IPv6

Enzo Mingozzi
Professor @ University of Pisa
e.mingozzi@iet.unipi.it

Motivation for IPv6

- IPv4 address space limitation
  - In 1994, the *IETF Address Lifetime Expectation* working group projected IPv4 address exhaustion sometime between 2005 and 2011 based on the available statistics
- RFC 1883, "Internet Protocol, Version 6 (IPv6) Specification" was published in 1995
  - The core set of IPv6 protocols became an IETF Draft Standard on August 10, 1998. This included RFC 2460, which obsoleted RFC 1883
  - IPv6 finally became an Internet Standard in July 2017 (RFC 8200) – really nothing changes, combined version of RFC 2460 along with other relevant RFCs and Errata

Motivation for IPv6

- IPv4 address space depletion (theoretical limit: 4.3 billions addresses)
  - Fast growth of Internet users (much faster than projected)
  - Inefficient allocation (also because of the IPv4 address space hierarchical organization)
- Why then IPv6 is not yet "the" current Internet protocol? Because of IPv4 "patches"
  - Variable Length Subnet Mask (VLSM) and Classless Interdomain Routing (CIDR)
  - Network Address Translation (NAT)

Motivation for IPv6

WORLD INTERNET USAGE AND POPULATION STATISTICS 2021 Year-Q1 Estimates						
World Regions	Population (2021 Est.)	Population % of World	Internet Users 31 Mar 2021	Penetration Rate (% Pop.)	Growth 2000-2021	Internet World %
Asia	**4,327,333,821**	54.9 %	**2,762,187,516**	63.8 %	2,316.5 %	53.4 %
Europe	**835,817,920**	10.6 %	**736,995,638**	88.2 %	601,3 %	14.3 %
Africa	**1,373,486,514**	17.4 %	**594,008,009**	43.2 %	13,058 %	11.5 %
Latin America / Carib.	**659,743,522**	8.4 %	**498,437,116**	75.6 %	2,658.5 %	9.6 %
North America	**370,322,393**	4.7 %	**347,916,627**	93.9 %	221.9 %	6.7 %
Middle East	**265,587,661**	3.4 %	**198,850,130**	74.9 %	5,953.6 %	3.9 %
Oceania / Australia	**43,473,756**	0.6 %	**30,385,571**	69.9 %	298.7 %	0.6 %
WORLD TOTAL	**7,875,765,587**	**100.0 %**	**5,168,780,607**	**65.6 %**	**1,331.9 %**	**100.0 %**

Source: http://www.internetworldstats.com/stats.htm

Motivation for IPv6

- Not only more users, but also more devices per user
  - "The other [milestone] is the growing demand for Internet addresses to be assigned to mobiles, set-top boxes, automobiles, and literally tens of billions of other programmable devices. This is the so-called ***Internet of Things***" – Vint Cerf, Internet Pioneer
- Always-on access
- Applications that are difficult, expensive or impossible to operate through NAT
  - IP telephony, peer-to-peer gaming, …

Motivation for IPv6

- IPv4 address space top-level depletion already happened!

COMPUTERWORLD

Home > Internet

News

Address allocation kicks off IPv4 endgame

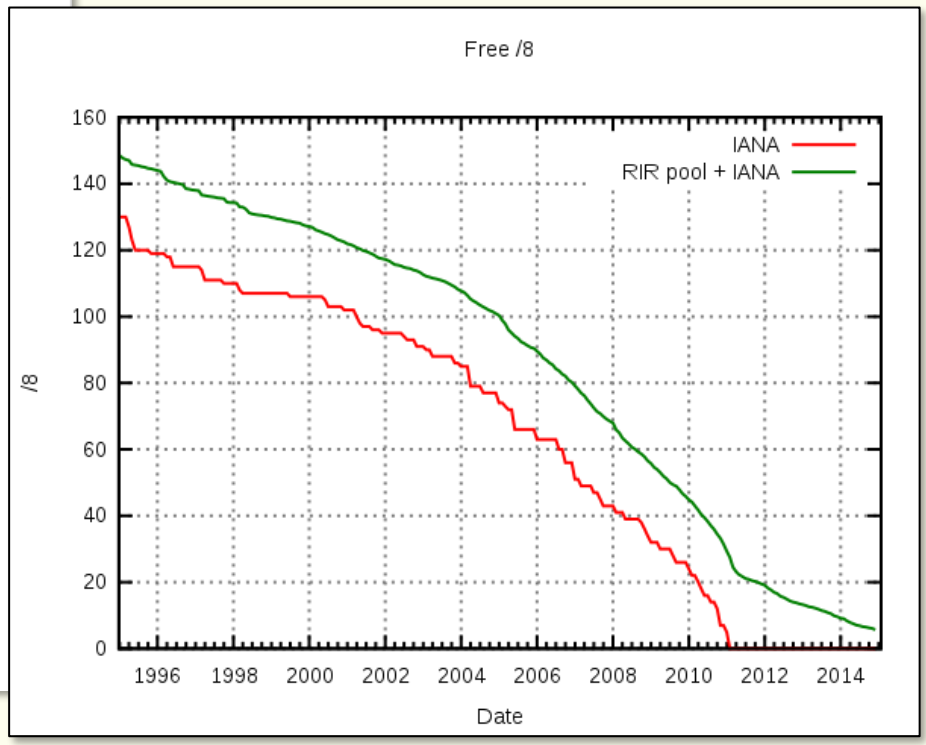
By Stephen Lawson

January 31, 2011 07:04 PM ET Add a comment

IDG News Service - The Internet Assigned Numbers Authority has assigned two large blocks of IPv4 addresses to the Asia-Pacific Network Information Centre, activating a rule under which the agency will give out the last of its IPv4 addresses.

The rule states that when only five large blocks of IP addresses remain, one will be handed out to each of the world's five regional Internet registries. With the latest allocation to APNIC, the number of remaining IP address blocks is down to five.

IANA is expected to assign the remaining blocks within a matter of days or less. After that, the regional bodies will have no higher source of addresses to turn to when they have assigned the addresses they hold.



Source: http://en.wikipedia.org/wiki/IPv4_address_exhaustion

Motivation for IPv6

https://www.ripe.net/publications/news/about-ripe-ncc-and-ripe/the-ripe-ncc-has-run-out-of-ipv4-addresses

- IPv4 address spac… already happened!

Home > Internet

News

Address allocation kicks off IPv…

By Stephen Lawson

January 31, 2011 07:04 PM ET Add a comment

IDG News Service - The Internet Assigned Numbers Aut… two large blocks of IPv4 addresses to the Asia-Pacific N… Centre, activating a rule under which the agency will give… addresses.

The rule states that when only five large blocks of IP add… will be handed out to each of the world's five regional Inte… the latest allocation to APNIC, the number of remaining I… down to five.

IANA is expected to assign the remaining blocks within a… less. After that, the regional bodies will have no higher so… turn to when they have assigned the addresses they hold.

RIPE NCC
@ripencc

Today, at 15:35, we made our final /22 IPv4 allocation from the last remaining addresses in our available pool. We have now run out of IPv4 addresses.

Read our full announcement here:
ripe.net/publications/n…

In the picture, the Registration Services team at the RIPE NCC

Traduci il Tweet

3:50 PM · 25 nov 2019 · Hootsuite Inc.

Source: http://en.wikipedia.org/wiki/IPv4_address_exhaustion

IPv4 address market

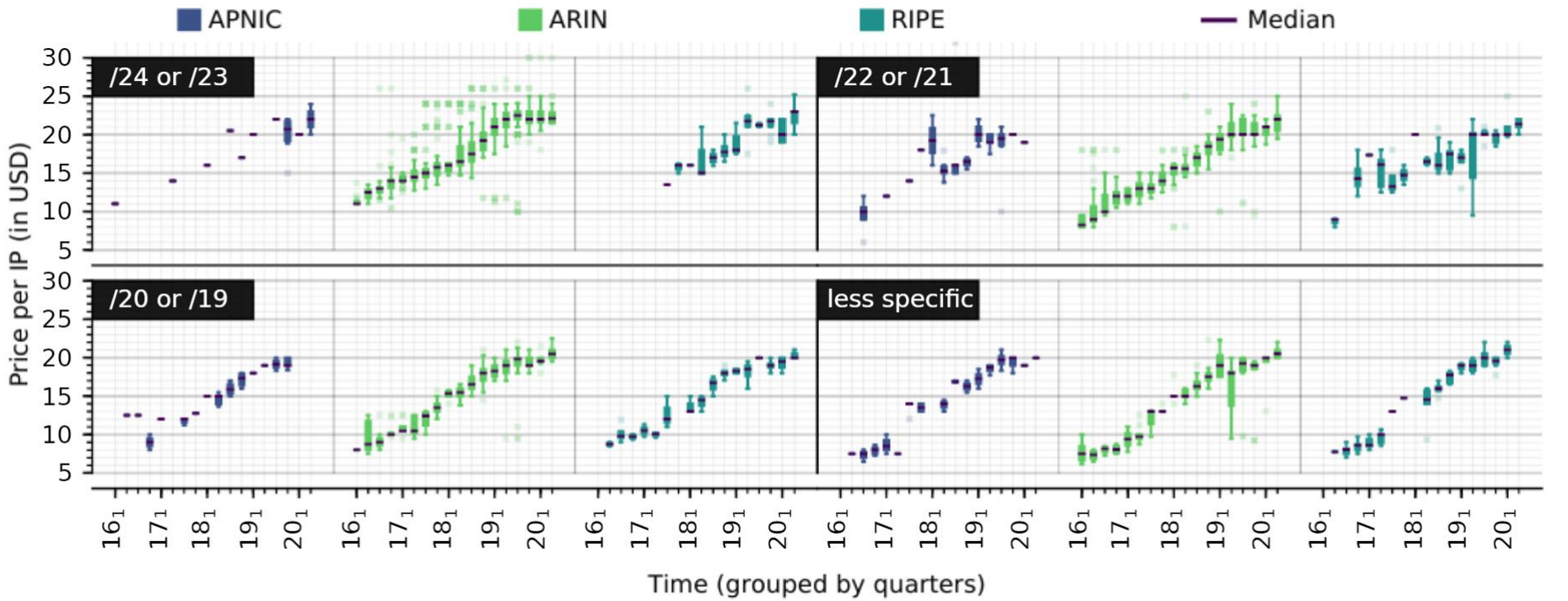
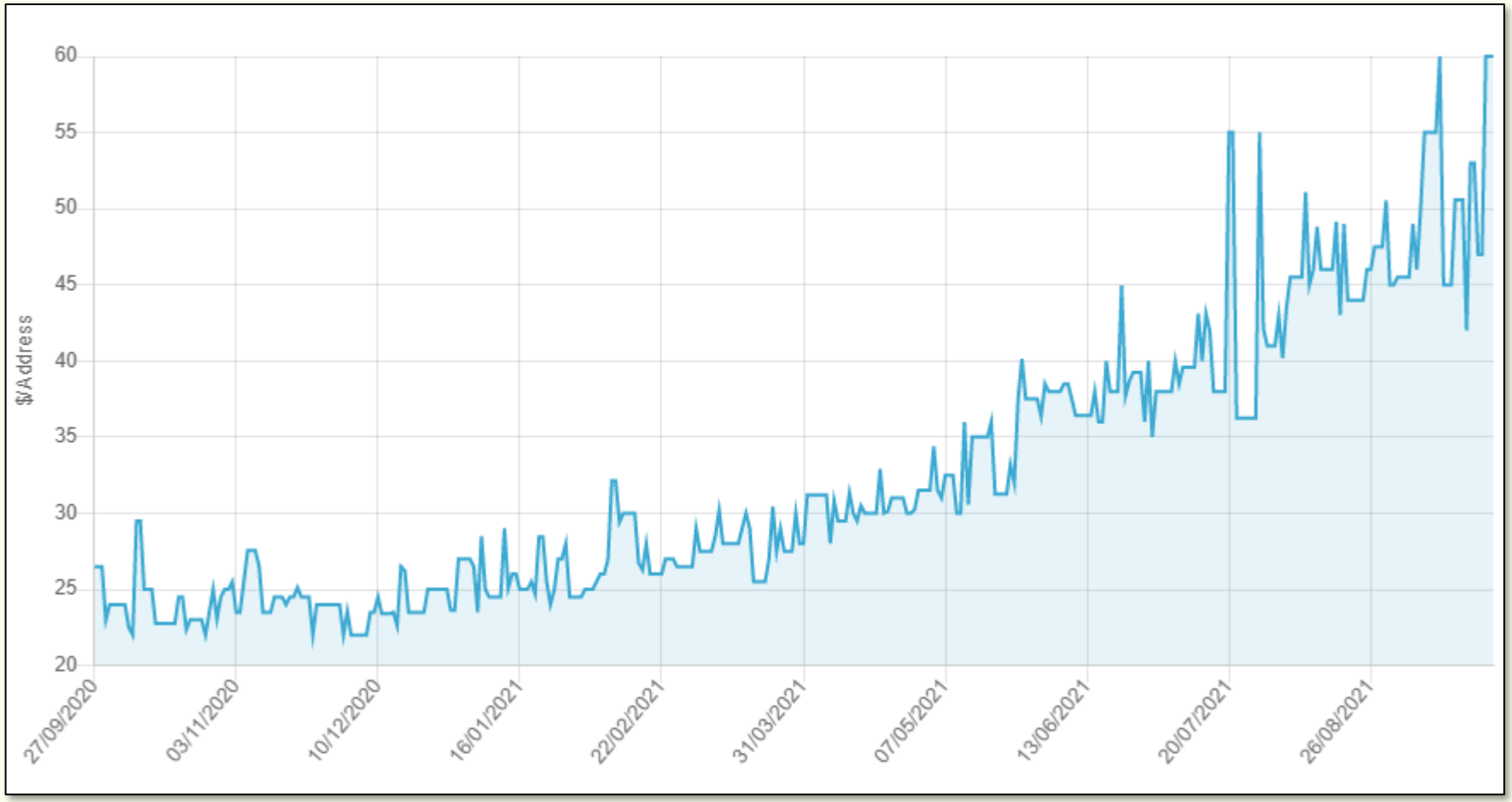


Figure 1: Evolution of Price per IP based on prefix size and region.

Source: [When wells run dry: the 2020 IPv4 address market | CoNEXT 2020]

IPv4 address market

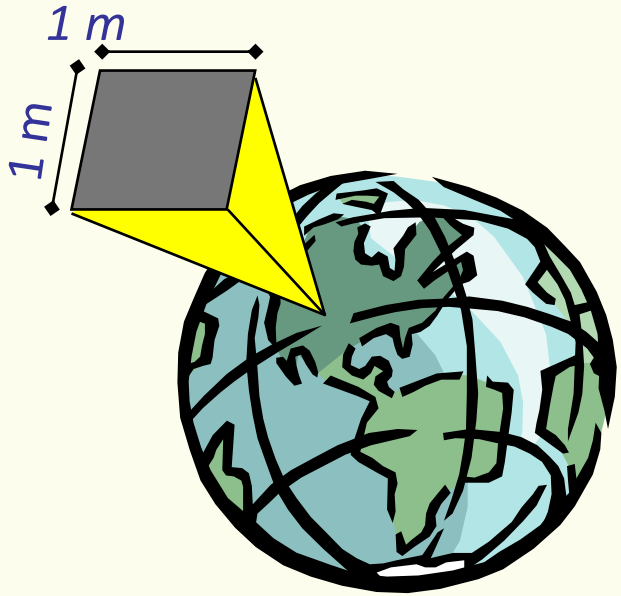


IPv4 Address Pricing - Previous IP Address Auction Sales Data | IPv4.Global

Motivation for IPv6

- IPv6 address space
  - 2^{128} = 340.282.366.920.938.463.463.374.607.431.768.211.456
  - 340 trillion trillion trillion (i.e. ~ 340 x 10^{36})

- About 6.65*10^{23} addresses per square meter on earth (including waters)



Motivation for IPv6

Not only address space extension, but also

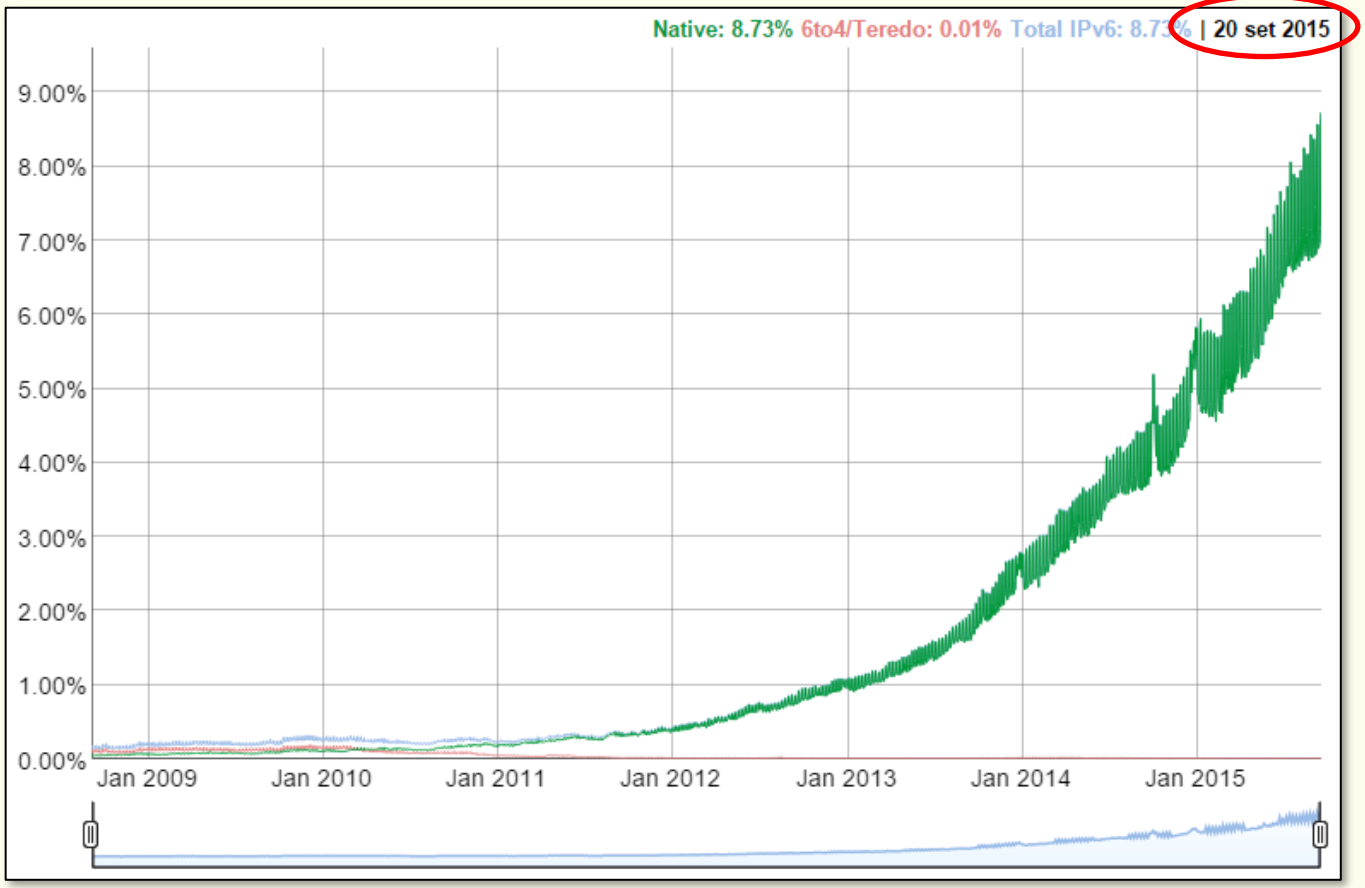
- Autoconfiguration
  - Purely **stateless** (!!!)
    - A must for Future Internet systems like IoT
- Simplification of the header format
  - Fixed length → faster processing
- Improved support for options and extensions
  - Information carried only when needed
  - Open and extensible

IPv6 today

- IPv6 deployment has started systematically
- World IPv6 Launch on June 6, 2012
  - Major Internet Service Providers (ISPs), home networking equipment manufacturers, and web companies around the world were involved (updated statistics available at http://www.worldipv6launch.org/)
- [Despite this, many popular services are still not reachable via IPv6: see IPv6 Status of Alexa 500 Websites]

IPv6 today

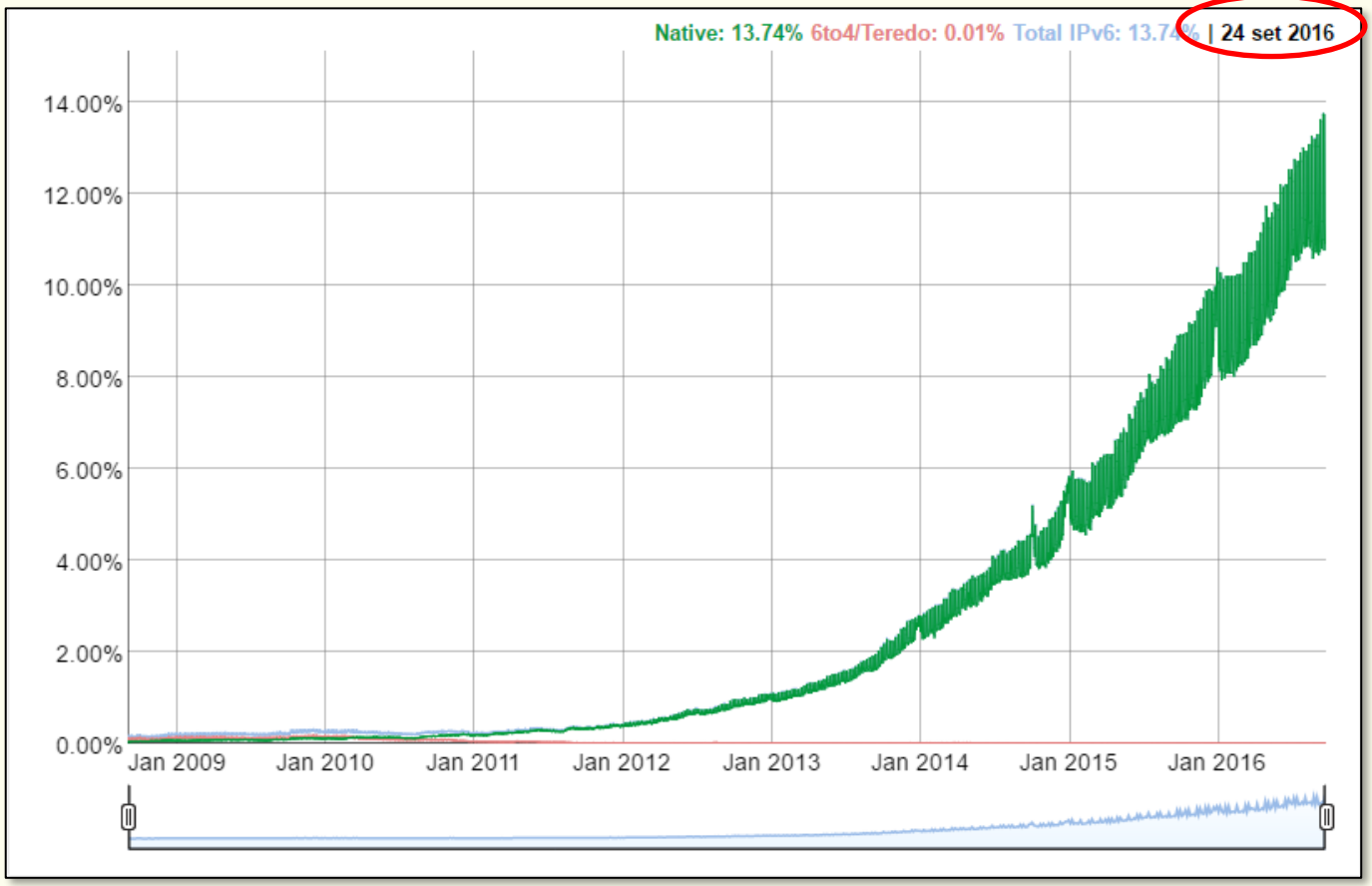
- Percentage of users that access Google over IPv6



Source: http://www.google.com/ipv6/statistics.html

IPv6 today

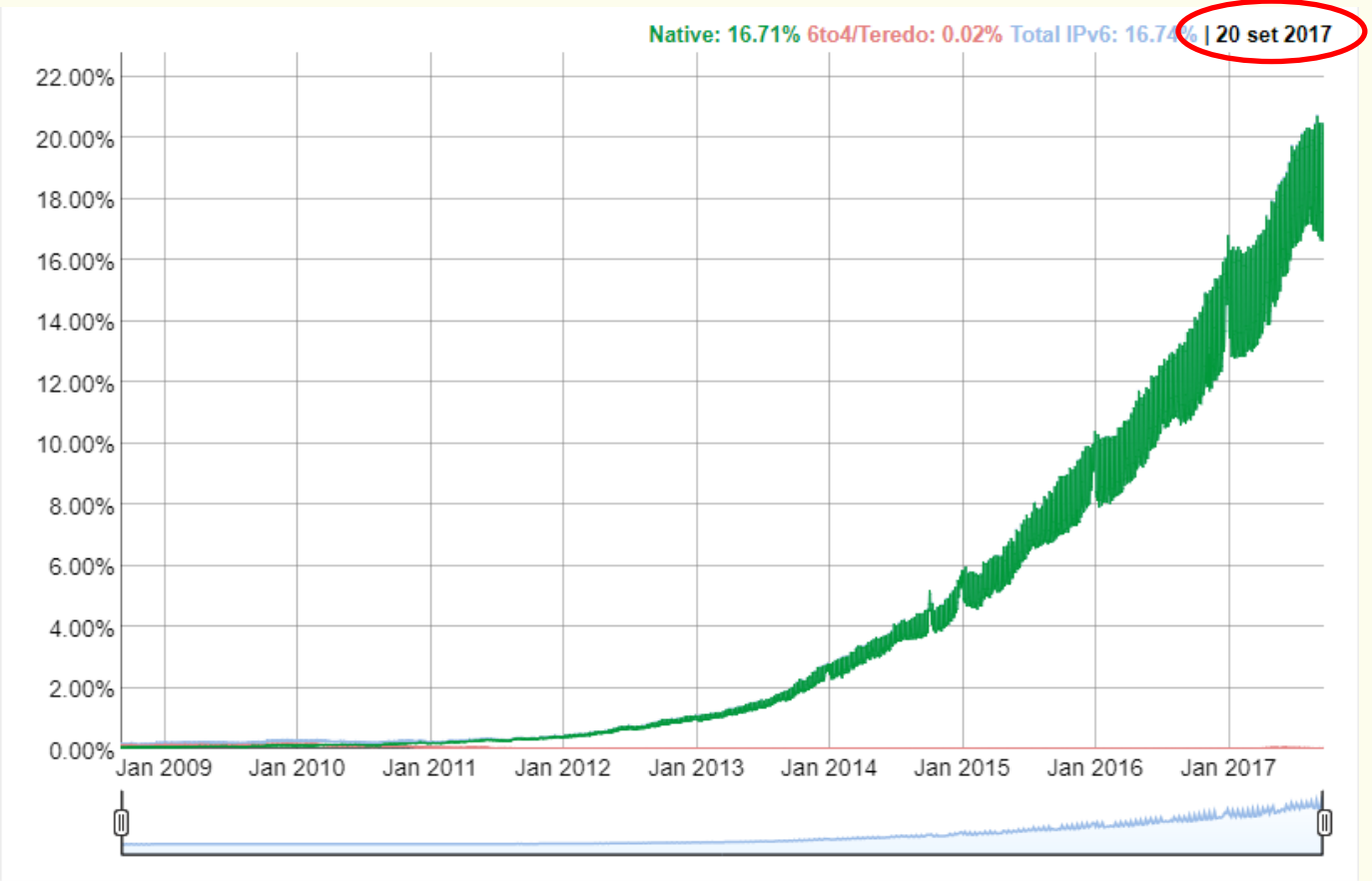
- Percentage of users that access Google over IPv6



Source: http://www.google.com/ipv6/statistics.html

IPv6 today

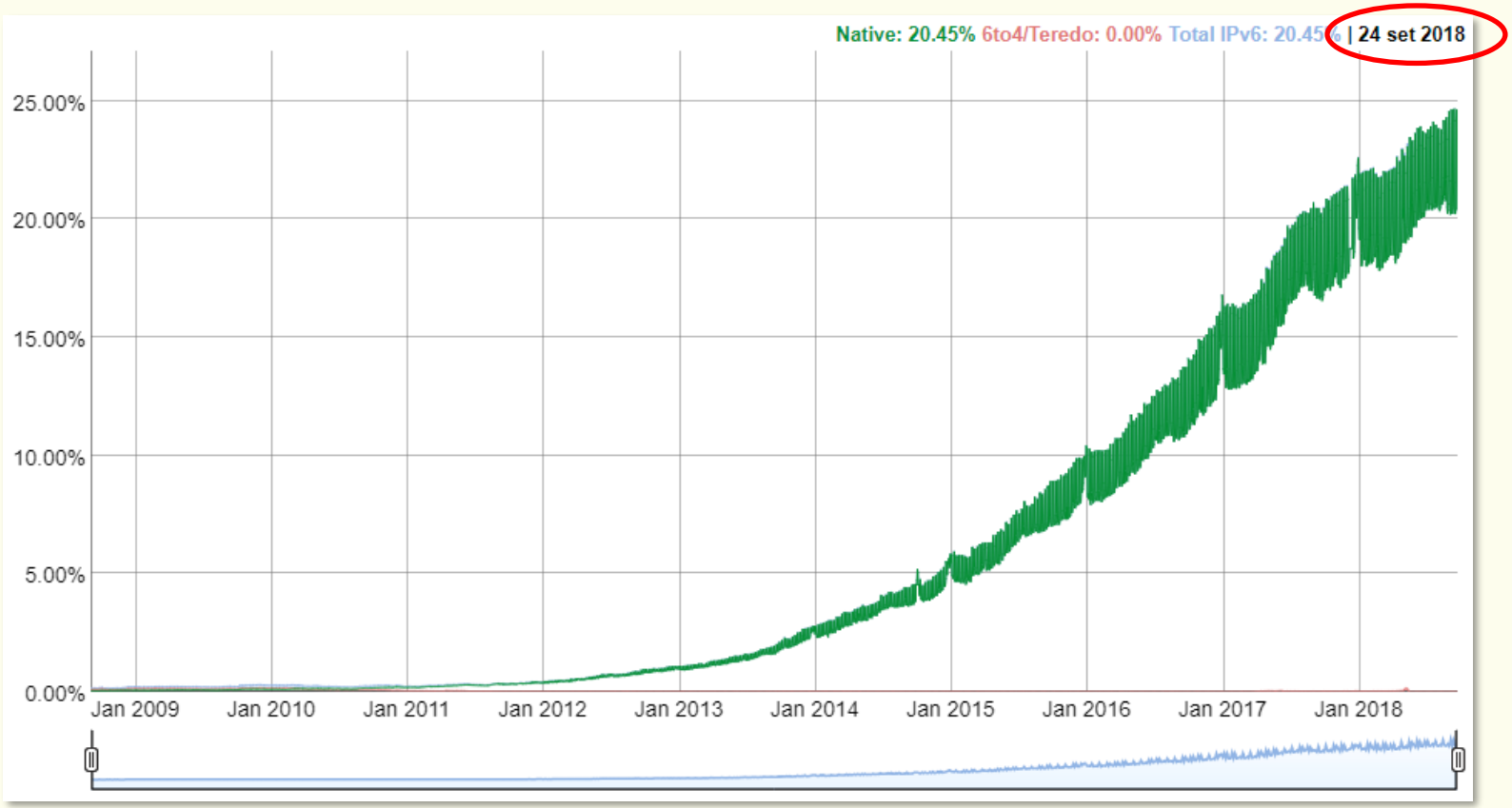
- Percentage of users that access Google over IPv6



Source: http://www.google.com/ipv6/statistics.html

IPv6 today

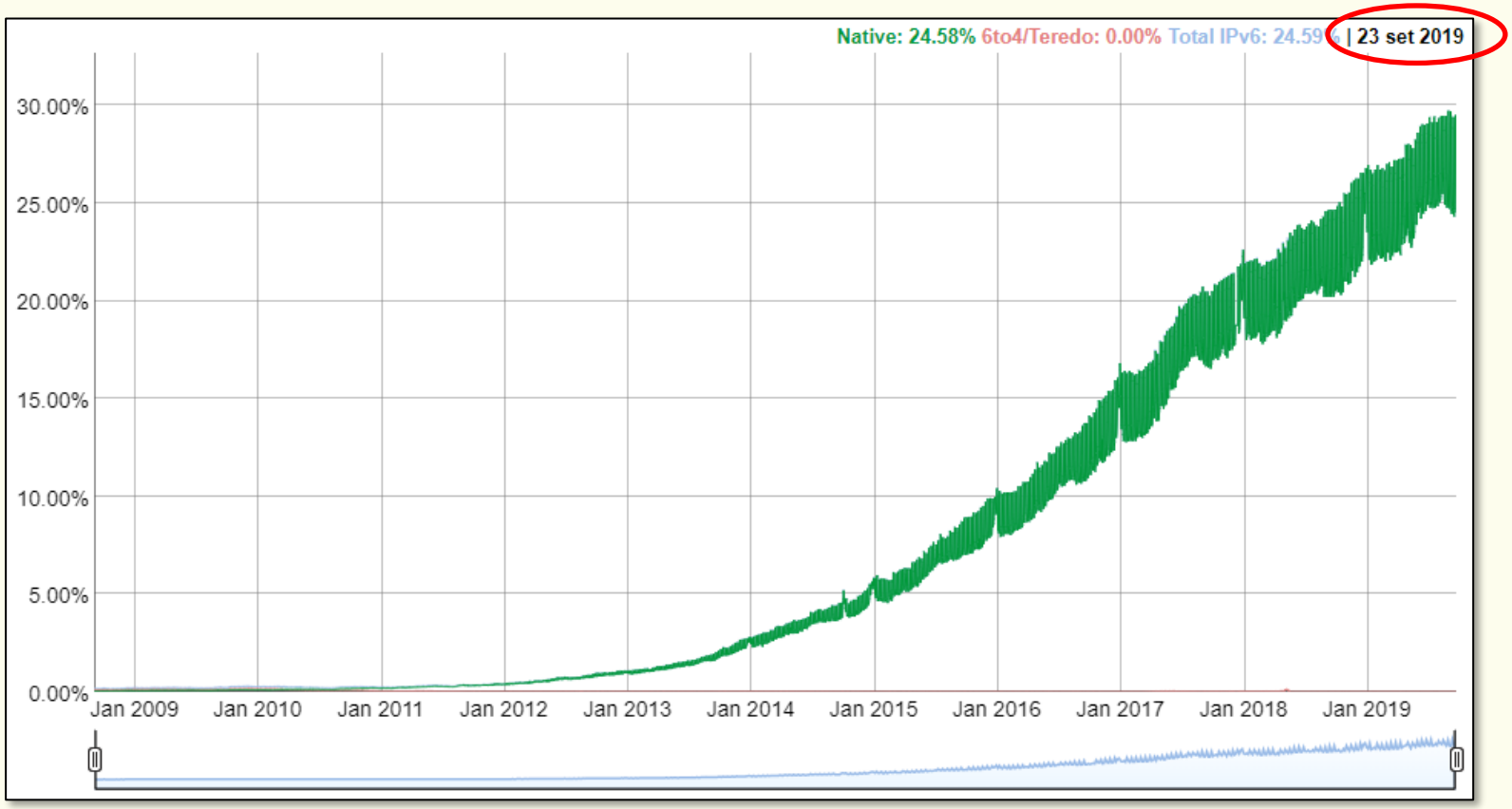
- Percentage of users that access Google over IPv6



Source: http://www.google.com/ipv6/statistics.html

IPv6 today

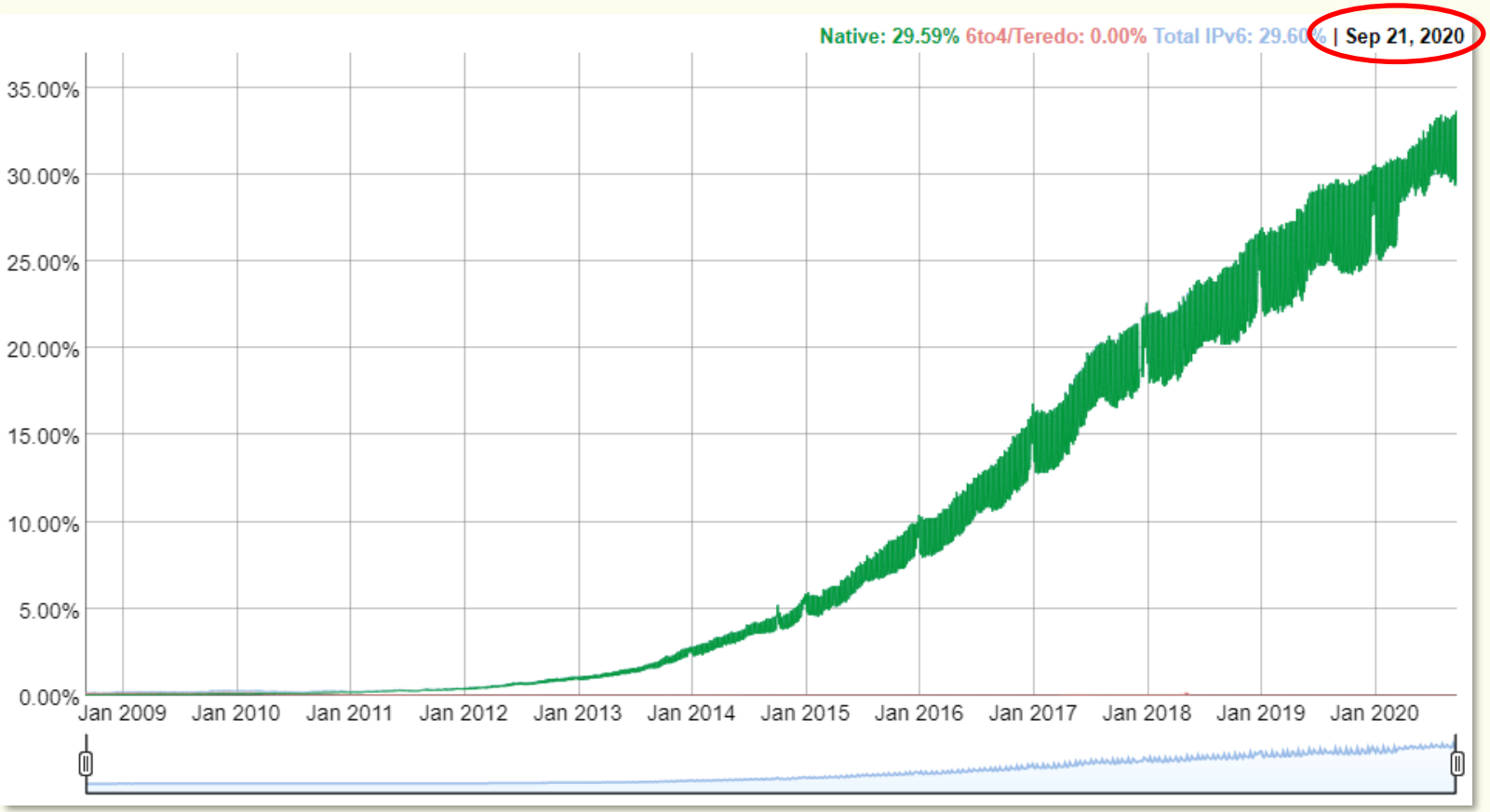
- Percentage of users that access Google over IPv6



Source: http://www.google.com/ipv6/statistics.html

IPv6 today

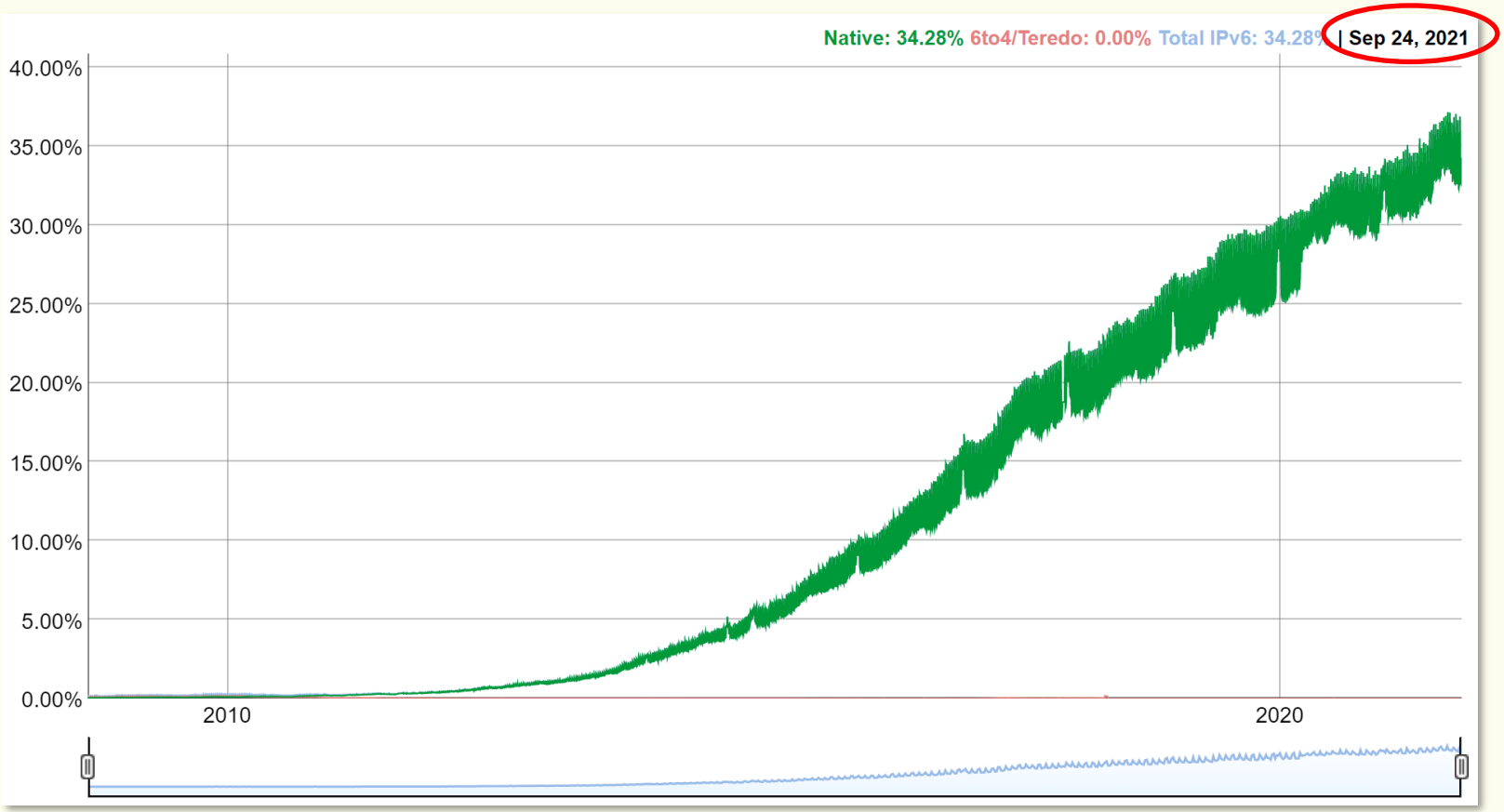
- Percentage of users that access Google over IPv6



Source: http://www.google.com/ipv6/statistics.html

IPv6 today

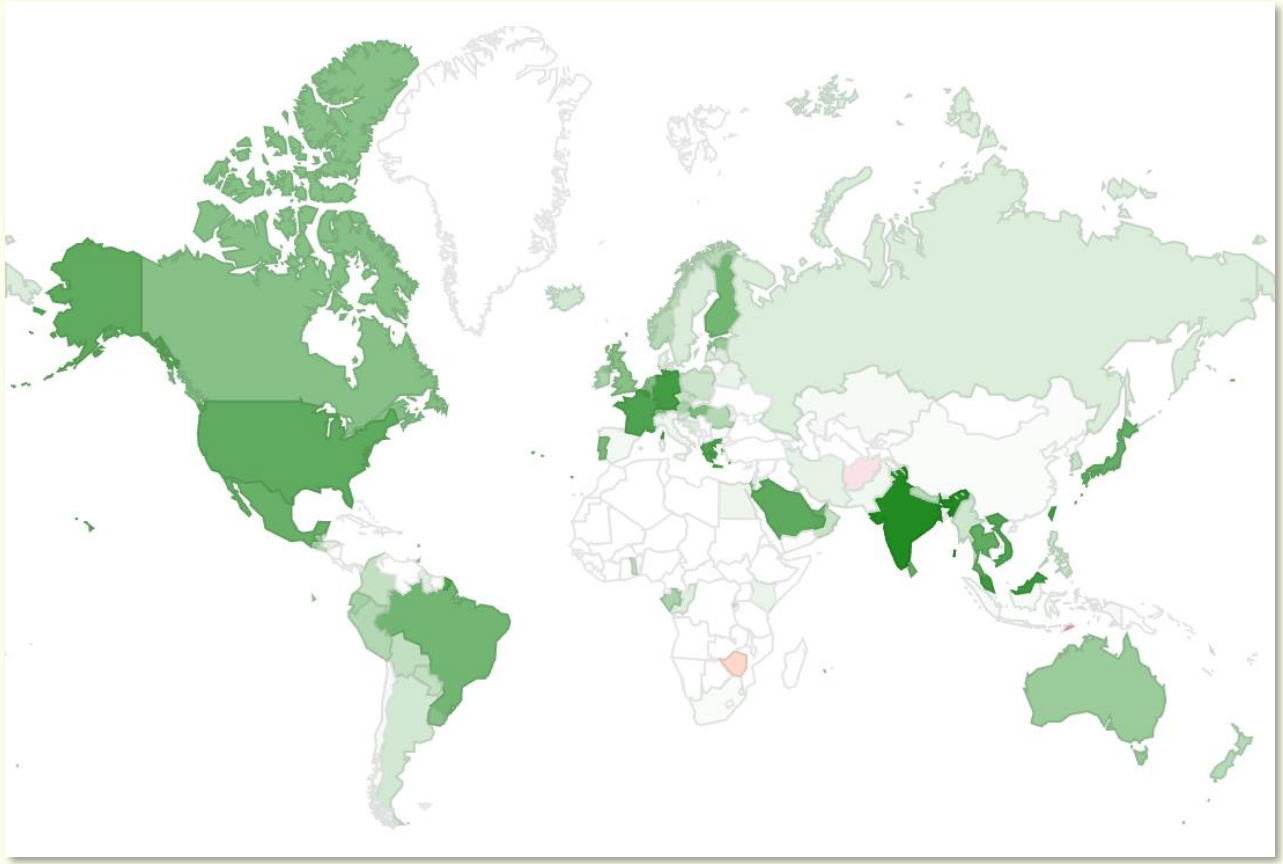
- Percentage of users that access Google over IPv6



Source: http://www.google.com/ipv6/statistics.html

IPv6 today

- Per-country IPv6 adoption



Source: http://www.google.com/ipv6/statistics.html