IP Addresses and Host-to-host Communication

Lecture 2

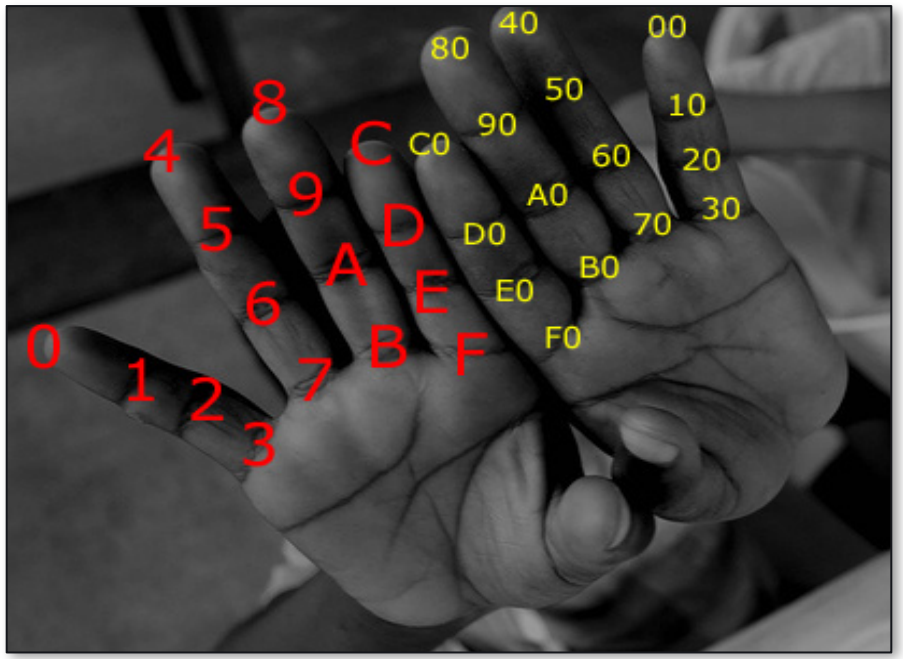
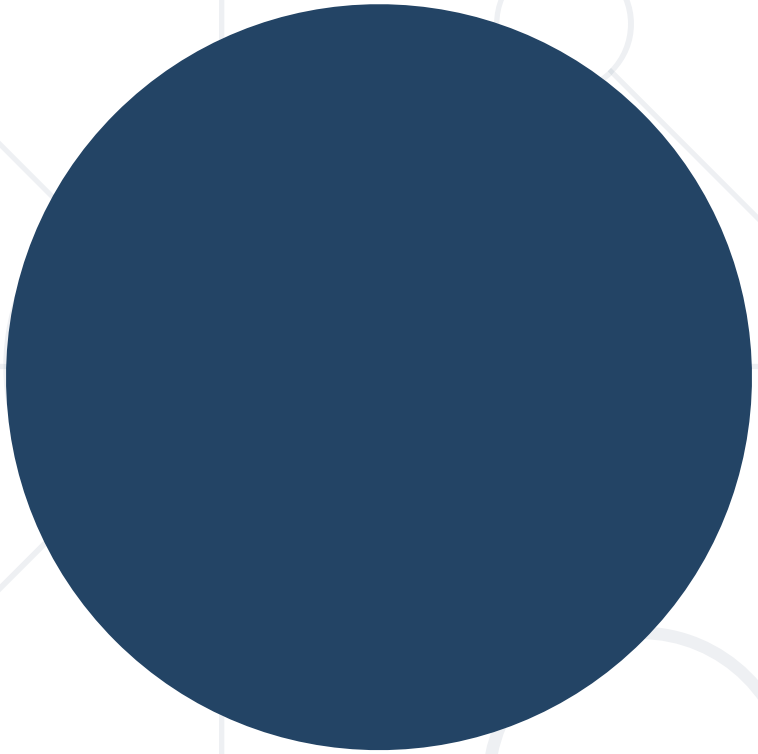


Table of Contents



Binary, decimal and hexadecimal numbers

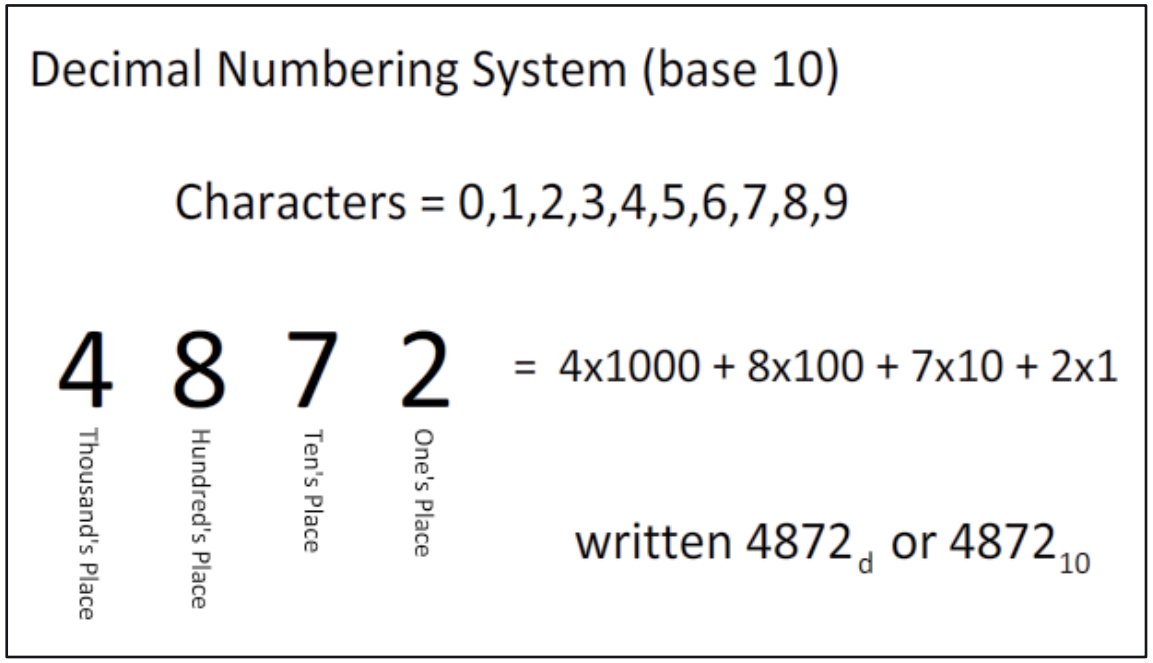
Different numeral systems

Hexadecimal	Binary	Decimal
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
A	1010	10
B	1011	11
C	1100	12
D	1101	13
E	1110	14
F	1111	15

Common Numeral Systems in Computer Networking:

- Decimal
- Binary
- Hexadecimal

Decimal Numeral System



- Base of 10
- Called decimal or denary
- A single digit can be:
  0 1 2 3 4 5 6 7 8 9

In this example:

$2x10^0 + 7x10^1 + 8x10^2 + 4x10^3 =$

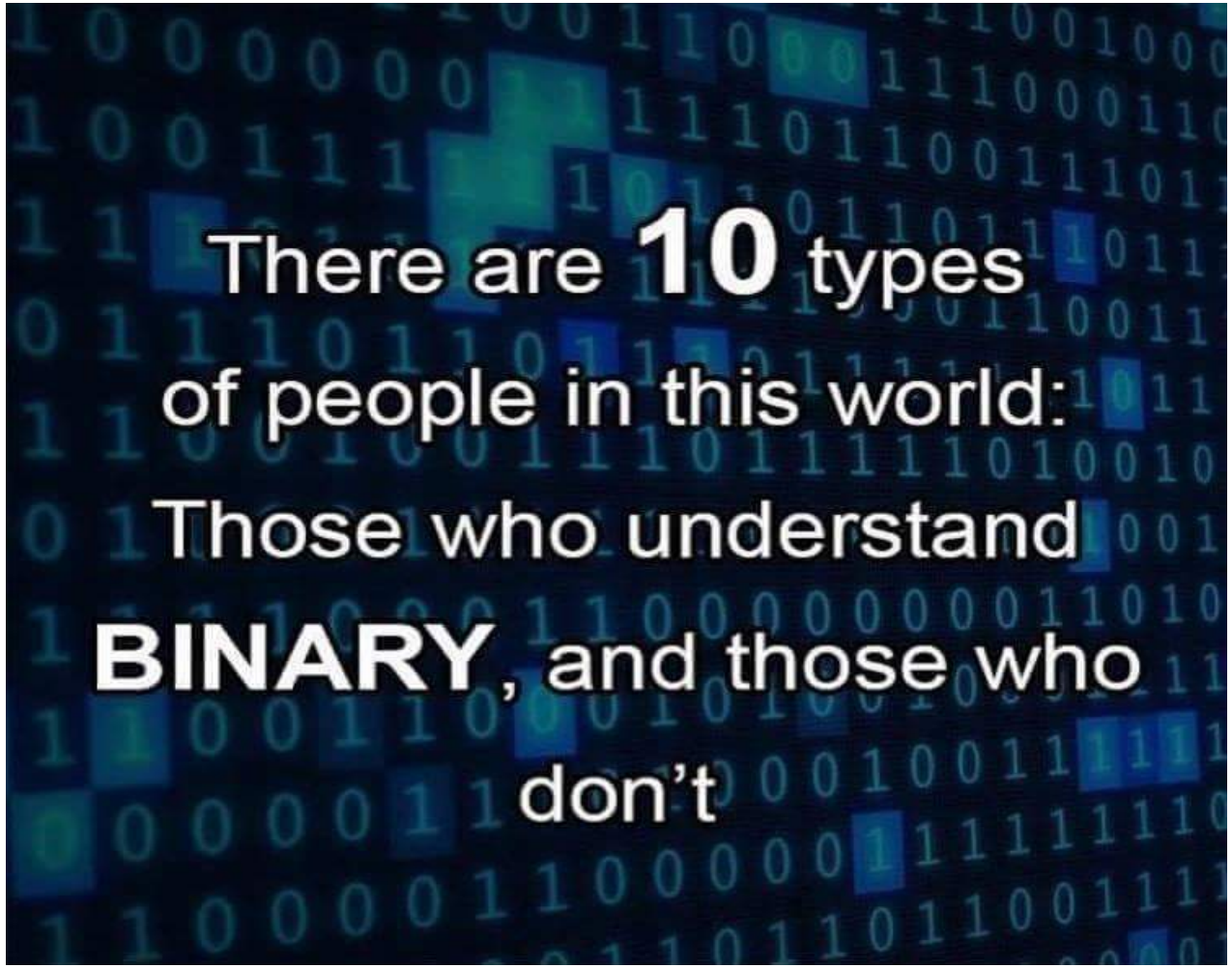
$2 + 70 + 800 + 4000 = 4872$

Binary Numeral System

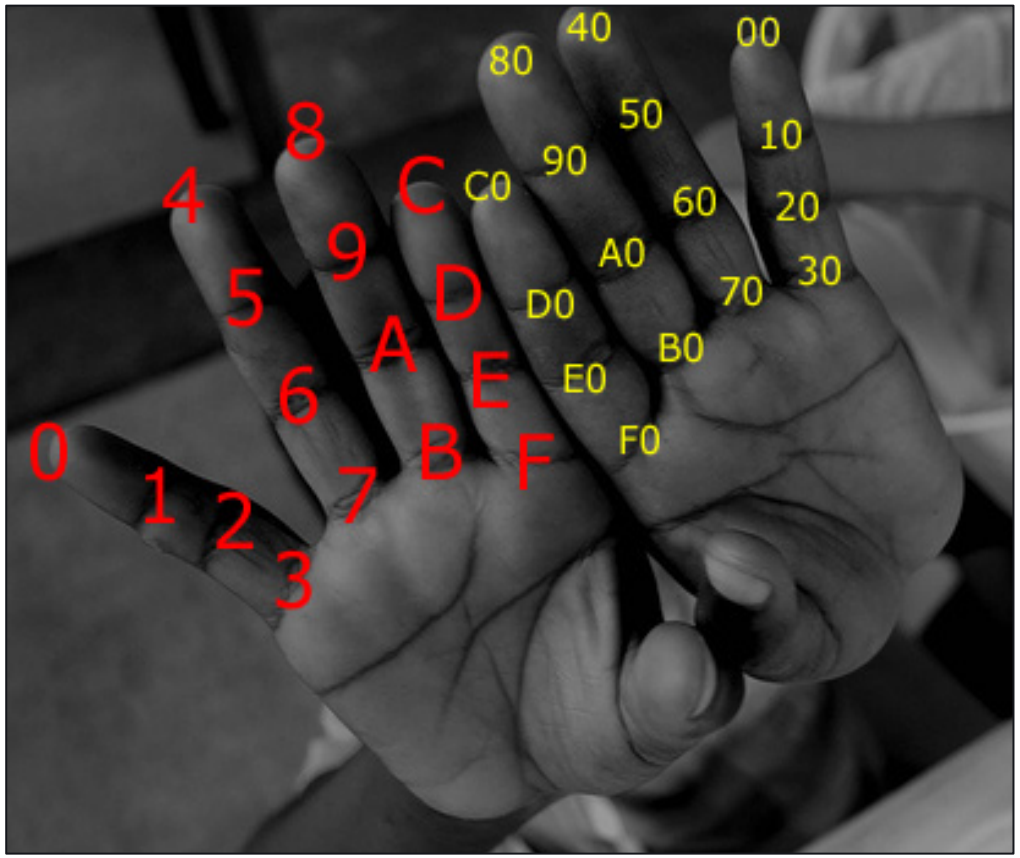
Decimal number	Binary number
0	0
1	1
2	10
3	11
4	100
5	101
6	110
7	111
8	1000
9	1001
10	1010

- Base of 2
- Used in computers and all computer-based devices
- Each digit is referred to as a bit
- A single digit (bit) can be either
  0 or 1

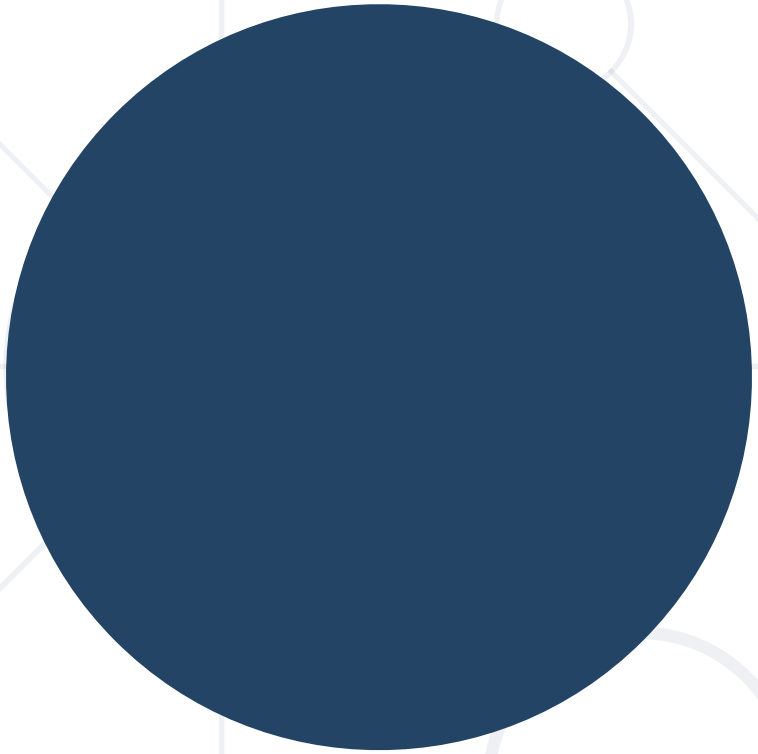
Binary joke


There are 10 types
of people in this world:
Those who understand
BINARY, and those who
don't

Hexadecimal numeral system

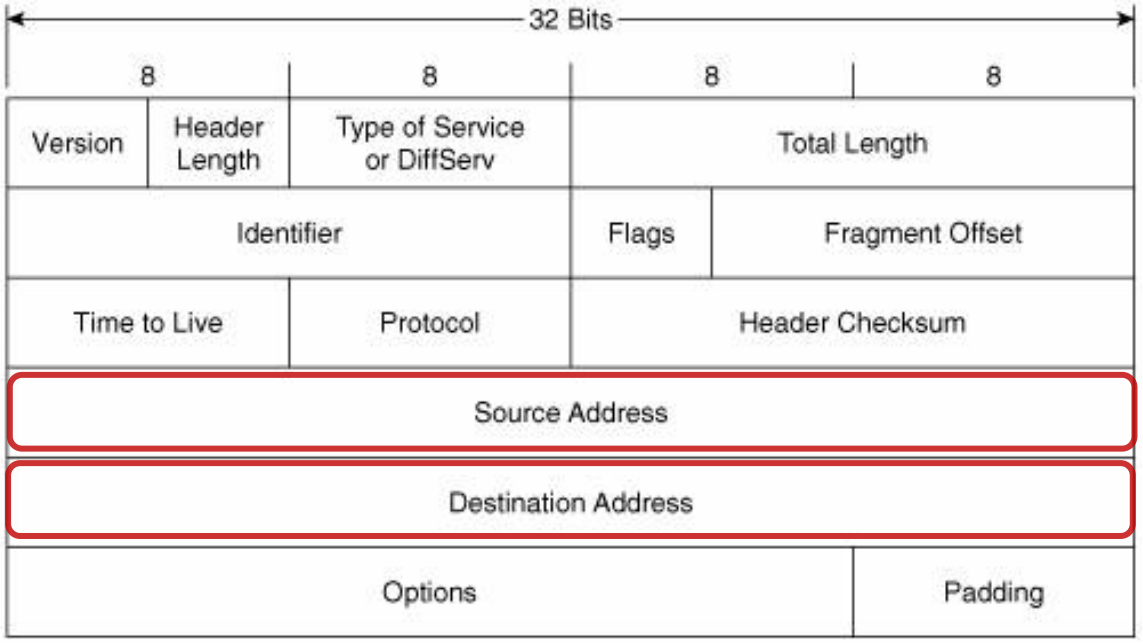


- Base of 16 (made of 16 symbols)
- Widely used by programmers and computer designers
- Used in MAC and IPv6 addresses
- A single digit can be:
  0 1 2 3 4 5 6 7 8 9 A B C D E F



IPv4

IPv4 address



- Plays important role for device connectivity
- It is a 32-bit address
- There are
  4 294 967 296
  IP addresses (2^{32})

Private IP addresses

Class	Start of range	End of range
A	10.0.0.0	10.255.255.255
B	172.16.0.0	172.31.255.255
C	192.168.0.0	192.168.255.255

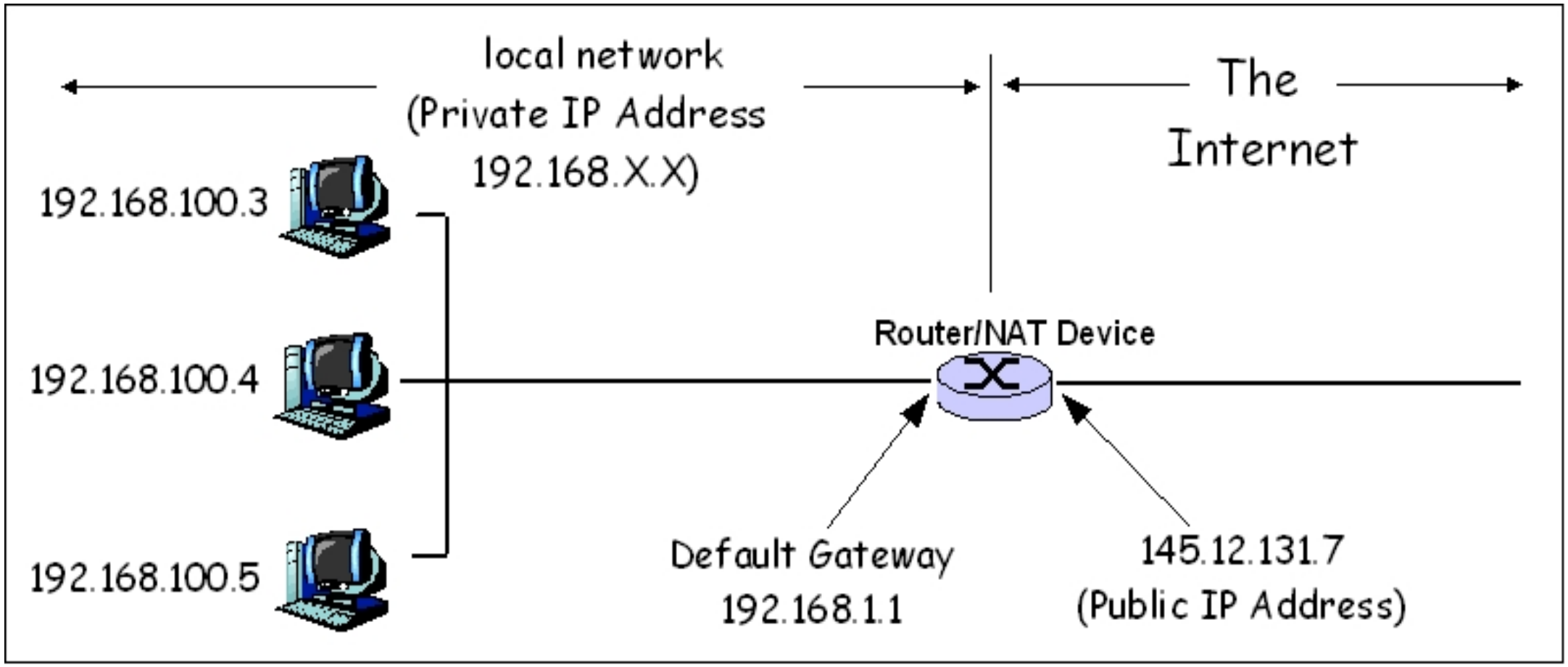
- Used for addressing internal networks (offices, HQs etc.)
- Not routable on the Internet
- Can be reused in many networks
- Range of private addresses for each class

  (classes are discussed later)

Public IP addresses

- Are not reserved for use in private networks
- Globally routed between ISP routers
- They are unique
- Example: 87.20.114.156

Network Address Translation – NAT



Network Address Translation – NAT (2)

- It is a method of translating one IP address into another

Example : 192.168.17.45 ---> 227.206.89.76

Private Public

Network masks

IP address: 50.211.197.5
Subnet Mask: 255.0.0.0

	IP network	Host Addresses		
IP address	**50.**	211.	197.	5
Subnet Mask	**255.**	0.	0.	0

- Define the border between the network and the hosts part
- Segment the network

Network masks (24-bit mask)

Subnet Mask 255.255.255.0				
	24 bits for Network ID			8 bits for Host ID
Decimal	255	255	255	0
Binary	11111111	11111111	11111111	00000000

The “subnet” part

The “host” part

Network masks (26-bit mask)

Subnet Mask 255.255.255.192				
	26 bits for Network ID			6 bits for Host ID
Decimal	255	255	255	192
Binary	11111111	11111111	11111111	11000000

The “subnet” part

The “host” part

Network masks – example 1

(Class A example)

- In decimal: 255.0.0.0
- Same mask written with prefix: /8
- Same mask written in binary:

11111111.00000000.00000000.00000000

One byte full of 1's.
No address space

Three more bytes full of 0's. This is 2^{24} - 2 or 16 million computers

Network masks – example 2

(Class B example)

- In decimal: 255.255.0.0
- Same mask written with prefix: /16
- Same mask written in binary:

11111111.11111111.00000000.00000000

Two bytes with 0's. This is 2^{16} - 2 or 65534 computers

Network masks – example 3

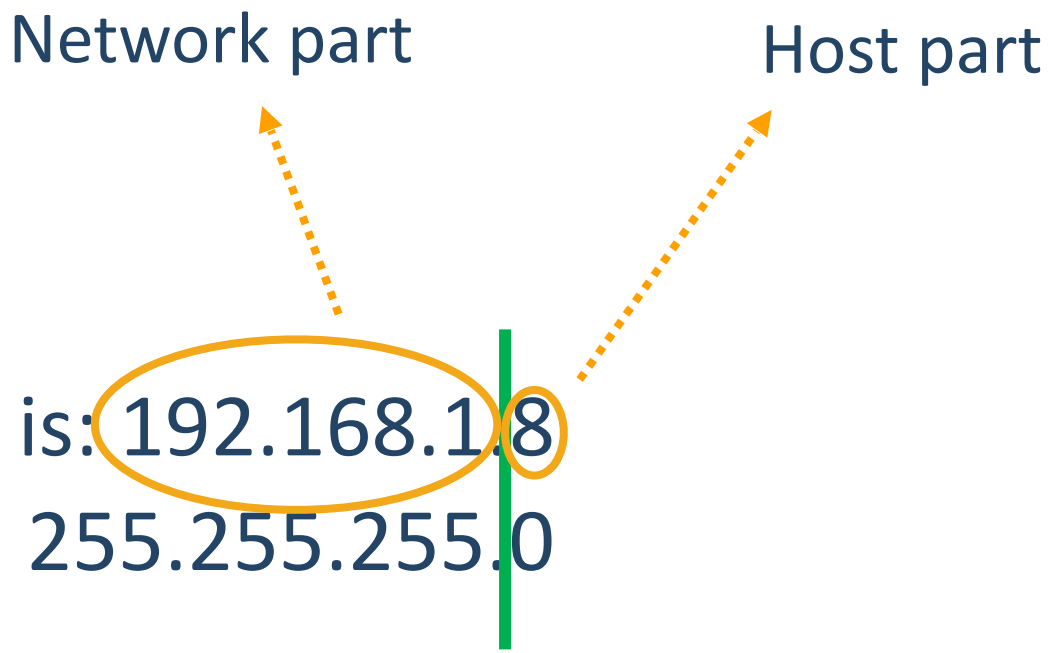
(Class C example)

- In decimal: 255.255.255.0
- Same mask written with prefix: /24
- Same mask written in binary:

11111111.11111111.11111111.00000000

One byte with 0's. This is $2^8 - 2$ or 254 computers

Network masks – IP/Mask example



Example:

Host IP address is: 192.168.1.8

Subnet mask is: 255.255.255.0

How many IP addresses for the hosts?

To calculate the number of hosts, use the formula $2^n - 2$ where **n** is the number of bits in the host part

- Example: 192.168.1.0 /24 – how many host addresses?

Answer: We have 8 bits in the host part (n), so:

$2^8 - 2 = 254$

The Network and the Broadcast address

- Two important and special addresses:
  - The network address – first possible address
  - The broadcast address – last possible address

- These can NOT be assigned to hosts

The Network and the Broadcast address (2)

Example:

192.168.1.5 /24

192.168.1.5

255.255.255.0

192.168.1.0 is the network address

192.168.1.255 is the broadcast address

A quick challenge

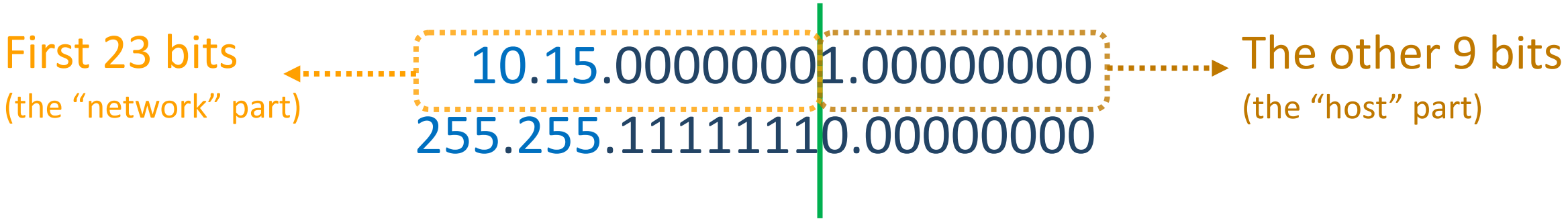
10.15.1.0

Is this a valid HOST IP Address?

A quick challenge (2)

It depends!

Let’s see it with /23 mask. 10.15.1.0 /23 can be presented as:



So, is it a valid host IP Address in this case?

A quick challenge (3)

In the example from the previous slide, which is the first and which is the last possible host address for the subnet to which this IP address belongs?

10.15.1.0 /23

10.15.00000001.00000000

255.255.11111110.00000000

- ✓ 10.15.0.0 is the network address
- ✓ 10.15.0.1 is the first host address
- ✓ 10.15.1.254 is the last host address
- ✓ 10.15.1.255 is the broadcast address

IP address classes

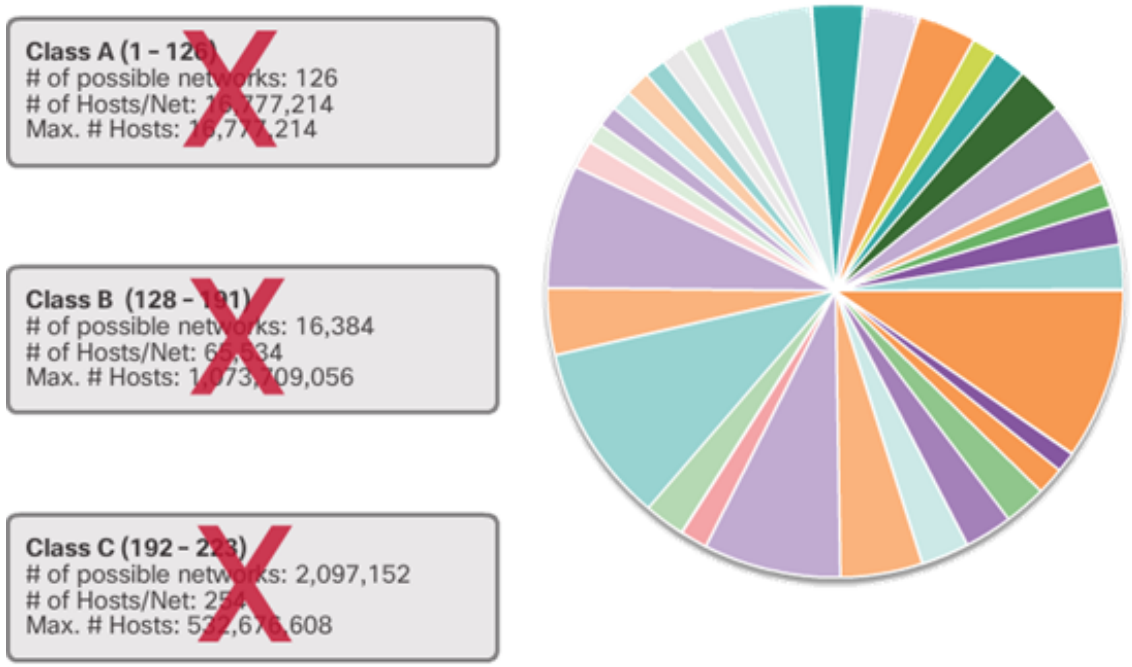
- IP Address class is determined by the first octet (byte)
- Three of them are used for addressing networks

Class A	0 - 127	For internetwork communication
Class B	128 - 191	For internetwork communication
Class C	192 - 223	For internetwork communication
Class D	224 - 239	Reserved for multicasting
Class E	240 - 254	Reserved for research and experiments

IP address classes (2)

- Examples of class **A** addresses
  - 10.0.0.1
  - 127.0.0.1
  - 0.0.0.1
- Examples of Class **B** addresses
  - 172.16.67.8
  - 169.254.x.x
- Examples of Class **C** addresses
  - 192.168.1.5
  - 198.51.100.0

Introduction to CIDR



- Ignores the concept Network Address Classes
- Reduces the amount of route advertisements

Without VLSM and CIDR:

10.1.1.0 /24 will be “seen” as 10.0.0.0 /8

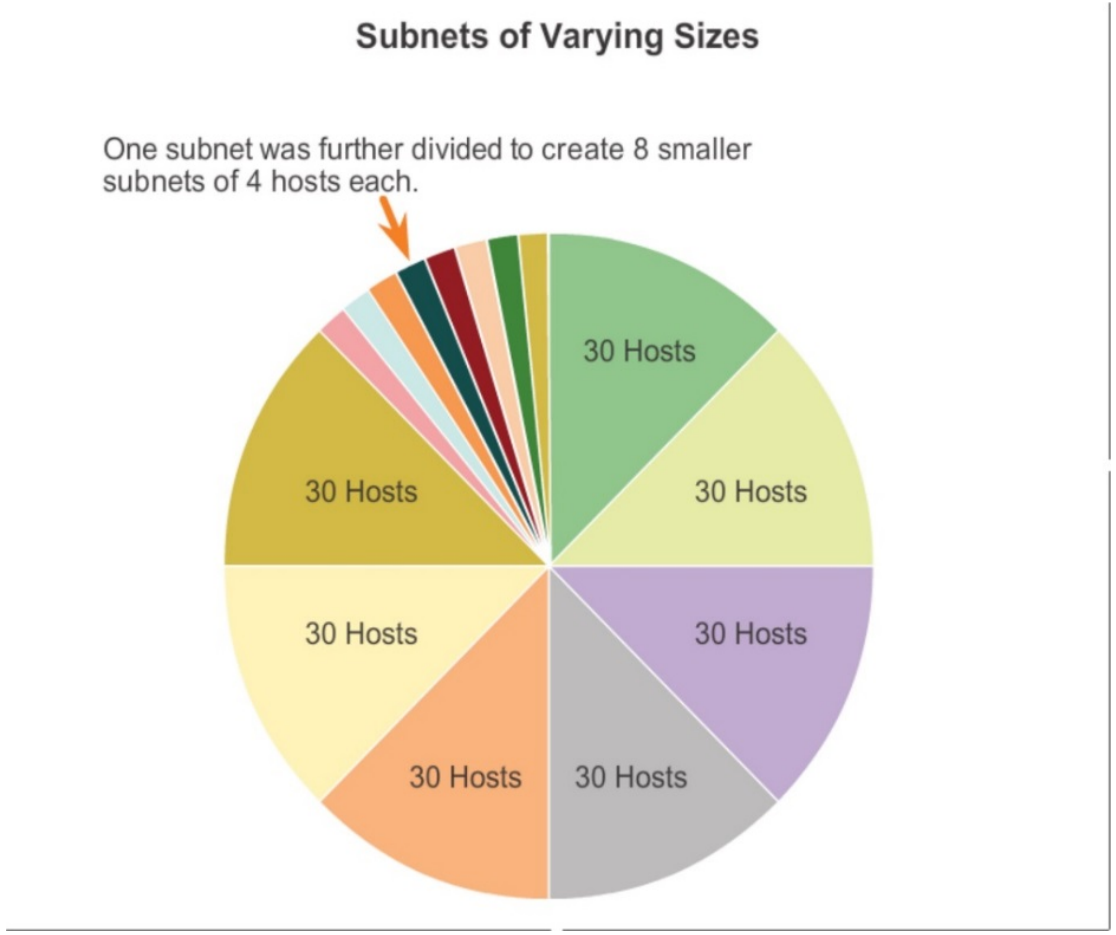
(because /8 is default for Class A)

With VLSM and CIDR:

10.1.1.0 /24 is “seen” as it is

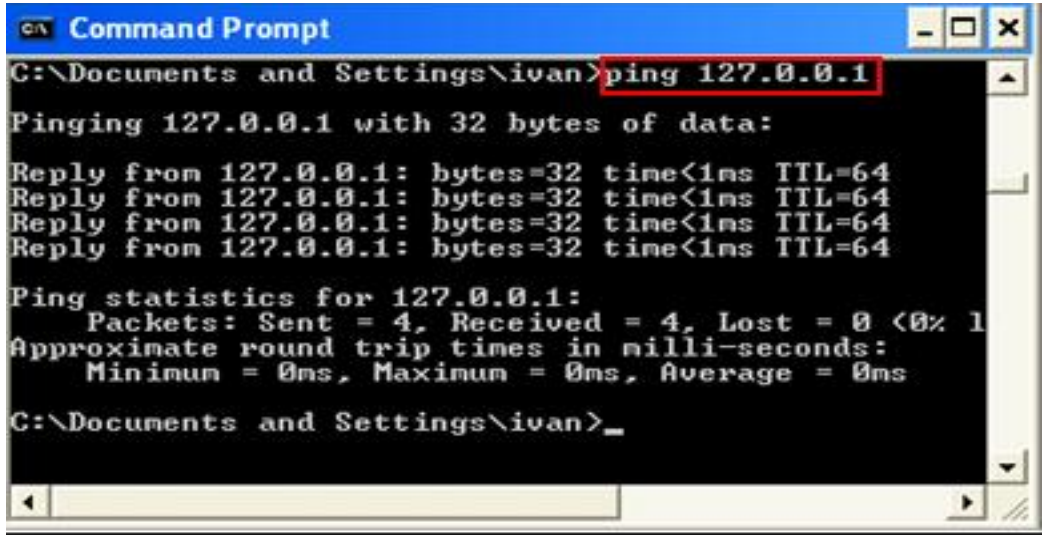
(although the mask is NOT the default)

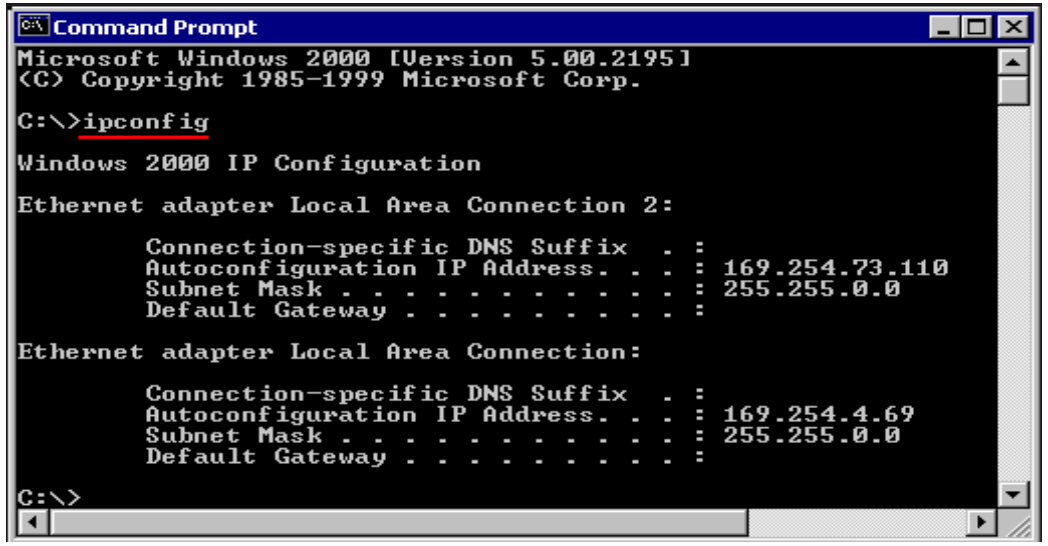
Introduction to VLSM



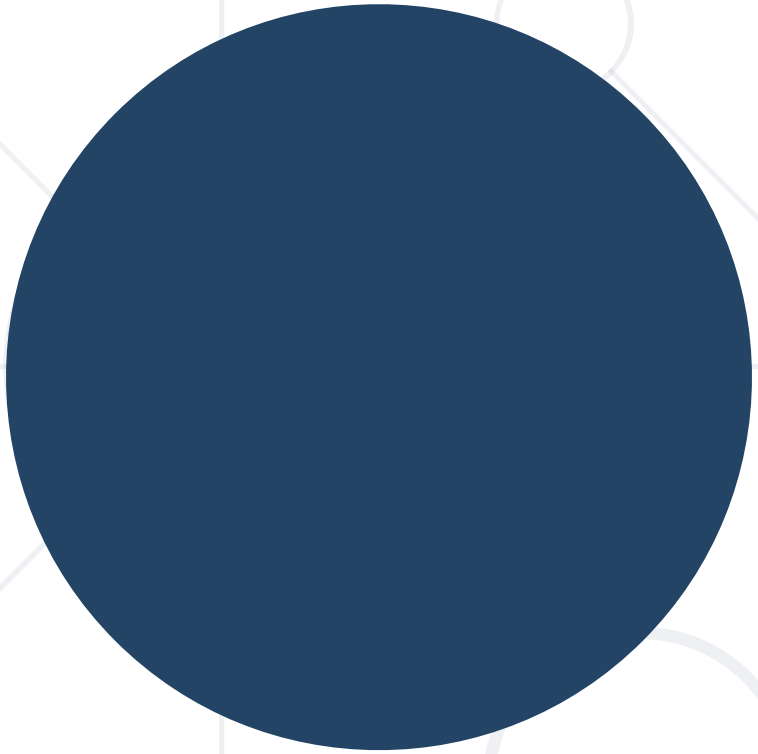
- VLSM: Variable-Length Subnet Masking
- Breaks the IP address classes idea
- “Subnetting of subnets”

Reserved/Special IP addresses





- There are some special IP addresses. For example:
  - 127.0.0.1 /8
    - ➢ Known as loopback address
    - ➢ On most computer systems, “localhost” resolves to the IP address 127.0.0.1
  - 169.254.X.X /16
    - ➢ When DHCP is not reachable
    - ➢ Known as APIPA (Microsoft)

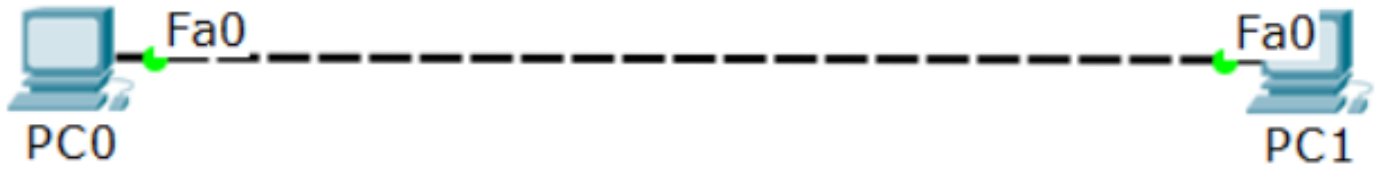


Host-to-host communication

Four addresses required

- There are 4 addresses needed for Ethernet communication:

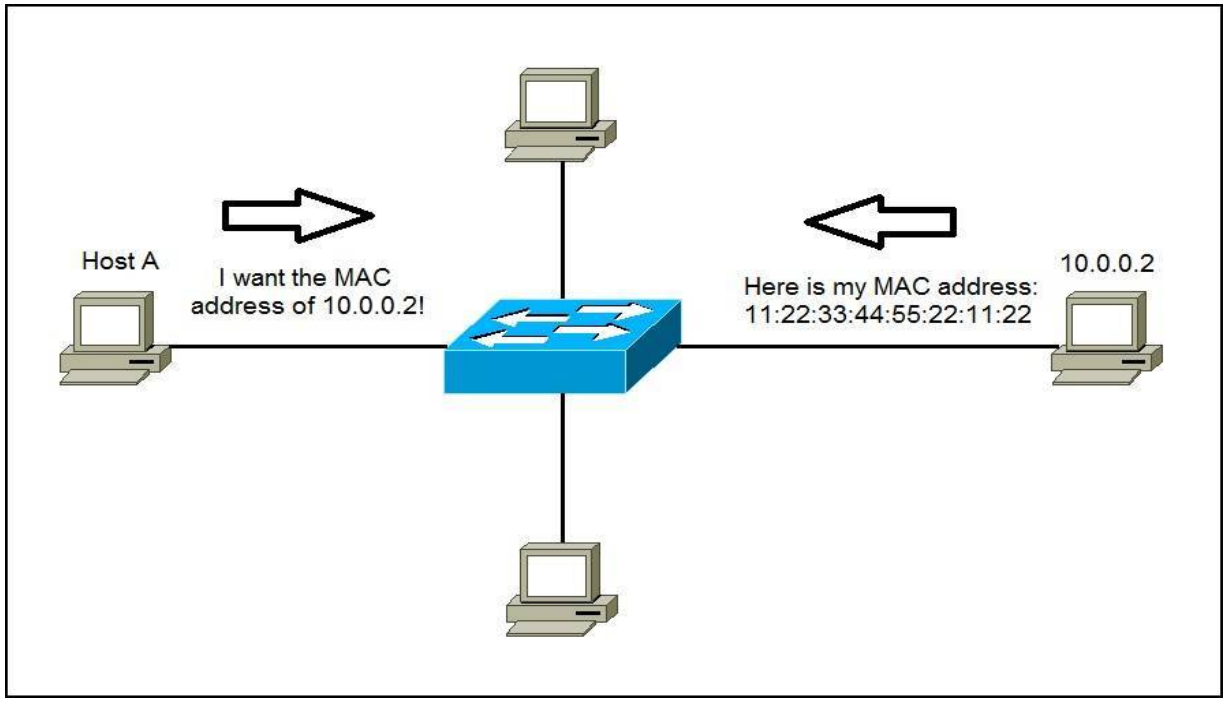
▪ Source IP	▪ Destination IP
▪ Source MAC	▪ Destination MAC



MAC Address: 00E0.F792.0D43
IP Address: 10.0.0.1/24

MAC Address: 000C.CF77.1713
IP Address: 10.0.0.2/24

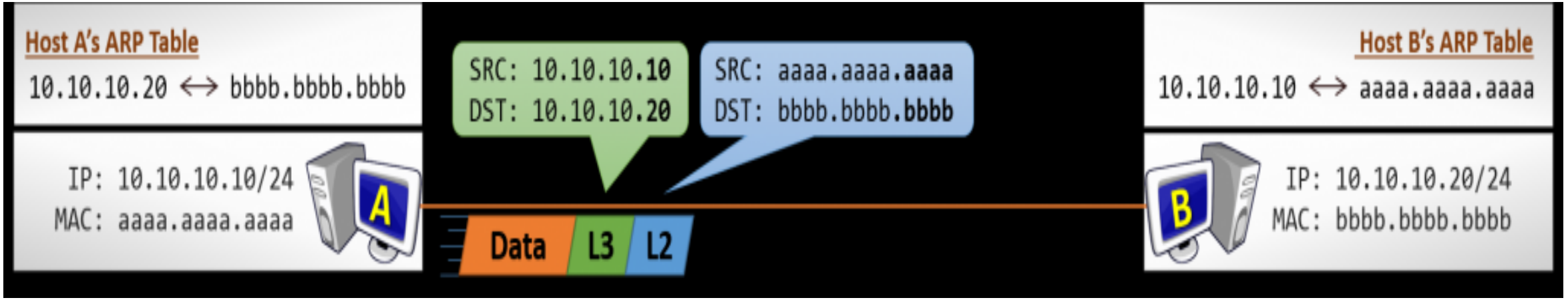
ARP: Address Resolution Protocol



- Used to find the MAC address of the destination
- Uses Broadcast

Direct communication (without router)

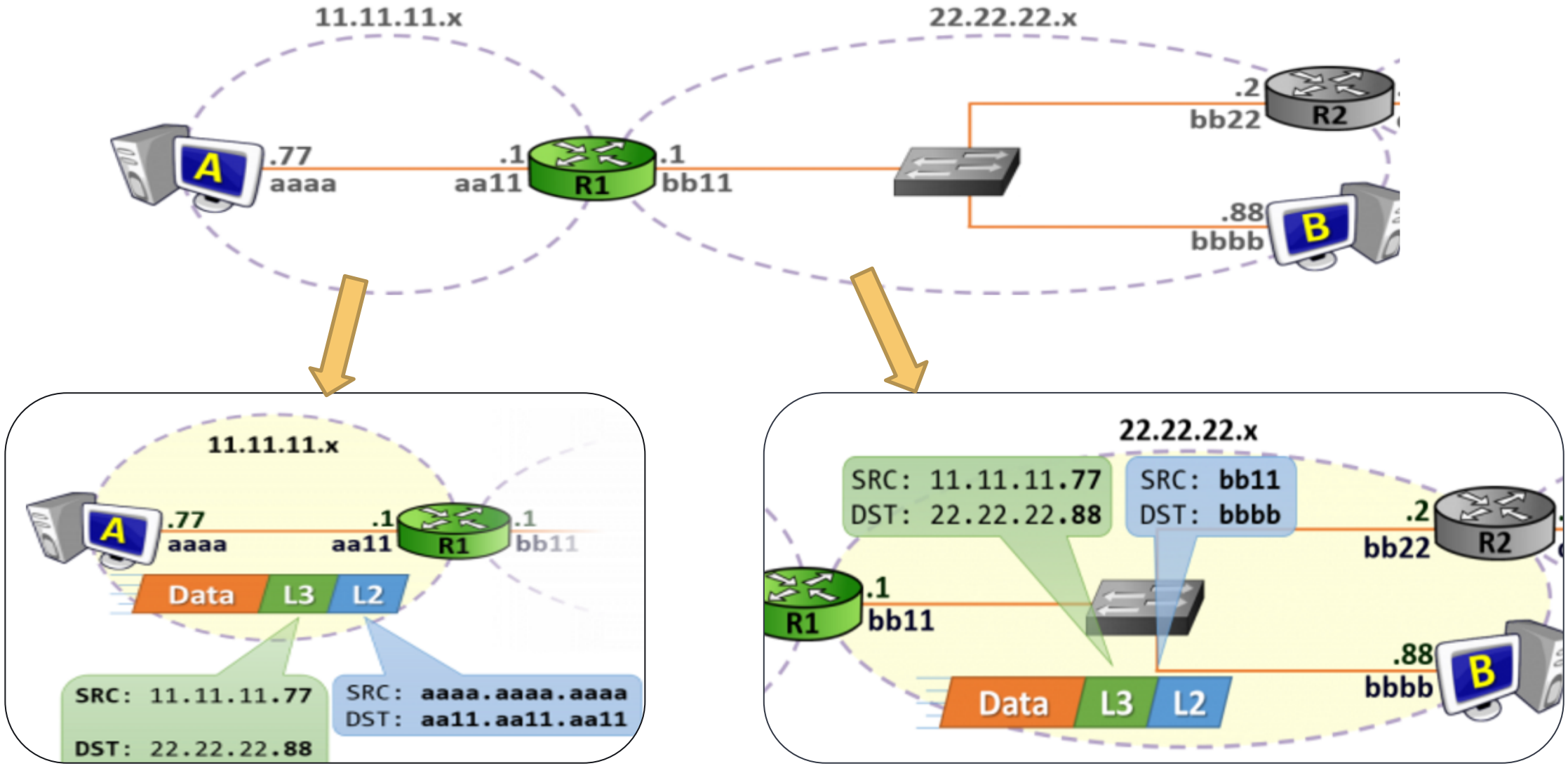
- Source and destination MAC addresses are constant
- Source and destination IP addresses are constant



Host-to-host communication with routers

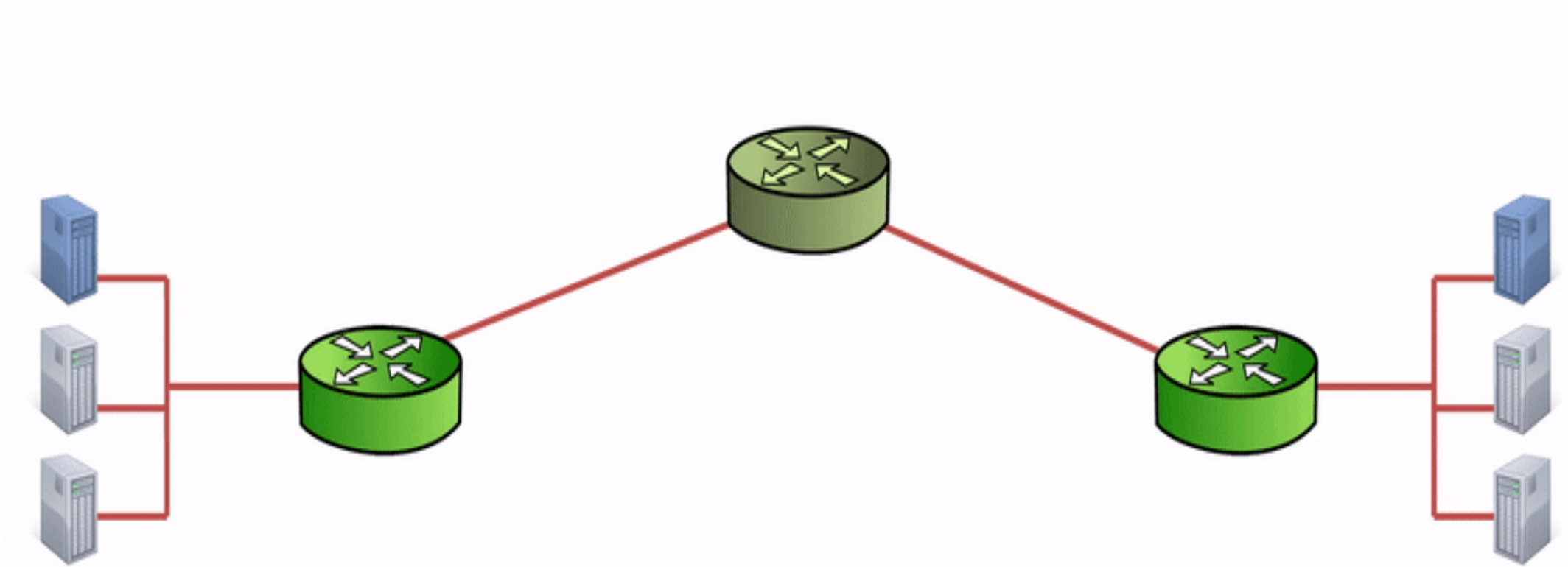
- Source and destination MAC addresses are changed at every hop (router)
- Source and destination IP addresses are constant
  (if we do not use NAT)

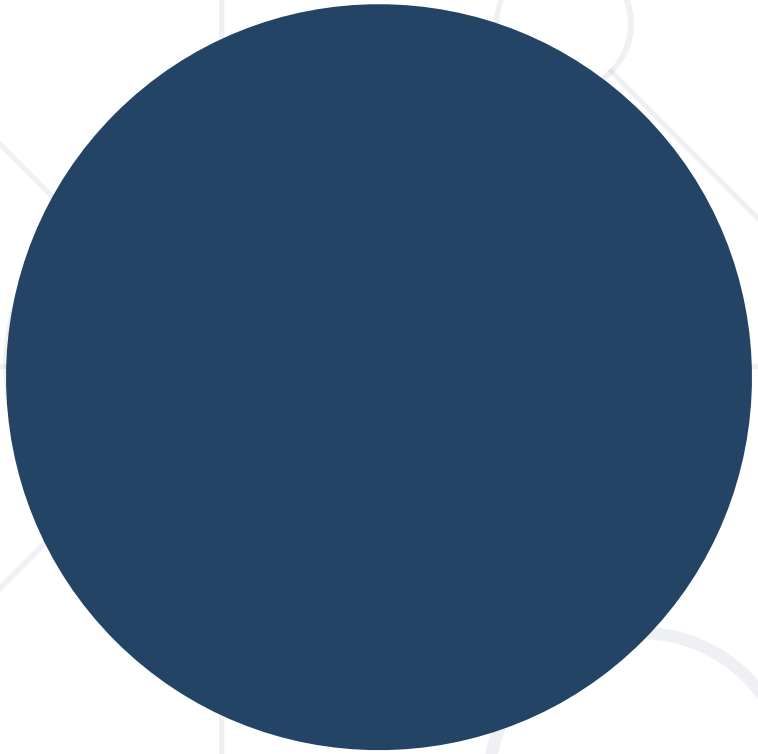
Host-to-host communication with routers (2)



Host-to-host communication with routers (3)

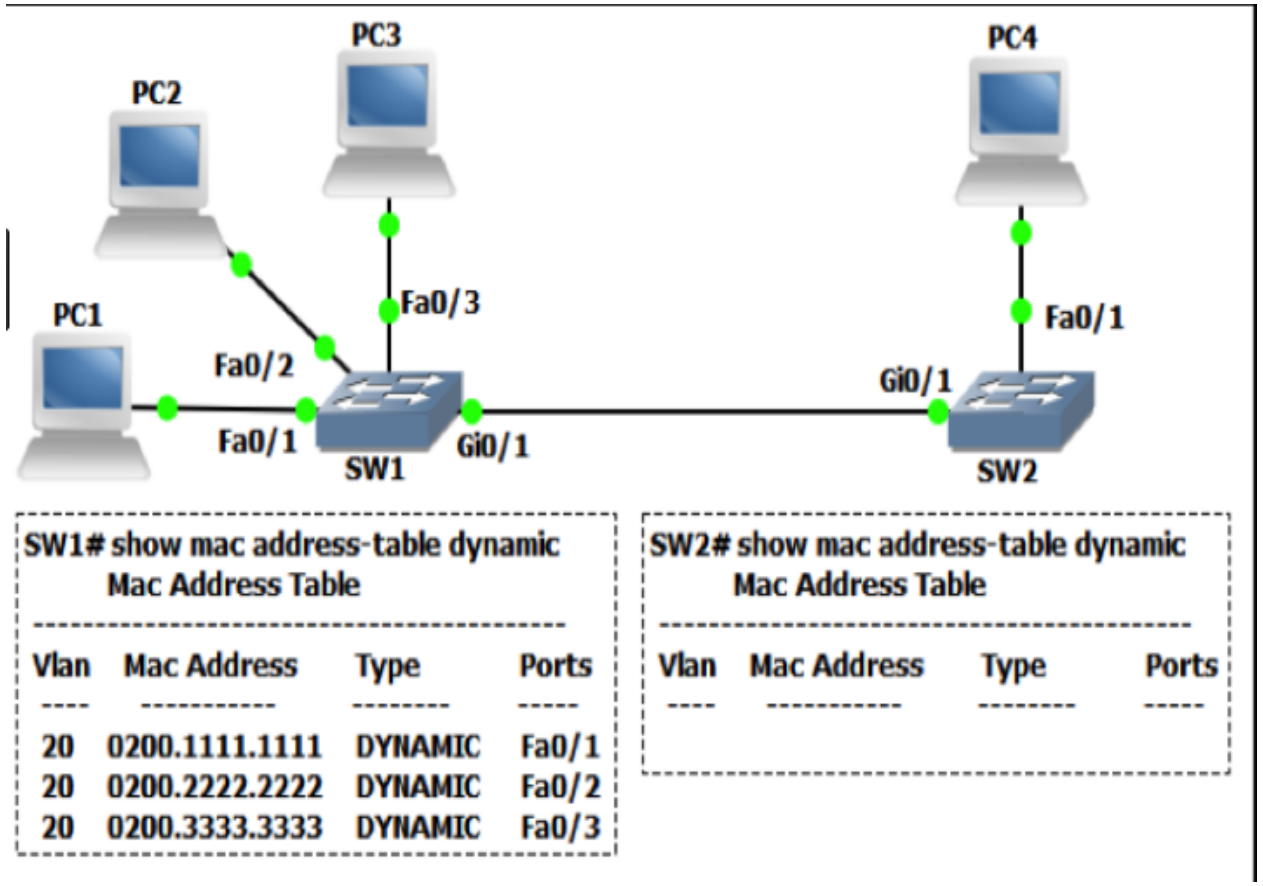
- Source and destination MAC addresses are changed at every hop/router





Switch MAC address table

The MAC address table



SW1# show mac address-table dynamic
Mac Address Table

Vlan	Mac Address	Type	Ports
20	0200.1111.1111	DYNAMIC	Fa0/1
20	0200.2222.2222	DYNAMIC	Fa0/2
20	0200.3333.3333	DYNAMIC	Fa0/3

SW2# show mac address-table dynamic
Mac Address Table

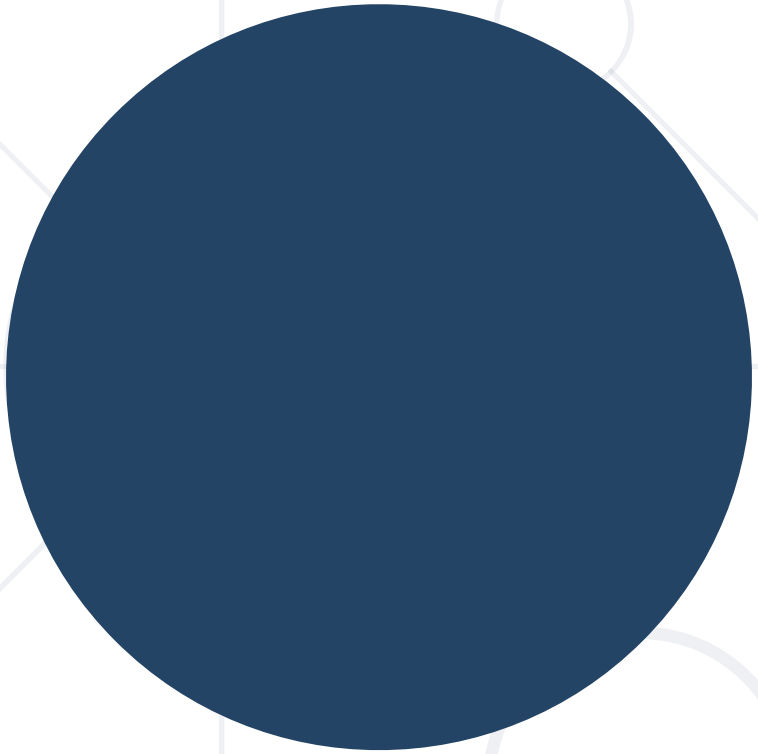
Vlan	Mac Address	Type	Ports

- It is a (dynamic) table that maps MAC addresses to ports
- Used to find the proper interface when the switch forwards a packet

The MAC address table (2)

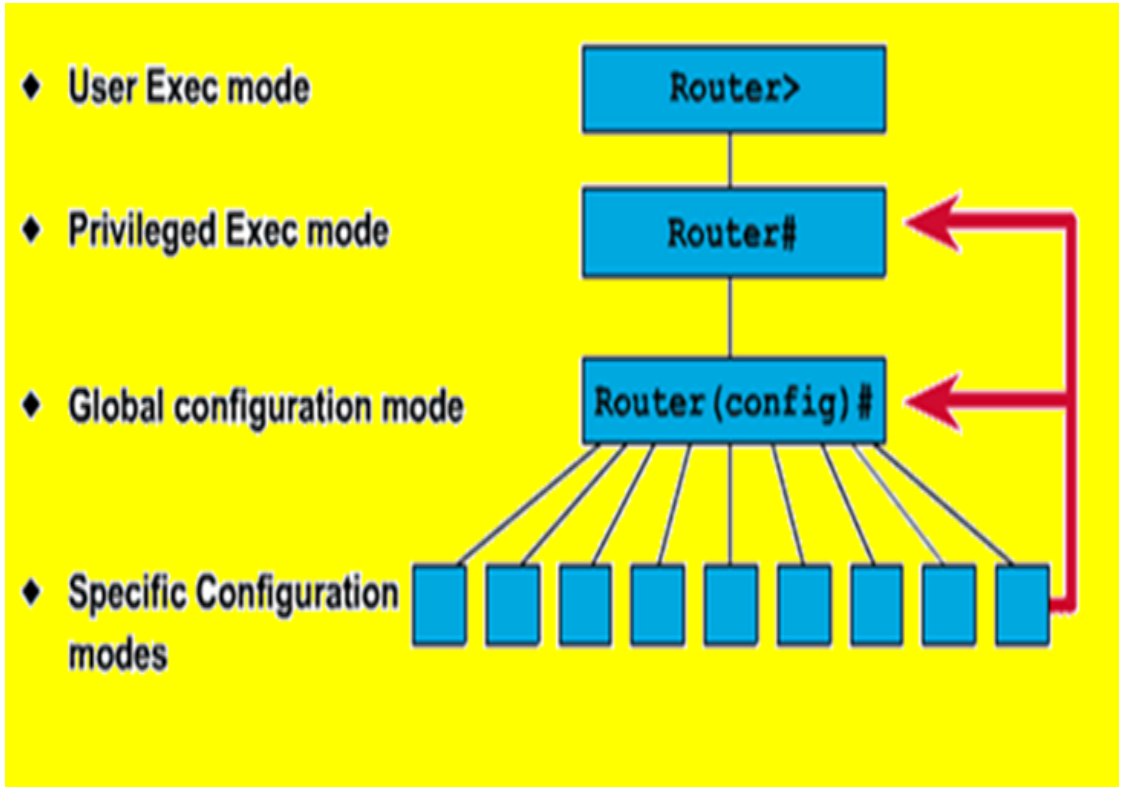
- You can assign MAC Address statically as well
  - Pros: It is more secure
  - Cons: It is bit slower and harder for sysadmin to assign it manually

```
SW1#show mac-address-table
          Mac Address Table
-------------------------------------------

Vlan    Mac Address       Type        Ports
----    -----------       --------    -----

   1    1111.1111.1111    STATIC      Fa0/2
```



The command line

Command line introduction



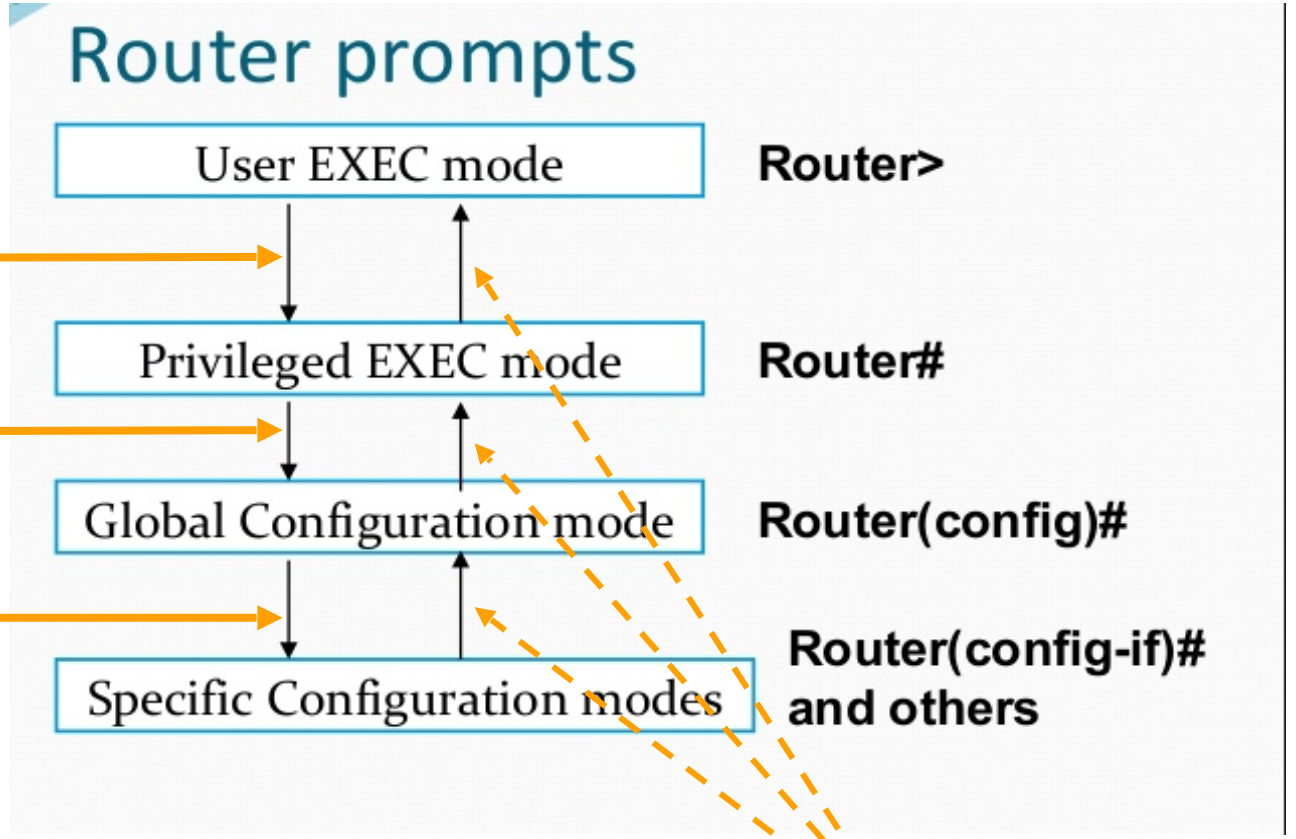
- Different vendors use different names but the logic is similar
- Typical CLI modes:
  - Read-only (User)
  - Read-write (Privilege)
  - Configuration (Global config)
  - Sub-configuration

Command line

type “enable”

type “configure terminal”

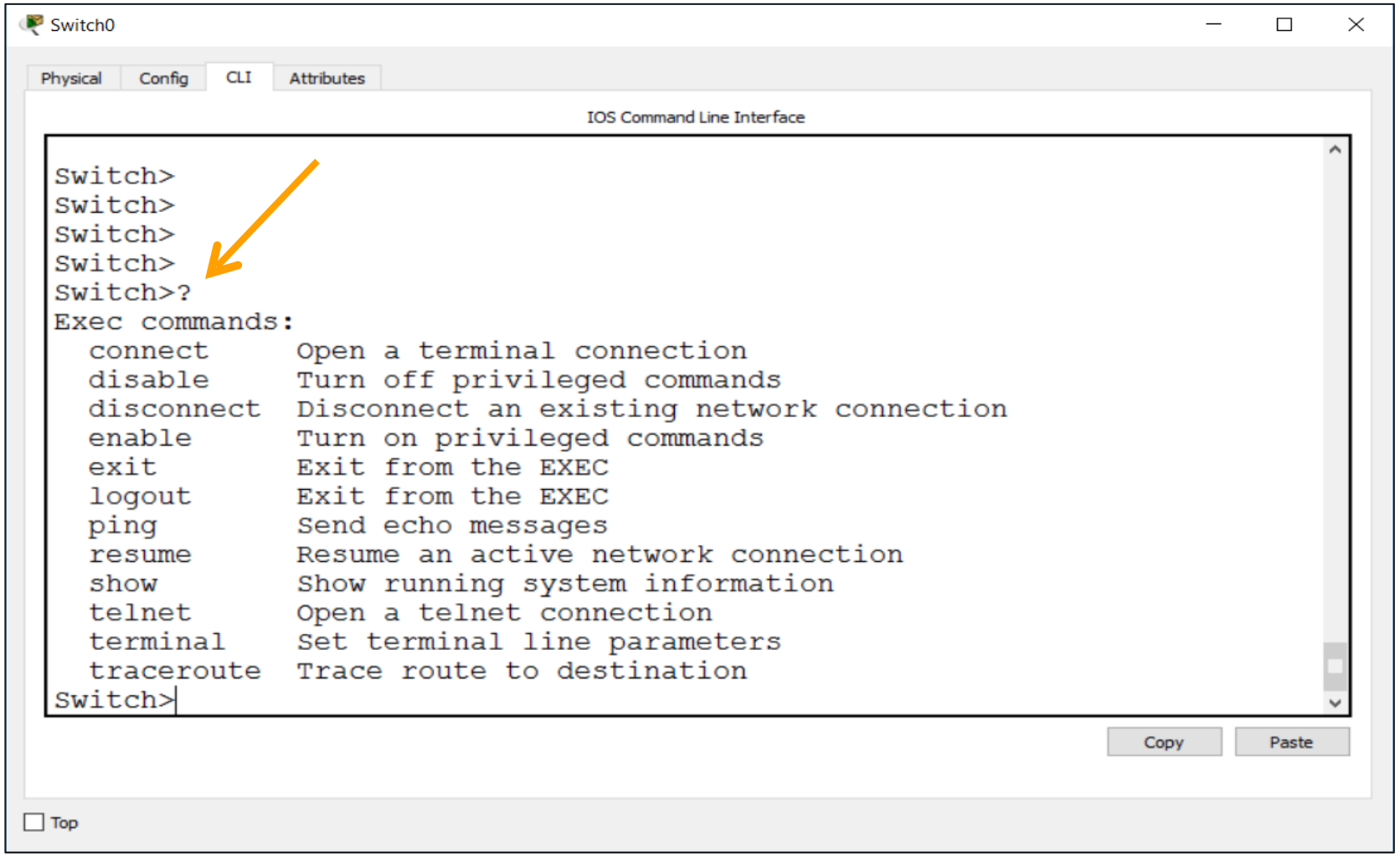
Interface, VLAN, routing, etc.



to go back, type “exit”

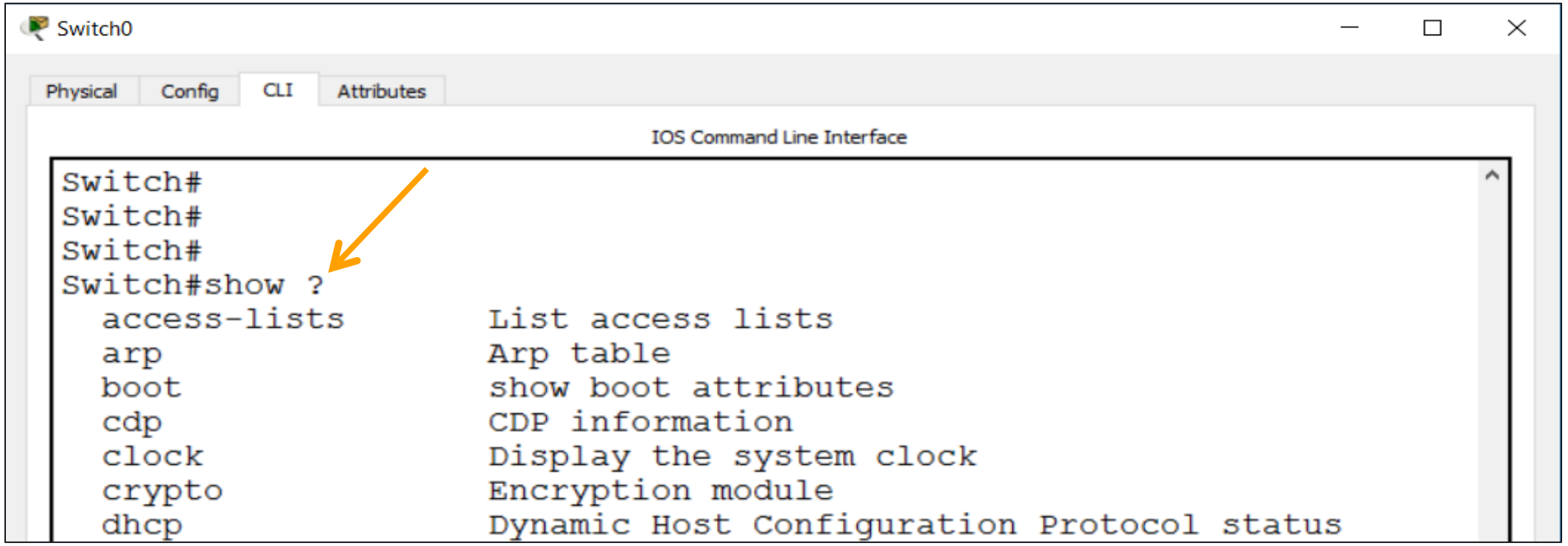
Using the help – “?”

- Use the “?” at each level to see the available commands



Using the help – “?” (2)

- Use the “?” as you type to see:
  - how to finish a command
  - what is/are the next word in the command

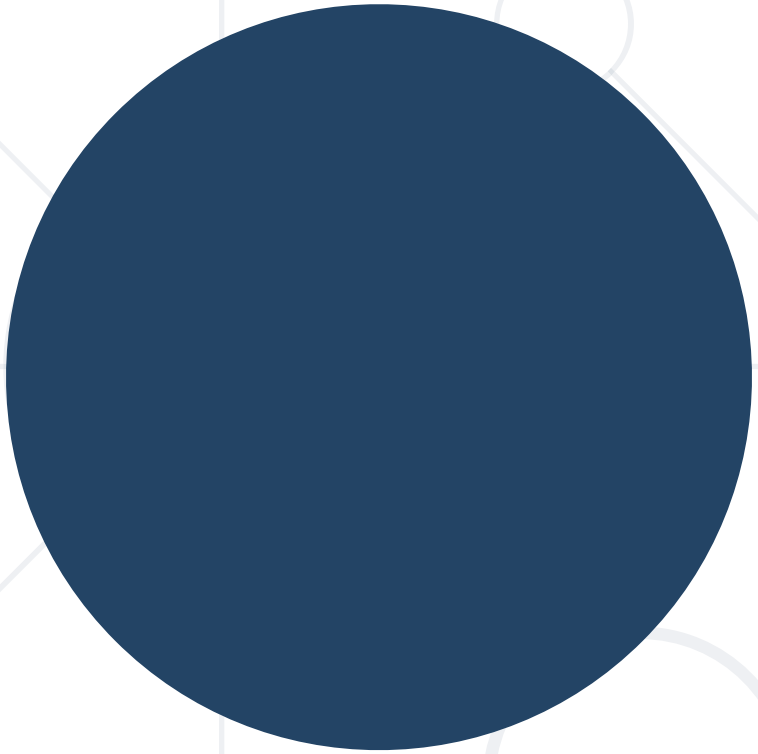


Using the help – TAB

```
  reload          Halt and perform a cold restart
  resume          Resume an active network connection
  setup           Run the SETUP command facility
  show            Show running system information

Switch#
Switch#conf
```

Copy Paste

Hit the TAB key here to autocomplete “configure”



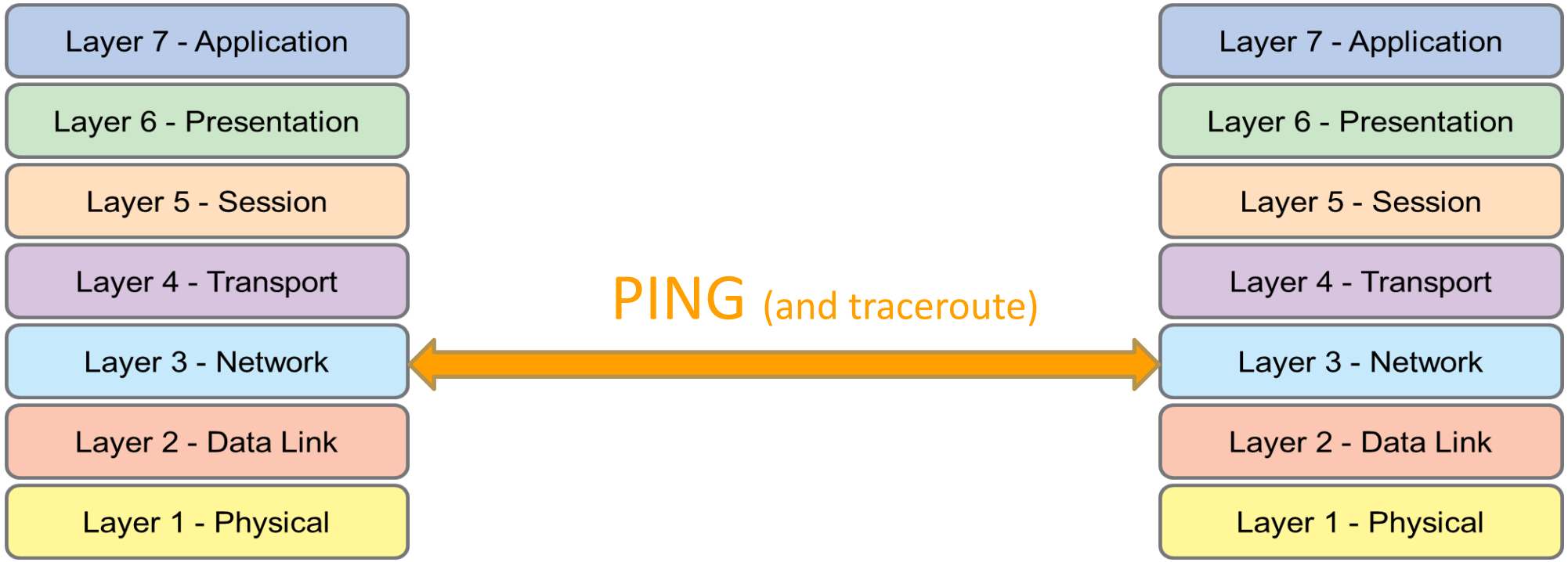
Basic connectivity checks

Basic Connectivity Checks

- Ping (Layer 3)
- Traceroute (Layer 3)
- LLDP (Layer 2)
- CDP (Layer 2)

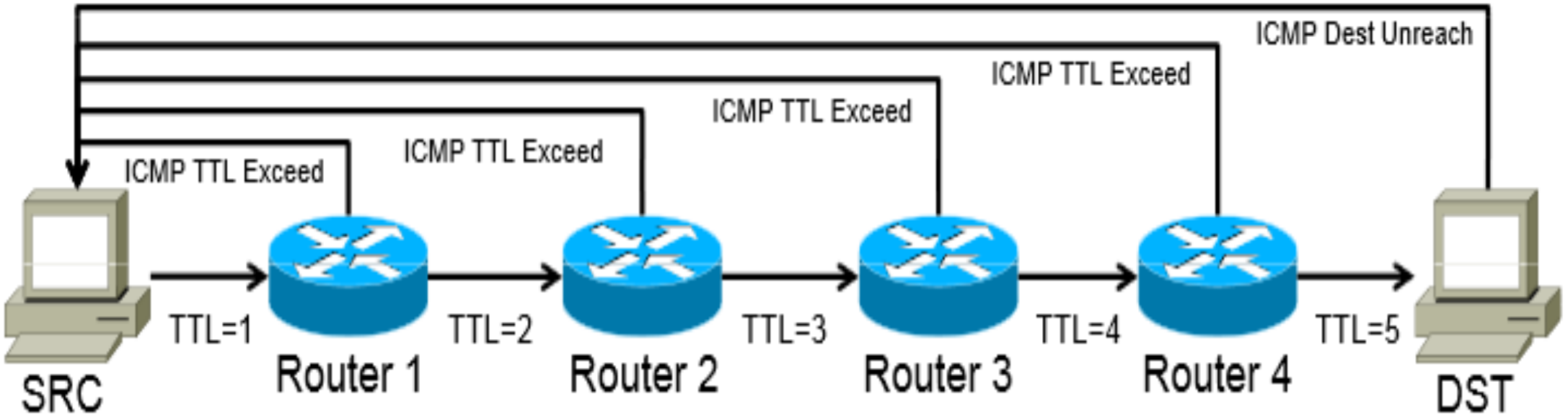
Ping

- Important Layer 3 connectivity check
- Must have IP addresses
- ICMP echo request and ICMP echo reply



Traceroute

- Another L3 connectivity check
- Uses the TTL (Time to Live) value in the packet
- Can determine the number of hops (routers) in the path

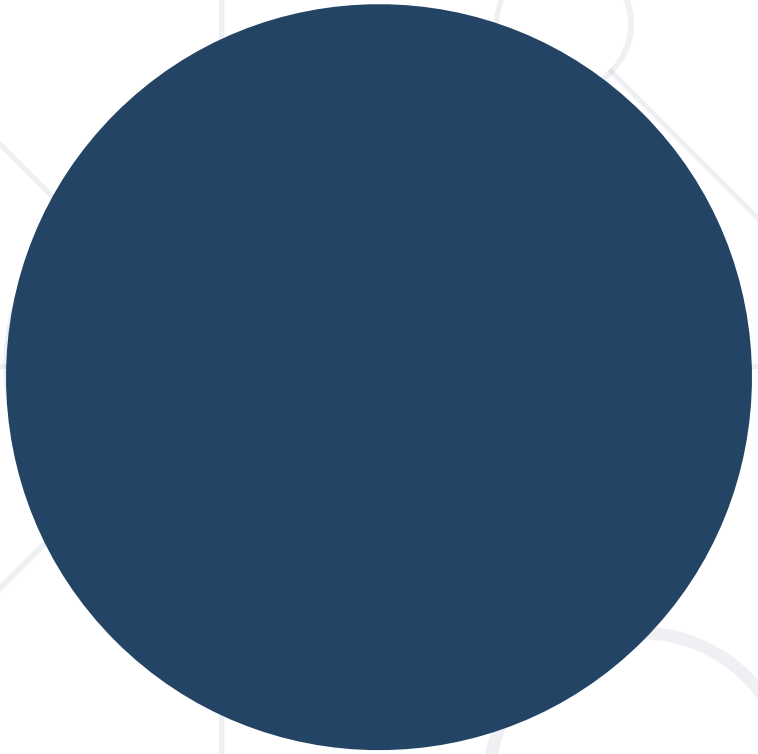


LLDP: Link Layer Discovery Protocol

- Who is connected to me?
- Works at Layer 2
- Must be enabled on both sides
- Vendor-neutral

CDP: Cisco Discovery Protocol

- Cisco proprietary
- Gathers info about other Cisco (CDP) neighbor devices
- Operates at L2
- Turned on default by all Cisco switches and routers



Demonstration

Summary

1. Binary, decimal and hexadecimal numbers
2. IPv4
3. Host-to-Host communication
4. Switch MAC Address table
5. The command line
6. Basic connectivity checks