IP Subnetting, IPv6

14 December 2025
Lecture 8

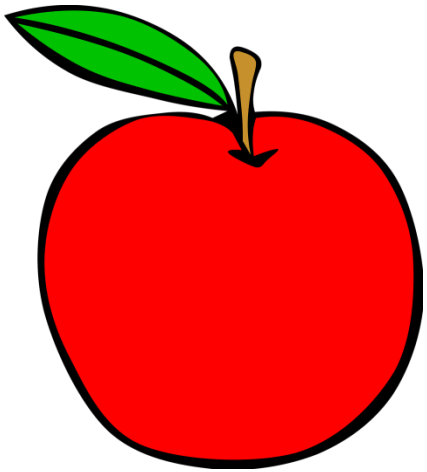
Topics for Today

- IP Subnetting
- IPv6

- Sources in PD:
  - Subnetting: 4.3.1
- Sources in Dordal:
  - IPv6: 11

Subnetting

- Idea: One IP network number allocated to several physical networks.
  - The multiple physical networks are called *subnets*
  - Should be close together (why?)
  - Useful when a large company (or university!) has many physical networks.



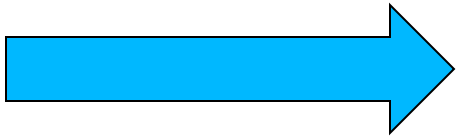
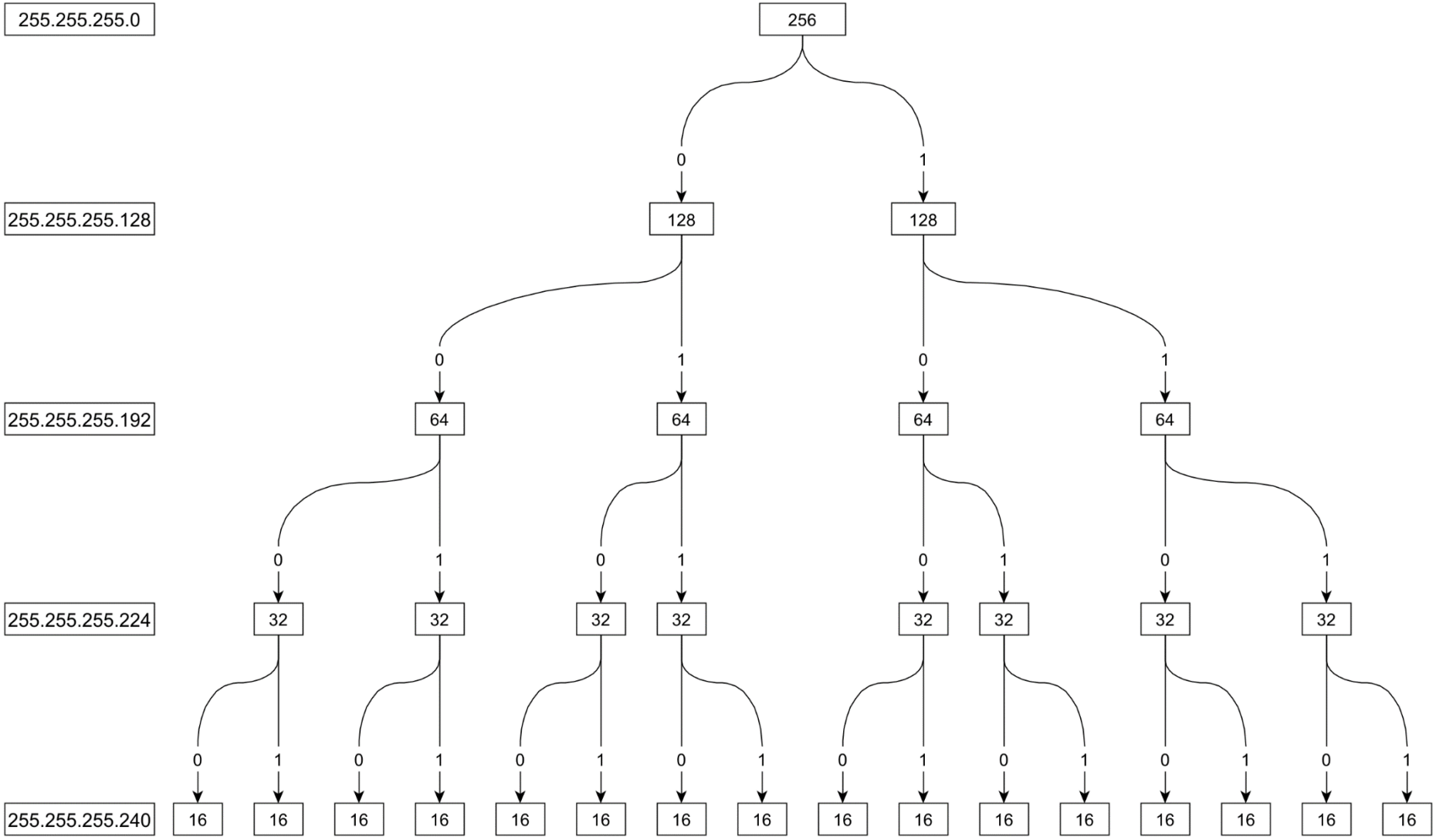


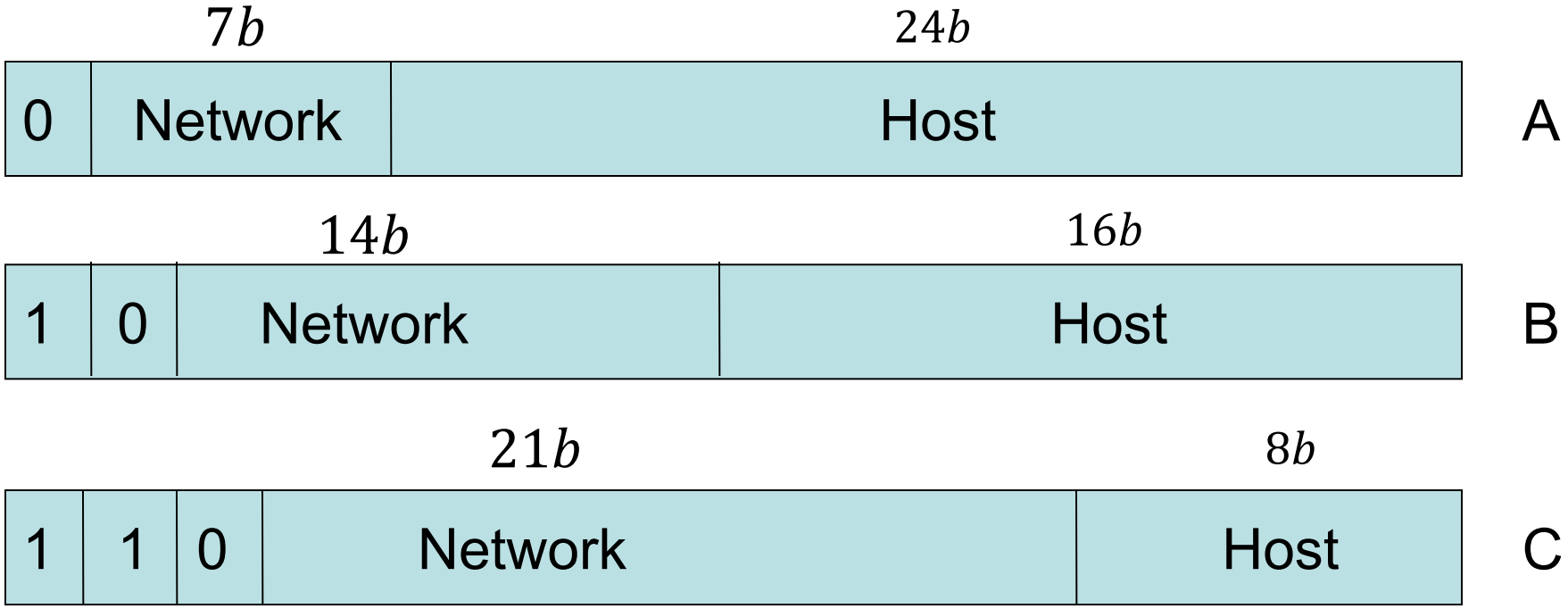
Image source: https://images-na.ssl-images-amazon.com/images/I/61wI3JN2G2L._SY355_.jpg

Prefix Hierarchy



IP addresses

- Hierarchical, not flat as in Ethernet



- Written as four decimal numbers separated by dots:
  158.130.14.2

Subnet Numbers

- *Subnetting*
  - All nodes are configured with *subnet mask*
  - Allows definition of a *subnet number*
- All hosts on a physical subnetwork share the same *subnet number*

Determines how many computers are on the subnet

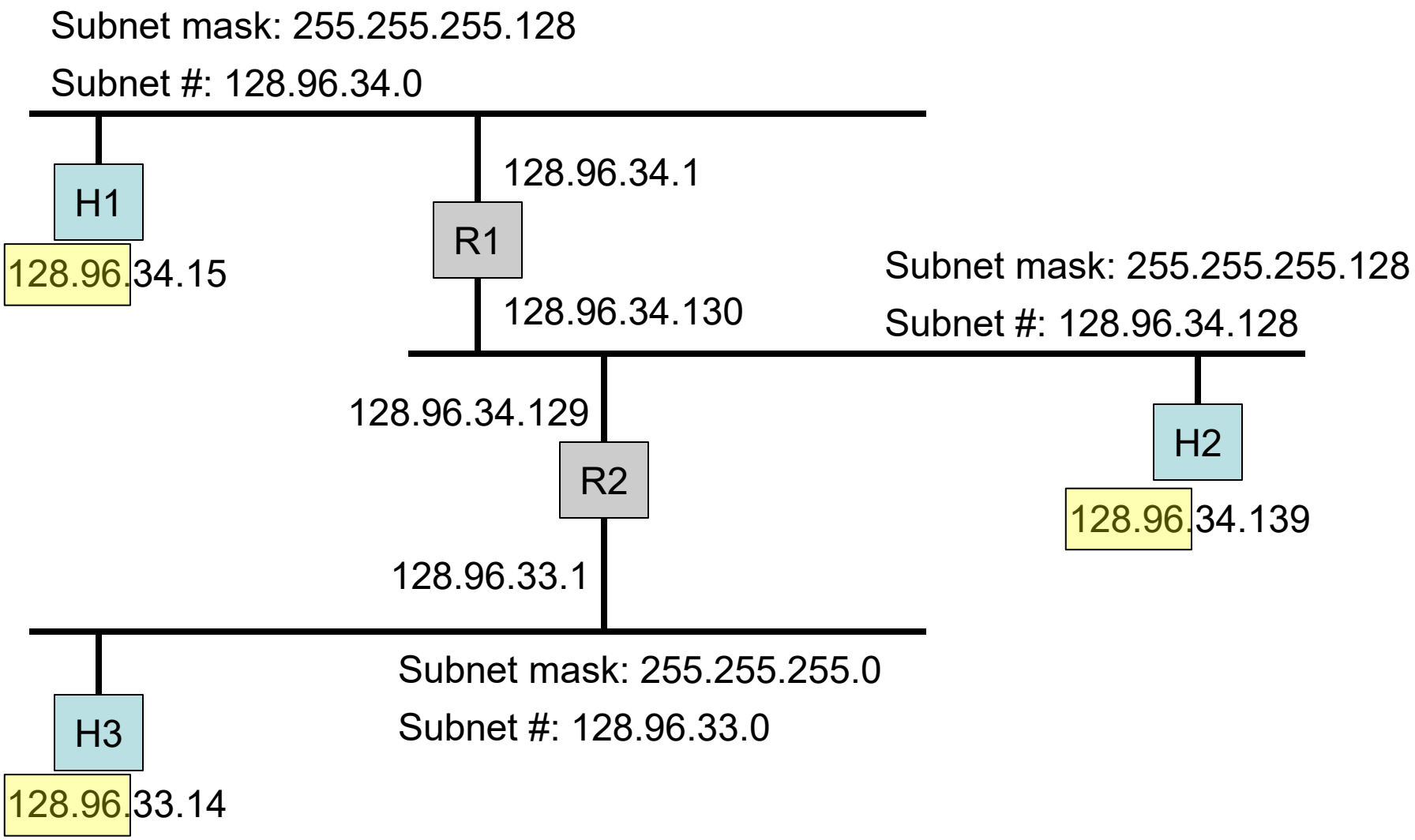
Subnet Mask (255.255.255.0)

1111 1111	1111 1111	1111 1111	0000 0000

Subnetted Address:

Network Number	Subnet ID	Host ID

Example of Subnetting



Subnets, continued

- Mask is bitwise-ANDed with address
- This is done at routers
- Router tables in this model:
  - $\langle Subnet\ \#, Subnet\ Mask, NextHop \rangle$
  - Routing table sorted by the length of the Subnet Mask (longest first).

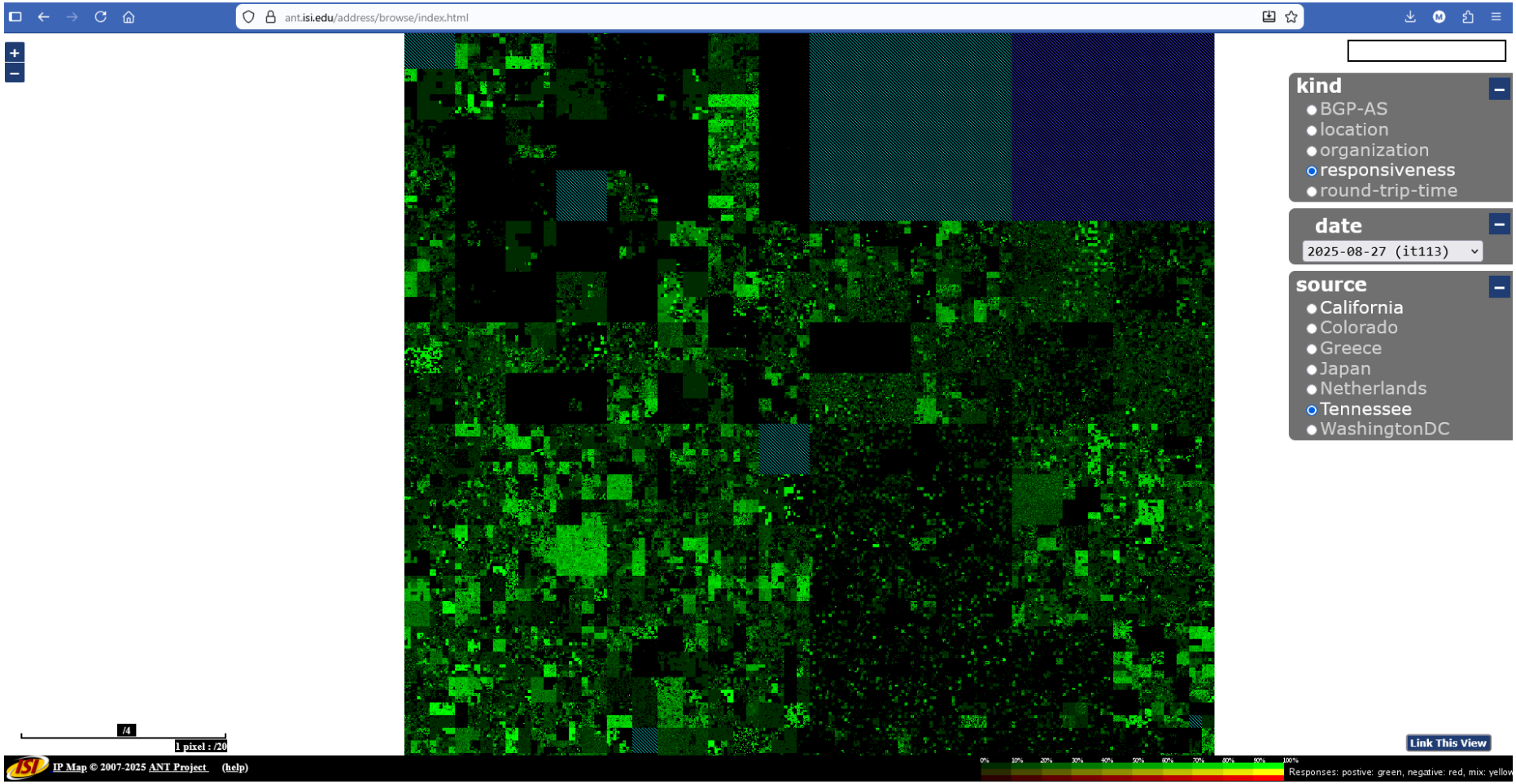
- Subnetting allows a set of physical networks to look like a single logical network from elsewhere

So Far

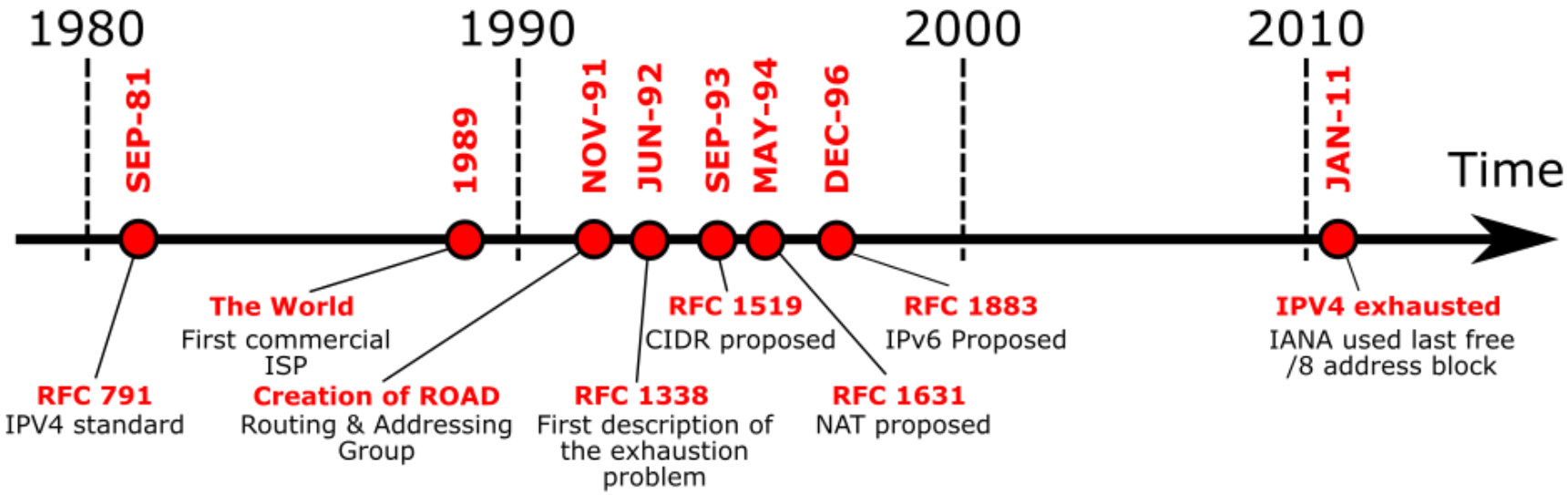
- IP Subnetting
- IPv6

Why IPv6? No more IPv4

https://ant.isi.edu/address/browse/index.html?kind=responsiveness&source=t&date=2025-08-27%20(it113)&scale=4&center=43.59.85.140



Why IPv6? No more IPv4



By Michel Bakni - RFC 791, The world, ROAD creation, RFC 1338, RFC 1519, RFC 1631, RFC 1883 & IANA., CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=85929080

https://en.wikipedia.org/wiki/IPv4_address_exhaustion

IPv6 Addresses

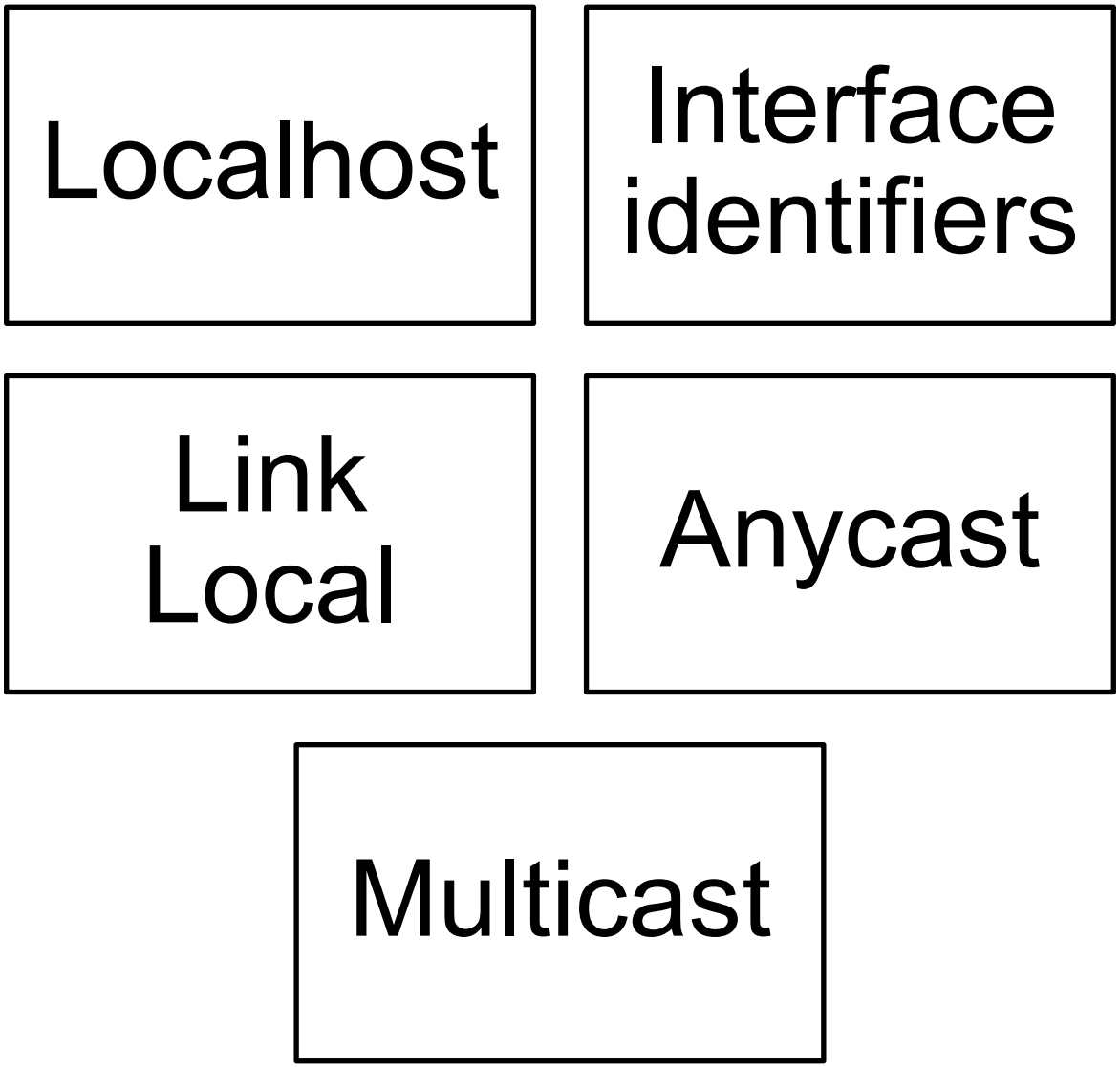
- 16 bytes = 128 bits
  - 3.4×10^{38} addresses in theory (16, 000 per m^2 of the Earth)
  - Written in 8 four letter hex blocks
  - Omit leading 0s, compress runs `::`

Examples:

- `2a00:1450:4028:804::200e`
- `2a03:2880:f142:182:face:b00c:0:25de`
- `2a02:26f0:7000::211:71f0`

https://m.facebook.com/whatismyip/photos/a.1015065033480218 0/10154092465582180/

IPv6 Address Types



IPv6 Address Types: Localhost

"this" for the computer

Like `127.0.0.1` in IPv4

`::1`

- `0:0:0:0:0:0:0:1`

IPv6 Address Types: Link Local

Unique only for local LAN

- Auto-configuration
- Site local addresses also

`fe80::/64`

- `fe80:0:0:0:XXXX:XXXX:XXXX:XXXX`
- Can embed the physical address in last 64 bits

Valid only on a single network

- Like 169.254.0.0/16
- Advertised to other hosts by routers
- Not routable on the internet

Scoped to a particular interface

- E.g. %eth0

EUI-64 format

- Take Ethernet 48 bits
- Add 1111 1110 between 3rd and 4th byte
- Flip 7th bit

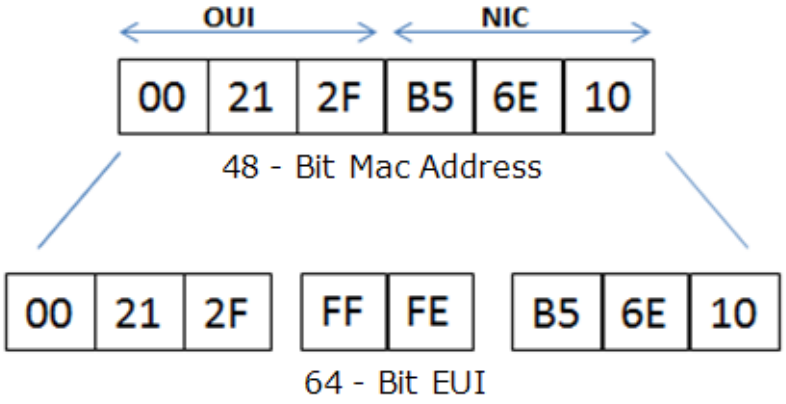
EUI-64 Example

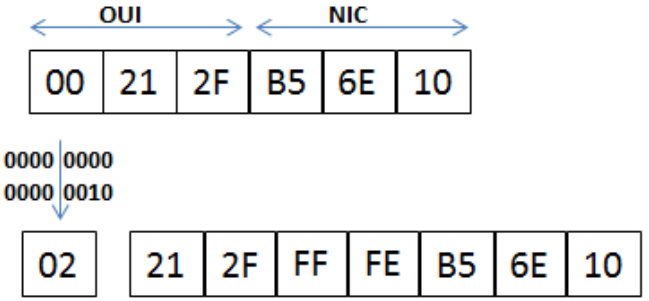
- Ethernet 00:a0:cc:24:b0:e4
- Result: fe80::2a0:ccff:fe24:b0e4

IPv6 Address Types: Link Local

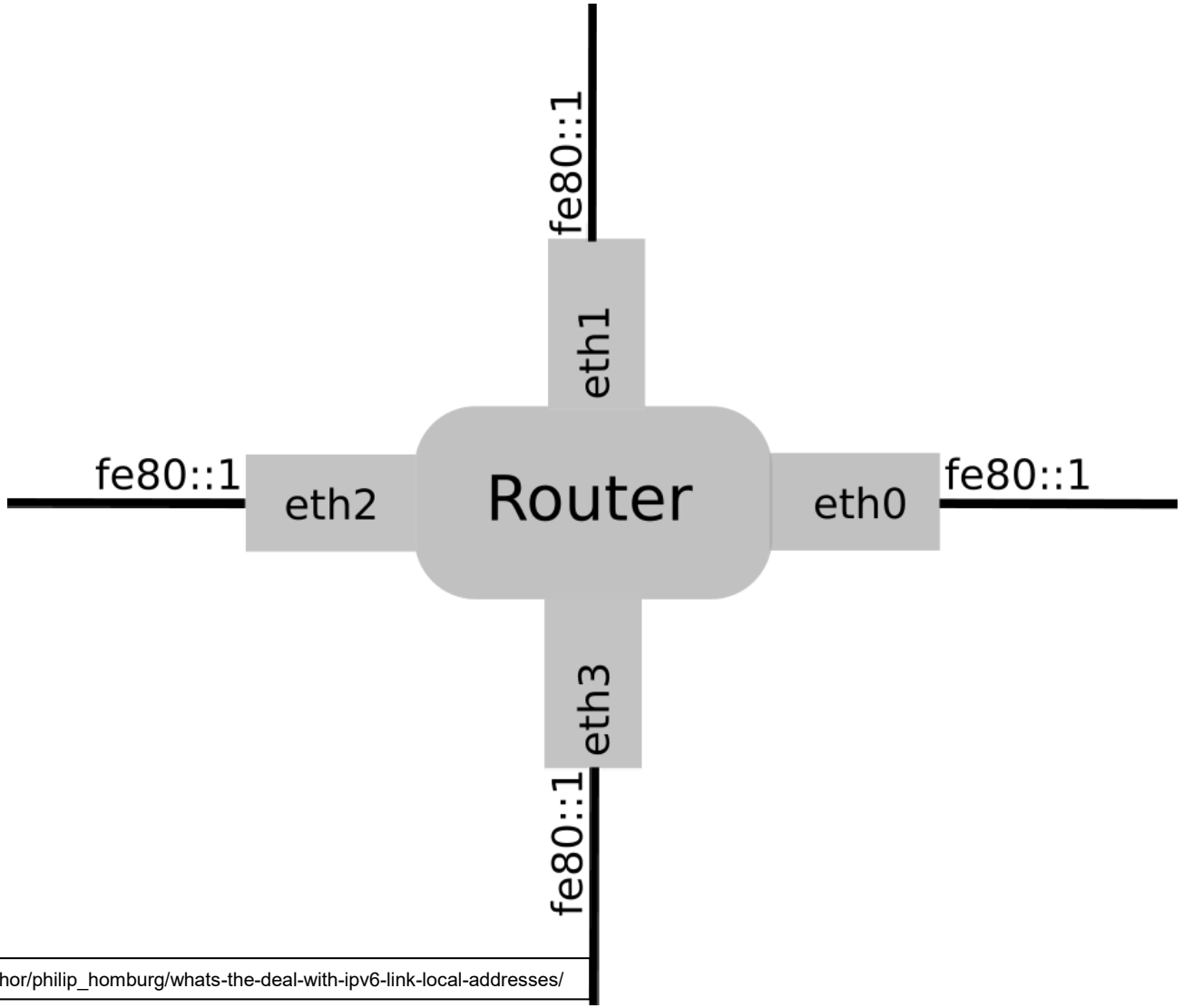
SPUI, Public domain, via Wikimedia Commons

EUI-64 Illustrated





Why you need to scope



https://labs.ripe.net/author/philip_homburg/whats-the-deal-with-ipv6-link-local-addresses/

IPv6 Address Types: Interface identifiers

Typical division

- 64 bits network prefix
- 64 bits host id

Started with `2000::/3` block

- `0200:0:0:0:0:0:0:0`

Used EUI-64 format for host identifier

- Privacy problems
- Can track your computer wherever it goes

IPvSeeYou vulnerability

- Home router might have fixed EUI-64 address
- Can track your public IPv6 address back to home router
- Easy to map MAC wireless router to map
- wigle.net

More secure idea using hashes and secret key for host id

IPv6 Address Types: Anycast

One address, many potential servers

Route to nearest one normally

One of the set receives the message and may respond

No special prefix

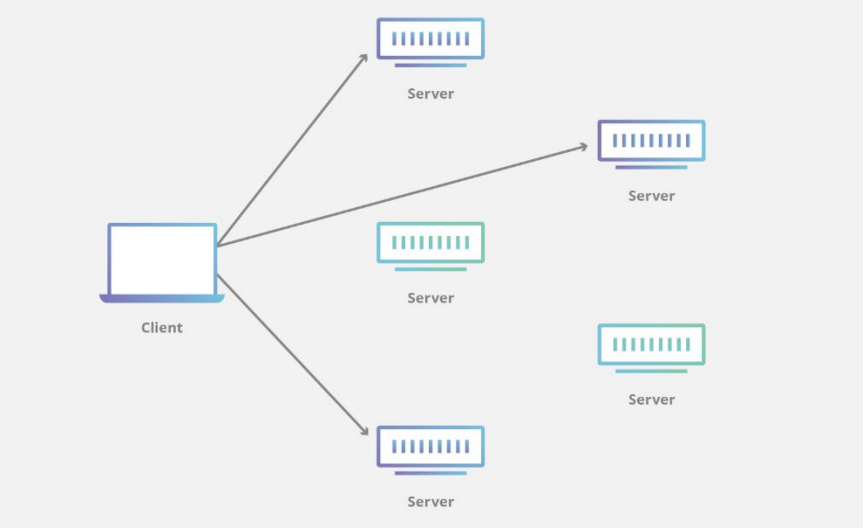


Image © Cloudflare, source: https://www.cloudflare.com/learning/cdn/glossary/anycast-network/

IPv6 Address Types: Multicast

Group of receivers

ff00:/8

- ff00:0:0:0:0:0:0:0

Lots of groups

- No more need for IP LAN broadcast
- Subscribe using Multicast Listener Discovery (MLD) messages
- Switches forward to routers to ensure only interested nodes receive

Ethernet multicast for LAN distribution

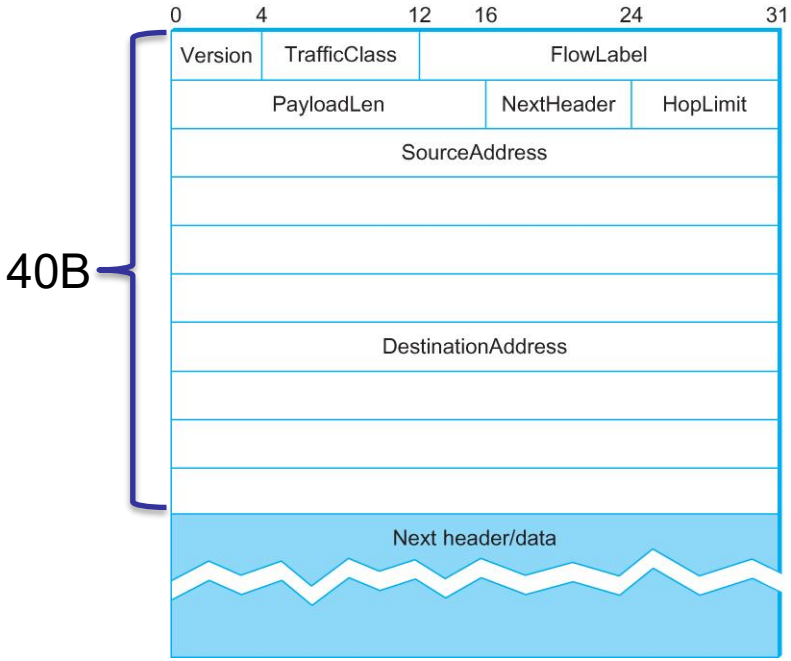
- Last 4 bytes of IPv6 multicast group embedded in Ethernet with 3333 prefix
- w, x, y, z last bytes of group, embedded as 33:33:w:x:y:z

Example:

- All nodes: ff02::1 →33:33:00:00:00:01
- All routers: ff02::2 →33:33:00:00:00:02

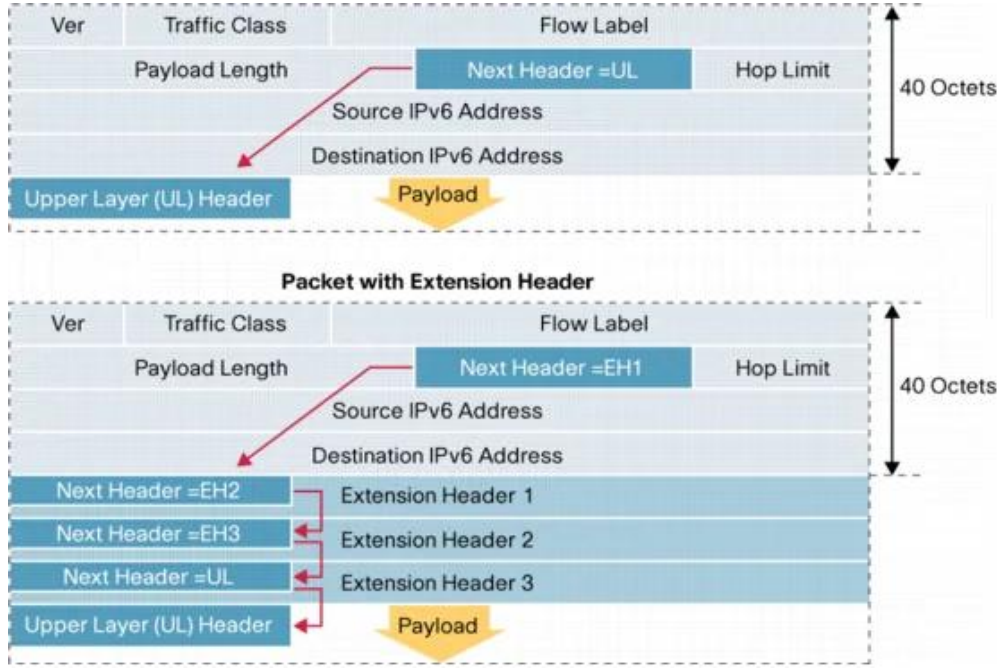
IPv6 Packet Format

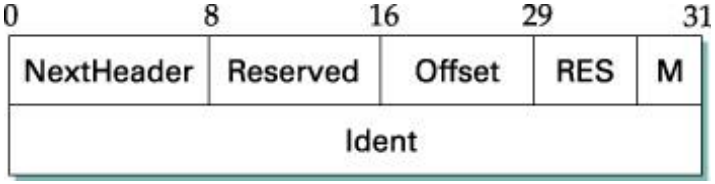
- Version (=6)
- Traffic class: for DiffServ QoS
- Flow label: grouping real time packets into flows for QoS and prioritizing
  - Non-real time traffic has no flow label
- Payload Length: Body length (bytes)
- Next Header: Higher level protocol the packet belongs to (Protocol in IPv4)
- Hop Limit: Same as TTL field of IPv4
  - No checksum!
- Source address (16B)
- Destination address (16B)



IPv6 Next Header

- Additional options and extensions are in headers after the initial 40B
  - Fixed order, multiple of 8 bytes
- If there are extensions → Next Header has the next extension header type
  - 44 for fragmentation
  - 43 mobile routing
  - 51 authentication
  - 50 encrypted data
- If no extensions → it's the inner protocol number
  - 59 if there is nothing inside





44 fragmentation header

Conclusion

- IP Subnetting
- IPv6