COMPUTER SYSTEMS FUNDAMENTALS
(4COSC004W)

Lecture: Week 10

In this part of the lecture

- Network topologies
  - *Physical & Logical*
- Types of network
- Network components
- IP Addressing
  - *Calculations*
  - *Masking*
  - *Classless & Classful systems*
- Subnetting calculations

NETWORK TOPOLOGIES

Physical & Logical Topologies

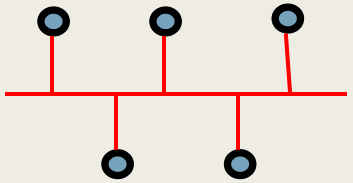
Networked computers

- Computers connected to each other
  - *Wired connections using cables*
  - *Wireless using WIFI, 4G/5G*
- We will concentrate on wired arrangement

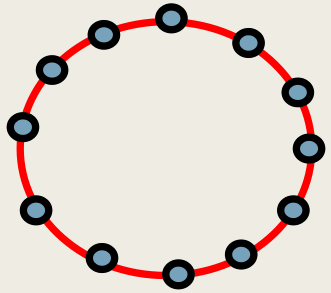
Physical & Logical Topologies

- **Physical Topologies** define the actual layout of the wire (media)
  - *eg. The wiring in the computer labs are laid out in an extended star arrangement*
  - ***Terminology:*** ***N****etwork* ***I****nterface* ***C****ard (NIC),* ***U****nshielded* ***T****wisted* ***P****air (UTP),* ***S****hielded* ***T****wisted* ***P****air (STP)*
- **Logical Topology** defines how the media is accessed by the hosts
  - *eg. In the computer labs, hosts access the media on a first come, first served basis*

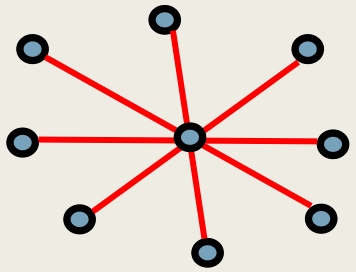
Physical Topologies



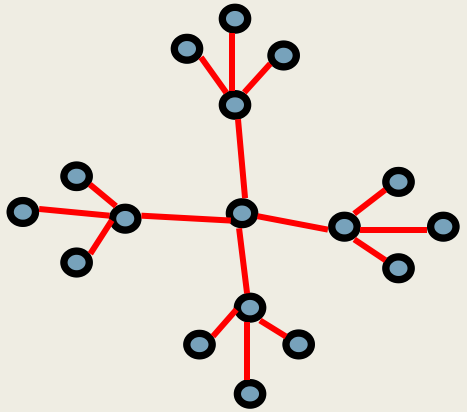
Bus



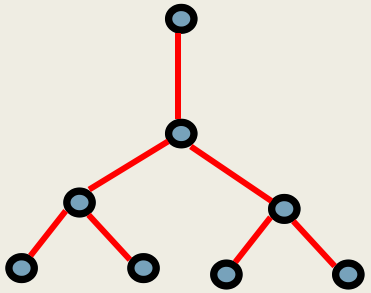
Ring



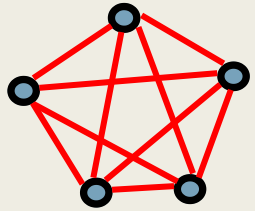
Star



Extended Star



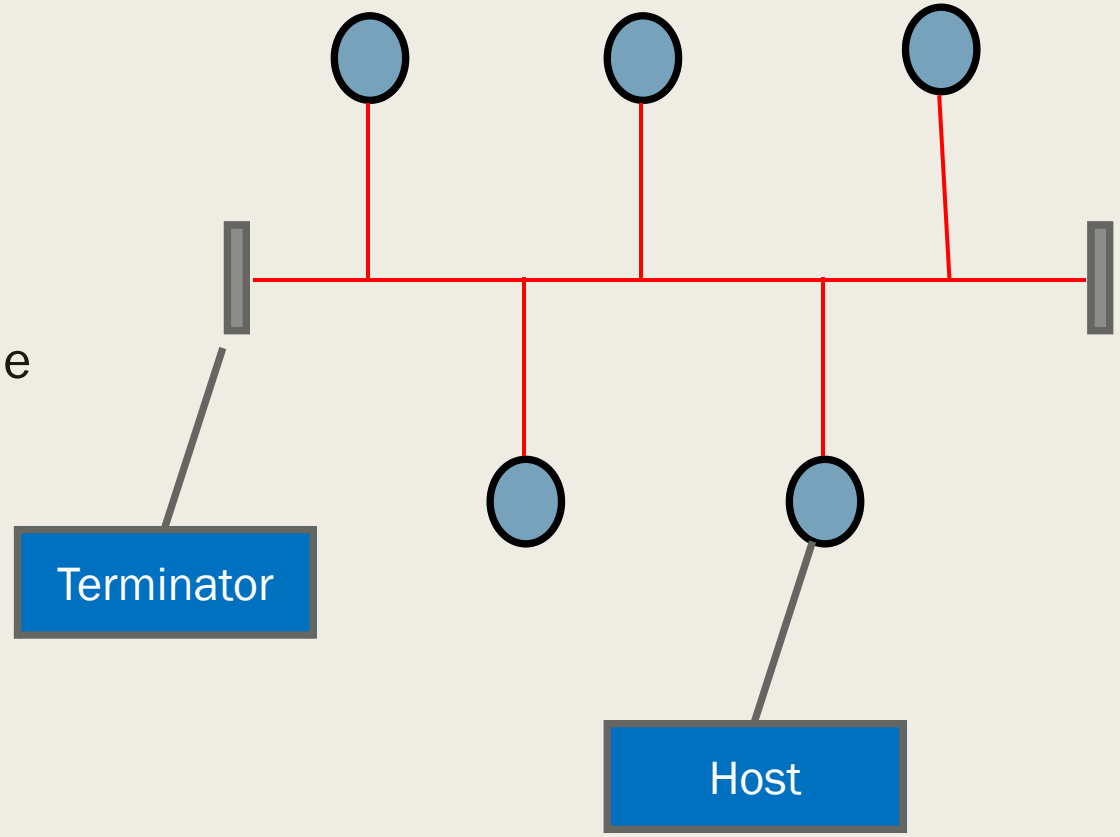
Hierarchical



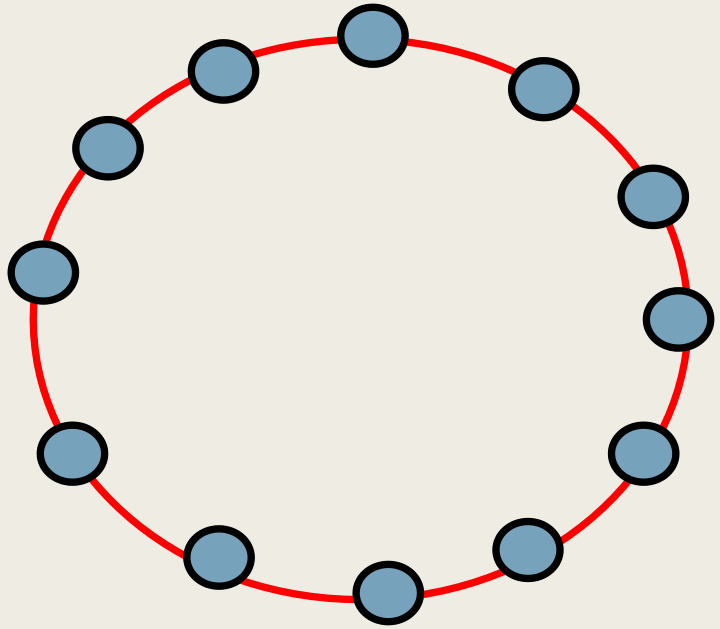
Mesh

Bus topology

- Single backbone
- All hosts connected to the backbone
- Each end must be terminated
- Susceptible to collisions



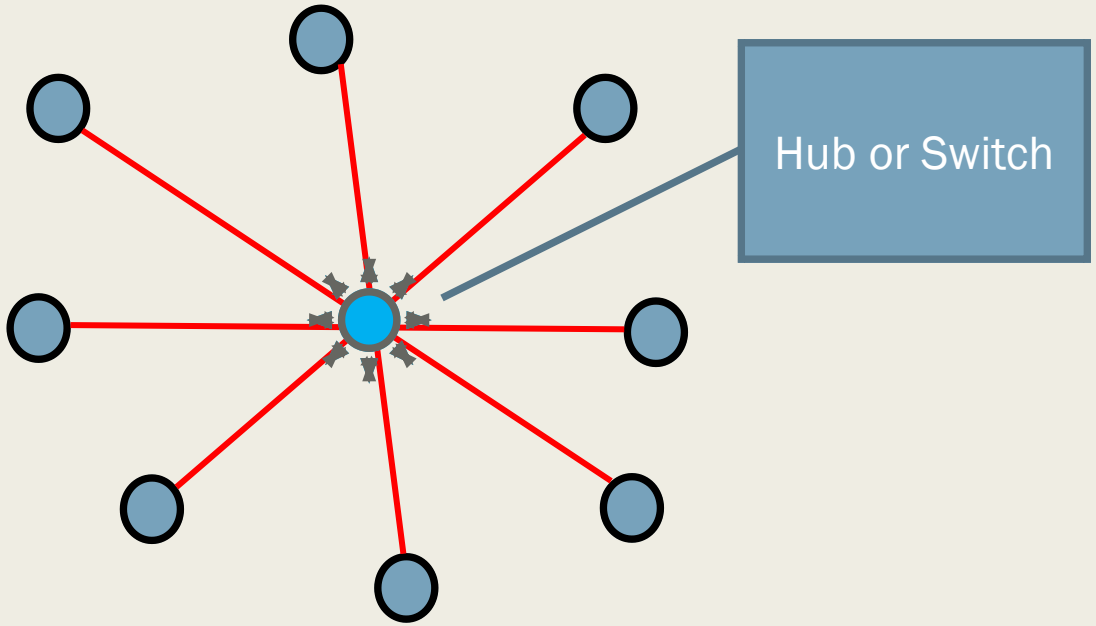
Ring Topology



- No Backbone
- A host is directly connected to each of its neighbours
- Used for Token Passing logical topologies

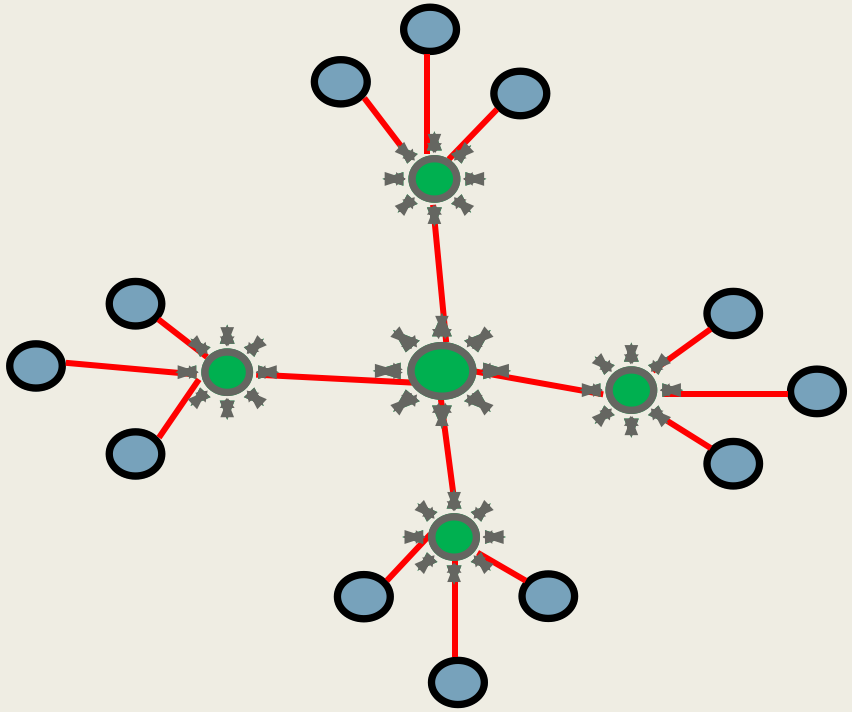
Star Topology

- All devices connected to a central point
- Used for Ethernet technologies



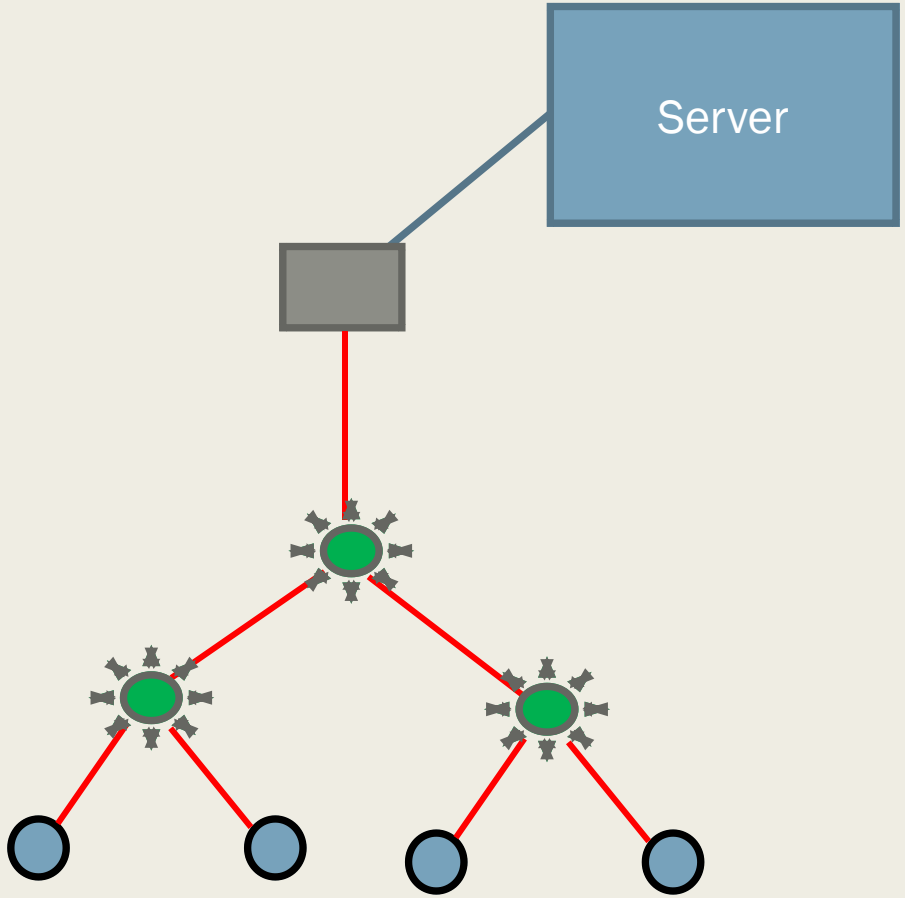
Extended Star Topology

- Connects Star topologies together
- Fractal pattern
- At the centre of Star is a Hub or Switch
- Extends the size of the network

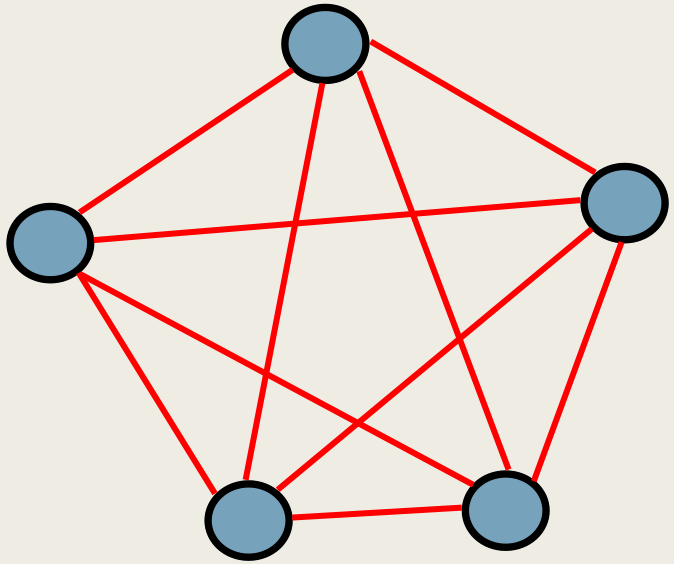


Hierarchical topology

- Like the extended star
- Except a computer controls traffic
  - *NOT a Hub or Switch*



Mesh Topology



- Maximally connected:
  - *Each host has its own connection to every other host*
  - *Use for critical systems*
- Non-maximally connected:
  - *Not every host is connected to every other host*
  - *Alternate routes if there are problems*

Logical Topologies:

- Broadcast topology:
  - *Each host on the LAN sends (or broadcasts) its data to every other host.*
  - *Access to media is based on "First come, first served"*
  - *Ethernet works this way*
- Token Passing Topology:
  - *Access to media is controlled by an electronic token*
  - *Possession of the token gives the host the right to pass data onto the media.*

TYPES OF NETWORK

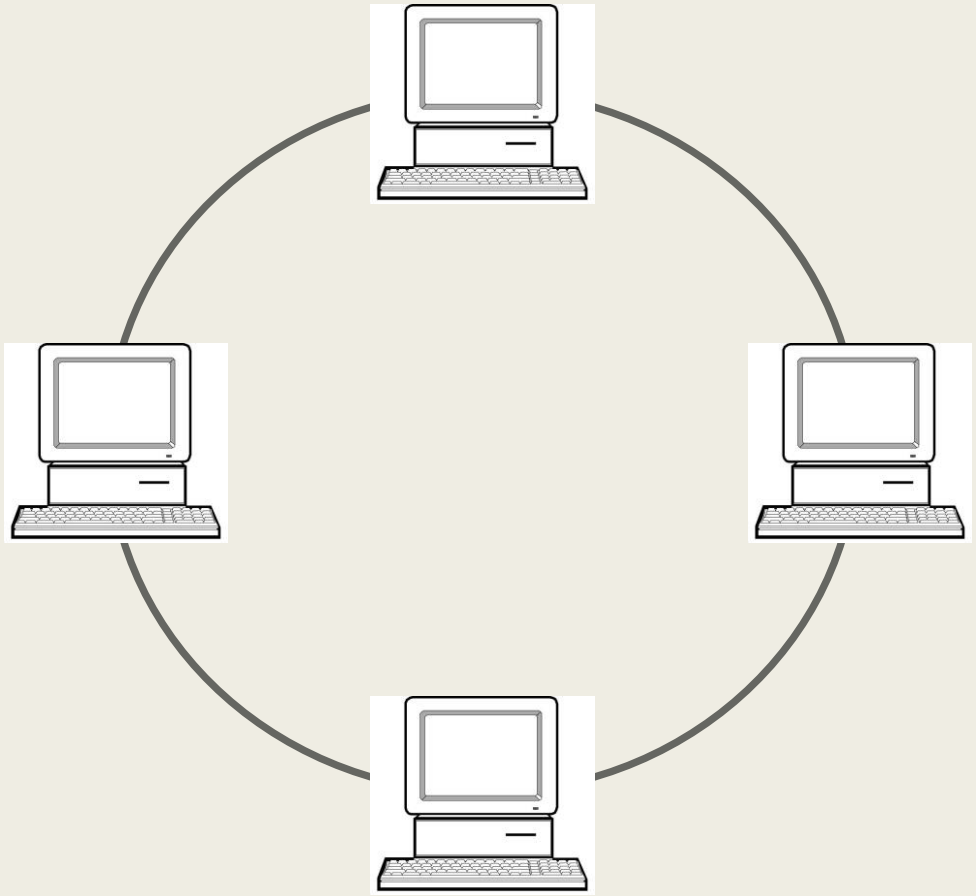
Peer-to-peer

Client-Server

Sizes of networks

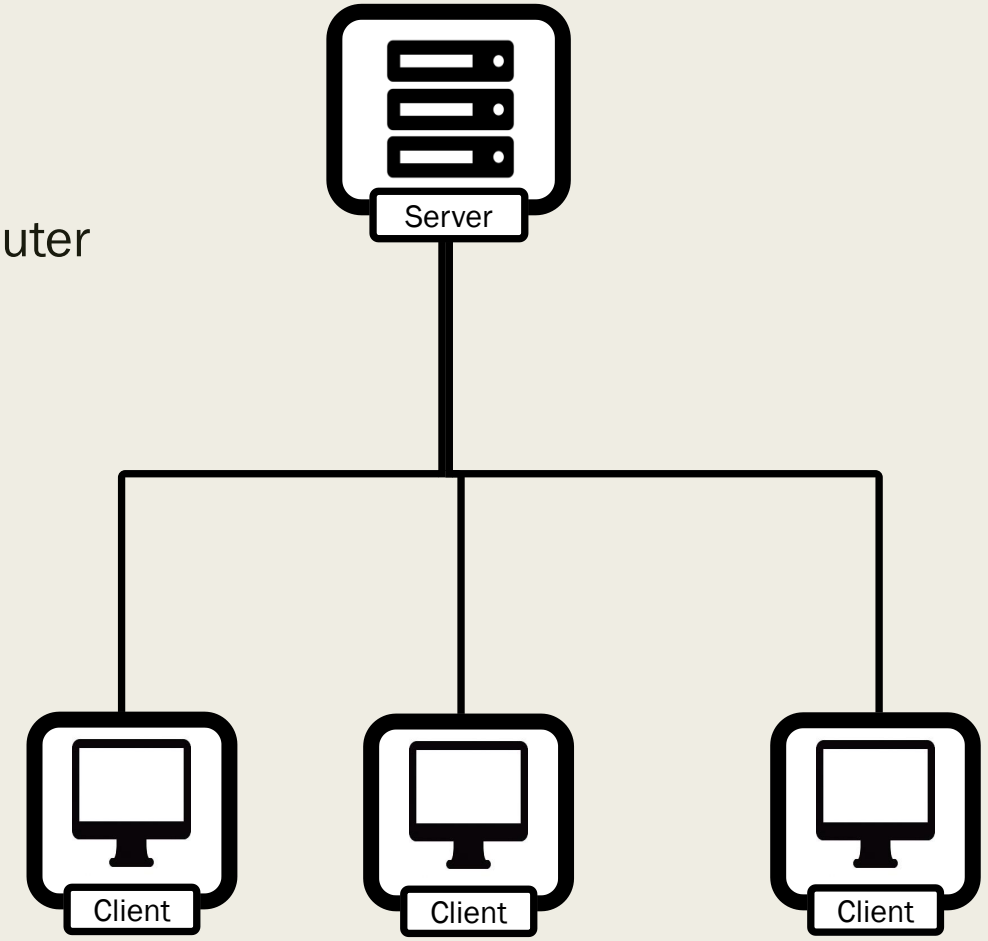
Peer-to-Peer Network

- Networked computers are equal partners
- Each computer can be a Server or Client
- Each component controls its own resources
- Resources can be shared
- Suitable for small networks



Client/Server network

- Network services are located on a dedicated computer
  - ***The Server***
- Server responds to requests from **Clients**
- Resources are shared
- Server can serve many Clients simultaneously
- Needs an administrator



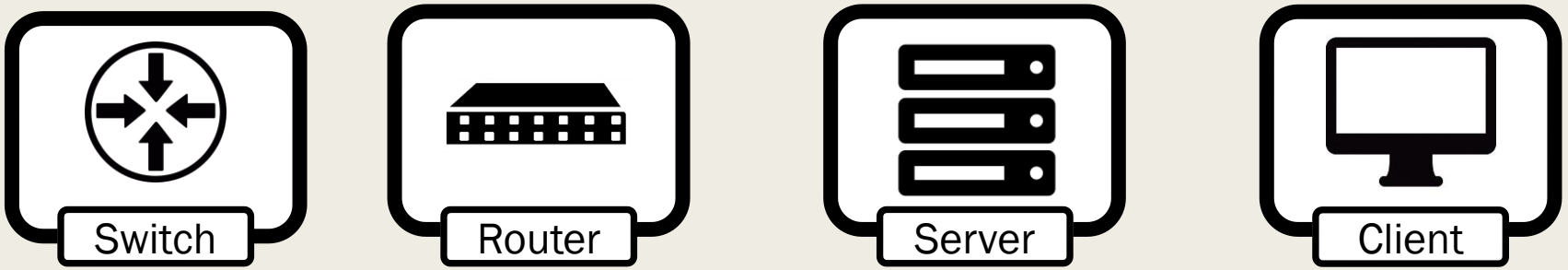
Terminology: Sizes of networks

- LAN
  - *Local Area Network*
- WAN
  - *Wide Area Network*
- MAN
  - *Metropolitan Area Network*
- SAN
  - *Storage Area Network*

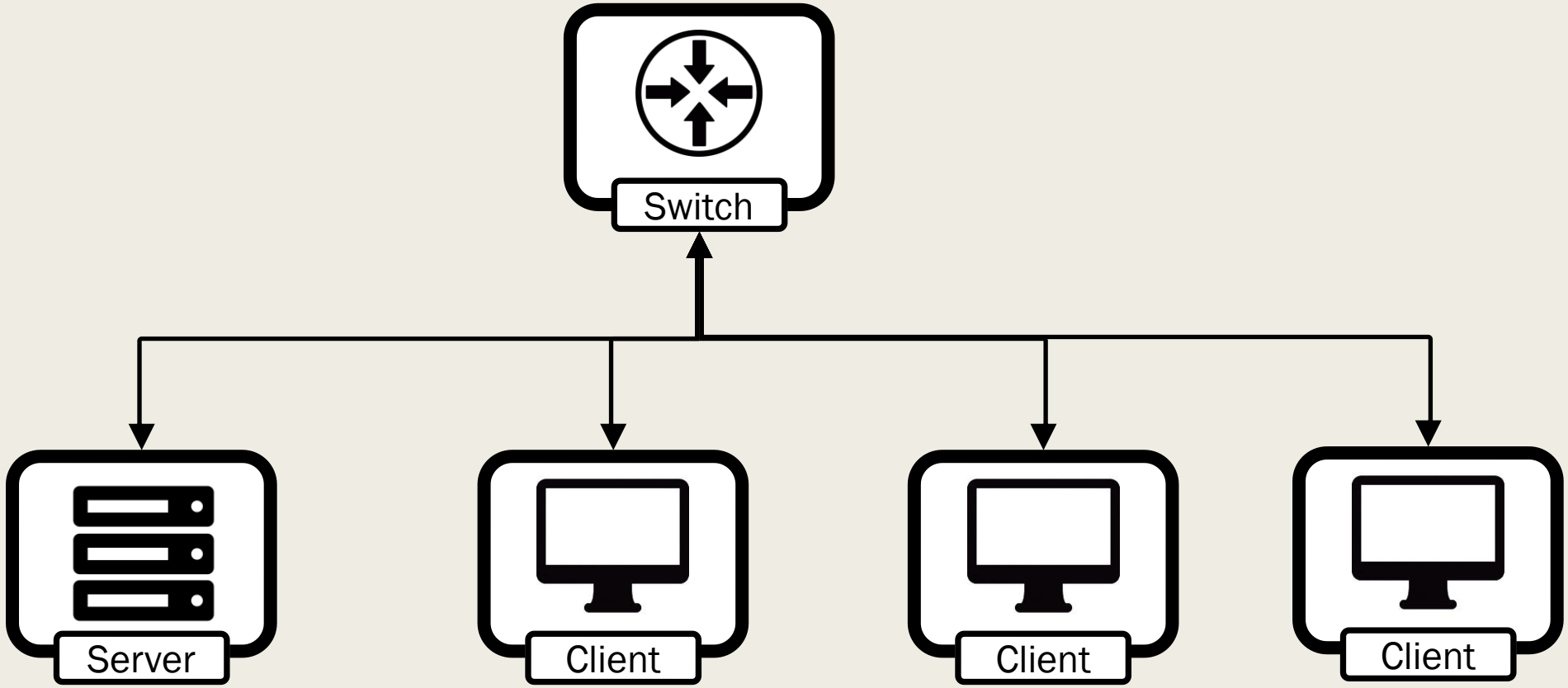
NETWORK COMPONENTS

Actors on the Network

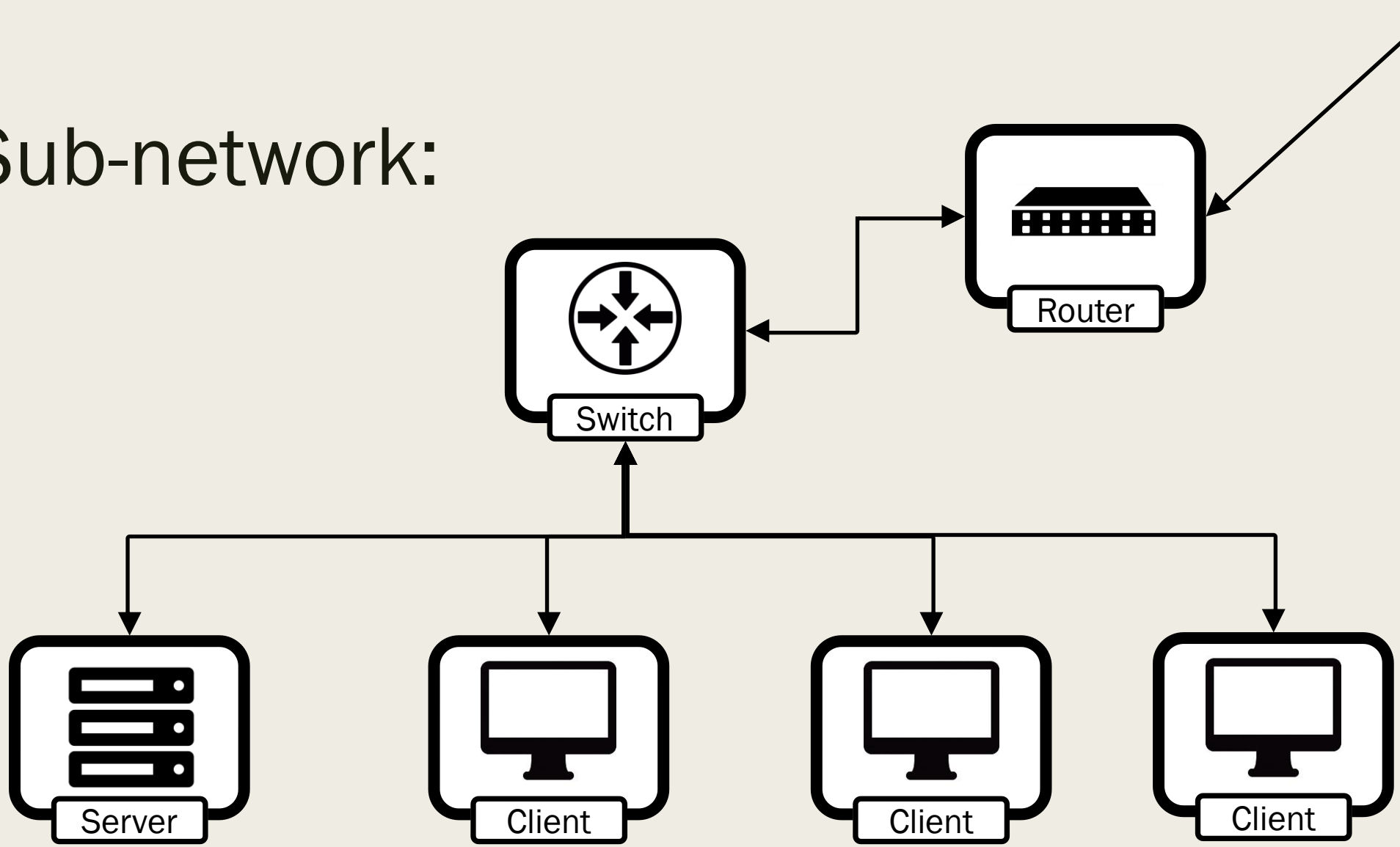
Network components:



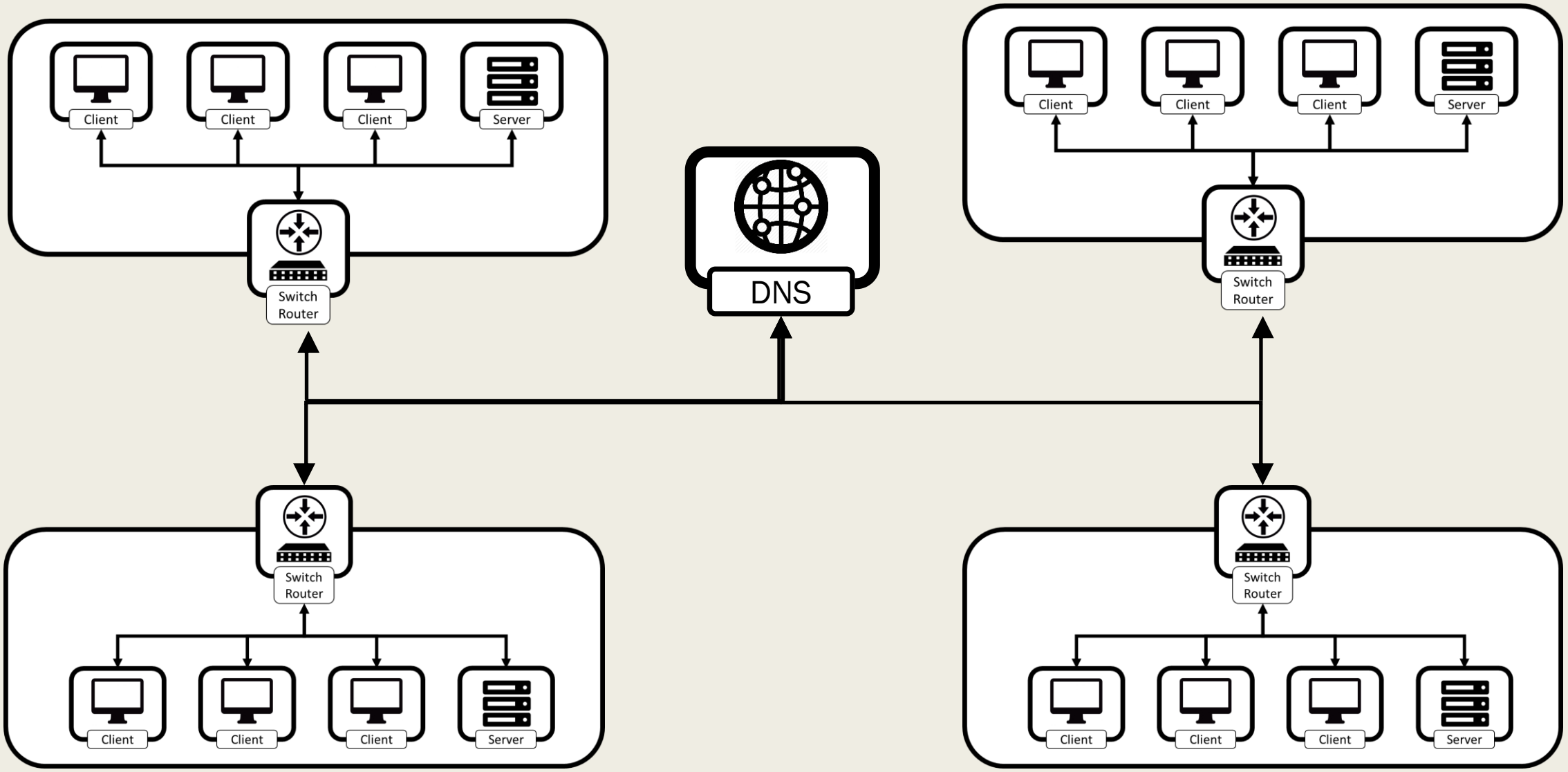
Closed network:



Sub-network:



Complete network:



IP ADDRESSING

IP Addresses:

- Unique Identification of:
  - *Network Host*
    - Source
    - Destination
- Identifies machine's connection to a network
- Moving to another network requires change of IP address
- Assigned by authorities such as:
  - *RIPE (**R**egional **I**nternet **R**egistry for **E**urope)*
  - *ARIN (**A**merican **R**egistry for **I**nternet **N**umbers)*
  - *LIR (**L**ocal **I**nternet **R**egistries)*
- TCP/IP uses unique 32-bit address
  - ***T**ransmission **C**ontrol **P**rotocol / **I**nternet **P**rotocol*

IP Addressing, limitations

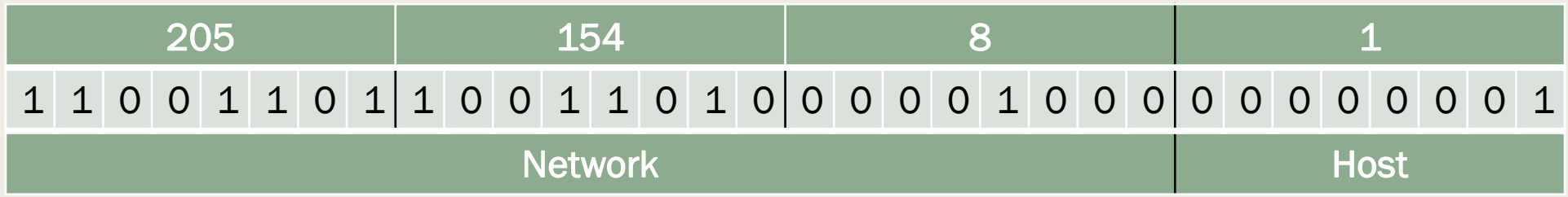
- IPv4
  - *32 bit address*
  - *Broken into 4 groups of 8 bits*
  - *2^{32} addresses in total*
  - *4,294,967,296*
  - *~2 addresses for every 3 persons on Earth*
- IPv6
  - *128 bit address*
  - *Broken into 12 groups of 8 bits*
  - *2^{128} addresses in total*
  - *$\sim 3.4 \times 10^{38}$*
  - *$\sim 5 \times 10^{28}$ addresses per persons on Earth*

Basic structure of an IP v4 address

- 32-bit number (4 octet number ; octet = 8 bits)
  - *Decimal representation:*
    - 133.27.168.125
  - *Binary representation:*
    - 10001010.00011011.10101000.01111101
  - *Hexadecimal representation:*
    - 85.1B.A2.7D

Anatomy of an IP Address:

- Hierarchical Division in IP Address:
  - *Network Part (Prefix)*
    - Describes which physical network
  - *Host Part (Host Address)*
    - Describes which host on that network



- Boundary can be anywhere
  - *Very often NOT at a multiple of 8 bits*

IP calculations terminology:

- Network Address:
  - *Identifies this network*
- Broadcast Address:
  - *Special IP address used to send a message to all the hosts on this network*
- Valid Host Address:
  - *And IP address that can be allocated to a host in this network*

Three flavours of Network Masks:

- CIDR
  - ***C**lassless **I**nter-**D**omain **R**outing*
  - *Network Prefix*
  - *192.168.1.0/24*
- Network Mask
  - *Bitmask*
  - *255.255.255.0*
- Classful systems

Classless Addressing

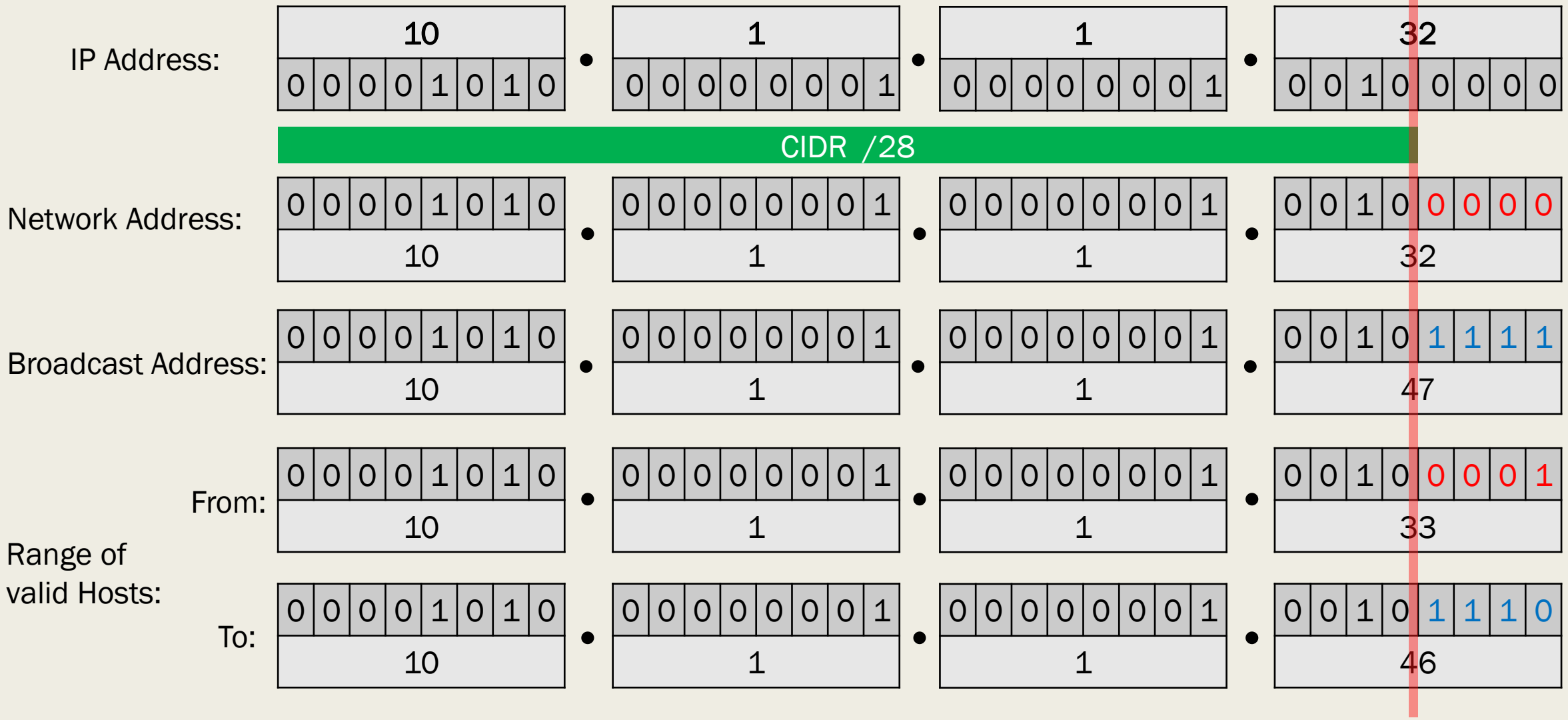
- Internet routing and address management today is classless
- CIDR = Classless Inter-Domain Routing
- VLSM = Variable–Length Subnet Masks

Process of Networking calculations:

0 Work out the CIDR
   - *The number of bits of the Network Mask*

1. Convert the whole IP address into Binary
2. Network Address is calculated by:
   - *Any bits to the left of the Mask, followed by all **zero**'s there after*
   - *Convert these 4 octet Binary values to Decimal*
3. Broadcast Address is calculated by:
   - *Any bits to the left of the Mask, followed by all **one**'s there after*
   - *Convert these 4 octet Binary values to Decimal*
4. The Network Address and Broadcast Address envelop the range of addressable host IP addresses
   - *From the address immediately after the Internet Address*
   - *To the address immediately before the Broadcast Address*

Network 10.1.1.32/28



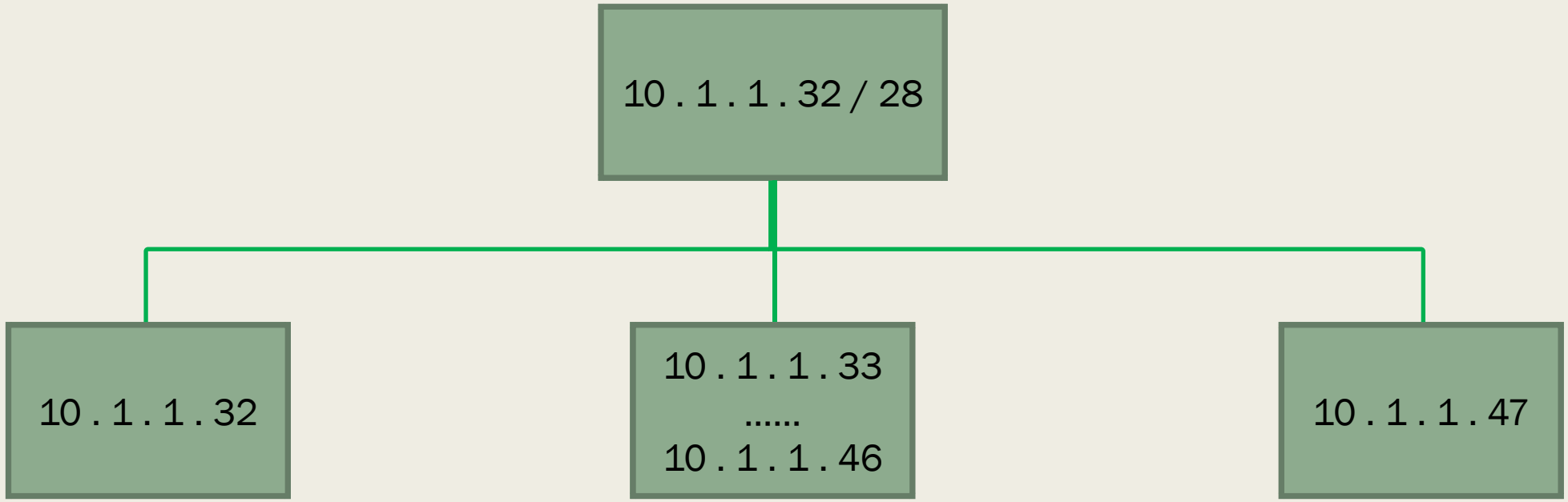
Network address & Broadcast address

- IP Address with subnet mask defines the range of addresses in the block:
  - *10.1.1.32/28 (subnet mask 255.255.255.240)*

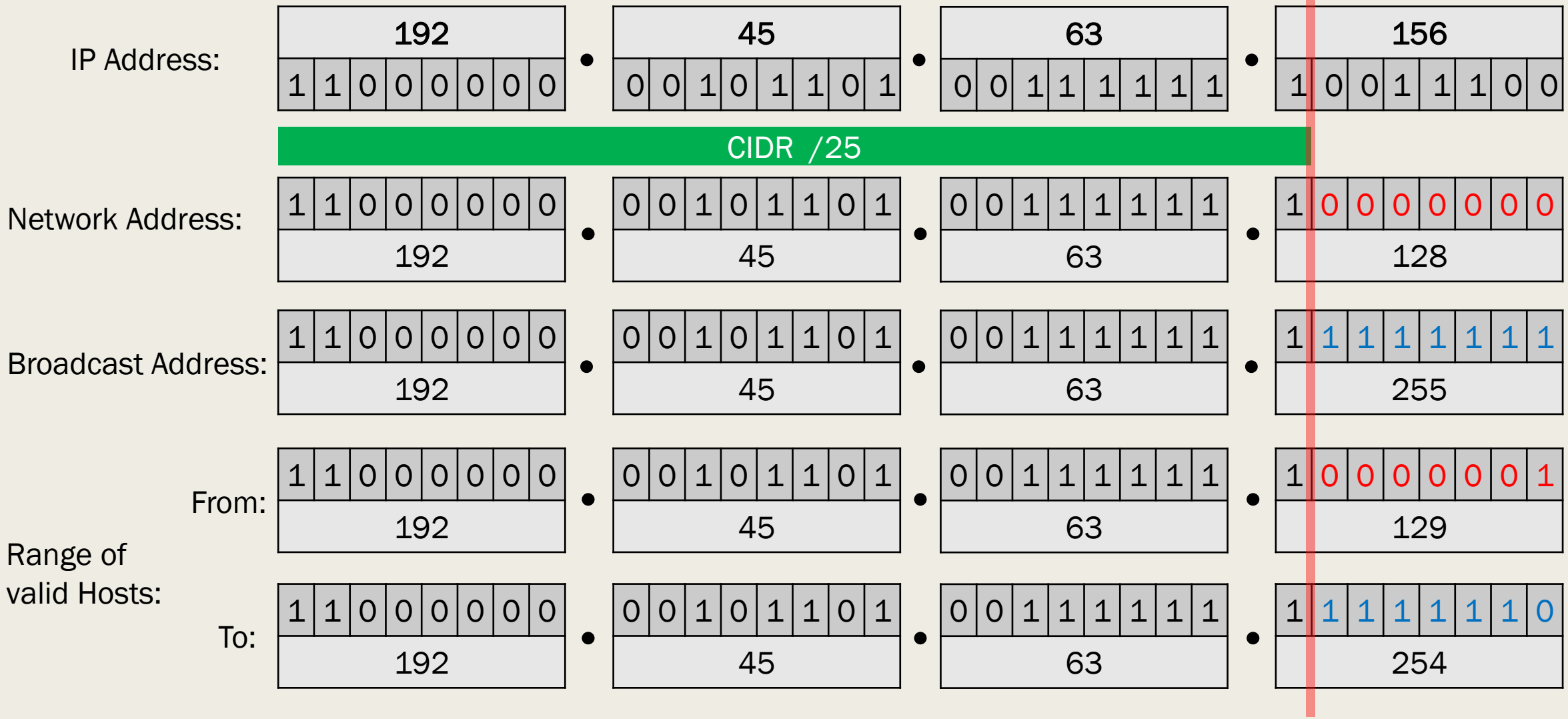
IP Address:	00001010 • 00000001 • 00000001 •	00100000		
Net Mask:	11111111 • 11111111 • 11111111 •	11110000		
Network Ad:	00001010 • 00000001 • 00000001 •	00100000		
	10 • 1 • 1 •	32		
Broadcast Ad:	00001010 • 00000001 • 00000001 •	00101111		
	10 • 1 • 1 •	47		

- 10.1.1.32 Network Address (AND operation)
- 10.1.1.47 Broadcast Address
  - *Total of 16 addresses in this subnet; ....0000 to 1111*
- 14 assignable addresses: 10.1.1.33 to 10.1.1.46

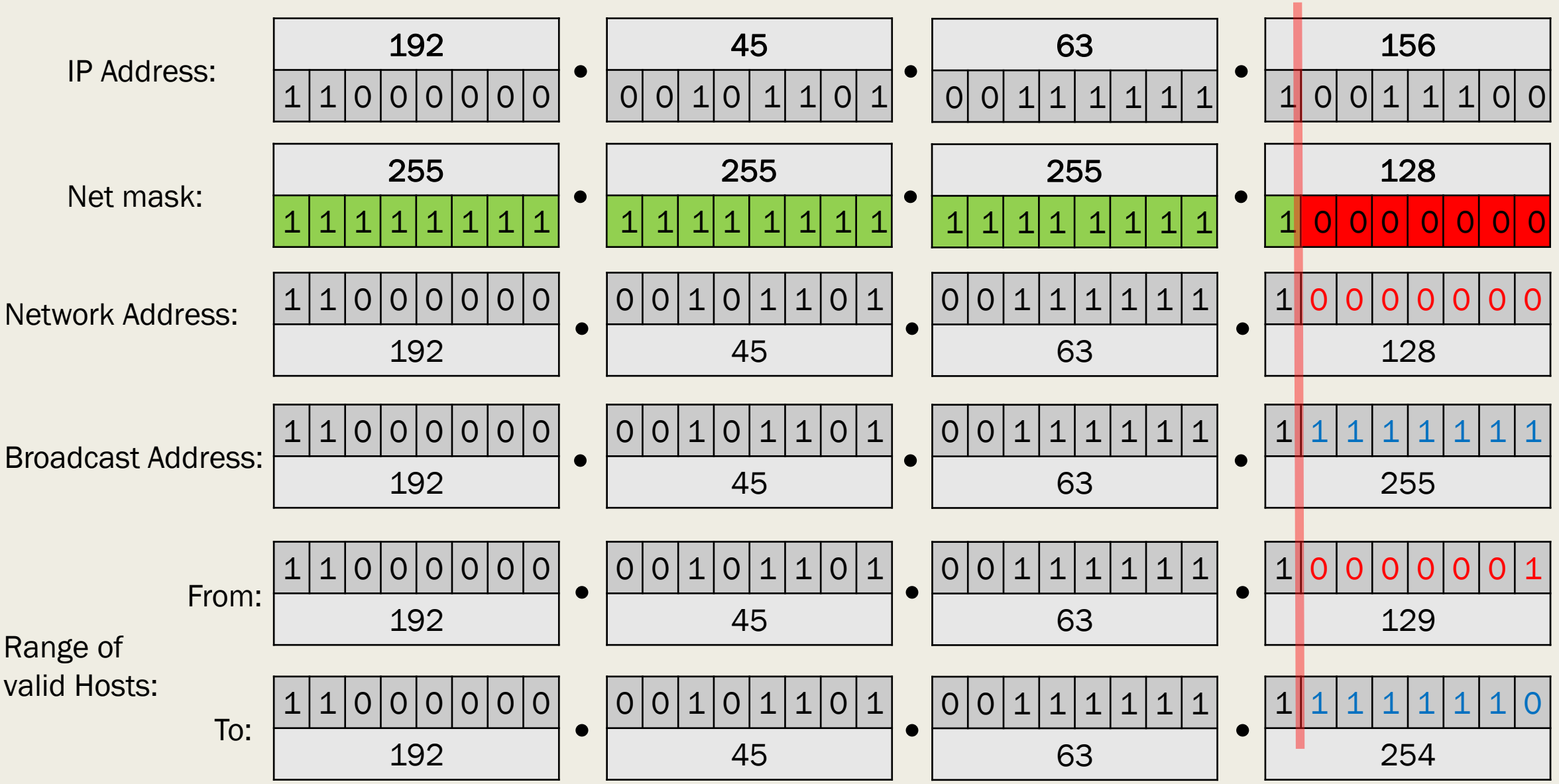
Network 10.1.1.32/28



Host: 192.45.63.156/25



Host: 192.45.63.156 255.255.255.128



Classful networking systems:

- Networks classed by size:
- Class A networks (large):
  - *8 bits network, 24 bits host (/8 , 255.0.0.0)*
  - *First byte in range 0-126*
- Class B Network (medium)
  - *16 bits network, 16 bits host (/16 , 255.255.0.0)*
  - *First byte in range 128-191*
- Class C network (small)
  - *24 bits network, 8 bits host (/24 , 255.255.255.0)*

How to determine what class it is:

- Just look at the IP address:
  - *Class A: 1.0.0.0 to 126.255.255.255*
    - Binary: 0xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
      - *16,777,214 hosts*
  - *Class B: 128.0.0.0 to 191.255.255.255*
    - Binary: 10xxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
      - *65,534 hosts*
  - *Class C: 192.0.0.0 to 223.255.255.255*
    - Binary: 110xxxxxxxxxxxxxxxxxxxxxxxxxxxxx
      - *254 hosts*
  - *Class D: (multicast) 224.0.0.0 to 239.255.255.255*
    - Binary: 1110xxxxxxxxxxxxxxxxxxxxxxxxxxxx
  - *Class E: (reserved) 240.0.0.0 to 255.255.255.255*
    - Binary: 1110xxxxxxxxxxxxxxxxxxxxxxxxxxxx

Class table

Class:	Host address range (Den):	Binary (first byte):	CIDR:	Network mask: (den)
A	1 . 0 . 0 . 0 to 126 . 255 . 255 . 255	0 # # # # # # #	/8	255 . 0 . 0 . 0
B	128 . 0 . 0 . 0 to 191 . 255 . 255 . 255	1 0 # # # # # #	/16	255 . 255 . 0 . 0
C	192 . 0 . 0 . 0 to 223 . 255 . 255 . 255	1 1 0 # # # # #	/24	255 . 255 . 255 . 0
D	224 . 0 . 0 . 0 to 239 . 255 . 255 . 255	1 1 1 0 # # # #	(multicast)	
E	240 . 0 . 0 . 0 to 255 . 255 . 255 . 255	1 1 1 1 # # # #	(reserved)	

SUBNETTING

Subnetting calculations:

Maximum number of subnets

Maximum number of hots per subnet

Traditional Subnetting of Classful Networks:

- Old routing systems allowed a classful network to be divided up into subnets:
  - *All subnets (of one classful network) must be the same size –same netmask*
  - *Subnets cannot be subdivided further*
- None of these restriction apply in modern systems

Class table

Class:	Host address range (Den):	Binary (first byte):	CIDR:	Network mask: (den)
A	1 . 0 . 0 . 0 to 126 . 255 . 255 . 255	0 # # # # # # #	/8	255 . 0 . 0 . 0
B	128 . 0 . 0 . 0 to 191 . 255 . 255 . 255	1 0 # # # # # #	/16	255 . 255 . 0 . 0
C	192 . 0 . 0 . 0 to 223 . 255 . 255 . 255	1 1 0 # # # # #	/24	255 . 255 . 255 . 0
D	224 . 0 . 0 . 0 to 239 . 255 . 255 . 255	1 1 1 0 # # # #	(multicast)	
E	240 . 0 . 0 . 0 to 255 . 255 . 255 . 255	1 1 1 1 # # # #	(reserved)	

The network 193.21.85.0/27
- Maximum number of subnets
- Maximum number of hosts per subnet

- Assume the Network mask is classful
  - *193 is Class C (Network Mask /24)*
- We are told that the Subnet Mask is /27

- Bits available for the Subnets: 27 – 24 = 3
  - $\text{Maximum number of subnets:}$
  - $2^3 = 8$
- Bits available for the hosts per subnet: 32 – 27 = 5
  - *Maximum number of hosts per subnet:*
  - $2^5 - 2 = 30$

The network 193.21.85.0/26
- Maximum number of subnets
- Maximum number of hosts per subnet

- Assume the Network mask is classful
  - *193 is Class C (Network Mask /24)*
- We are told that the Subnet Mask is /26

- Bits available for the Subnets: 26 – 24 = 2
  - $\text{Maximum number of subnets:}$
  - $2^2 = 4$
- Bits available for the hosts per subnet: 32 – 26 = 6
  - *Maximum number of hosts per subnet:*
  - $2^6 - 2 = 62$

The network 171.21.0.0/22
- Maximum number of subnets
- Maximum number of hosts per subnet

- Assume the Network mask is classful
  - *171 is Class B (Network Mask /16)*
- We are told that the Subnet Mask is /22

- Bits available for the Subnets: 22 – 16 = 6
  - $\text{Maximum number of subnets:}$
  - $2^6 = 64$
- Bits available for the hosts per subnet: 32 – 22 = 10
  - *Maximum number of hosts per subnet:*
  - $2^{10} - 2 = 1022$

What we have covered in this unit:

- Network topologies
  - *Physical & Logical*
- Types of network
- Network components
- IP Addressing
  - *Calculations*
  - *Masking*
  - *Classless & Classful systems*
- Subnetting calculations

Thank you