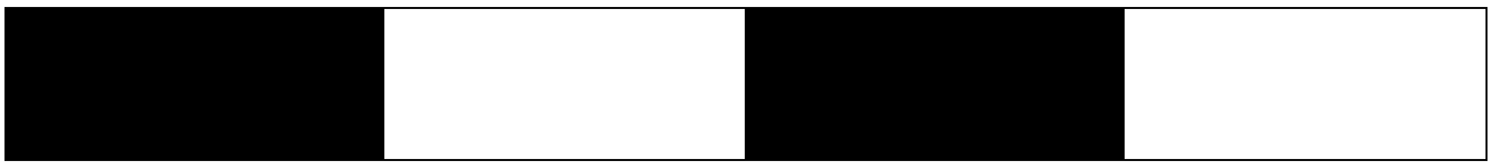
Campus Networking Workshop

IP Addressing and Routing

IPv4 addresses

- 32-bit binary number
- How many unique addresses in total?
- Conventionally represented as four dotted decimal octets

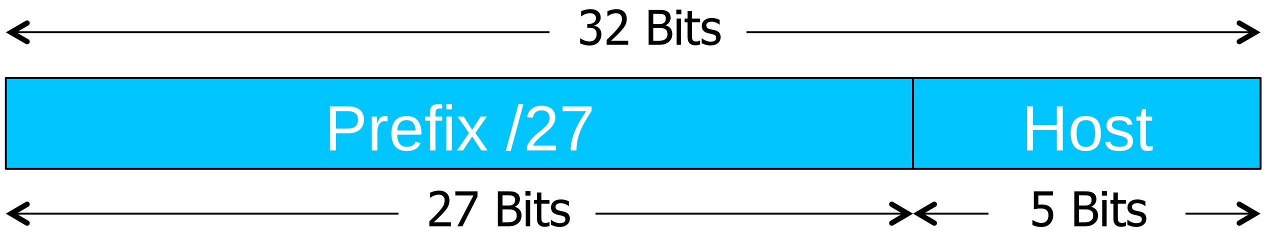
10000000110111111001110100010011



128 . 223 . 157 . 19

Can you explain why 00010011 = 19 in decimal?

Prefixes



- A range of IP addresses is given as a *prefix*, e.g. 192.0.2.128/27
- In this example:
- How many addresses are available?

- What are the lowest and highest addresses?

Prefix calculation

192 . 0 . 2 . 128

110000000000000000000000010 0000

Prefix length /27 è□ First 27 bits are fixed

Lowest address:

11000000000000000000000010100**00000**

192 . 0 . 2 . 128

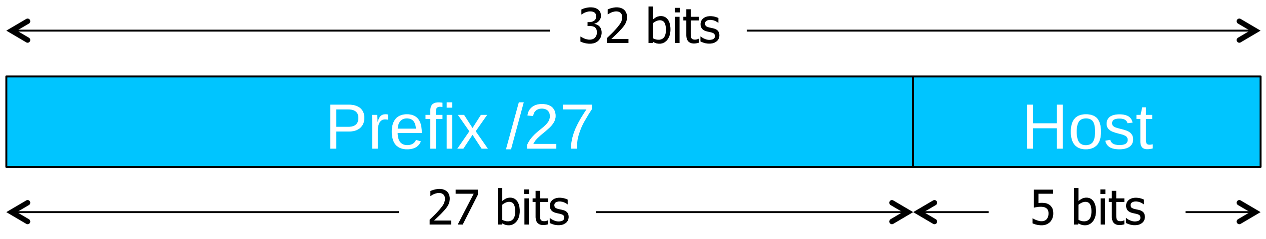
Highest address:

1100000000000000000000010100**11111**

[redacted]

192 . 0 . 2 . 159

IPv4 “Golden Rules”



1. All hosts on the same L2 network must share the *same* prefix
2. All hosts with the same prefix have *different* host part
3. Host part of all-zeros and all-ones are reserved

Golden Rules for 192.0.2.128/27

- Lowest 192.0.2.128 = network address
- Highest 192.0.2.159 = broadcast address

- Usable: 192.0.2.129 to 192.0.2.158
- Number of usable addresses: 32 - 2 = 30

Exercises

Network 10.10.10.0/25

  - How many addresses in total?
  - How many usable addresses?
  - What are the lowest and highest usable addresses?
  - Network 10.10.20.0/22

- How many addresses in total?
- How many usable addresses?
- What the the lowest and highest usable addresses?

An edge case

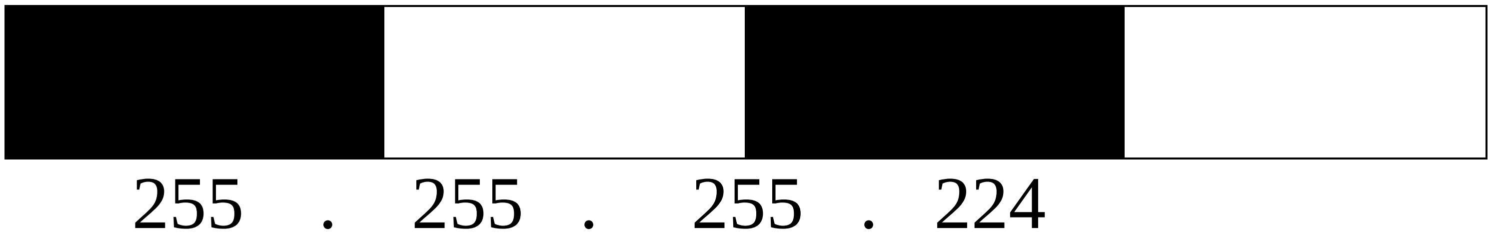
- How many usable addresses in a /30 prefix?
- What is this used for?
- (Note: modern routers support /31 for this purpose to reduce IP address wastage)

Netmask

- Netmask is just an alternative (old) way of writing the prefix length
- A '1' for a prefix bit and '0' for a host bit
- Hence N x 1's followed by (32-N) x 0's

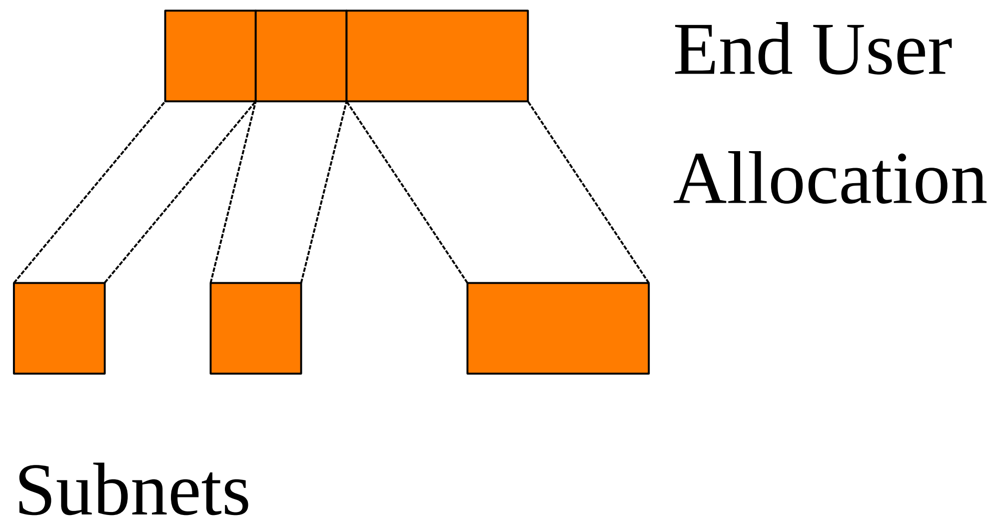
/27 =

11111111111111111111111111100000



Subnetting

- Since each L2 network needs its own prefix, then if you route more than one network you need to divide your allocation
- Ensure each prefix has enough IPs for the number of hosts on that network



Subnetting Example

- You have been given 192.0.2.128/27
- However you want to build two Layer 2 networks and route between them

- The Golden Rules demand a different prefix for each network
- Let's split this address space into two equal-sized pieces

Subnetting /27

192 . 0 . 2 . 128

110000000000000000000010100**00000**

Move one bit from host part to prefix

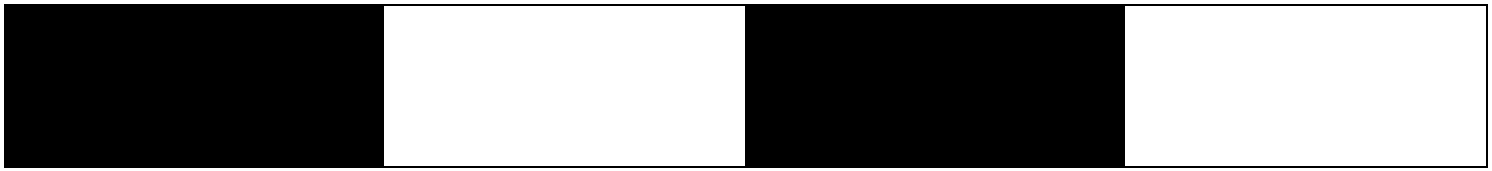
We now have two /28 prefixes

11000000000000000000001010000000

192 . 0 . 2 . 128

Second prefix:

1100000000000000000000101001 0000



192 . 0 . 2 . 144

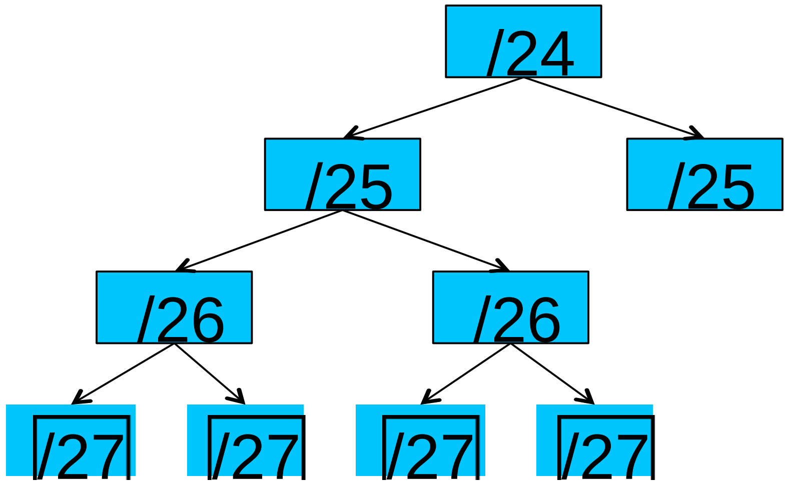
Check correctness

- Expand each new prefix into lowest and highest
- Ranges should not overlap

- 192.0.2.128/28
- Lowest (network) = 192.0.2.128
- Highest (broadcast) = 192.0.2.143
- 192.0.2.144/28
- Lowest (network) = 192.0.2.144
- Highest (broadcast) = 192.0.2.159
- How many usable addresses now?

Aggregation tree

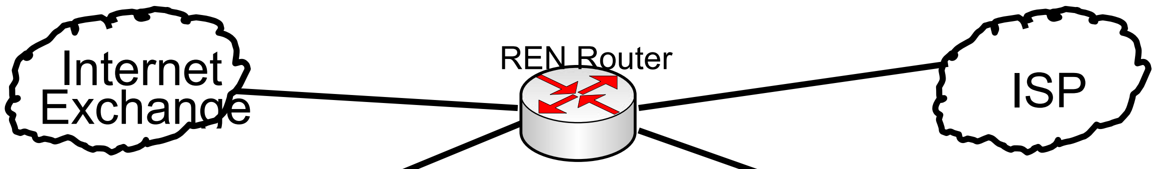
- Continue to divide prefixes as required
- Can visualize this as a tree



How Much Space for a REN

- Every member connected with a point to point link
- Every point to point link requires at least a /30 (4 addresses)
- REN will address space for;Network management equipment and Services such as web, video conferencing
- Build a spreadsheet that details all the above

A Simple (Small) REN Example



Simple (Small) REN Example

Network	Hosts	CIDR block	Size	Qty	Total
Point to point links	2	/30	4	7	28
Server network for network Mgmt	40	/26	64	1	64
Server network for Services	40	/26	64	1	64
Future network for services	40	/26	64	1	64
Future customer links	2	/30	4	4	16
Total					236

You can't get a CIDR block of 236 addresses - rounding up, you get 256 or a /24. **That doesn't include any addresses for customers**

Questions on IPv4?

IPv6 addresses

- IPV6 provides a platform on new internet functionality that will be needed in the immediate future and provide **flexibility** for future **growth** and **expansion**.
- 128-bit binary number
- Conventionally represented in hexadecimal
- 8 words of 16 bits, separated by colons

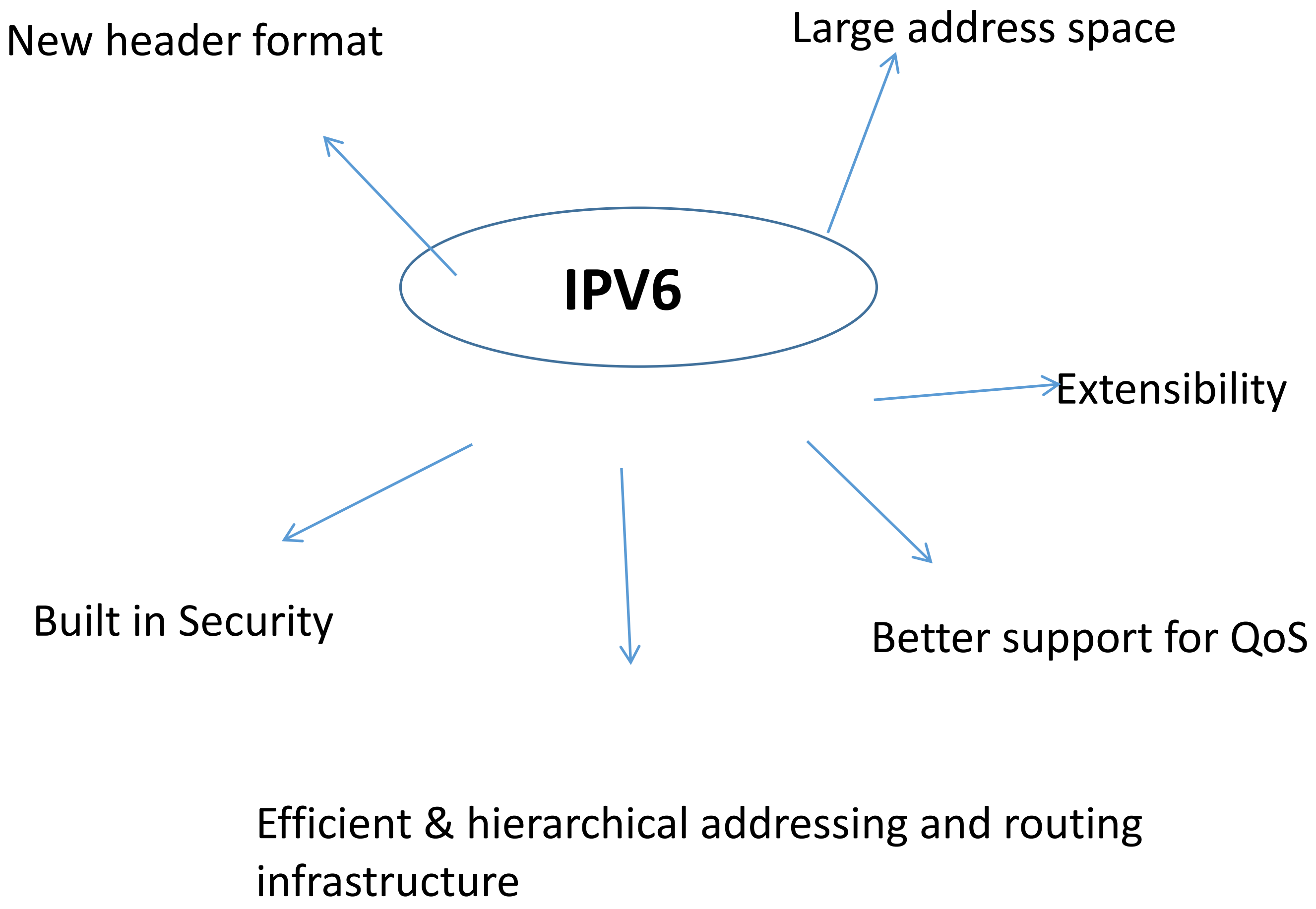
2607:8400:2880:0004:0000:0000:80df:9d13

- Leading zeros can be dropped

- One contiguous run of all-zero words can be replaced by "::"

2607:8400:2880:4::80df:9d13

Benefits of IPV6…..



IPv6 rules

With IPv6, every network prefix is /64

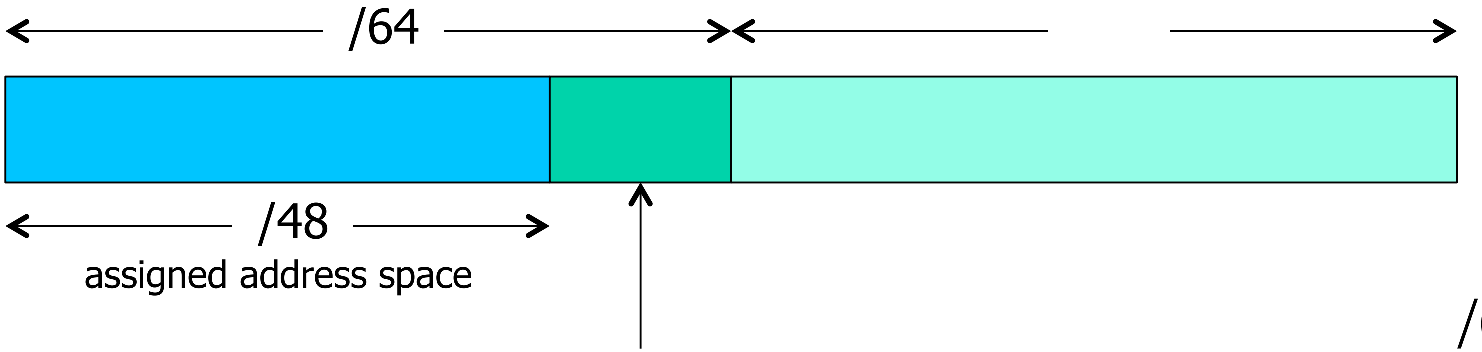
(OK, some people use /127 for P2P links)

- The remaining 64 bits can be assigned by hand, or picked automatically

- e.g. derived from NIC MAC address
- There are special prefixes e.g. link-local addresses start fe80::
- Total available IPv6 space is $\approx 2^{61}$ subnets
- Typical end-user allocation is /48

IPv6 addressing

network prefix host ID



/64

network ID

- How many /64 networks can you build given a /48 allocation?

IPv6 addressing

- You are assigned 2001:db8:123::/48
- 2001:0db8:0123:0000:0000:0000:0000:0000
- Lowest /64 network?
- 2001:db8:123:0000::/64 • written simply

2001:db8:123::/64 • Highest /64 network?

- 2001:db8:123:ffff::/64

Ways to allocate the host part

- Do it automatically from MAC address – "stateless auto configuration"
- Not recommended for servers: if you change the NIC then the IPv6 address changes!
- Can number sequentially from 1, or use the last octet of the IPv4 address
- Or embed the whole IPv4 address
- e.g. 2607:8400:2880:4::80df:9d13

- 80df9d13 hex = 128.223.157.19 in decimal
- Can write 2607:8400:2880:4::128.223.157.19