Meetup

IPv6 101 / Refresher

Meetup #2: IPv6 101 / Refresher

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Agenda

WELCOME

WHY IPV6?

IPV6 101

IPV6 CONFIGURATION AT HOME

THIERRY VAN STEIRTEGHEM

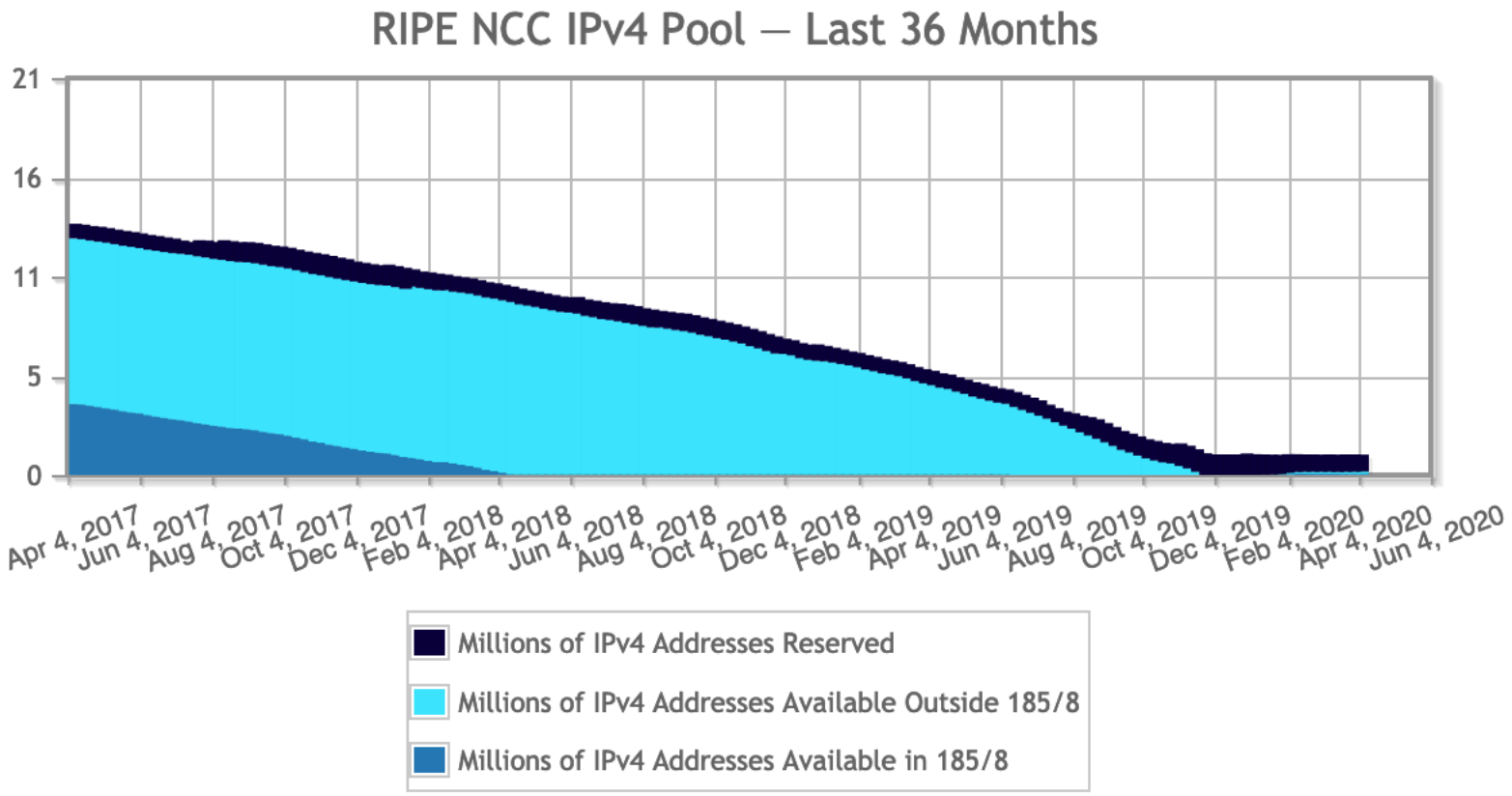
EXCLUSIVE NETWORKS

Why do we need IPv6?

Why IPv6?

- ✓ IPv4's are running out
  - ✓ IPv4 $ going up
  - ✓ More and more transfers
- ✓ NATs and CGNs are breaking applications
- ✓ IPv6 is being used in production
  - ✓ Belgium >50% penetration in home
  - ✓ Google, Facebook, Amazon, Netflix, Azure…
- ✓ Cleaner design
  - ✓ Easier troubleshooting
  - ✓ Lower OPEX
- ✓ Not easy to find remaining private IPv4 space in organization
- ✓ Containers overlapping IPv4 space
- ✓ Mergers are messy
- ✓ VNFs: Mobile packet core, 5G…
- ✓ IoT
- ✓ …

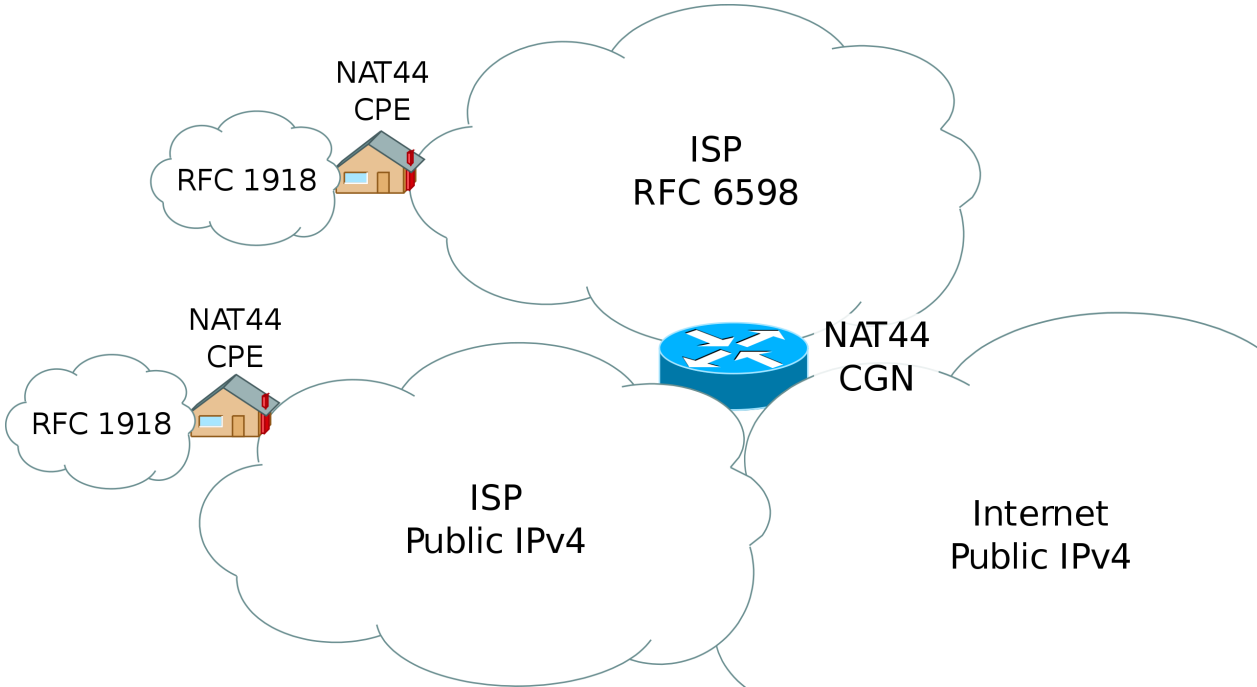
RIPE NCC IPv4 Pool



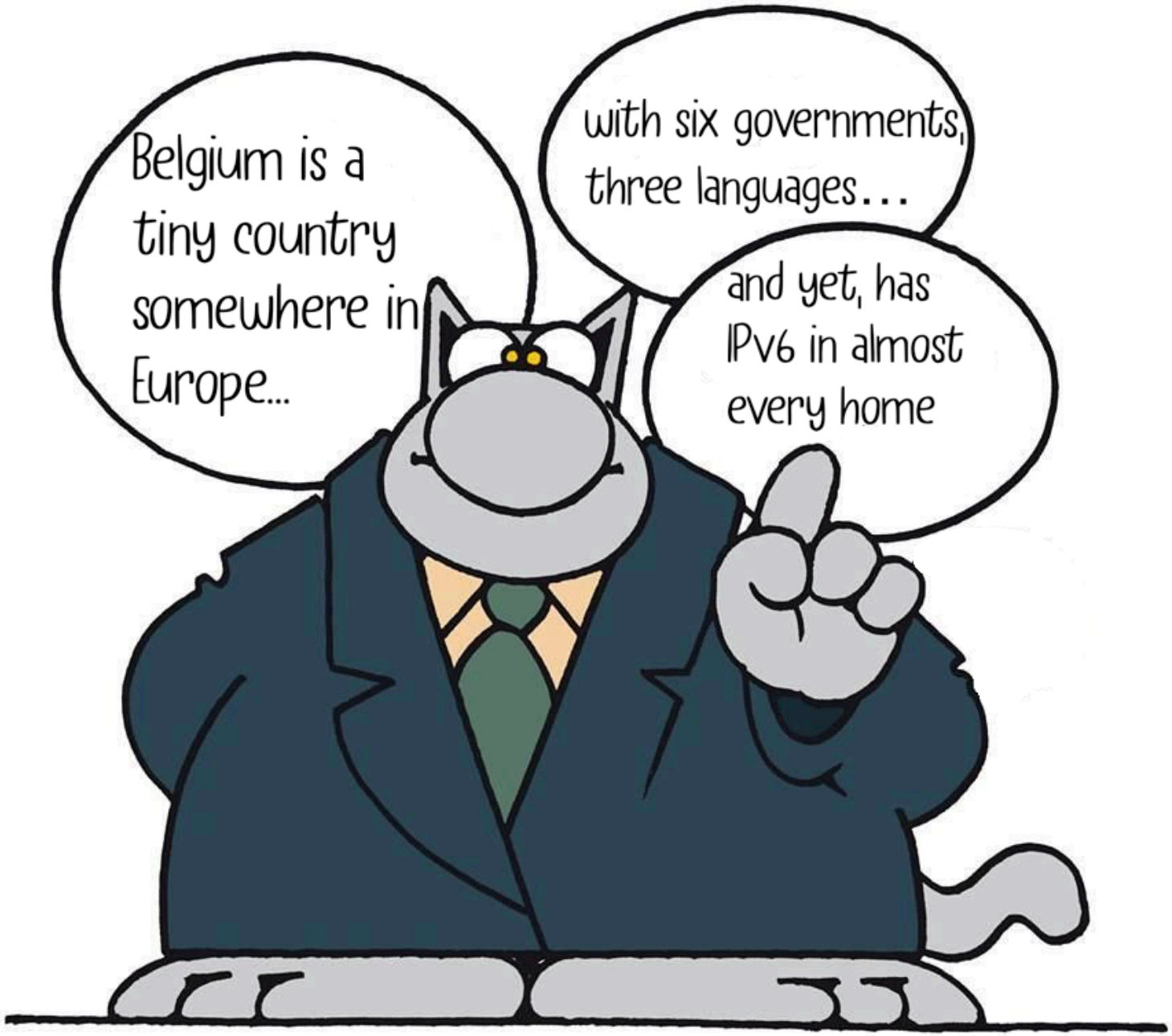
https://www.ripe.net/manage-ips-and-asns/ipv4/ipv4-available-pool

A small word on NAT and CGN…

- ✓ Network Address Translation and Carrier Grade Nat
- ✓ Due to lack of IPs, we typically only have one public routable IPv4 at home
- ✓ We are used to not having end to end connectivity
- ✓ Many apps require “port-forwarding”, “NAT traversal”…
- ✓ Breaks end to end principles
- ✓ DoS prevention is harder
- ✓ Geolocalisation is harder



https://en.wikipedia.org/wiki/Carrier-grade_NAT

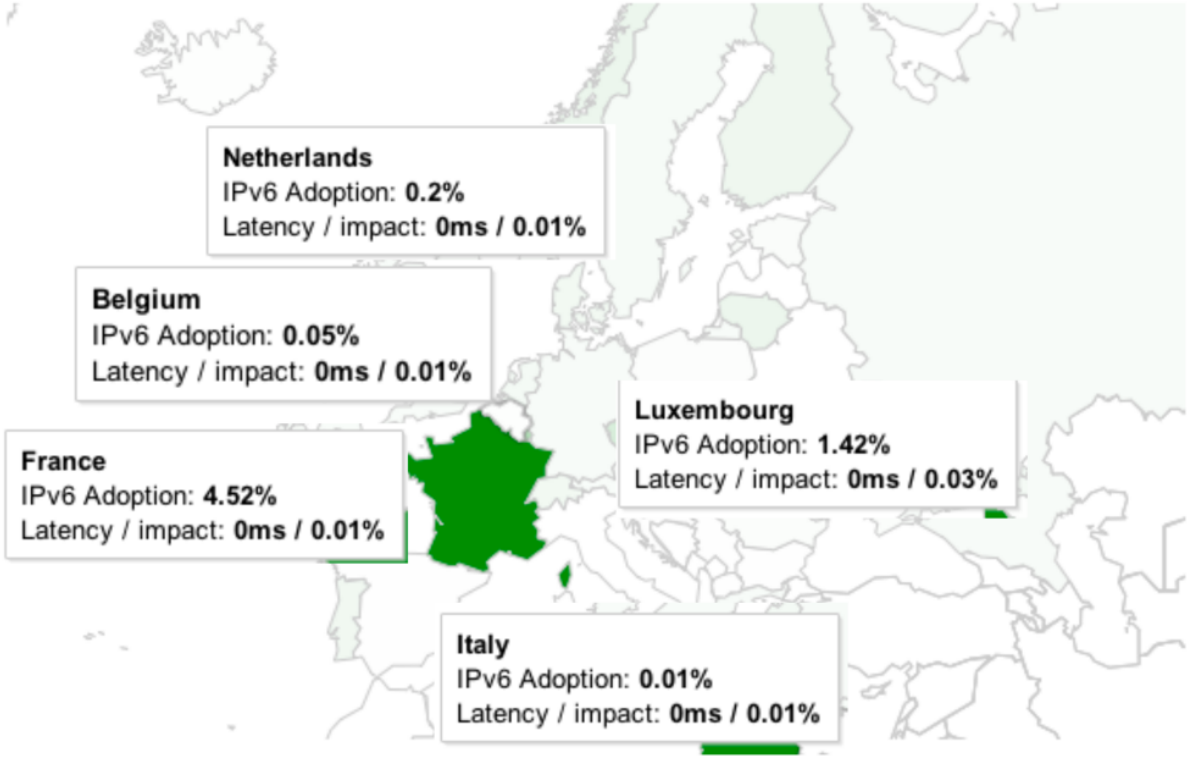


IPv6 in Belgium

"Lechat copyright Philippe Geluck: https://geluck.com/"

IPv6 status in March 2012

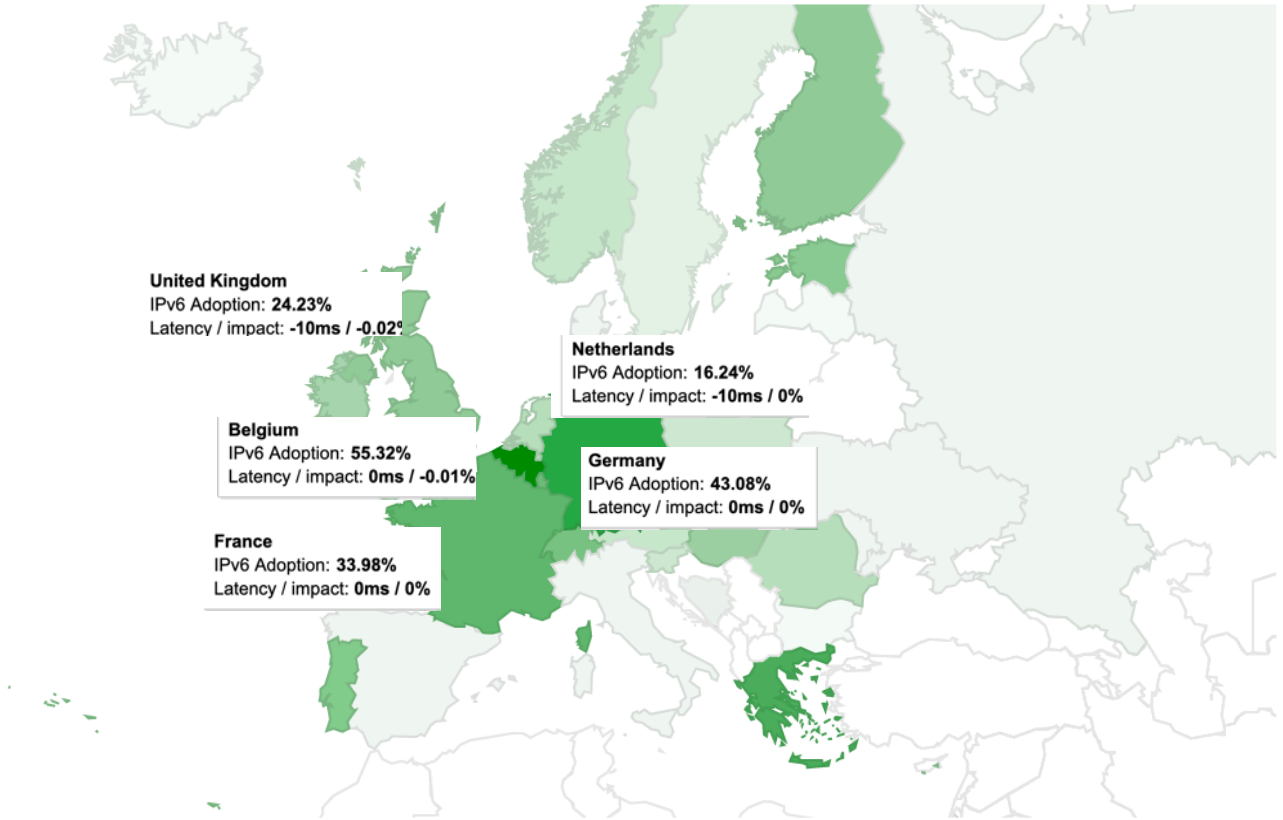
Belgium: User



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

IPv6 status 18 August 2019

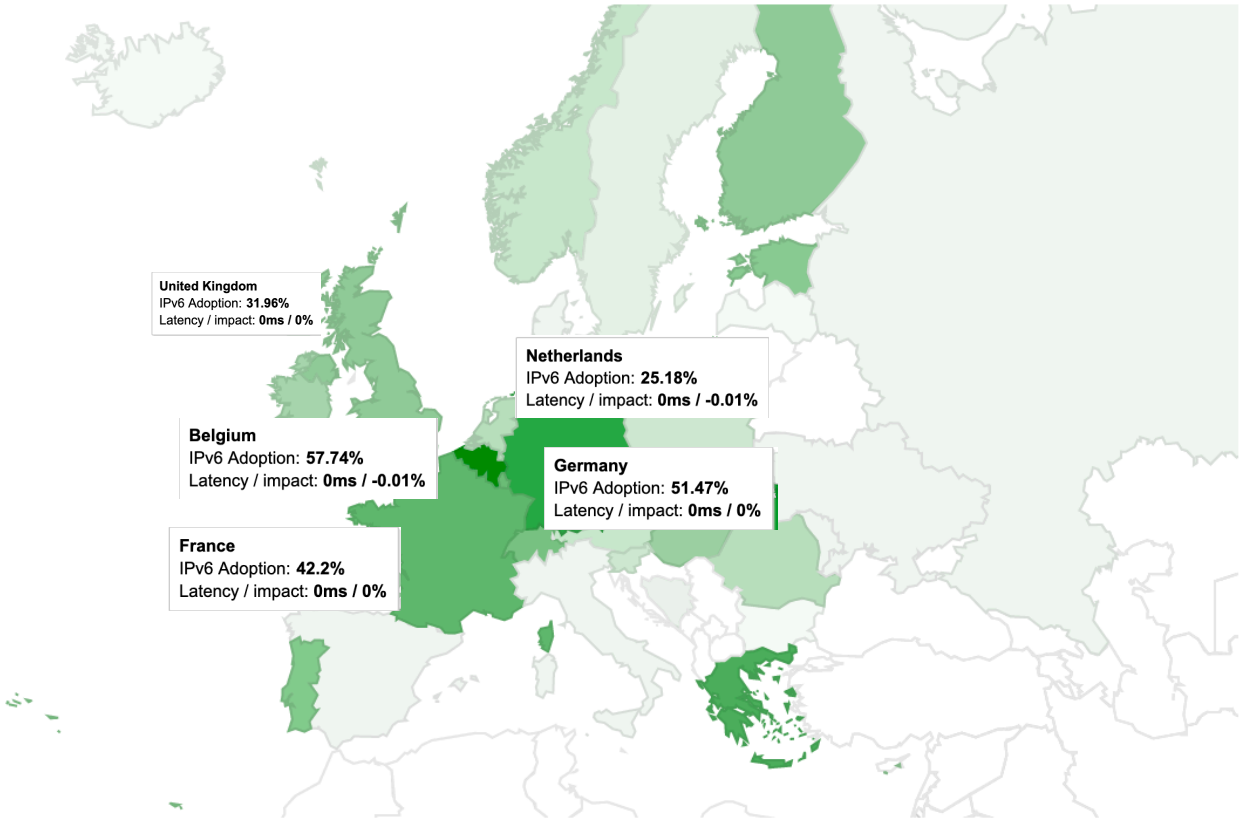
Per-Country IPv6 adoption



Source: https://www.google.com/intl/en/ipv6/statistics.html#tab=per-country-ipv6-adoption

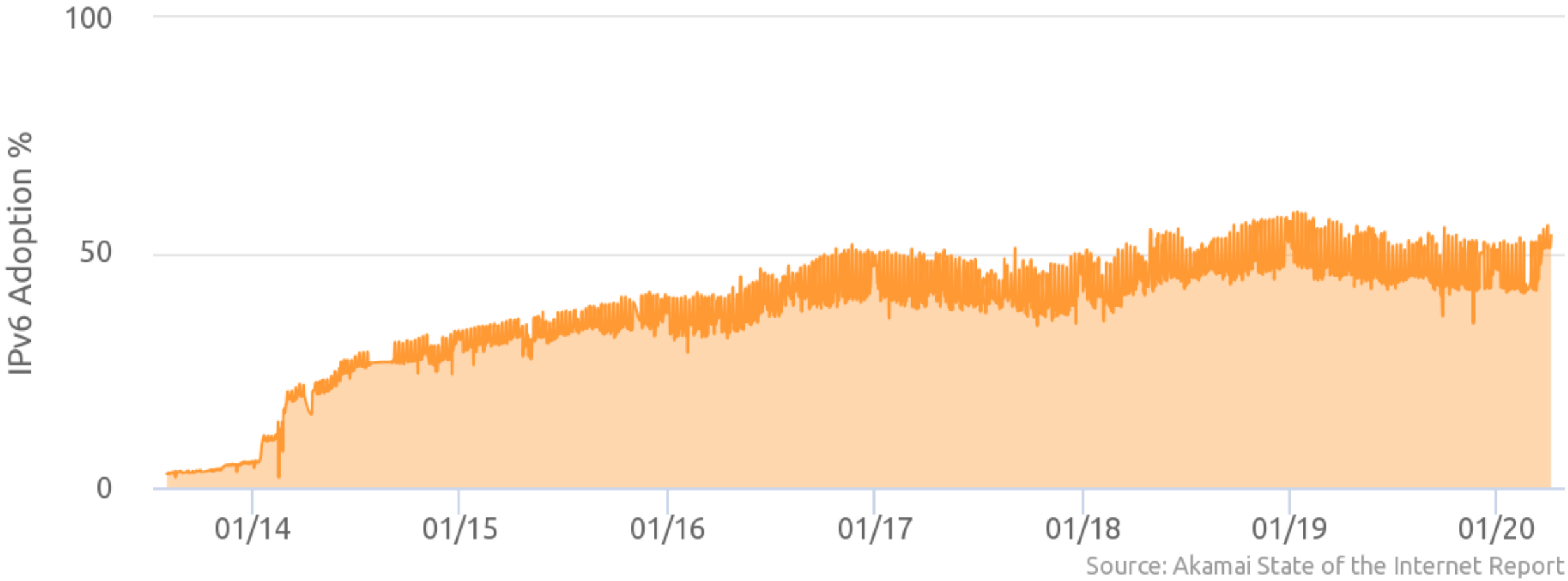
IPv6 status today (15 April 2020)

Per-Country IPv6 adoption



Source: https://www.google.com/intl/en/ipv6/statistics.html#tab=per-country-ipv6-adoption

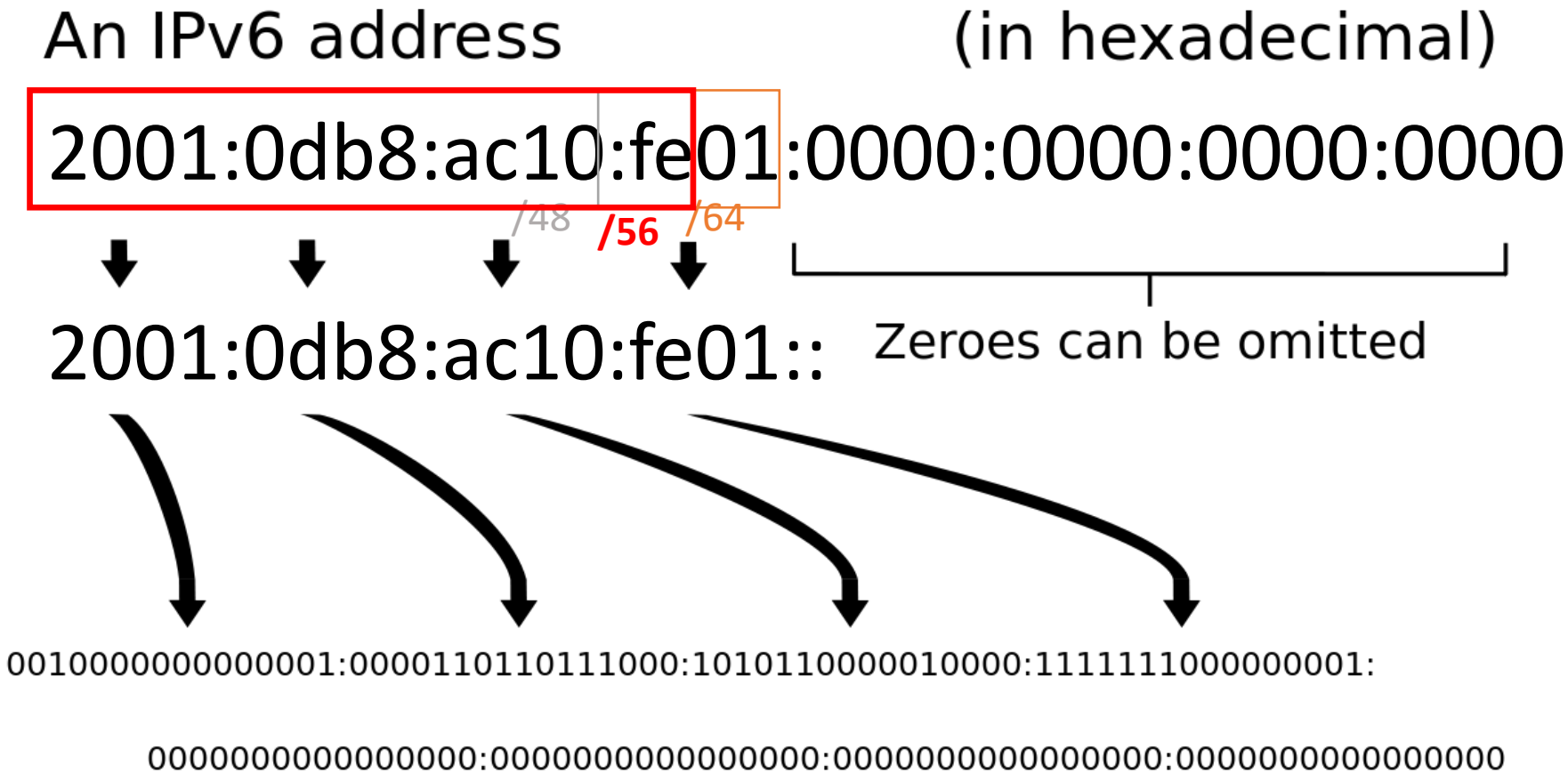
Belgium IPv6 evolution



https://www.akamai.com/uk/en/resources/our-thinking/state-of-the-internet-report/state-of-the-internet-ipv6-adoption-visualization.jsp

IPv6 basics

IPv6 Basics



https://en.wikipedia.org/wiki/IPv6_address

IPv6 Examples

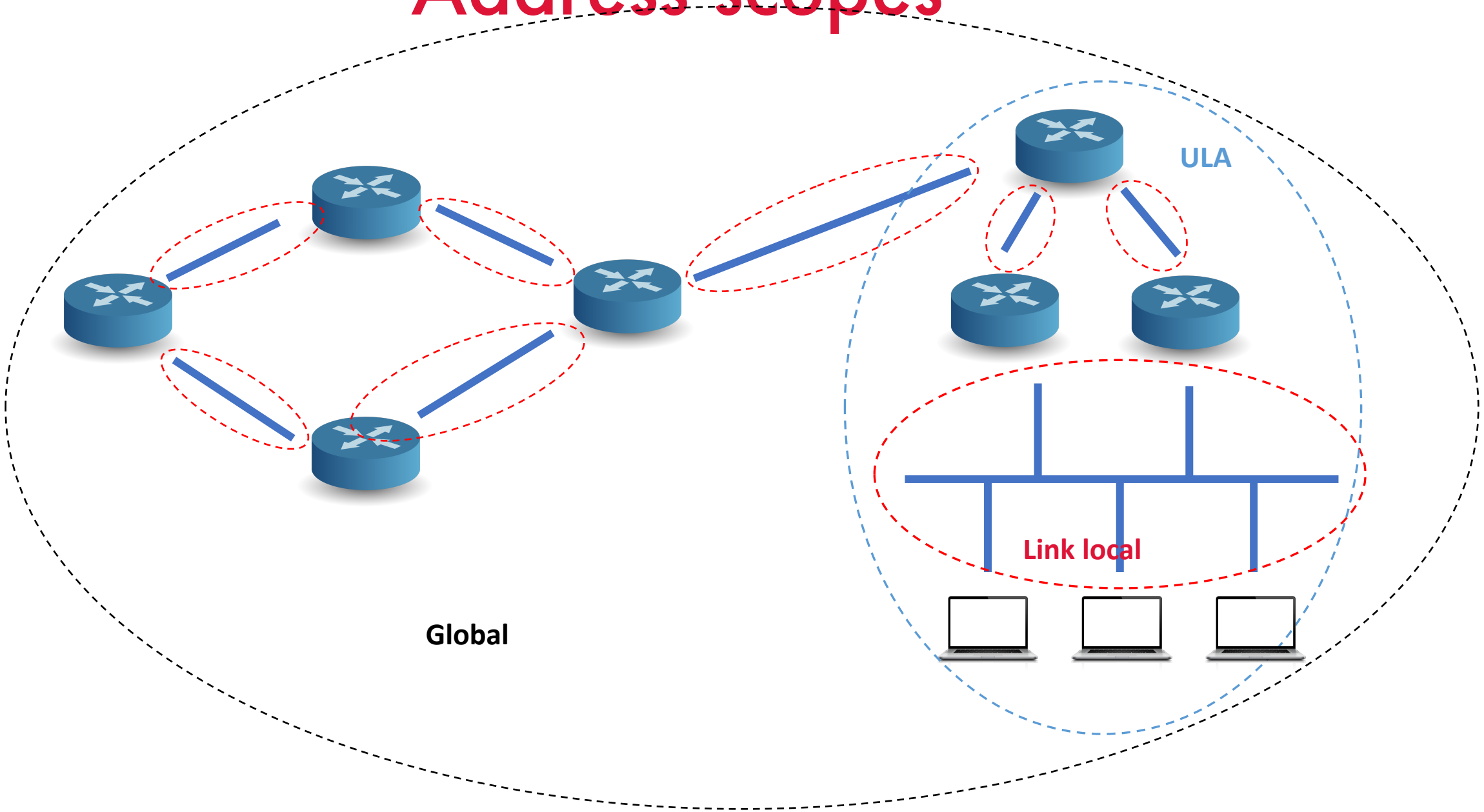
- ✓RFC 5952 recommends to use the **compressed** format for IPv6 address textual representation: 2001:db8:a0b:12f0::1
- ✓ Leading zeros MUST be suppressed.
  - ✓For example, 2001:0db8::0001 is not acceptable and must be represented as 2001:db8::1
- ✓The use of the symbol "::" MUST be used to its maximum capability.
  - ✓For example, 2001:db8:0:0:0:0:2:1 must be shortened to 2001:db8::2:1.
- ✓The symbol "::" MUST NOT be used to shorten just one 16-bit 0 field.
  - ✓For example, the representation 2001:db8:0:1:1:1:1:1 is correct, but 2001:db8::1:1:1:1:1 is not correct.
- ✓The characters "a", "b", "c", "d", "e", and "f" in an IPv6 address MUST be represented in lowercase.

Address types

Addresses	Range	Scope
Loopback	::1	Host
Link Local	fe80::/10	Link
Unique local	fc00::/7	Organisation, no Internet connection Don’t do NAT66!
Global Unicast	2000::/3	Global
Multicast	ff00::/8	Global
Documentation	2001:db8::/32	Documentation

www.ripe.net/ipv6-address-types

Address scopes

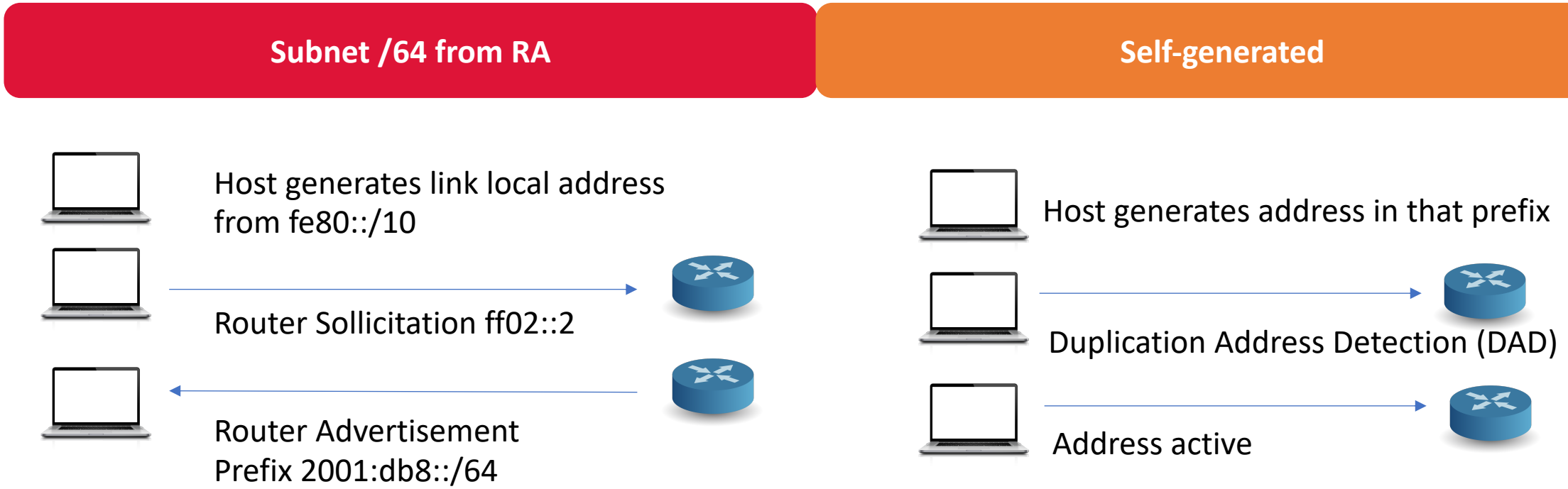


Configuring an IPv6 address

- ✓Manual configuration
- ✓Router advertisement (RA) only
- ✓DHCPv6 with ‘M’ flag in RA (Stateful DHCPv6)
- ✓RA + DHCPv6 with ‘O’ flag (Stateless DHCPv6)

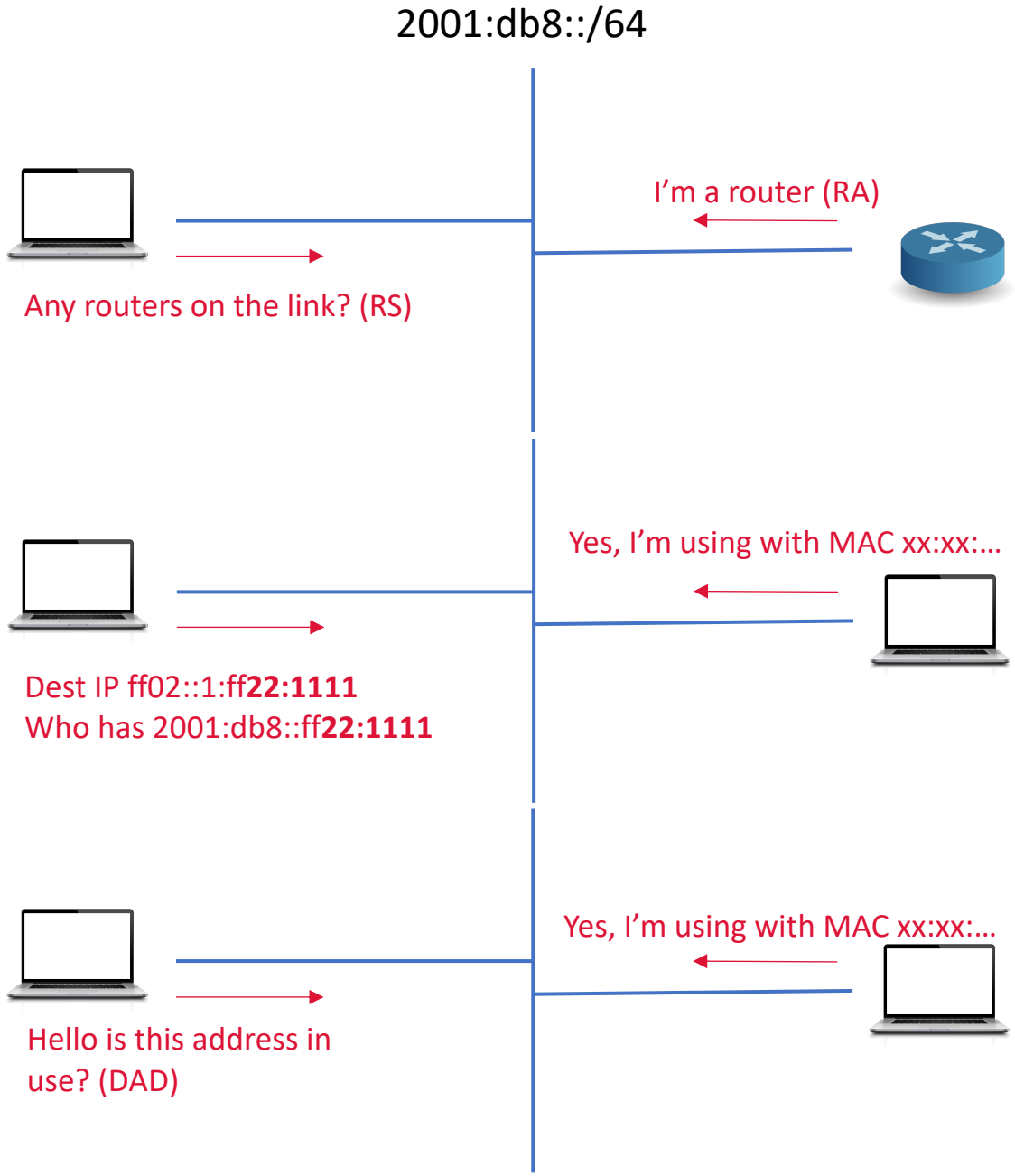
Address autoconfiguration

- SLAAC: Stateless Address AutoConfiguration
- SLAAC relies on NDP (Neighbour Discovery Protocol)

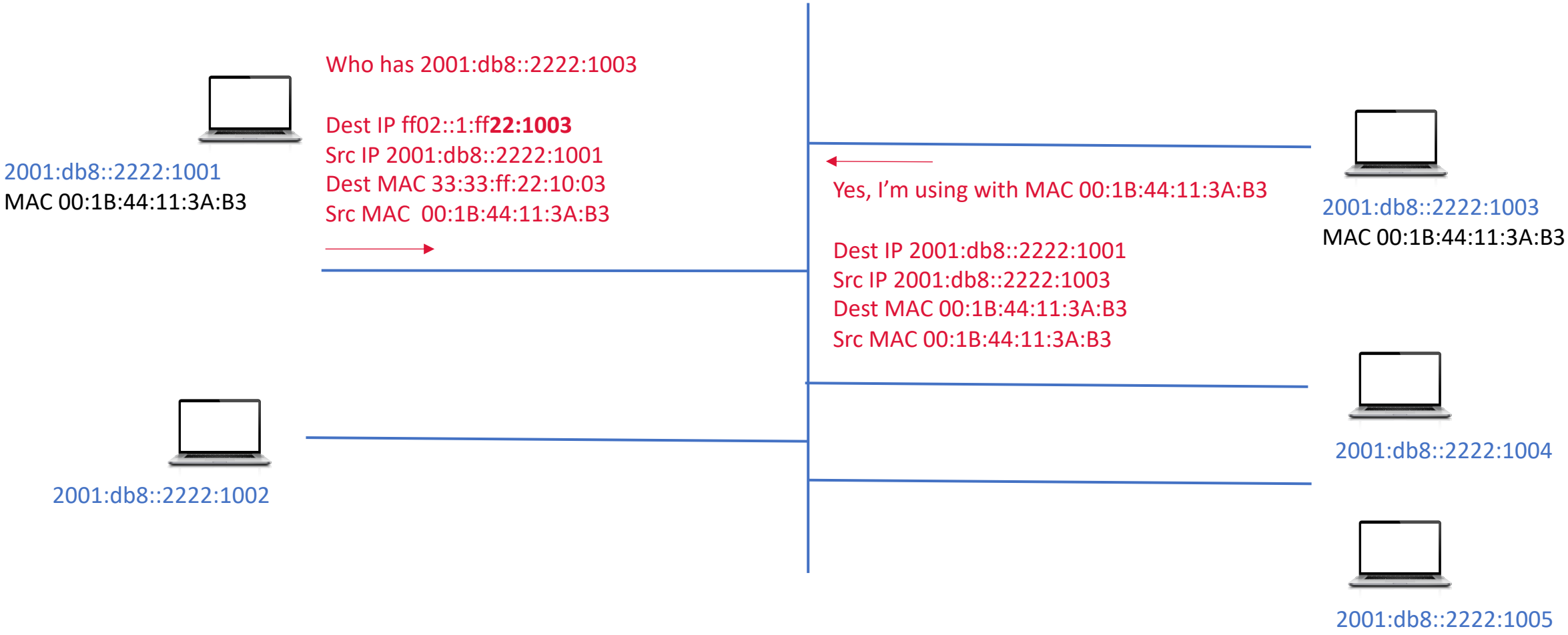


Neighbour Discovery

- ✓Replaces ARP from IPv4
- ✓Uses ICMPv6 and Multicast
- ✓Roles of ND:
  - Address resolution
  - Find neighbouring routers
  - Track address changes
  - Check neighbour reachability
  - Duplicate Address Detection



Solicited Node Multicast Address



Example 1 of IPv6 enabled interface

- “Secured” address will not change for a specific network. Likely generated as described in RFC7217
- “Temporary” changes from time to time to protect your privacy

Example 2 of IPv6 enabled interface

```
utun4: flags=80d1<UP,POINTOPOINT,RUNNING,NOARP,MULTICAST> mtu 1390
        inet 10.61.245.246 --> 10.61.245.246 netmask 0xffffffff
        inet6 fe80::aede:48ff:fe00:1122%utun4 prefixlen 64 scopeid 0x12
        inet6 2001:    :c0c0:1008::47 prefixlen 128
        nd6 options=201<PERFORMNUD,DAD>
```

- DHCPv6 exists as well. RA specifices if SLAAC is allowed and if DHCPv6 is available.

Other IPv6 differences with IPv4

- ✓ No more in-network fragmentation.
  - Fragmentation is done by the host.
  - “Packet too big” ICMPv6 message
  - Sender who gets this message tries with a smaller packet. Hint of size is in the error message. This is also called “Path MTU discovery”.
- ✓ IPv6 has no broadcast. “All nodes” multicast group ff02::1
- ✓ IPv6 has no ARP. It uses Neighbour Discovery with ICMPv6 and multicast.
  - ARP wakes every node, ND wakes only a few nodes
- ✓ Minimum MTU is 1280bytes
- ✓ Multiple IPv6 addresses per interface
- ✓ No more space optimised subnets! ☺

Security considerations

- ✓Use RA guard to filter unauthorised RAs (RFC 6105)
  - ✓IPv6 equivalent of IPv4 rogue DHCP server
- ✓IPv6 is not inherently more secure than IPv4
- ✓IPv6 has no NAT and is true to end-2-end paradigm. You are responsible for filtering.

DNS

- ✓DNS works the same way, AAAA record for IPv6
- ✓AAAA request can be done over IPv4 DNS Request
- ✓A request can be done over IPv6 DNS Request

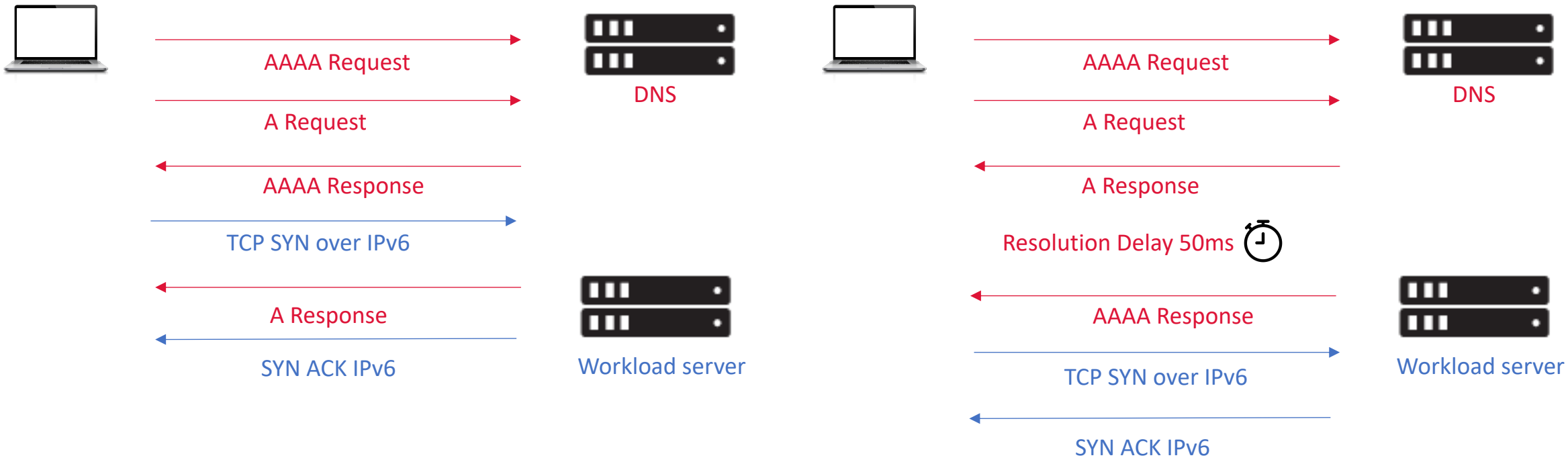
```
pilewyll@PILEWYLL-M-L2F5 ~ % dig AAAA facebook.com

; <<>> DiG 9.10.6 <<>> AAAA facebook.com
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 17242
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 13, ADDITIONAL: 27

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 1280
;; QUESTION SECTION:
;facebook.com.                  IN      AAAA

;; ANSWER SECTION:
facebook.com.           5       IN      AAAA    2a03:2880:f142:82:face:b00c:0:25de
```

Happy Eyeballs (RFC8305)



Any questions?

References

- ✓RFCs (IETF)
  - ✓IPv6 Basics: https://tools.ietf.org/html/rfc8200
  - ✓Important RFCs: https://tools.ietf.org/html/rfc8504
- ✓RIPE IPv6 basics training: https://www.ripe.net/support/training/material/basic-ipv6-training-course/BasicIPv6-Slides.pdf
- ✓https://fr.wikipedia.org/wiki/IPv6
- ✓https://www.ciscolive.com “On demand Library”
- ✓Thanks to Eric Vyncke and Carl Wuyts for the contributions and corrections