“When a tree falls, we can hear it. When the forest grows, not a sound”

Gandhi
Measuring on-going IPv6 adoption is the best way to foster deployment, monitor success and spot trouble areas, and in the end, make better (data driven) business decision.
IPv6 deployment phases – The associated metrics

1 – Planning
*Prefixes (allocated, routed, traffic)*
Sources: RIR db, routeview.org, BitTorrent agent

2 – The Network
*IPv6 Transit AS’s BGP tables*
Source: routeview.org, RIPE Lab

3 – Content enablement
*Alexa top sites / country + 6lab http probes*
Sources: Alexa.com, 6lab.cisco

4 – Users adoption
*Google users/browsers stats APNIC Ad’s embedded http probes*
Sources: google stats, apnic lab
The Internet Core is ready for IPv6!

IPv4 transit AS’s: 11088
IPv6 transit AS’s: 1906*
IPv6 enabled AS’s: 3996

Concentrated in the Core
93% of Top100 and
85% of Top300 AS’s are IPv6 transit

Call for Action: Enable the long tail, the AS’s at the periphery
Per country IPv6 Transit readiness

- Norway: 91%
- Sweden: 87%
- Netherlands: 82%
- Germany: 81%
- Switzerland: 76%
- UK: 73%
- France: 71%
- Japan: 81%
- Thailand: 79%
- India: 76%
- Saudi: 75%
- New Z.: 74%
- Australia: 67%
- Malaysia: 65%

Per country IPv6 enabled Content.
Sites among top500 - % of pageview over IPv6

~ 50% of content is reachable over IPv6 …
Mainly from Internet Giants (Google, Facebook, Yahoo, YouTube, Wikipedia,…)
CDN and some Cloud providers

LOCAL Content is missing, primarily from Enterprises and public sector
(e-commerce, e-banking, e-health…e-education, e-government)

CloudFlare has impacted long tail (+1% overnight, emerging countries)

Sources: alexa.com top500/country+ 6lab.cisco.com probes
Forget the past, IPv6 to end users is rolling out FAST!

Actual % IPv6 usage measured and reported by Akamai, Facebook, Google, and Yahoo!
From: [http://www.worldipv6launch.org/measurements](http://www.worldipv6launch.org/measurements) (as of July 15, 2014)
IPv6: One Year from Today

IPv6 use has more than doubled in under a year in the USA and Germany

Source: https://www.vyncke.org/ipv6status/project.php
Core networks and Content are IPv6 enabled... Users coming on line

How does it feel to be on IPV6 Internet?
Performance study in a dual-stack world

- Create our dataset to do own analysis against it.
- VPS spread globally
- Compare with other datasets
  - APNIC
  - 6lab.cz
- Work with RIPE Atlas probes
  - Dual-Stack Traceroute
  - Vast diversity of sources

To 10,000’s Web servers (over 90 days)

HTTP request

TCP dump + Java

⇒ Hadoop

Top 1000

Long Tail / Random
In over 90%, RTT over IPv6 is identical to IPv4 (+/-100ms)

Let’s do a deep dive on the anomalies!

\[ \log\left( \frac{\text{average (RTT}_v^4)}{\text{average (RTT}_v^6)} \right) \]

distribution for each source/destination pair
Are other research finding the same results? => Yes

Distribution of IPv4 and IPv6 RTTs (in µs) from labs.apnic.net (Millions sources, few destinations)

Distribution of IPv4 and IPv6 RTTs from 6lab.cz (few sources, thousand of destinations)
First type of Anomaly
Consistently shorter IPv6 RTT fm Singapore toward Europe

IPv6 is 800ms faster than IPv4 from Singapore to European Web server

IPv4 and IPv6 Paths fm Singapore to EU are very divergent
AS6939 (HE) always in the path for IPv6
Anomalies analysis: The Hurricane Electric effect

HE: AS6939 in 44.8% of IPv6 routes, 16.9% of IPv4 routes (source routeview.org)

Many AS’s are peering with HE for IPv6 (but not necessarily for IPv4) => non-congruent Path

HE has a Cable between Singapore and France
Second type of Anomaly:
RTT fm Rackspace to many WEB sites within US is shorter on IPv4

IPv4 is 200-400ms faster than IPv6 between my Probe in Virginia and a .gov web site in DC

IPv6 path within AS6453 (TATA communication) Fm Rackspace (Va) to .gov (DC) via Dallas!
Good News and Lessons learnt

- IPv6 and IPv4 Performance are identical (+/- 100ms) in most cases
- Most performance anomalies are due to non-congruent paths
  - Peering must be done dual-stack to avoid path divergence
  - Monitor Performance for both protocol is a MUST DO
- BUT Happy Eyeballs (RFC6555) hides performance discrepancies. Users do NOT complain
IPv4: Limitations due to scaling beyond original design
IPv6: Application-Centric, Programmable, IP Networking

- Multiple addresses per device (Homenet)
- Share IPv4 without CGN (MAP)
- IPv6-Only Massively Scaled Data Centers
IPv6: Application-Centric, Programmable, IP Networking

IPv6 SR: “IPv6 with Segment Routing is SDN done right”
– John Leddy, SVP Network Architecture, Comcast
IPv6: The Internet Protocol for the Internet of Everything

People + Processes + Data + Things
Questions?

Thank: Hugo Kazmareck
Marcel Enghenard
Guillaume Ladhuie
Eric Vyncke
Thank You

email:  afiocco@cisco.com
Twitter:  @alainfiocco
         @cisco6lab
All of our devices, applications and services...

100s of IPv6 features
Engineering Process changes – Test and Hardening – broadest USGv6 certified Portfolio
- 95% WEB properties/apps
  - ~5% of cisco.com users
  - ~$2B business is over v6
- 100% Core/WAN and iPOP
- DC : 100%
- DNS: 90%, DHCP: 100%
- 84% user VLANs (304 of 361 bldg)
- 38% Voice VLANs (138 of 362)
- 91% LABs (634 of 693)