T-Mobile USA IPv6 Deployment

IPv6-only Mobile Perspective

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News Flash!

- T-Mobile IPv6 Network Deployment COMPLETED.
- Android Phones are starting to support IPv6 on GSM / UMTS / LTE
  - Nexus 4, Galaxy Nexus, Nexus S
  - Samsung Note, Note2, Galaxy S2 and S3
  - 464XLAT code accepted by Android
    - https://android-review.googlesource.com/#/q/owner:dan-android%2540drown.org+status:merged,n,z
    - ROM supporting 464XLAT and dual-stack WLAN tether

      http://dan.drown.org/android/clat/

IPv6 in 3GPP Mobile Networks is Easy

- Verizon Wireless in the USA has IPv6 on by default on all LTE devices
  - One exception is the iPhone
  - But, LTE iPad has IPv6
  - IPv6 used for all OAM and device management functions as well as IMS / VoLTE
- T-Mobile USA has had IPv6 as an optional APN setting for 2 years
  - All users have IPv6 provisioning by default in the network (HLR/HSS, …)
  - Manual setup on phones today by user
  - IPv4v6 will be default for all LTE devices in 2013

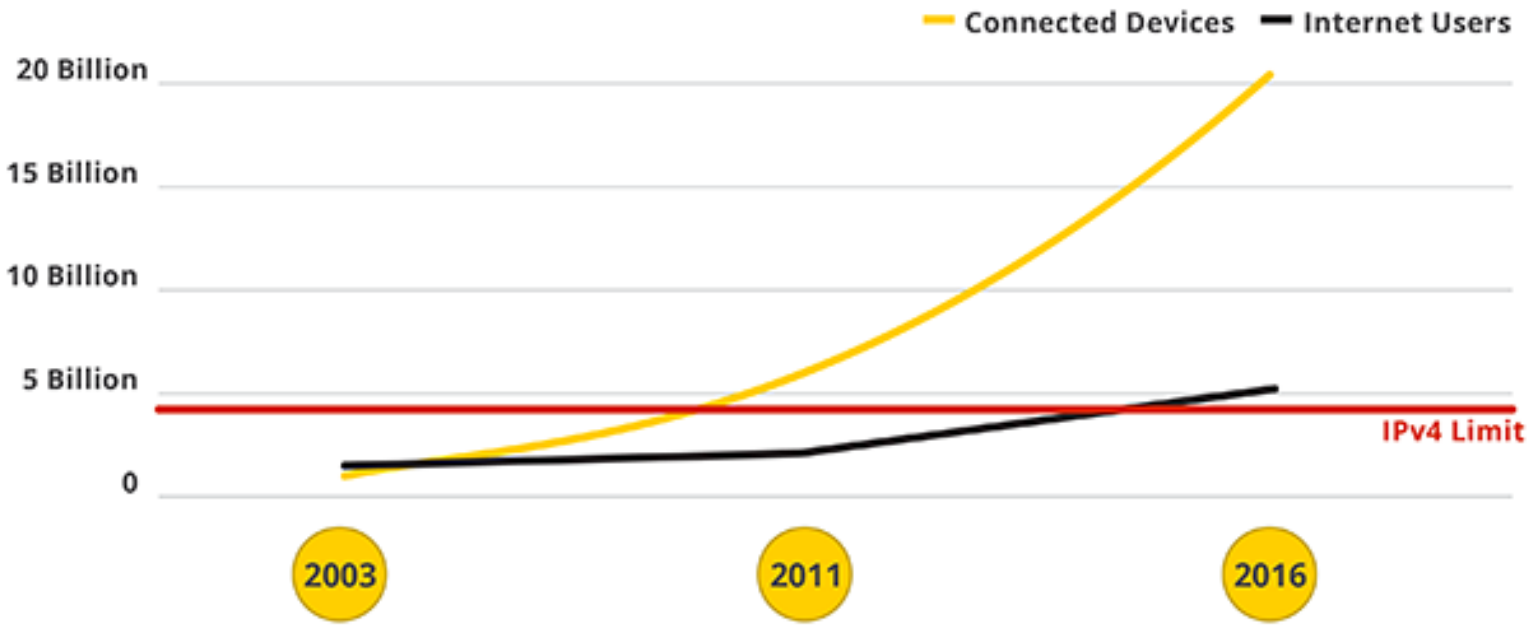
Objectives

- Share IPv4 exhaustion situation
  - How did we get here?
- Business and Technology Strategy for IPv6-only
- The Tactical Pieces
- Share perspective
  - IPv6 is needed for the Internet to grow
  - Dual-stack is not the answer (always…)
  - IPv6-only can work
  - User experience is key
- The road ahead
  - Let's talk about how to start an beta project

We are doing IPv6 because IPv4 is broken

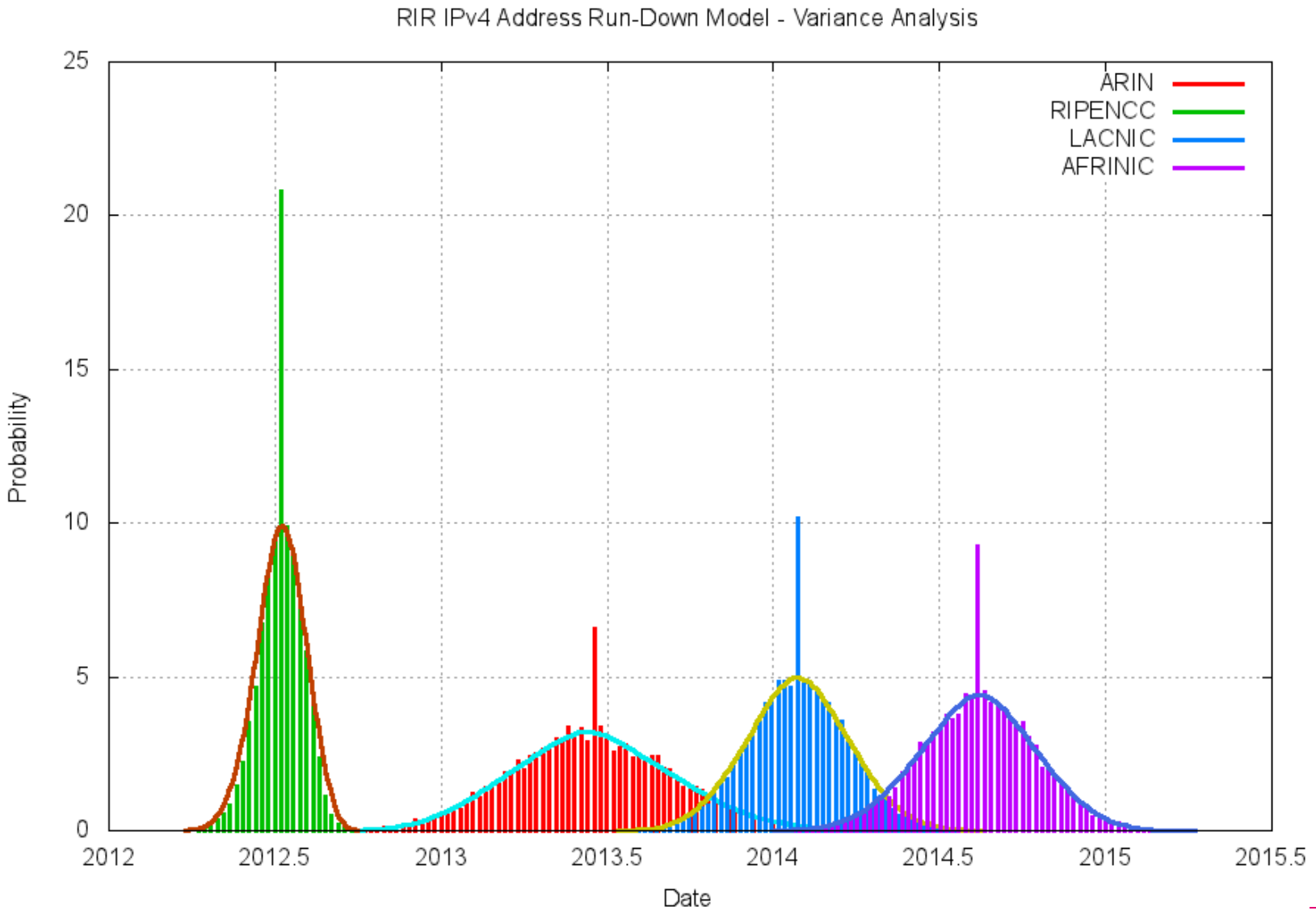
- Not enough addresses for everyone and everything
- NAT issues (CGN, ALG, Signaling / Battery drain, IMS …)
- BGP scale issues (fractured assignments)
- LTE voice (VoLTE) requires 2 IP addresses per handset– IP exhaustion just became 2x worse

Simply more internet device than internet addresses

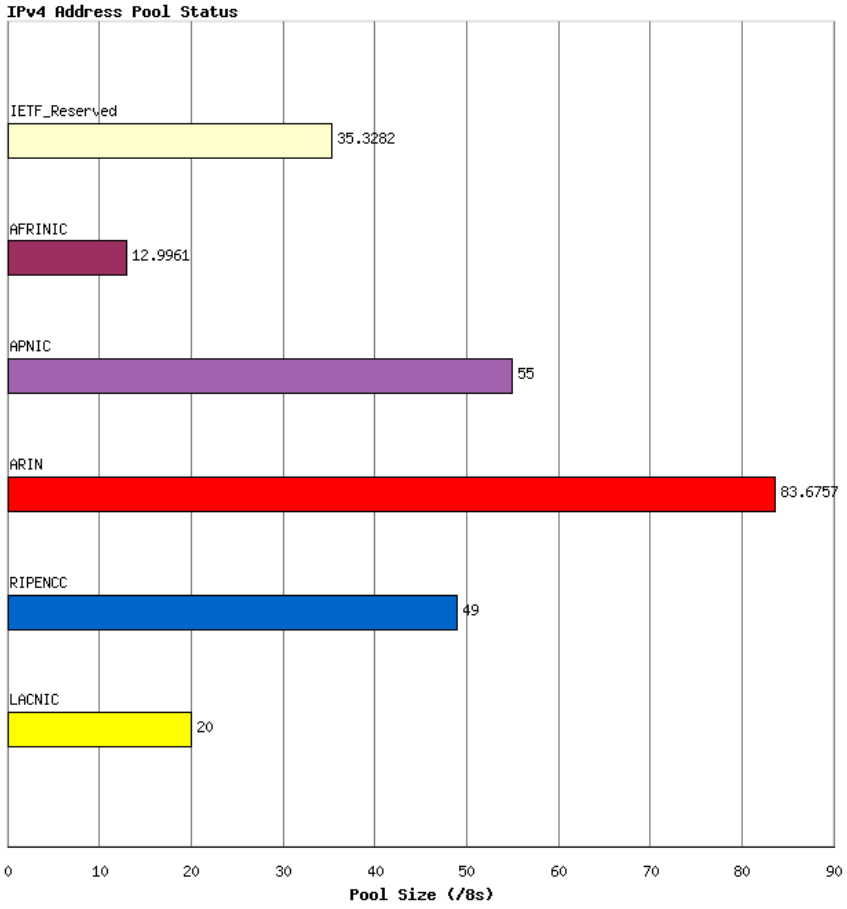


http://www.google.com/intl/en/ipv6/

http://www.potaroo.net/tools/ipv4/plotv



If you don't move to IPv6, who will you pay to get IPv4?



2011 – Number of mobile phones exceed number of people

solidated in developed countries, Brazil is still beginning its 3G experience – from carriers and suppliers as well as consumers. People are just starting to access the Internet through cellphones. In June, Brazil's mobile-phone penetration rate reached 111.6%, counting 217.3 million subscribers, a 17% increase compared to the 185.1 million customers in the second quarter of 2010. Brazil is Latin America's biggest market, which could explain high-level investments from international companies, such as Telefónica, Telecom Itália and América Móvil, as well as infrastructure manufacturers and device providers.

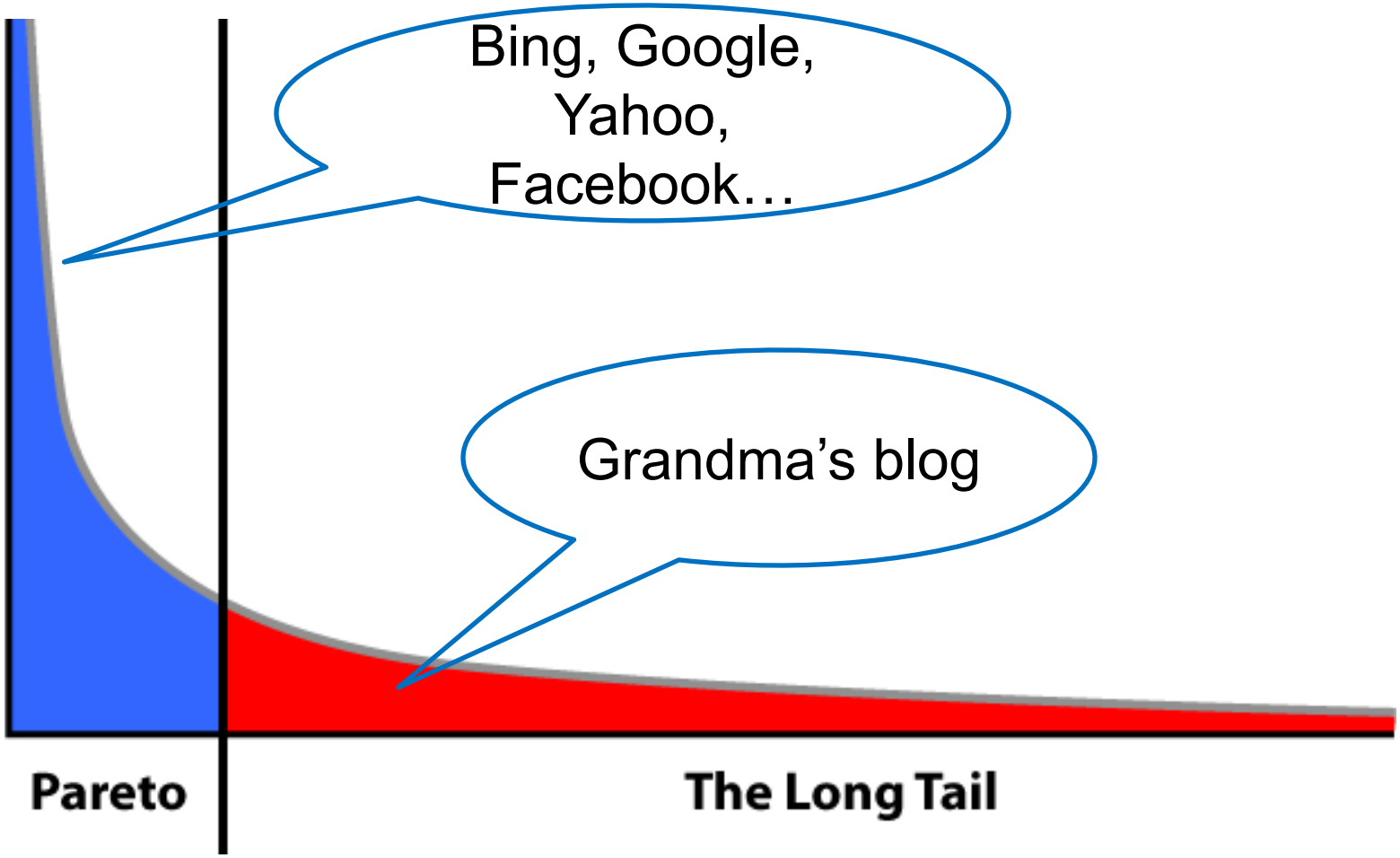
So IPv4 is broken, now what?

- It's not so much that IPv4 is broken, it is simply the case that IPv4 is not strategically aligned with your business's growth objectives
- Keep in mind Monday's presentations from LINX on Olympic scale and mobile growth

Is IPv6 ready?

- Yes: A meaningful and significant amount of access networks and content networks are using IPv6

A few big fish make IPv6 possible



IPv6 end-to-end is > 50% of total traffic to the Google, Yahoo, and Facebook

Participating website measurements are available here.

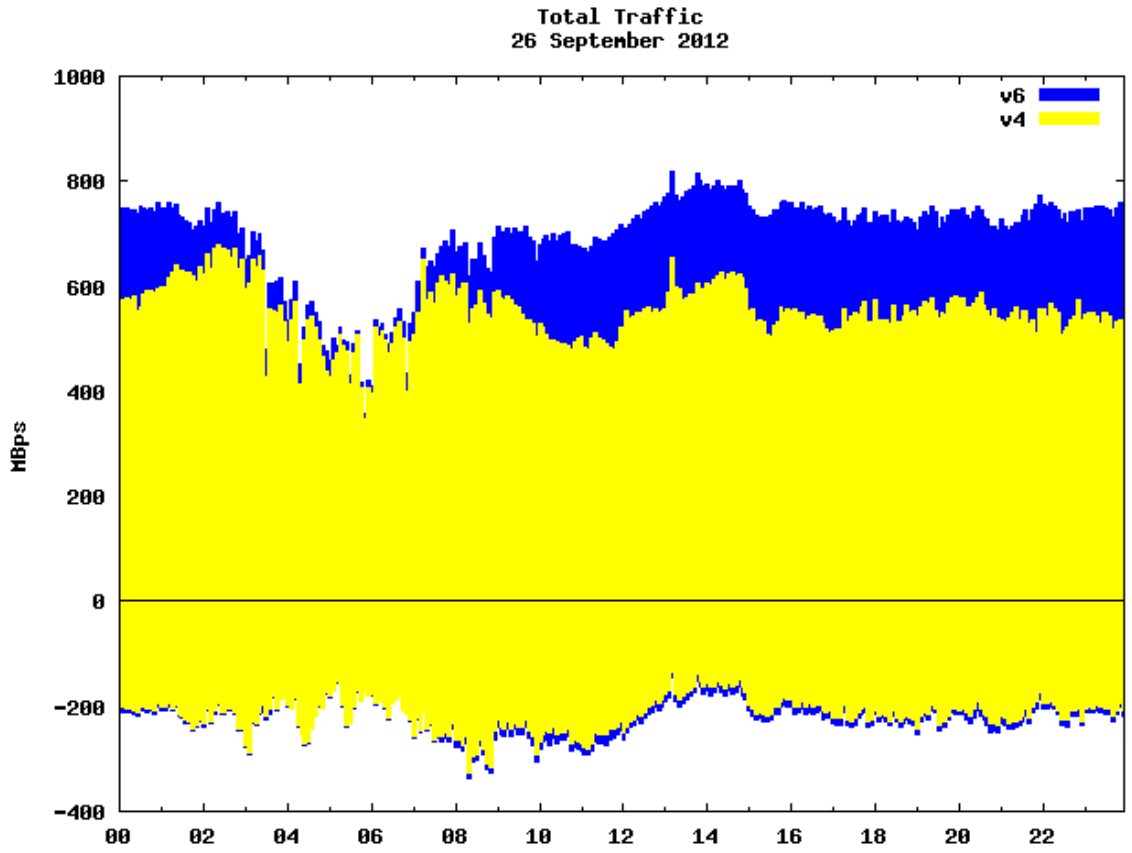
Network operator measurements, 16th November 2012 (notes)

Show 10 entries Search:

Participating Network	ASN(s)	IPv6 traffic
Louisiana State University	2055	63.70%
Virginia Tech	1312	61.47%
DreamHost	26347	56.73%
Rensselaer Polytechnic Institute	91	55.57%
US Dept of Transportation	2576	53.85%
Indiana University	87	42.31%
DMZGlobal	17649	39.96%
Gustavus Adolphus College	17234	38.19%
DegNet GmbH	20902	27.87%
University of Iowa	3676	23.96%

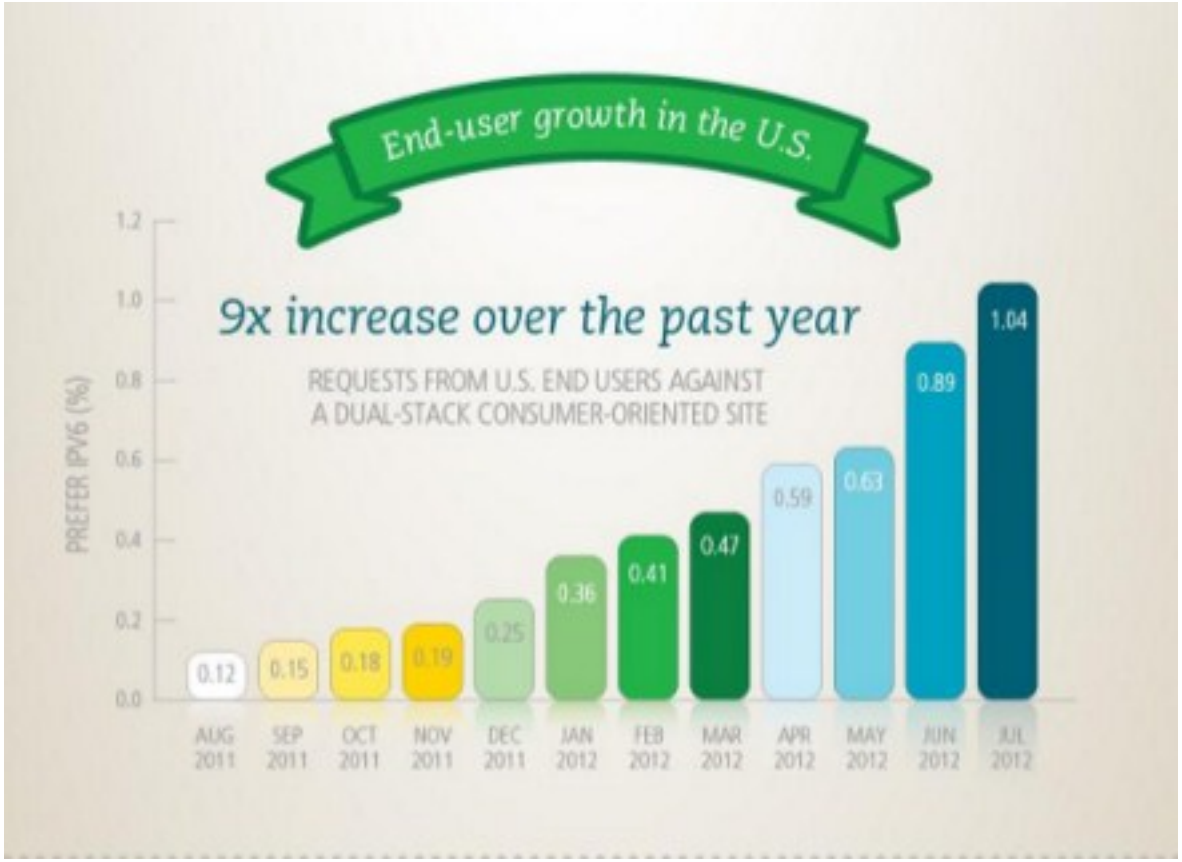
Showing 1 to 10 of 79 entries First Previous 1 2 3 4 5 Next Last

Virginia Tech v4 and v6 Traffic



http://www.flickr.com/photos/n3pb/8047086504/sizes/o/in/set-72157629740831445/

Akamai's view of IPv6 Growth



Conclusion #1

- IPv6 is ready and deployed on large mobile networks
  - The Verizon Wireless has IPv6 on by default for nearly all LTE devices
  - T-Mobile USA has IPv6 on GSM/UMTS optionally, and will have IPv6 by default in LTE
- When IPv6 is turned on, a large percentage of content is delivered over IPv6
  - Many IPv6 enabled networks reporting over 50% of traffic is IPv6 when the network is IPv6 and IPv4
  - Google and Akamai both reporting exponential growth in IPv6 use

So …

- IPv4 broken
- IPv6 is real
- What is the business strategy for getting to IPv6 and off of IPv4?

Strategy

"**skate** where
the **puck's going**,
not where it's been"

-- **Wayne Gretzky**

Strategy

IPv4 Tactical

IPv6
Strategic

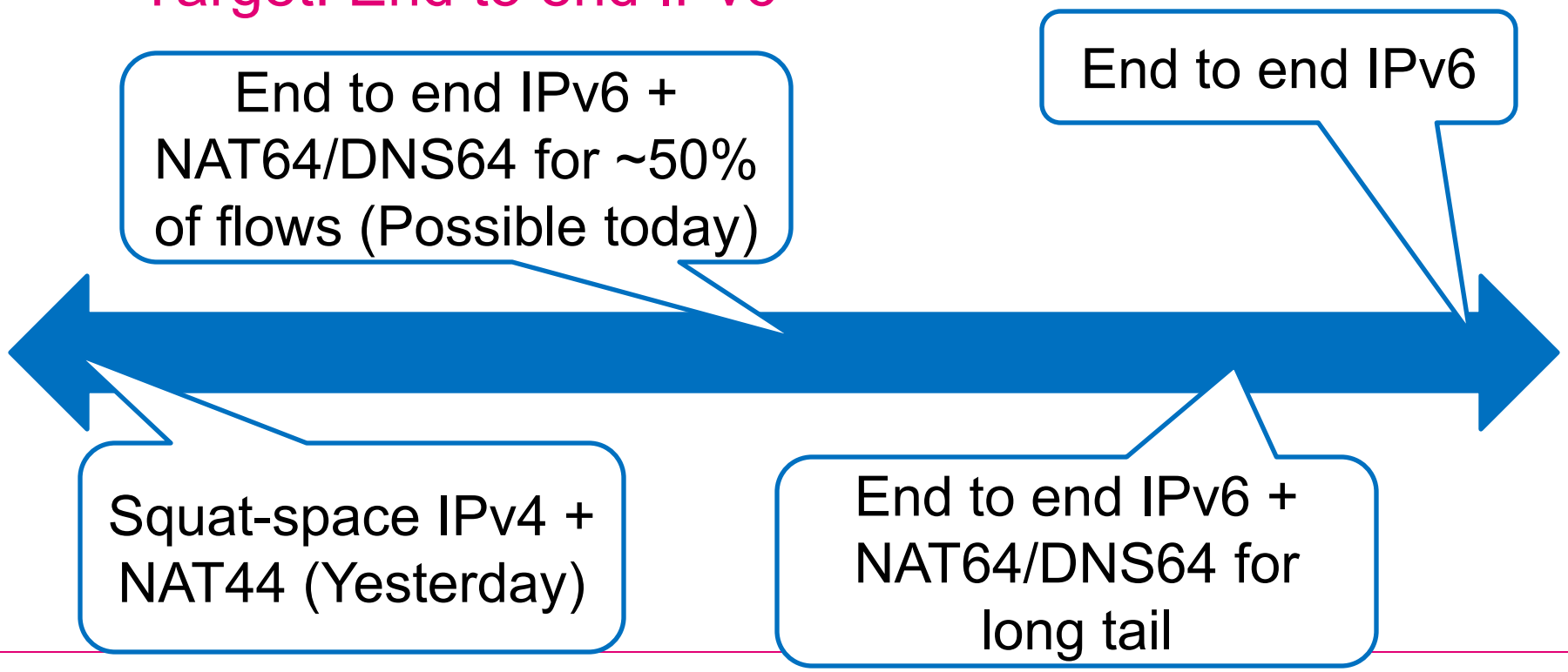
IPv4 Tactical

IPv6
Strategic

Strategy: Define desired result, and then work backwards

Problem: Global IPv4 exhaustion

Target: End to end IPv6



Everyone agree IPv4 is a dead-end for “strategy”?

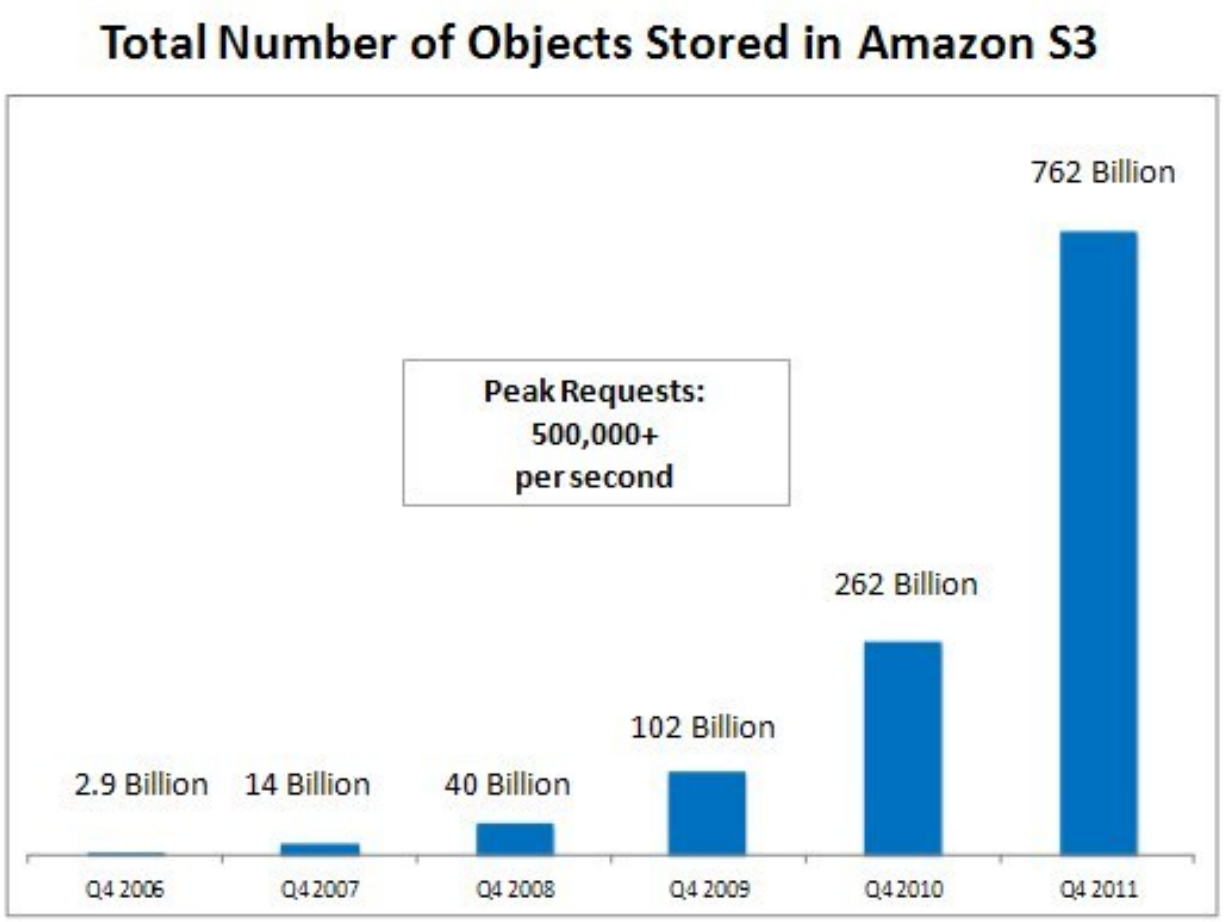
- Mobile
- Grid (m2m)
- Cloud

FAST GROWING EDGES THAT CAN ONLY GROW ON IPV6

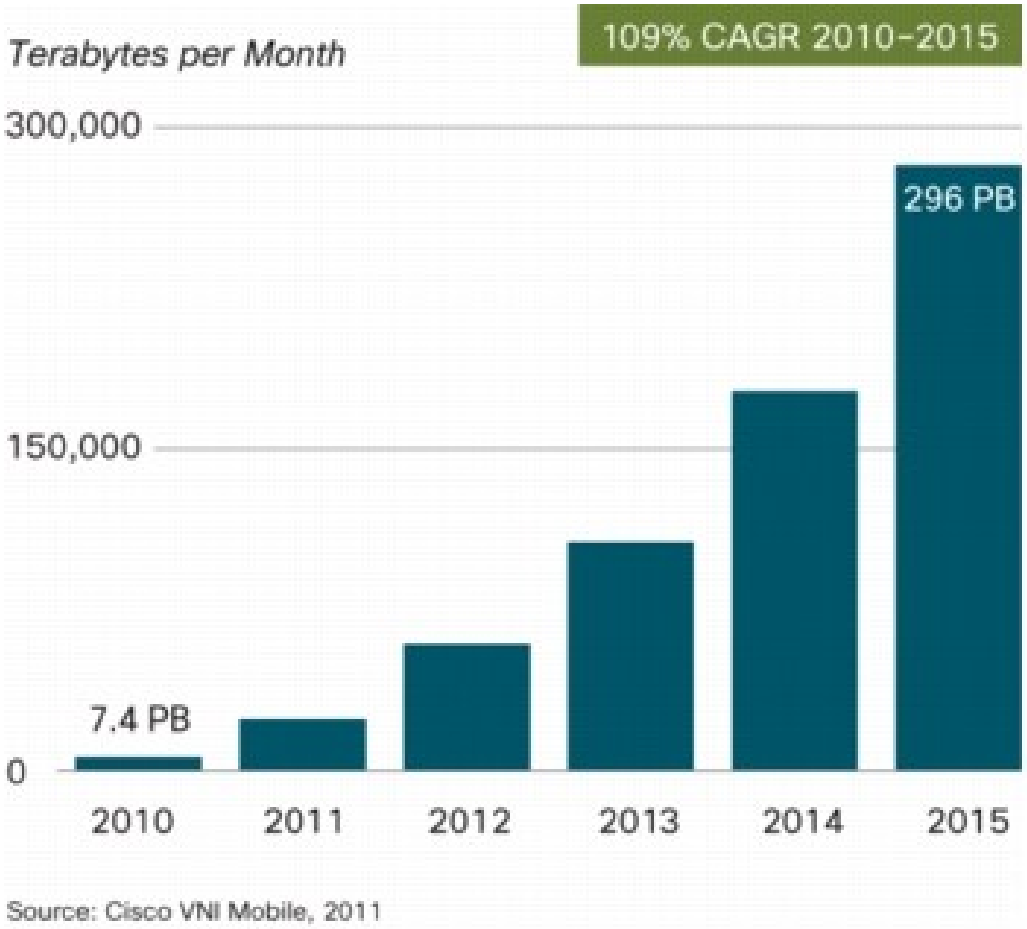
Migration steps

1. Public IPv4
2. ~~Private IPv4 + NAT44~~
3. ~~Private IPv4 + NAT44 + IPv6~~
4. IPv6 + 464XLAT / NAT64
5. IPv6

Amazon is big, and how many servers in Google? And why did Microsoft and Amazon.com *BUY* IPv4 addresses?



Machine-to-Machine Traffic to Increase 40-Fold Between 2010 and 2015



Nearly 6 Billion Mobile Subscribers

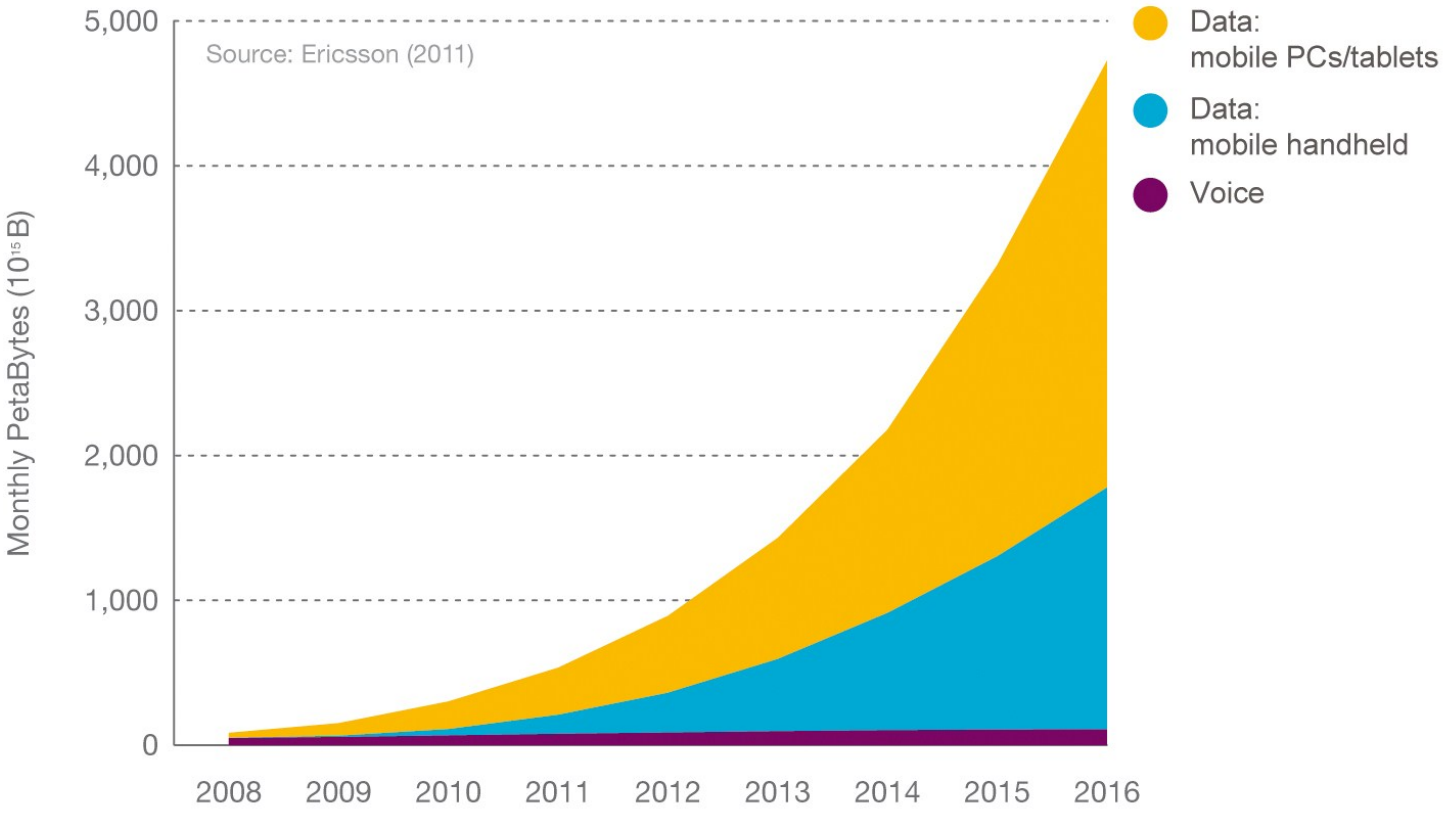
Key Global Telecom Indicators for the World Telecommunication Service Sector in 2011 (all figures are estimates)									
	Global	**Developed nations**	**Developing nations**	**Africa**	**Arab States**	**Asia & Pacific**	**CIS**	**Europe**	**The Americas**
Mobile cellular subscriptions (millions)	5,981	1,461	4,520	433	349	2,897	399	741	969
Per 100 people	86.7%	117.8%	78.8%	53.0%	96.7%	73.9%	143.0%	119.5%	103.3%
Fixed telephone lines (millions)	1,159	494	665	12	35	511	74	242	268
Per 100 people	16.6%	39.8%	11.6%	1.4%	9.7%	13.0%	26.3%	39.1%	28.5%
Active mobile broadband subscriptions (millions)	1,186	701	484	31	48	421	42	336	286
Per 100 people	17.0%	56.5%	8.5%	3.8%	13.3%	10.7%	14.9%	54.1%	30.5%
Fixed broadband subscriptions (millions)	591	319	272	1	8	243	27	160	145
per 100 people	8.5%	25.7%	4.8%	0.2%	2.2%	6.2%	9.6%	25.8%	15.5%
Source: International Telecommunication Union (November 2011)								**via: mobiThinking**	

Over 1 Billion Mobile Broadband Subscribers

- 45% annual growth over the last 4 years
- Mobile broadband subscriptions outnumber fixed by 2:1

Active mobile broadband subscriptions by region in 2010 and 2011 (2011 figures are estimates)									
	Global	**Developed nations**	**Developing nations**	**Africa**	**Arab States**	**Asia & Pacific**	**CIS**	**Europe**	**The Americas**
Active mobile broadband subscriptions 2011 (millions)	1,186	701	484	31	48	421	42	336	286
Per 100 people 2011	17.0%	56.5%	8.5%	3.8%	13.3%	10.7%	14.9%	54.1%	30.5%
Active mobile broadband subscriptions 2010 (millions)	870	569	301	20	36	289	31	254	224
Per 100 people 2010	12.6%	46.2%	5.3%	2.5%	10.2%	7.4%	11.2%	41.3%	24.1%
Source: International Telecommunication Union (November 2011)								**via: mobiThinking**	

Mobile Traffic Growth



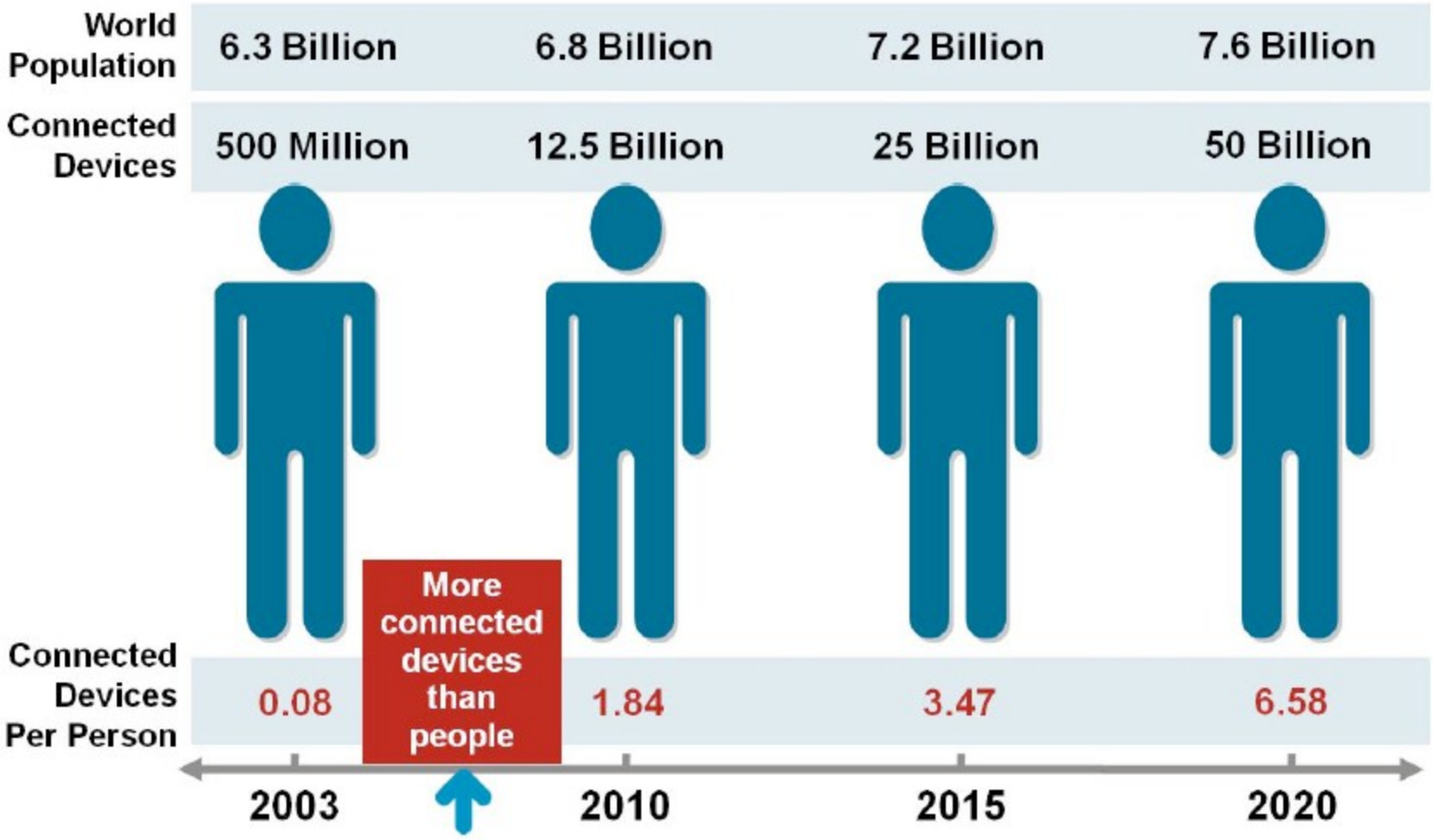
Review

- Mobile
- Grid
- Cloud

FAST GROWING EDGES THAT CAN ONLY GROW ON IPV6

We all have to engineer for IPv4-only, IPv6-only, and Dual-stack users and services

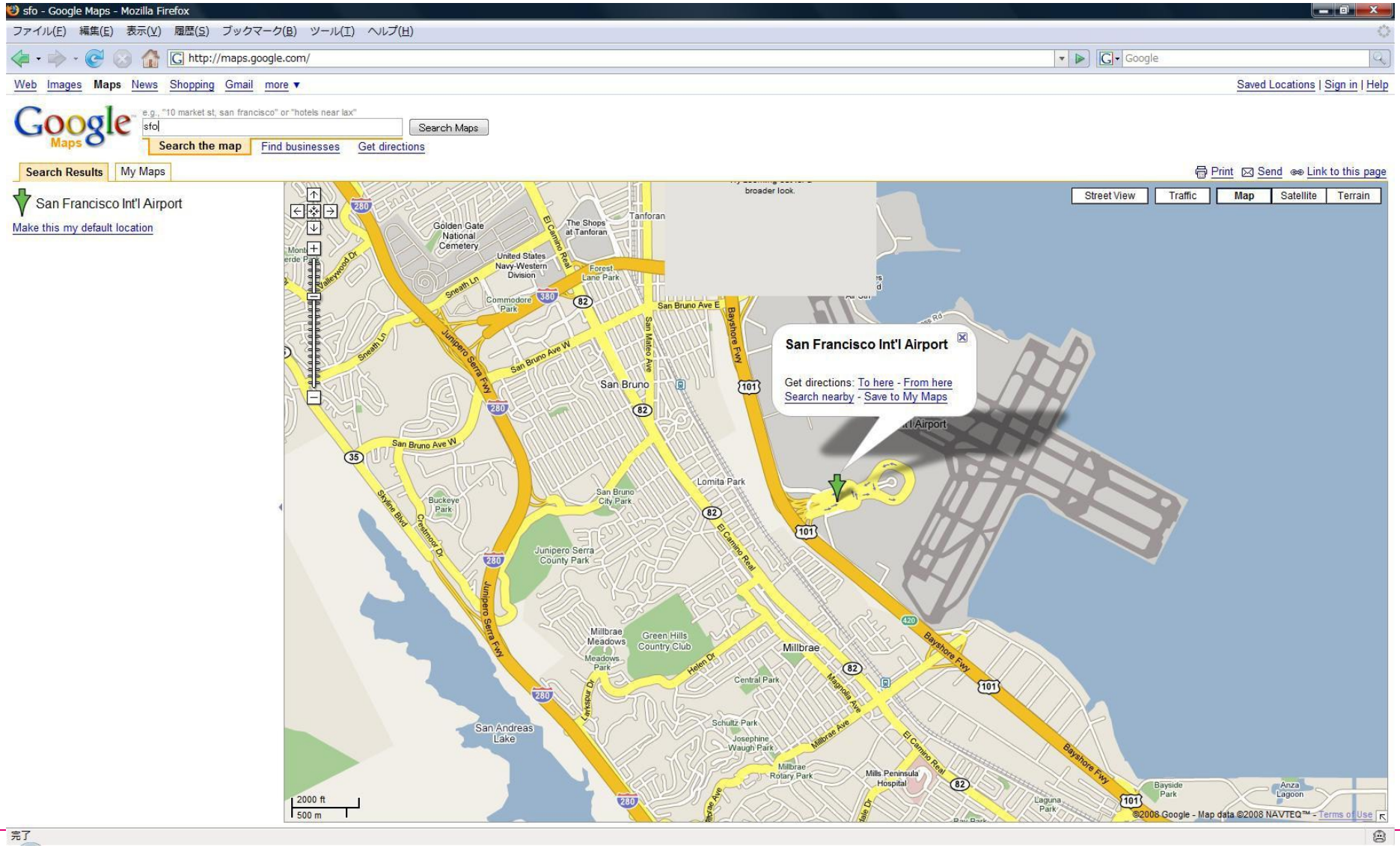
Total of 4.3 Billion IPv4 Addresses?



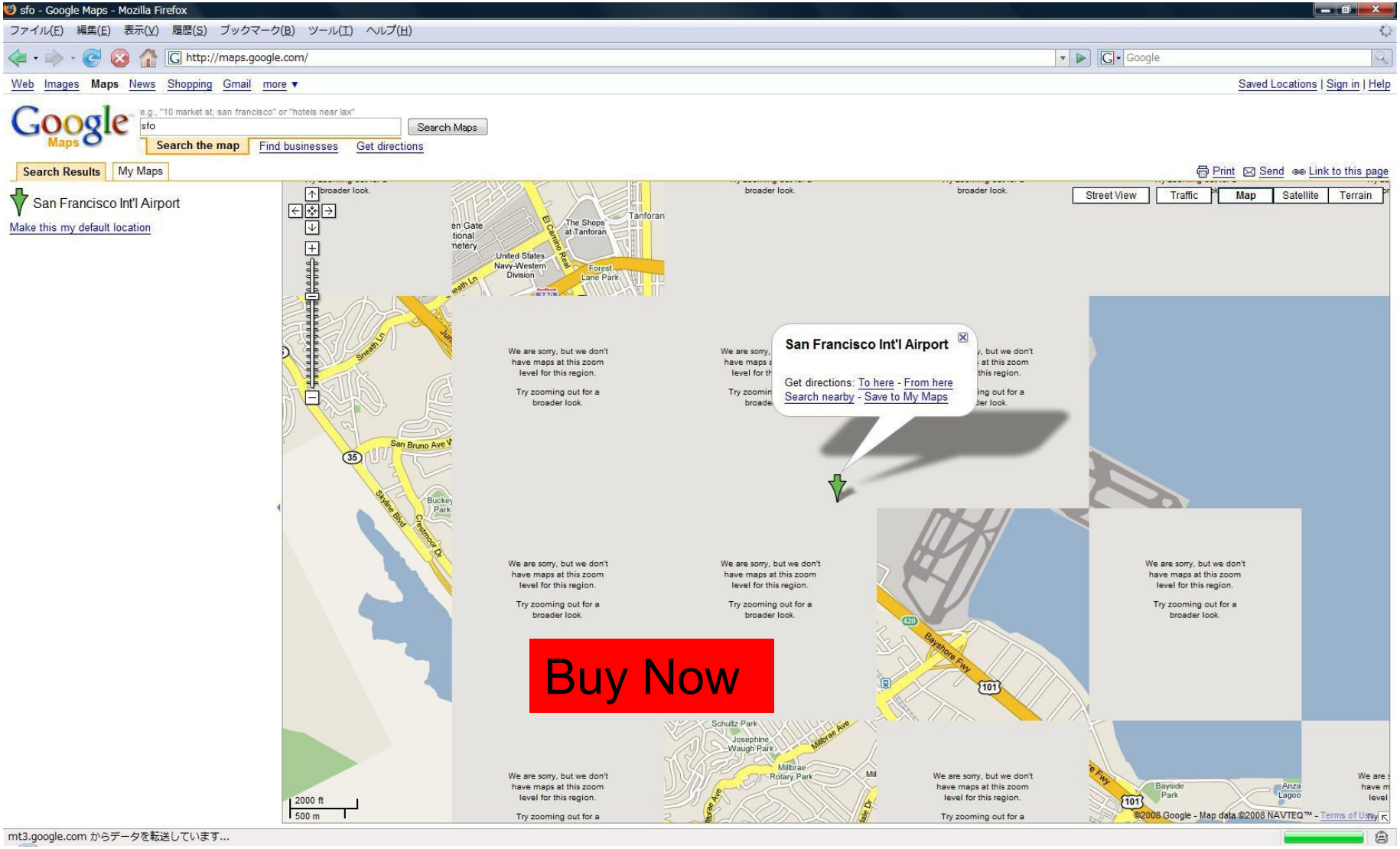
Source: Cisco IBSG, April 2011

20 Connections

http://www.nttv6.jp/~miyakawa/IETF72/IETF-IAB-TECH-PLENARY-NTT-miyakawa-extended.pdf



15 Connections

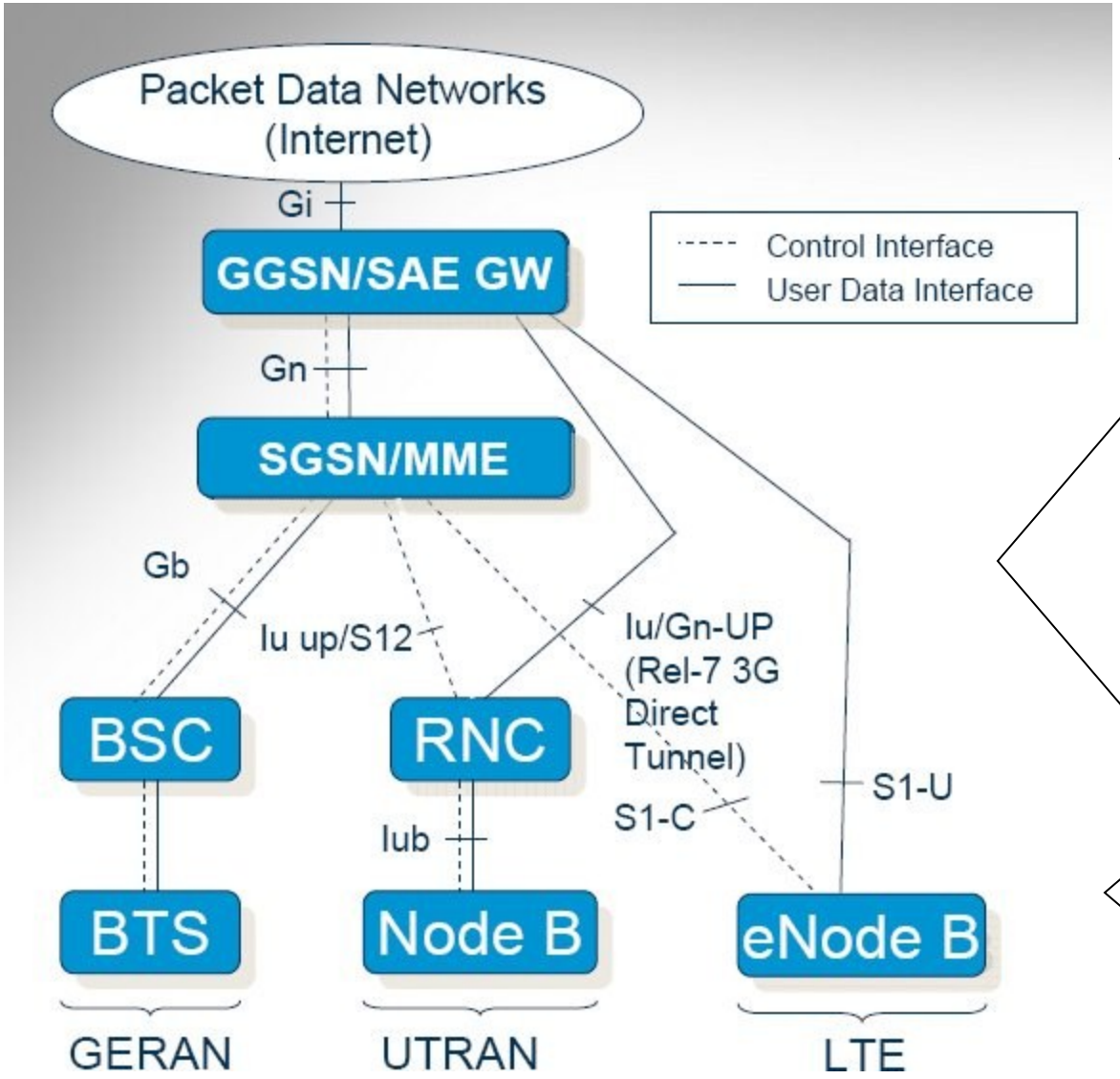


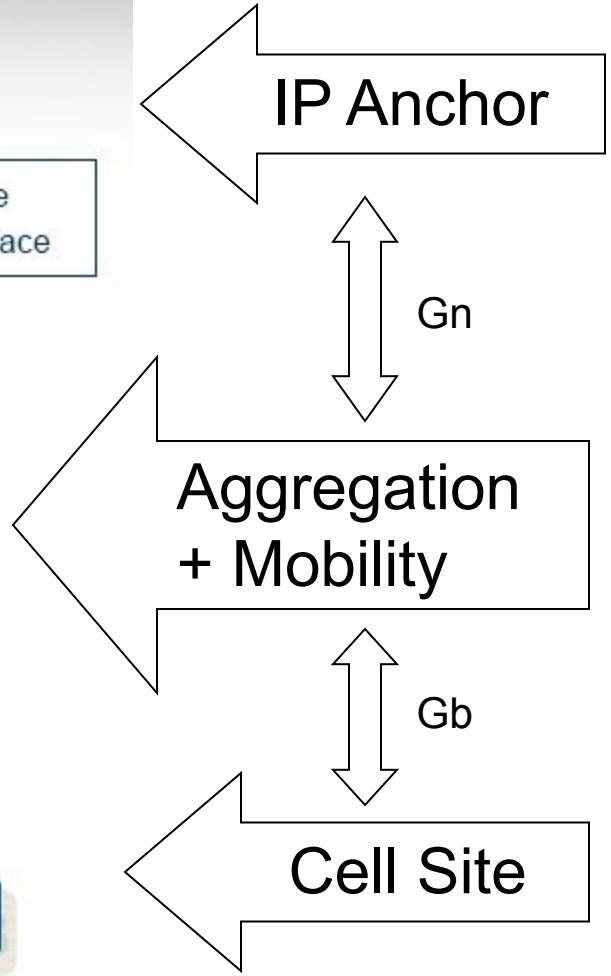
From a network perspective, what does a smartphone want?

Constant connection to 30+ clouds for updates

push notifications, advertisement streaming, real time communications

Quick Architecture Briefing





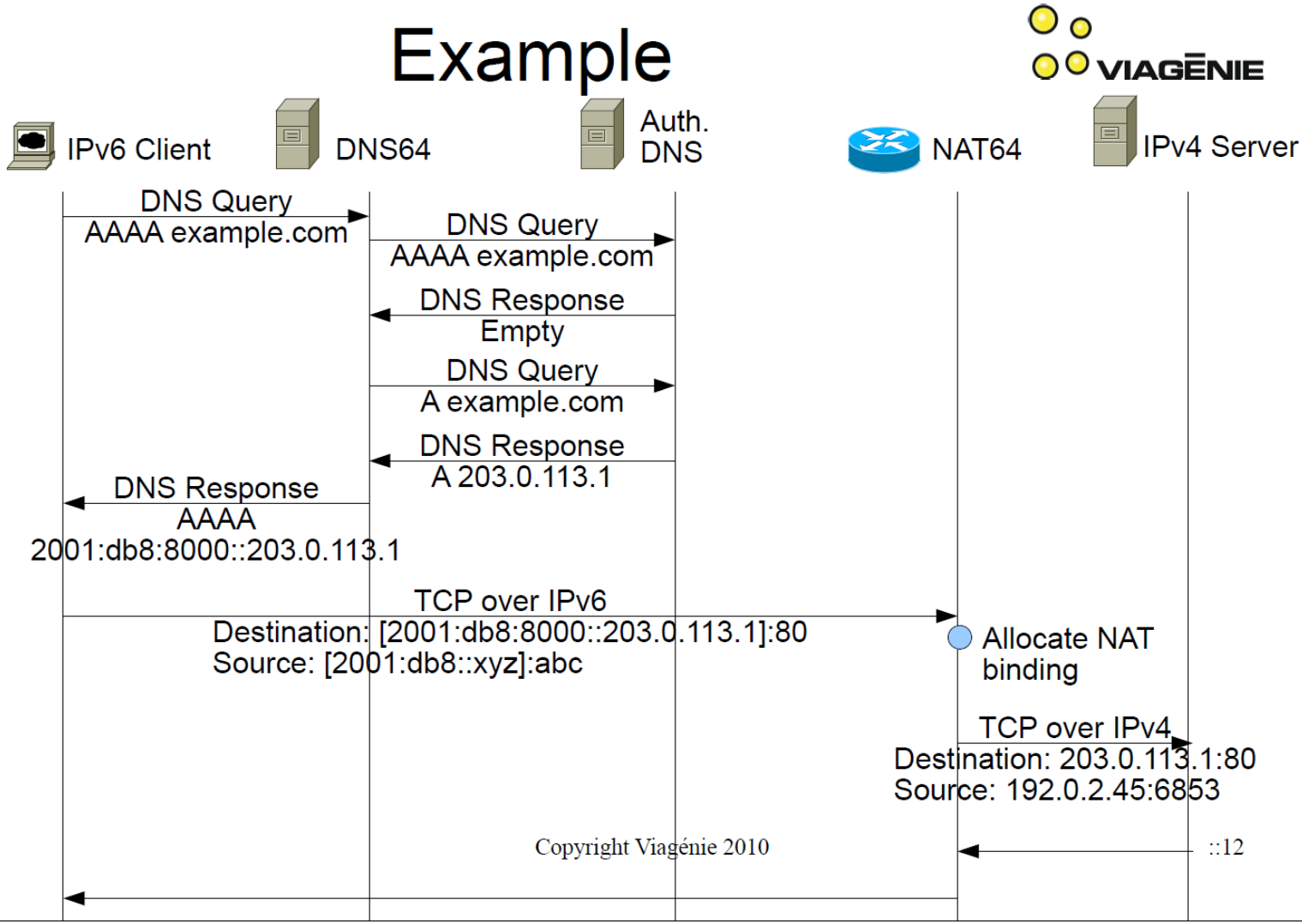
T-Mobile USA's Path to IPv6

(as a new service, incrementally per handset model deployment)

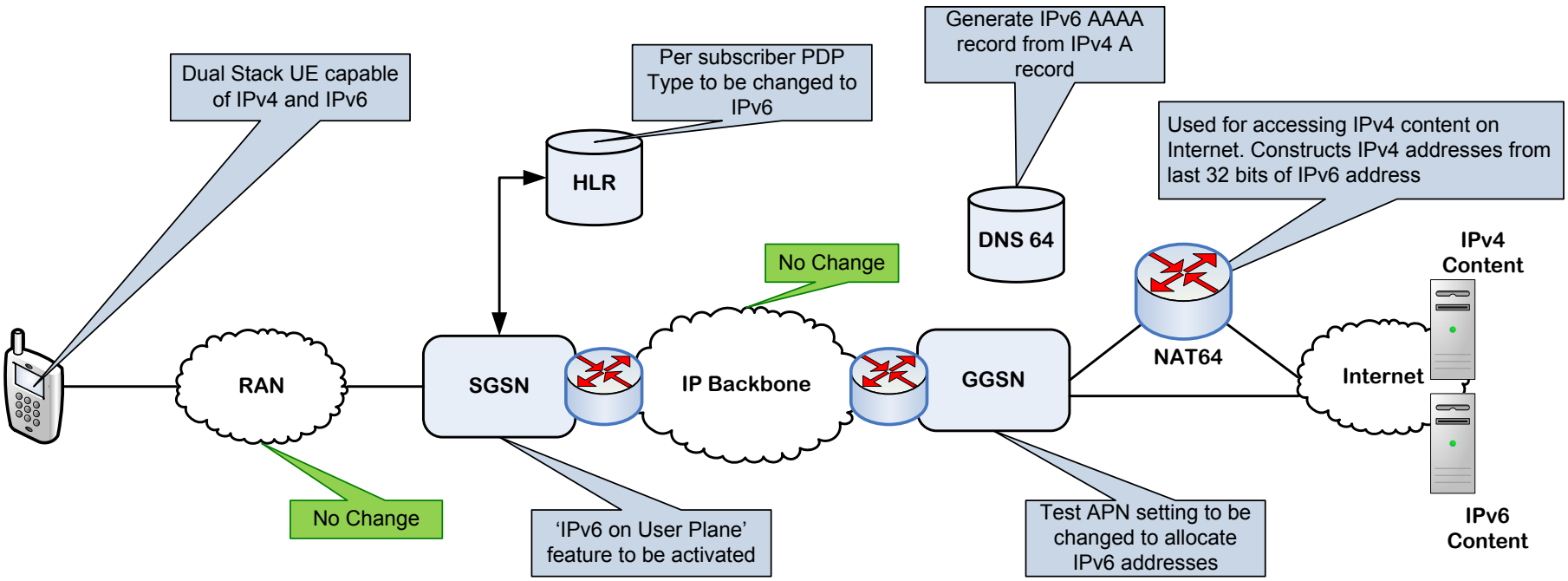
- Dual-stack + NAT44
  - Drives 2x the PDP and thus 2x the cost directly via contract or indirectly via utilization (bearer setup, mobility events …)
  - Relies on IPv4 addresses that legitimately are not available
  - Two different transports make troubleshooting at the user level more difficult, harder to isolate the variables
- ✓IPv6-only + NAT64/DNS64
  - ✓ Cost neutral for packet core (single PDP) and drives down cost of NATs as IPv6 content goes up (AAAA)
  - ✓ Familiar architecture to today (1 PDP + NAT function)
  - ✓ Enhances current NAT with DNS64 load steering functionality, NAT no longer must be "on path"
  - ✓ Positively incentivizes use of IPv6 in the content network to by-pass NAT

Brief on how NAT64 / DNS64 works

www.viagenie.ca/publications/2010-06-03-terena-nat64.pdf

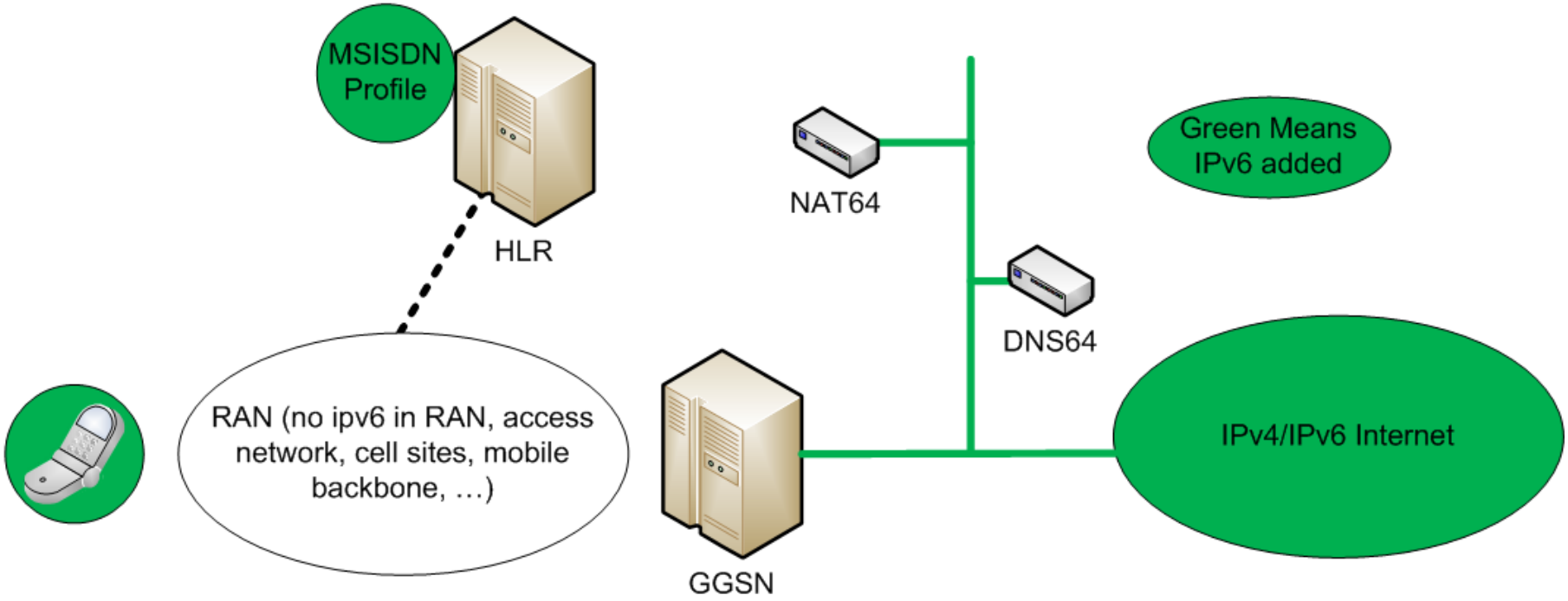


Impact to Network Entities



High Level View of IPv6 deployment:

Phone, HLR profile, GGSN, NAT64, IPv6 ISP



Step by step guide to turning IPv6 on in an IPv6 test APN in a mobile network

1. For a given user, enable IPv6 access to the APN in the HLR/HSS
2. Create an IPv6 APN on the GGSN
3. Install NAT64/DNS64 (open source OK)
4. Extend IPv6 ISP to GGSN Gi
5. Drink a beer
   - You just accomplished something, be happy
   - But, not you have to do the 99% of the work that is still in front of you

Findings From the Beta

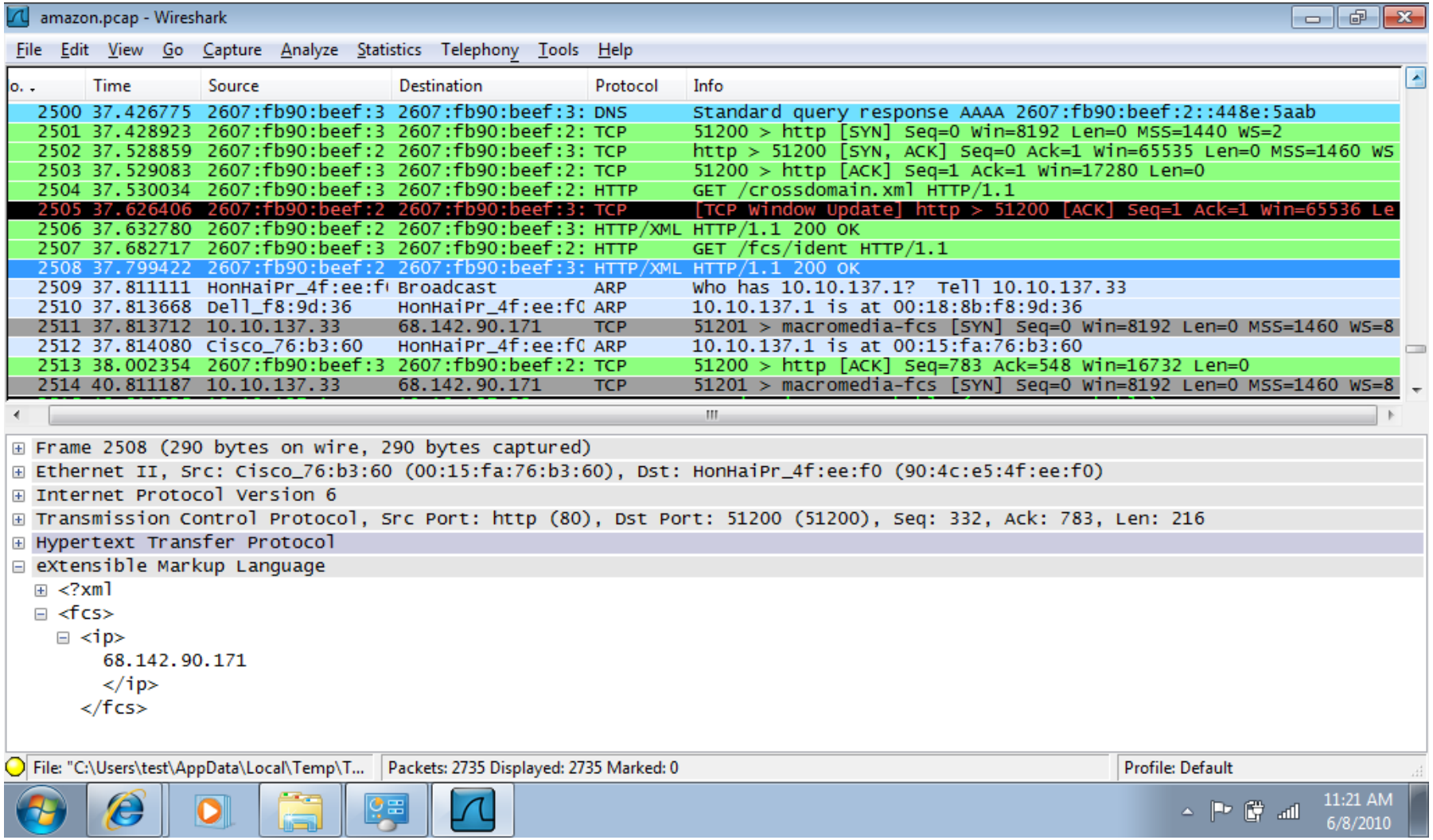
- ***Most things works fine***
  - Web, email, … work fine. No user impact
  - 85% of Android apps work fine, similar general experience with Symbian market (Ovi)
  - Apps are developed in modern SDKs with high-level APIs that work well with IPv6
- Some things don't work
  - Peer to peer communication using IPv4 referrals (Skype, MSN, …)
  - IPv4 literals http://10.1.1.1
  - IPv4 sockets APIs

But with 464XLAT, all things work with IPv6-only

What breaks in IPv6-only environments? goo.gl/z3j3q

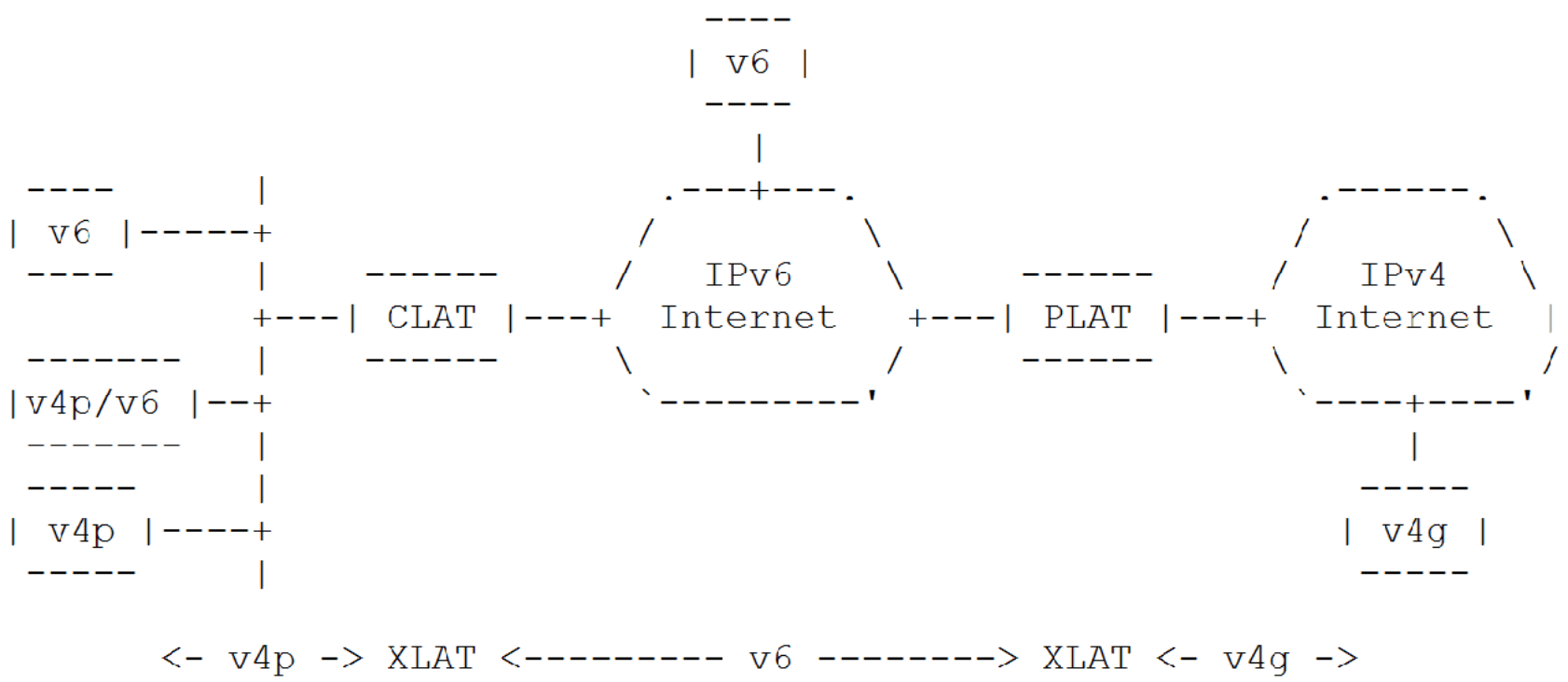
App Name	Functionality	Version	Description	Test Notes
connection tracker	Broken	NA	utilility	does not show ipv6 connections
Crackle	Broken	NA	Video	Does not play videos
DoubleTwist	Broken	1.6.3	media	cannot load radio station, says there is a network error
Go SMS Pro	Broken	NA	Social	sends SMS, but invites have ipv4 literals
Google Market	Broken	3.4.4.	shopping	says it cannot connect when downloading free song for purchase. It cannot load carrier billing agreement
Google Talk	Broken	4.0.3	communication	text chat works fine, but video chat fails to connect
Google+	Broken	2.3.0	social	status updates and instant upload, and IM works, but no video hangouts. Says it times out while connecting
Hotels.com	Broken	2.0.2	shopping	cannot load search, says error connecting
IP Track	Broken	NA	utilility	does not show ipv6
Last.fm	Broken	NA	music	cant create account, says network error
Lookout	Broken	7	utility	fails to login
Netflix	Broken	NA	video	fails to login
ooVoo	Broken	NA	communication	fails to login
Pirates of the Caribean	Broken	NA	game	says no network connection
Scrabble Free	Broken	1.12.57	game	cannot create account or find random opponent
Skype	**Broken**	2.6.0.95	communication	Cannot connect to Skype, will not sign in
Spotify	Broken	NA	music	unknown error 101
T-Mobile MyAccount	Broken	5.6.11	utilility	cannot get any data
Tango	Broken	NA	communication	fails to login
Texas Poker	Broken	NA	game	cannot connect to servers
TiKL	Broken	2.7	communication	fails to connect

The Face Of IPv4 Literals



How to make EVERYTHING work on IPv6-only?

http://tools.ietf.org/html/draft-ietf-v6ops-464xlat



Why should YOU deploy IPv6

- This project is good for your career
  - Internally, you will learn a lot about your own network and applications. Drive positive change within your organization
  - Externally, become part of the global network of IPv6 leaders
- "IPv6 operators forum" ipv6-ops@lists.cluenet.de
- v6ops@ietf.org

References

[1] 464 IETF Draft http://tools.ietf.org/html/draft-ietf-v6ops-464xlat

[2] T-Mobile USA IPv6 Beta http://goo.gl/HGmsy or https://sites.google.com/site/tmoipv6/lg-mytouch

[3] Open Source 464XLAT CLAT implementation on Android http://dan.drown.org/android/clat/

[4] T-Mobile USA Android Market Application Functionality http://goo.gl/z3j3q or https://docs.google.com/spreadsheet/ccc?key=0AnVbRg3DotzFdGVwZWlWeG5wXzVMcG5qczZEZloxWGc

[5] Write up on the T-Mobile USA IPv6 Service http://goo.gl/W55YQ or http://www.androidpolice.com/2012/01/29/t-mobile-usa-testing-ipv6-on-select-devices-here-is-what-it-all-means-and-yes-no-more-nat/