Six Years of Six:
Perspectives since the IPv6 Launch 2012

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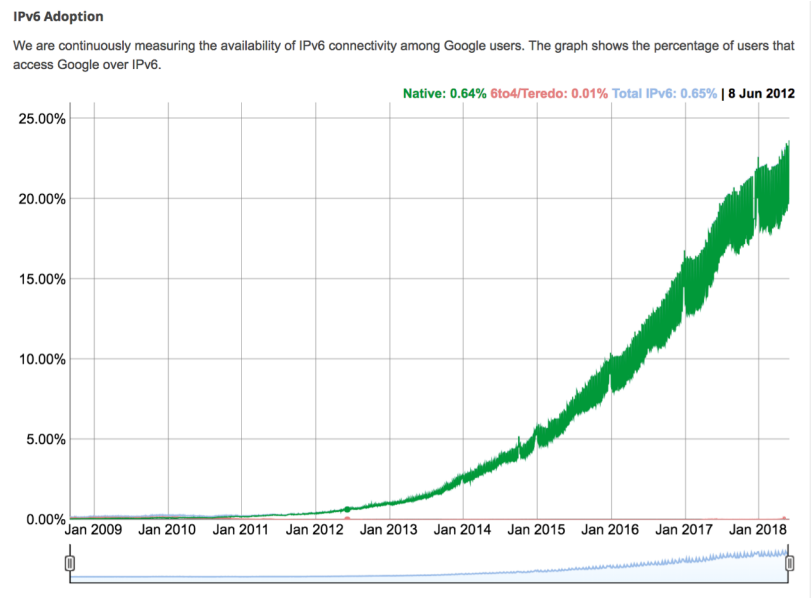
RIPE NCC::EDUCA IPv6 Day, 6 June 2018

Time flies!

- The World IPv6 Launch doesn't feel six years ago!
- Hard to consider IPv6 deployment globally was just 0.6% back then



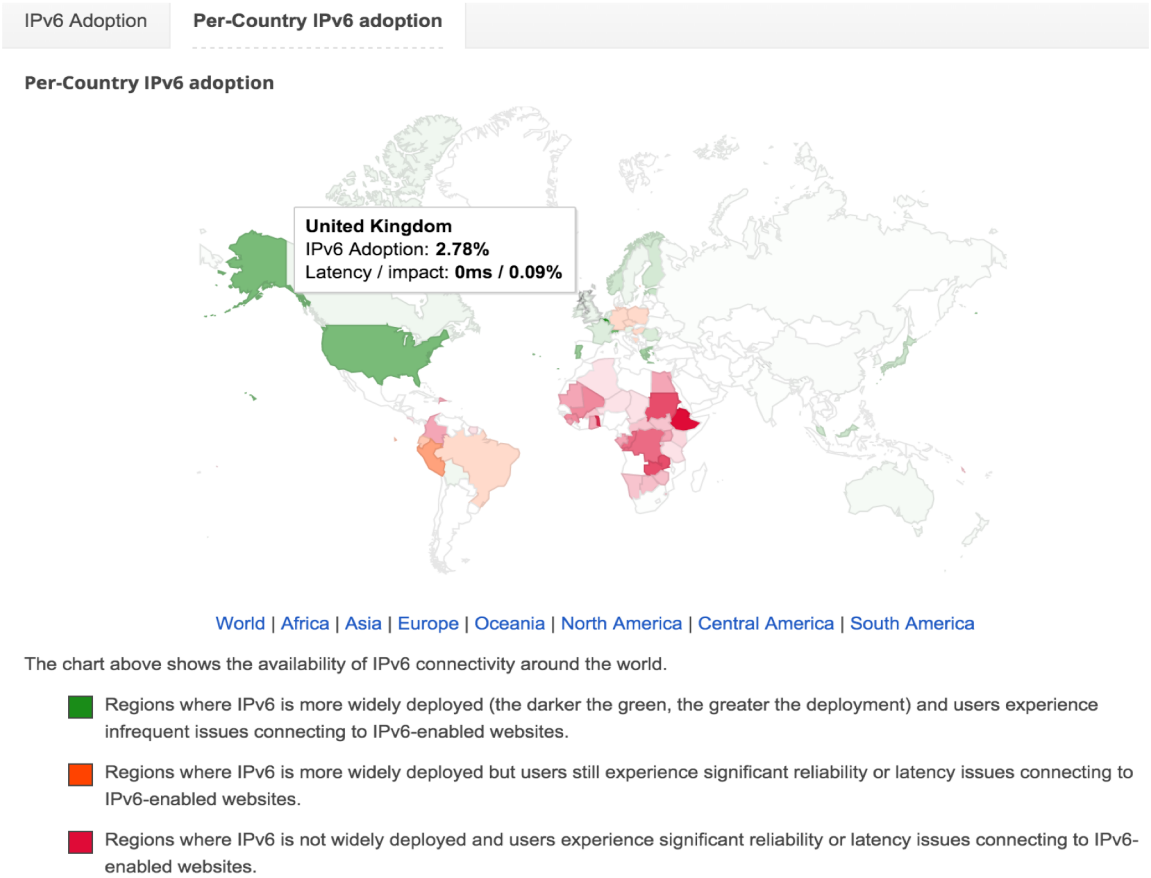
The barren BL years (Before Launch)

- There was a long tail of IPv6 activity before June 2012
  - Not least the World IPv6 Day in June 2011
  - The 6bone “Gordian Knot” of Tunnels ran from 1996
- IANA began handing out IPv6 address space in 1999
- Jisc, the UK NREN, was an early adopter in around 2002
  - The NRENs deployed early, e.g., through the 6NET project
  - Generally, just small ISPs deploying then, e.g., A&A in the UK
- All good work that has paved the way for today’s growth
- But up to 15 years of activity only led to that 0.6% adoption

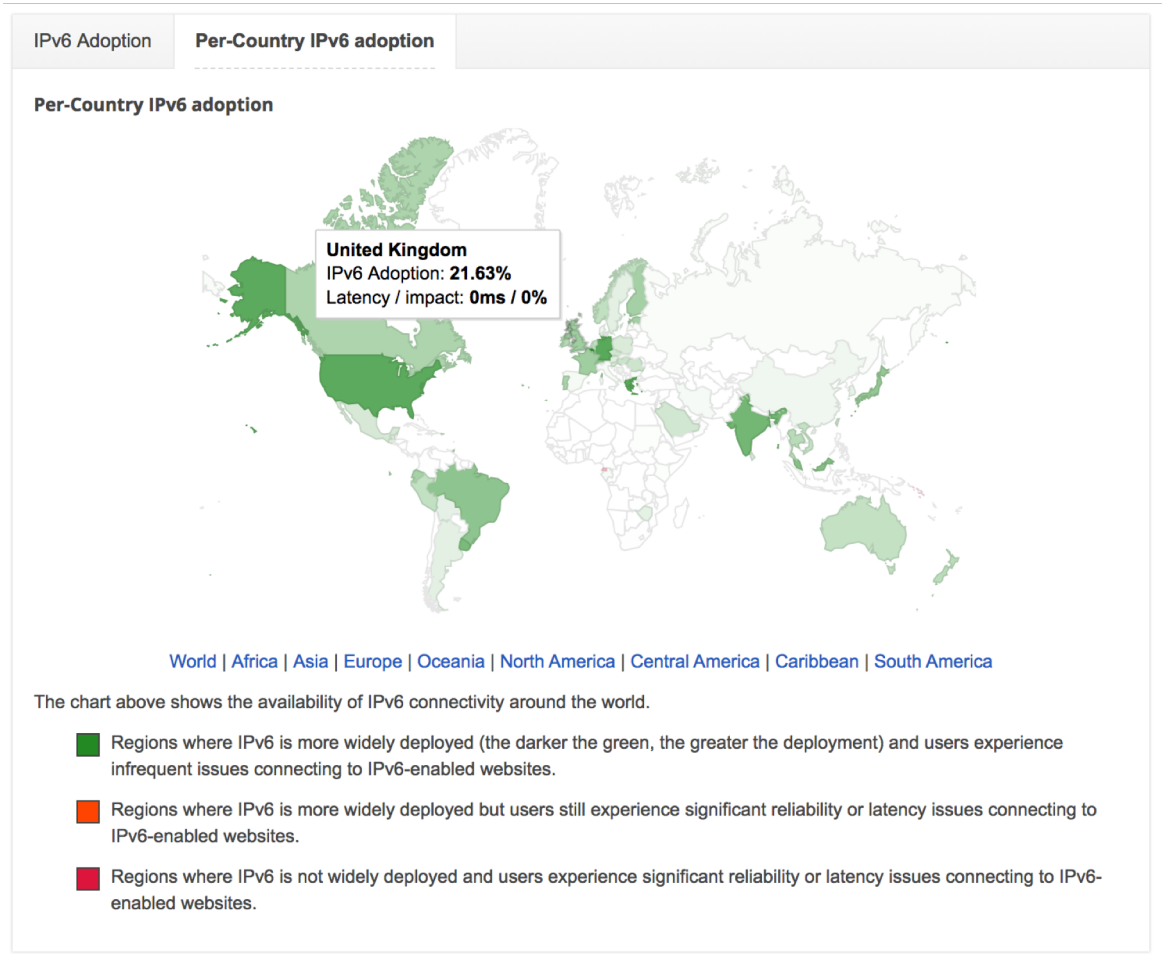
UK IPv6 Deployment Growth

- Today, UK IPv6 deployment is pretty much at the world average level
- Back in 2012, it was largely just Janet and some smaller ISPs
- That has grown to just over 20% deployment in 6 years
- Most of that growth has been in the last couple of years
- Sky UK were the first big ISP to move, with 5M+ customers
- BT not far behind, now at over 3M customers enabled
- EE/BT leading IPv6-only mobile, with 2M+ users; all EE 4G voice is over IPv6
- For info, see the UK IPv6 Council event material - http://www.ipv6.org.uk/
- Also see presentations at UKNOF – https://www.uknof.org.uk

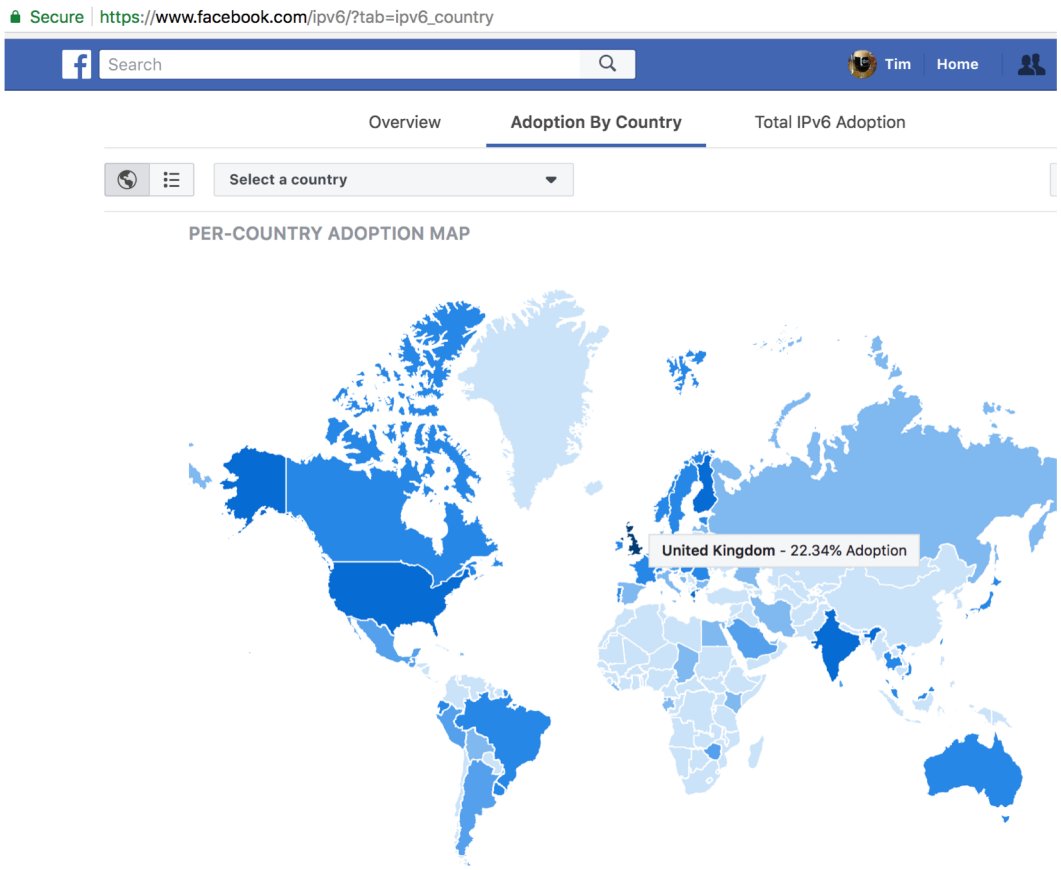
Google UK IPv6 stats, late 2015 (2.78%)



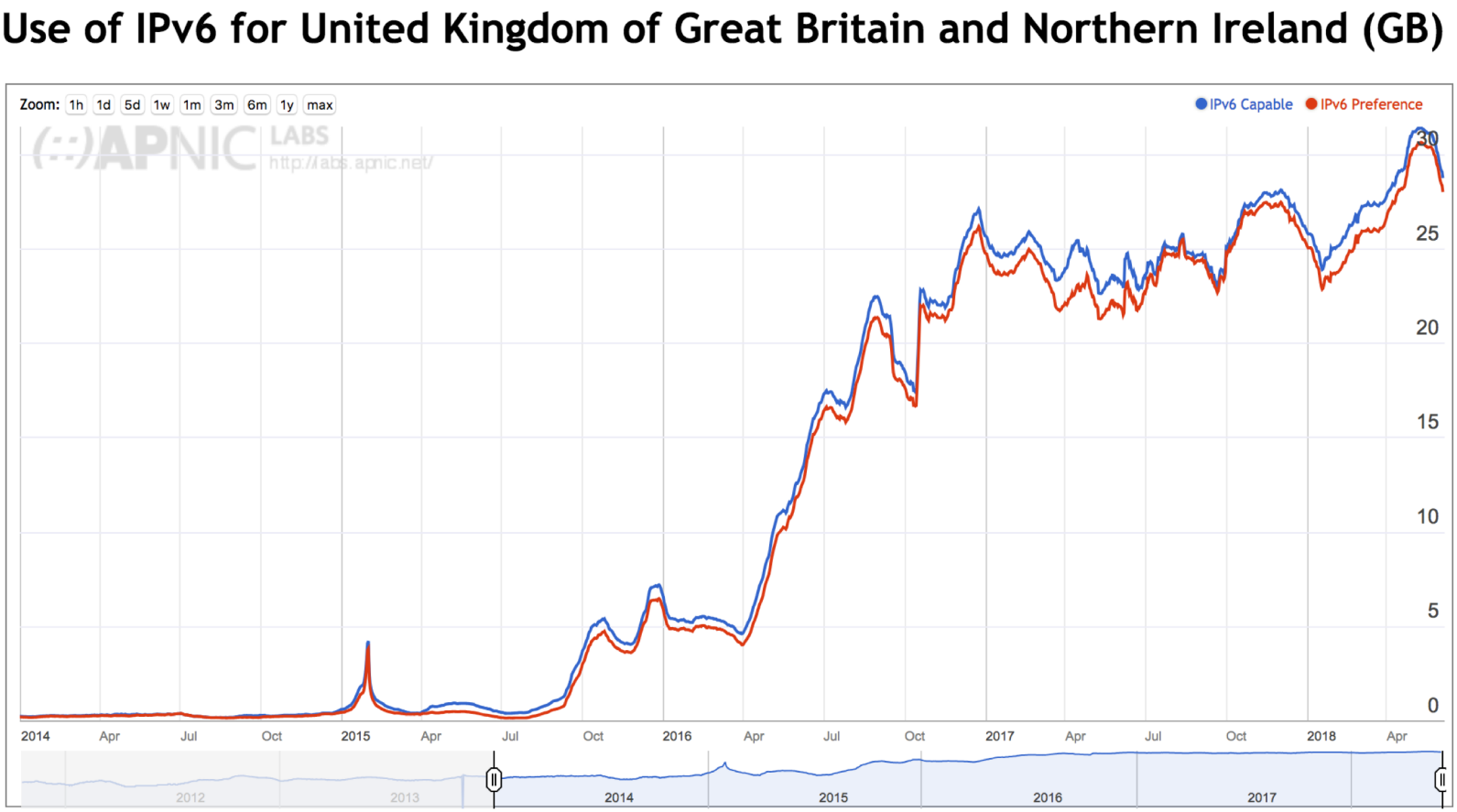
Google UK IPv6 stats, June 2018 (21.63 %)



New: Facebook UK IPv6 stats, June 2018 (22.34%)



APNIC UK IPv6 measurements



APNIC – UK IPv6 detail, by ASN / ISP

ASN	AS Name	IPv6 Capable	IPv6 Preferred	Samples
AS5607	BSKYB-BROADBAND-AS	93.02%	90.72%	1,145,008
AS5089	NTL	0.01%	0.01%	1,072,051
AS2856	BT-UK-AS BTnet UK Regional network	37.52%	36.84%	909,305
AS12576	ORANGE-PCS	8.50%	8.42%	319,939
AS9105	TISCALI-UK ISP Network, UK	0.01%	0.01%	215,633
AS13285	OPALTELECOM-AS TalkTalk Communications Limited	0.05%	0.05%	215,510
AS6871	PLUSNET UK Internet Service Provider	0.01%	0.01%	145,006
AS60339	H3GUK	0.18%	0.08%	111,956
AS43234	TT-AOLUK-AS	0.00%	0.00%	91,778
AS29180	O2-ONLINE-AS ripeo2.com 20170104	0.35%	0.15%	88,367
AS34825	ONAVO	0.01%	0.01%	85,686
AS5378		0.00%	0.00%	62,993
AS25135	VODAFONEUKASN	0.28%	0.10%	55,319
AS42831	UKSERVERS-AS UK Dedicated Servers, Hosting and Co-Location	0.01%	0.01%	51,089
AS14061	DIGITALOCEAN-ASN - DigitalOcean, LLC	0.63%	0.54%	42,768
AS786	JANET Jisc Services Limited	6.35%	6.18%	41,775
AS36351	SOFTLAYER - SoftLayer Technologies Inc.	0.32%	0.00%	29,121
AS12390	KINGSTON-UK-AS	0.00%	0.00%	25,210
AS31404	LYCATEL-AS	0.06%	0.02%	21,366
AS5413	AS5413	14.86%	14.16%	20,804
AS63949	LINODE-AP Linode, LLC	43.17%	42.45%	19,641

What about university/HE deployment?

Jisc

- IPv6 was deployed on Janet in 2002; Jisc was a partner on 6NET
- While there is a business case to be made, deployment is slow within universities; only a dozen or so with any notable deployment (of 160); at the very least it's important for teaching and research
- Having led the way, NRENs now overtaken by commercial ISPs
- But some interesting new deployment drivers are emerging
- For example, the requirement to support IPv6 for WLCG sites; storing experimental data from CERN for processing worldwide
- See HEPiX IPv6 WG - http://hepix-ipv6.web.cern.ch/
- In the UK, Imperial College takes in up to 40Gbit/s of CERN data over IPv6

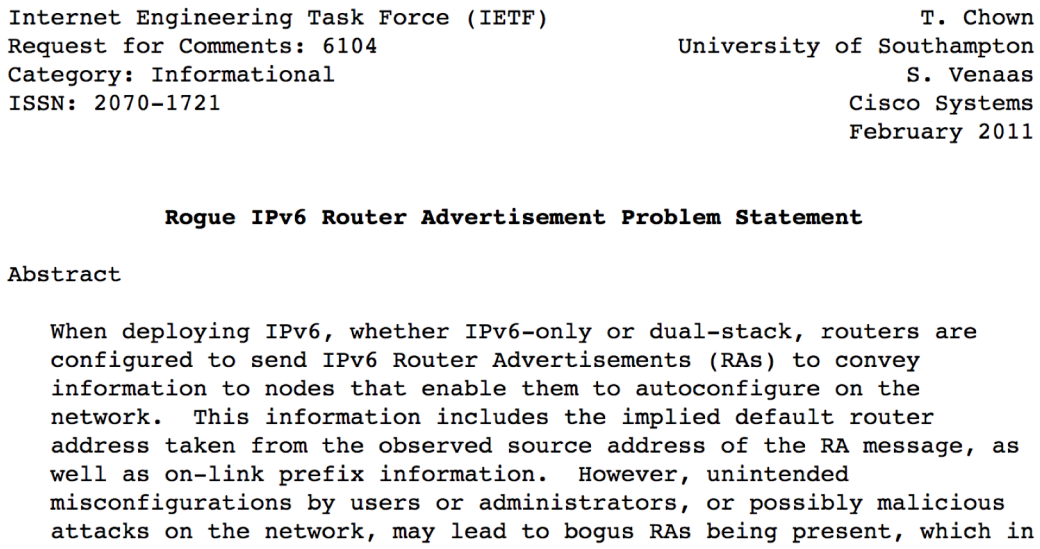
IPv6 in the IETF

- The IETF sets IPv6 standards
- The core IPv6 protocol document RFC 2460, published in 1998, was recently updated to RFC 8200 (moving to Internet Standard)
- That core standard has proven pretty stable over 20 years
- Experience coming from deployment; enhancements, changes in thinking
- Some amount of ongoing work in the 6man and v6ops WGs
- I've been a co-author on some Internet Drafts and subsequent RFCs

- It's interesting to see how we've moved from 2011/12 to today

Example: RFC 6104 (2011)

- Rogue IPv6 Router problem statement
- Implemented via RA Guard – but beware fragments! (RFC 6980, 7113)
- See https://labs.ripe.net/Members/jacky_hammer/lets-talk-about-rfc-6980



Internet Engineering Task Force (IETF) T. Chown
Request for Comments: 6104 University of Southampton
Category: Informational S. Venaas
ISSN: 2070-1721 Cisco Systems
February 2011

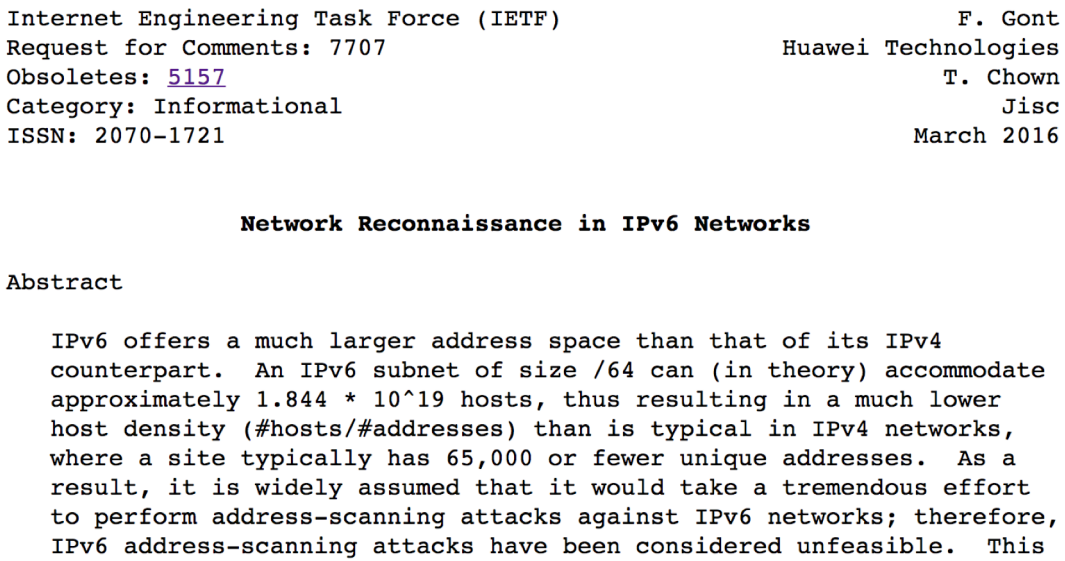
Rogue IPv6 Router Advertisement Problem Statement

Abstract

When deploying IPv6, whether IPv6-only or dual-stack, routers are configured to send IPv6 Router Advertisements (RAs) to convey information to nodes that enable them to autoconfigure on the network. This information includes the implied default router address taken from the observed source address of the RA message, as well as on-link prefix information. However, unintended misconfigurations by users or administrators, or possibly malicious attacks on the network, may lead to bogus RAs being present, which in

Example: RFC 7707 (2014)

- Network reconnaissance (scanning) in IPv6 Networks
- Not as infeasible as you might think, despite having 64-bit host subnets
- See for example https://www.si6networks.com/tools/ipv6toolkit/



Internet Engineering Task Force (IETF) — F. Gont
Request for Comments: 7707 — Huawei Technologies
Obsoletes: 5157 — T. Chown
Category: Informational — Jisc
ISSN: 2070-1721 — March 2016

Network Reconnaissance in IPv6 Networks

Abstract

IPv6 offers a much larger address space than that of its IPv4 counterpart. An IPv6 subnet of size /64 can (in theory) accommodate approximately 1.844 * 10^19 hosts, thus resulting in a much lower host density (#hosts/#addresses) than is typical in IPv4 networks, where a site typically has 65,000 or fewer unique addresses. As a result, it is widely assumed that it would take a tremendous effort to perform address-scanning attacks against IPv6 networks; therefore, IPv6 address-scanning attacks have been considered unfeasible. This

An active Internet Draft – RFC 6434-bis

- An update to RFC 6434 IPv6 Node Requirements (from 2011)
- A reflection of the enhancements to IPv6, and changes in IPv6 thinking, since the IPv6 Launch
- Authors – myself, Tim Winters, John Loughney

- Current draft is with the IESG for review
- https://tools.ietf.org/html/draft-ietf-6man-rfc6434-bis-08

- So, what sort of things have changed since 2011?

Ways to generate IPv6 addresses

- Original IPv6 stateless autoconfiguration (SLAAC) based on the hardware MAC address in the EUI-64 host part of the address
- RFC 4941 IPv6 Privacy Addresses help; allows host to initiate new connections with a randomized (non-predictable) interface identifier
- A problem is balancing privacy with ease of management
- RFC 7217 now allows SLAAC to use stable, per-prefix interface identifiers; you use the same IID when you revisit the same link (and prefix)
- RFC 8064 recommends that RFC 7217 is used for SLAAC, and against embedded stable link-layer identifiers in IPv6 IIDs
- You can still use privacy addresses with RFC 7217

Multiple global IPv6 addresses per host

- There has been growing interest in ensuring IPv6 hosts can use multiple global IPv6 addresses
- RFC 7934 recommends that networks provide general-purpose end hosts with multiple global IPv6 addresses; a SHOULD in 6434-bis
- RFC 8273 describes a deployment model supporting a Unique IPv6 Prefix per Host; advantageous for many scenarios, and provides improved host isolation in shared network segments
- Important: ISPs should consider supporting these RFCs; don’t just look to assign a single global IPv6 address

Configuring by RAs or DHCP?

- Quite a “religious” topic, with long mail threads!
- There is no DHCPv6 default gateway option, so a host can only learn about routers (and on-link prefixes) from router advertisements (RAs)
- In 6434-bis, we currently have RFC 8106 support a MUST (so hosts can configure DNS from an RA) and DHCPv6 client support a SHOULD
- 6434-bis also says hosts SHOULD support RFC 7844 anonymity profiles for privacy when using DHCPv6
- Remember that Snowden hadn’t happened as of the World IPv6 Launch; the IETF has pushed privacy a lot since then (see RFC 7258)

Some other new things in 6434-bis

- Coverage of constrained devices, 6LoWPAN – important for IoT
- Related – RFC 7772 – power consumption recommendations
- MLDv2 made a MUST – for SSM support for multicast – to avoid the need to use ASM interdomain
- Inclusion of RESTCONF and NETCONF for network management
- Text on the /64 boundary – RFC 7421; quite a lot of discussion on how “hard” the /64 boundary is; this RFC explains the rationale, but this is another source of lengthy email discussions!

Some closing comments

- We've come a long way since June 2012 – it's great to celebrate this!

- There's still a long way to go, and IPv4 will be around for a long time
- The core IPv6 protocols have been pretty stable
- Deployment experience has resulted in many enhancements to IPv6, and some changes in IPv6 thinking
- There's (always) important security work to do

- Go forth and deploy!