we risk same situation in future with IPv6? And who owns IPv6 addresses, anyway?

CAIDA 2011 IPv4 & IPv6 Topology Maps



IPv6 Topology Measurements

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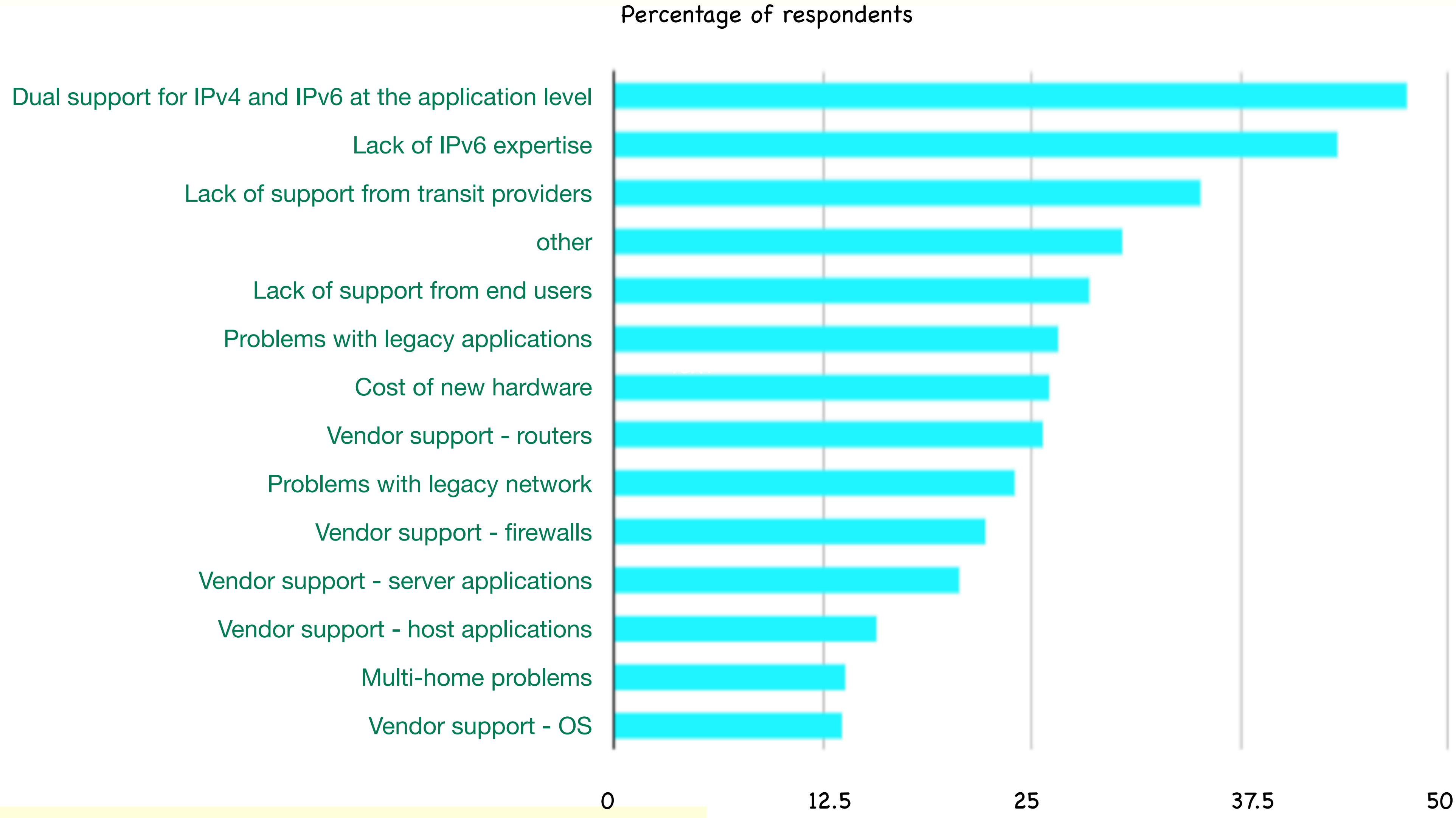
- CAIDA began measuring IPv6 topology in December 2008 from 6 Ark monitors (now 27)
- For the 2010 IPv6 map, CAIDA collected data from 12 Ark monitors (6 countries, 3 continents)
- Probed to 307K destinations in 3302 IPv6 prefixes
  - 99.6% of globally visible IPv6 prefixes in RouteViews 1 August 2010)
- Observed 715 AS nodes and 1,672 links.

2010 IPv6 AS-core vitals

- 715 AS nodes
- 1,672 links
- Top degree-ranked ASes differ from IPv4 to IPv6
- IPv4 core in U.S., IPv6 core includes Europe
- Similar average degree
- Similar average shortest AS path distances
- Example: same radius (4) and diameter (8)
- Reflects operational preference for short AS paths

Major Hurdles for IPv6

Survey of ARIN members, March 2008



Case Study: IPv6 at UCSD

- Drivers
  - Research labs requesting
    - to work w research collaborators in IPv6-is-cheaper countries
  - "Reducing sysadmin cost for client registration" --UCSD IPv6 lead
- Achievements
  - Updated IPv6 numbering scheme
  - IPv6 routing available on backbone
  - IPv6 client VLAN tests work
  - 6-to-4 traffic capture
  - First research lab using IPv6
- Challenges
  - Network hardware and software not so far along in IPv6 services/features as it seemed at first
  - Need tools to streamline our normal services
  - Management and monitoring, e.g., netflow
  - Security, security, security! (e.g., port 80 checks.)

Case Study: IPv6 at UCSD (cont)

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Two major security needs:

- Visibility into packets
  - Need to get IPv6 netflows to make sure no one is attacking campus
  - Need to extend port 80 exploit checking to IPv6
  - Our current tools don’t do these things
- Visibility into ownership
  - Need to match MAC address to (often transitory) IPv6 address
  - Can comb through logs
  - Evaluating various packages to do this more efficiently

Research universities are most likely path to IPv6

Measurements that would add insight

(1) IPv6 topology: from core to edge

(a) extracting, annotating,validating topology inferences
(b) better characterization of edge
(c) need help deploying measurement nodes from IPv6-enabled regions!

(2) Correlate deployment with socioeconomic parameters

(a) address allocation patterns vs. economic evolution
(b) routing policies, geography, demographics, organizational characteristics

(3) Quantify IPv6 performance

(a) converter characteristics performance
(b) workload characteristics

CAIDA will begin focused IPv6 measurements this year, please help deploy measurement nodes!

U.S. FCC Technological Advisory Council IPv6 Transition Working Group

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- Charter:
  - Outline issues related to IPv6 evolution
  - **Define benchmarks** to gauge progress against rest of world
  - Develop goals for key sectors to accelerate transition
  - **Identify costs** and market drivers for investment in IPv6
- Concern: IPv4 accommodations may slow transition to IPv6
  - IPv6 is about business continuity, not new applications
  - Some potential to reduce operational costs eventually, e.g., NAT complexity, IPv4 ownership conflicts
  - Transition technologies add complexity and cost and impede innovation
- Recognition that market-driven transition will be **slow**
  - ***and possibly fail***
  - **IPv4 address markets may kill IPv6 (btw, not U.S. idea)**
  - Different sectors/applications have different incentives, effects
  - Some sectors (content) not opposed to regulation, if necessary
  - Other sectors (carriers) not incented to support public IPs

IPv6 Target Data Collection List

i. Peering: Terms of IPv6 interconnection agreements

ii. Purchasing: IPv6-capable hardware and software

iii. Workload: Total and peak utilization of access links (IPv6)

iv. Traffic characteristics: types of IPv6 traffic (e.g netflow)

v. Total and peak (v4/v6) utilization on links to other networks

vi. IPv4 and IPv6 address utilization (absolute and %), allocation, and BGP-announcement dates

vii. IPv6 support (transition) strategies used

viii. Topology: router connectivity and geolocation info (to validate external reachability measurements)

ix. IPv6 DNS queries/response data

Recommendations

- *Political and economic incentives*

  economic incentives
  - make IPv6 backbone free (or charge more for IPv4 traffic)

  political/economic incentives
  - forbid access to (IPTV) content on IPv4
  - regulate (like 1984 NCP->TCP/IP)
  - soft-regulate (US government procurement rules)
- *Standarize metrics and measurements*
  - *“International Bureau of IPv6 Statistics”*
- *Community-building drivers*
  - *videoconferencing among researchers*
- *Hedge bets*
  - *Future Internet Research (ICN, NDN)*