ZOOM
TECHNOLOGIES

CCNA | Cisco Certified Network Associate

Course Presentation

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CCNA

(Cisco Certified Network Associate)

Certification Mapped Course

Routing and Switching

Course Presentation

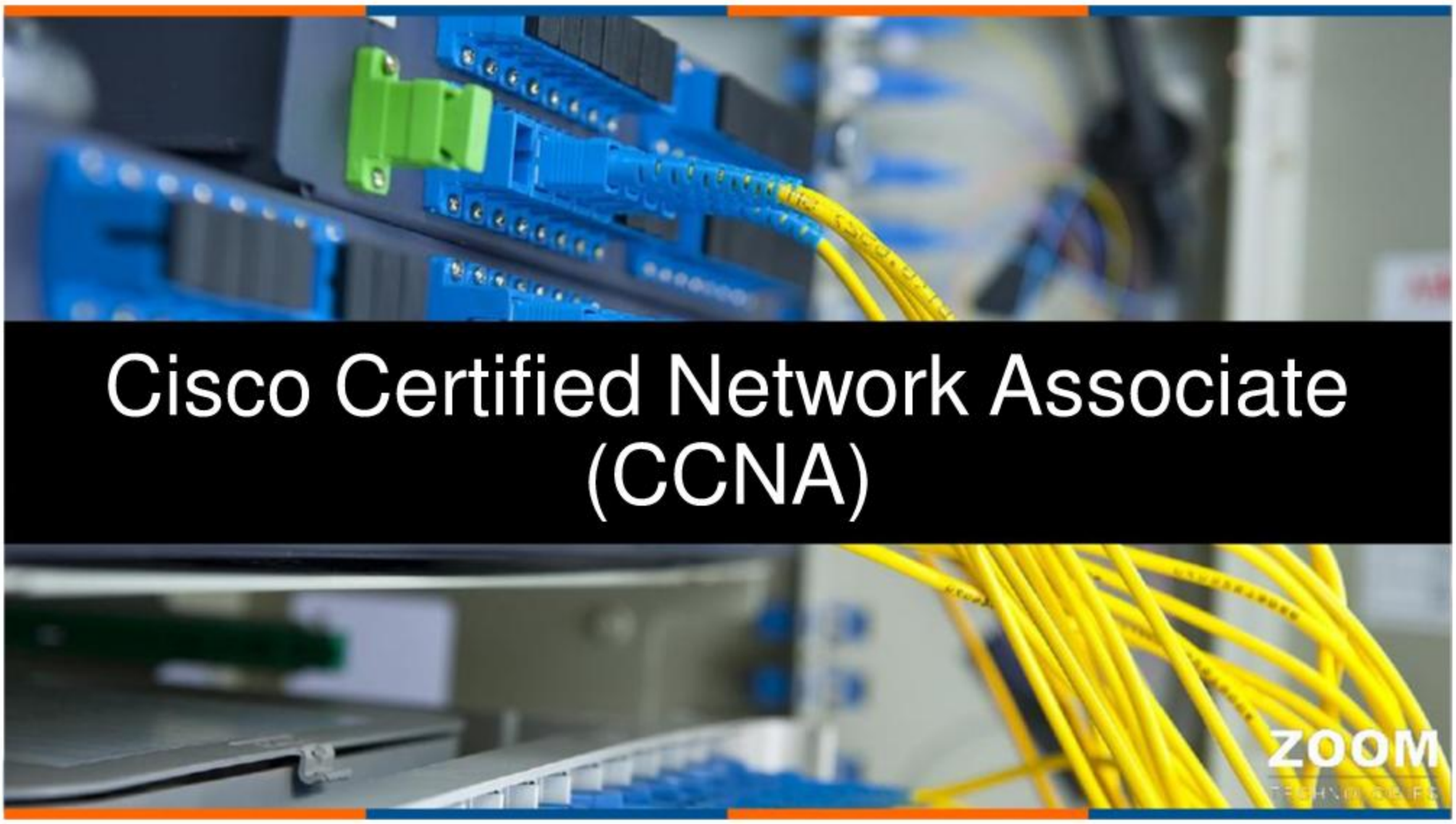
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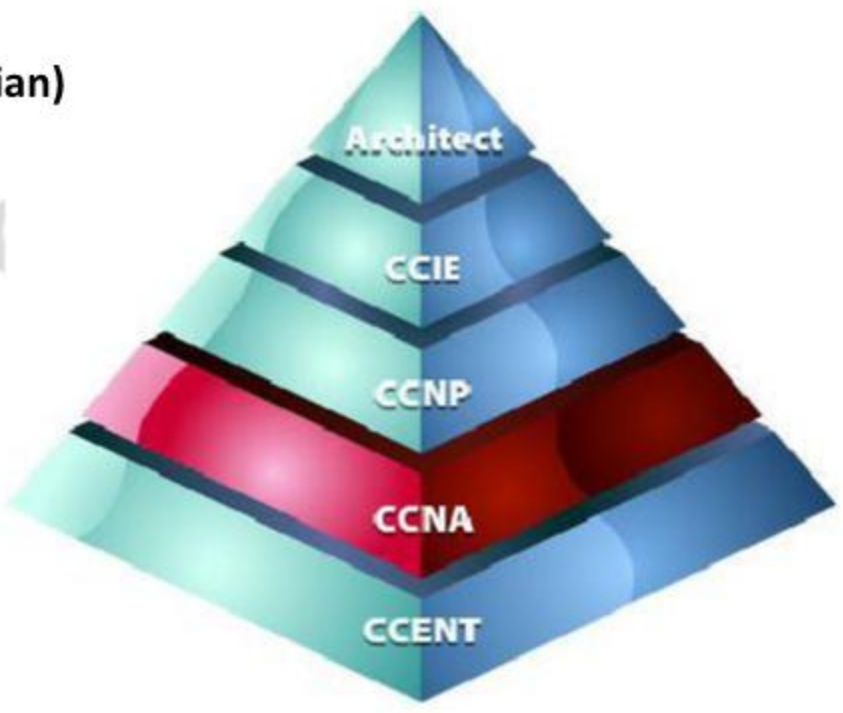




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CERTIFICATIONS

- Cisco certifications are globally respected IT certification programs for Wide Area Networking (Internetworking).
- Cisco has five levels of certification:
  - CCENT (Cisco Certified Entry Networking Technician)
  - CCNA (Cisco Certified Network Associate)
  - CCNP (Cisco Certified Network Professional)
  - CCIE (Cisco Certified Internetworking Expert)
  - CCAr (Cisco Certified Architect)



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CCNA Certification Track

There are 2 tracks for CCNA examination :

- Two paper track
  - ICND 1 (100-101) (On passing this exam the candidate is CCENT)
  - ICND 2 (200-101) (On passing both exams the candidate is CCNA)

OR

- One paper track
  - CCNA (200-120) (On passing this exam the candidate is CCNA)

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CCNA Certification

- Cisco Certified Network Associate R&S exam is the associate level exam into Wide Area Networking.

Exam Number	:	200-120 CCNAX
Duration	:	90 Minutes
Number of questions	:	50-60 questions
Passing Mark	:	825 / 1000
Available Languages	:	English
Exam Questions	:	Multiple-choice single answer
		Multiple-choice multiple answer
		Drag-and-drop
		Simulations (Simlet)
		Scenario Based (Testlet)

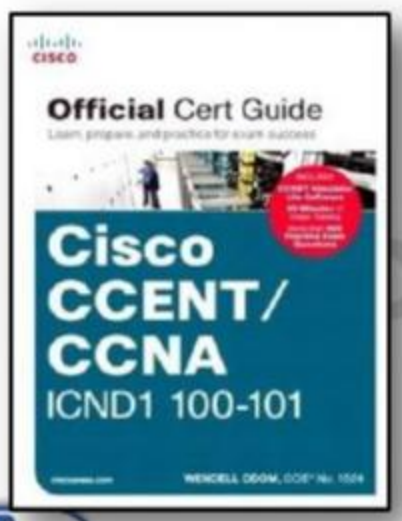
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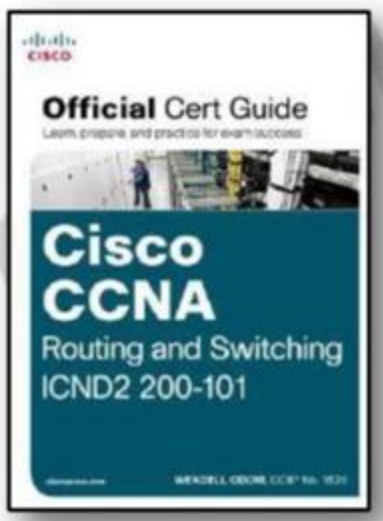
Reference Books

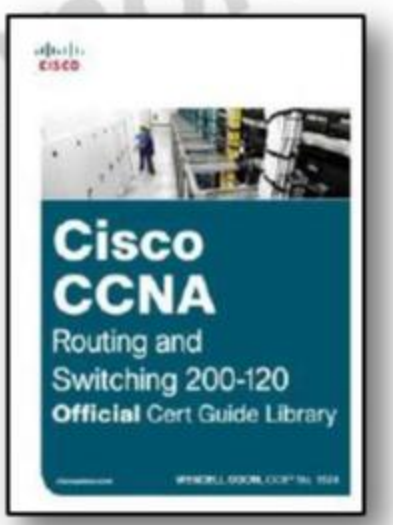
- CCNA ICND 1 (100-101) - Wendell Odom - Cisco Press
- CCNA ICND 2 (200-101) - Wendell Odom - Cisco Press

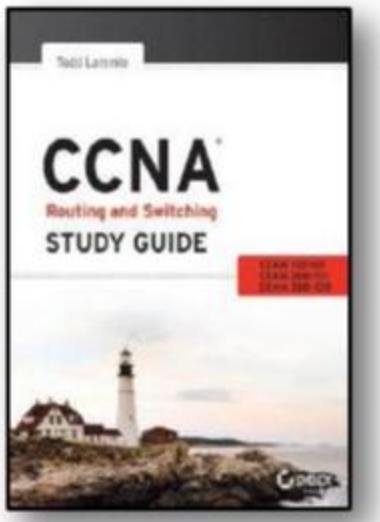
OR

- CCNA Study Guide (200-120) – Todd Lamle

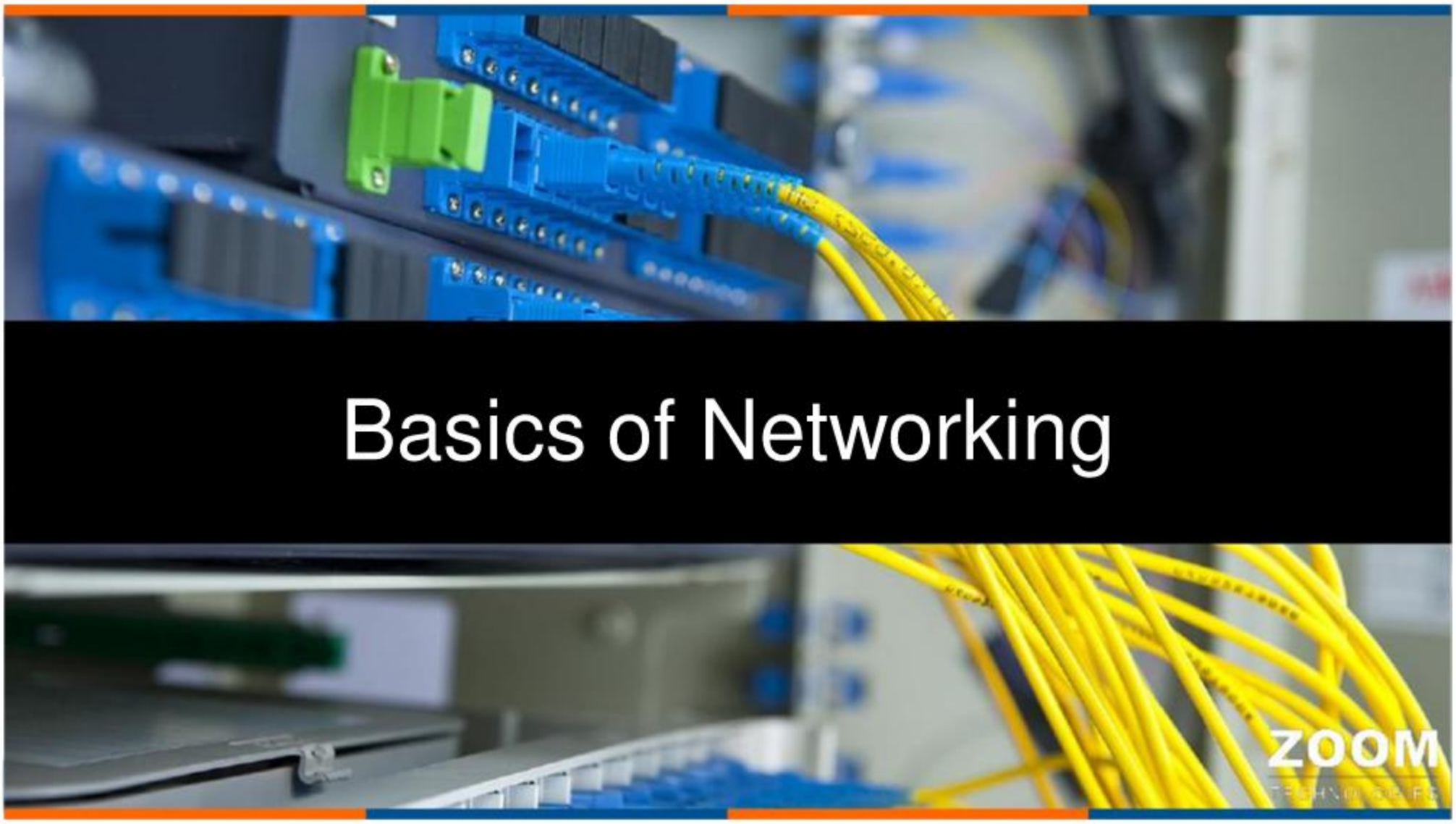








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Network

- Interconnection of two or more devices is called as a network.
- The communication between two or more interconnected devices is called networking.
- An internetwork is a connection of two or more networks.
- Internetworking means communication between different networks.

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Types of Networks

- **LAN**

  Local Area Networks are used to connect networking devices that are in a very close geographic area such as a floor of a building, a building itself or within a campus.

- **MAN**

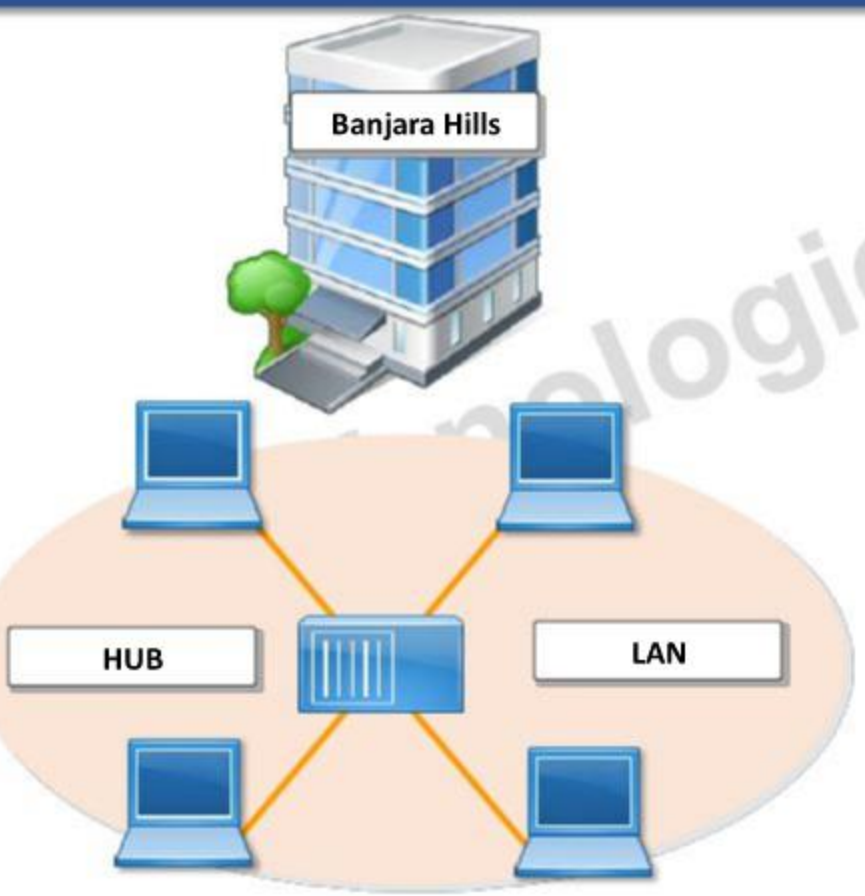
  Metropolitan Area Network are used to connect networking devices that may span around the entire city.

- **WAN**

  Wide Area Networks which connects two or more LANs present at different geographical locations.

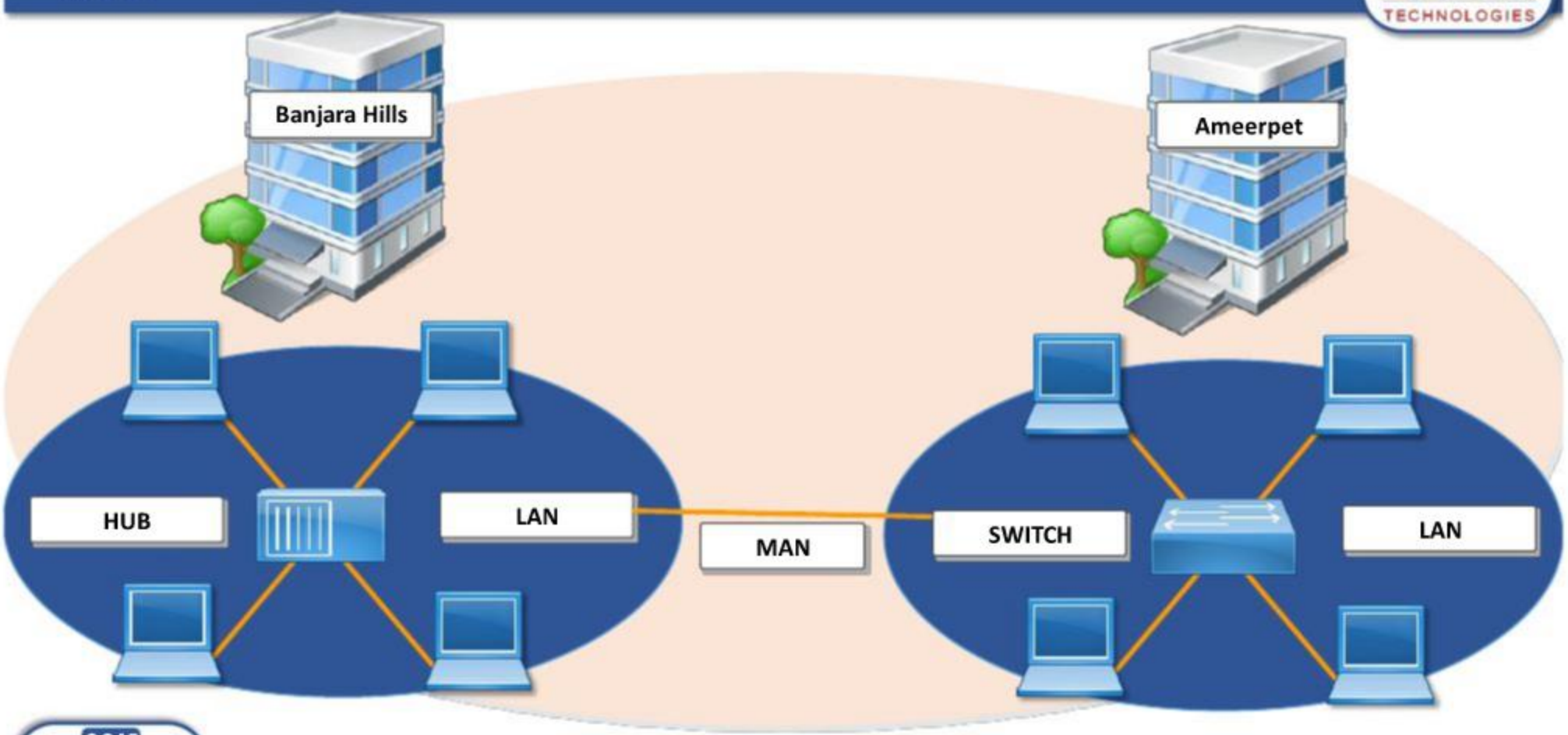
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LAN

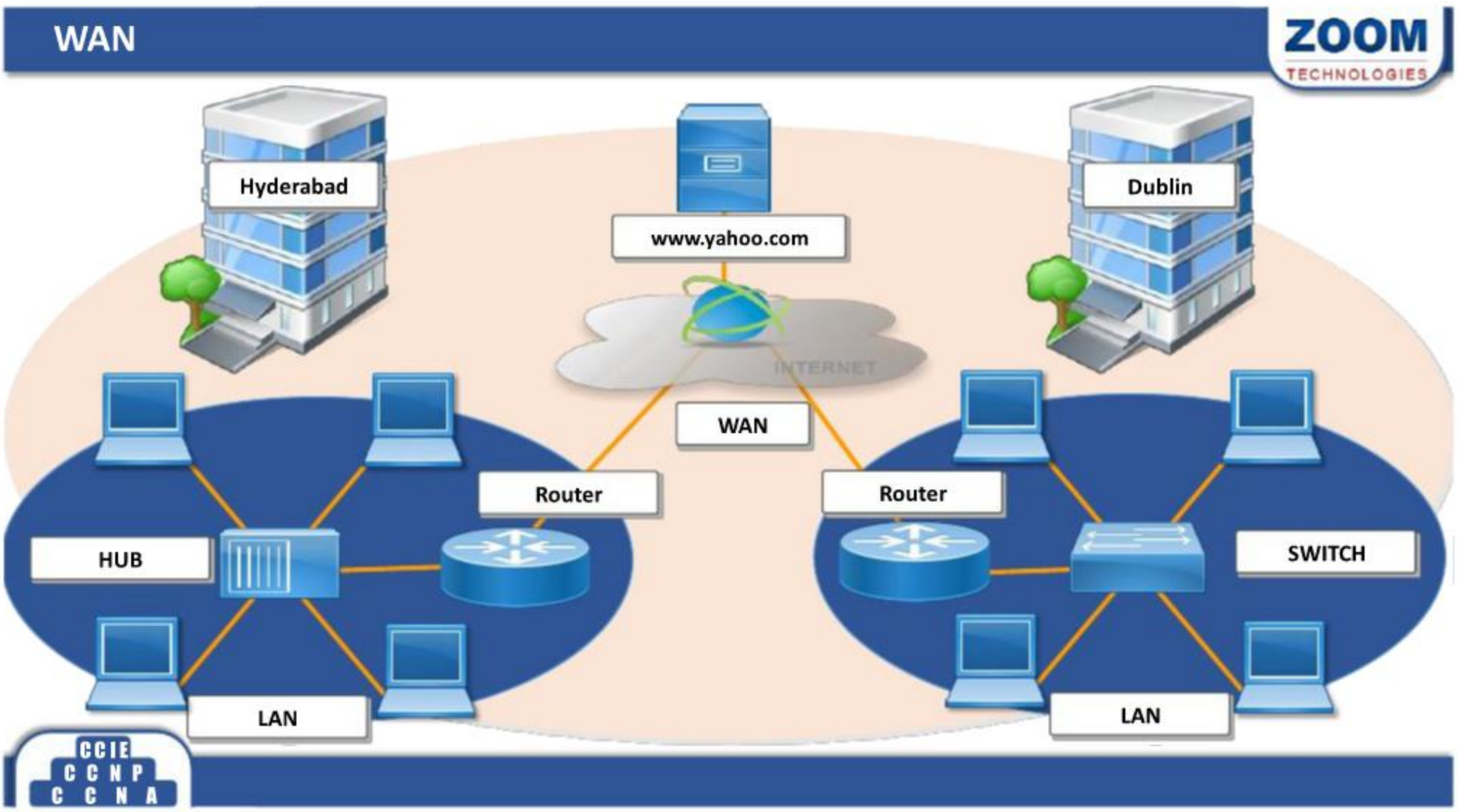


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MAN


Banjara Hills
Ameerpet
HUB
LAN
MAN
SWITCH
LAN

WAN


Hyderabad
www.yahoo.com
Dublin
INTERNET
WAN
Router
Router
HUB
SWITCH
LAN
LAN

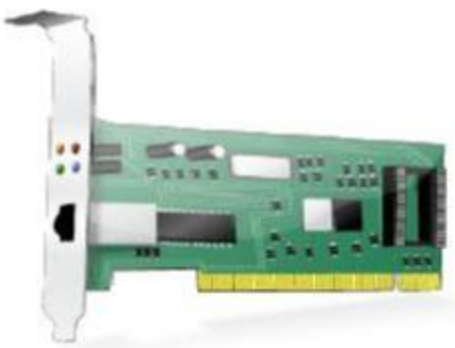
Basic requirements to form a network

- NIC (Network interface card) also called as LAN card
- Media
- Networking devices (Hub, Switch, Router etc.)
- Protocols
- Logical Address (IP address)

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NIC(Network Interface Card)

- NIC is the interface between the computer and the network
- It is also known as the Lan card or Ethernet card
- Ethernet cards have a unique 48 bit address called as MAC (Media access control) address
  - MAC address is also called as Physical address or hardware address
  - The 48 bit MAC address is represented as 12 Hexa-decimal digits
  - Example: 0016.D3FC.603F
- Network cards are available in different speeds
  - Ethernet (10 Mbps)
  - Fast Ethernet (100 Mbps)
  - Gigabit Ethernet (1000 Mbps)

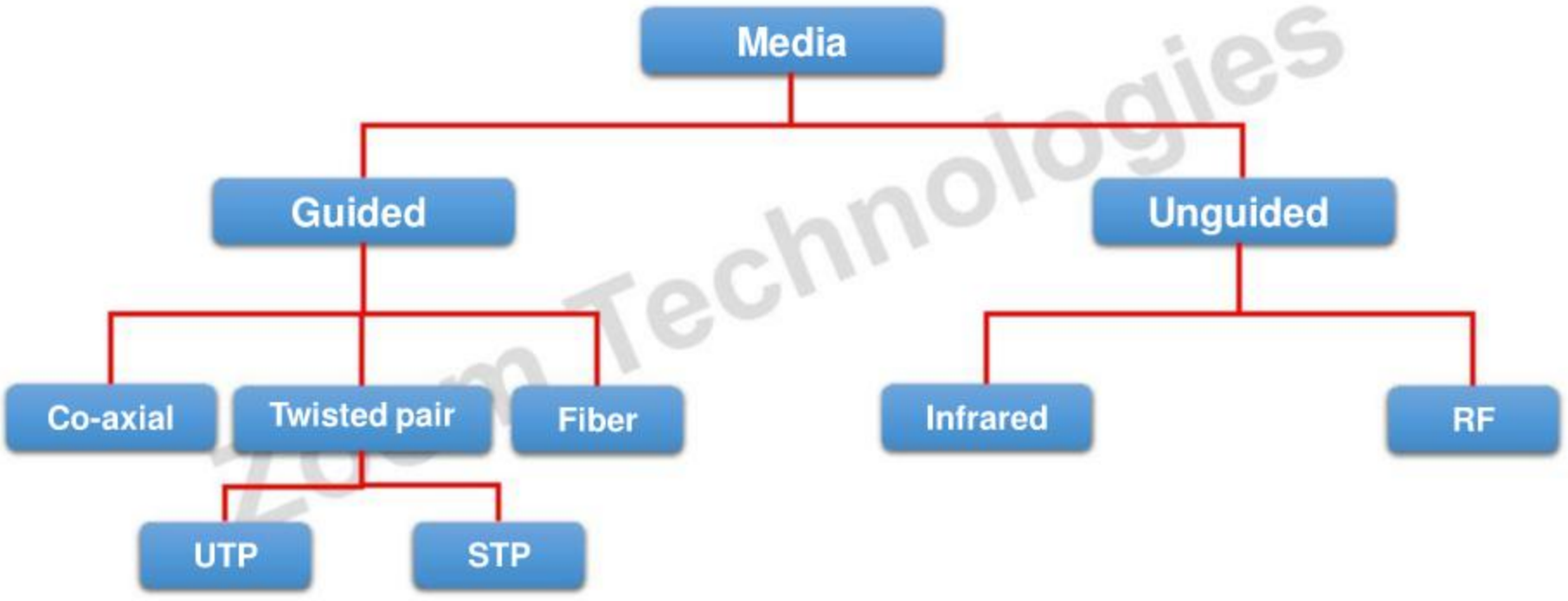


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Media

- The purpose of the media is to transport bits from one machine to another.



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Media



UTP Cable



Co-axial cable



STP Cable



Fiber optic

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Types of Twisted Pair cables

Category	DTR	Purpose	Connector
CAT 1	1 Mbps	Telephone Lines	RJ 11
CAT 2	4 Mbps		RJ 11
CAT 3	10 Mbps	Ethernet	RJ 45
CAT 4	16 Mbps		RJ 45
CAT 5	100 Mbps	Fast Ethernet	RJ 45
CAT 5e	500 Mbps		RJ 45
CAT 6	1000 Mbps	Gigabit Ethernet	RJ 45

Topology

Topology is a physical layout of the systems connected in a network.

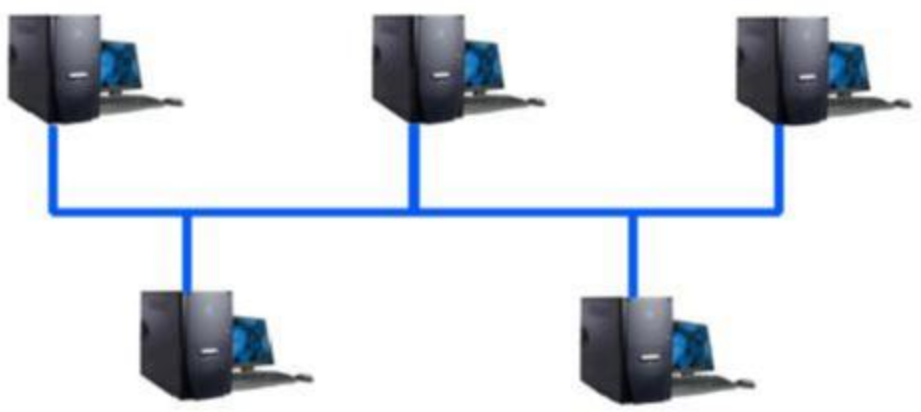
Different types of topology are:

- Bus
- Ring
- Mesh
- Star

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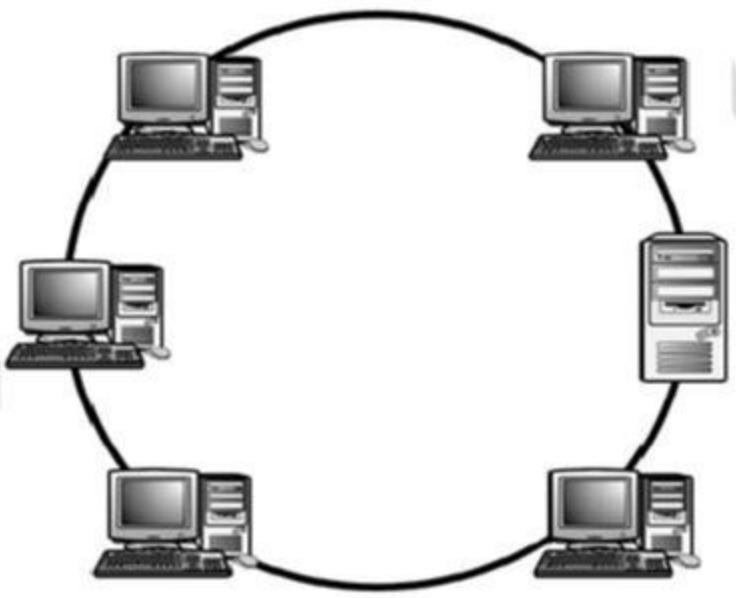
Bus Topology

- In bus topology all devices are connected to a single cable or backbone.
- It supports half duplex communication.
- A break at any point along the backbone will result in total network failure.



Ring Topology

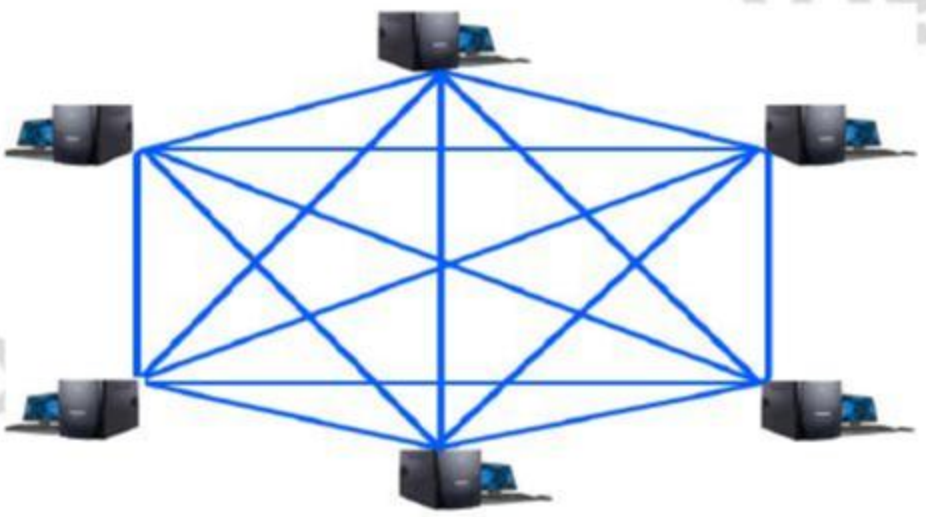
- In ring topology each computer or device is connected to its neighbor forming a loop.
- Failure of a single device or a break anywhere in the cable causes the full network to stop communicating



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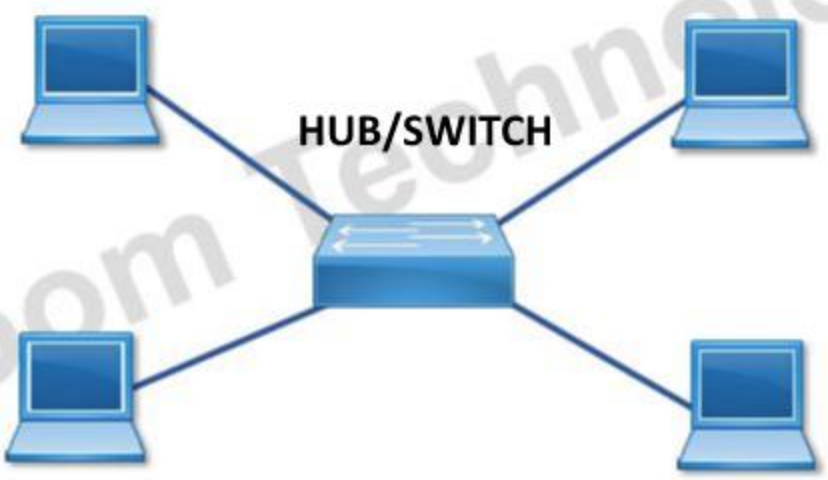
Mesh Topology

- In mesh topology each device is directly connected to all other devices
- The disadvantage is the number of NIC's required on each device and the complex cabling.



Star Topology

- The most commonly used topology
- It consist of one centralized device which can be either a switch or a hub.
- The devices connect to the various ports on the centralized devices.



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Networking devices

The various types of networking devices are:

- Hub
- Switch
- Router

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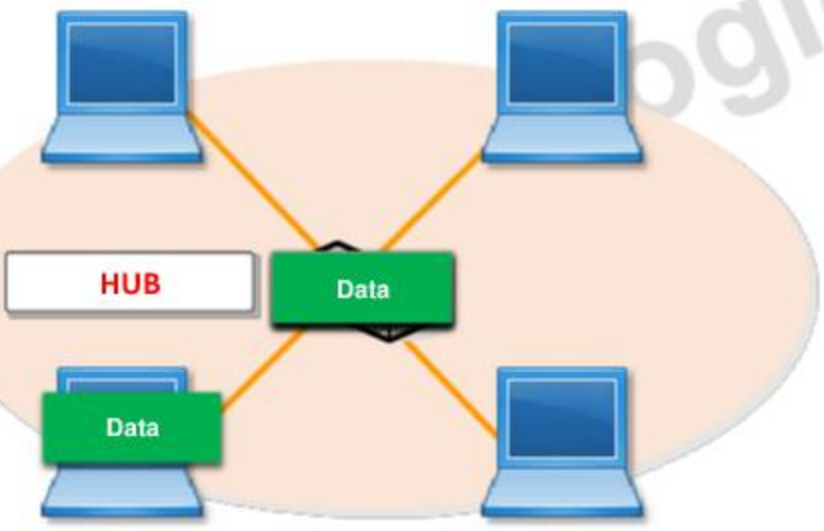
Hub / Repeater

- It is not an Intelligent Device.
- It works with bits.
- Uses broadcast for communication.
- Bandwidth is shared.
- Half-duplex communication.

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Functions of HUB



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Functions of HUB



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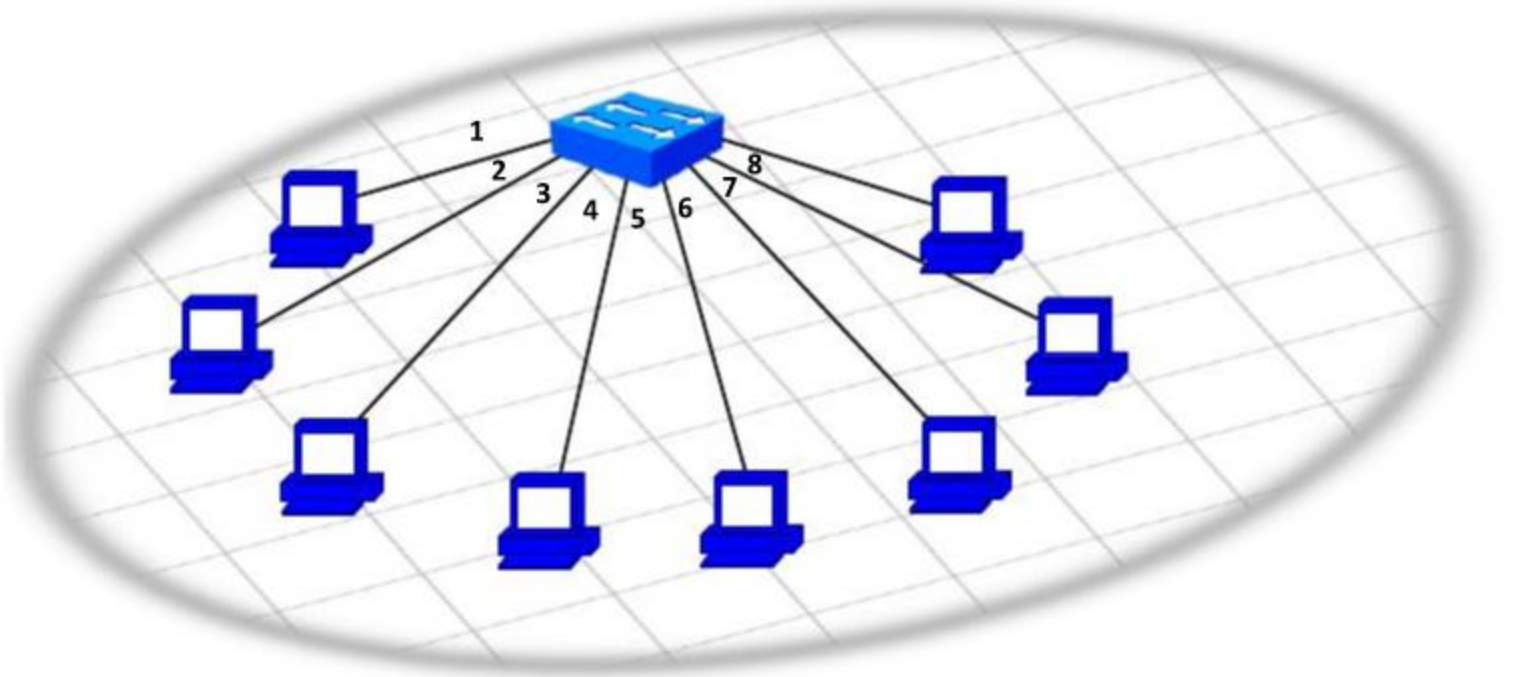
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Switch

- It is an Intelligent device.
- It maintains MAC address table (hardware address).
- Each port of the switch has fixed bandwidth.
- It works with Flooding and Unicast.
- Supports full duplex communication

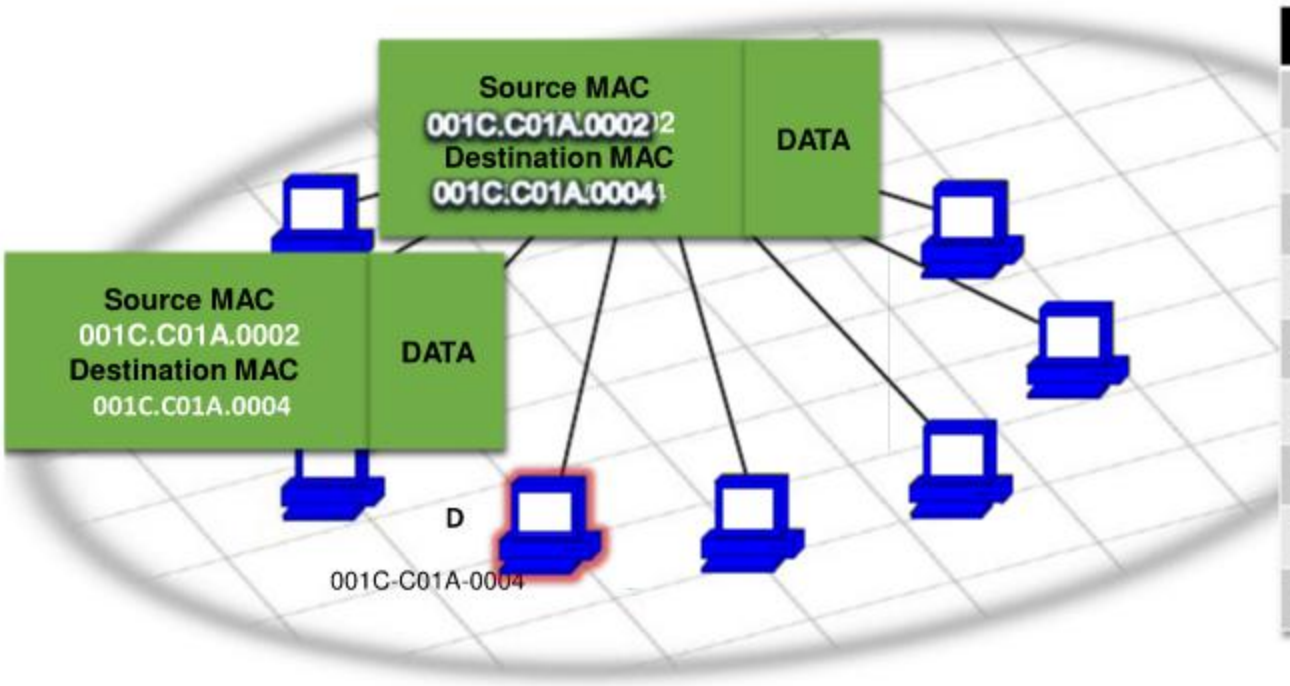
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Functions of Switch



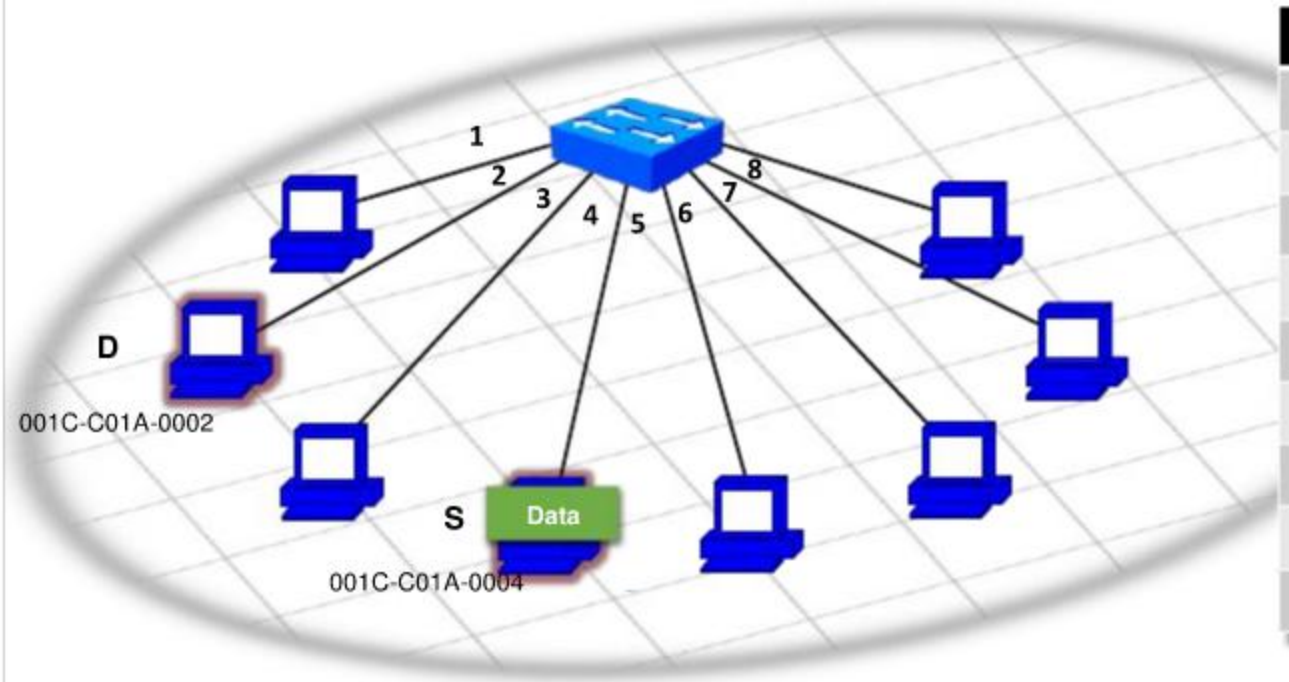
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Functions of Switch



MAC ADDRESS TABLE	
PORT	MAC-ADDRESS
1	
2	001C-C01A-0002
3	
4	
5	
6	
7	
8	

Functions of Switch



MAC ADDRESS TABLE	
PORT	MAC-ADDRESS
Fa0/1	
Fa0/2	001C-C01A-0002
Fa0/3	
Fa0/4	001C-C01A-0004
Fa0/5	
Fa0/6	
Fa0/7	
Fa0/8	

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Router

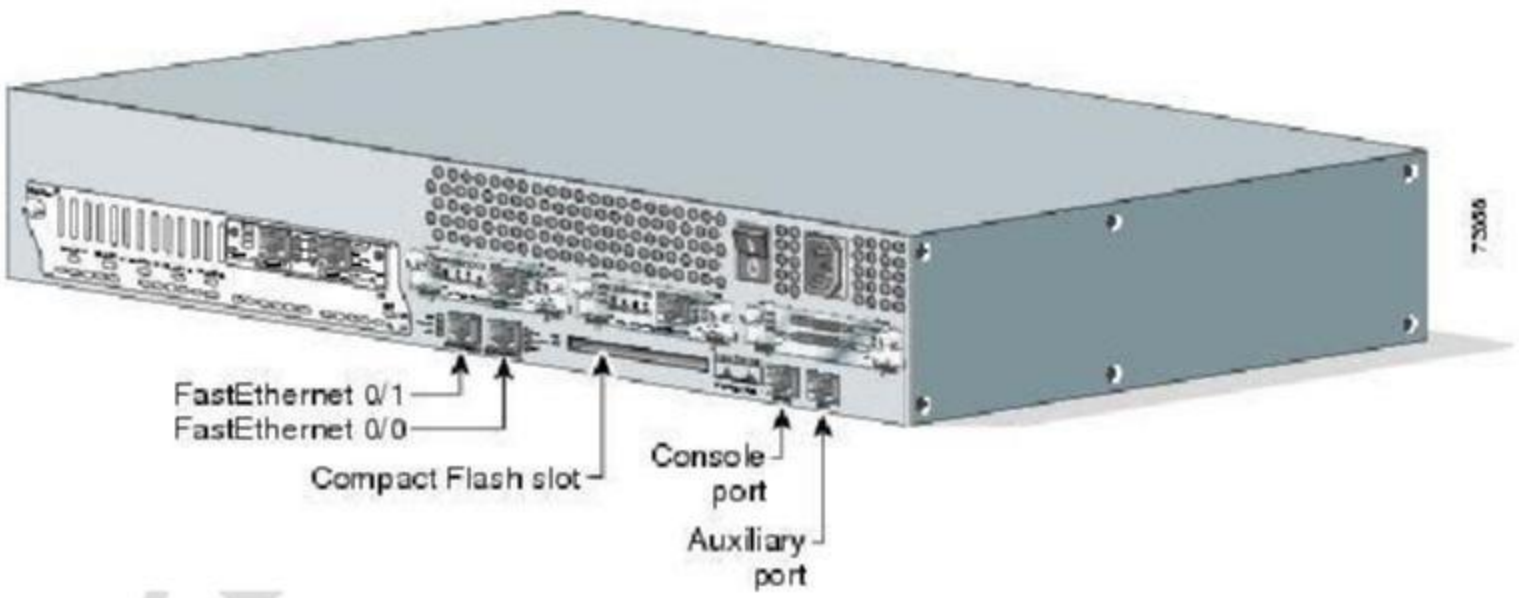
- It is an Intelligent device
- It works with Logical Addressing (i.e. IP, IPX, AppleTalk)
- It works with Fixed bandwidth

Symbolic Representation:



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ROUTER



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	PC	HUB	Bridge	Switch	Router
PC	Cross Cable	Straight	Cross Cable	Straight	Cross Cable
HUB	Straight	Cross Cable	Straight	Cross	Straight
Bridge	Cross Cable	Straight	Cross Cable	Straight	Cross Cable
Switch	Straight	Cross	Straight	Cross Cable	Straight
Router	Cross Cable	Straight	Cross Cable	Straight	Cross Cable



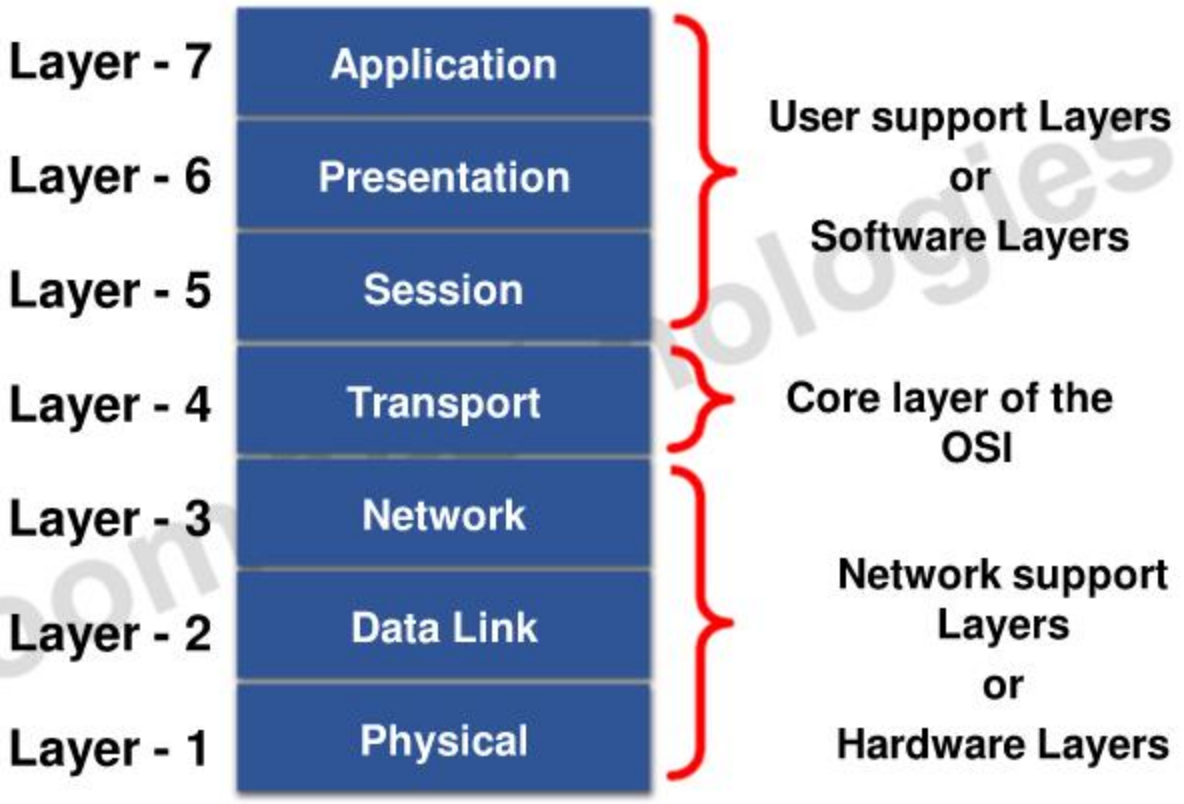
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OSI

- OSI was developed by the International Organization for Standardization (ISO) and introduced in 1984.
- It is a layered architecture (consists of seven layers).
- Each layer defines a set of functions which takes part in data communication.

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OSI Model Layers



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Application Layer



Application Layer : is responsible for providing an interface for the users to interact with application services or Networking Services .

Ex: Web browser(HTTP), Telnet etc.

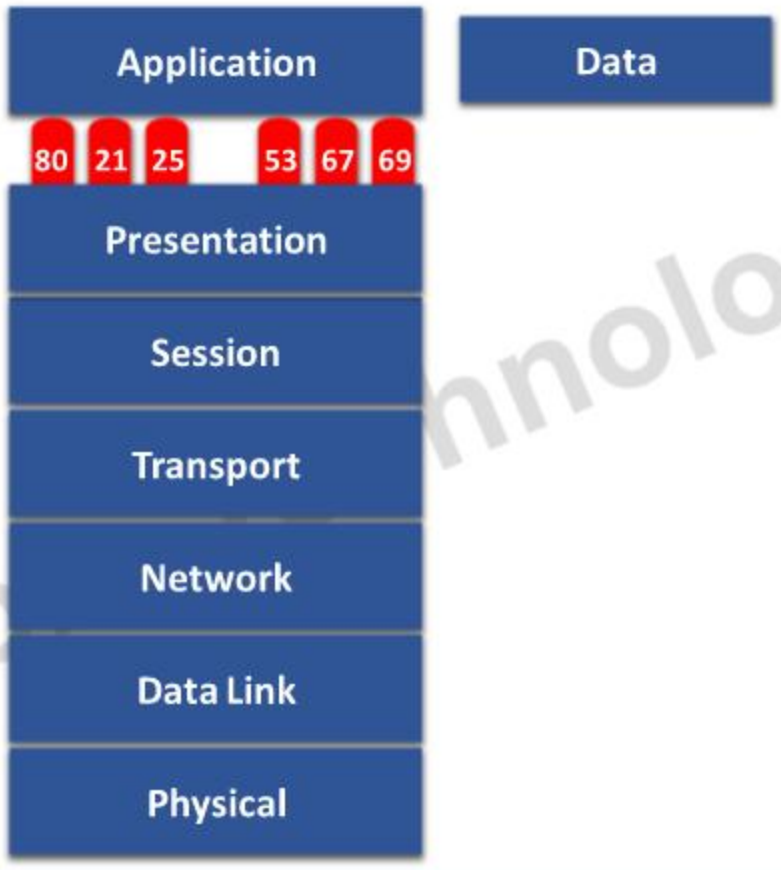
Technologies

Examples of Networking Services

Service	Port No.
HTTP	80
FTP	21
SMTP	25
TELNET	23
TFTP	69

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Data flow from Application Layer



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Presentation Layer



Presentation Layer : It is responsible for defining a standard format to the data.

It deals with data presentation.

The major functions described at this layer are..

Encoding – Decoding

Ex : ASCII, EBCDIC (Text)

JPEG,GIF,TIFF (Graphics)

MIDI,WAV (Voice)

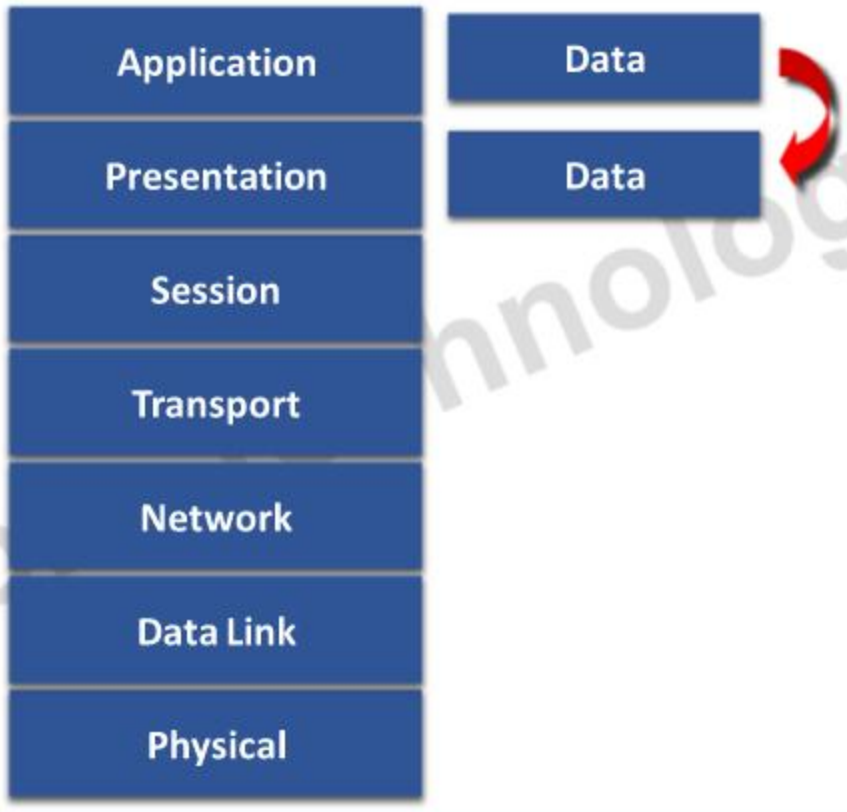
MPEG,DAT,AVI (Video)

Encryption – Decryption

Compression – Decompression

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Data flow from Presentation Layer



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Session Layer



Session Layer : It is responsible for establishing, maintaining and terminating the sessions.

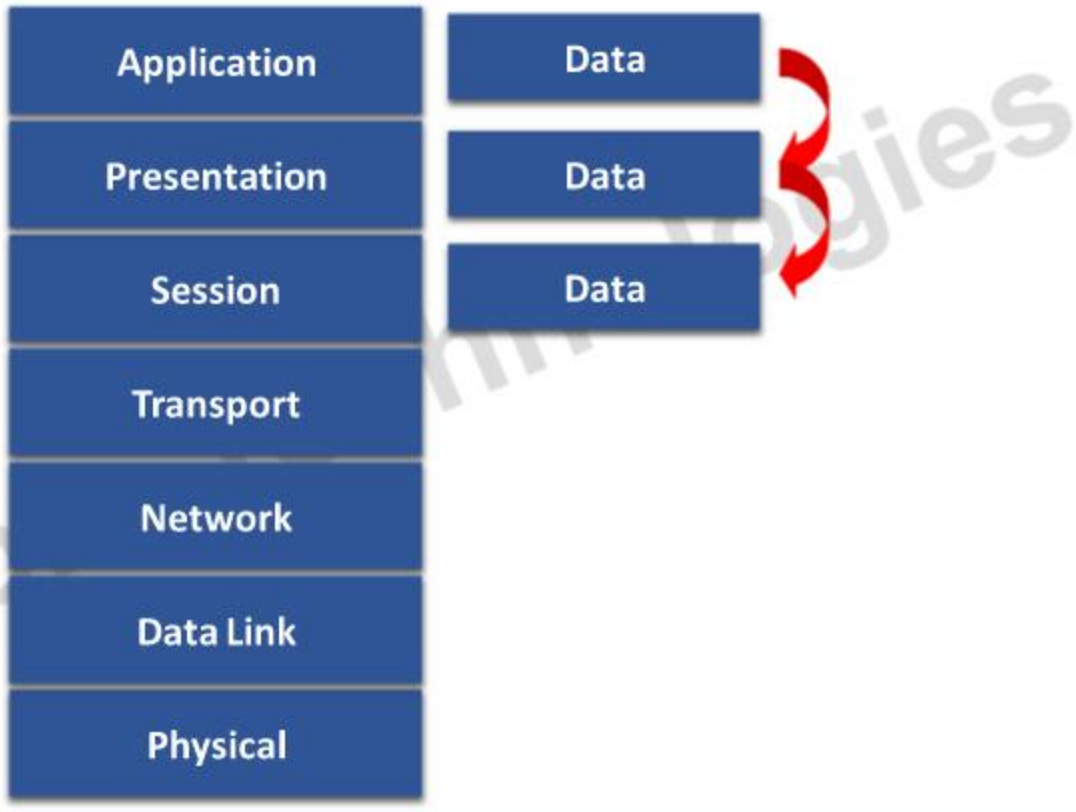
Session ID is used to identify a session or interaction.

Ex :

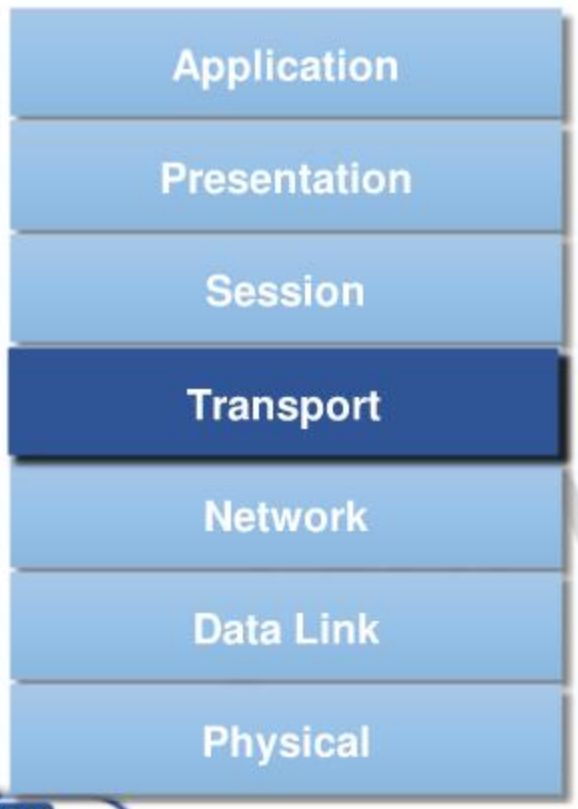
- **RPC Remote Procedural Call**
- **SQL Structured Query Language**
- **ASP AppleTalk Session protocol**

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Data flow from Session Layer



Transport Layer



Transport Layer : It provides data delivery mechanism between the applications in the network.

The major functions described at the Transport Layer are.

- **Identifying Service**
- **Multiplexing & De-multiplexing**
- **Segmentation**
- **Sequencing & Reassembling**
- **Error Correction**
- **Flow Control**

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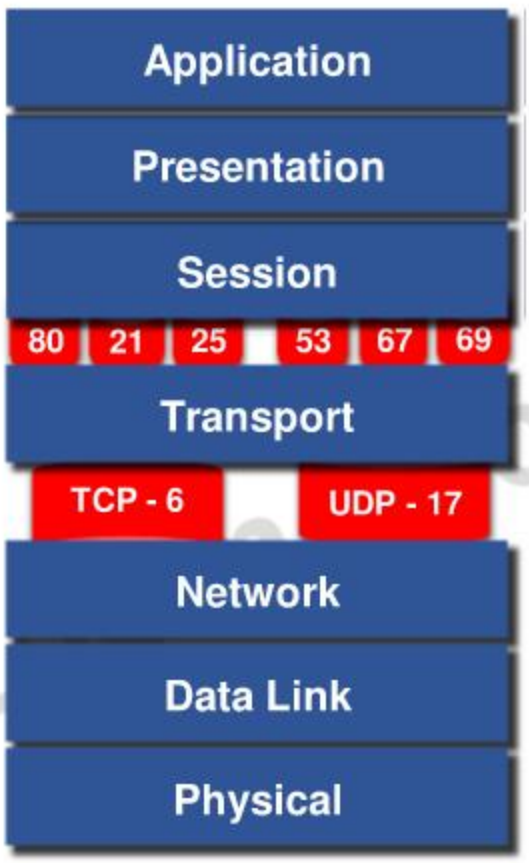
Identifying a Service

- Identification of Services is done using port Numbers.
- Port is a logical communication Channel

Total No. Ports	0 – 65535
Reserved Ports	1 - 49151
Open Ports	49152 – 65535

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Multiplexing & De-multiplexing



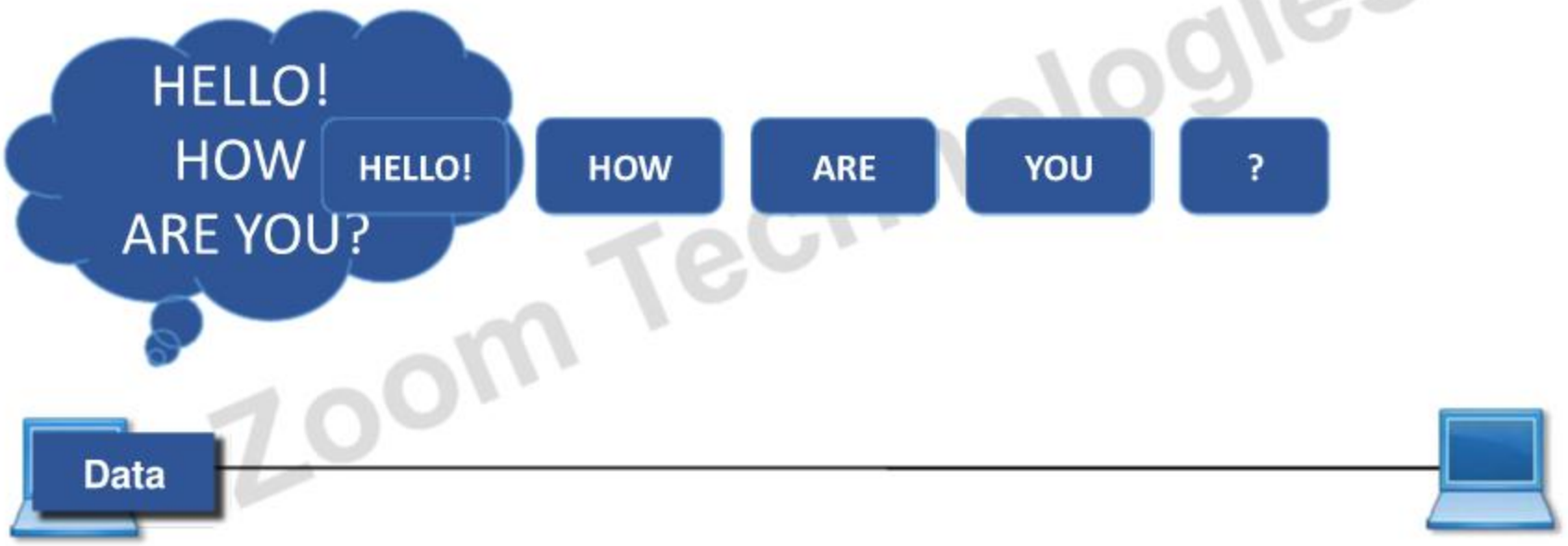
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Transport Layer Protocols

- The protocols which takes care of Data Transportation at Transport layer are TCP and UDP

TCP	UDP
• Transmission Control Protocol • Connection Oriented • Supports Acknowledgements • Reliable communication • Slower data Transportation • Protocol No is 6 • Ex: HTTP, FTP, SMTP	• User Datagram Protocol • Connection Less • No support for Acknowledgements • Unreliable communication • Faster data Transportation • Protocol No is 17 • Ex: DNS, DHCP, TFTP

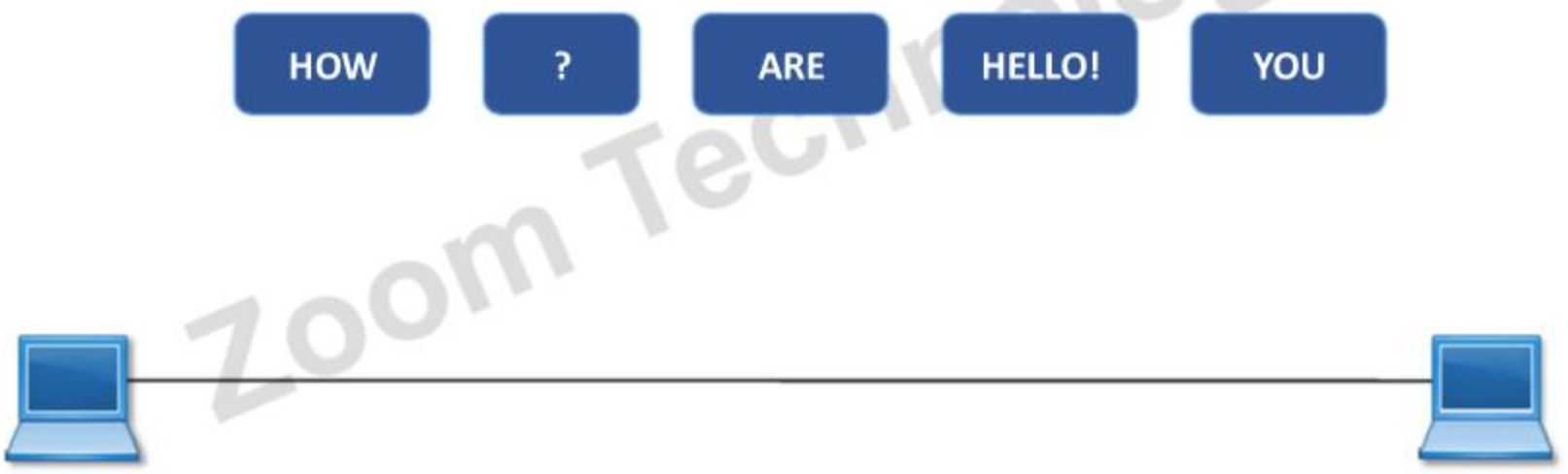
Segmentation



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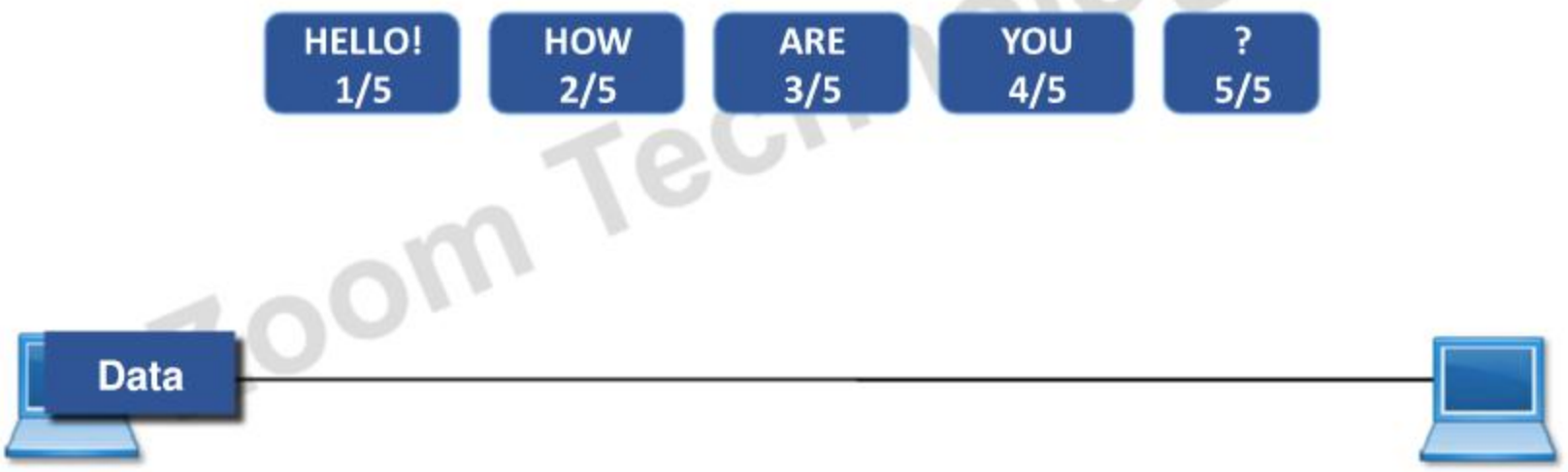
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Sequencing



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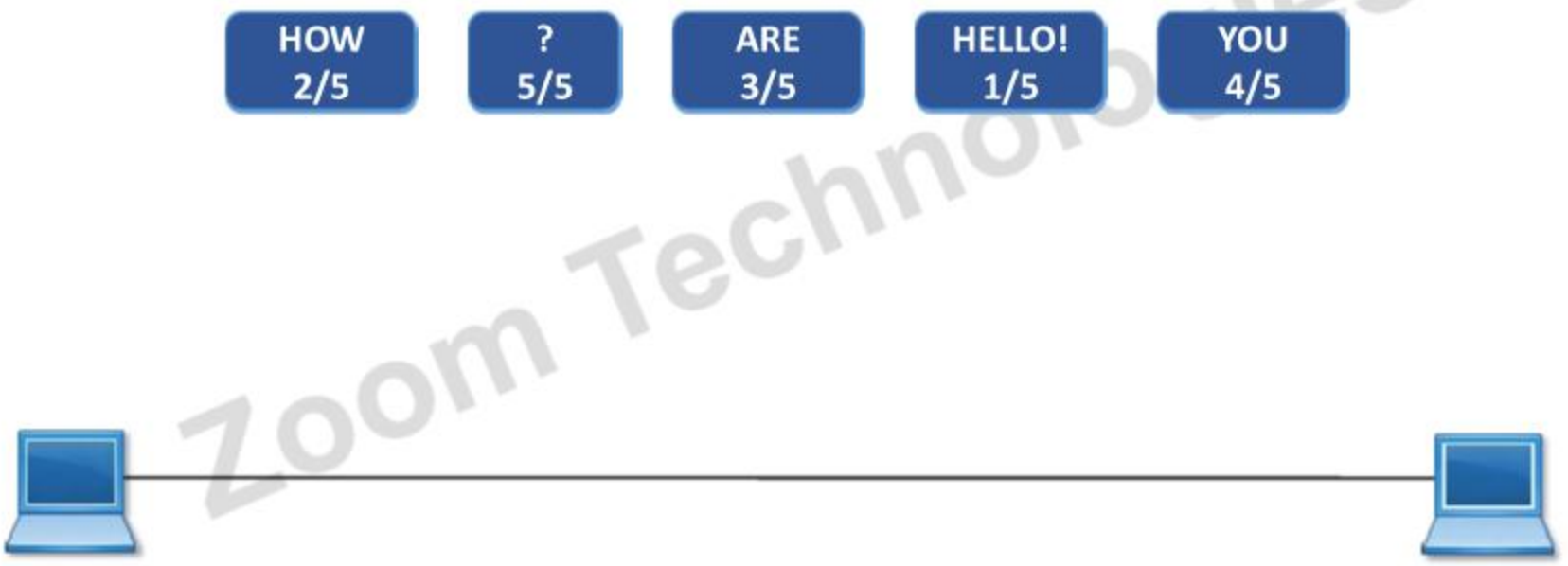
Sequencing



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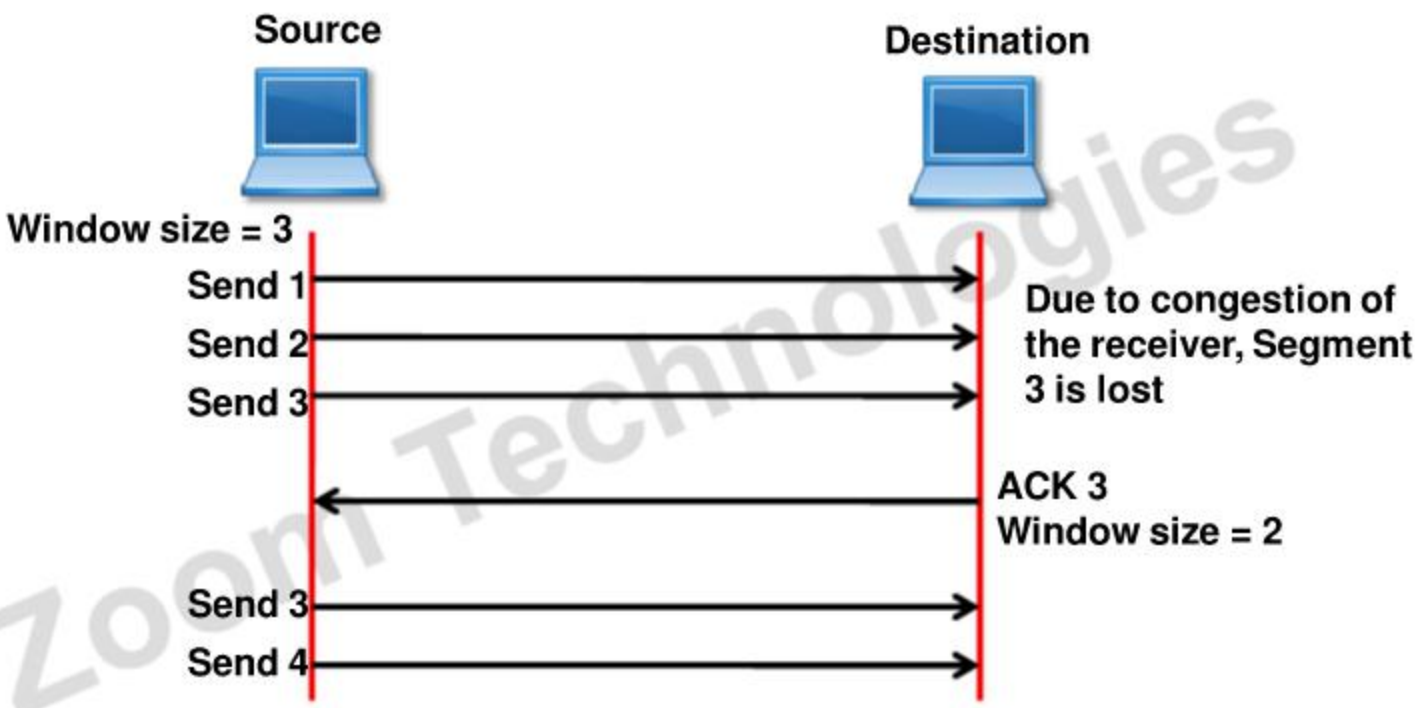
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Reassembling



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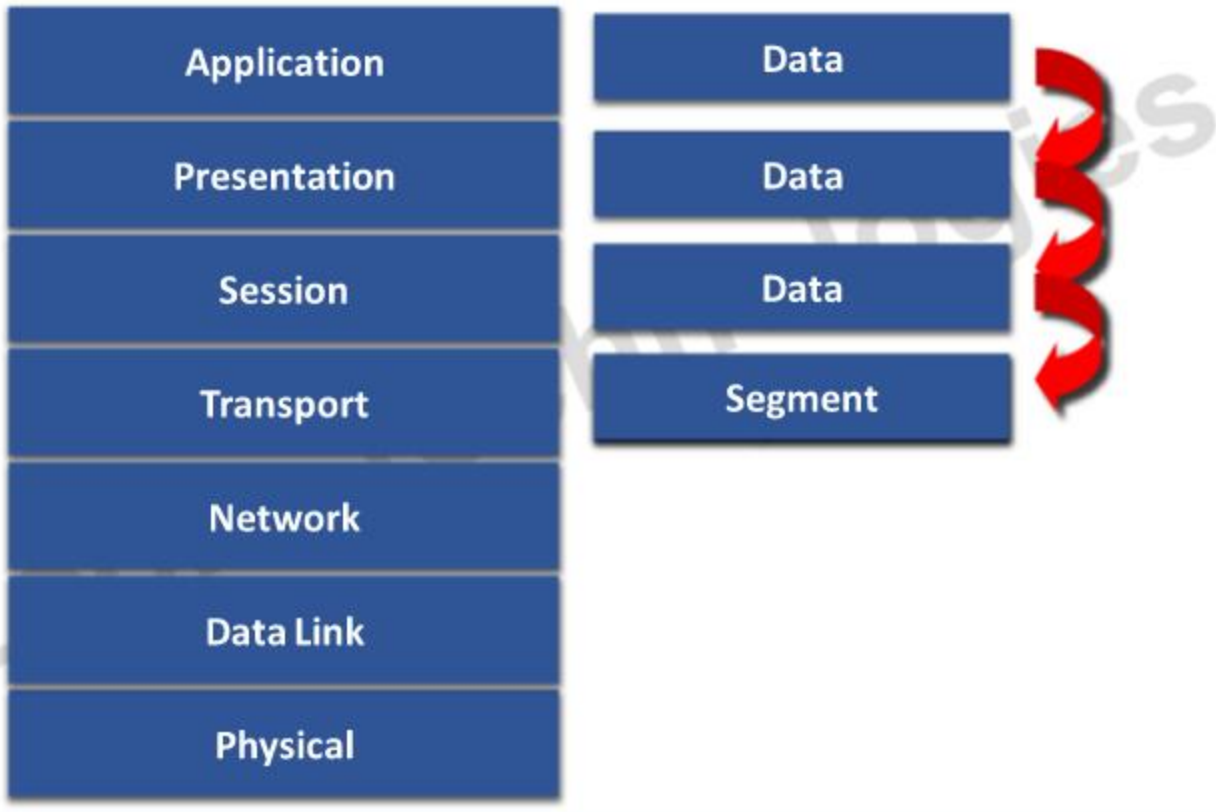
Flow Control and Error Correction



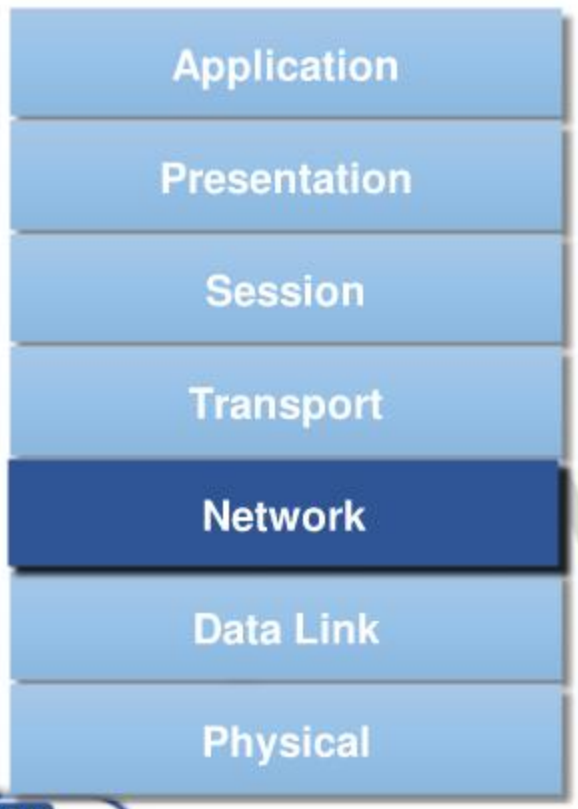
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Data flow from Transport Layer



Network Layer



Network Layer : It provides Logical addressing & Path determination (Routing)

The protocols that work in this layer are:

Routed Protocols :

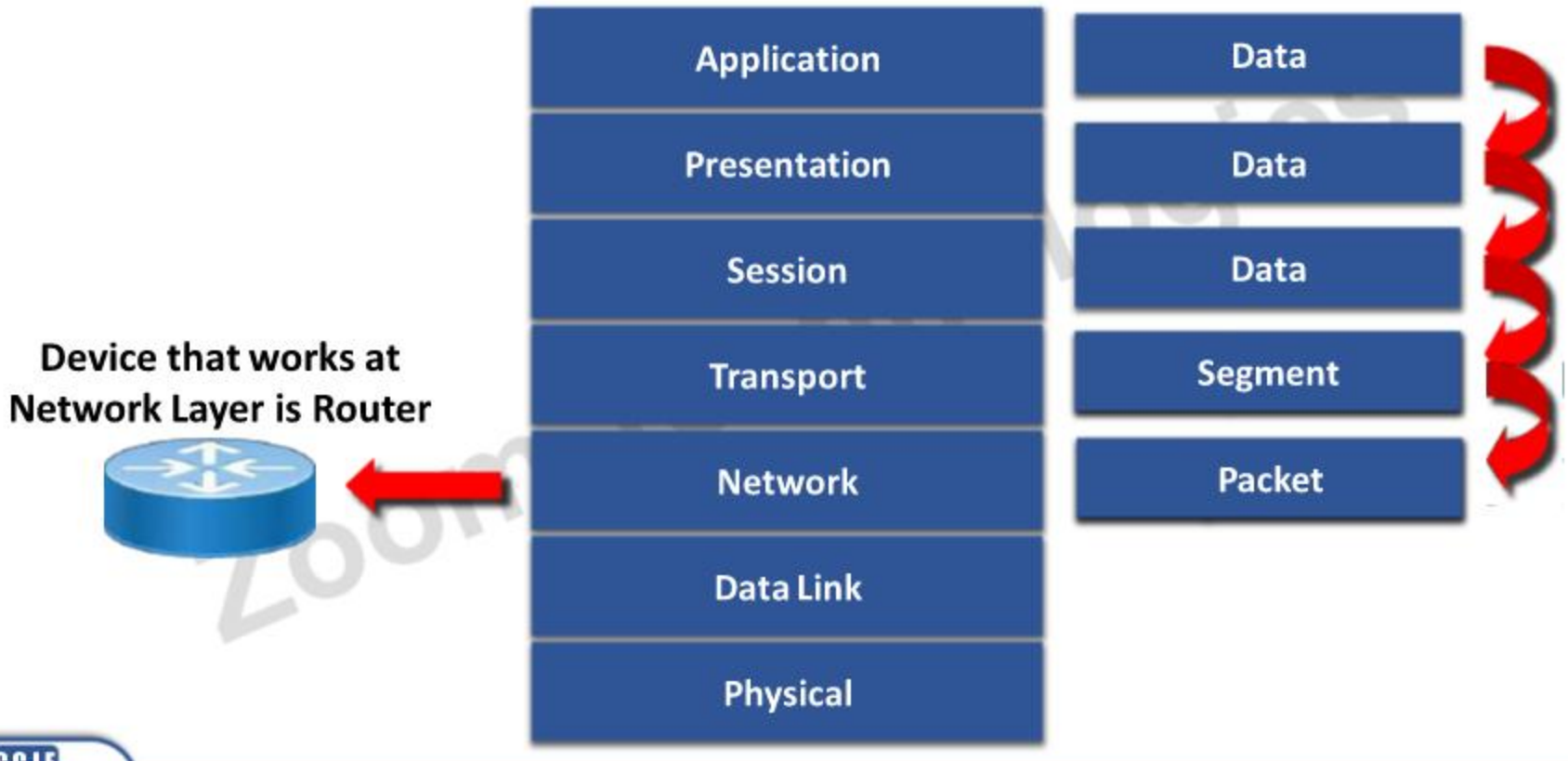
- IP, IPX, AppleTalk.. Etc
- Routed protocols used to carry user data between hosts.

Routing Protocols :

- RIP, OSPF.. Etc
- Routing protocols performs Path determination (Routing).

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Data flow from Network Layer



Datalink Layer



Datalink Layer

It has 2 sub layers

- MAC (Media Access Control) It provides reliable transit of data across a physical link.

  It also provides ERROR DETECTION using CRC (Cyclic Redundancy Check)

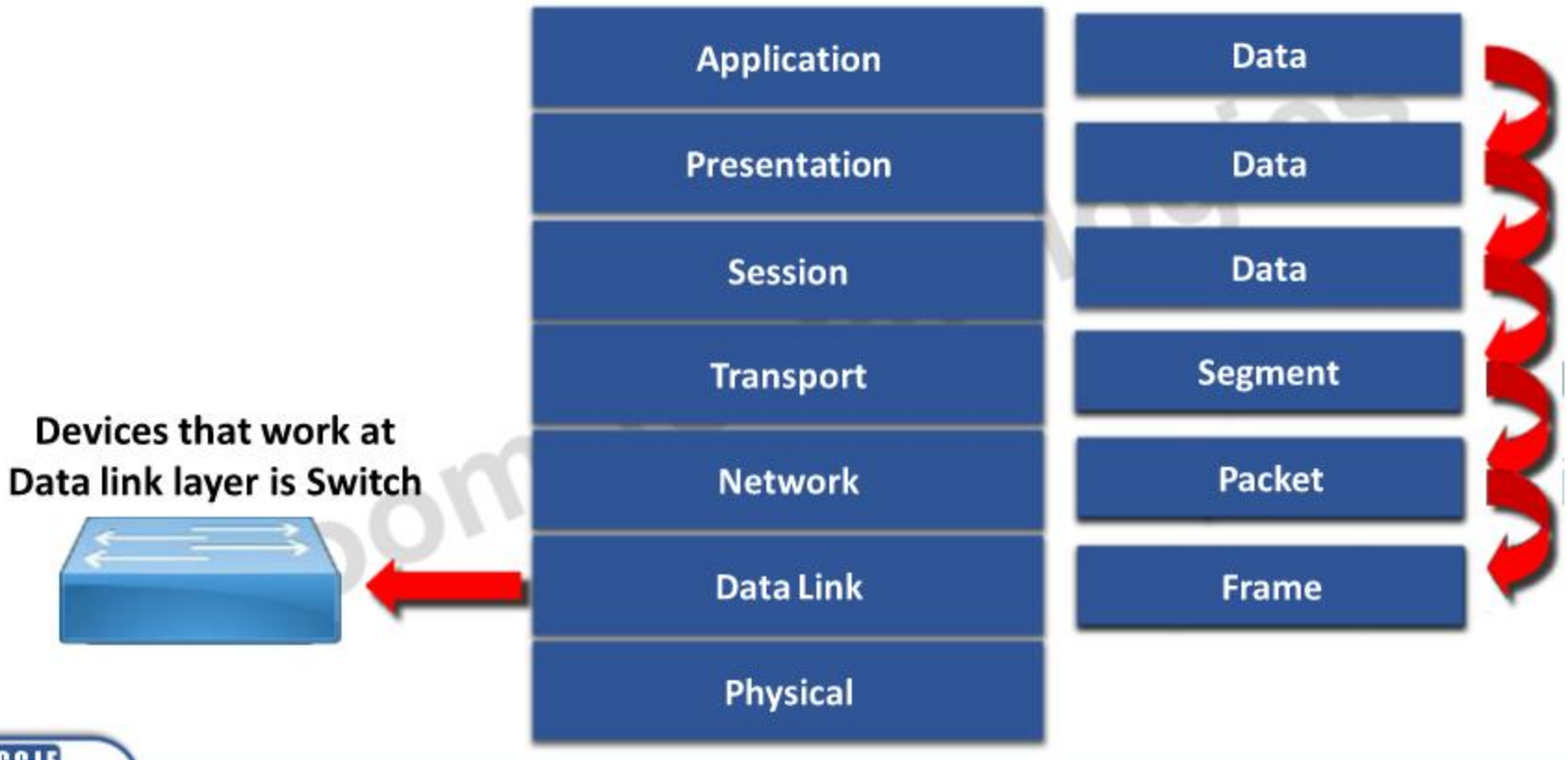
Ex: Ethernet, Token ring...etc

- LLC (Logical Link Control)

  It provides communication with Network layer.

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Data flow from Data link Layer



Physical Layer



Physical Layer : It defines the electrical, Mechanical & functional specifications for communication between the Network devices.

The functions described at this layer are

Encoding/decoding:

It is the process of converting the binary data into signals based on the type of the media.

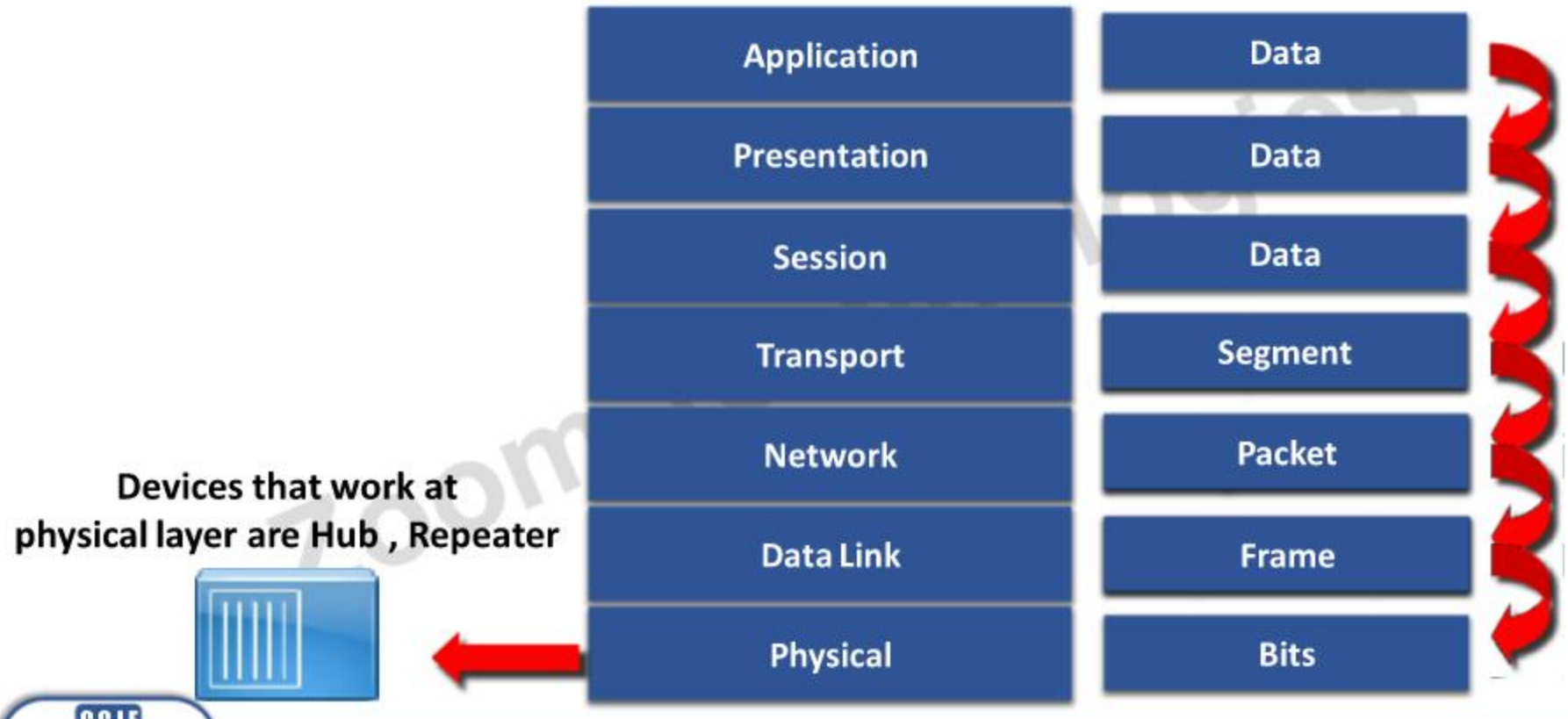
Copper media : Electrical signals of different voltages

Fiber media: Light pulses of different wavelengths

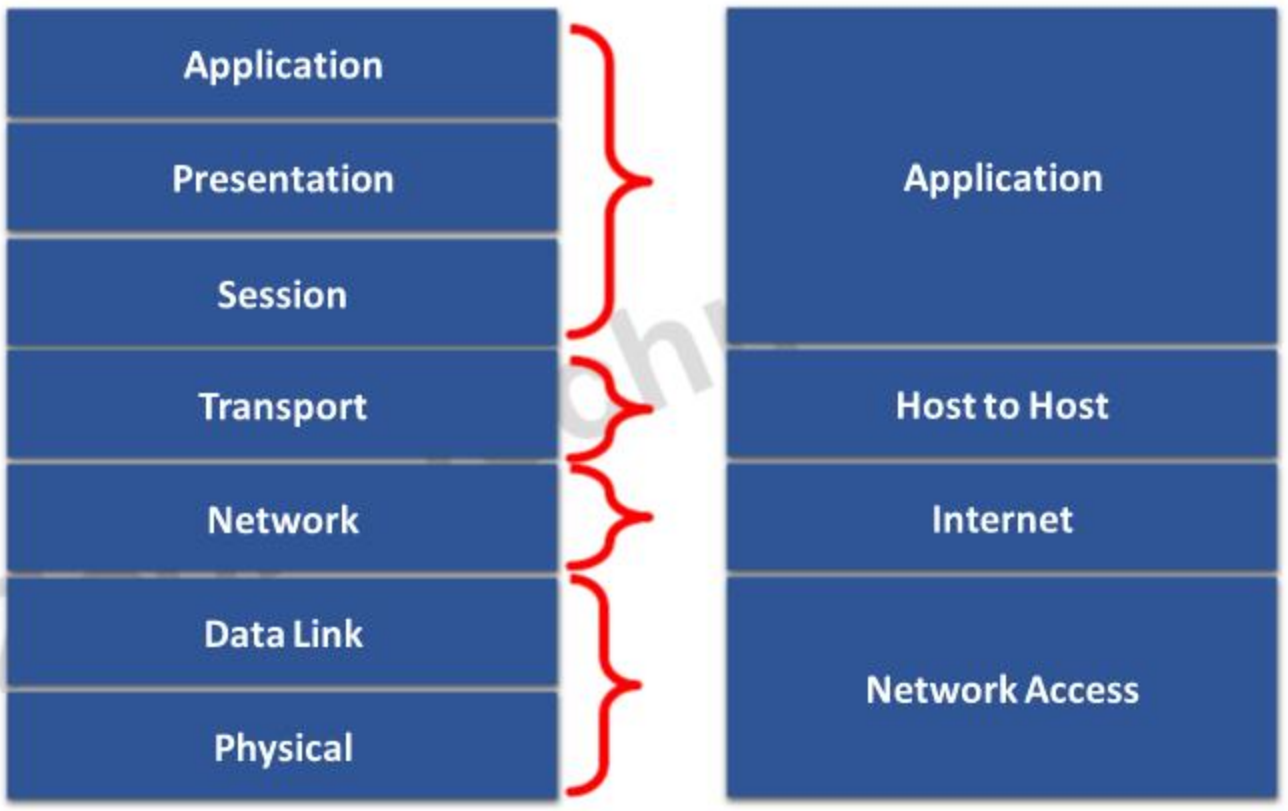
Wireless media: Radio frequency waves

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Data flow from Physical Layer



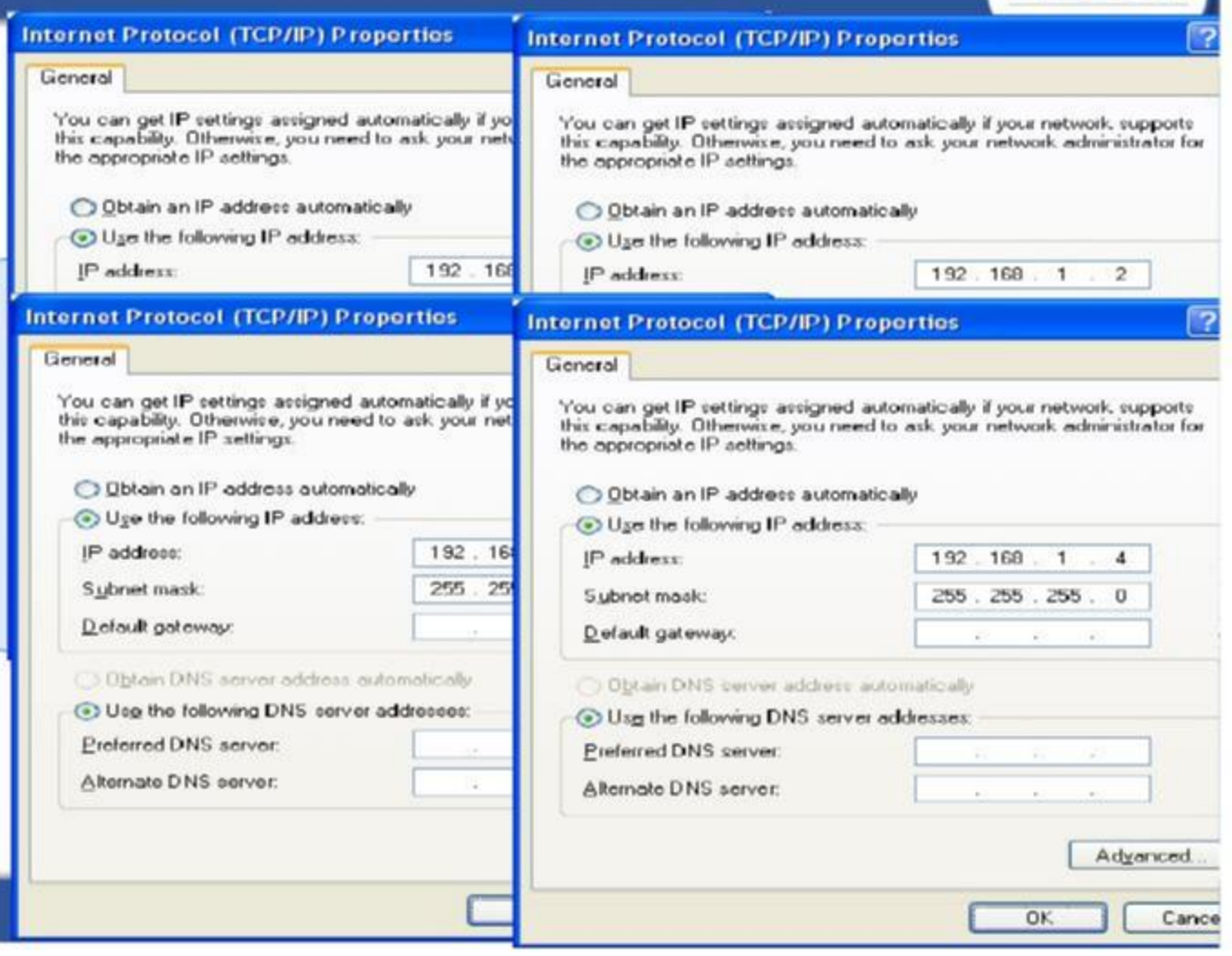
Comparison between OSI & TCP/IP Model



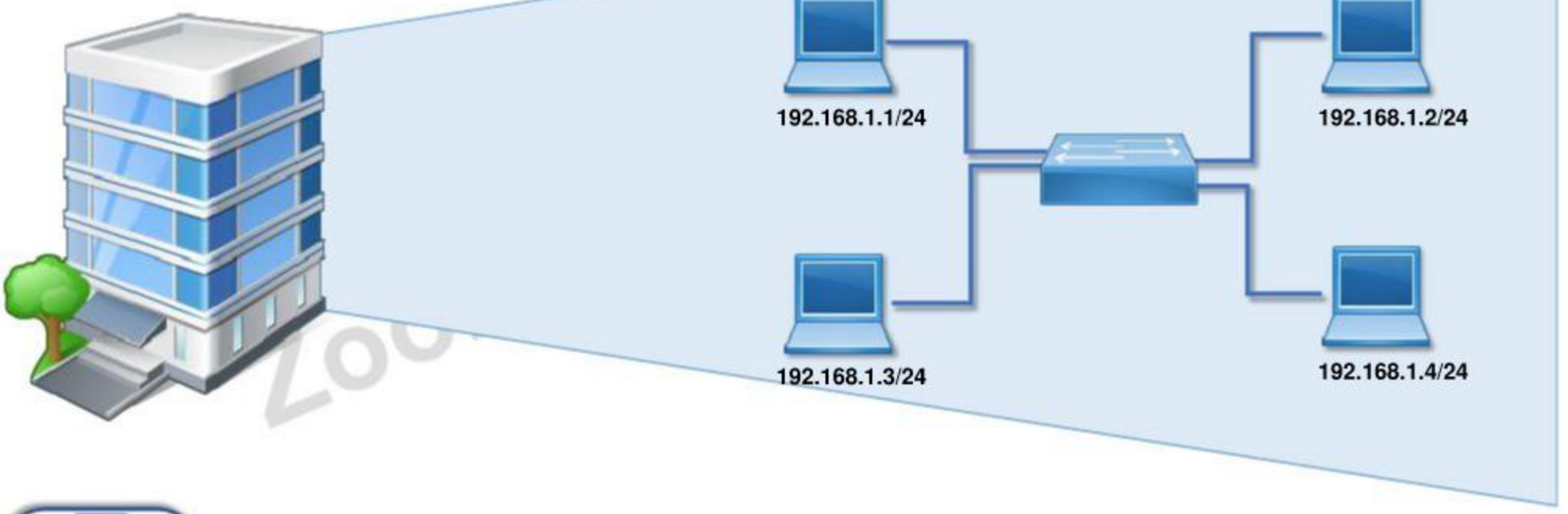
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LAN Setup

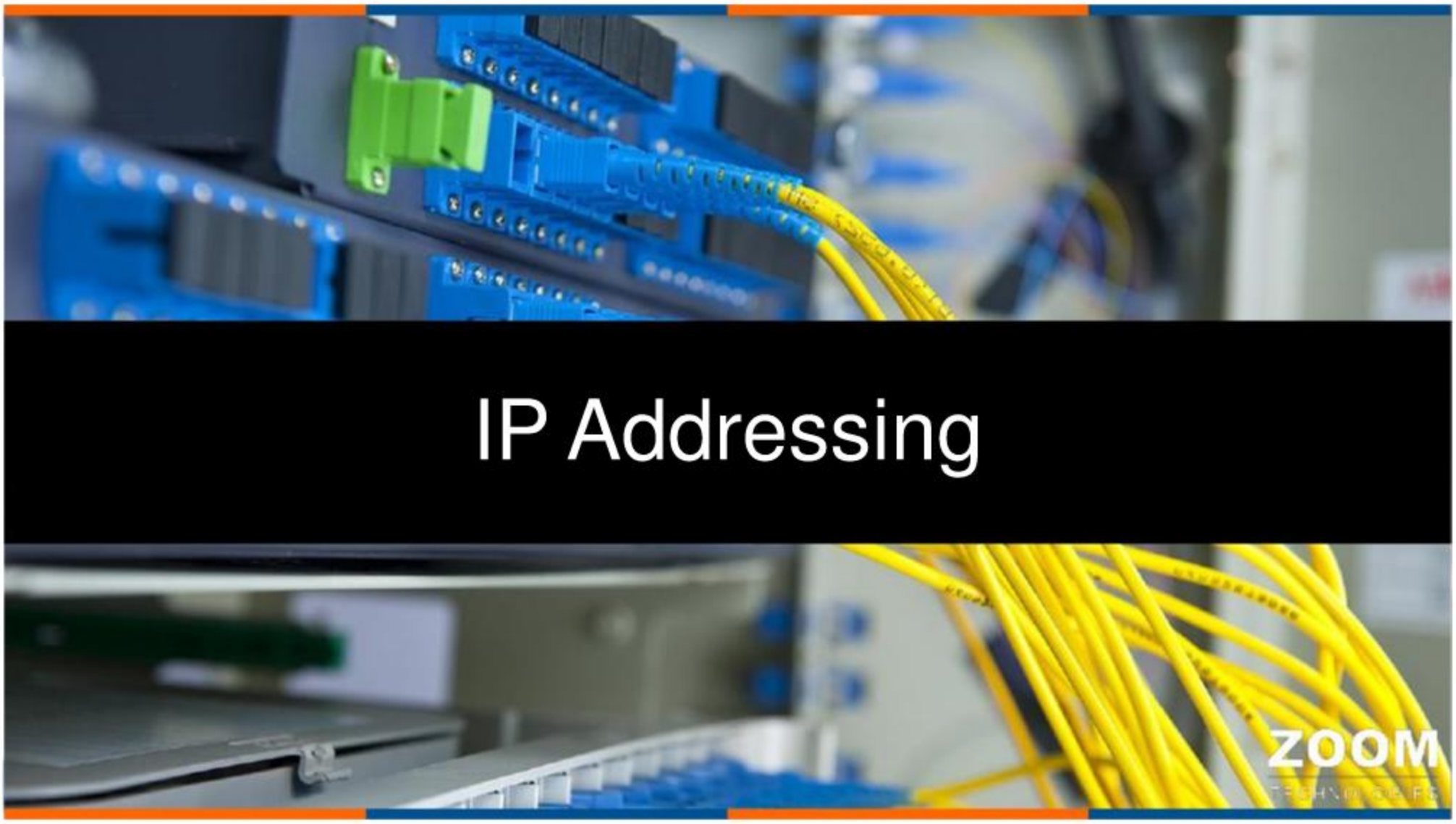




LAN - Same Network Communication



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IP Address

- IP Address is a Logical Address
- It is a Network Layer address (Layer 3)
- Two Versions of IP:
  - IP version 4 is a 32 bit address
  - IP version 6 is a 128 bit address

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IP version 4

- Bit is represent by 0 or 1 (i.e. Binary)
- IP address in binary form (32 bits):
  01010101000001011011111100000001
- 32 bits are divided into 4 Octets:

First Octet	Second Octet	Third Octet	Forth Octet
01010101.	00000101.	10111111.	00000001

- IP address in decimal form:

  85.5.191.1

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IPv4 address range

Taking Example for First Octet :

Total 8 bits, Value will be 0's and 1's

i.e. $2^8 = 256$ combination

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
0	0	0	0	0	0	0	0	= 0
0	0	0	0	0	0	0	1	= 1
0	0	0	0	0	0	1	0	= 2
0	0	0	0	0	0	1	1	= 3
0	0	0	0	0	1	0	0	= 4
1	1	1	1	1	1	1	1	= 255

Total IP Address Range
0 . 0 . 0 . 0
to
255.255.255.255

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Binary to Decimal

128	64	32	16	8	4	2	1	Answer
1	1	0	0	0	0	0	0	192
0	0	0	0	1	0	1	0	10
1	0	1	0	1	0	0	0	168
1	0	1	0	1	1	0	0	172
0	0	0	1	0	0	0	0	16

Decimal to Binary

Decimal	128	64	32	16	8	4	2	1
18	0	0	0	1	0	0	1	0
152	1	0	0	1	1	0	0	0
200	1	1	0	0	1	0	0	0
15	0	0	0	0	1	1	1	1
240	1	1	1	1	0	0	0	0

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IP Address Classification

IP address are divided into 5 Classes

- CLASS A
- CLASS B
- CLASS C

Used in LAN & WAN

- CLASS D

Reserved for Multicasting

- CLASS E

Reserved for Research & Development

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Priority Bit

- Priority Bit is used for IP Address classification.
- Most significant bit(s) from the first octet are selected for Priority Bit(s).
- Class A priority bit is 0
- Class B priority bits are 10
- Class C priority bits are 110
- Class D priority bits are 1110
- Class E priority bits are 1111

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Class A Range

- In Class A : First bit of the first octet is reserved as priority bit, bit value is zero.
- 0xxxxxxx. xxxxxxxx. xxxxxxxx. xxxxxxxx

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
0	0	0	0	0	0	0	0	= 0
0	0	0	0	0	0	0	1	= 1
0	0	0	0	0	0	1	0	= 2
0	0	0	0	0	0	1	1	= 3
0	0	0	0	0	1	0	0	= 4
0	1	1	1	1	1	1	1	= 127

Class A Range
0 . 0 . 0 . 0 to
127 . 255 . 255 .255

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Class B Range

- In Class B : First two bits of the first octet are reserved as priority bits, bit value as 10.
- 10xxxxxx. xxxxxxxx. xxxxxxxx. xxxxxxxx

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
1	0	0	0	0	0	0	0	= 128
1	0	0	0	0	0	0	1	= 129
1	0	0	0	0	0	1	0	= 130
1	0	0	0	0	0	1	1	= 131
1	0	0	0	0	1	0	0	= 132
1	0	1	1	1	1	1	1	= 191

Class B Range
128 . 0 . 0 . 0 to
191 . 255 . 255 .255

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Class C Range

- In Class C : First three bits of the first octet are reserved as priority bits, bit value as 110.
- 110xxxxx. xxxxxxxx. xxxxxxxx. xxxxxxxx

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
1	1	0	0	0	0	0	0	= 192
1	1	0	0	0	0	0	1	= 193
1	1	0	0	0	0	1	0	= 194
1	1	0	0	0	0	1	1	= 195
1	1	0	0	0	1	0	0	= 196
1	1	0	1	1	1	1	1	= 223

Class C Range
192 . 0 . 0 . 0 to
223 . 255 . 255 .255

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Class D Range

- In Class D : First four bits of the first octet are reserved as priority bits, bit value as 1110.
- 1110xxxx. xxxxxxxx. xxxxxxxx. xxxxxxxx

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
1	1	1	0	0	0	0	0	= 224
1	1	1	0	0	0	0	1	= 225
1	1	1	0	0	0	1	0	= 226
1	1	1	0	0	0	1	1	= 227
1	1	1	0	0	1	0	0	= 228
1	1	1	0	1	1	1	1	= 239

Class D Range
224 . 0 . 0 . 0 to
239 . 255 . 255 .255

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Class E Range

- In Class E : First four bits of the first octet are reserved as priority bits, bit value as 1111.
- 1111xxxx. xxxxxxxx. xxxxxxxx. xxxxxxxx

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
1	1	1	1	0	0	0	0	= 240
1	1	1	1	0	0	0	1	= 241
1	1	1	1	0	0	1	0	= 242
1	1	1	1	0	0	1	1	= 243
1	1	1	1	0	1	0	0	= 244
1	1	1	1	1	1	1	1	= 255

Class E Range
240 . 0 . 0 . 0 to
255 . 255 . 255 .255

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Ranges

Class A Range
0 . 0 . 0 . 0 to
127.255.255.255

Class B Range
128 . 0 . 0 . 0 to
191.255.255.255

Class C Range
192 . 0 . 0 . 0 to
223 . 255 . 255 .255

Class D Range
224 . 0 . 0 . 0 to
239 . 255 . 255 .255

Class E Range
240 . 0 . 0 . 0 to
255 . 255 . 255 .255

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Identifying Class

IP Address	Class
10.1.100.1	A
150.17.2.200	B
192.1.1.1	C
224.0.0.10	D
120.200.1.1	A

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Octet Format

- IP address is divided into Network & Host Portion
  - CLASS A is written as N.H.H.H
  - CLASS B is written as N.N.H.H
  - CLASS C is written as N.N.N.H

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CLASS A – No. Networks & Hosts

- Class A Octet Format is N . H . H . H
  Network bits : 8 Host bits : 24
- No. of Networks
  = $2^{\text{no of network bits– Priority bit}}$
  = 2^{8-1} (-1 is Priority Bit for Class A)
  = 2^{7}
  = 128 – 2 (-2 is for 0 & 127 Network)
  = 126 Networks

- No. of Host
  = $2^{\text{no of host bits}}$ -2
  = 2^{24} – 2 (-2 is for Network ID & Broadcast ID)
  = 16777216 - 2
  = 16777214 Hosts/Network

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CLASS B – No. Networks & Hosts

- Class B Octet Format is N . N . H . H
  Network bits : 16 Host bits : 16
- No. of Networks
  = $2^{\text{no of network bits– Priority bit}}$
  = 2^{16-2} (-2 is Priority Bit for Class B)
  = 2^{14}
  = 16384 Networks

- No. of Host
  = $2^{\text{no of host bits}}$ -2
  = 2^{16} – 2 (-2 is for Network ID & Broadcast ID)
  = 65536 - 2
  = 65534 Hosts/Network

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CLASS C – No. Networks & Hosts

- Class C Octet Format is N . N . N . H
  Network bits : 24 Host bits : 8
- No. of Networks
  = $2^{\text{no of network bits– Priority bit}}$
  = 2^{24-3} (-3 is Priority Bit for Class C)
  = 2^{21}
  = 2097152 Networks

- No. of Host
  = $2^{\text{no of host bits}} - 2$
  = $2^{8} - 2$ (-2 is for Network ID & Broadcast ID)
  = 256 - 2
  = 254 Hosts/Network

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Network & Broadcast Address

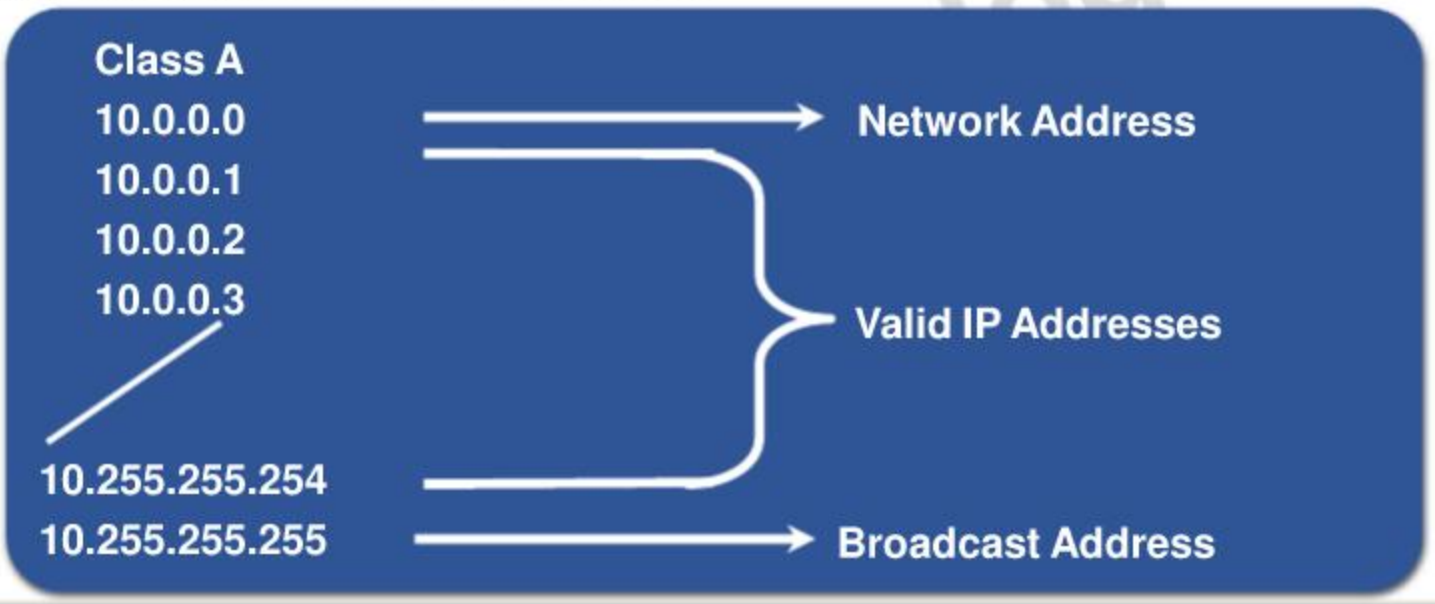
- Network address: IP address with all bits as ZERO in the host portion.
- Broadcast address: IP address with all bits as ONES in the host portion.
- Valid IP Addresses lie between the Network Address and the Broadcast Address.
- Only Valid IP Addresses are assigned to hosts/clients

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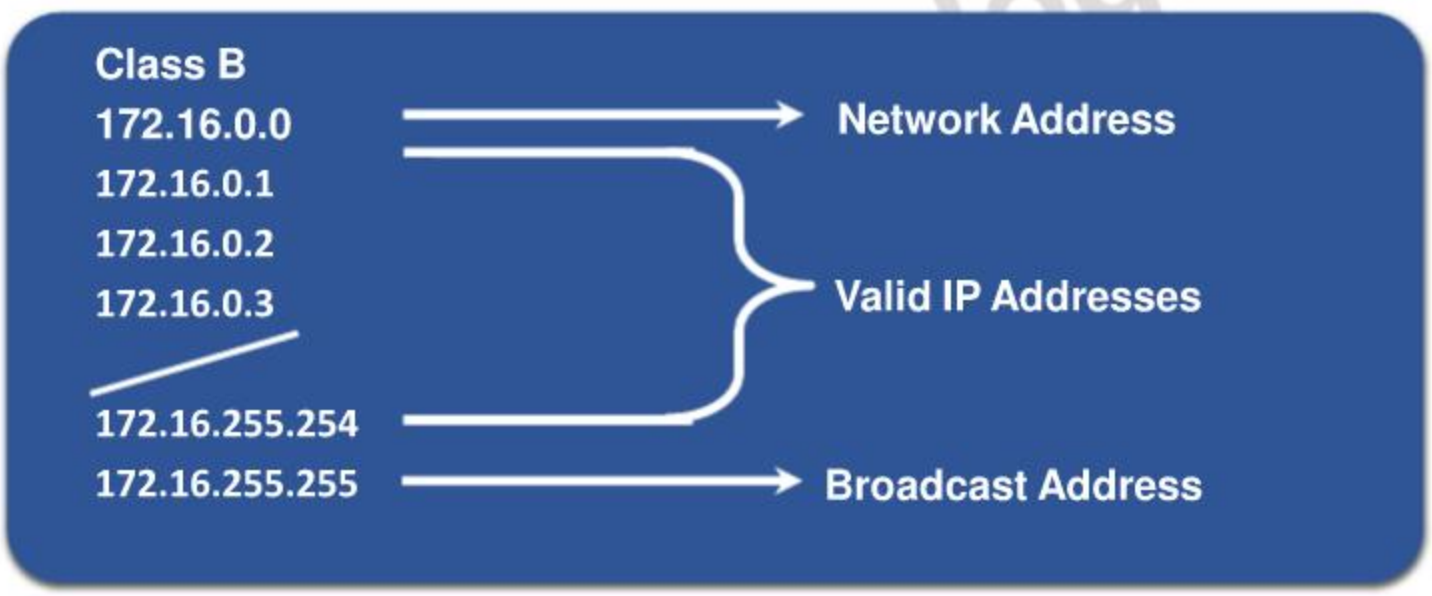
Example - Class A

- Class A : N.H.H.H
  - Network Address :
    0xxxxxxx.00000000.00000000.00000000
  - Broadcast Address :
    0xxxxxxx.11111111.11111111.11111111



Example - Class B

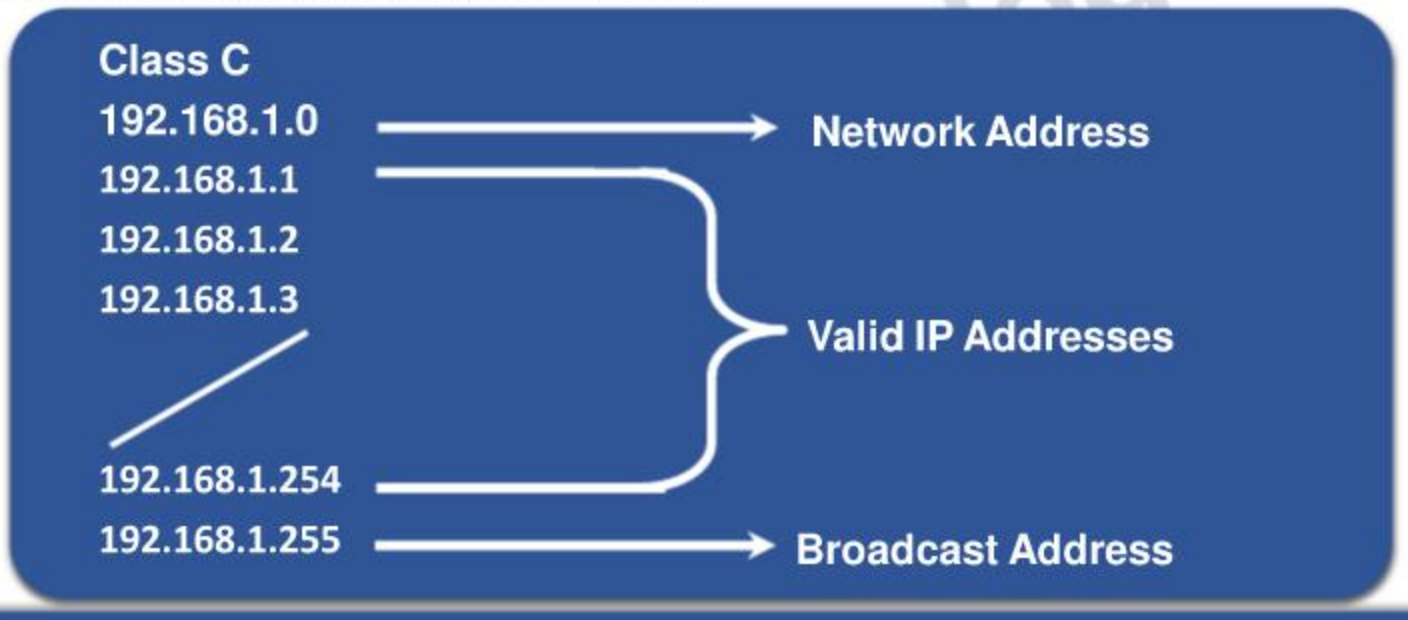
- Class B : N.N.H.H
  - Network Address :
    10xxxxxx.xxxxxxxx.00000000.00000000
  - Broadcast Address :
    10xxxxxx.xxxxxxxx.11111111.11111111



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Example - Class C

- Class C : N.N.N.H
  - Network Address :
    110xxxxx.xxxxxxxx.xxxxxxxx.00000000
  - Broadcast Address :
    110xxxxx.xxxxxxxx.xxxxxxxx.11111111



Identifying Network Address and Broadcast Address

IP Address	Network Address and Broadcast Address
120.1.1.1	120.0.0.0 and 120.255.255.255
172.16.1.1	172.16.0.0 and 172.16.255.255
10.100.1.10	10.0.0.0 and 10.255.255.255
192.168.1.10	192.168.1.0 and 192.168.1.255
150.10.1.1	150.10.0.0 and 150.10.255.255

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Private IP Address

- There are certain addresses in each class of IP address that are reserved for Private Networks. These addresses are called private addresses.
- These addresses are not Routable (or) valid on Internet.

Class A
10.0.0.0 to 10.255.255.255

Class B
172.16.0.0 to 172.31.255.255

Class C
192.168.0.0 to 192.168.255.255

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Subnet Mask

- Subnet Mask differentiates the Network and Host portions of an IP address
- Represented with all 1's in the network portion and with all 0's in the host portion.

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Subnet Mask - Examples

- Class A : N.H.H.H

  11111111.00000000.00000000.00000000

  Default Subnet Mask for Class A is 255.0.0.0

- Class B : N.N.H.H

  11111111.11111111.00000000.00000000

  Default Subnet Mask for Class B is 255.255.0.0

- Class C : N.N.N.H

  11111111.11111111.11111111.00000000

  Default Subnet Mask for Class C is 255.255.255.0

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Default subnet mask

IP Address	Default subnet mask
17.1.1.1	255.0.0.0
202.1.0.18	255.255.255.0
190.10.1.1	255.255.0.0
102.10.1.10	255.0.0.0
192.0.0.1	255.255.255.0

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How Subnet Mask Works ?

IP Address : 192.168.1.1

Subnet Mask : 255.255.255.0

ANDING PROCESS :

192.168.1.1 = 11000000.10101000.00000001.00000001

255.255.255.0 = 11111111.11111111.11111111.00000000

==========

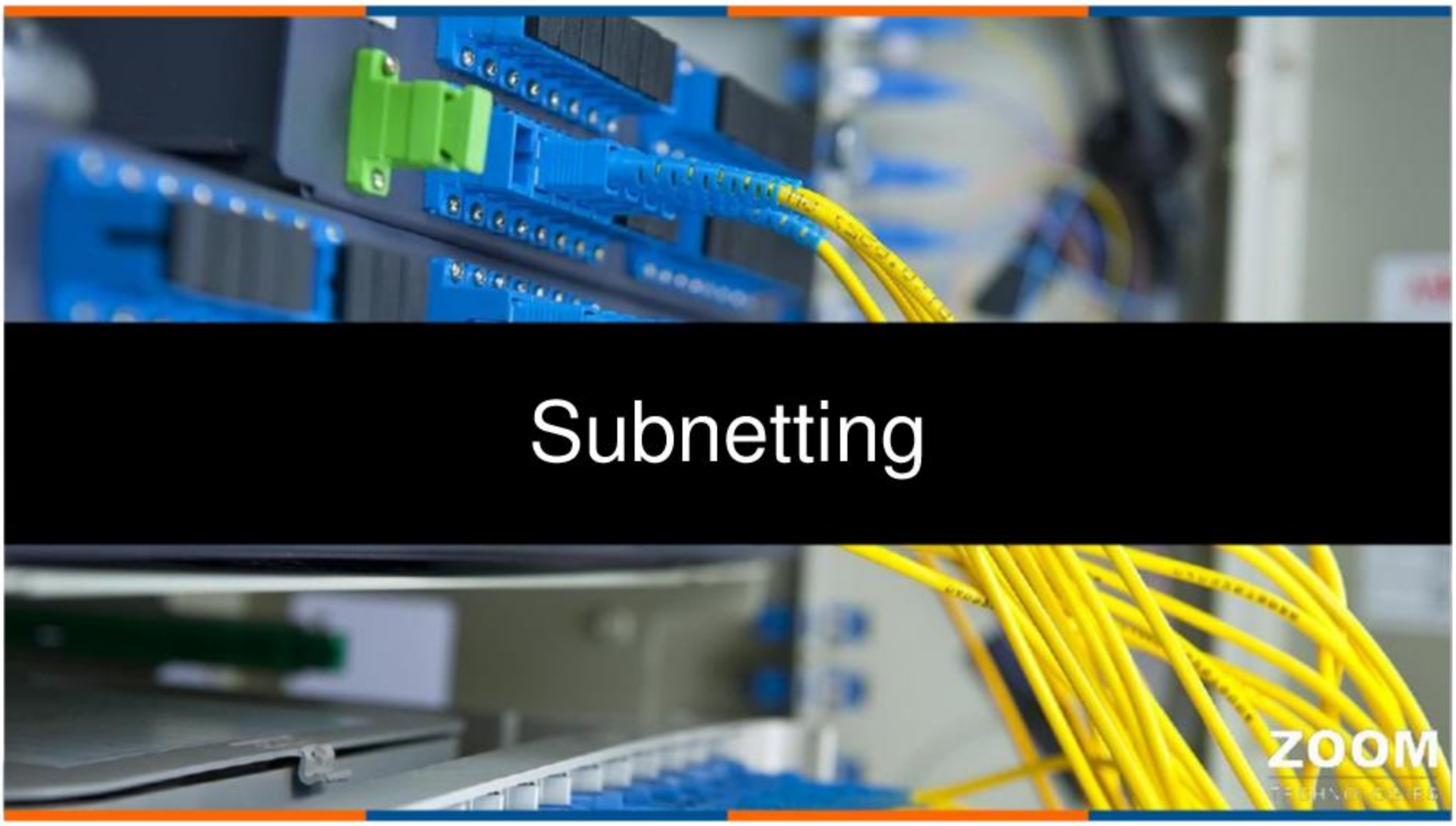
192.168.1.0 = 11000000.10101000.00000001.00000000

==========

The output of an AND table is 1 if both its inputs are 1.

For all other possible inputs the output is 0.

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Subnetting

- Creating Multiple independent Networks from a single Network
- Converting Host bits into Network bits

  (i.e. converting 0's into 1's)
- Subnetting can be performed in two ways
- FLSM (Fixed Length Subnet Mask)
- VLSM (Variable Length Subnet Mask)
- Subnetting can be done based on requirement
- Number of Networks Required?
- Number of Hosts Required?

Note:- It is very Useful for Internet Service Providers (ISP), Large Organizations /Companies etc.,

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Requirement of Networks

- A corporate network has 200 PC's
- Which class of IP Address is preferred for the network ?

  Answer : class C
- There are 4 departments with 50 pc's each

Marketing	→	192.168.1.1 to 192.168.1.50
Sales	→	192.168.1.51 to 192.168.1.100
Finance	→	192.168.1.101 to 192.168.1.150
IT	→	192.168.1.151 to 192.168.1.200

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- Administrators requirement :
- Inter-department communication should not be there

Solution :

- Allocate different Networks to each Department

i.e.,

Marketing	→	192.168.1.1 to 192.168.1.50
Sales	→	192.168.2.1 to 192.168.2.50
Finance	→	192.168.3.1 to 192.168.3.50
IT	→	192.168.4.1 to 192.168.4.50

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Main Aim of Subnetting

- Problem with the previous scenario is
- Wastage of IP addresses, if it is Public IP addresses (Approx. 800)
- To reduce the wastage of IP addresses, we have Subnetting
  - Requirement of Networks

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Requirement of Subnets – 4 no's ?

Class C : 192.168.1.0

255.255.255.0

Subnets required : 4 no's

= $2^n \geq$ Req. of Subnet

= $2^n \geq 4$

= $2^2 \geq 4$

= 4 subnets

Customized subnet mask =

255. 255. 255. 0

11111111. 11111111. 11111111. 00000000

. 11000000

255. 255. 255. 192

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Calculation of Hosts / subnet

= $2^h - 2$ (-2 is for Network ID & Broadcast ID)

= $2^6 - 2$

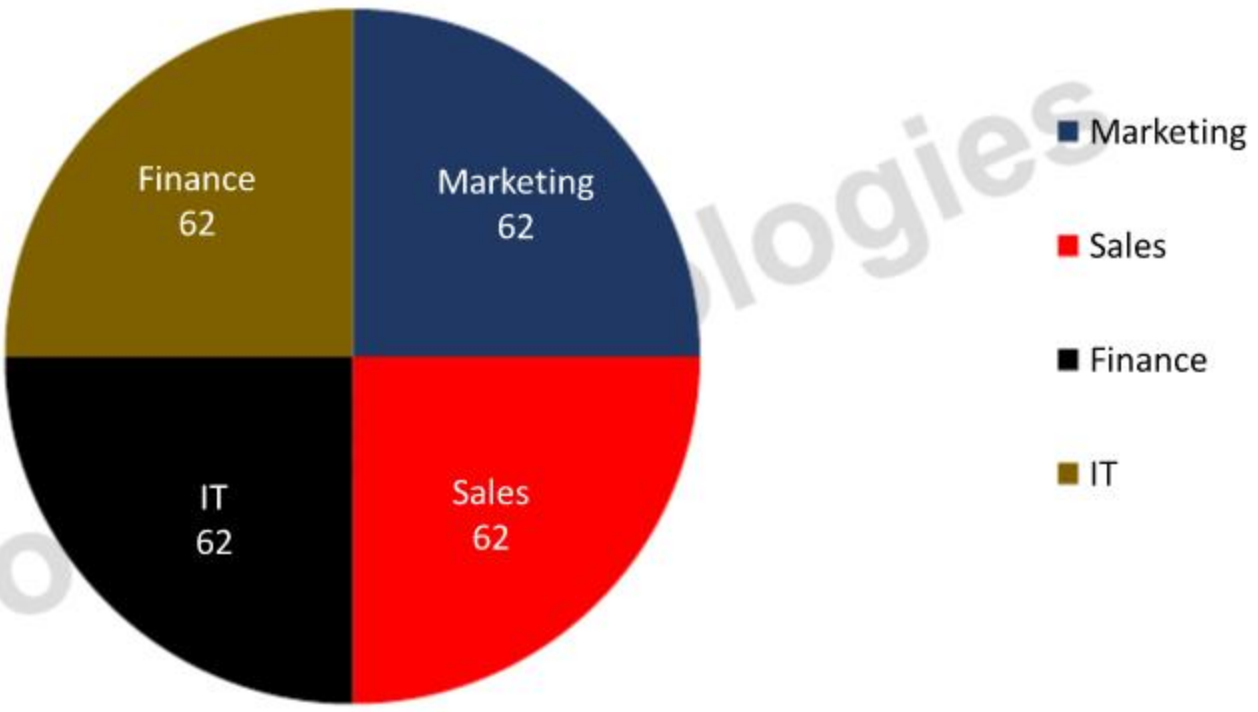
= 64 – 2

= 62 Hosts/subnet

Subnet Range

Network ID	Broadcast ID
192.168.1.1	192.168.1.63
192.168.1.64	192.168.1.127
192.168.1.128	192.168.1.191
192.168.1.192	192.168.1.255

FLSM



VLSM

- Subnetting a subnet is called as Variable Length Subnet Mask
- VLSMs provide the capability to include more than one subnet mask within a major network

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Requirement of Hosts

- In corporate network there are 4 departments and their requirement as follows,

Marketing → 10

Sales → 50

Finance → 25

IT → 100

Arrange them in Descending Order

IT → 100

Sales → 50

Finance → 25

Marketing → 10

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Requirement of Hosts

Class C : 192.168.1.0

255.255.255.0

Hosts required : 100 , 50 , 25 and 10

First , we calculate for IT = 100 Hosts

$2^h - 2 \geq$ Req. of Hosts

$= 2^h - 2 \geq 100$

$= 2^7 - 2 \geq 100$

$= 128 - 2 = 126$ hosts/subnet

Customized subnet mask =

255. 255. 255. 0

11111111. 11111111. 11111111. 00000000

. 10000000

255. 255. 255. 128

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Calculation of subnets

= 2^n

= 2^1

= 2

= 2 Hosts/subnet

Subnet Range

Network ID	Broadcast ID	
192.168.1.0	192.168.1.127	➡ I T
192.168.1.128	192.168.1.255	

Now , Available network is 192.168.1.128 to 192.168.1.255

Next, we calculate for Sales = 50 Hosts

$2^h - 2 \geq$ Req. of Hosts

= $2^h - 2 \geq 50$

= $2^6 - 2 \geq 50$

= 64 – 2 = 62 hosts/subnet

Customized subnet mask =

255. 255. 255. 128

11111111. 11111111. 11111111. 10000000

. 11000000

255. 255. 255. 192

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Calculation of subnets

= 2^n

= 2^1

= 2

= 2 Hosts/subnet

Subnet Range			
Network ID		Broadcast ID	
192.168.1.128	to	192.168.1.191	➡ SALES
192.168.1.192	to	192.168.1.255	

- Similarly, we can calculate for Finance = 25 Hosts

Using 192.168.1.192 to 192.168.1.255

Subnet Mask 255.255.255.192

$2^h - 2 \geq$ Req. of Hosts

= $2^h - 2 \geq 25$

= $2^5 - 2 \geq 25$

= 32 – 2 = 30 hosts/subnet

Customized subnet mask =

255. 255. 255. 192

11111111. 11111111. 11111111. 11000000

. 11100000

255. 255. 255. 224

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Subnet Range	
Network ID	Broadcast ID
192.168.1.192 to 192.168.1.223	FINANCE
192.168.1.224 to 192.168.1.255	

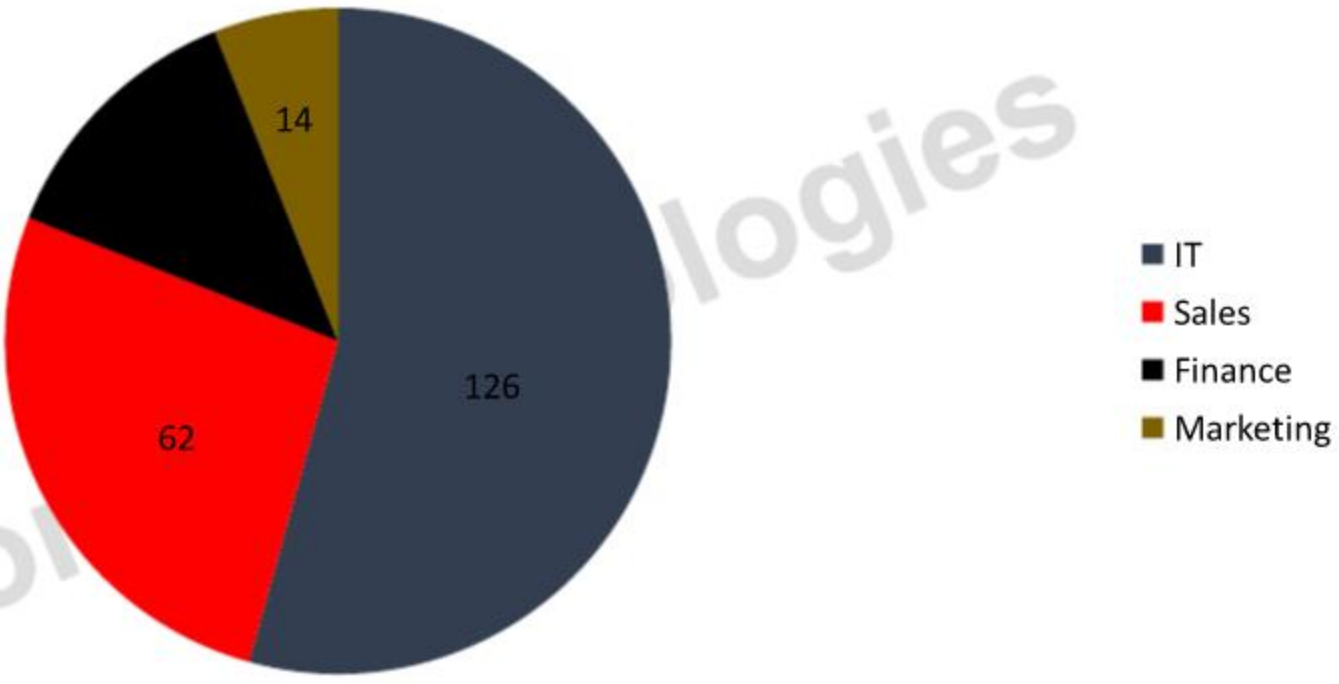
- For Marketing = 10 Hosts

Using 192.168.1.224 to 192.168.1.255 with Subnetmask 255.255.255.224

- If we calculate, then we will get customized subnet mask 255.255.255.240 and Range as follows

Subnet Range	
Network ID	Broadcast ID
192.168.1.224 to 192.168.1.239	MARKETING
192.168.1.240 to 192.168.1.255	

VLSM



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Power table

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POWER TABLE

$2^1 = 2$	$2^9 = 512$	$2^{17} = 131072$	$2^{25} = 33554432$
$2^2 = 4$	$2^{10} = 1024$	$2^{18} = 262144$	$2^{26} = 67108864$
$2^3 = 8$	$2^{11} = 2048$	$2^{19} = 524288$	$2^{27} = 134217728$
$2^4 = 16$	$2^{12} = 4096$	$2^{20} = 1048576$	$2^{28} = 268435456$
$2^5 = 32$	$2^{13} = 8192$	$2^{21} = 2097152$	$2^{29} = 536870912$
$2^6 = 64$	$2^{14} = 16384$	$2^{22} = 4194304$	$2^{30} = 1073741824$
$2^7 = 128$	$2^{15} = 32768$	$2^{23} = 8388608$	$2^{31} = 2147483648$
$2^8 = 256$	$2^{16} = 65536$	$2^{24} = 16777216$	$2^{32} = 4294967296$

CCIE CCNP CCNA

Some Important Values

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VALUES IN SUBNET MASK

Bit	Value	Mask
1	128	10000000
2	192	11000000
3	224	11100000
4	240	11110000
5	248	11111000
6	252	11111100
7	254	11111110
8	255	11111111

CCIE CCNP CCNA

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Example – 1 : Requirement of subnet is 14?

Class C : 192.168.1.0

Requirement of Subnet

$2^n \geq$ Req. of Subnet

$= 2^4 \geq 14$

$= 16 \geq 14$

= 16 Subnet

No. of Hosts/subnet

$= 2^h - 2$ (-2 is for Network ID & Broadcast ID)

$= 2^4 - 2$

$= 16 - 2$

= 14 Hosts/Subnet

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Example – 1 (Continued…)

Customized Subnet Mask =

255.	255.	255.	240
11111111.	11111111.	11111111.	11110000
			128 64 32 16

Range of Networks

Network ID	Broadcast ID
192.168.1.0	192.168.1.15
192.168.1.16	192.168.1.31
192.168.1.32	192.168.1.47
192.168.1.48	192.168.1.63
192.168.1.224	192.168.1.239
192.168.1.240	192.168.1.255

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Example – 1 (Continued…)

If you convert 4 Host Bits to Network Bits
16 Subnet & 14 Hosts/Subnet

Customized Subnet Mask
255.255.255.240

Subnet Range

192.168.1.16 to 192.168.1.31
192.168.1.32 to 192.168.1.47
192.168.1.48 to 192.168.1.63
192.168.1.64 to 192.168.1.79

192.168.1.224 to 192.168.1.239
192.168.1.240 to 192.168.1.255

Example – 2 : Requirement of Hosts is 2 ?

Class C : 192.168.1.0
Requirement of Host

$2^h - 2 \geq$ Req. of Host
$= 2^2 - 2 \geq 2$ (-2 is for Network ID & Broadcast ID)
$= 4 - 2$
$= 2$ Hosts/Subnet

No. of Subnets
$= 2^n$
$= 2^6$
$= 64$
$= 64$ Subnet

Zoom Technologies

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Example – 2 (Continued…)

- Customized Subnet Mask =

255.	255.	255.	252
11111111.	11111111.	11111111.	11111100
			128 64 32 16 8 4

Range of Networks

Network ID	Broadcast ID
192.168.1.0	192.168.1.3
192.168.1.4	192.168.1.7
192.168.1.8	192.168.1.11
192.168.1.12	192.168.1.15
192.168.1.248	192.168.1.251
192.168.1.252	192.168.1.255

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Example – 3 : Requirement of Networks is 4 ?

Class B : 172.16.0.0

Requirement of Subnet

$2^n \geq$ Req. of Subnet

$= 2^2 \geq 4$

$= 4 = 4$

= 4 Subnet

No. of Host

$= 2^h - 2$ (-2 is for Network ID & Broadcast ID)

$= 2^{14} - 2$

$= 16384 - 2$

= 16382 Hosts/Subnet

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Example – 3 (Continued…)

- Customized Subnet Mask =

255.	255.	192.	0
11111111.	11111111.	128 64 11000000.	00000000

Range of Networks

Network ID	Broadcast ID
172.16.0.0	172.16.63.255
172.16.64.0	172.16.127.255
172.16.128.0	172.16.191.255
172.16.192.0	172.16.255.255

Zoom Technologies

Example – 4 : Requirement of Hosts is 126 ?

Class B : 172.16.0.0

Requirement of Hosts

= $2^h - 2 \geq$ Req. of Host

= $2^7 - 2 \geq 126$ (-2 is for Network ID & Broadcast ID)

= 128 – 2

= 126 Hosts/Subnet

No. of Subnets

= 2^n

= 2^9

= 512

= 512 Subnets

Zoom Technologies

Example – 4 (Continued…)

- Customized Subnet Mask =

255.	255.	255.	128
11111111.	11111111.	11111111.	10000000

128

Range of Networks

Network ID	Broadcast ID
172.16.0.0	172.16.0.127
172.16.0.128	172.16.0.255
172.16.1.0	172.16.1.127
172.16.1.128	172.16.1.255
…	…
172.16.255.0	172.16.255.127
172.16.255.128	172.16.255.255

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Scenario

- A co-operate network is having 100 PC

Co-operate – 192.168.1.0/24

- Marketing
- Sales
- Accounts
- H/R
- Training

Administrator's requirement : Inter-department communication should not be possible ?

Best Solution is :

FLSM i.e. Subnetting

Zoom Technologies

Scenario (...continued)

- Now we are also having sub departments



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Scenario (...continued)

Administrator does not want inter-department communication in the sub departments ?

Answer : You will use the subnet range to further divide it into smaller ranges, this time its Subnetting of a Subnet i.e. VLSM.

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Calculation of FLSM

Class C : 192.168.1.0

Requirement of Subnet

$2^n \geq$ Req. of Subnet

$= 2^3 \geq 5$

$= 8$

$=$ 8 Subnet

No. of Hosts/subnet

$= 2^h - 2$ (-2 is for Network ID & Broadcast ID)

$= 2^5 - 2$

$= 32 - 2$

$=$ 30 Hosts/Subnet

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(Continued...)

- Customized Subnet Mask =

255.	255.	255.	224
11111111.	11111111.	11111111.	11100000
			128 64 32

Range of Networks

Network ID	Broadcast ID
192.168.1.0	192.168.1.31
192.168.1.32	192.168.1.63
192.168.1.64	192.168.1.95
192.168.1.96	192.168.1.127
192.168.1.128	192.168.1.159
192.168.1.160	192.168.1.191
192.168.1.192	192.168.1.223
192.168.1.224	192.168.1.255

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Assigning of the Ranges

CO-OPRATE NETWORK

- MARKETING → 192.168.1.32 – 1.63/27
- SALES → 192.168.1.64 – 1.95/27
  - Purchase
  - Stock
- ACCOUNTS → 192.168.1.96 – 1.127/27
  - Billing
  - Salary
  - Loans
  - Stationary
  - Tax
- H/R → 192.168.1.128 – 1.159/27
  - Interview
  - Public relation
  - Finance
- TRAINING → 192.168.1.160 – 1.191/27

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Calculation of VLSM for CISCO Dept.

Class C : 192.168.1.64

Requirement of Subnet

= $2^n \geq$ Req. of Subnet

= $2^1 \geq 2$

= 2

= 2 Subnet

No. of Host

= $2^h - 2$ (-2 is for Network ID & Broadcast ID)

= $2^4 - 2$

= 16 – 2

= 14 Hosts/Subnet

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VLSM (Continued…)

Customized Subnet Mask =

255.	255.	255.	240
11111111.	11111111.	11111111.	11110000
			128 64 32 16

Range of Networks

Network ID	Broadcast ID
192.168.1.64	192.168.1.79
192.168.1.80	192.168.1.95

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Assigning of the Ranges

- **CO-OPERATE NETWORK**
  - MARKETING → 192.168.1.32 – 1.63/27
  - SALES → 192.168.1.64 – 1.95/27
    - Purchase → 192.168.1.64 – 1.79/28
    - Stock → 192.168.1.80 – 1.95/28
  - ACCOUNTS → 192.168.1.96 – 1.127/27
    - Billing
    - Salary
    - Loans
    - Stationary
    - Tax → 192.168.1.128 – 1.159/27
  - H/R
    - Interview
    - Public Relation
    - Finance → 192.168.1.160 – 1.191/27
  - TRAINING

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Calculation of VLSM for Firewall Dept.

Class C : 192.168.1.96
Requirement of Subnet

$2^n \geq$ Req. of Subnet
= $2^3 \geq 5$
= 8
= 8 Subnet

No. of Host

= $2^h - 2$ (-2 is for Network ID & Broadcast ID)
= $2^2 - 2$
= 4 – 2
= 2 Hosts/Subnet

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VLSM (Continued…)

Customized Subnet Mask =

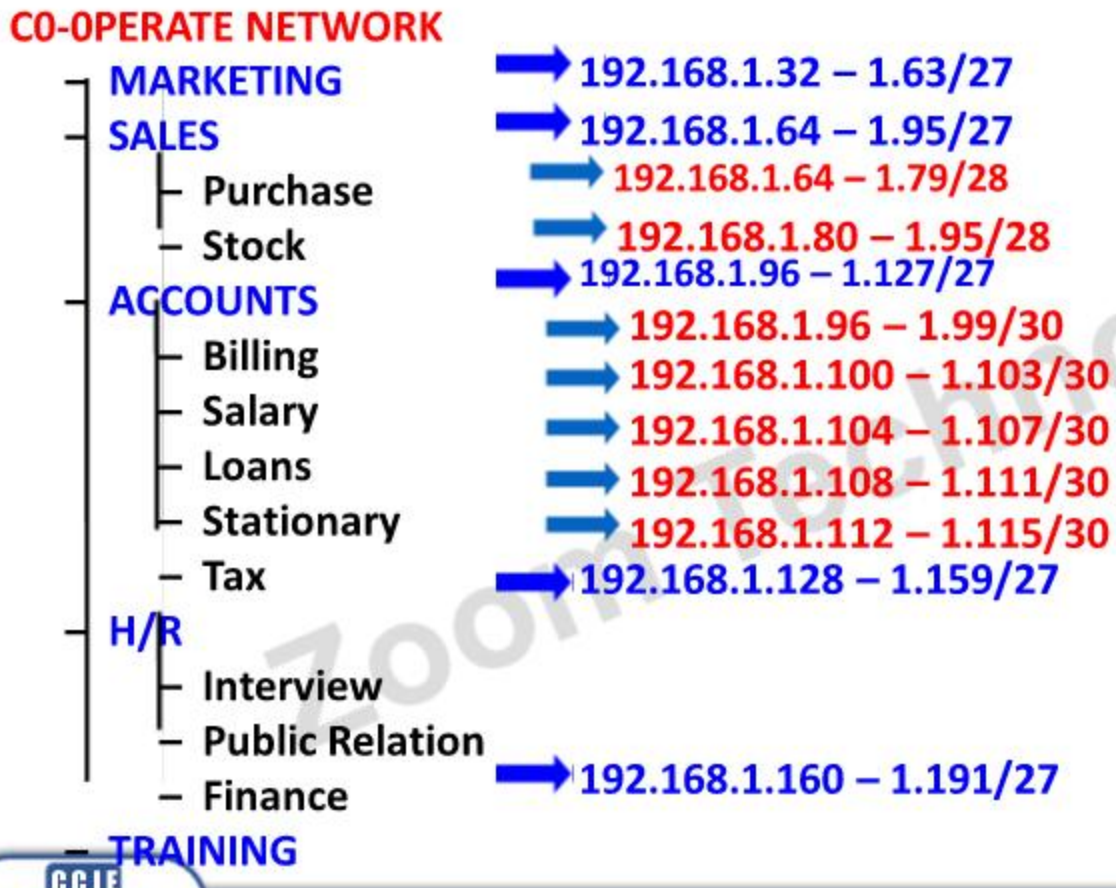
255.	255.	255.	252
11111111.	11111111.	11111111.	11111100
			128 64 32 16 8 4

Range of Networks

Network ID	Broadcast ID
192.168.1.96	192.168.1.99
192.168.1.100	192.168.1.103
192.168.1.104	192.168.1.107
192.168.1.108	192.168.1.111
192.168.1.112	192.168.1.115
192.168.1.116	192.168.1.119
192.168.1.120	192.168.1.123
192.168.1.124	192.168.1.127

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Assigning of the Ranges



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Calculation of VLSM for Solaris Dept.

Class C : 192.168.1.128

Requirement of Subnet

= $2^n \geq$ Req. of Subnet

= $2^2 \geq 3$

= 4

= 4 Subnet

No. of Host

= $2^h - 2$ (-2 is for Network ID & Broadcast ID)

= $2^3 - 2$

= 8 – 2

= 6 Hosts/Subnet

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VLSM (Continued…)

- Customized Subnet Mask =

255.	255.	255.	248
11111111.	11111111.	11111111.	11111000
			128 64 32 16 8

Range of Networks

Network ID	Broadcast ID
192.168.1.128	192.168.1.135
192.168.1.136	192.168.1.143
192.168.1.144	192.168.1.151
192.168.1.152	192.168.1.159

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Assigning of the Ranges

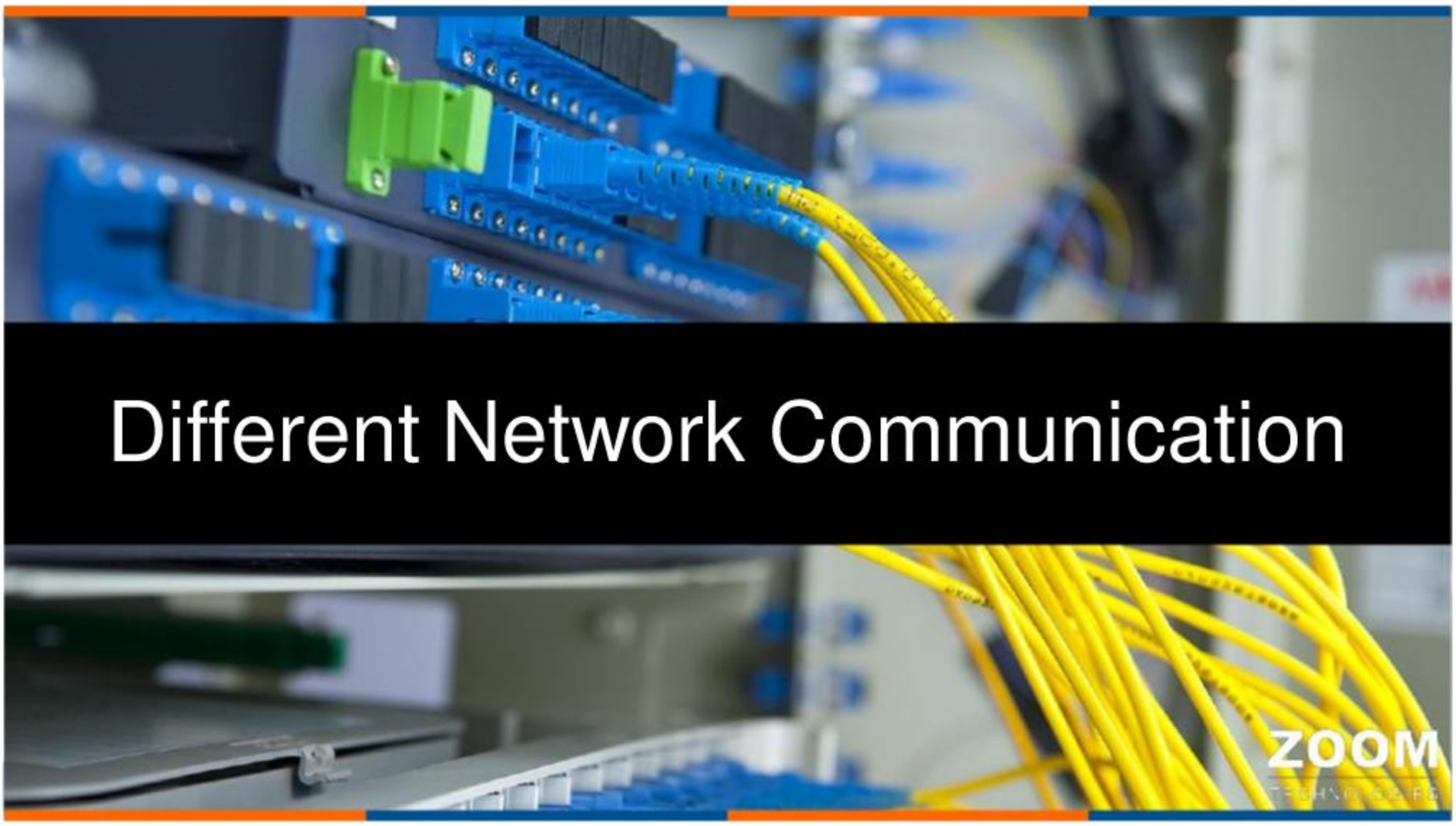
CO-OPERATE NETWORK

- MARKETING → 192.168.1.32 – 1.63/27
- SALES → 192.168.1.64 – 1.95/27
  - Purchase → 192.168.1.64 – 1.79/28
  - Stock → 192.168.1.80 – 1.95/28
- ACCOUNTS → 192.168.1.96 – 1.127/27
  - Billing → 192.168.1.96 – 1.99/30
  - Salary → 192.168.1.100 – 1.103/30
  - loans → 192.168.1.104 – 1.107/30
  - Stationary → 192.168.1.108 – 1.111/30
  - Tax → 192.168.1.112 – 1.115/30
- H/R → 192.168.1.128 – 1.159/27
  - Interview → 192.168.1.128 – 1.135/29
  - Public Relation → 192.168.1.136 – 1.143/29
  - Finance → 192.168.1.144 – 1.151/29
- TRAINING → 192.168.1.160 – 1.191/27

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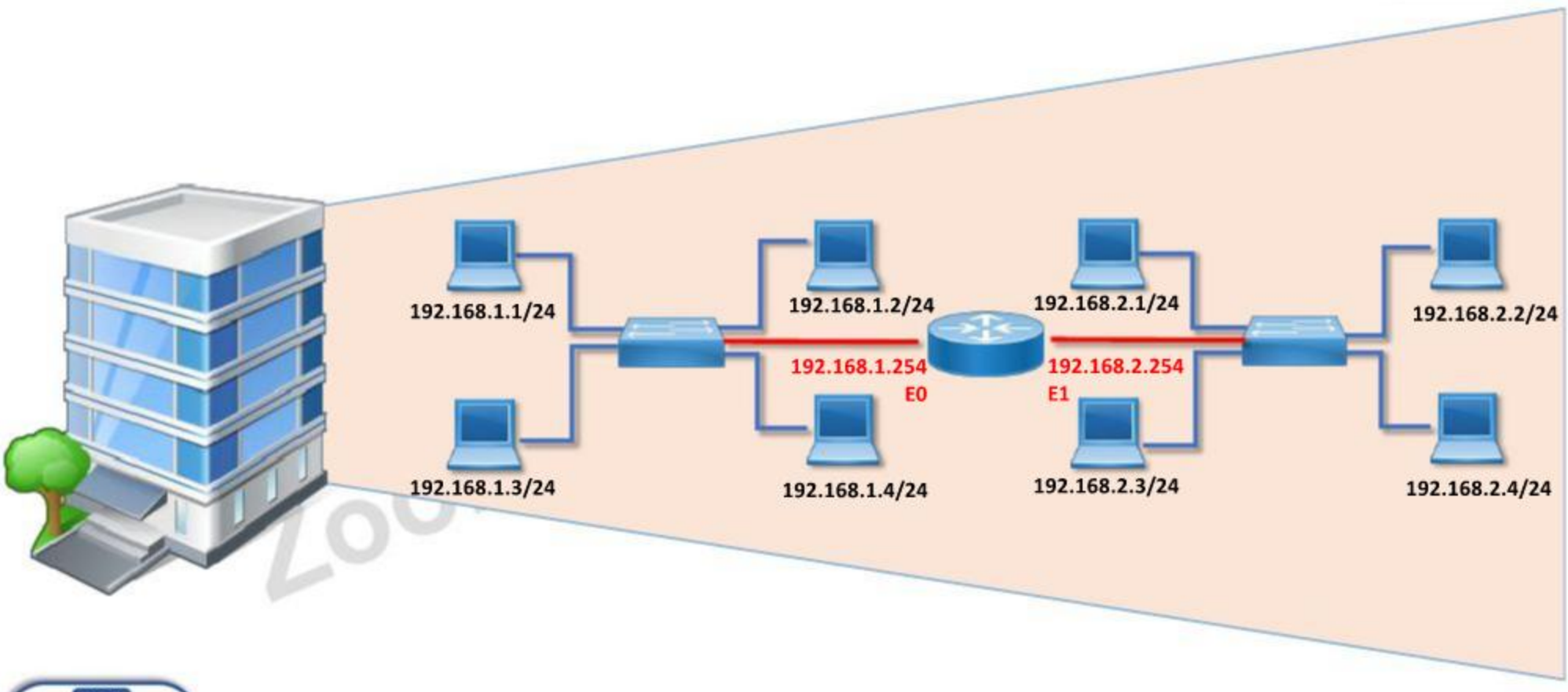
Slash notation

Slash notation	subnet mask
/8	255.0.0.0
/12	255.240.0.0
/16	255.255.0.0
/22	255.255.252.0
/24	255.255.255.0

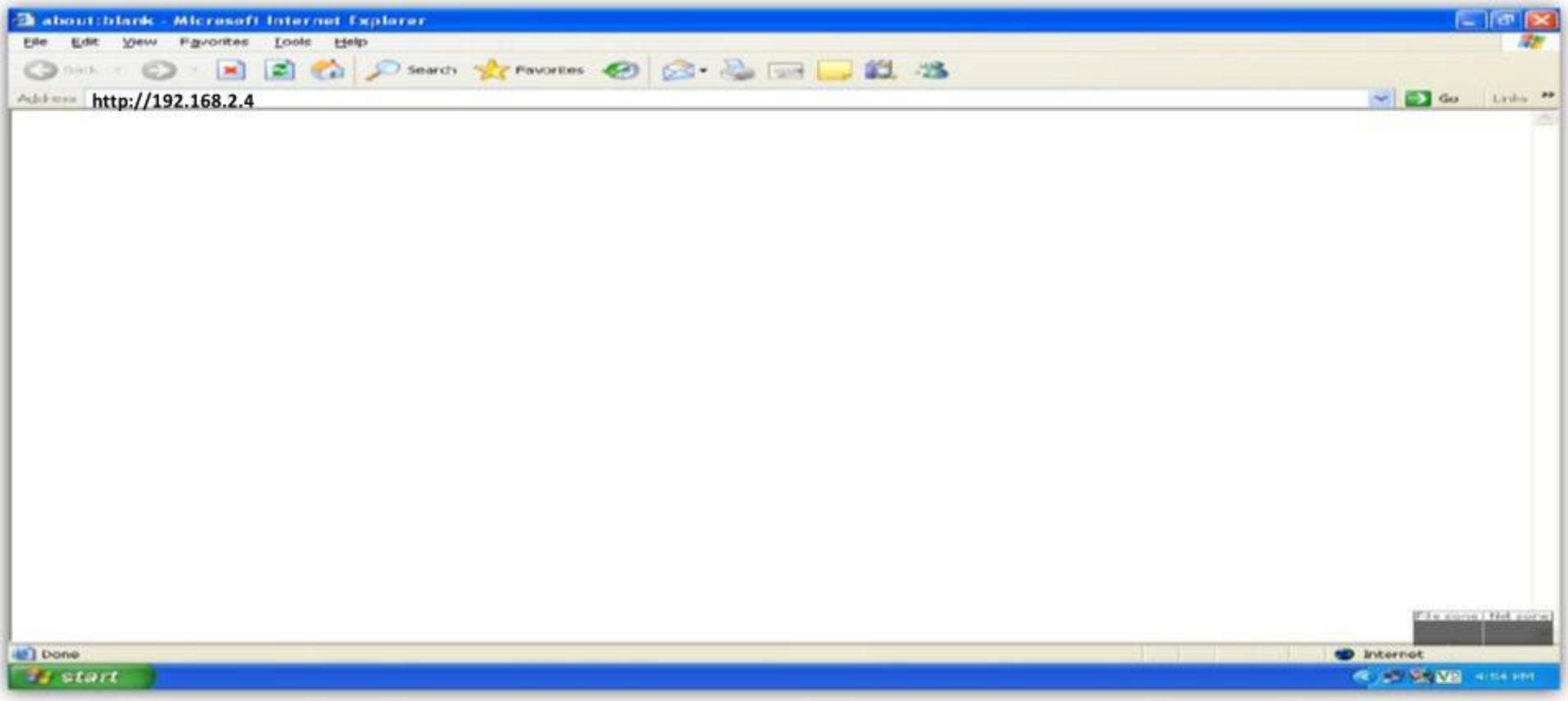


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LAN - Different Network Communication

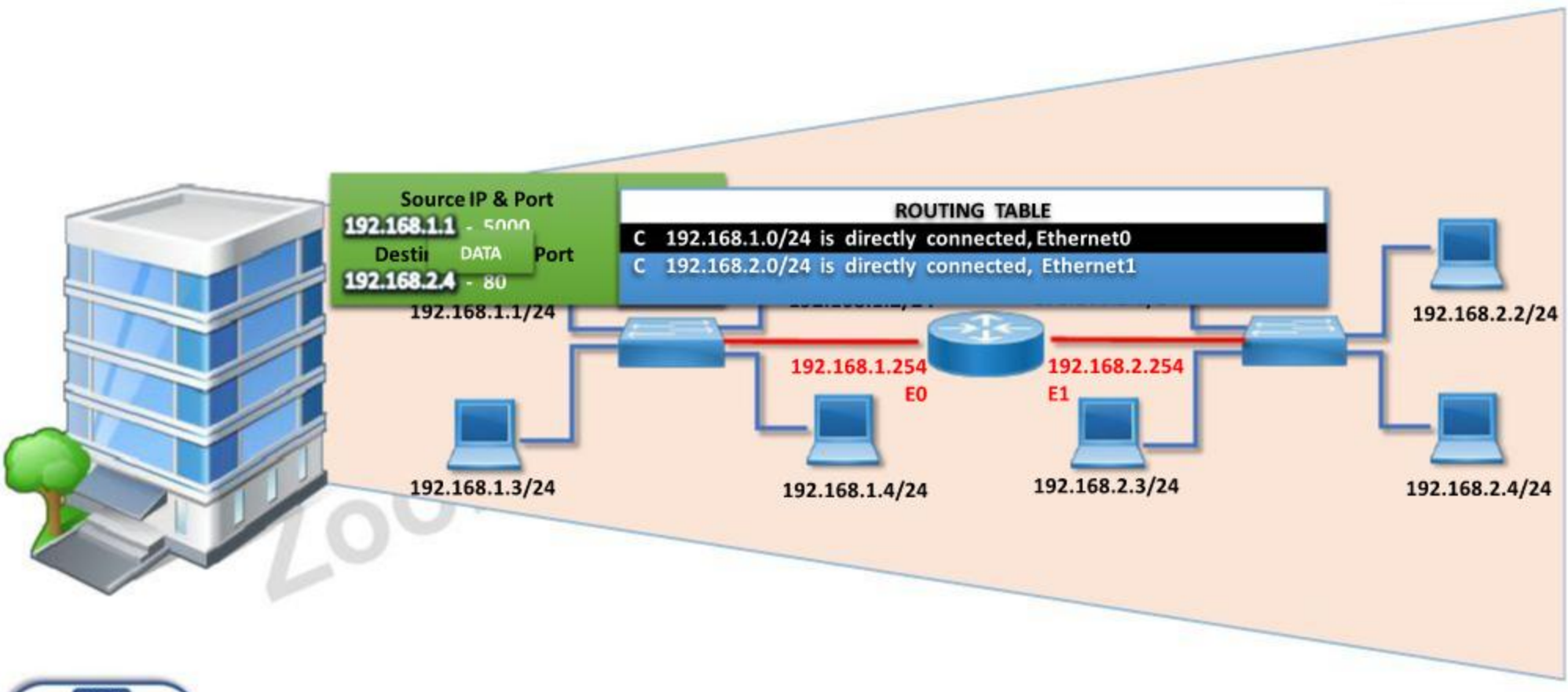


LAN - Different Network Communication

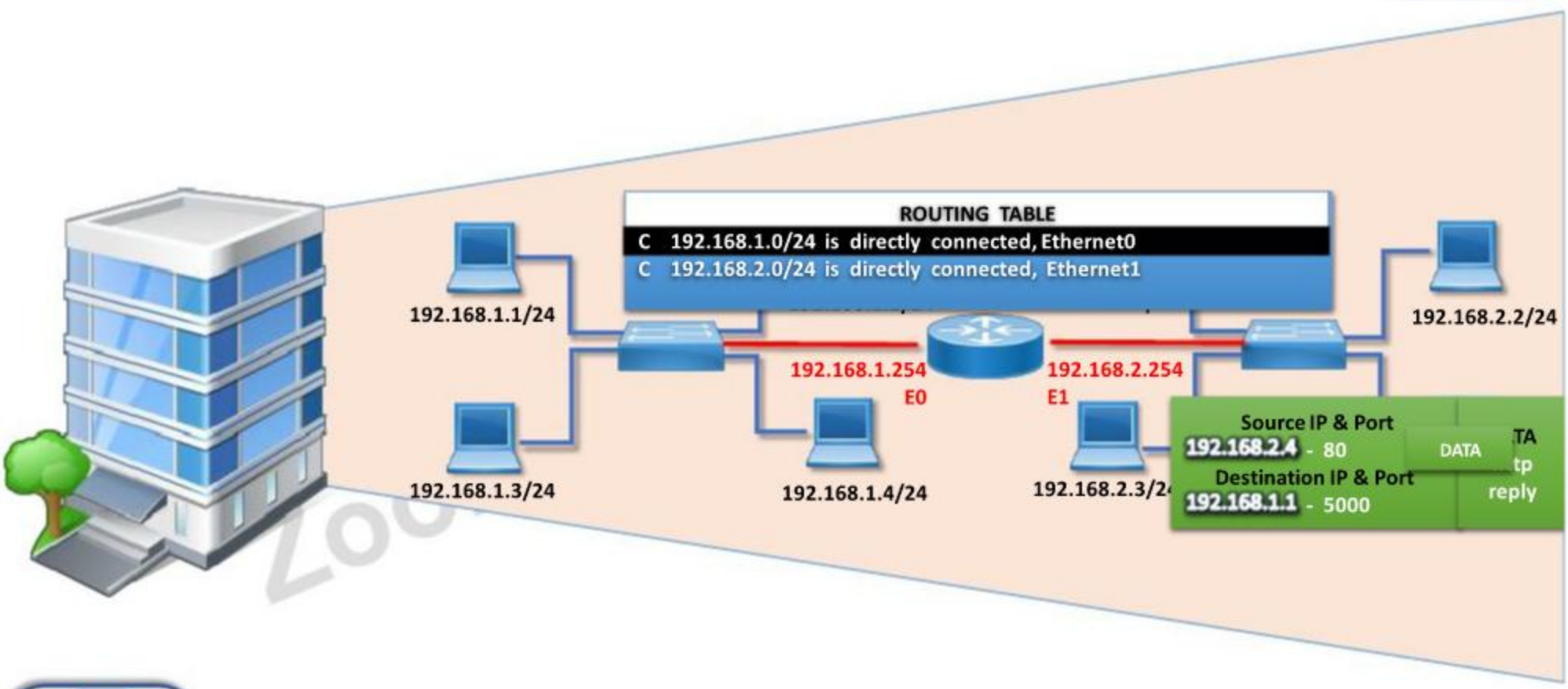


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LAN - Different Network Communication



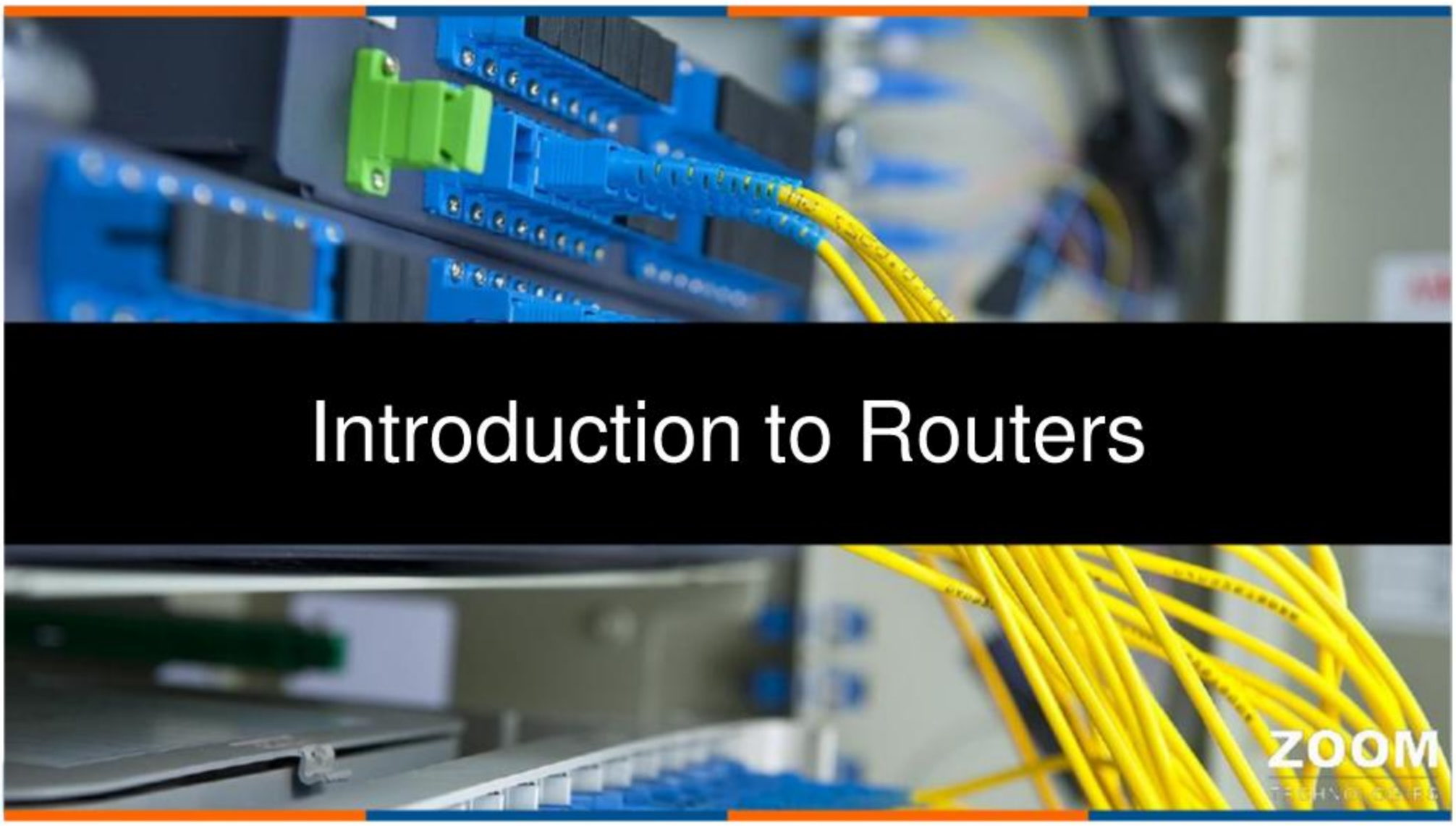
LAN - Different Network Communication



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LAN - Different Network Communication





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Router

- Router is an internetworking device.
- It enables communication between two or more different logical networks.
- It is a Network Layer (layer 3) device.
- It comes from the word “ROUTE”. Hence it is also a device that finds the best route (path) for networks.
- The IP of Router is the default gateway for all devices in LAN.

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Type of Routers

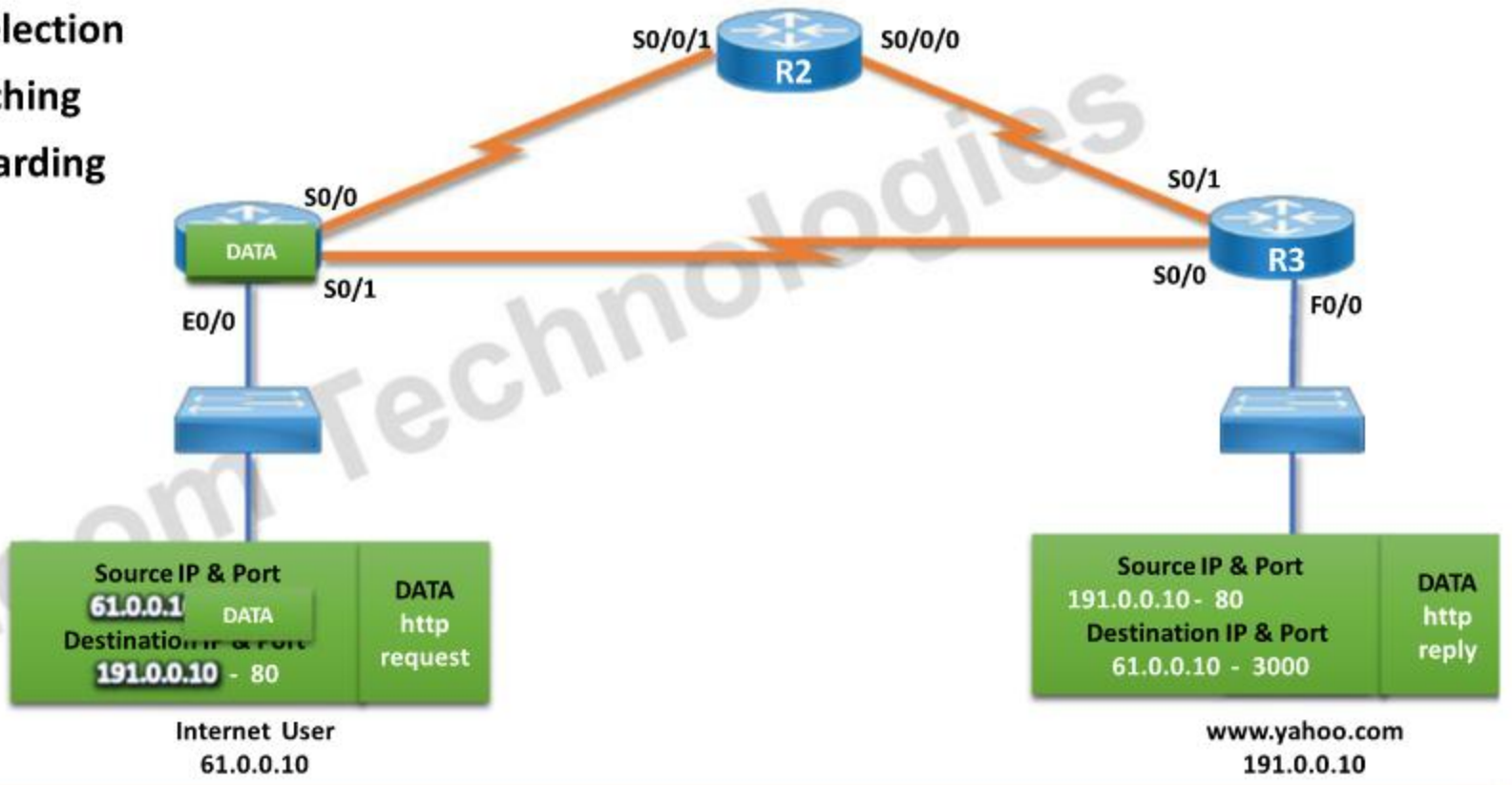
There are two type of Routers

- Hardware Routers:
  - Cisco, Juniper, Multicom, HP, Dlink, Maipu and many more…
- Software Routers:
  - Microsoft Server, Linux Server

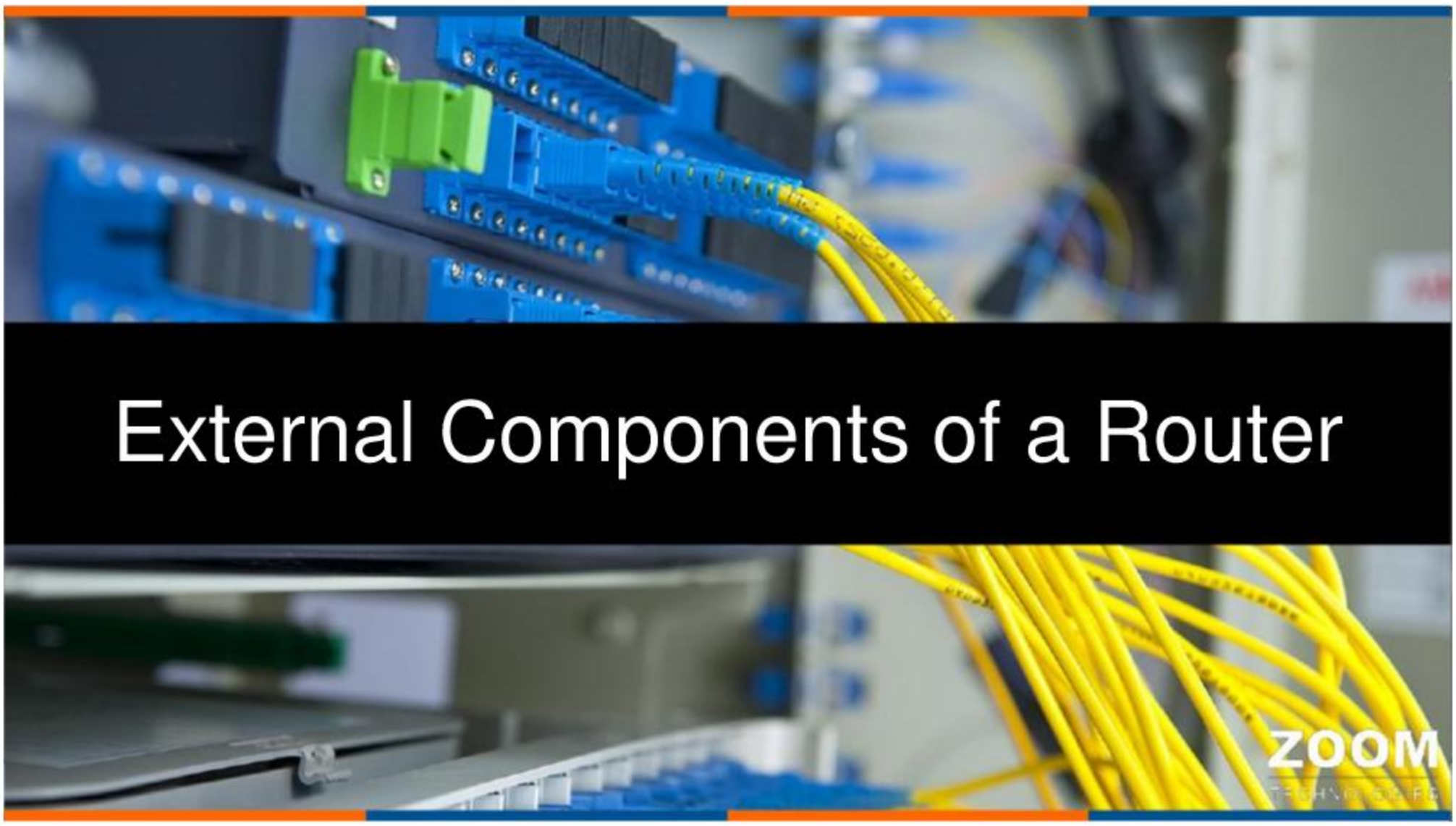
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Functions of a Router

- Inter-network Communication
- Best Path Selection
- Packet Switching
- Packet forwarding



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Hardware Routers

- Fixed Router
- Modular Router

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Fixed Router



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Modular Router



Cisco 1700 Modular Router

WIC – Wan Interface Card

Cisco 2600 Modular Router



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2800 Series

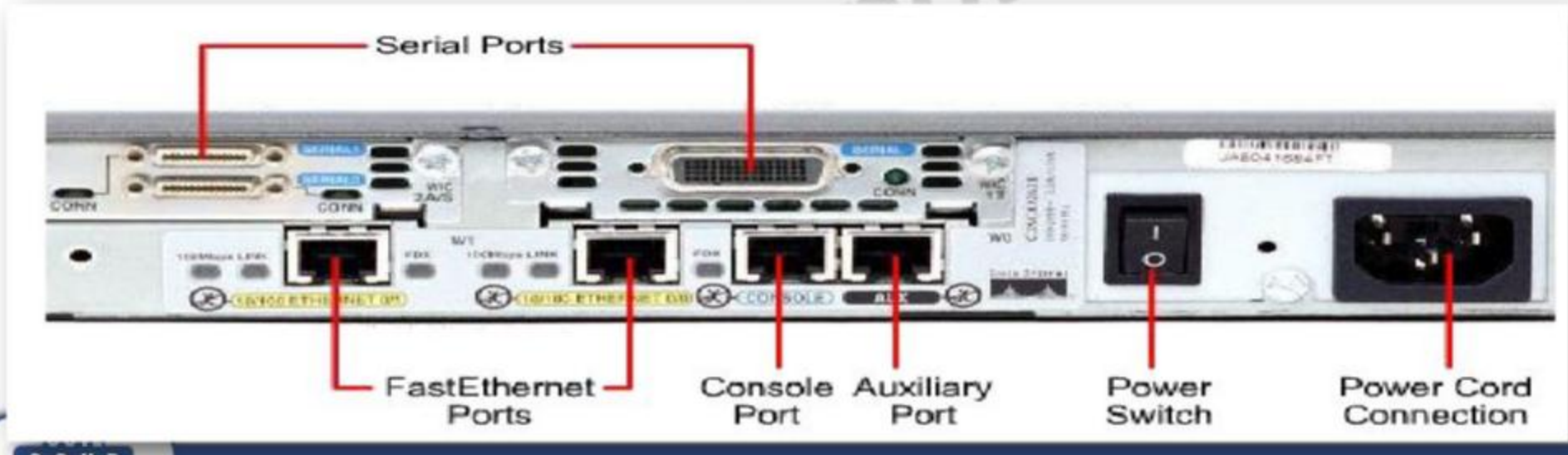




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Types of routers





Attachment Unit Interface

- Attachment Unit Interface (AUI) is used to connect the Router to the LAN.
- It is also called as the Ethernet interface.
- AUI is an DB 15 pin female interface.
- Transceiver is used to connect AUI port to LAN HUB / Switch.
- Transceiver converts DB-15 signal to RJ-45.



Transceiver



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Other LAN Interfaces - RJ-45 ports

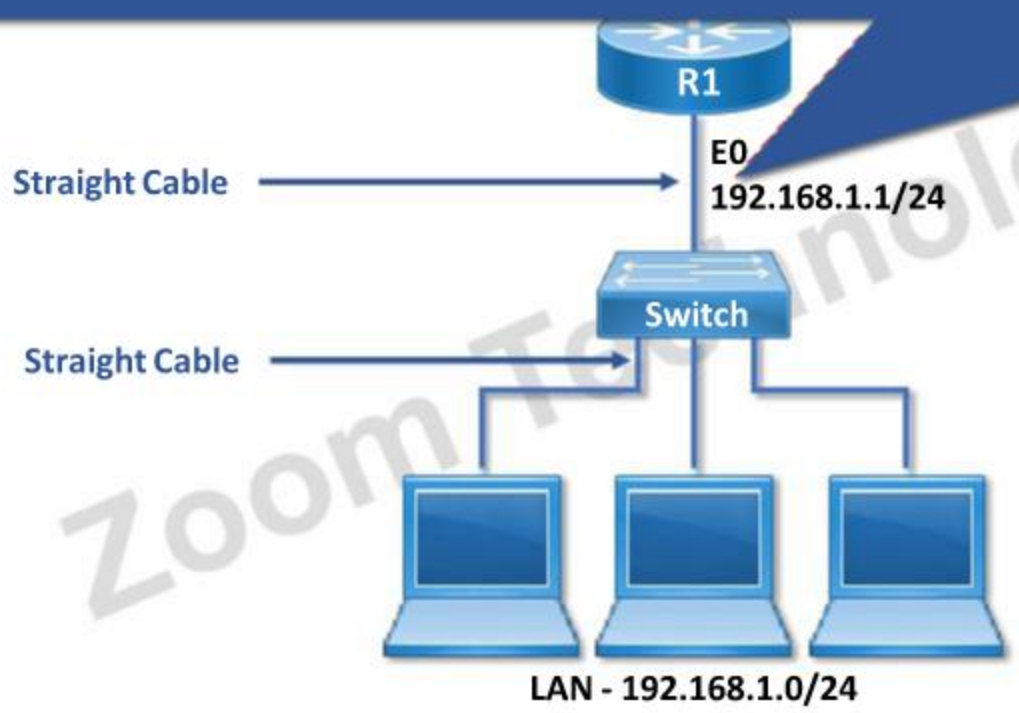
- Routers have RJ-45 ports to connect the Router to the LAN.
- The speed of the RJ-45 ports can be
  - 10 Mbps Ethernet
  - 10/100 Mbps Fast Ethernet
  - 10/100/1000 Mbps Gigabit Ethernet



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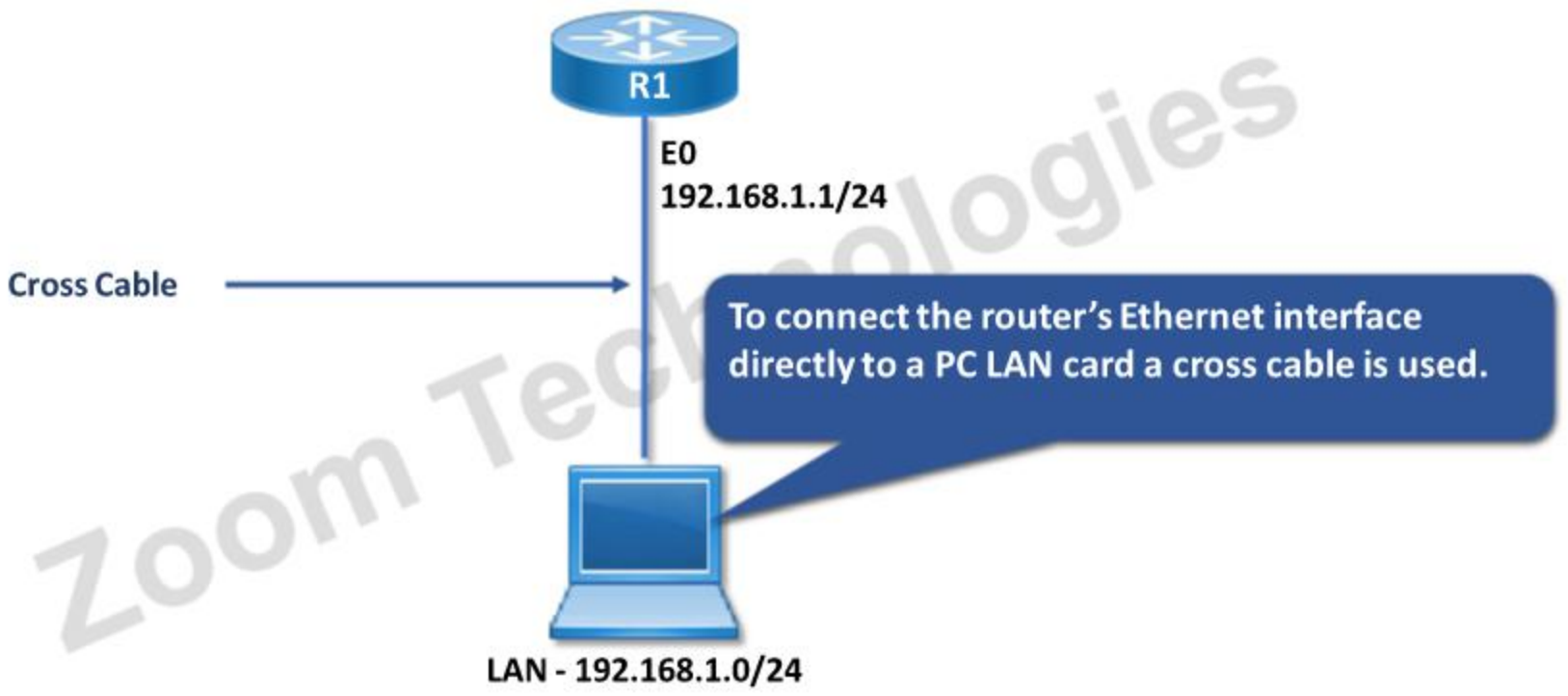
LAN Connectivity

An IP address has to be assigned to this interface. It should be in the same network as that of the LAN. This IP address is the default gateway address for all LAN systems.



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LAN Connectivity



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Serial Port

- Serial port is used for WAN Connectivity.
- Serial port are available as
  - 60 pin female connectors.
  - Smart Serial 26 pin female connectors.



- V.35 cable is used to connect the serial port of the router to the leased line modem (CSU/DSU).







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HWIC

- High-speed WAN interface cards (HWICs) provide connectivity to a Wide Area Network



Console Port

- It is a local administrative port.
- It is a RJ-45 Port.
- It is used for initial configuration and advance troubleshooting.
- Note : It is the most important and sensitive port on the Router.



DB-9 Convertor

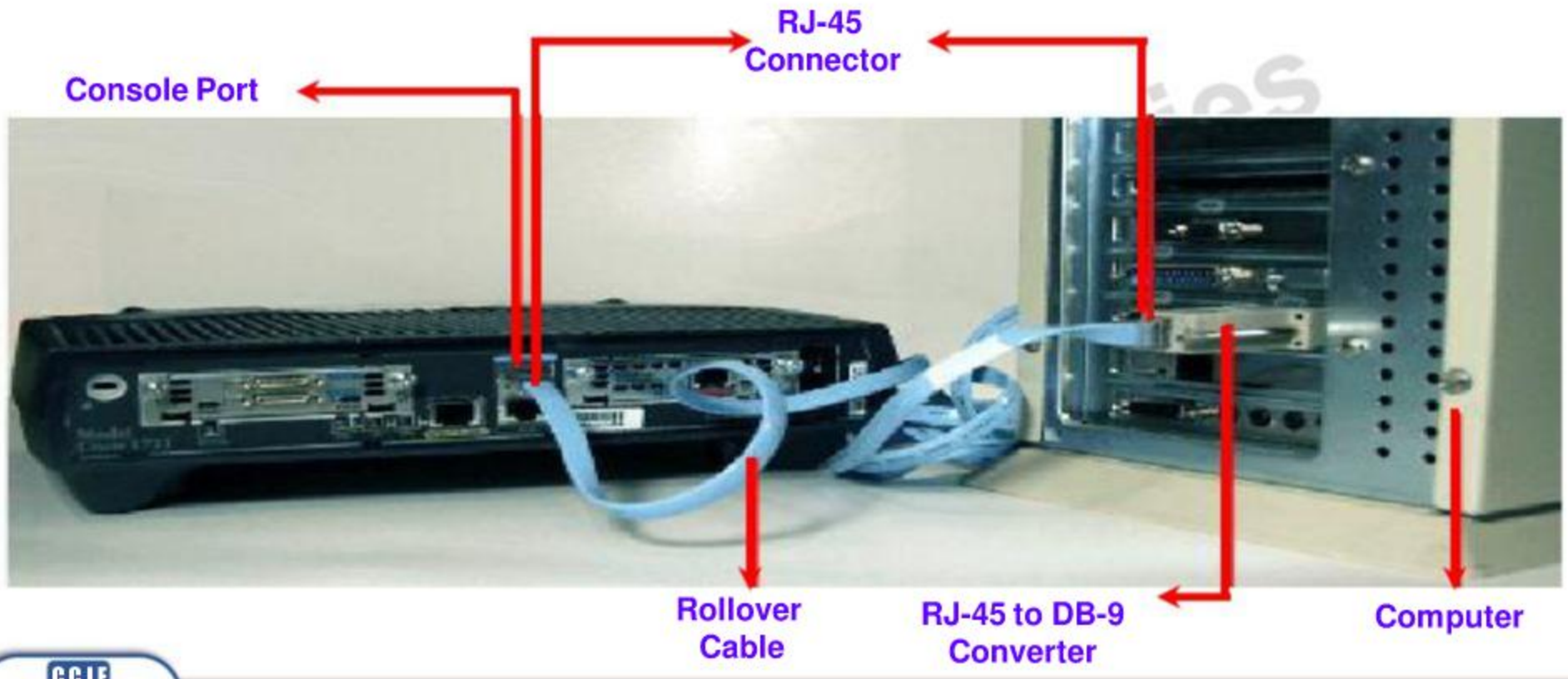


Console cable



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Console Connectivity



Auxiliary Port



- It is a remote administrative port.
- Used for remote administration / configuration.
- Its an RJ-45 port.
- A console / rollover cable is used to connect the auxiliary port to a dial-up modem.

Zoom Technologies

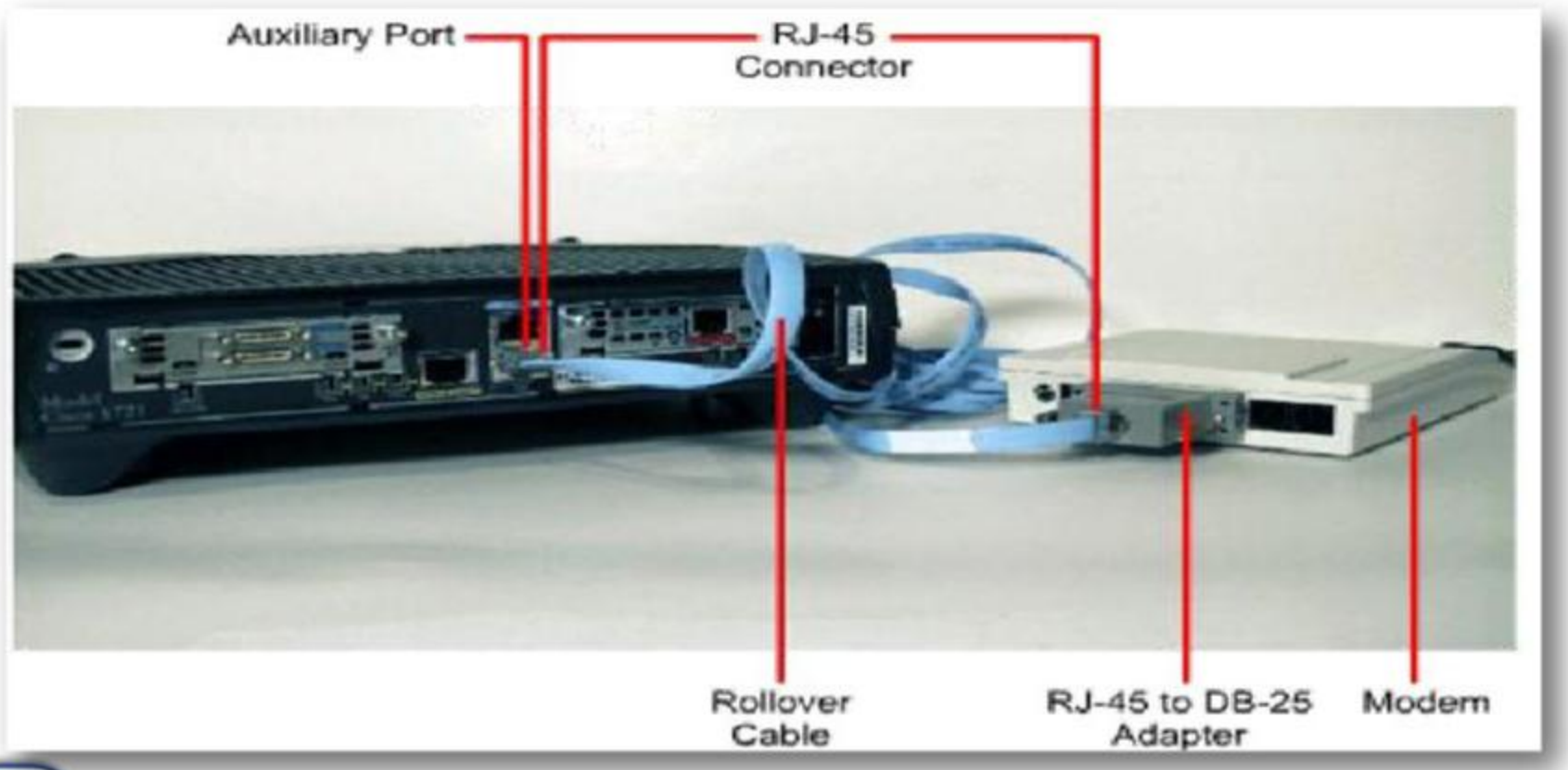
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Roll over Cable

One End	Other End
Orange-white	Brown
Orange	Brown-white
Green-white	Green
Blue	Blue-white
Blue-white	Blue
Green	Green-white
Brown-white	Orange
Brown	Orange-white

Zoom

Auxiliary Connectivity

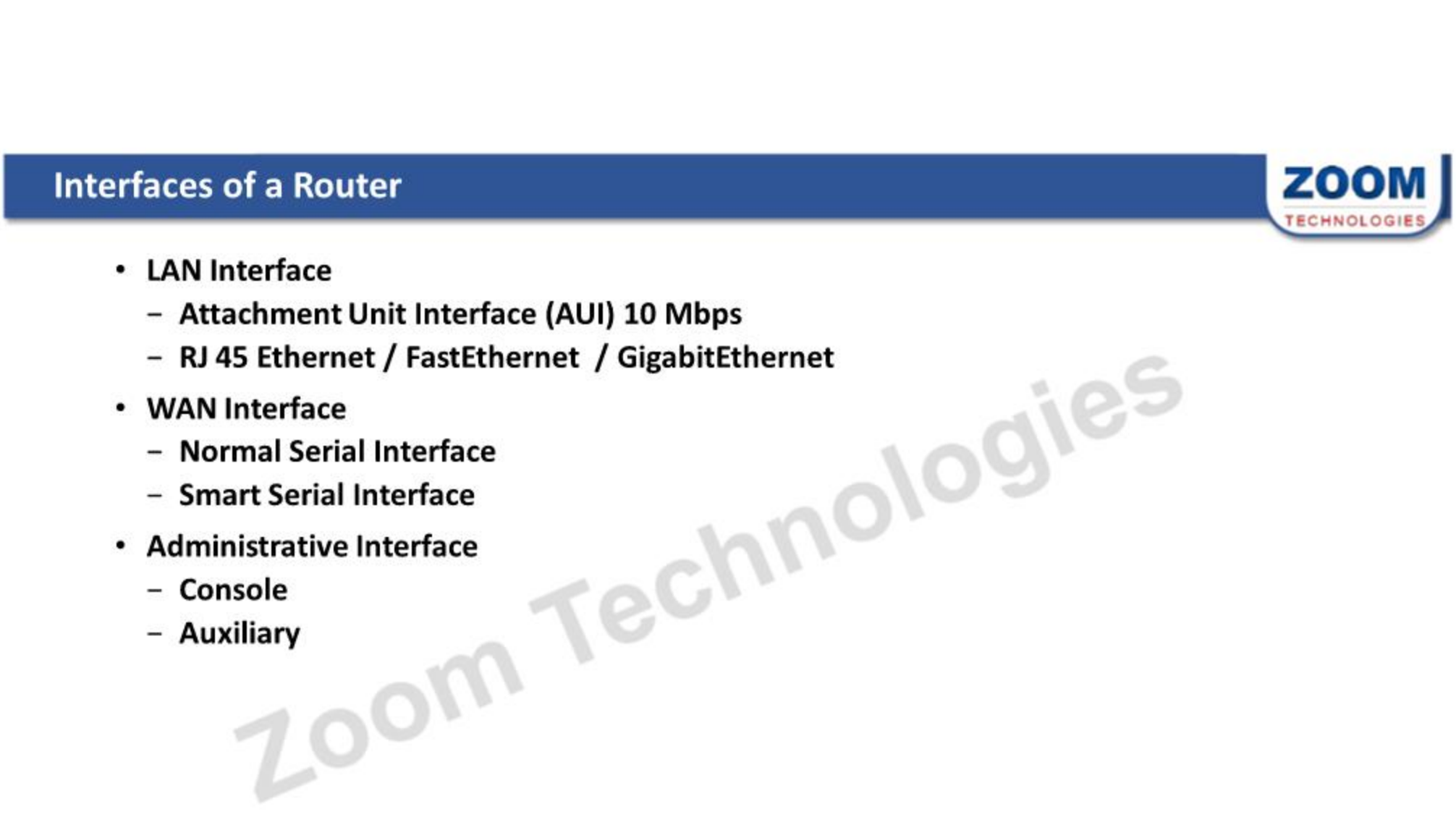


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Interfaces of a Router

- LAN Interface
  - Attachment Unit Interface (AUI) 10 Mbps
  - RJ 45 Ethernet / FastEthernet / GigabitEthernet
- WAN Interface
  - Normal Serial Interface
  - Smart Serial Interface
- Administrative Interface
  - Console
  - Auxiliary

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Internal Components of Router

- ROM (Read only Memory)
  - It contains a bootstrap program which searches and loads the operating system.
  - It is similar to the BIOS of a PC.
  - It also contains a ROMMON for advance troubleshooting.

- Flash memory
  - The Internetwork Operating System (IOS) is stored here.
  - IOS is a Cisco proprietary operating system.

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Internal Components of Router

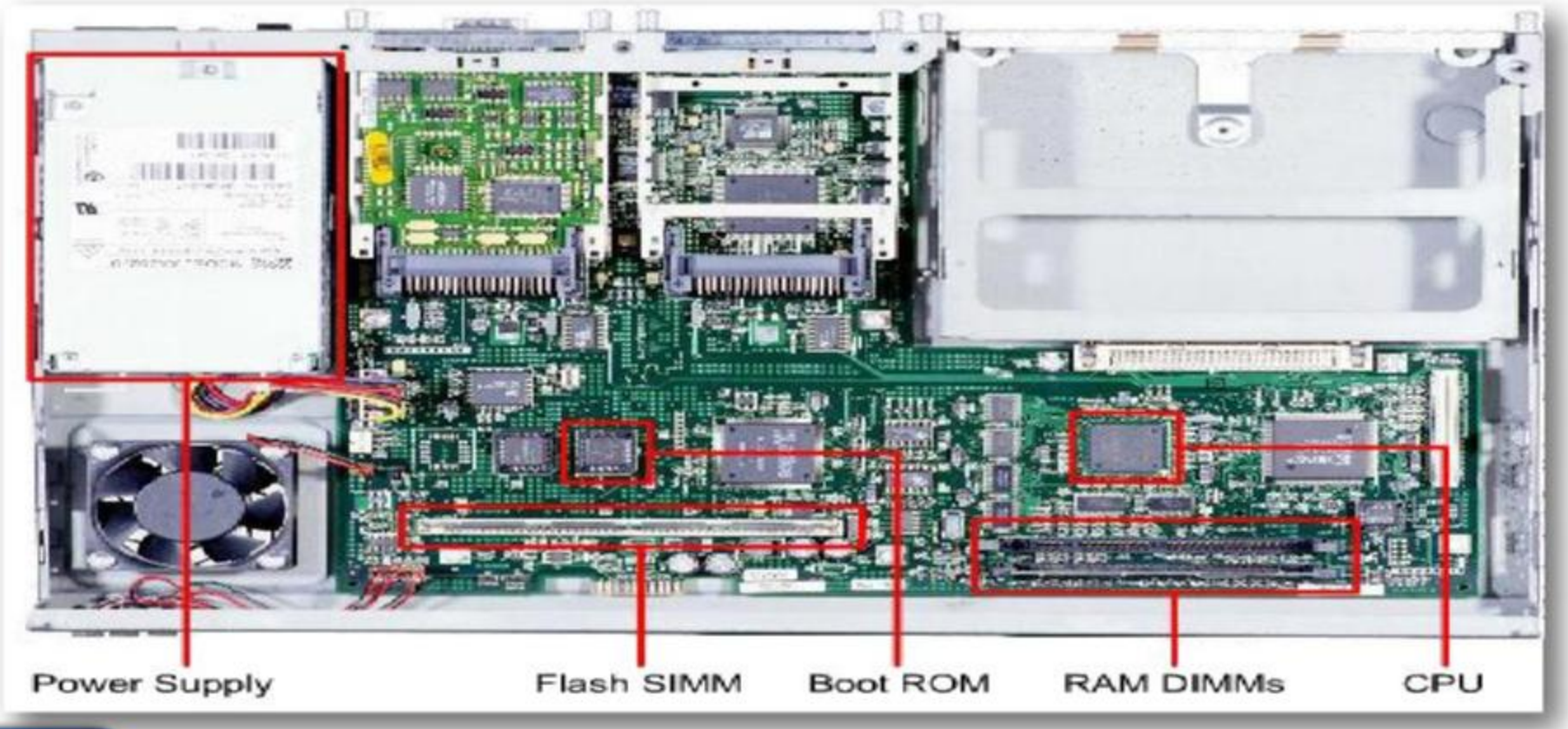
- NVRAM (Non Volatile Random Access Memory)
  - NVRAM is similar to a hard disk.
  - It is also known as permanent storage.
  - The startup configuration is stored here.

- RAM (Random Access Memory)
  - It is also called as the main memory.
  - It is a temporary storage.
  - The running configuration is stored here.

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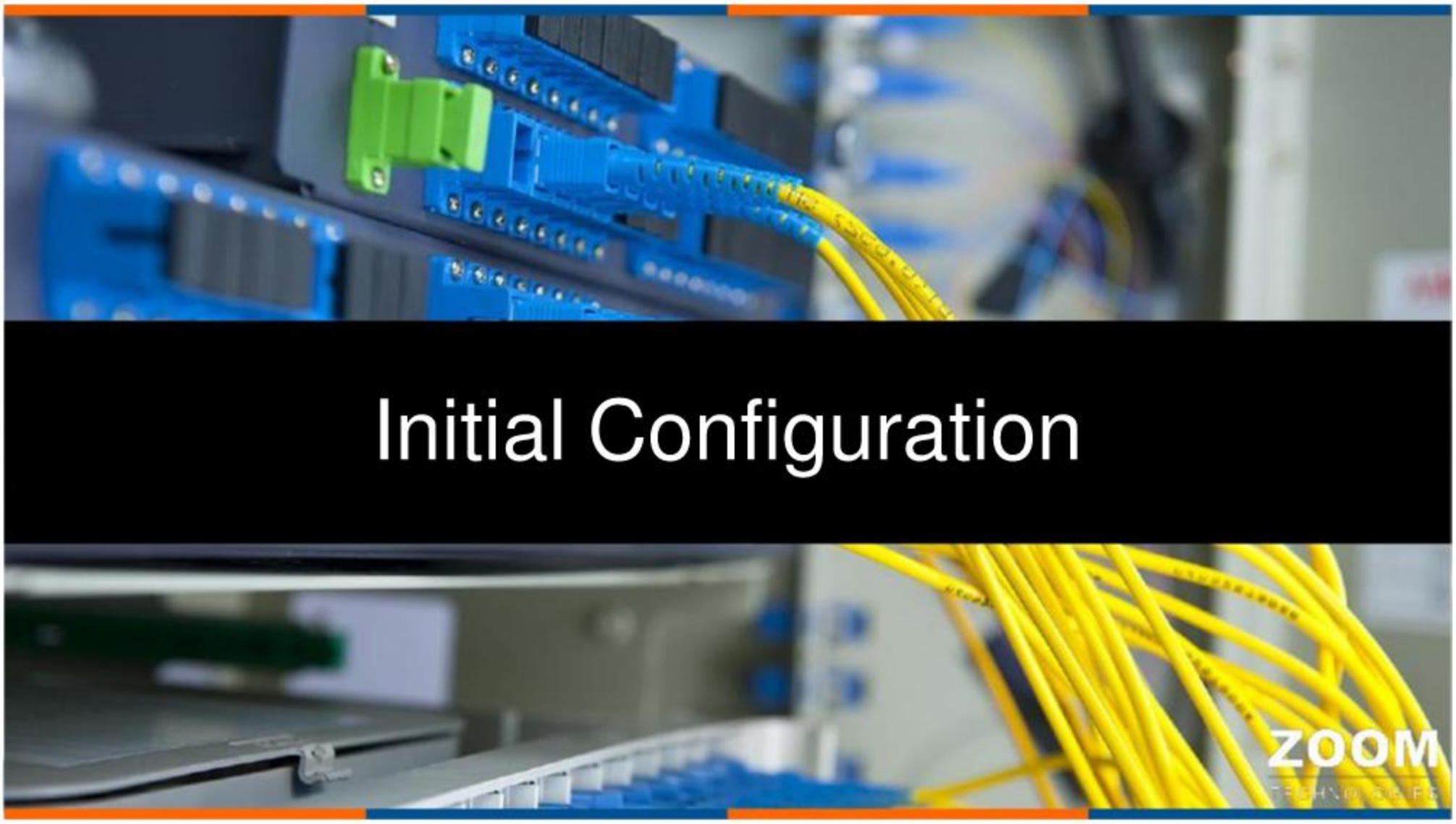
Internal Components of Router



BOOT Sequence

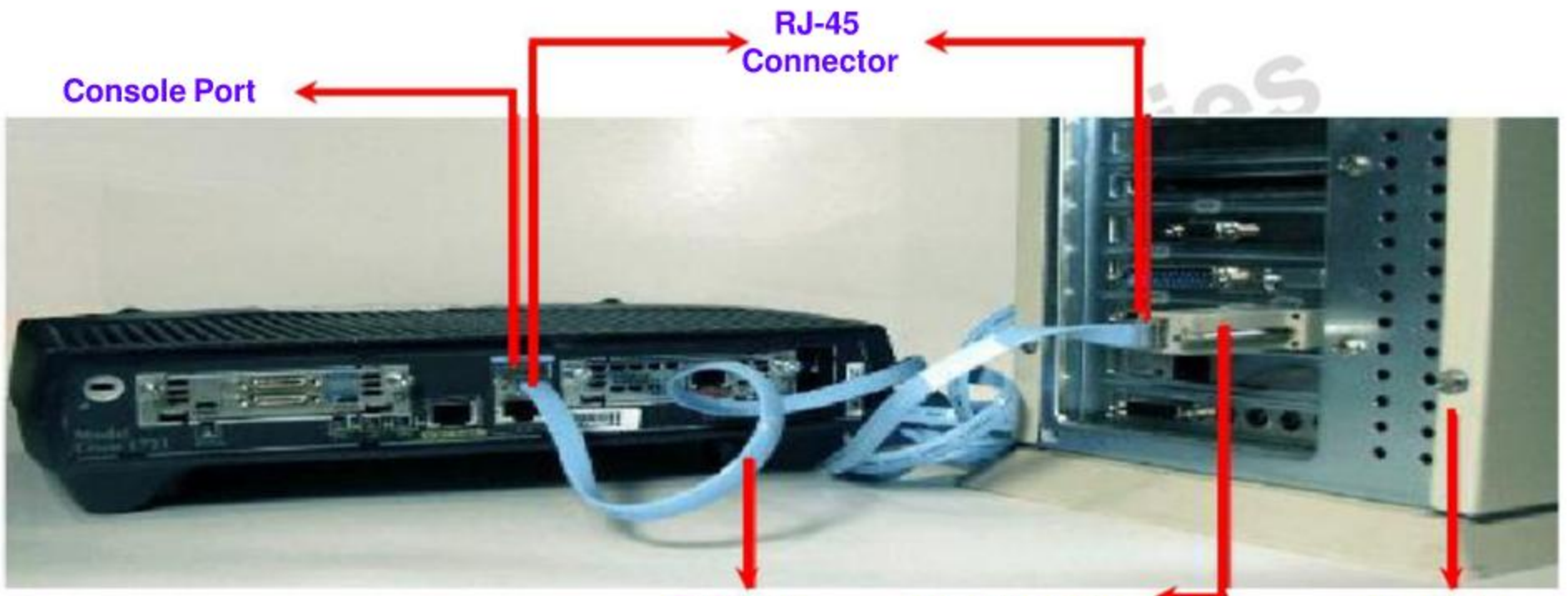
Power On Self Test – checks the hardware	POST
ROM loads Bootstrap program and searches for the IOS	ROM
IOS from Flash is loaded	FLASH
The startup configuration is loaded from the NVRAM	NVRAM
Boot process is completed as everything is loaded into the RAM	RAM

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Initial Configuration

Console Connectivity



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Console Connectivity

- Cisco Routers & Switches does not have any default IP address or Configuration, hence require to use the Console port for Initial Configuration.
- Require physical connection between the Cisco Router/Switch and PC via console cable.





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Emulation Software

WINDOWS

- Hyper-terminal / Putty / Teraterm

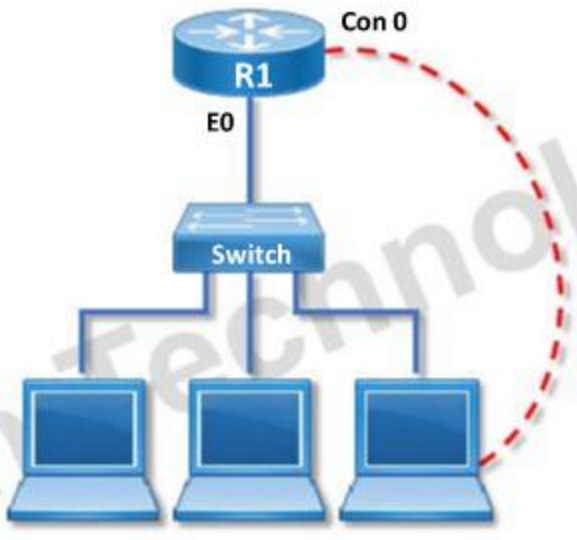
LINUX

- Minicom -s

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Initial Configuration



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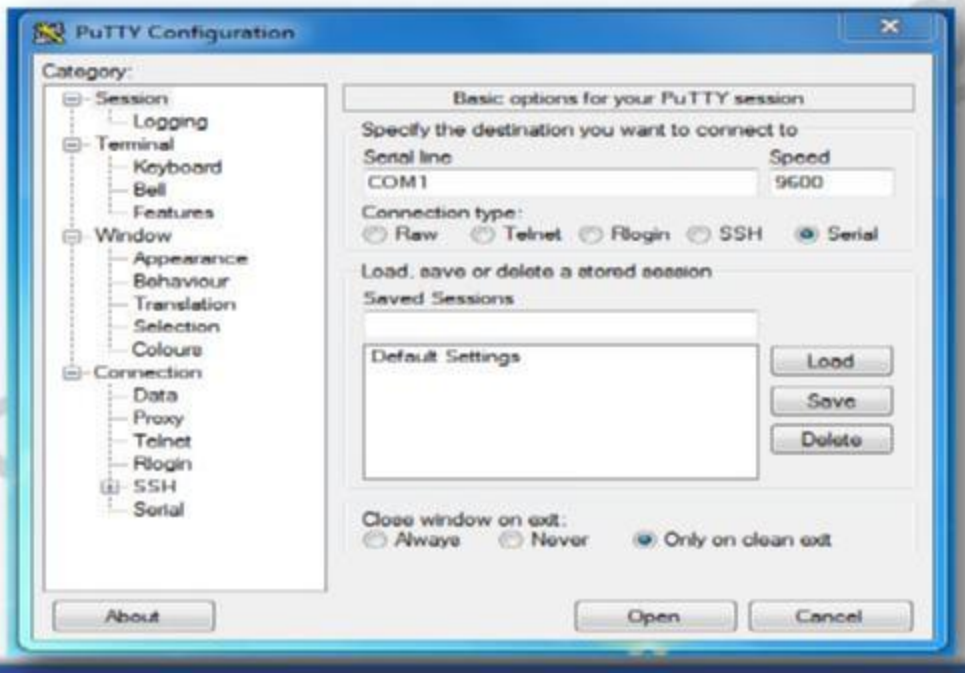
Accessing Router



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- Accessing router via console from Microsoft Windows Computer
- Start a terminal emulator application, such as PUTTY.exe
- Select Serial option and set speed to 9600
- Click Open





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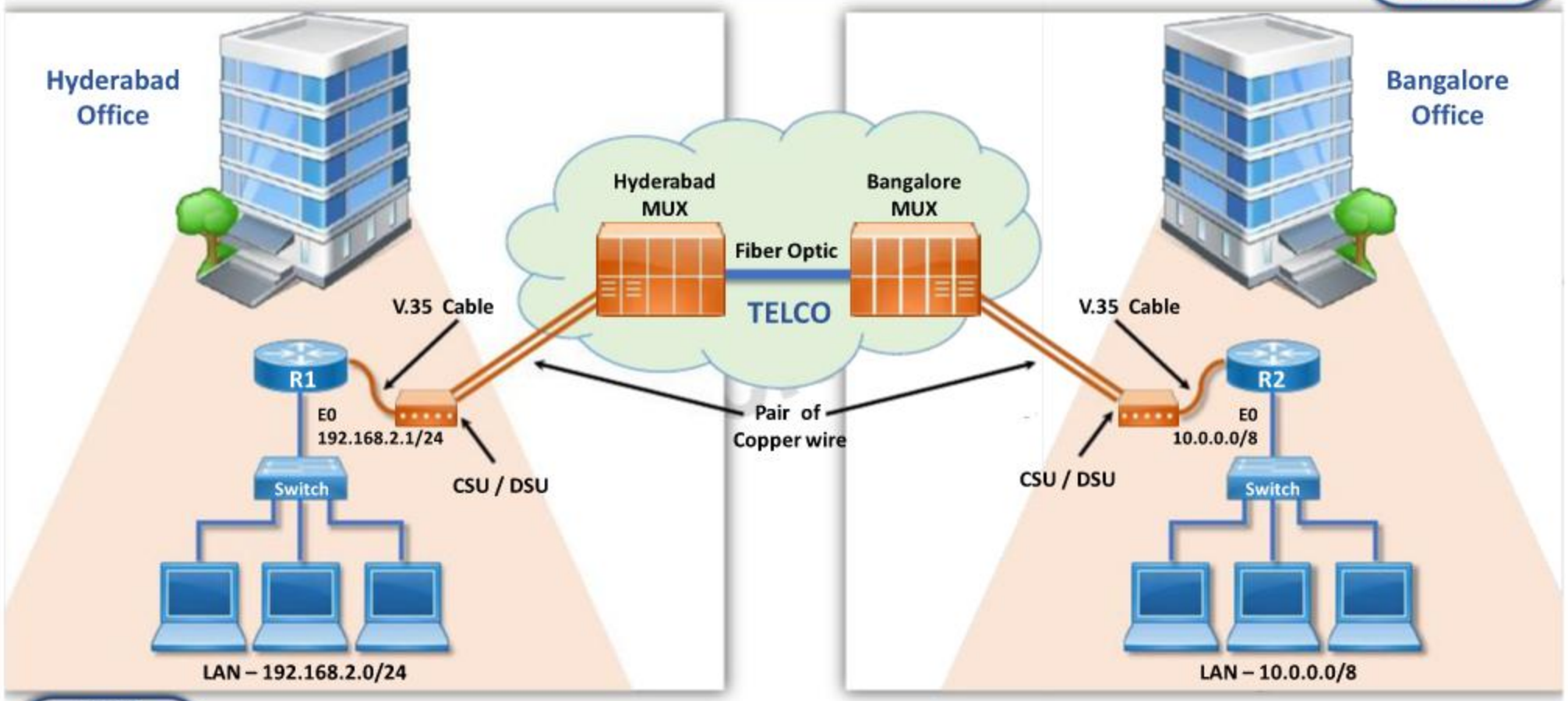
Types of WAN Technologies

- Dedicated service
  - Leased Line
    - MLLN (Managed Leased Line Networks)
- Circuit switching
  - PSTN (Public Switched Telephone Networks)
  - ISDN (Integrated Services Digital Networks)
- Packet Switching
  - Frame-relay
  - MPLS (Multi Protocol Label Switching)
  - ATM (Asynchronous Transfer Mode)
- Broadband
  - DSL
  - Cable Internet
- VSAT
- MOBILE - 3G/4G

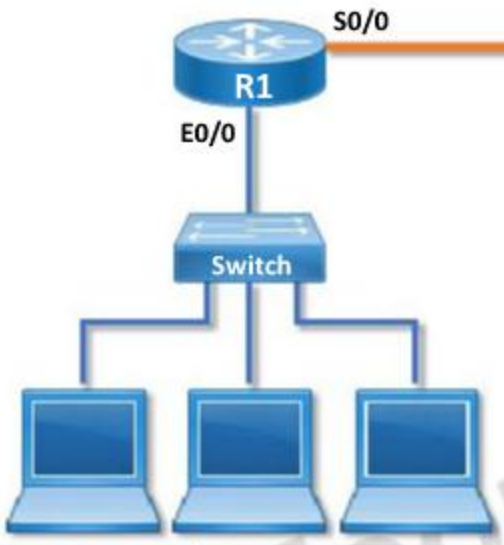
Zoom Technologies



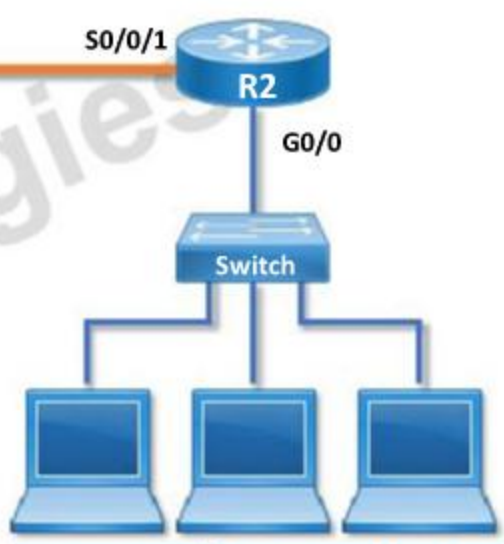
Wan Connectivity



Wan Connectivity Representation



Interface	IP Address / Mask
E0/0	192.168.2.1/24
S0/0	172.16.0.1/16



Interface	IP Address / Mask
G0/0	10.0.0.1/8
S0/0/1	172.16.0.2/16

Zoom Technologies

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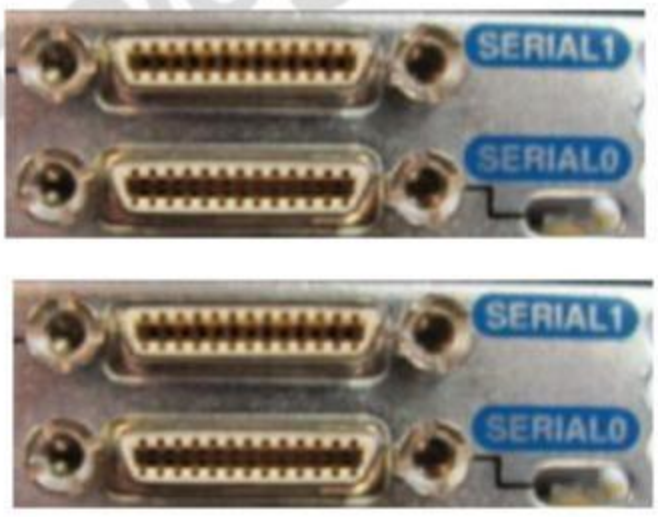
Device Classification

DCE	DTE
• Data Communication Equipment • Generate clocking (i.e. Speed) • Master • Example of DCE:- CSU/DSU	• Data Termination Equipment • Accept clocking (i.e. Speed) • Slave • Example of DTE:- Router

Serial - back to back cable

- When the distance between two Routers is short, a special V.35 Back to Back Cable is used to replace the copper wire, CSU/DSU and MUX.
- For data communication using back to back Serial cable, one end has to be a DCE and the other has to be a DTE.





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Encapsulation

- Encapsulation is the process of adding a new Header or Trailer to data.
- The header and trailer contains information which is needed for proper transportation of the data.
- There are different types of WAN Encapsulation:
  - PPP
  - HDLC
  - Frame Relay

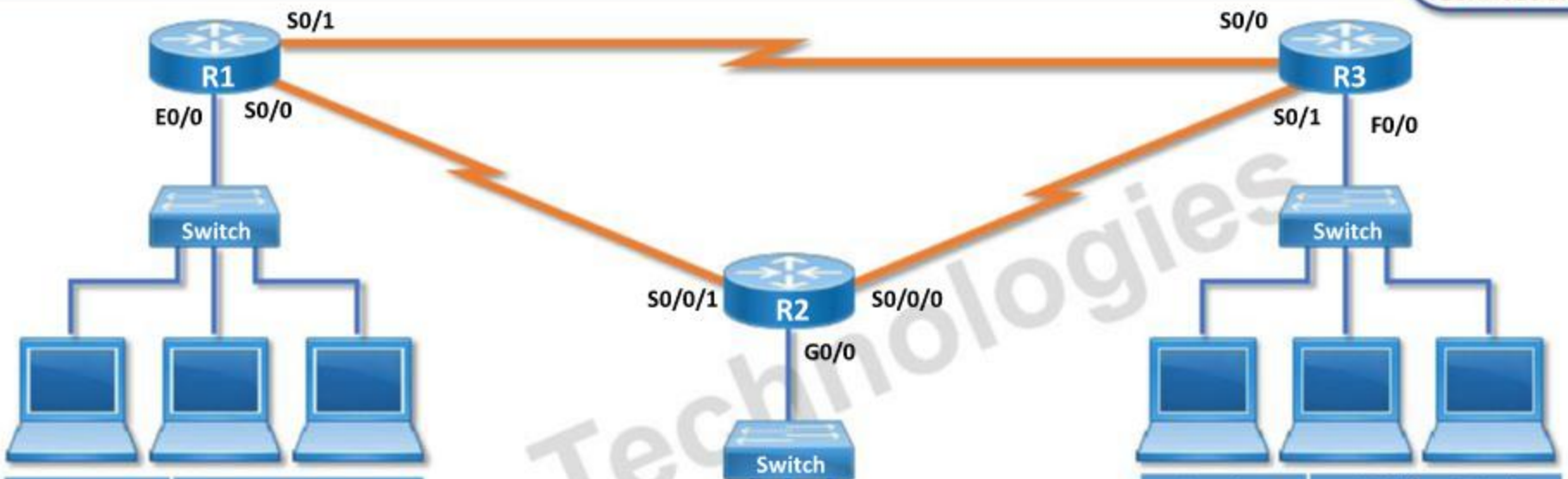
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Wan Encapsulation

PPP	HDLC
• Point to Point Protocol • Open Standard Protocol • Supports Authentication • Supports Compression	• High level Data link Control • Vendor proprietary Protocol • No Support for Authentication • No Support for Compression

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Wan Interface Configuration



Interface	IP Address / Mask
E0/0	192.168.2.1/24
S0/0	172.16.0.1/16
S0/1	172.18.0.2/16

Interface	IP Address / Mask
G0/0	10.0.0.1/8
S0/0/0	172.17.0.1/16
S0/0/1	172.16.0.2/16

Interface	IP Address / Mask
F0/0	192.168.3.1/24
S0/0	172.18.0.1/16
S0/1	172.17.0.2/16

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Serial Interface Configuration

To check DCE/DTE

- Router# Show controllers Serial < no. >

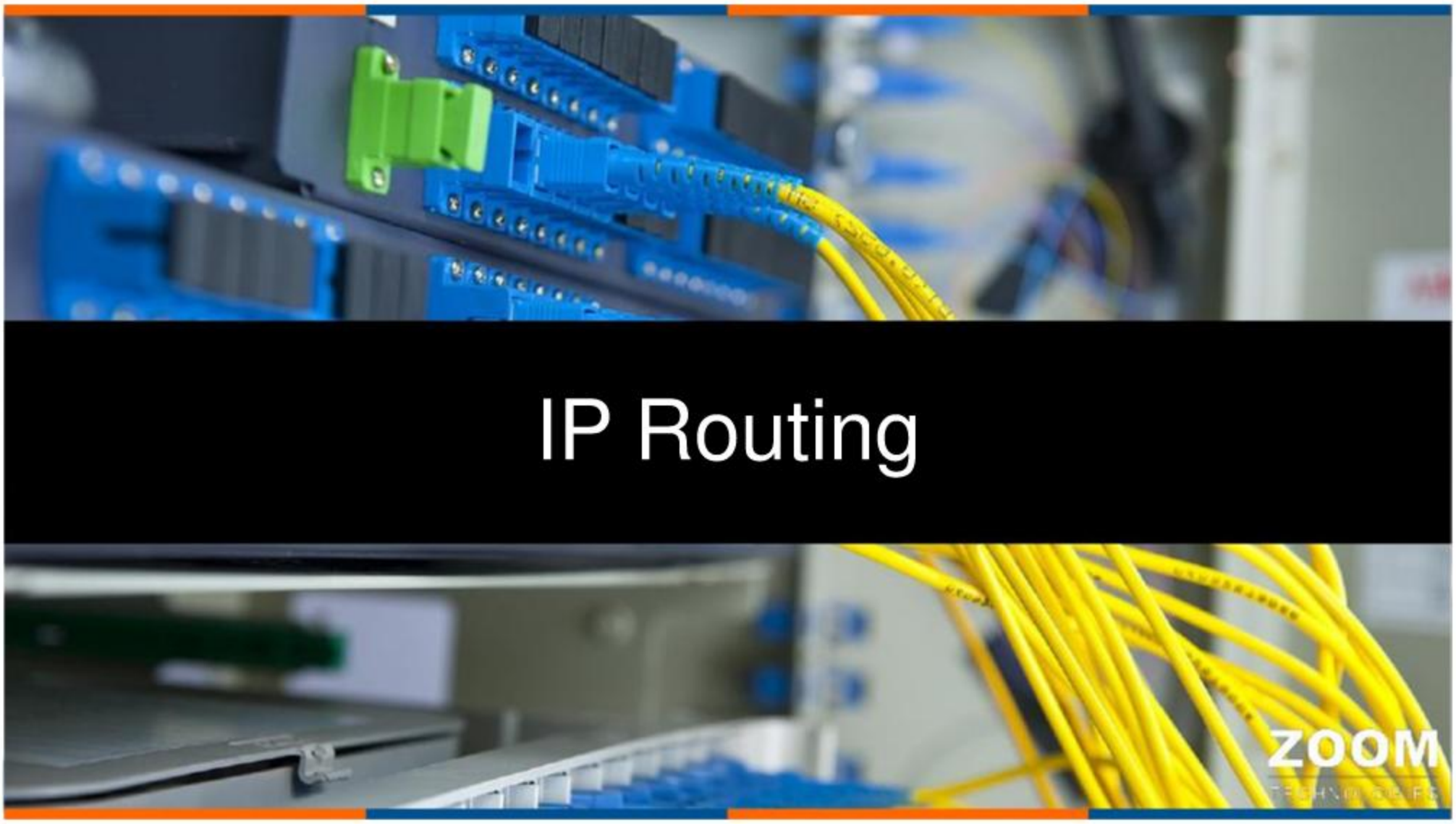
Serial Interface Configuration

- Router(config)# interface Serial <no.>
- Router(config-if)# ip address < ip > < Subnet mask >
- Router(config-if)# no shutdown
- Router(config-if)# clock rate < bandwidth >
- Router(config-if)# encapsulation < HDLC/PPP >

Verification

- Router# Show interface Serial <no. >

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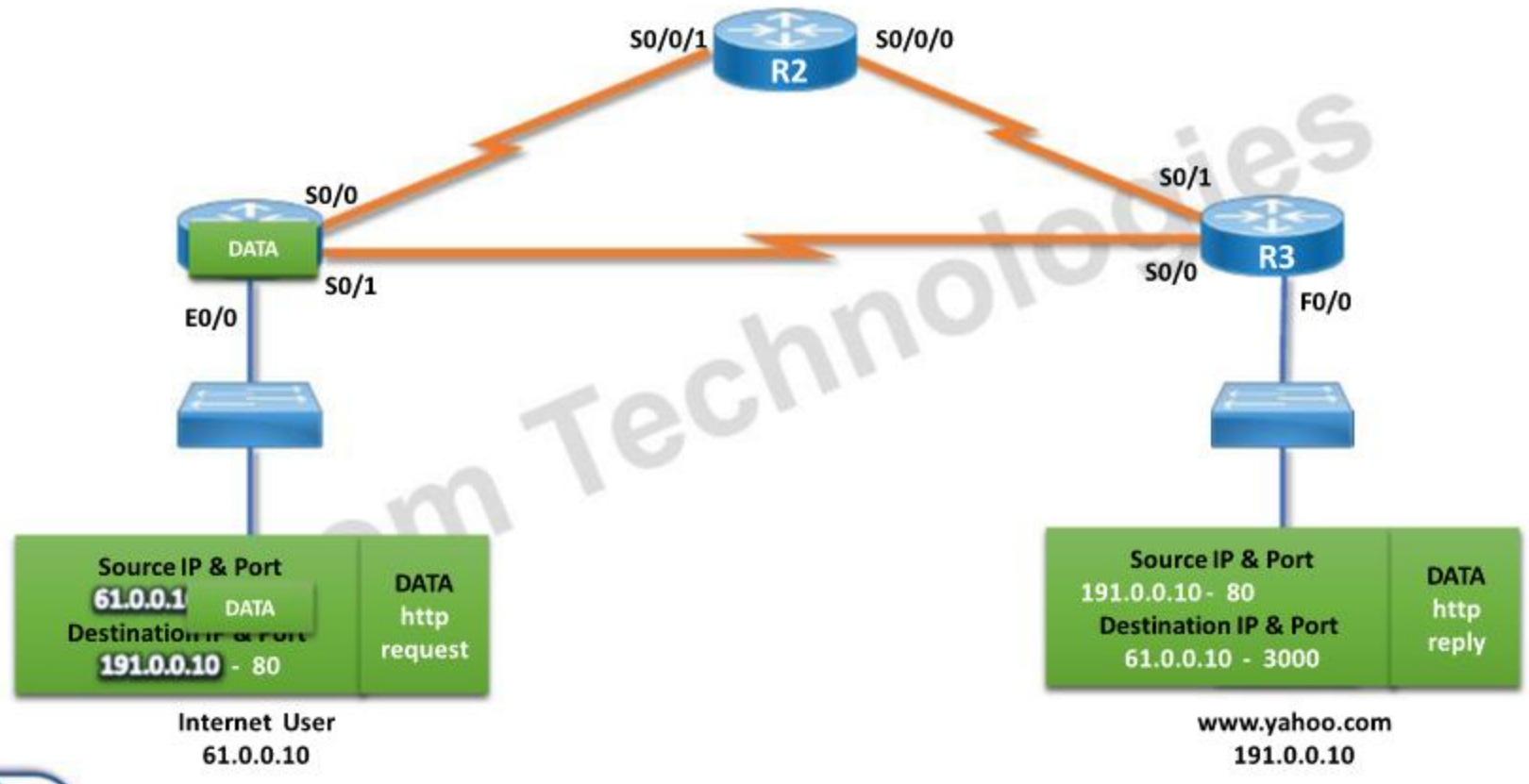
IP Routing

- Routing is the process of moving IP packets from one network to another network.
- Routing involves two basic activities:
  - Determining best paths.
  - Forwarding packets through these paths.

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IP Routing



Routing Network Diagram



Interface	IP Address / Mask
E0/0	192.168.2.1/24
S0/0	172.16.0.1/16

Interface	IP Address / Mask
G0/0	10.0.0.1/8
S0/0/1	172.16.0.2/16

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Conditions for Routing

- The Head office router's Ethernet interface should be in the same network as the Head office LAN and similarly on Branch office side, the router's Ethernet interface should belong to the same network as the branch office LAN.
- The serial interface between the head office and the branch office should be in same network.
- Head office LAN and Branch office LAN should be in different network.
- All interfaces of a Router should be in different network.

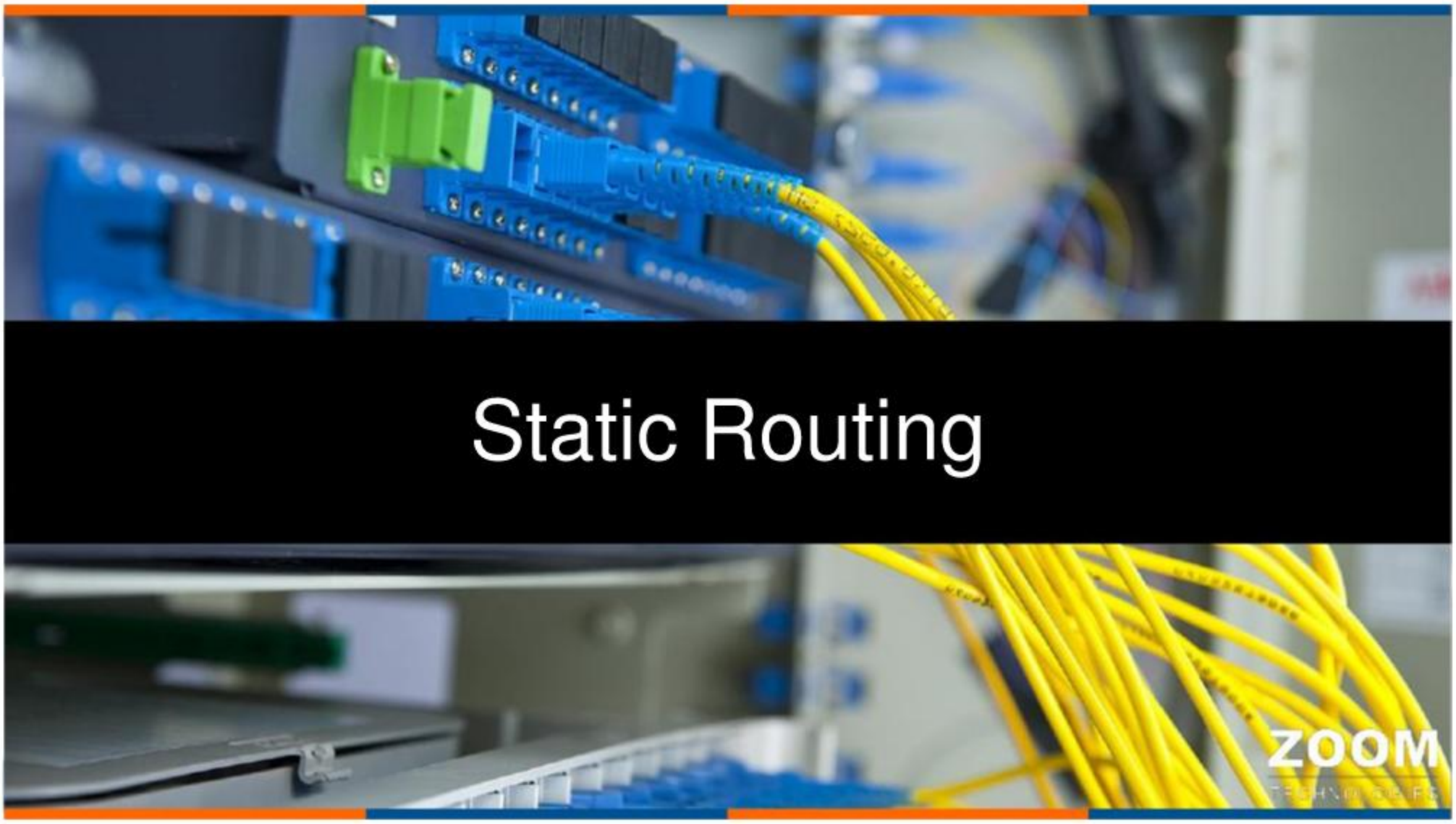
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Types of Routing

- Static Routing
- Default Routing
- Dynamic Routing

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Static Routing

Static Routing

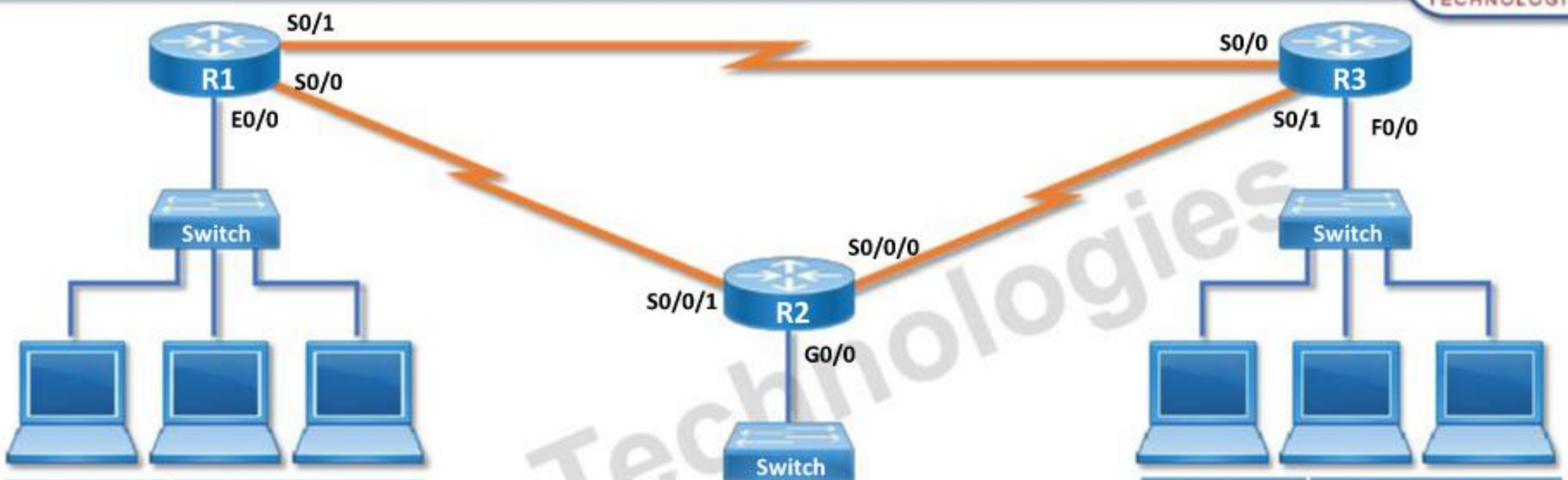
- Static routes are configured, maintained and updated by network administrator manually.
- Administrator should know the destination IP network for configuration.
- Administrative distance for Static Route is 1.

Administrative Distance (AD) is the "reliability" of the routing protocol. AD range is 0-255, lesser the administrative distance, higher the priority

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Static Routing



Interface	IP Address / Mask
E0/0	192.168.2.1/24
S0/0	172.16.0.1/16
S0/1	172.18.0.2/16

Interface	IP Address / Mask
F0/0	192.168.3.1/24
S0/0	172.18.0.1/16
S0/1	172.17.0.2/16

Interface	IP Address / Mask
G0/0	10.0.0.1/8
S0/0/0	172.17.0.1/16
S0/0/1	172.16.0.2/16

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Static Route Configuration

Static Route configuration

- Router(config)# ip route < Destination network ID > < Destination Subnet mask > < Exit Interface type > < Exit interface no. >

Or

- Router(config)# ip route < Destination network ID > < Destination Subnet mask > < Next Hop IP address >

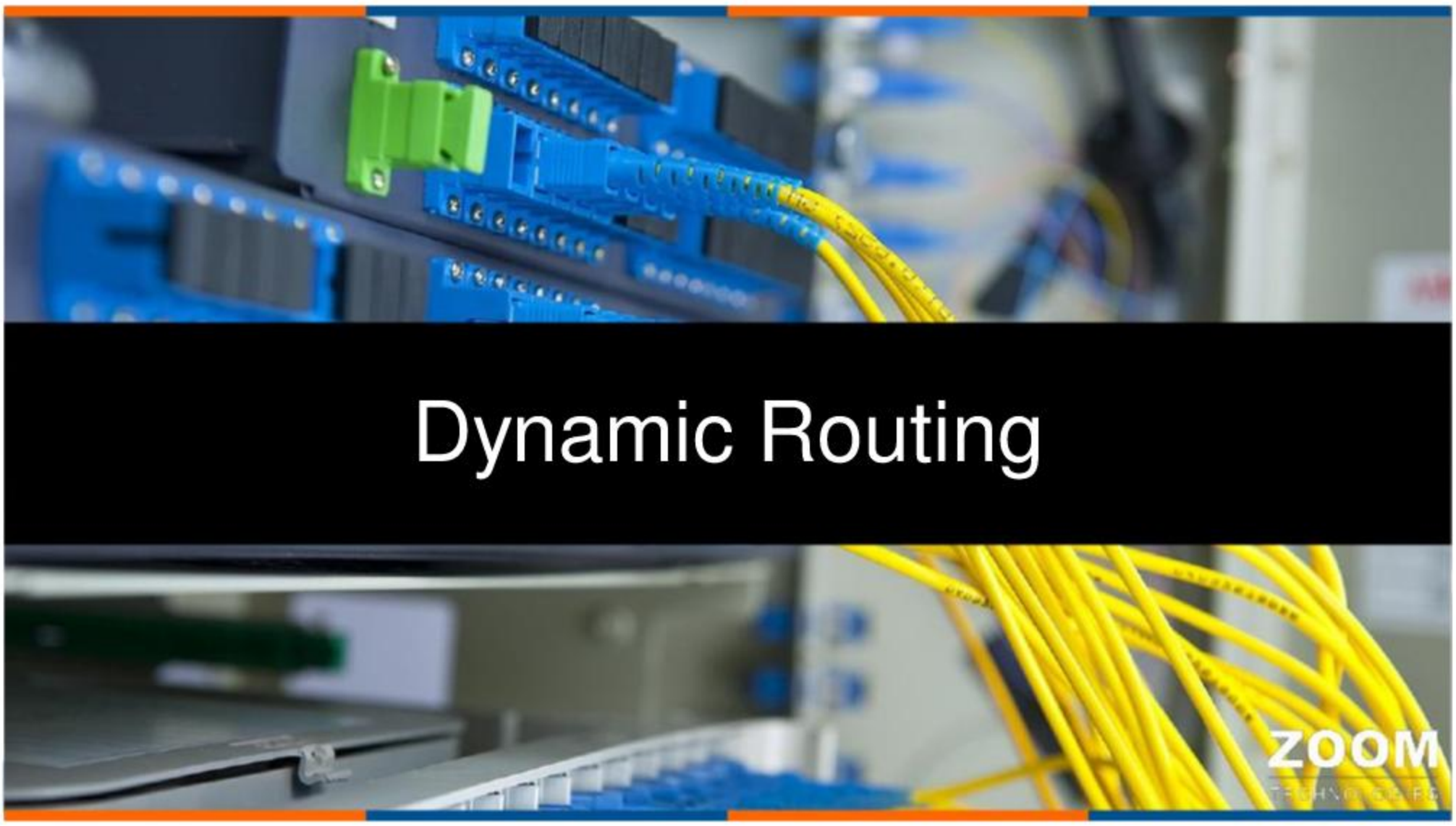
Verification

- Router# Show ip route

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Advantages and Disadvantages of Static routing

Advantages	Disadvantages
Secured	No Automatic Updates
Reliable	Need of Destination network ID for the configuration
Faster	Administrative work is more
No wastage of bandwidth	Used in Small networks



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Advantages of Dynamic routing

- Changes in the network topology are updated dynamically
- Only the directly connected network information is required for the configuration
- Administrative work is reduced
- Used for medium and large Networks

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Types of Dynamic Routing Protocols

- Distance vector
  - RIP (Routing Information Protocol)
  - IGRP (Interior gateway routing protocol)
- Advanced distance vector
  - EIGRP(Enhanced Interior gateway routing protocol)
- Link-state
  - OSPF (open shortest path first)
  - IS-IS (intermediate system to intermediate system)

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Routing Information Protocol

- Distance vector protocol
- It is open standard protocol
- Uses Bellmen-ford Algorithm
- Classfull routing protocol
- Updates are periodically broadcasted using IP address 255.255.255.255
- Complete routing table sent as an update
- Each Update can contain maximum of 25 routes
- Administrative Distance is 120
- Metric is Hop count
- Maximum hop count supported is 15
- Load balancing on 4 equal paths by default (maximum 16 equal paths)
- Also known as “Routing by Rumor”

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RIP Timers

- Update Timer : 30 sec

  Time between two consecutive updates
- Invalid Timer : 180 sec

  Time a router waits to hear an update from the neighbor

  The route is marked as unreachable if there is no update for this time period
- Flush Timer : 240 sec

  Time after which the invalid route is removed from the routing table

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Disadvantages of RIP

- More Bandwidth is utilized for sending the updates.
- Does not consider the bandwidth in metric calculations, uses only hop count
- Slow convergence
- Formation of routing loops

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Routing loops

- Routing loops are formed due to the default behavior of RIP
- Complete routing tables are exchanged
- Slow convergence
- No verification of updates received

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Routing loop avoidance

Built in Mechanisms to avoid switching loops

- Split Horizon

  A route learnt through an interface is never advertised back out of that same interface

- Route poisoning

  The route is marked as 16 hops

  It is a mechanism to inform regarding unreachable route to neighbor

- Poison reverse

  Violating split horizon rule, sending the update through an interface from where it is being received, only in a case when network is unreachable (16hops)

- Hold down timer : 180 sec

  The router does not accept any update for the invalid route for this time period

- Flash update (Triggered update)

  Change in the network topologies causes the router to send the update immediately without waiting for the update timer to get over

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Comparison between RIPv1 and RIPv2

RIP v1	RIP v2
• Classfull routing protocol • Does not advertise subnet mask information in routing update • It works with broadcasting (255.255.255.255) • It does not support Authentication	• Classless routing protocol • Advertises the subnet mask information in routing update • It works with multicasting (224.0.0.9) • It supports Authentication

RIP configuration

RIP configuration

```
Router(config)# ip routing
Router(config)# router rip
Router(config-router)# network < Network ID >
```

Verification

```
Router# Show ip route
```

To check the logs

```
Router# debug ip rip
Router# terminal monitor
```

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Enhanced Interior Gateway Routing Protocol

- Advance Distance vector routing protocol
- It is open standard protocol, was Cisco proprietary
- Uses DUAL (Diffusion Update Algorithm)
- Classless routing protocol
- Updates are sent through Multicast IP address (224.0.0.10)
- Incremental Updates and Triggered updates
- Administrative distance is 90
- Metric : Composite Metric
  - Bandwidth, delay, load, reliability and MTU
  - Bandwidth and delay is used by default

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EIGRP

- Maximum hop count supported is 255 (Default is 100)
- Hello packets are sent every 5 seconds
- Supports multiple Routed Protocols - IP, IPX and Apple Talk protocols
- Support equal and unequal cost load balancing (default 4 paths and maximum 16 equal or unequal path)
- Fast Convergence to topology changes

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EIGRP Tables

- Neighbor Table
  - Contains information about directly connected neighbors.
- Topology Table
  - Contains entries for all destinations, along with the feasible distance and the advertised distance.
  - Contains the successors.
  - Contains feasible successor if any.
- Routing Table
  - Entries with the best path for each destination from the Topology table are moved into the Routing Table

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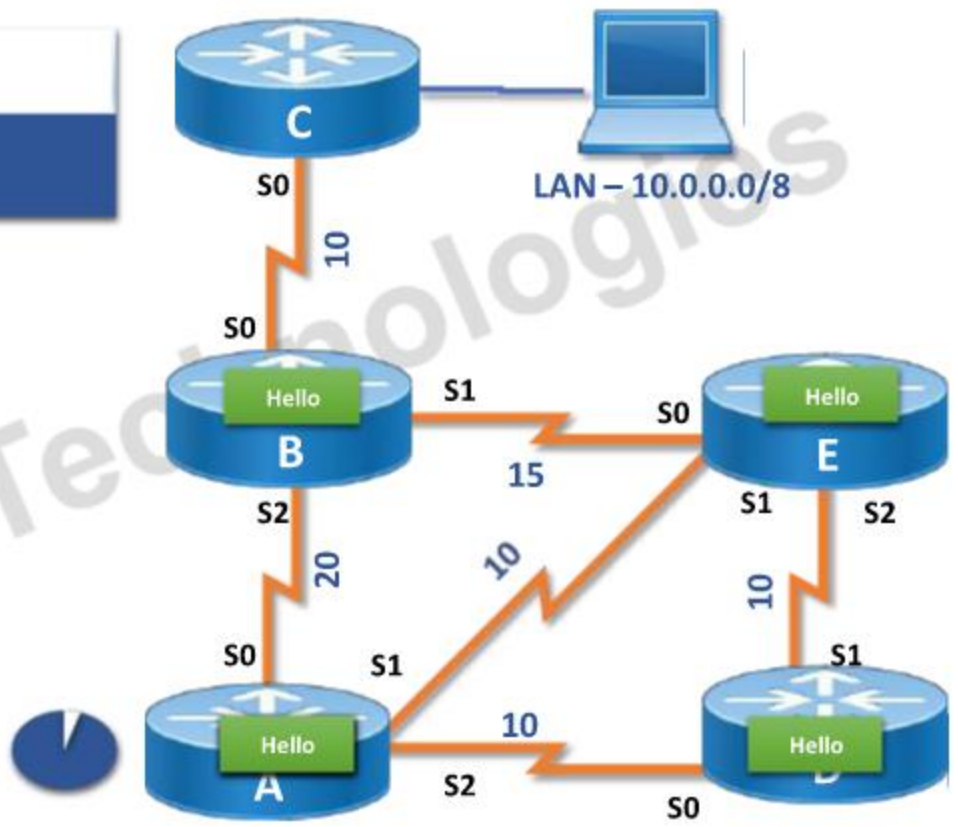
EIGRP Terminology

- Feasible Distance FD :
  - Feasible distance (FD) is the metric of the best route to a destination, including the local link distance.
  - Feasible distance = advertised distance + local link distance (of the best path)
- Advertised Distance AD:
  - The distance of a route as advertised by the neighbor. It does not include the local link distance.
- Successor :
  - The neighbor with best distance to the destination.
- Feasible Successor :
  - The neighbor with second best distance to the destination, which meets this criteria: advertised distance should be less than the feasible distance (AD <FD)

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EIGRP - Neighbor Table

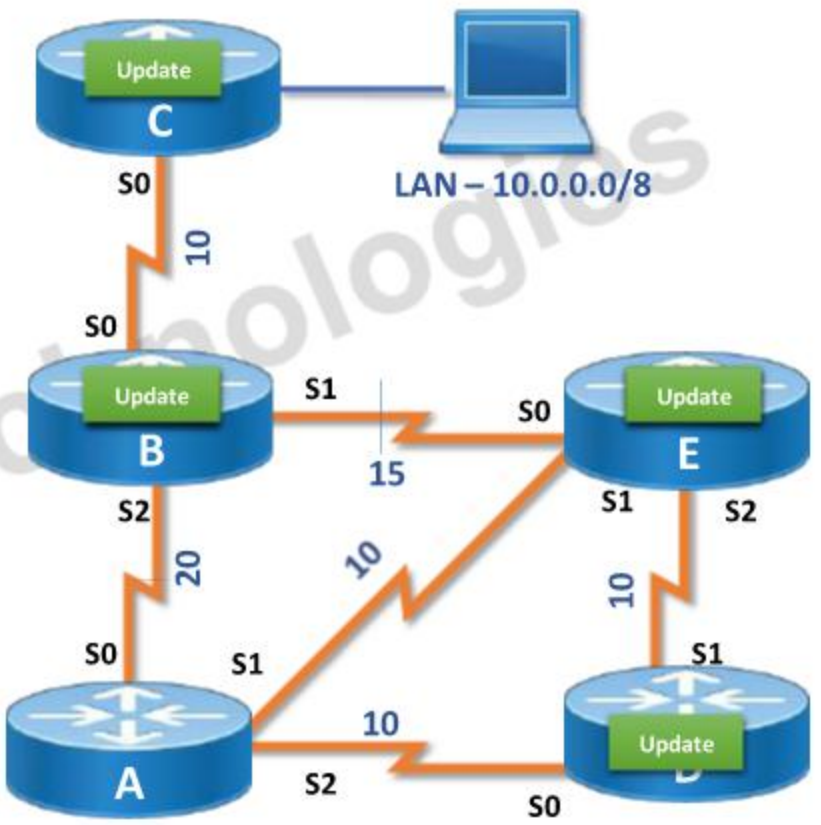
NEIGHBOR TABLE (Router A)	
Neighbor	Interface
B	S0
D	S2
E	S1



EIGRP - Topology Table

NEIGHBOR TABLE (Router A)	
Neighbor	Interface
B	S0
D	S2
E	S1

TOPOLOGY TABLE (Router A)					
Network	Neighbor	TD	AD	FD	
10.0.0.0/8	via B	30	10	30	S
	via E	35	25		FS
	via D	45	35		



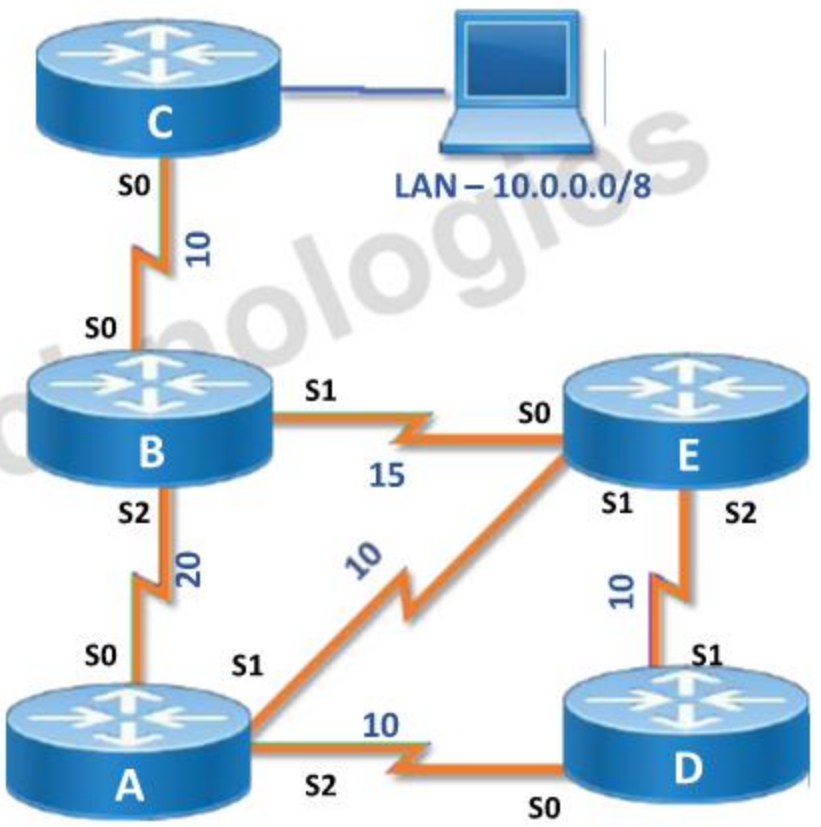
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EIGRP - Routing Table

NEIGHBOR TABLE (Router A)	
Neighbor	Interface
B	S0
D	S2
E	S1

TOPOLOGY TABLE (Router A)					
Network	Neighbor	TD	AD	FD	
10.0.0.0/8	via B	30	10	30	S
	via E	35	25		FS
	via D	45	35		

ROUTING TABLE (Router A)
D 10.0.0.0/8 [90/30] via B, 01:36, Serial0



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Autonomous System

- An autonomous system is a collection of networks or routers under a common administrative policy
- Autonomous systems are identified using numbers
- Autonomous system number ranges from 0 - 65535
  - Public : 1 – 64511
  - Private : 64512 – 65535

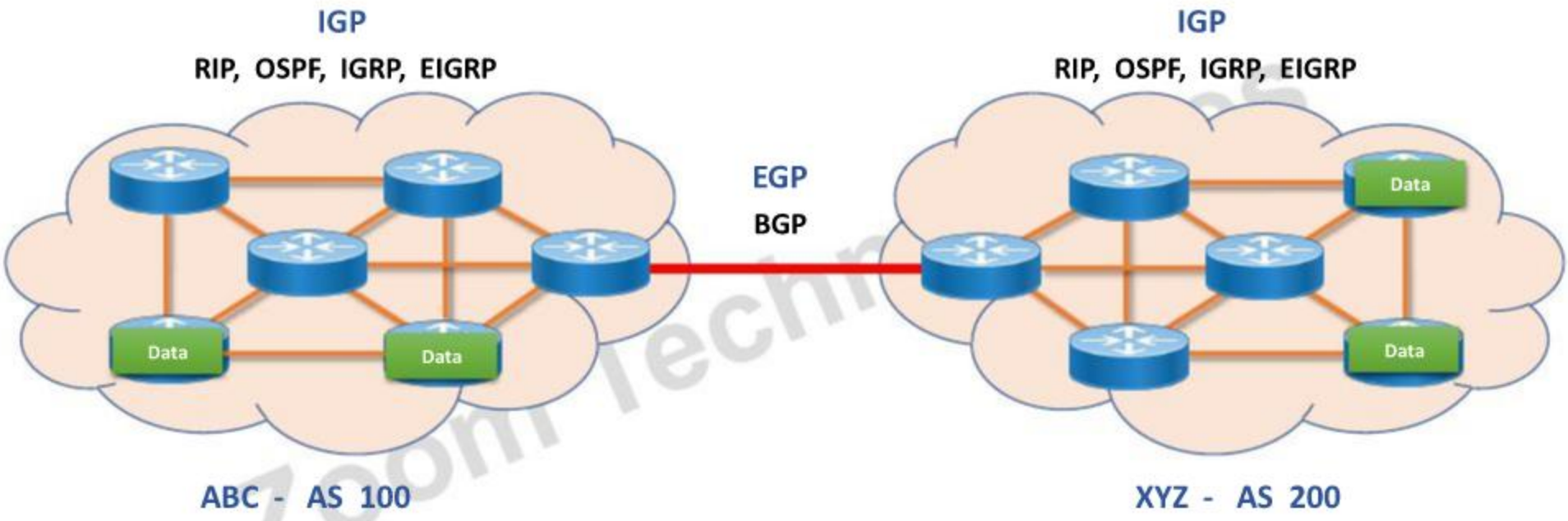
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Routing Protocol Classification

IGP	EGP
• Interior Gateway Protocol • Routing protocols used within an Autonomous system • Ex: RIP, IGRP, EIGRP, OSPF, IS-IS	• Exterior Gateway Protocol • Routing protocol used between different Autonomous systems • Ex: Border Gateway Protocol is extensively used as EGP

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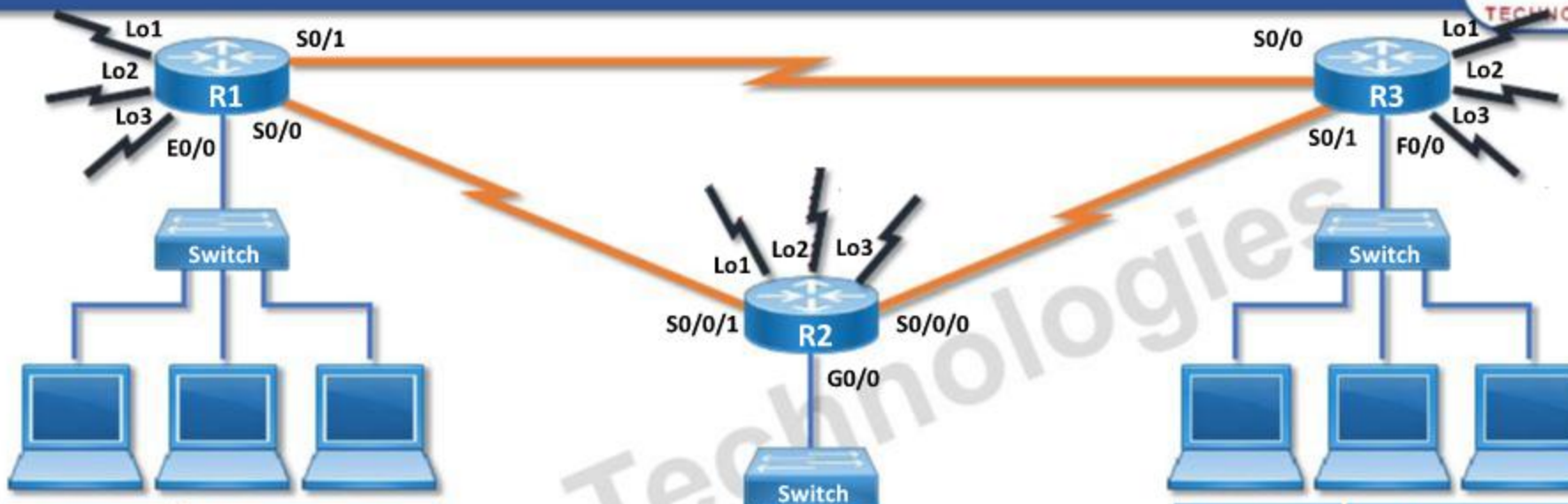
IGP and EGP



- IGPs operate within an autonomous system
- EGPs connect different autonomous systems

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CCIE CCNP CCNA

EIGRP



Interface	IP Address / Mask
E0/0	192.168.2.1/24
S0/0	172.16.0.1/16
S0/1	172.18.0.2/16
Lo1	16.1.1.1/24
Lo2	16.1.2.1/24
Lo3	16.1.3.1/24

Interface	IP Address / Mask	Interface	IP Address / Mask
G0/0	10.0.0.1/8	Lo1	17.1.1.1/24
S0/0/0	172.17.0.1/16	Lo2	17.1.2.1/24
S0/0/1	172.16.0.2/16	Lo3	17.1.3.1/24

Interface	IP Address / Mask
F0/0	192.168.3.1/24
S0/0	172.18.0.1/16
S0/1	172.17.0.2/16
Lo1	18.1.1.1/24
Lo2	18.1.2.1/24
Lo3	18.1.3.1/24

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CCIE CCNP CCNA
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Eigrp configuration and Verification Syntax

EIGRP configuration

- Router(config)# ip routing
- Router(config)# router eigrp <As no. >
- Router(config-router)# network < Network ID >

Verification

To check Routing Table

- Router # show ip route

To check Neighbor Table

- Router # show ip eigrp neighbor

To check Topology Table

- Router # show ip eigrp topology

Summarization

- Route summarization takes a set of contiguous networks or subnets and groups them together using a shorter subnet mask.
- The advantages of summarization are that it reduces the number of entries in the route table.

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OTHER EIGRP FUNCTIONS

- EIGRP supports Auto-summarization and Manual summarization.
- EIGRP support unequal-cost load-balancing
- EIGRP supports passive-interface

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EIGRP summarization

- EIGRP supports summarization at any location in the internetwork.
- By default EIGRP has auto-summarization enabled.
- Summarize the routes that are advertised through classfull network boundaries.

To disable auto-summarization

```
Router(config)#  router eigrp <As. no.>
Router(config-router)#  no auto-summary
```

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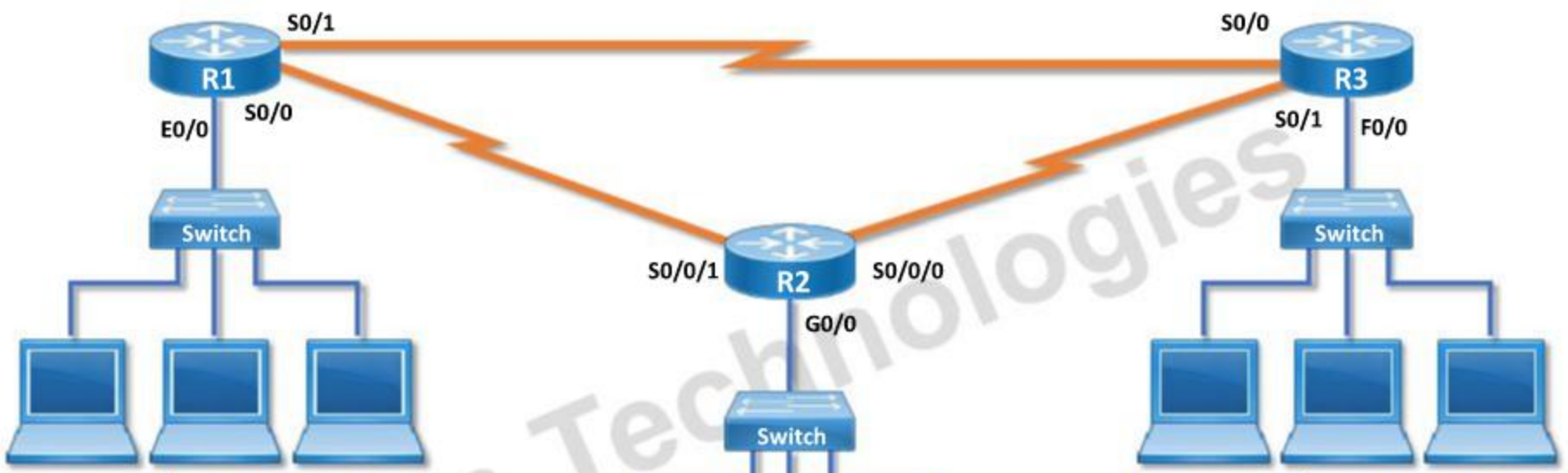
EIGRP Unequal Cost Load balancing

- Every routing protocol supports equal cost path load balancing.
- EIGRP also support unequal cost path load balancing.
- To configure unequal cost load balancing, next available paths should be feasible successors.
- Unequal cost load balancing can be configured by using "Variance"
- Default Variance value is 1 (Equal cost load balancing)

To configure variance

```
Router(config)# router eigrp  <As. no.>
Router(config-router)# variance  <1-128>
```

EIGRP variance



Interface	IP Address / Mask
E0/0	192.168.2.1/24
S0/0	172.16.0.1/16
S0/1	172.18.0.2/16

Interface	IP Address / Mask
F0/0	192.168.3.1/24
S0/0	172.18.0.1/16
S0/1	172.17.0.2/16

Interface	IP Address / Mask
G0/0	10.0.0.1/8
S0/0/0	172.17.0.1/16
S0/0/1	172.16.0.2/16

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EIGRP Passive interface

- The interface can be configured as passive , for stopping the hellos and Updates.
- The passive interface cannot send any hellos over the interface , but it can receive hellos.

To configure passive interface

Router(config)# router eigrp <As. no.>

Router(config-router)# passive-interface <interface type> <no.>



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Open Shortest Path First

- Link State Protocol
- Open standard
- Classless routing protocol
- Uses Dijkstra (Shortest Path First (SPF)) Algorithm
- Updates are sent through Multicast IP address 224.0.0.5 and 224.0.0.6
- Supports Triggered Updates and incremental updates
- Administrative distance is 110
- Metric = Cost = 10^8/Bandwidth in bps (CISCO)

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OSPF (contd..)

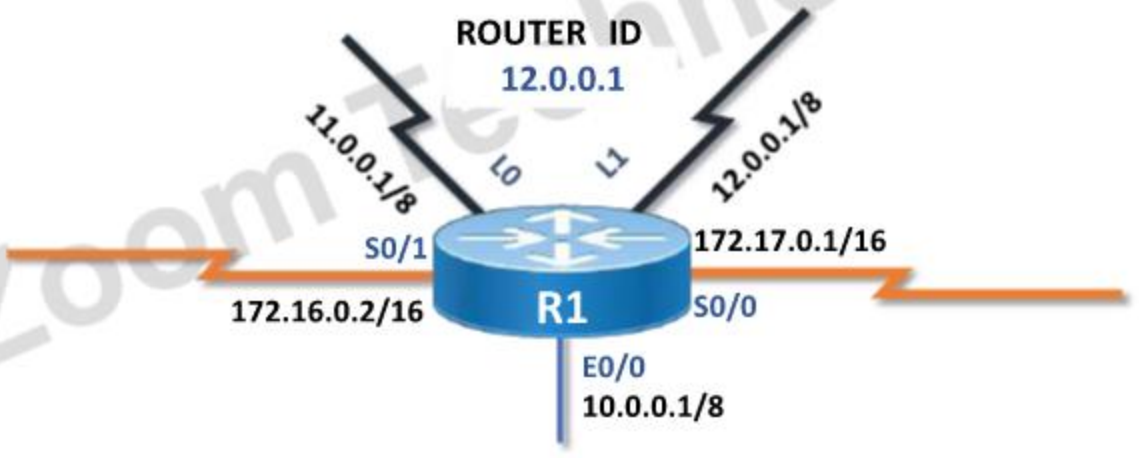
- Hello packets are sent every 10 seconds, Dead interval 40 sec
- OSPF sends updates (LSAs) when there is a change to one of its links
- LSAs are additionally refreshed every 30 minutes.
- Unlimited Hop Count
- Designed to scale and support large / Enterprise networks
- Hierarchical network design using Areas
- One area has to be designated as Area 0
- Area 0 is called the Backbone Area

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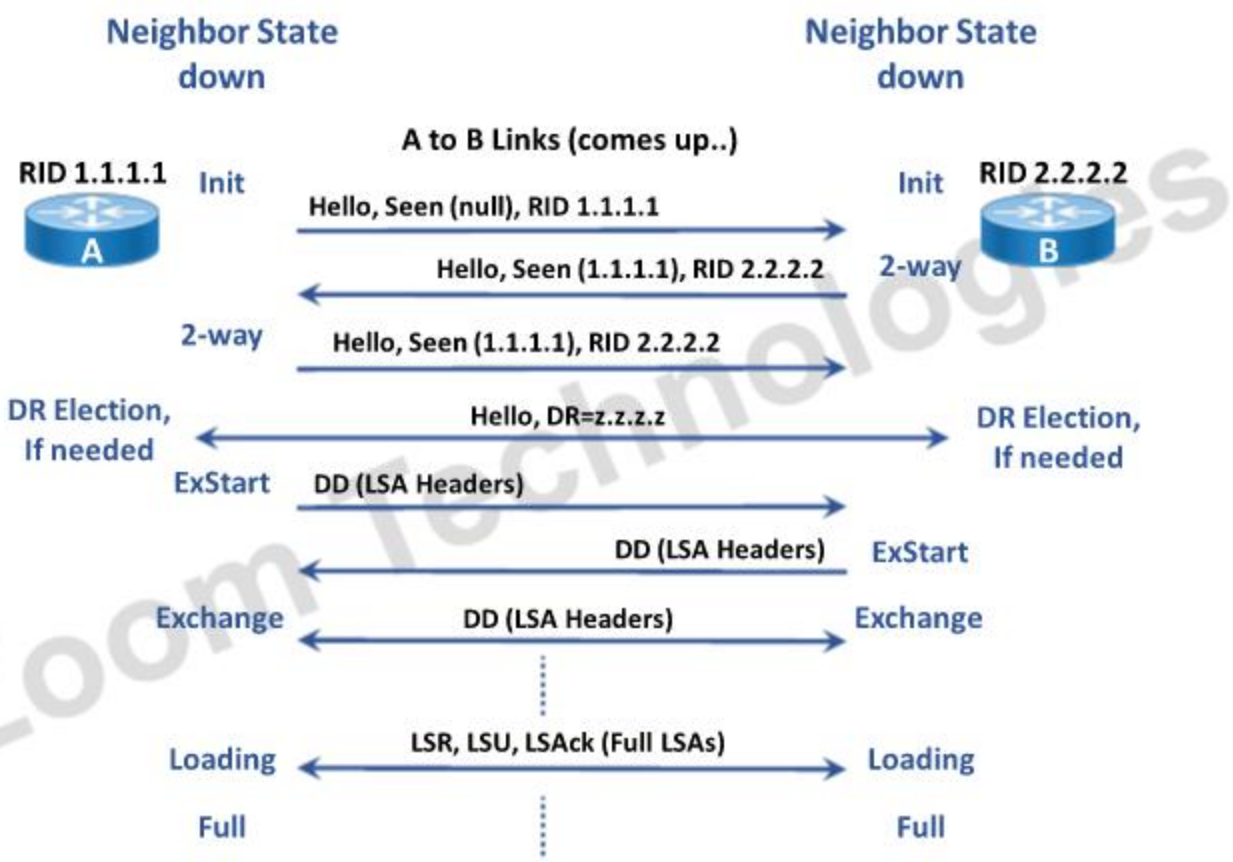
Router ID

- Router ID is used to identify the Router.
- The highest IP assigned to an active physical interface is the Router ID.
- If logical interface is configured then the highest IP assigned to a logical interface (loopback) is the Router ID.



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OSPF Neighbor States



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OSPF Terminology

- Neighbor
  - Routers that share a common link become neighbors.
  - Neighbors are discovered by Hello Packets.
  - To become neighbors the following should match
    - Area ID
    - Network ID and Subnet Mask
    - Hello and Dead Intervals
    - Authentication

- Adjacencies
  - Adjacencies are formed once neighbor relation is established.
  - In Adjacencies the database details are exchanged.

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OSPF Tables

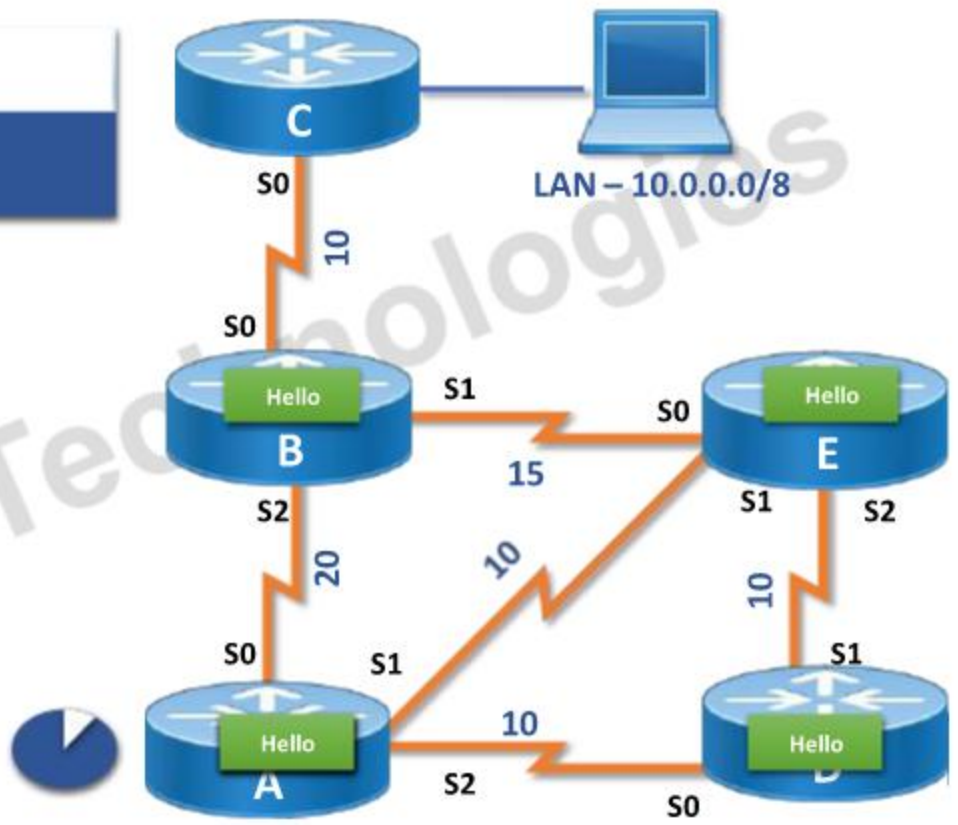
- It maintains three tables :
- Neighbor Table
  - Neighbor table contains information about the directly connected OSPF neighbors forming adjacency.
- Database Table
  - Database table contains information about the entire view of the topology with respect to each router.
- Routing Table
  - Routing table contains information about the best path calculated by the shortest path first algorithm in the database table.

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OSPF - Neighbor Table

NEIGHBOR TABLE (Router A)	
Neighbor	Interface
B	S0
D	S2
E	S1

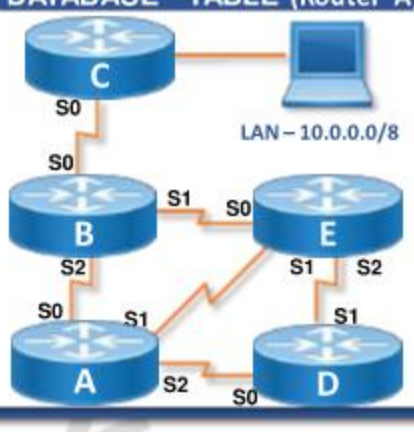


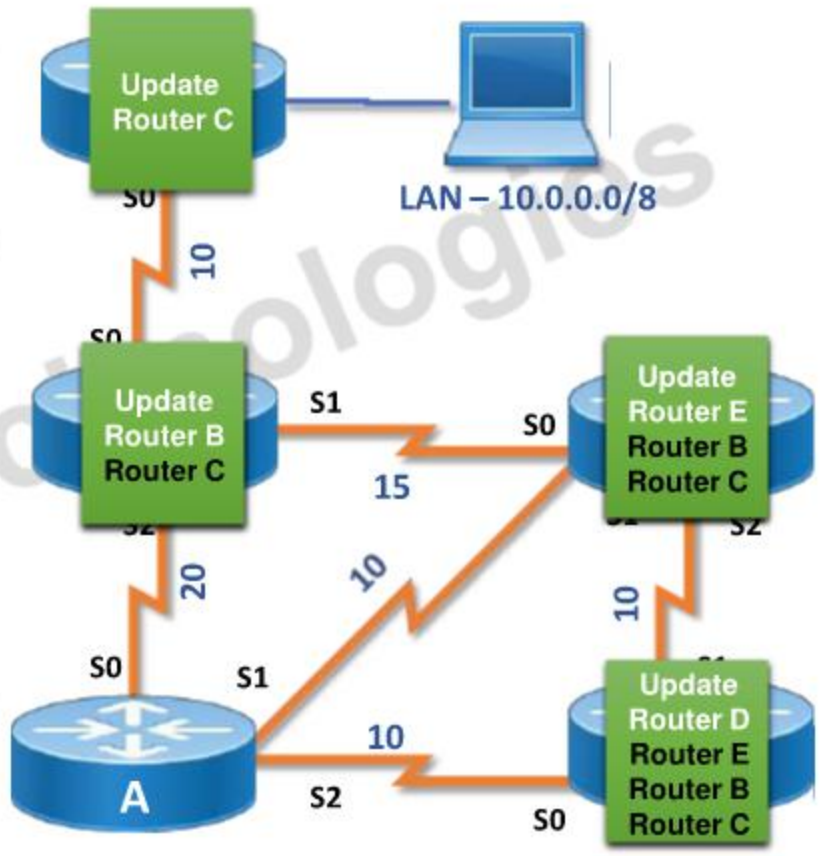
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OSPF - Database Table

NEIGHBOR TABLE (Router A)	
Neighbor	Interface
B	S0
D	S2
E	S1

DATABASE TABLE (Router A)





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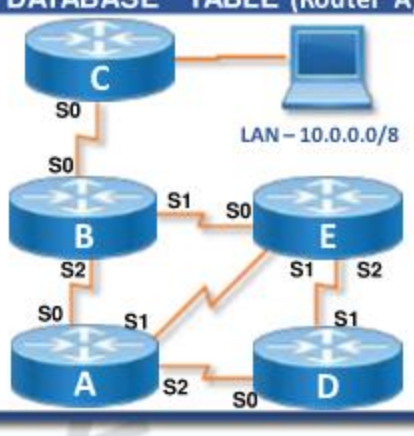
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OSPF - Database Table

NEIGHBOR TABLE (Router A)

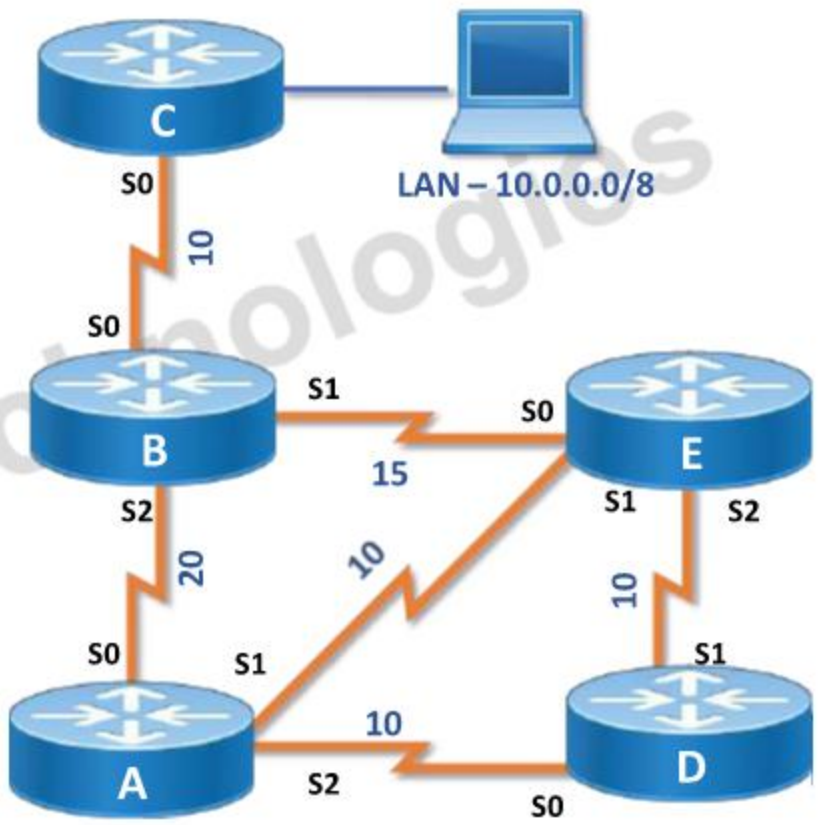
Neighbor	Interface
B	S0
D	S2
E	S1

DATABASE TABLE (Router A)



ROUTING TABLE (Router A)

O 10.0.0.0/8 [110/30] via B, 01:36, Serial0



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Wild Card Mask

- A wild card mask can be calculated using the formula :

  Global Subnet Mask

  – Subnet Mask

  Wild Card Mask

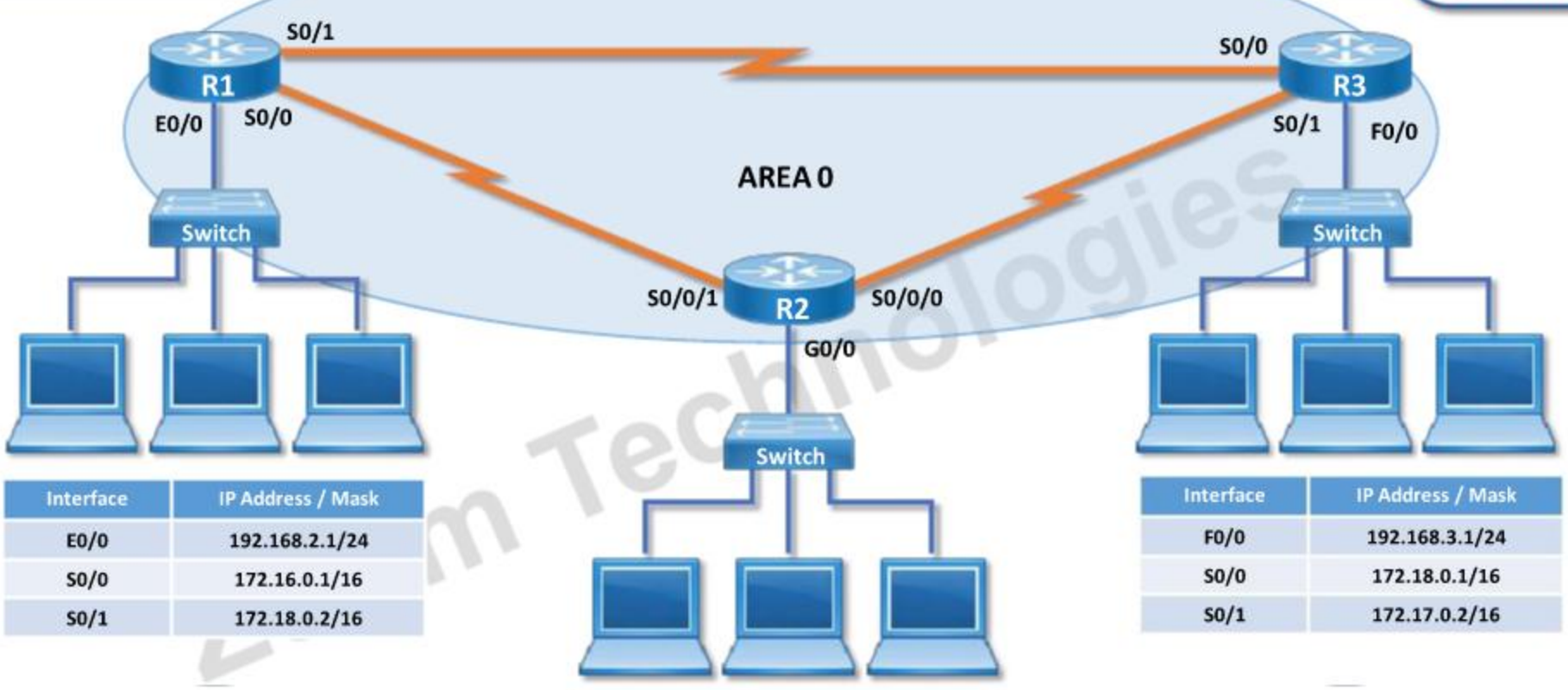
E.g.

	255.255.255.255		255.255.255.255
–	255.255.255. 0	–	255.255.255.240
	---		---
	0. 0. 0.255		0. 0. 0. 15

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OSPF Single Area



Interface	IP Address / Mask
E0/0	192.168.2.1/24
S0/0	172.16.0.1/16
S0/1	172.18.0.2/16

Interface	IP Address / Mask
F0/0	192.168.3.1/24
S0/0	172.18.0.1/16
S0/1	172.17.0.2/16

Interface	IP Address / Mask
G0/0	10.0.0.1/8
S0/0/0	172.17.0.1/16
S0/0/1	172.16.0.2/16

OSPF configuration and Verification syntax

OSPF configuration

- Router(config)# ip routing
- Router(config)# router ospf < Process ID >
- Router(config-router)# network < Network ID > <Wildcard mask > area <area ID >

Verification

To check Routing Table

- Router # show ip route

To check Neighbor Table

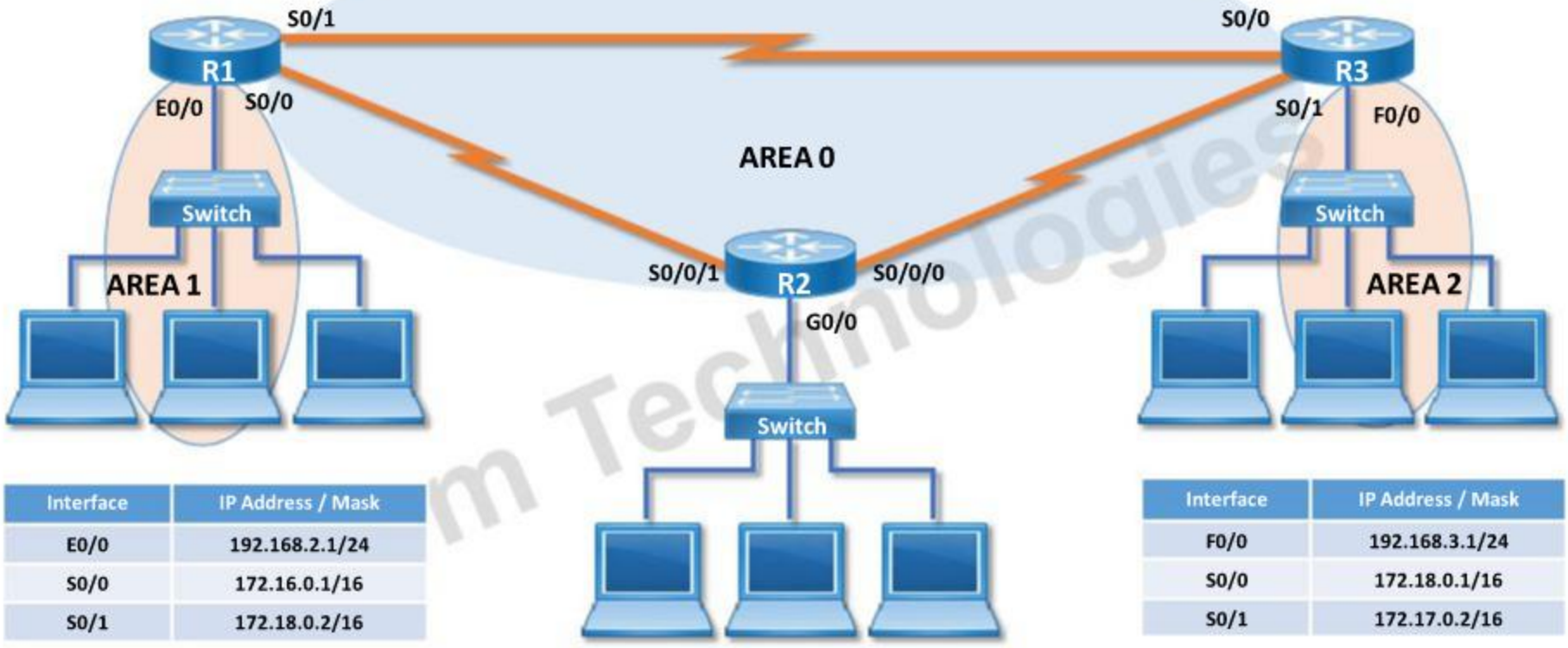
- Router # show ip ospf neighbor

To check Database Table

- Router # show ip ospf database

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Multi Area



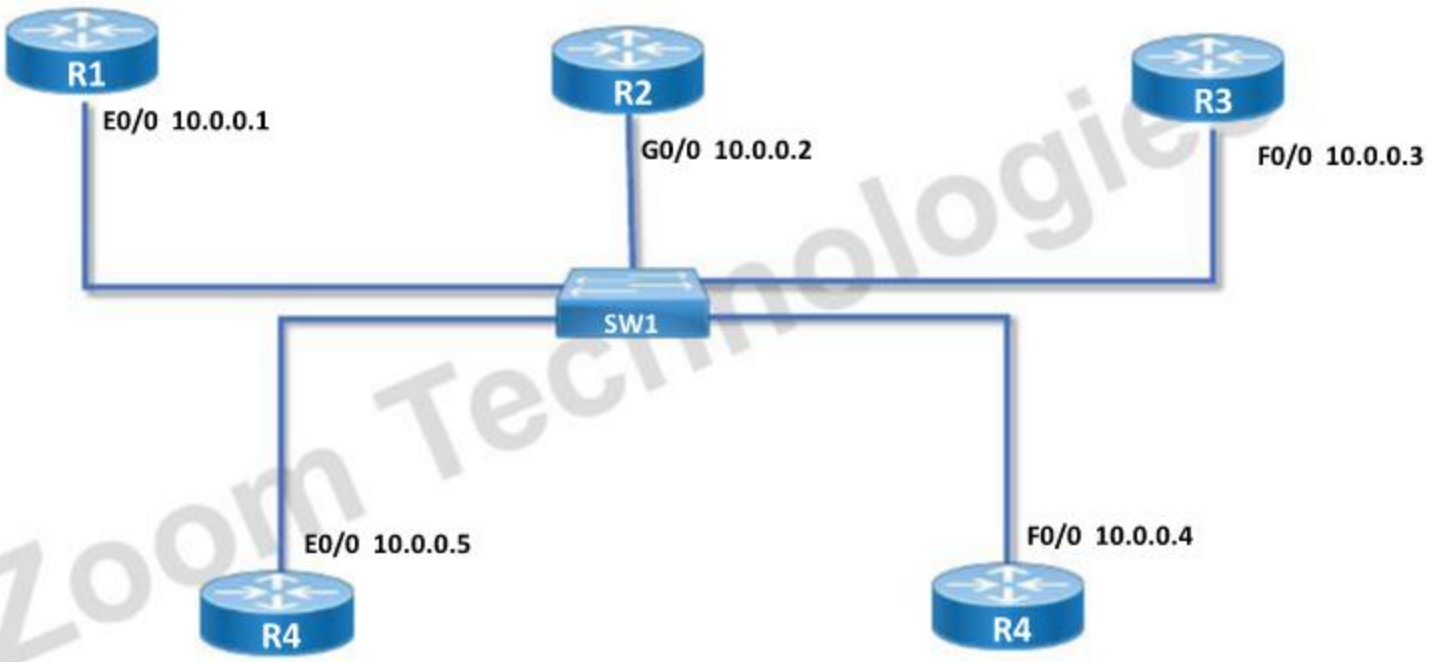
Interface	IP Address / Mask
E0/0	192.168.2.1/24
S0/0	172.16.0.1/16
S0/1	172.18.0.2/16

Interface	IP Address / Mask
G0/0	10.0.0.1/8
S0/0/0	172.17.0.1/16
S0/0/1	172.16.0.2/16

Interface	IP Address / Mask
F0/0	192.168.3.1/24
S0/0	172.18.0.1/16
S0/1	172.17.0.2/16

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OSPF in LAN



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DR and BDR

- Designated Router (DR)
  - Designated Router is elected when ever OSPF routers are connected to the same multi-access networks.
  - This is done to reduce the number of adjacencies formed.
  - If there is a change in topology the initial router will only update the DR and BDR and no other router. The DR in turn will update the remaining routers.
- Backup Designated Router (BDR)
  - This is a backup to the DR and will only receive updates but will not update the other routers.
  - If the DR goes down then the BDR will act as the DR.

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DR and BDR Elections

- DR and BDR Election is done by the Hello Packets
- The router with the highest OSPF priority will become the DR and the router with the second highest priority will become BDR
- On all routers the default priority is 1
- In that case, the router with the highest Router ID will become the DR and the Router with the second highest ID will become the BDR
- Multicast address used for updating
  - Other routers to DR → 224.0.0.6
  - DR to other routers → 224.0.0.5

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DR and BDR

To check DR/BDR status

To check DR/BDR Status

- Router # show ip ospf neighbor

To check the self status

- Router # show ip ospf interface ethernet < no. >

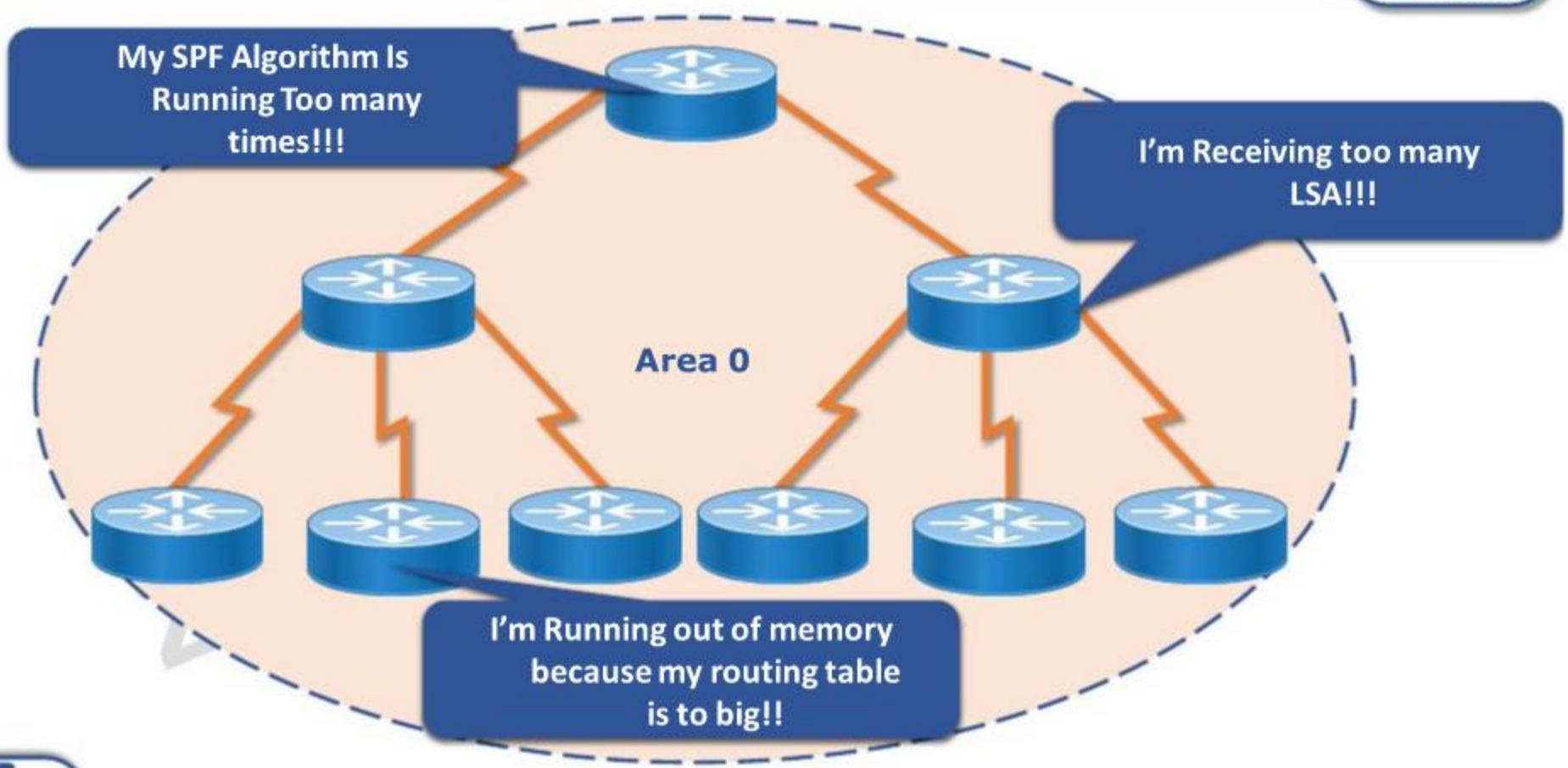
To change the priority

- Router(config) # interface ethernet < no. >
- Router(config-if) # ip ospf priority < priority >

For Election process

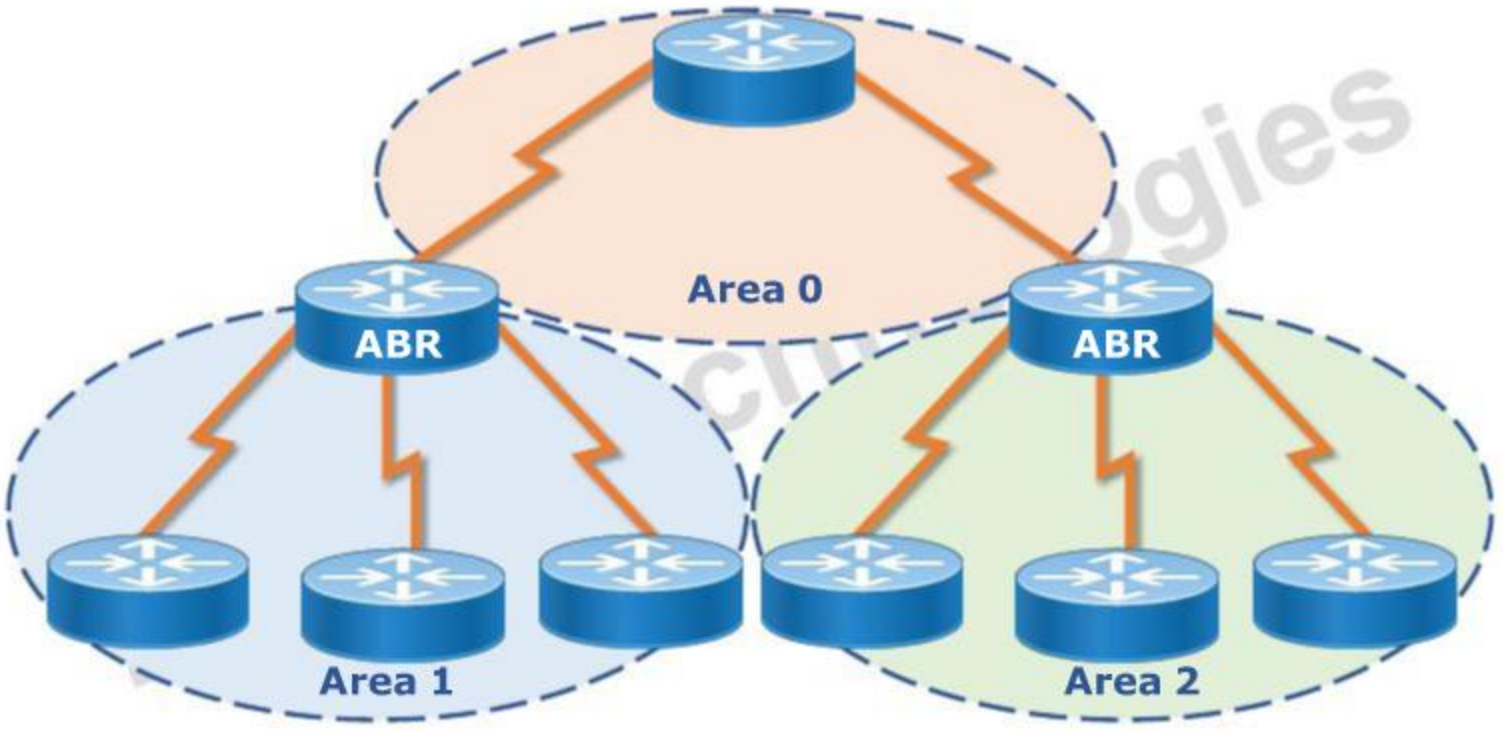
- Router # clear ip ospf process

OSPF Multi Area



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Issue of Maintaining of large OSPF network



ABR and ASBR

- **ABR (Area Border Router)**

  An OSPF Router with interfaces connected to the backbone area and to other area

- **ASBR (Autonomous System Border Router)**

  A router that exchanges routing information with routers belonging other AS (Autonomous System)

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Types of LSAs

LSA Types	Name
1	Router LSAs
2	Network LSAs
3	Summary LSAs

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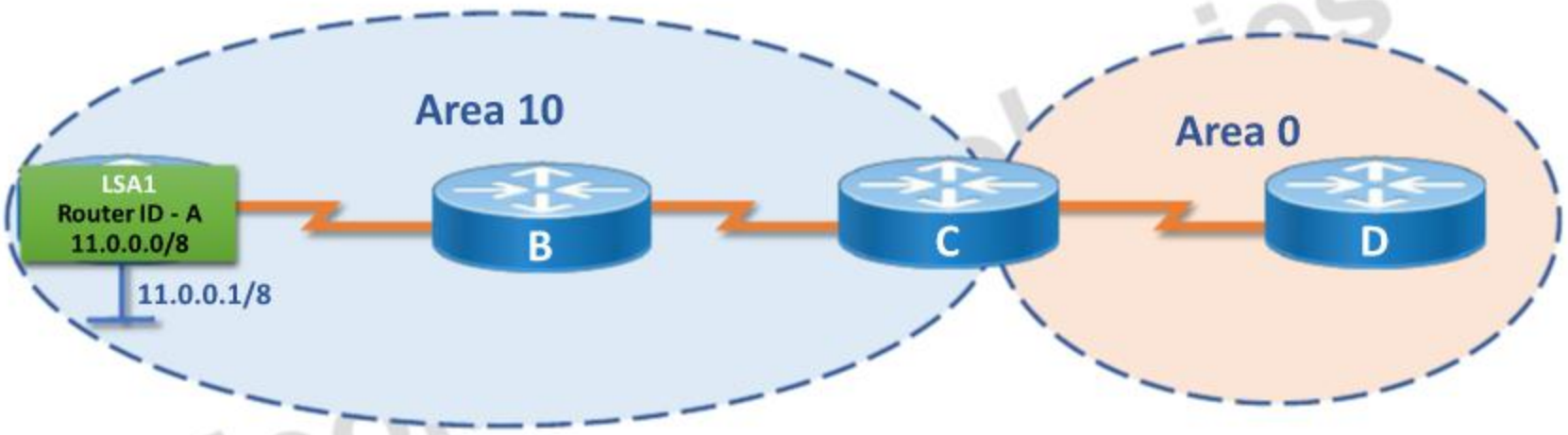
LSA Type - 1

- One Router LSA (type 1) for every router in an area
  - Includes list of directly attached links
  - Each link identified by IP prefix and link type
- Identified by the router ID of the originating router
- Floods within its area only; does not cross the ABR

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LSA Type - 1



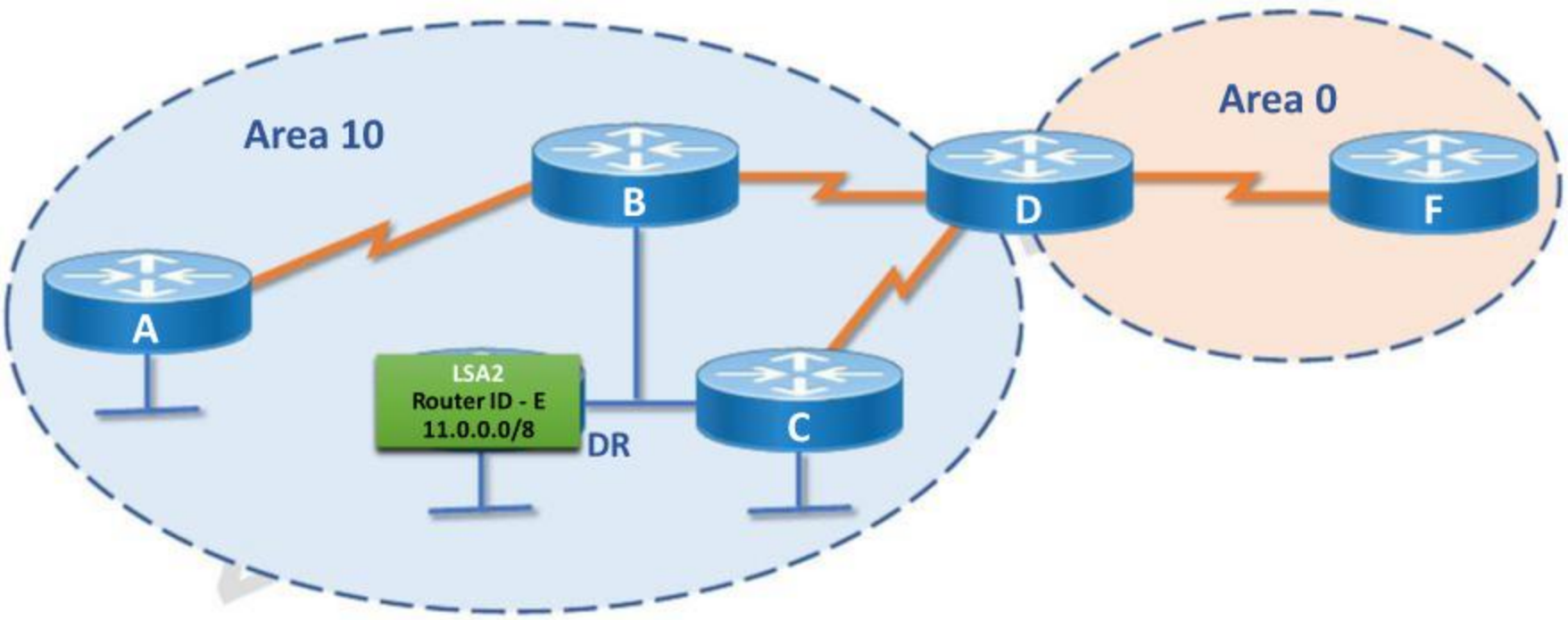
LSA Type - 2

- One Network (type 2) LSA for each transit broadcast or NBMA network in an area
  Includes Network ID, subnet mask and list of attached routers on that transit link
- Advertised by the DR of the transit network
- Floods within its area only; does not cross ABR

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LSA Type - 2



LSA Type - 3

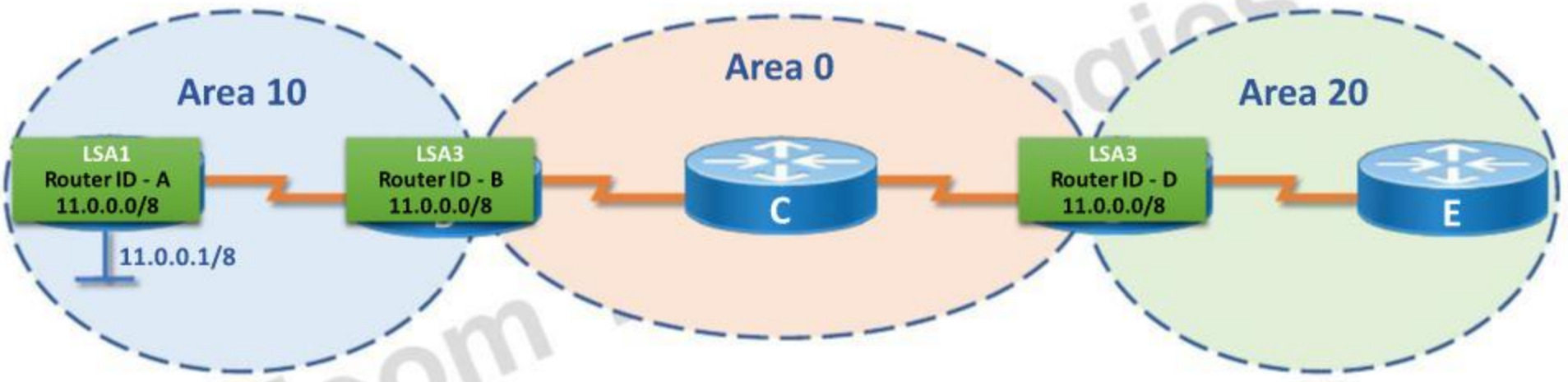
- Type 3 LSAs are used to flood network information to areas outside the originating area (inter-area)

  contains network ID and subnet mask
- Advertised by the ABR of originating area
- Regenerated by subsequent ABRs to flood throughout the autonomous system.
- By default, routes are not summarized and there is one type 3 LSA for every subnet

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LSA Type - 3



Disadvantages of OSPF

- Consumes More Memory and CPU processing time
- Complex configuration

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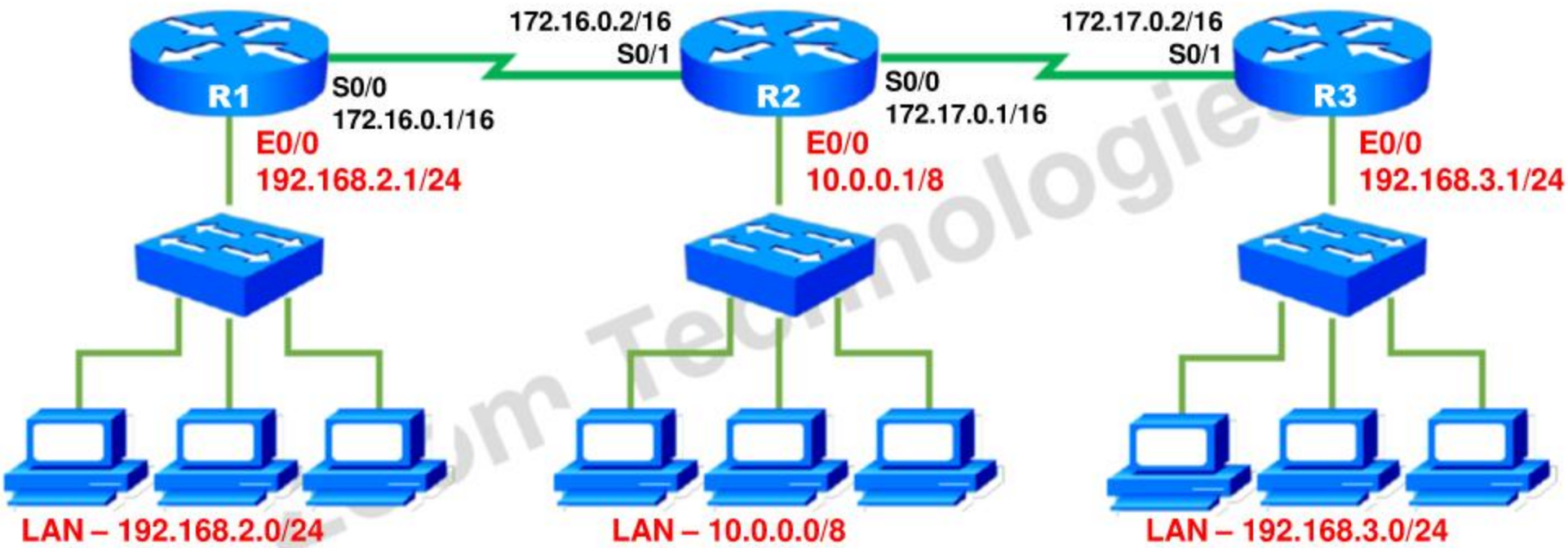
Access Control List

- Access Control List provides network security.
- It provides layer 3 and layer 4 security.
- Controls the flow of traffic from one network to another.
- Filters IP Packets (Packet Filtering Firewall)

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ACL - Network Diagram



192.168.2.10 should not communicate with 10.0.0.0 network

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Terminology

- Deny : Blocking a network/subnet/host/service.
- Permit : Allowing a network/subnet/host/service.
- Source Address : The address from where the request starts.
- Destination address : The address where the request ends.
- Inbound : Traffic coming into the interface.
- Outbound : Traffic going out of the interface.

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Terminology

- Protocols : IP (Internet Protocol)
  - TCP (Transmission control protocol)
  - UDP (User datagram protocol)
  - ICMP (Internet control messaging protocol)
- Operators :
  - eq (equal to)
  - neq (not equal to)
  - lt (less than)
  - gt (greater than)
- Services : HTTP (80), FTP (20,21), TELNET (23), DNS (53), DHCP (67,68)

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Wildcard Mask

- It's the inverse of the subnet mask, hence is also called as inverse mask.
- A bit value of 0 indicates MUST MATCH (Check Bits).
- A bit value of 1 indicates IGNORE (Ignore Bits).
- Wildcard Mask for a host is 0.0.0.0
- Wildcard Mask for Class A network is 0.255.255.255
- Wildcard Mask for Class B network is 0.0.255.255
- Wildcard Mask for Class C network is 0.0.0.255

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Wild Card Mask

- A wild card mask can be calculated using the formula :

  Global Subnet Mask

  – Subnet Mask

  Wild Card Mask

E.g.

	255.255.255.255	255.255.255.255
–	255.255.255. 0	– 255.255.255.240
	---	---
	0. 0. 0.255	0. 0. 0. 15

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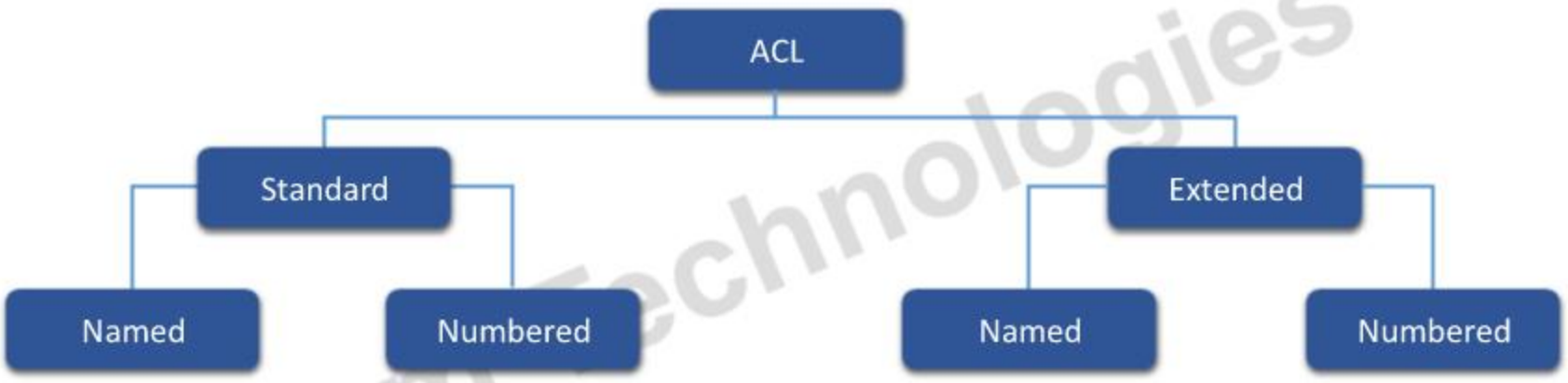
Working of Access Control List

- Works in a sequential order from top to bottom.
- If a match is found it does not check further.
- There should be at least one permit statement.
- An implicit deny blocks all traffic by default when there is no match (an invisible statement).
- New entries are automatically added to the bottom.
- Can have one access-list per interface per direction.
- Removing of specific statement in a numbered access-lists is not possible.

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Types of Access-List



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Standard Access List

- The access-list number range is 1 – 99.
- Can filter a network, subnet or host.
- Two way communication is stopped.
- All services are either blocked or allowed.
- Filters traffic based only on the source address.
- Implemented closest to the destination. (Guideline)

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Standard Access Control List Configuration

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Creation of Standard Access List

```
Router(config)# access-list <acl no> <permit/deny> <source address>
                <source wildcard mask>
```

Implementation of Standard Access List

```
Router(config)# interface <interface type> <interface no>
Router(config-if)# ip access-group <number> <out/in>
```

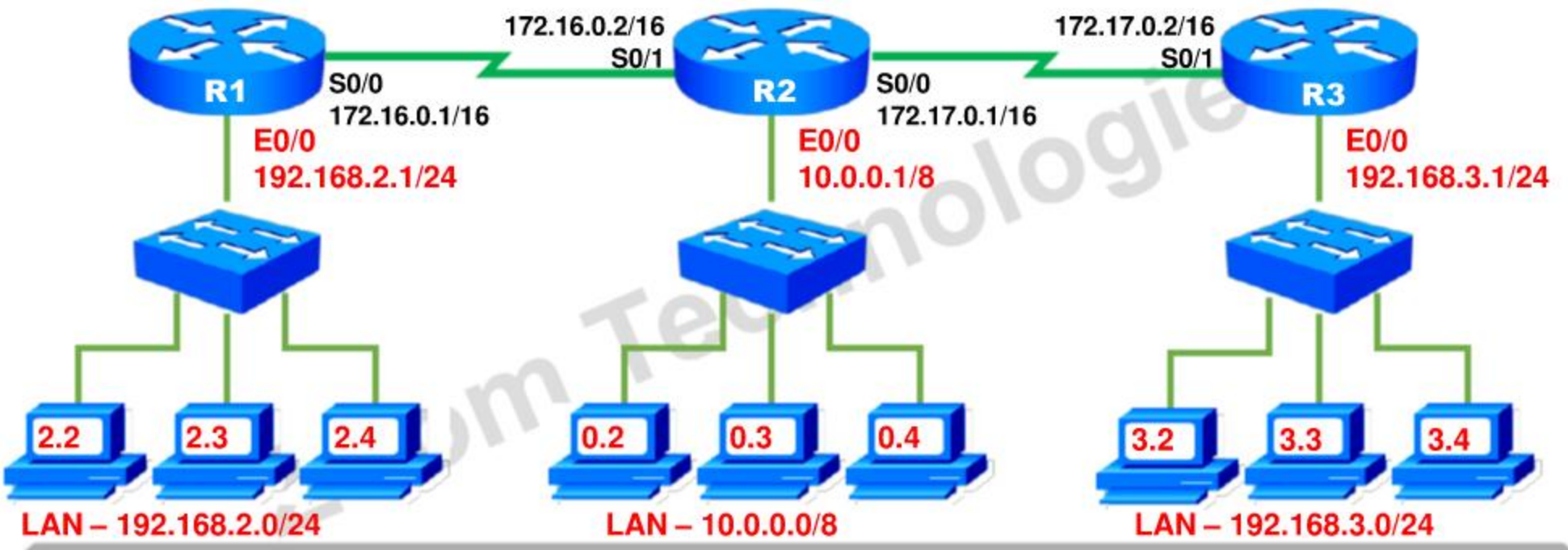
Verification

```
Router# Show access-list
```

CCIE CCNP CCNA

Standard ACL - Network Diagram

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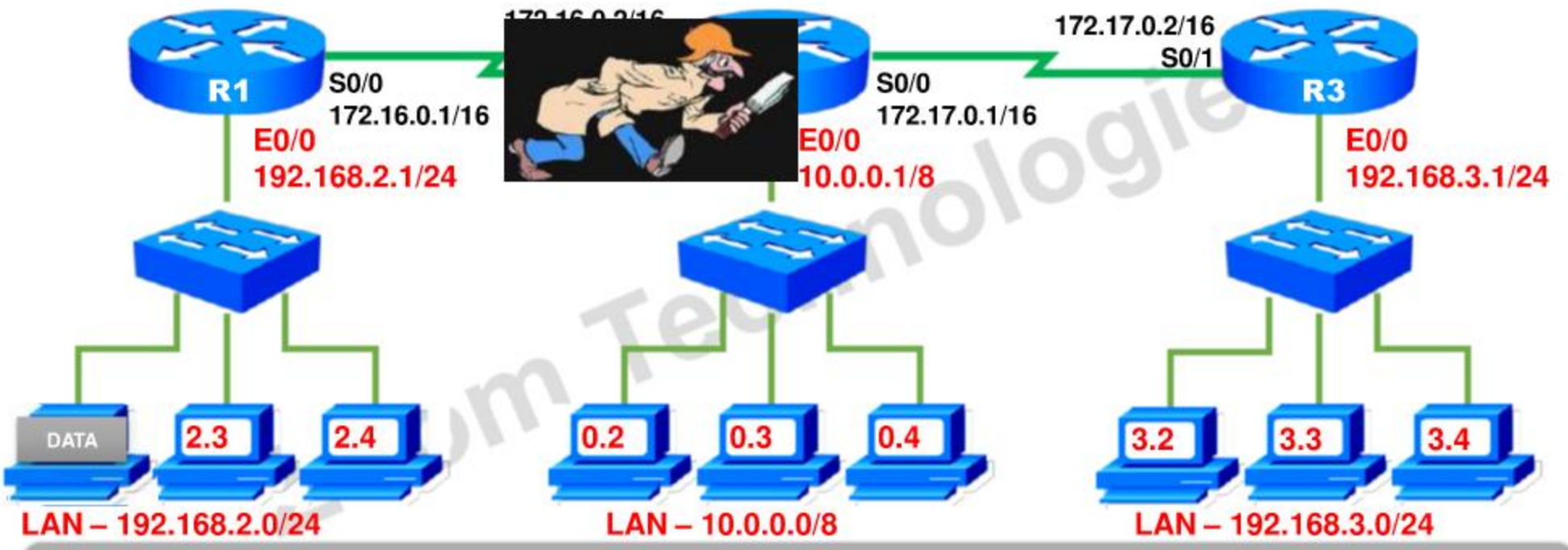


192.168.2.2 and 192.168.2.3 should not communicate with 10.0.0.0 network

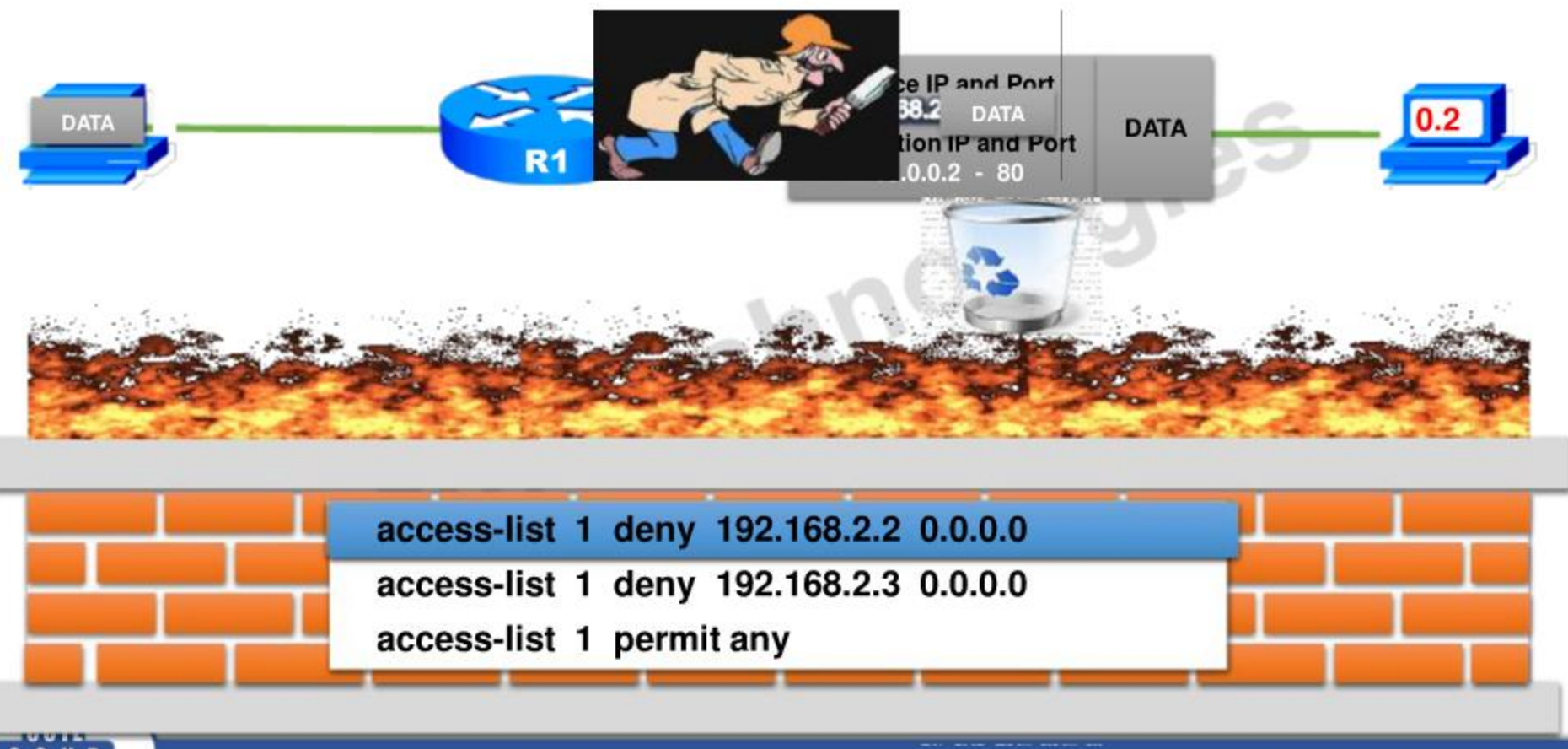
CCIE CCNP CCNA

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How does a Standard ACL work ?

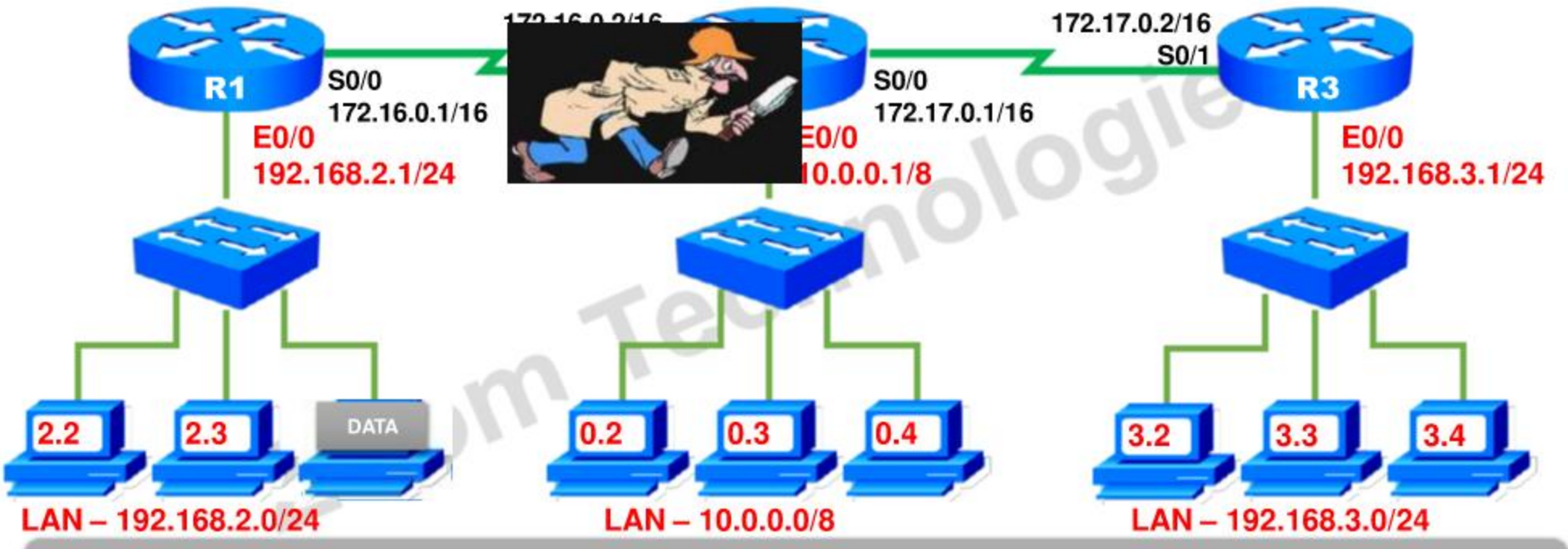


How does a Standard ACL work ?

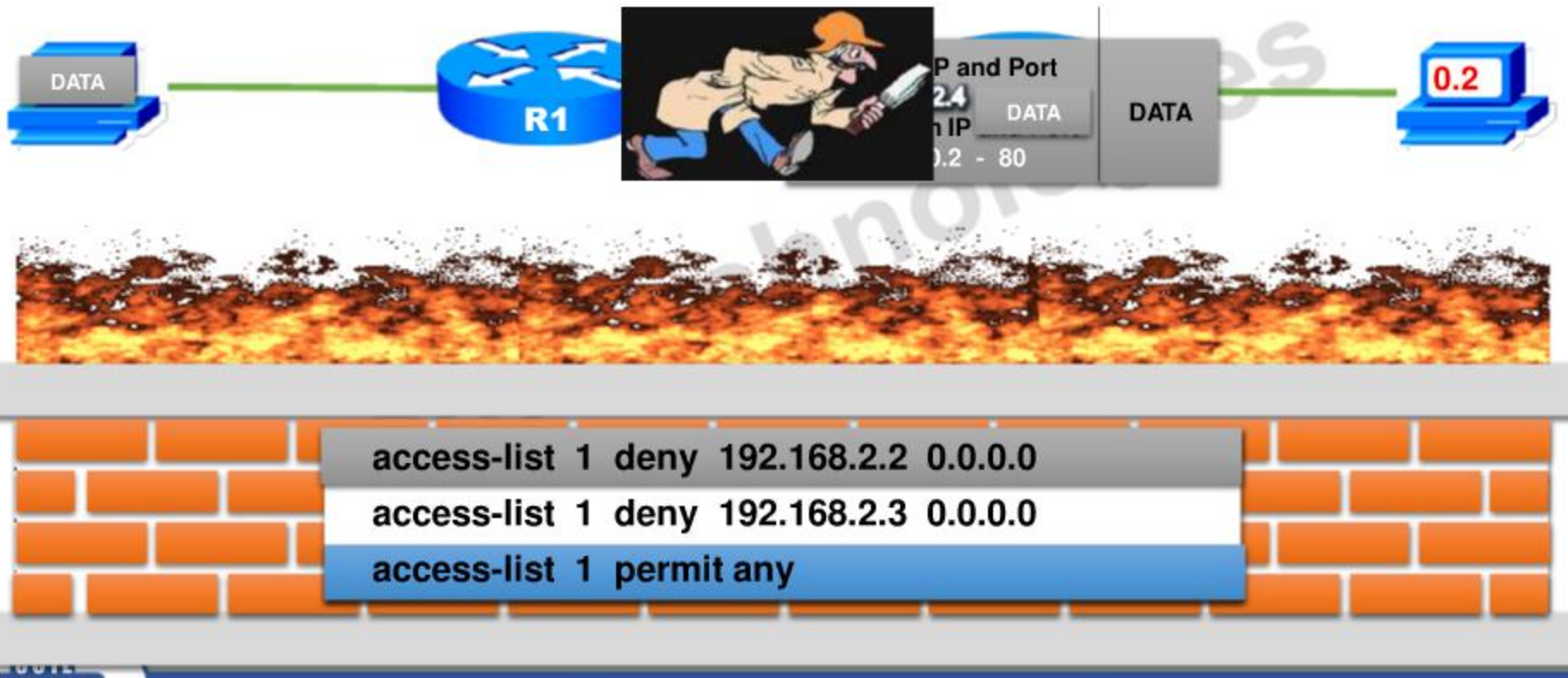


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How does a Standard ACL work ?



Example of a standard access list



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Extended Access List

- The access-list number range is 100 – 199.
- Can filter a network, subnet, host and service.
- One way communication is stopped.
- Selected services can be blocked or allowed.
- Filters traffic based on the source address, destination address and service.
- Implemented closest to the source. (Guideline)

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Extended Access Control List configuration

Creation of Extended Access List

```
Router(config)# access-list <acl no> <permit/deny> <protocol>
  <source address> <source wildcard mask>
  <destination address> < destination wildcard mask>
  <operator> <service>
```

Implementation of Extended Access List

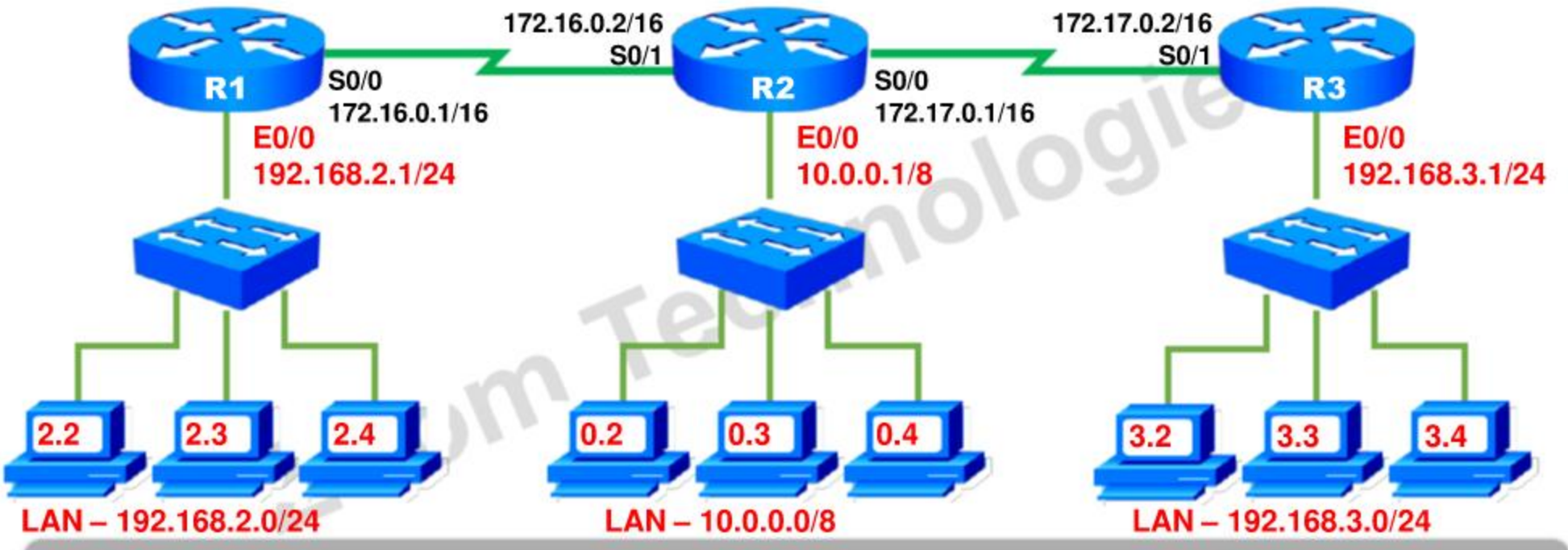
```
Router(config)# interface <interface type> <interface no>
Router(config-if)# ip access-group <number> <out/in>
```

Verification

```
Router# Show access-list
```

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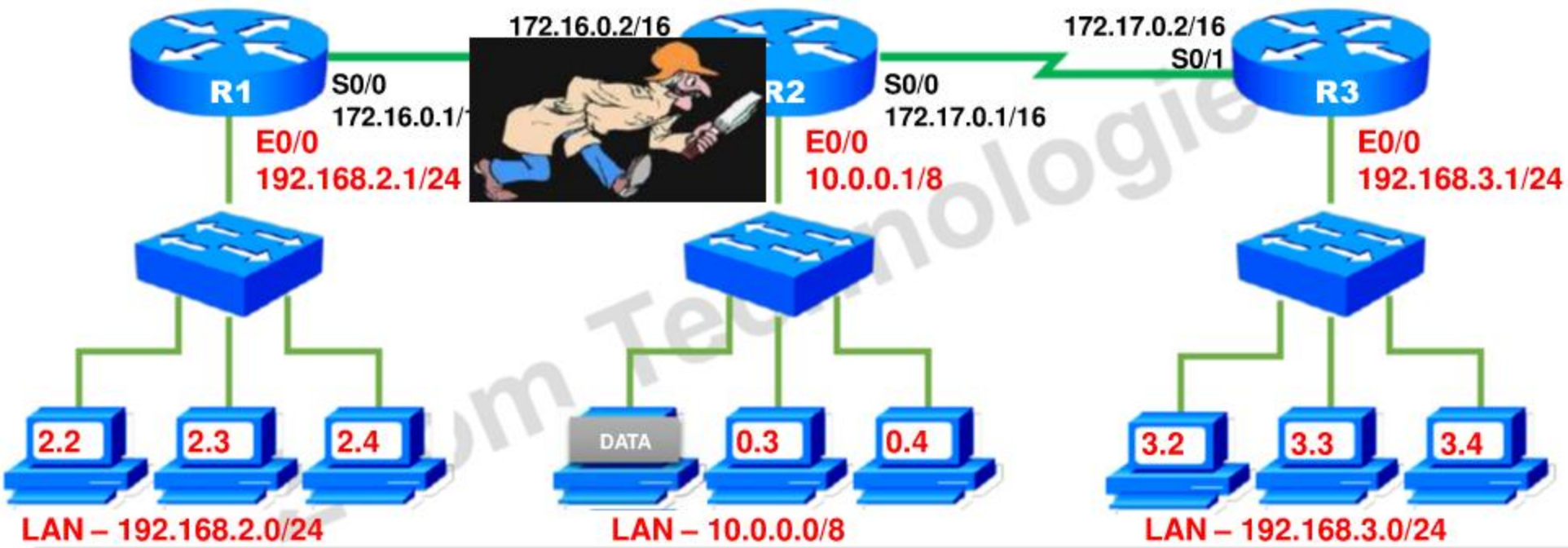
Extended ACL - Network Diagram



10.0.0.0 should not access 192.168.3.2 (Web Service)

10.0.0.0 should not ping 192.168.2.0 Network

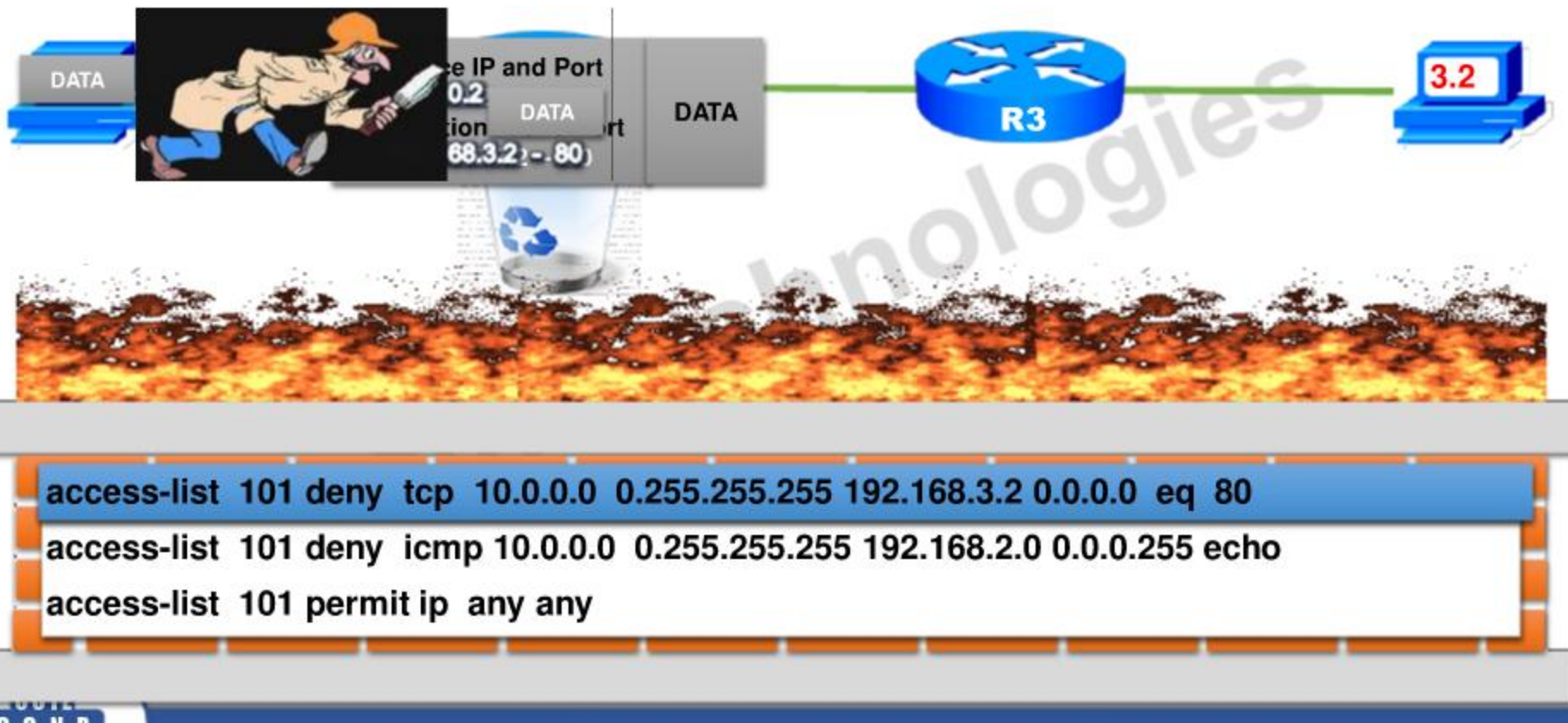
How does an Extended ACL work ?



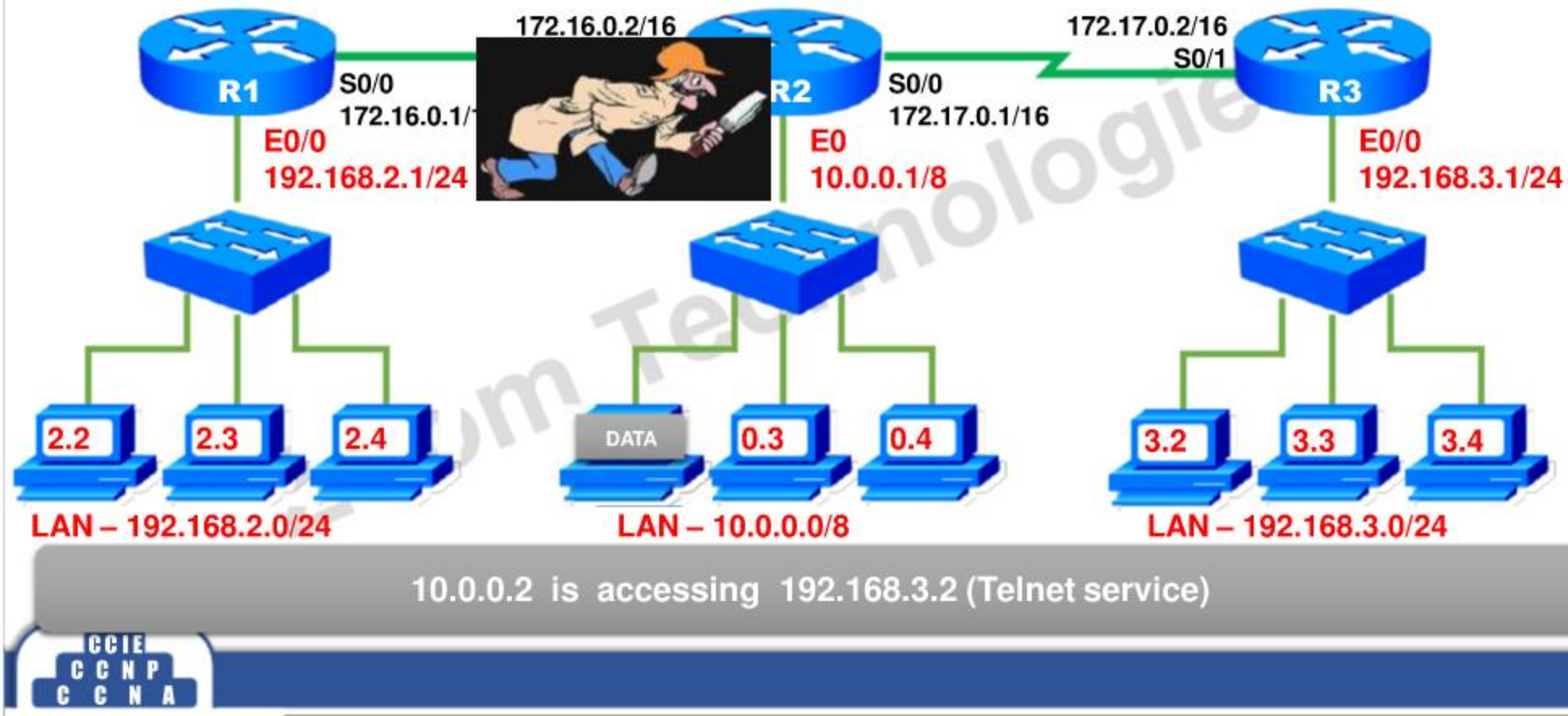
10.0.0.2 is accessing 192.168.3.2 (Web service)

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How does an Extended ACL work ?

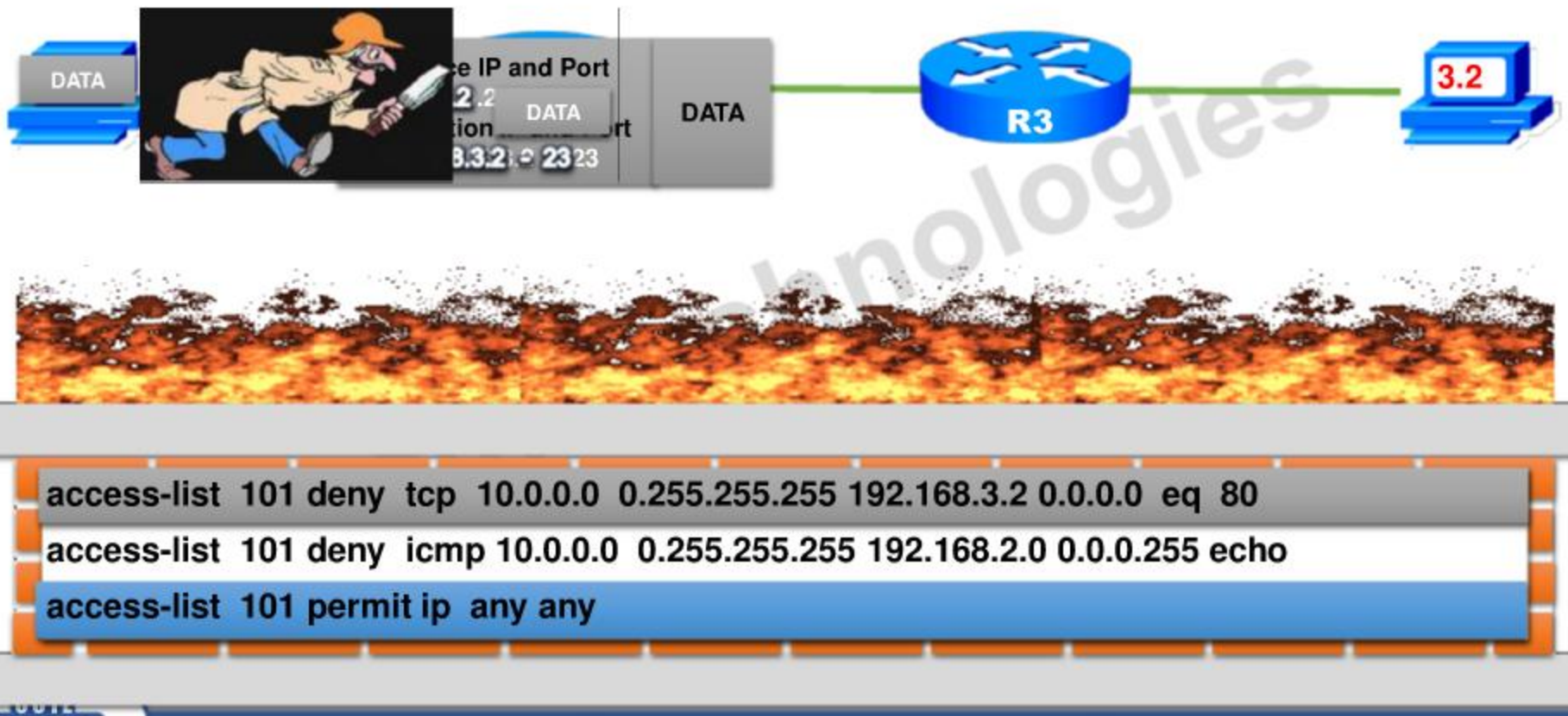


How does an Extended ACL work ?



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How does an Extended ACL work ?





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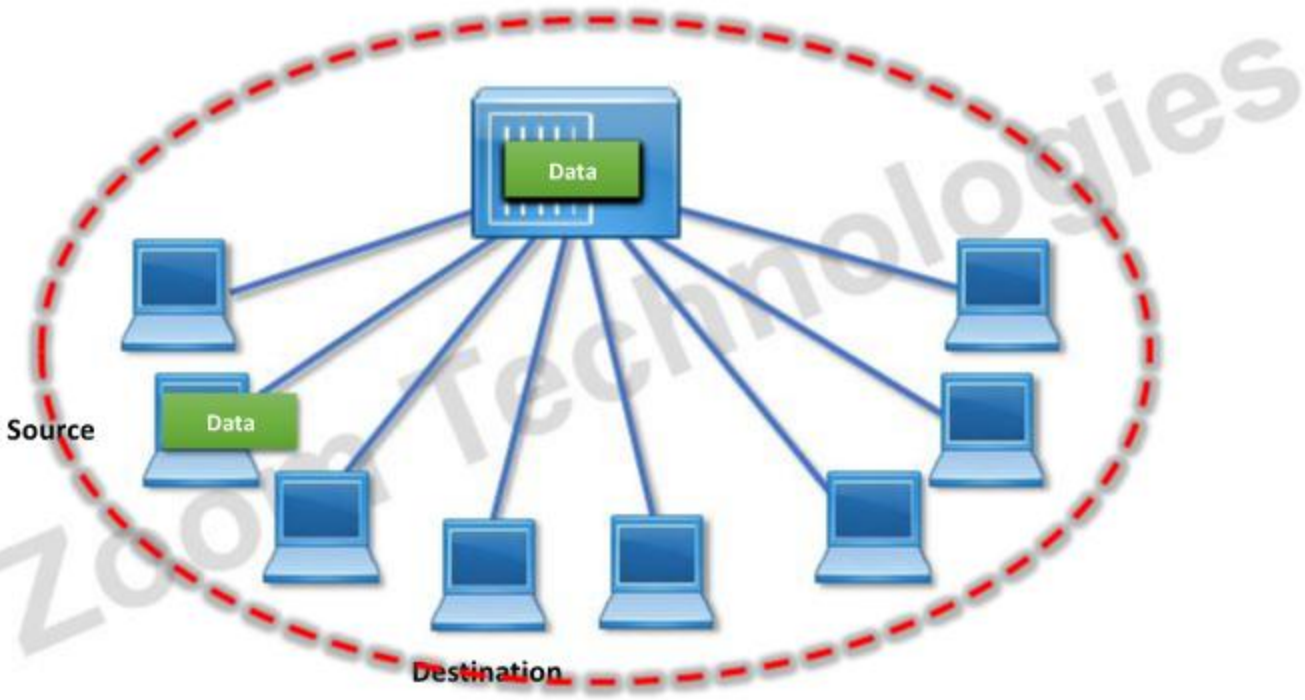
Broadcast and Collision Domain

- **Broadcast Domain: A broadcast domain is a set of network devices for which a broadcast frame sent by one device is received by all other devices in that LAN segment.**

- **Collision Domain: A collision domain is a set of network devices for which a frame sent by one device could result in a collision with a frame sent by any other device in the same LAN segment.**

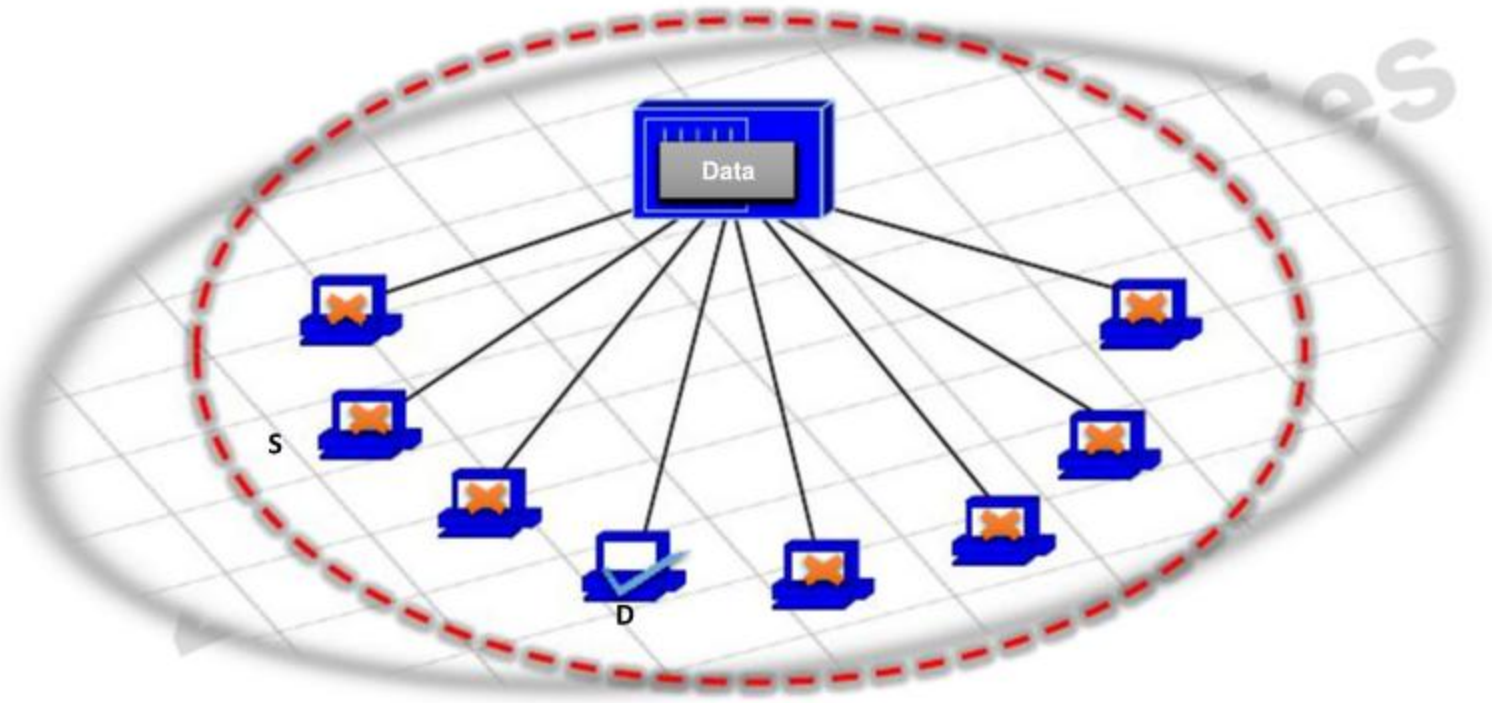
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Functions of HUB

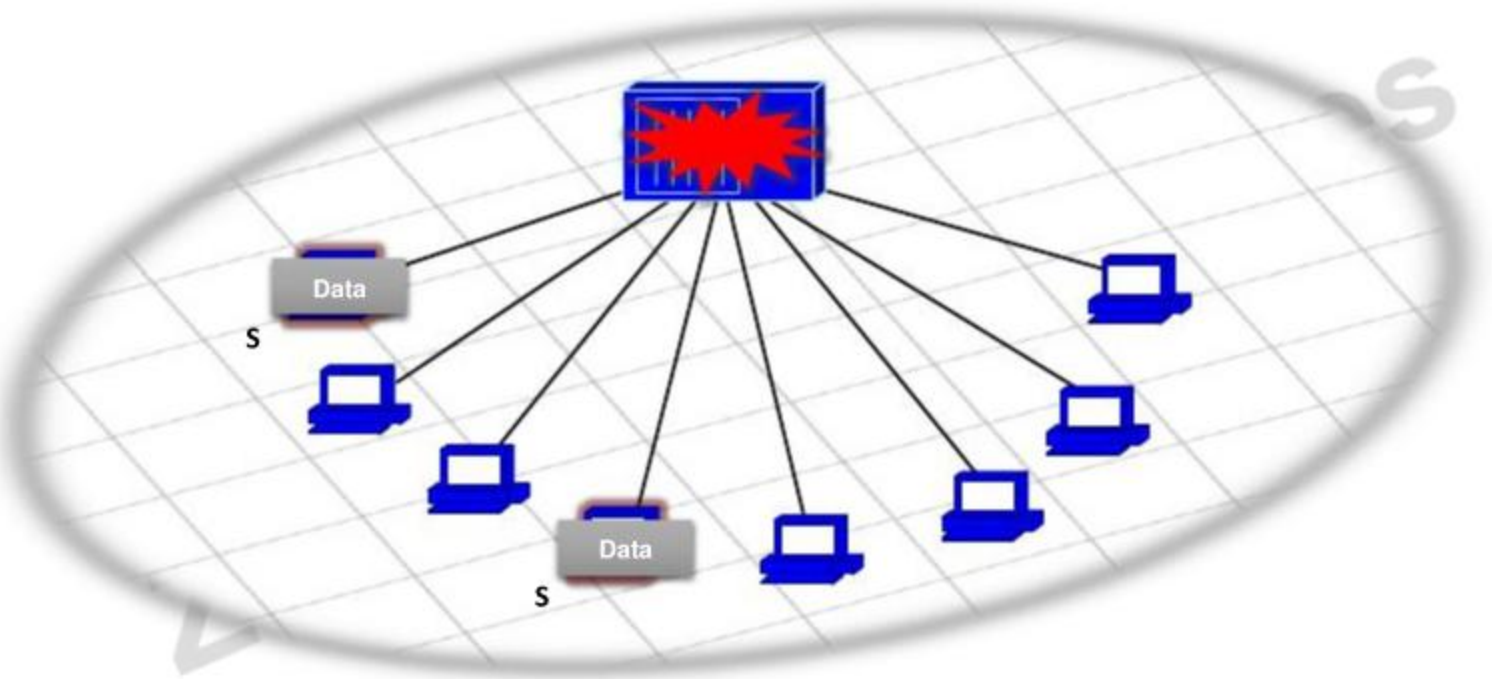


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Functions of HUB

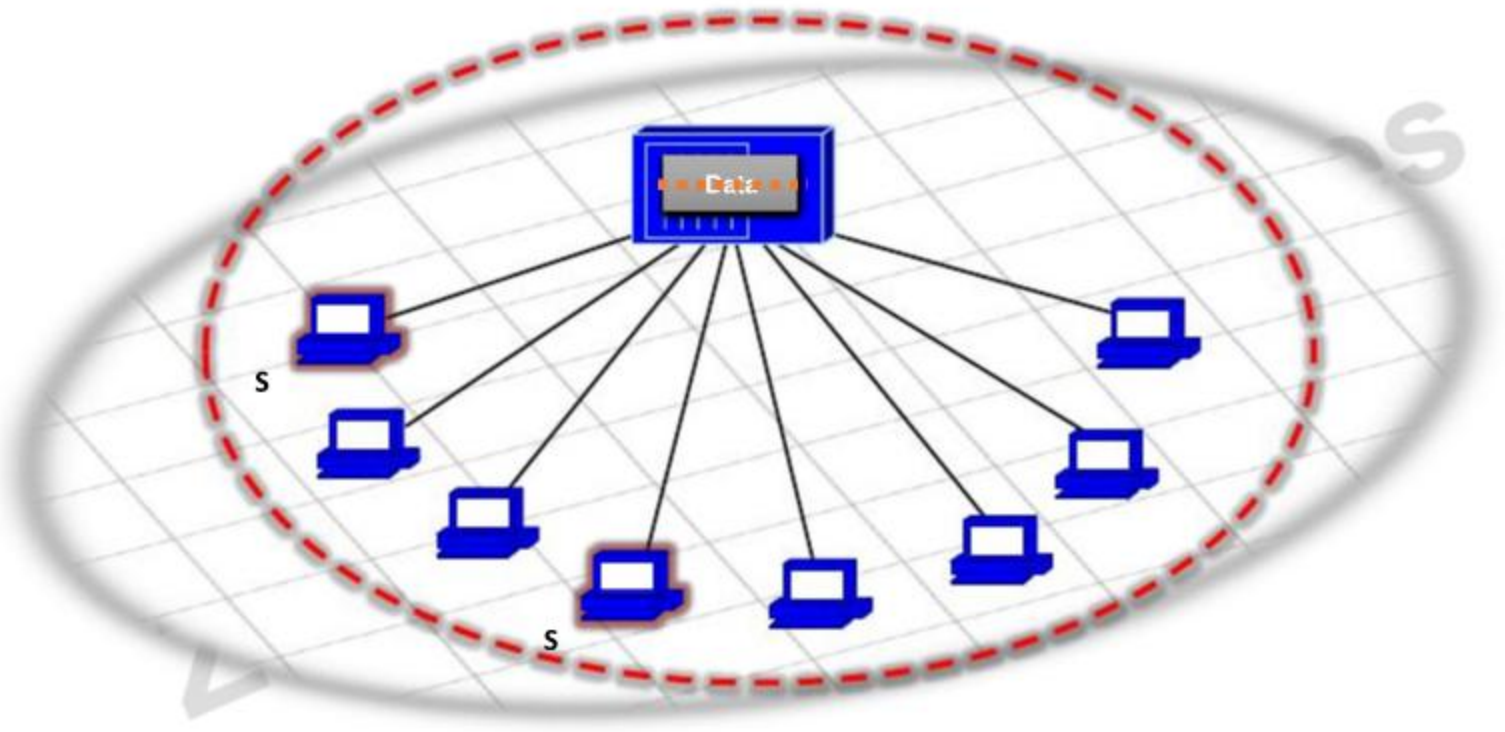


Functions of HUB

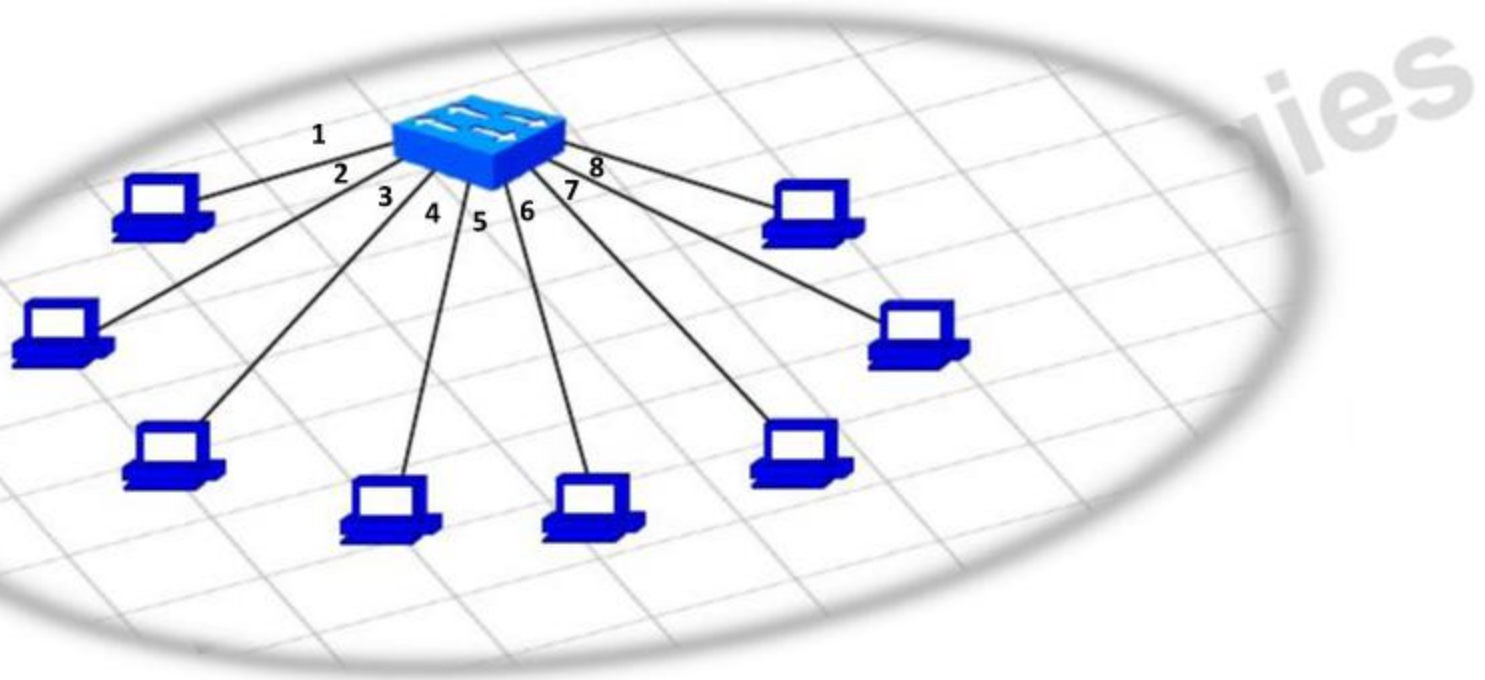


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Functions of HUB

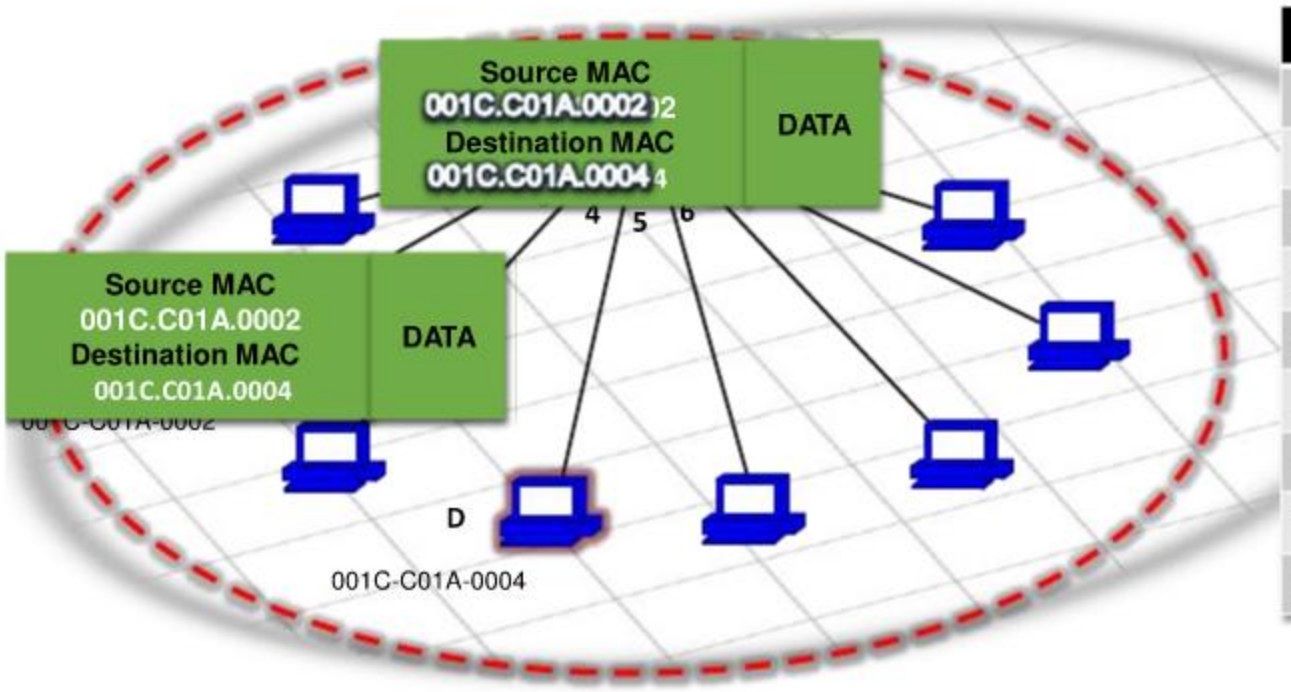


Functions of Switch



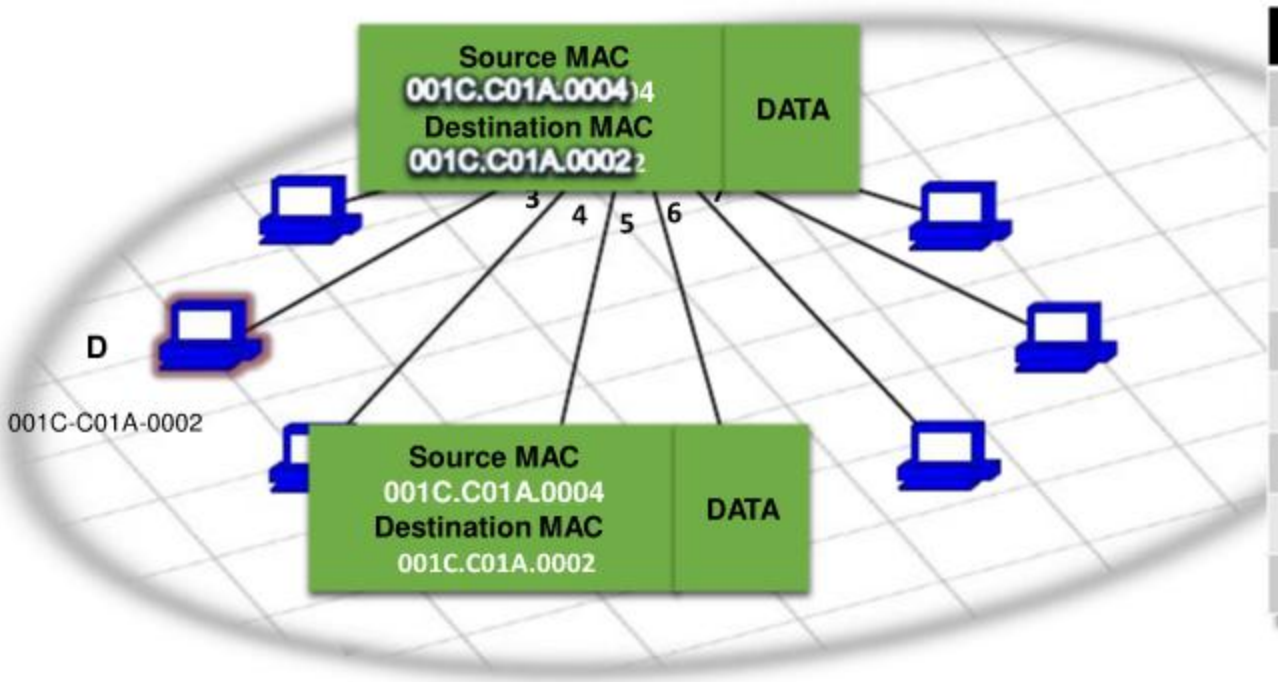
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Functions of Switch



MAC ADDRESS TABLE	
PORT	MAC-ADDRESS
1	
2	001C-C01A-0002
3	
4	
5	
6	
7	
8	

Functions of Switch



MAC ADDRESS TABLE	
PORT	MAC-ADDRESS
Fa0/1	
Fa0/2	001C-C01A-0002
Fa0/3	
Fa0/4	001C-C01A-0004
Fa0/5	
Fa0/6	
Fa0/7	
Fa0/8	

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Types of Switches

- Manageable switches
  - On a Manageable switch an IP address can be assigned and configurations can be made. It has a console port .
- Unmanageable switches
  - On an Unmanageable switch configurations cannot be made, an IP address cannot be assigned as there is no console port.

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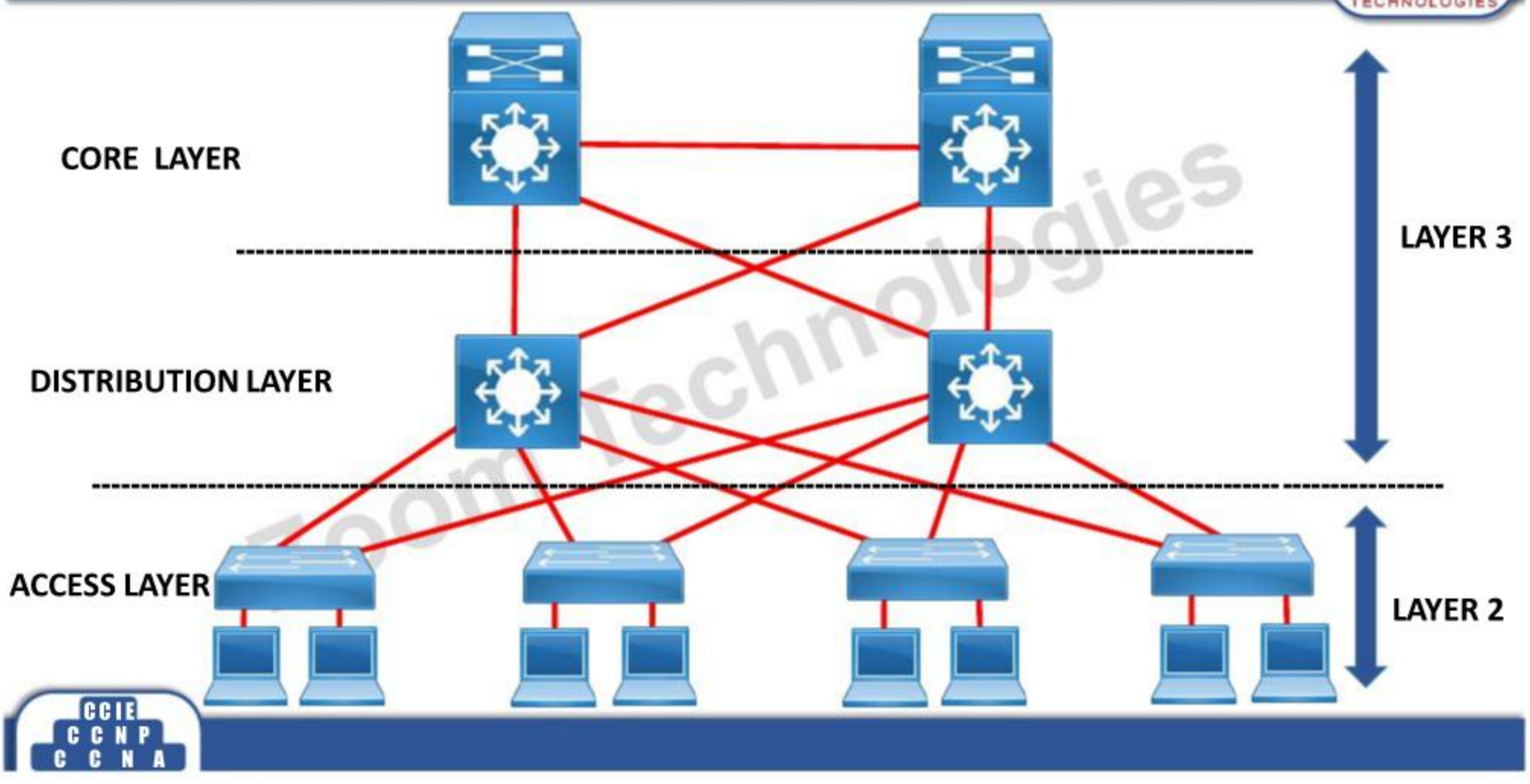
Campus Network

- Campus is a LAN network supporting larger buildings or multiple buildings close to a specific area
- Cisco uses three terms to describe the role of each switch in a campus design
  - Access
  - Distribution
  - Core

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Hierarchical Design



Cisco's Hierarchical Design for switches

- Cisco Switches can be categorized into 3 Layers
  - Access Layer Switches
    Switches Series : 1900, 2950, 2960
  - Distribution Layer Switches
    Switches Series :
    - Fixed : 3550, 3560, 3750
    - Modular: 4500, 5500
  - Core Layer Switches
    Switches Series : 6500

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Virtual LAN

- Divides a Single Broadcast domain into Multiple Broadcast domains
- provides L2 Security
- By default all ports of the switch are in VLAN1 . VLAN1 is known as Administrative VLAN or Management VLAN
- VLAN can be created from 2 – 1001

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Static VLAN

- Static VLANs are port based hence they are also called as Port-based VLANs.
- Ports have to be manually assigned to a VLAN.
- A Port can be a member of a single VLAN.

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Dynamic VLAN

- Dynamic VLANs are based on the MAC address of a device
- Switch automatically assigns the port to a VLAN
- Each port can be a member of multiple VLAN's
- For Dynamic VLAN configuration, a software called VMPS(VLAN Management Policy Server) is needed

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Creating VLAN

Switch(config)# Vlan < vlan number >

Switch(config-vlan)# name < name >

Implementation of Vlan

Switch(config)# interface <interface type> <interface no>

Switch(config-if)# switchport mode access

Switch(config-if)# switchport access vlan < Vlan ID >

Switch(config-if)#exit

Verification

Switch# Show vlan brief

Trunk

- Trunk Port allows multiple Vlan traffic to pass through a single physical connection by adding a header to Ethernet frame.

Trunking Protocols of two different types

ISL(Inter Switch Link)	802.1q
Cisco proprietary	Open standard
30 bytes	4 bytes

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Trunk configuration

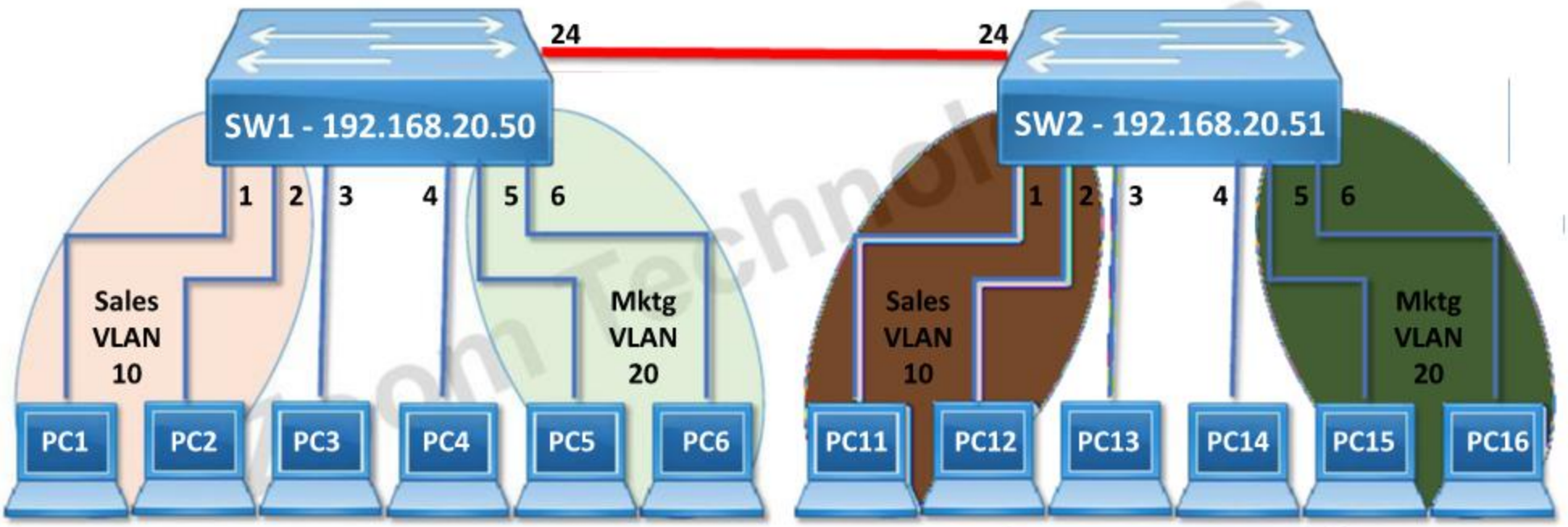
Trunk configuration

```
Switch(config)# interface  <interface  type> <interface  no>
Switch(config-if)#  switchport mode trunk
Switch(config-if)# switchport trunk allowed vlan < all/vlan ID >
Switch(config-if)#exit
```

Verification

```
Switch# Show interface trunk
```

VLAN and Trunk



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Dynamic Trunking Protocol (DTP)

- DTP is a Cisco proprietary protocol.
- DTP is responsible for dynamically negotiates trunks between Switches.
- DTP is enabled in all Cisco switches by default.
- DTP modes
  - Access mode
  - Trunk mode
  - Dynamic desirable
  - Dynamic auto

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DTP Modes

Command Option	Description
Access	Always act as an access(Non-Trunk) port
Trunk	Always act as a Trunk port
Dynamic Desirable	Initiates negotiation messages and responds to negotiation messages to start using Trunking
Dynamic Auto	Passively waits to receive trunk negotiation messages

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Administrative mode	Access	Dynamic Auto	Trunk	Dynamic Desirable
Access	Access	Access	Do not Use	Access
Dynamic Auto	Access	Access	Trunk	Trunk
Trunk	Do not Use	Trunk	Trunk	Trunk
Dynamic Desirable	Access	Trunk	Trunk	Trunk



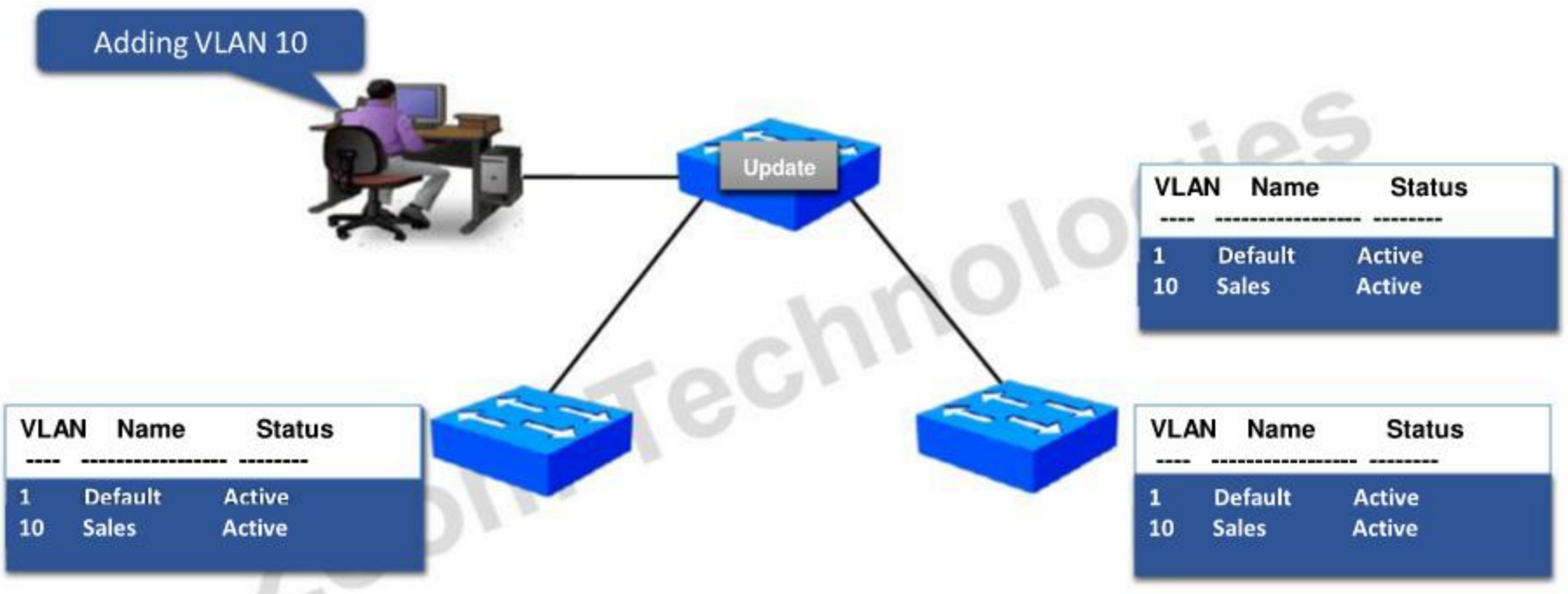
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Virtual LAN Trunking Protocol (VTP)

- VTP is a CISCO proprietary protocol
- It is used to share the VLAN configurations with multiple switches
- The new VLAN needs to be added only on one switch and the configuration will automatically be sent to all other switches
- VTP only works when trunking is configured on FastEthernet or higher ports
- Note: Switches Should be configured with same Domain Name. Domain Names are Case sensitive

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VTP



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VTP Modes

- Server
  - Default mode
  - Create , Modify and Delete VLANs
  - Forwards advertisements
  - Synchronizes
- Client
  - Cannot create, Modify or delete VLANs
  - forwards advertisements
  - Synchronizes
- Transparent
  - Create ,Modify and Delete local VLANs only
  - Forwards advertisements
  - Does not synchronize

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VTP configuration

Configuring VTP

Switch(config)# VTP Mode < server/client/transparent >

Switch(config)# VTP Domain < Name >

Switch(config)# VTP Password < password >

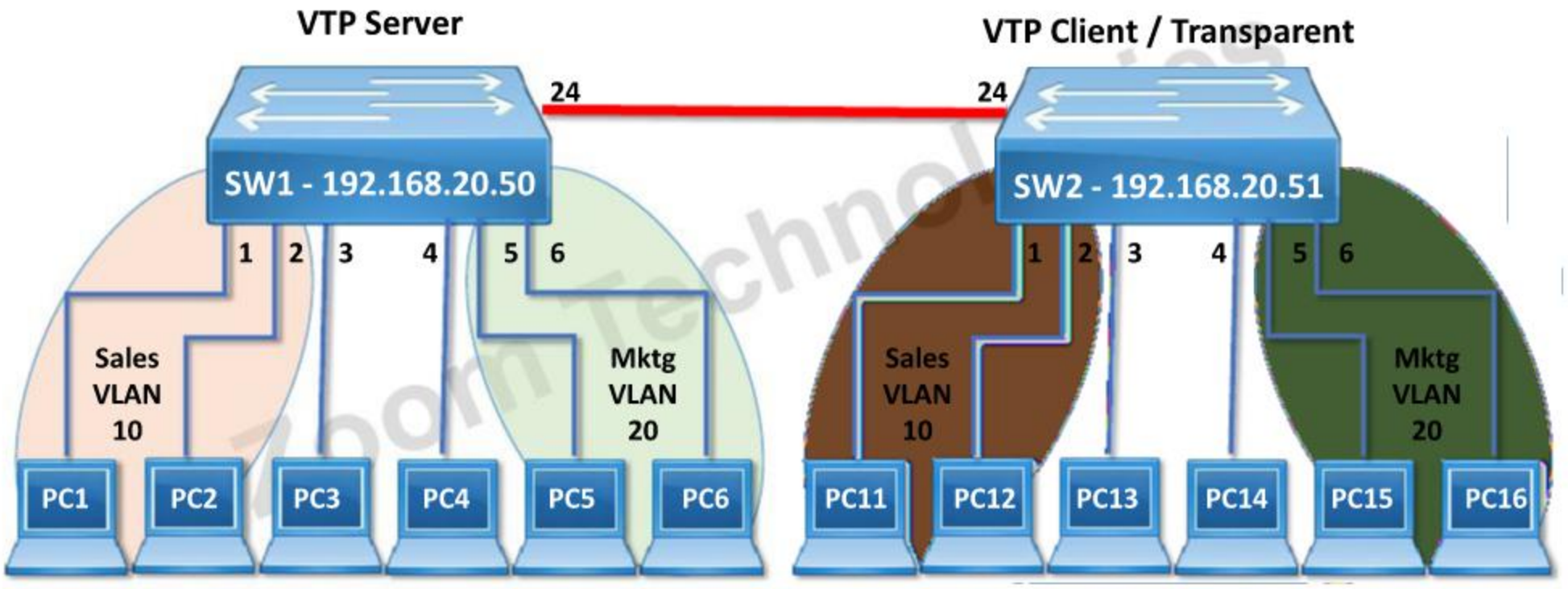
Verification

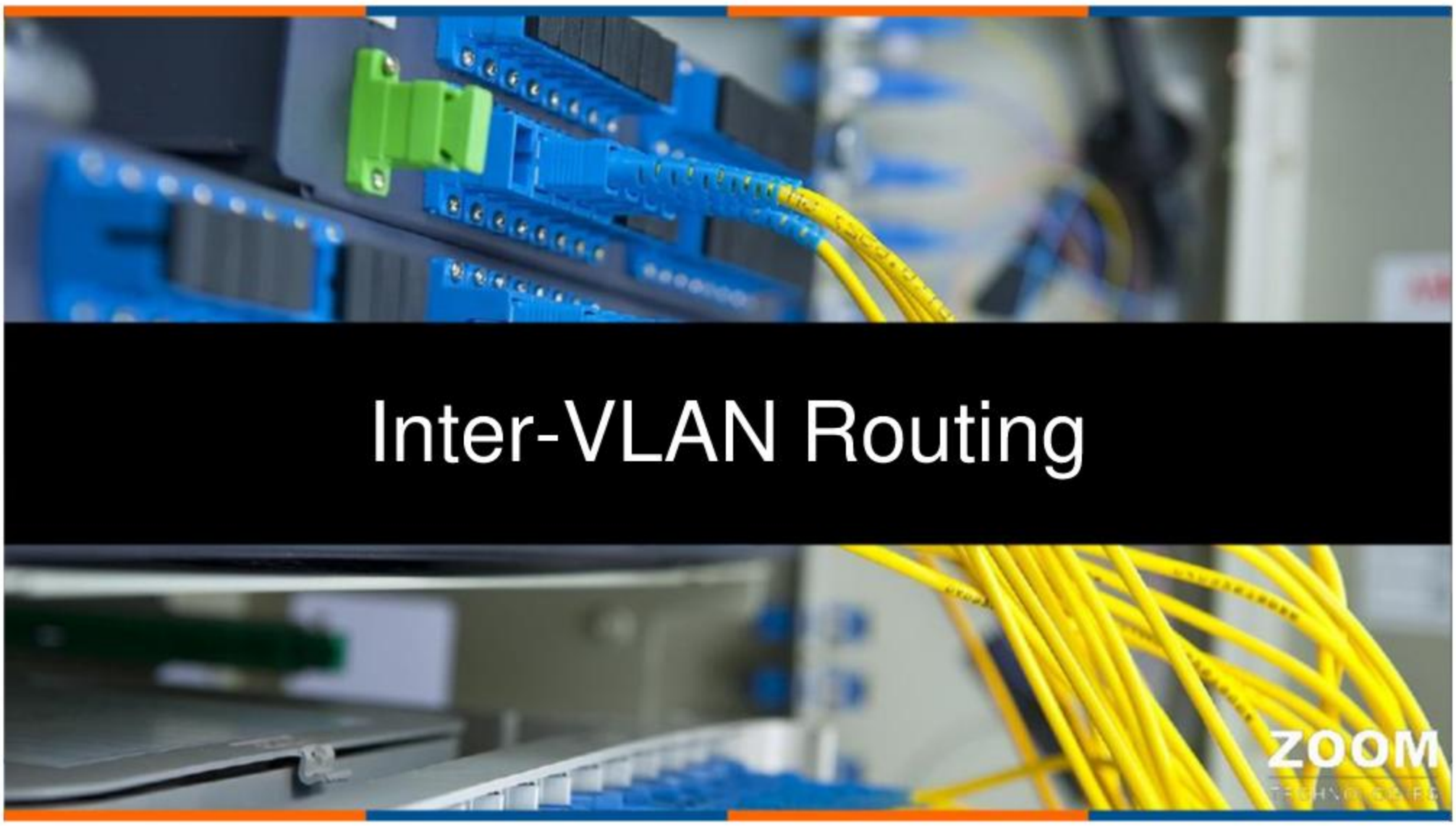
Switch# Show vtp status

Switch# Show vtp password

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VLAN Trunking Protocol





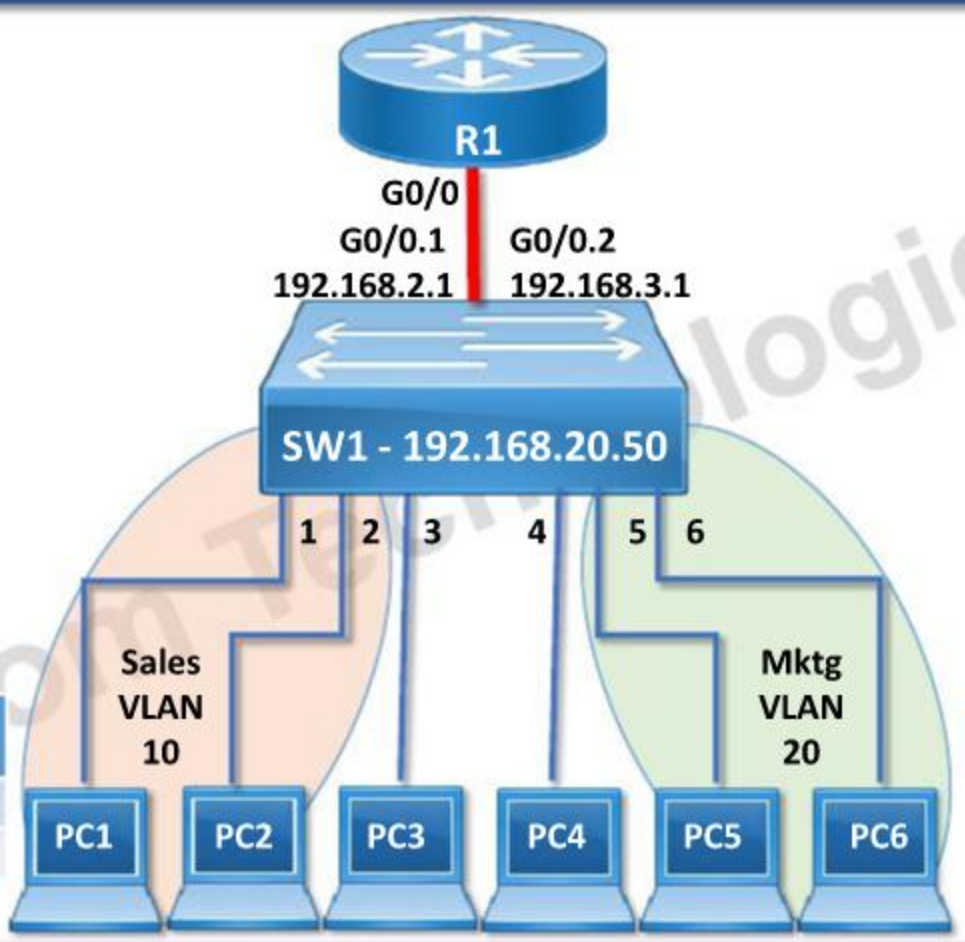
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Inter-VLAN Routing

- Inter-VLAN routing is a process of forwarding network traffic from one VLAN to another
- Layer-3 device is required for Inter-VLAN routing
- Each VLAN should be configured in a different IP subnet.
- The switch port connected to the Router must be configured as a trunk
- One sub-interface for each VLAN should be configured on the physical interface.
- Router-on-a-stick is a type of Router configuration in which a single physical interface routes traffic between multiple VLANs

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Inter-VLAN Routing



Computer	Vlan No.	IP Address / Mask
PC1	10	192.168.2.10/24
PC2	10	192.168.2.20/24

Computer	Vlan No.	IP Address / Mask
PC5	20	192.168.3.10/24
PC6	20	192.168.3.20/24

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Router on a Stick configuration

Router Sub Interface Configuration

```
Router(config)#interface Ethernet 0/0.< no. >
Router(config-subif)#encapsulation dot1q < vlan ID >
Router(config-subif)#ip address < ip > < subnet mask >
```

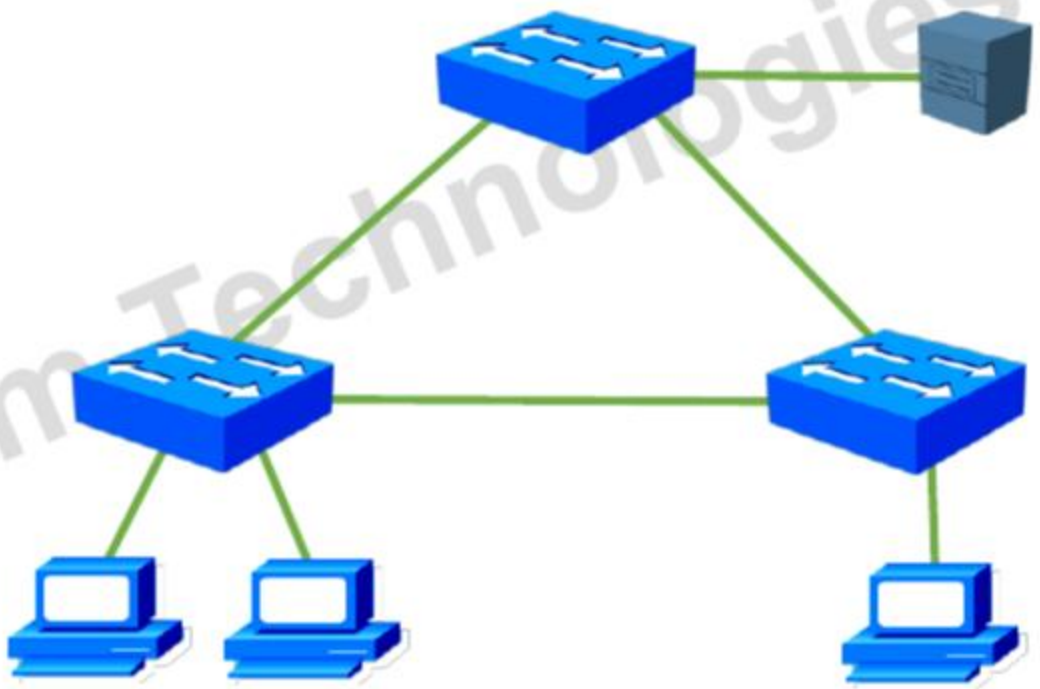
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Redundant Topology

- To eliminate single point of failure, backup links are used.
- This type of network is called as a redundant topology.



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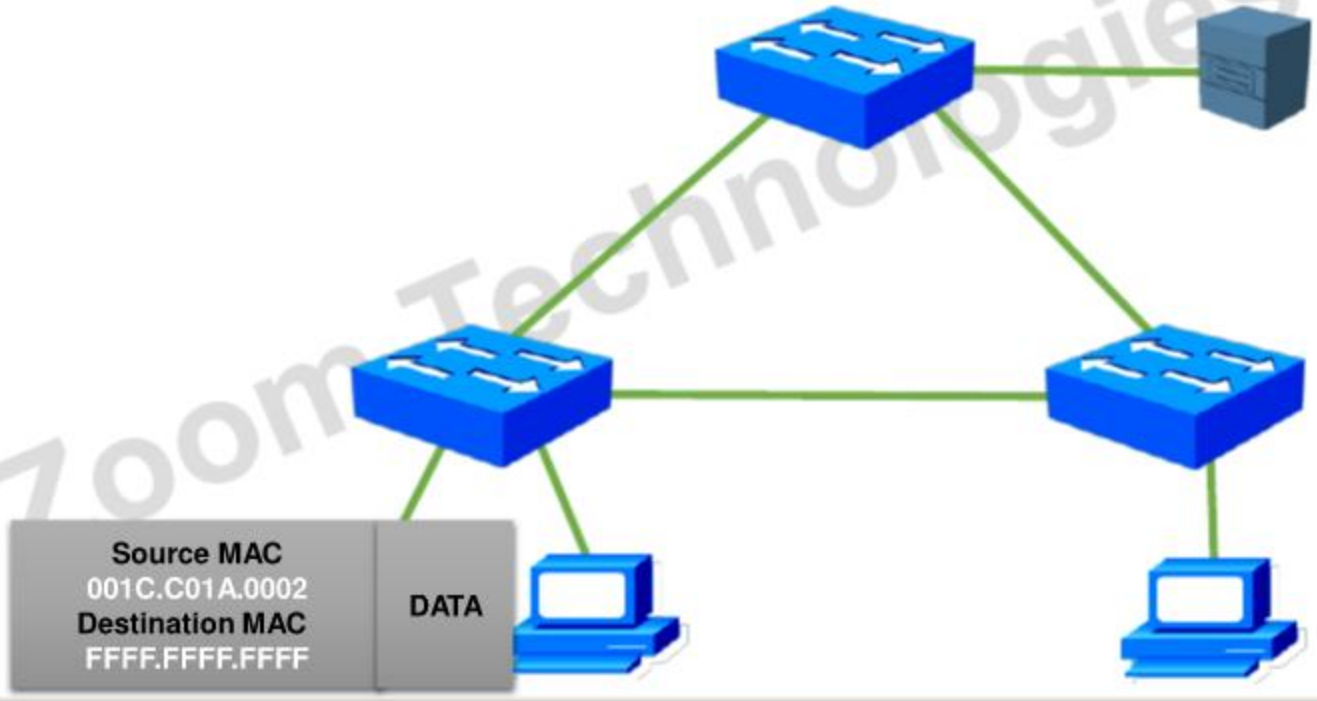
Problems in Redundant Topologies

- Redundant topology causes
  - Multiple frame copies
  - MAC address table instability
  - Broadcast storms
- The above problems are collectively called layer 2 switching loops.

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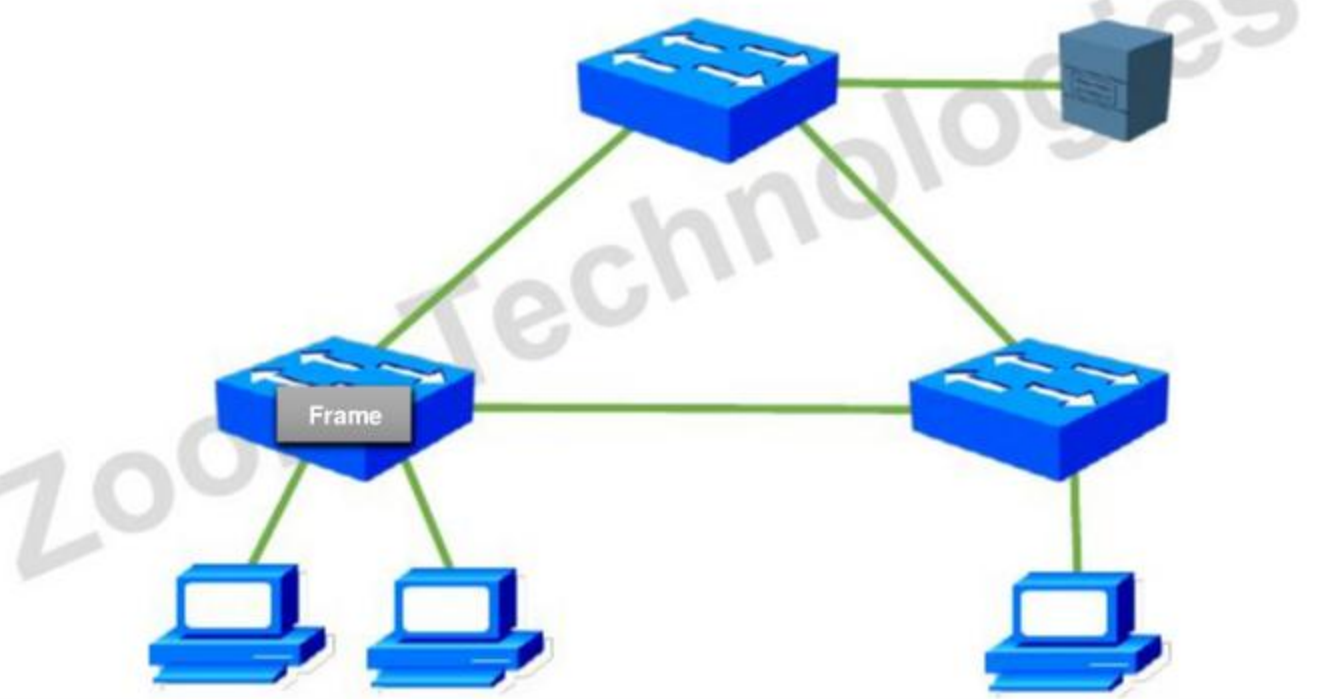
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Problems in Redundant Topologies



Zoom Technologies

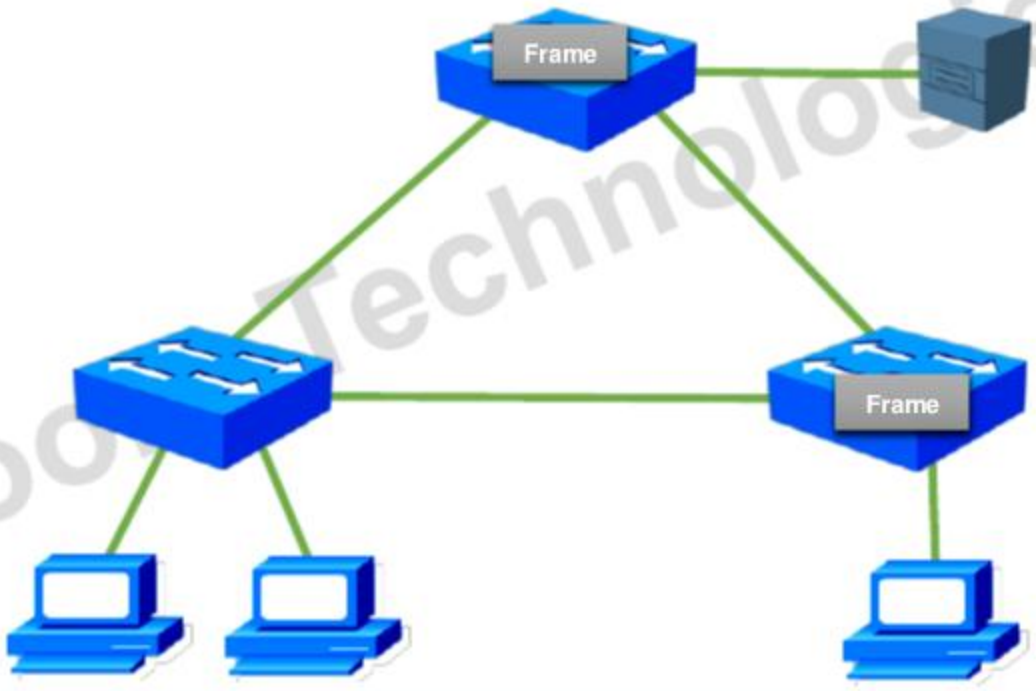
Problems in Redundant Topologies



Zoom Technologies

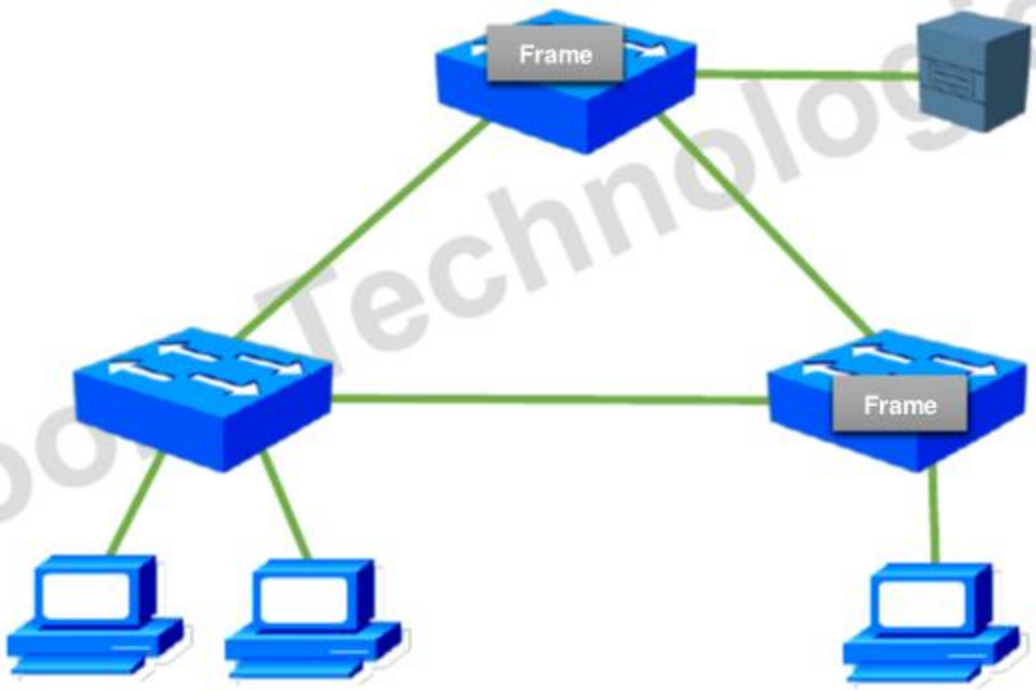
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Problems in Redundant Topologies



Zoom Technologies

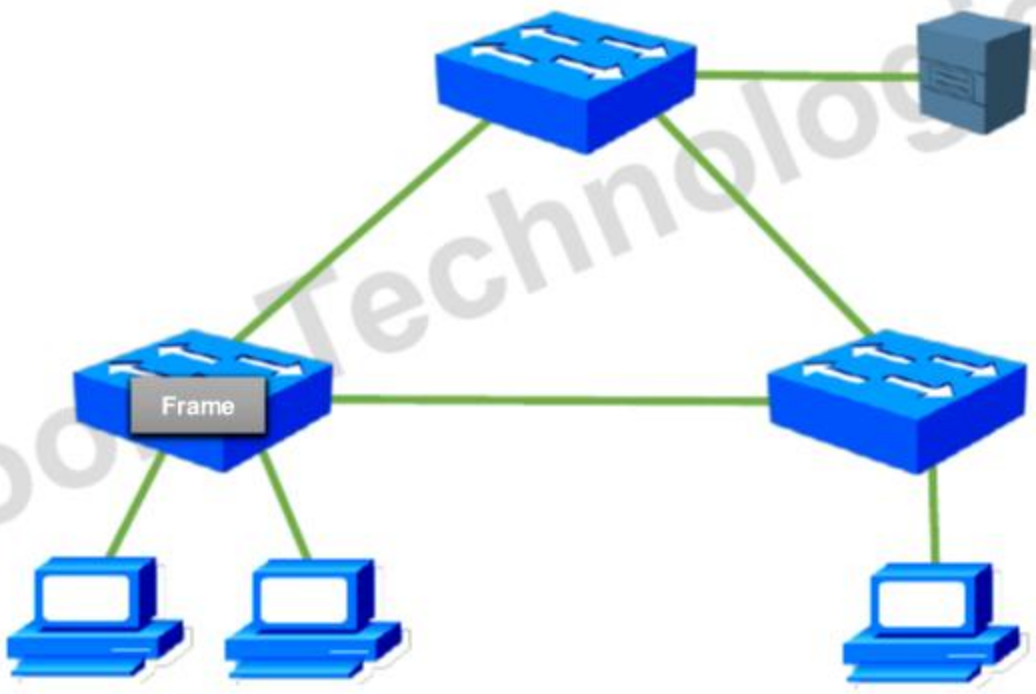
Problems in Redundant Topologies



Zoom Technologies

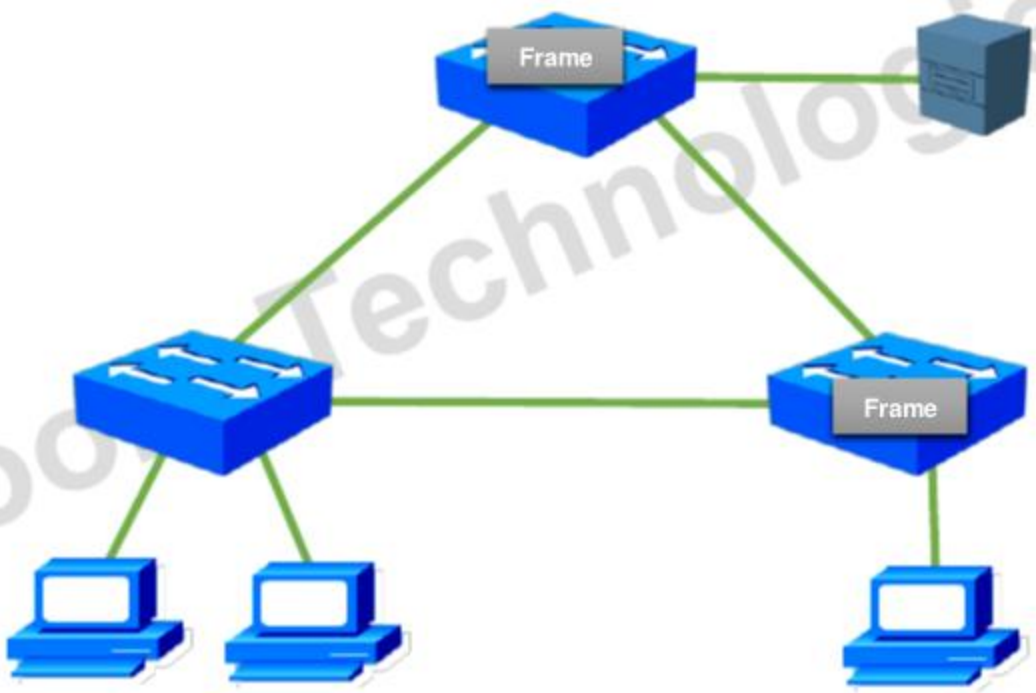
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Problems in Redundant Topologies



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Problems in Redundant Topologies

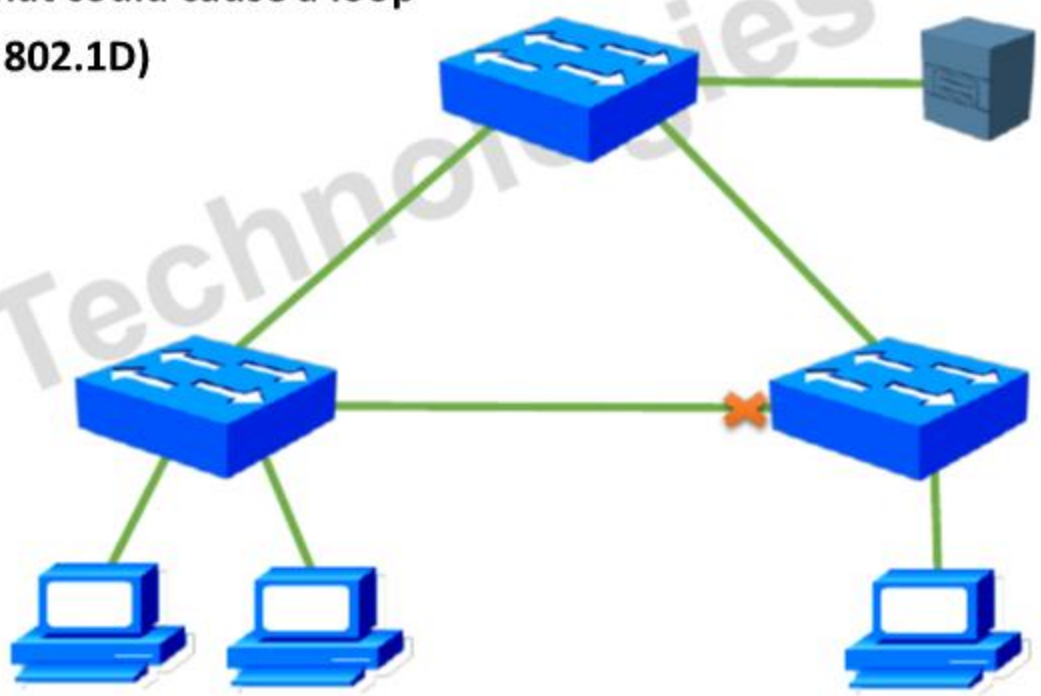


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Spanning-tree Protocol

- Spanning-tree protocol is used in switched network to avoid switching loops
- It uses spanning-tree algorithm
- STP blocks redundant paths that could cause a loop
- STP is a open standard (IEEE 802.1D)



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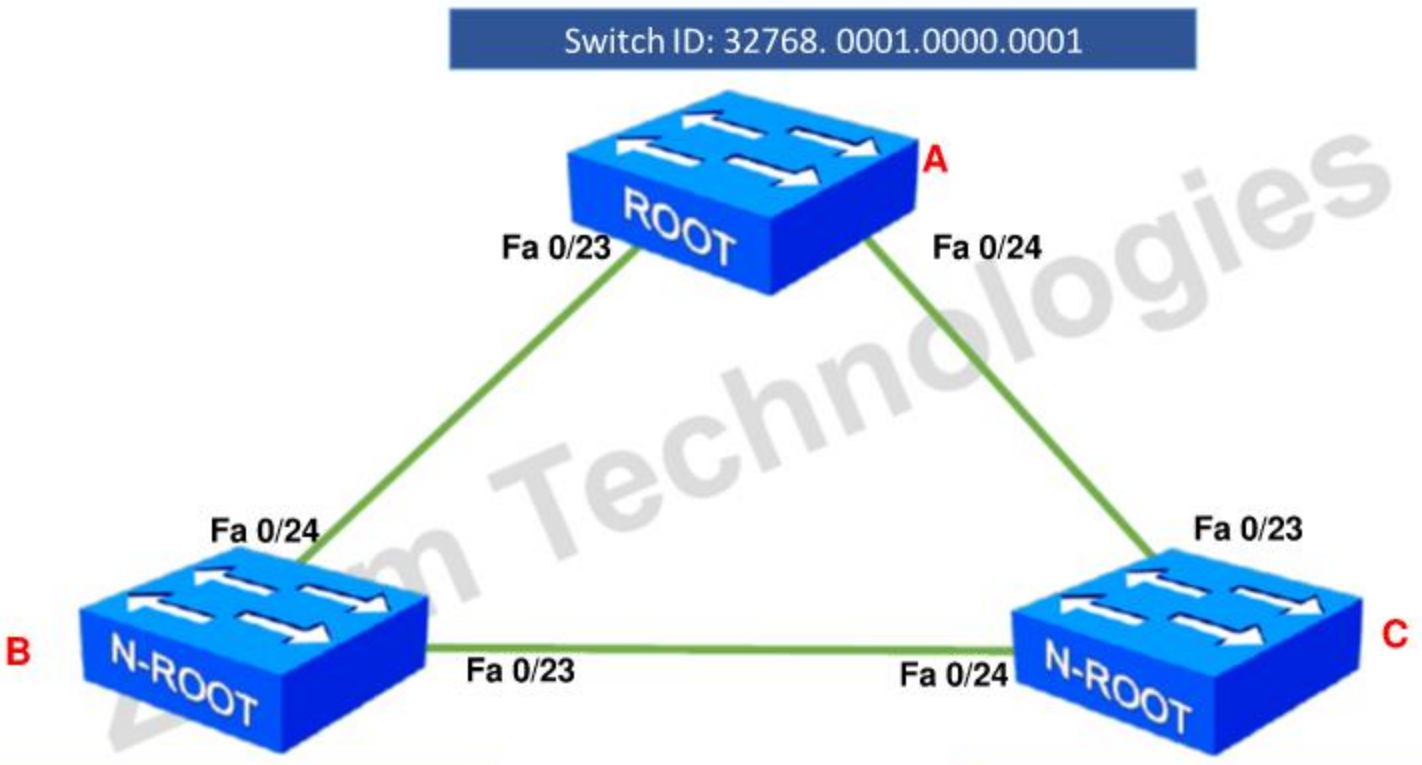
STP Terminology

- Root Switch
  - The switch with the best (lowest) Switch ID.
  - Out of all the switches in the network, one switch is elected as a Root switch. This Root switch becomes the focal point of the network.
- Switch ID
  - Each switch has a unique identifier called a Bridge ID or Switch ID
  - Bridge ID = Priority + MAC address of the switch
    - Default priority is 32768
- Non-Root Switch
  - All switches other than the Root switch are called Non-root switches.

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Root Switch Election



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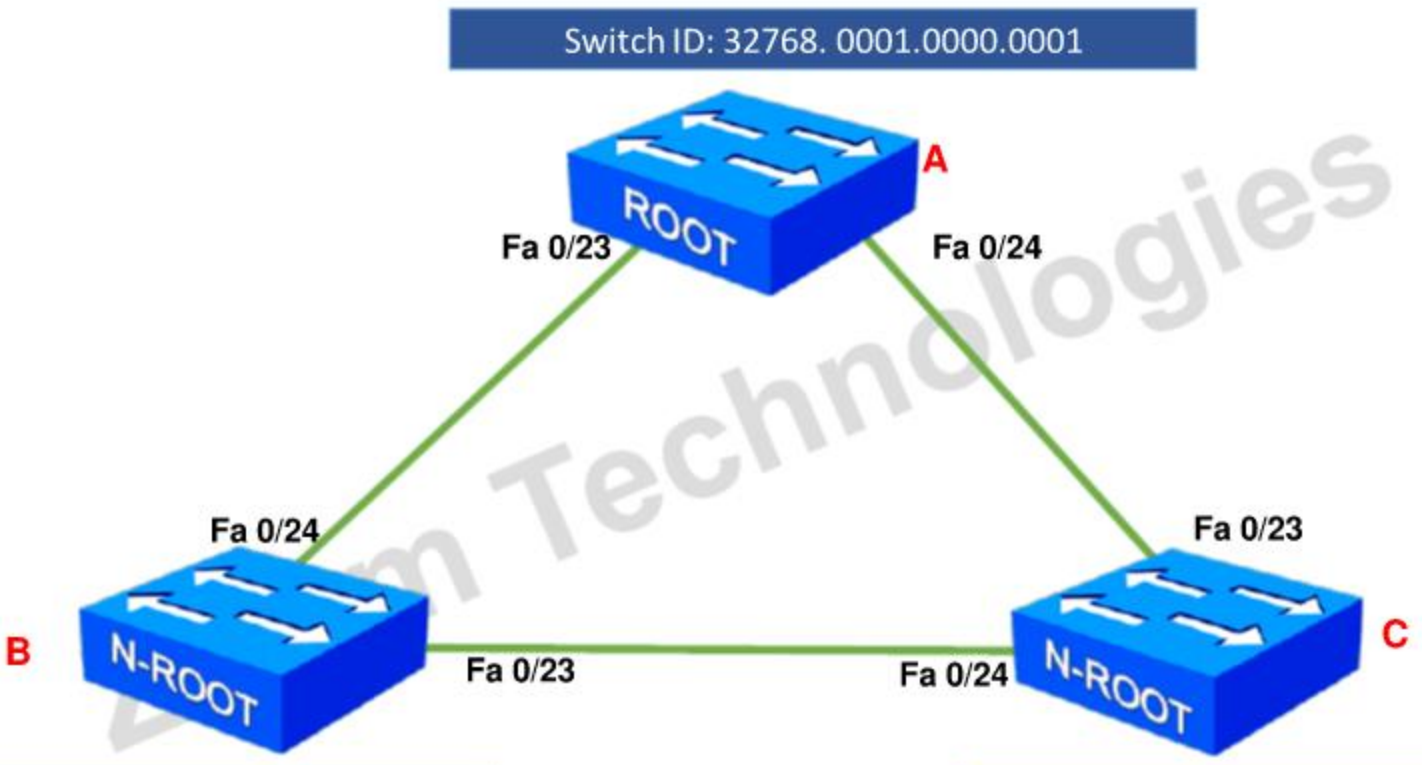
STP Terminology

- BPDU
  - Switches exchange information using Bridge Protocol Data Units (BPDUs)
  - BPDUs contain information that helps the switch to determine the topology
  - BPDUs are sent every 2 sec

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Root Switch Election



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STP Terminology

- Root port
  - Every Non-Root Switch must have a Root port
  - Only one port per switch can be the Root port
  - All Root ports will be in forward mode
  - A Switch's Root port is the port closest to the Root Switch
    - The port with the least cost
    - The port with the lowest Neighbor switch ID
    - Lowest Physical Port Number

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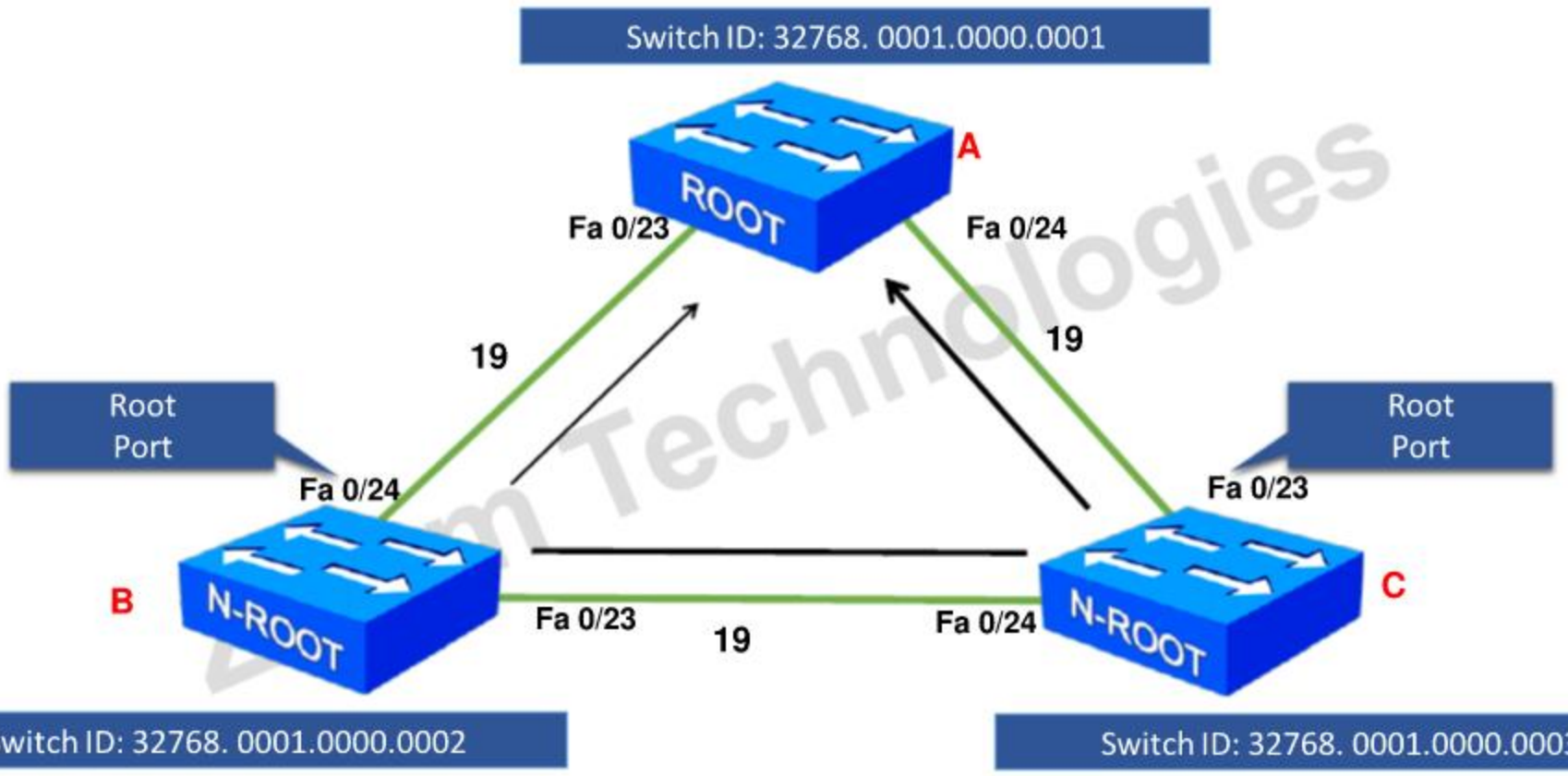
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IEEE Cost Values

Type	Cost Value
Ethernet	100
Fast Ethernet	19
Gigabit Ethernet	4
10 Gigabit Ethernet	2

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Root Port Election



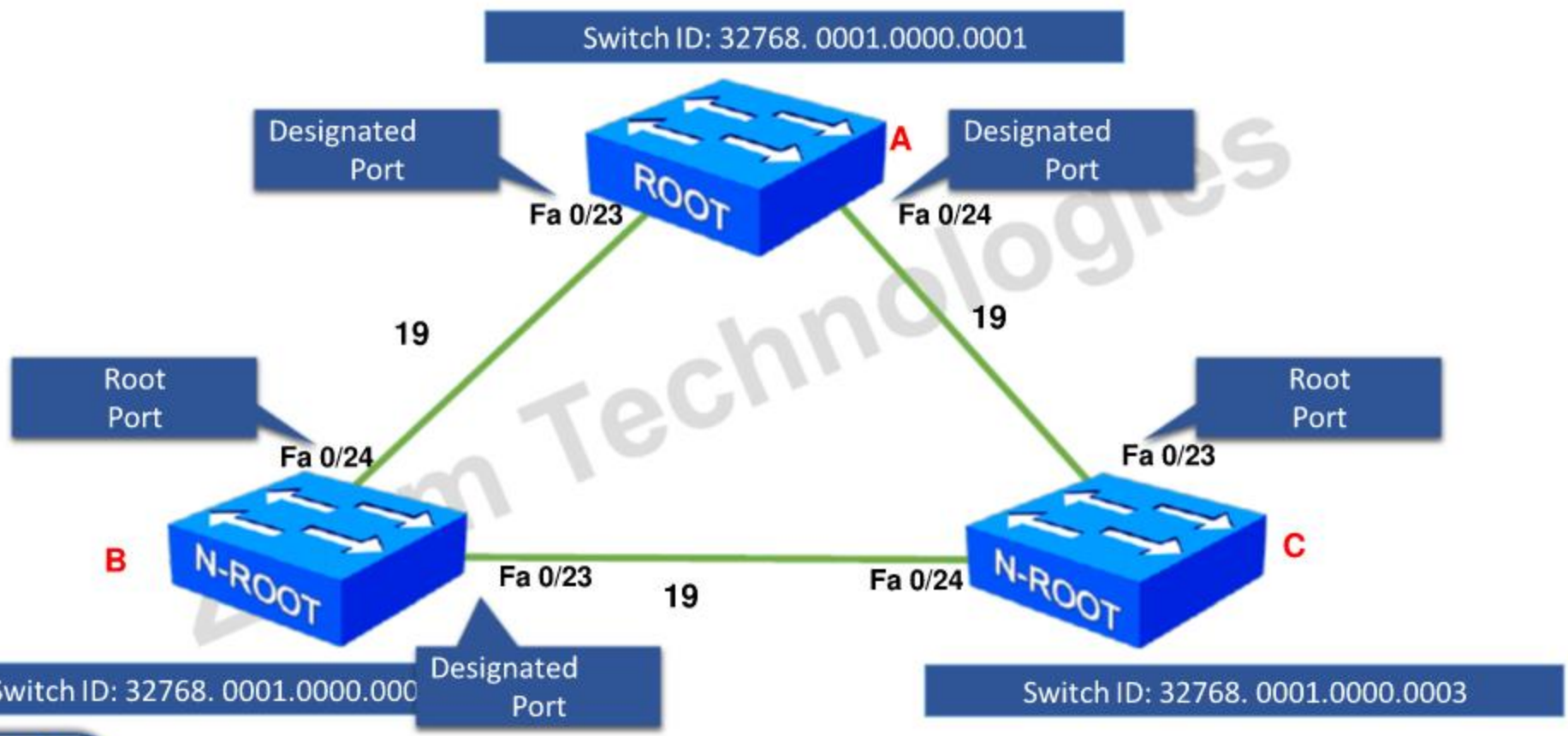
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STP Terminology

- Designated port
  - For Every segment there will be a Designated port
  - A designated port will always be in Forward Mode
    - The port with the least cost
    - The port with the lowest Neighbor switch ID
    - Lowest Physical Port Number
  - All ports(Trunk ports) on the Root bridge are Designated ports

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Designated Port Election

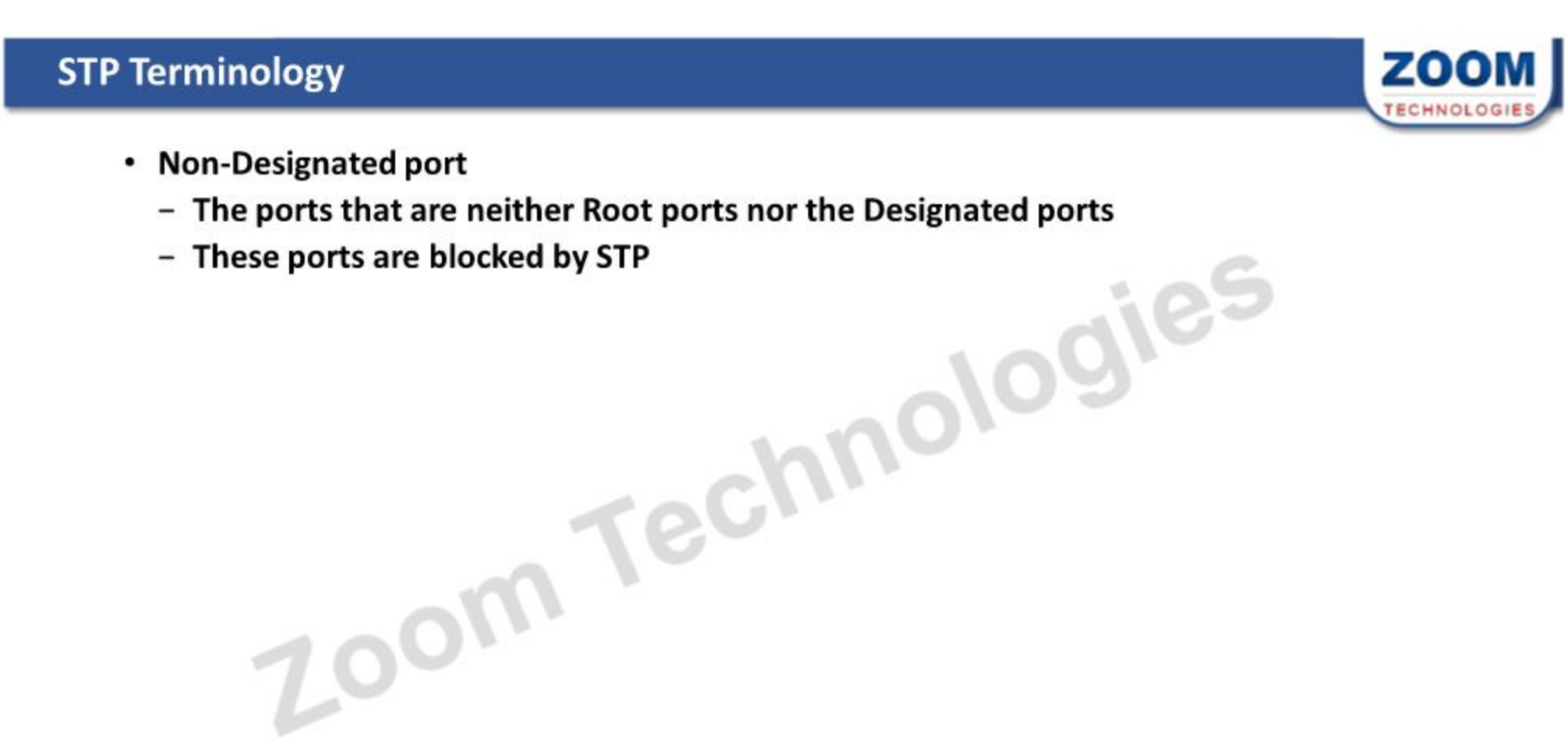


STP Terminology

- Non-Designated port
  - The ports that are neither Root ports nor the Designated ports
  - These ports are blocked by STP

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Non-Designated Port Election



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Switch - Port States

- Blocking - 20 Sec Or No Limits.
- Listening - 15 Sec.
- Learning - 15 Sec.
- Forwarding - No Limits

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STP Verification

Verification

Switch# show spanning-tree

To change the Priority

Switch(config)#spanning-tree vlan 1 priority < priority >

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PortFast

- Portfast allows a port to switch from blocking to forwarding bypassing listening and learning states.
- The portfast feature can be enabled on a port where there are no Bridges and switches connected, otherwise it may create loops.
- Portfast is recommended to be enabled on a port where end user devices are connected.

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BPDU Guard

- The Cisco BPDU guard feature disables the port ,if any BPDUs are received on the port.
- This is recommended to be enabled on a port where Portfast is configured, because if any switch connects to such a port, the local switch can block the port preventing loops.

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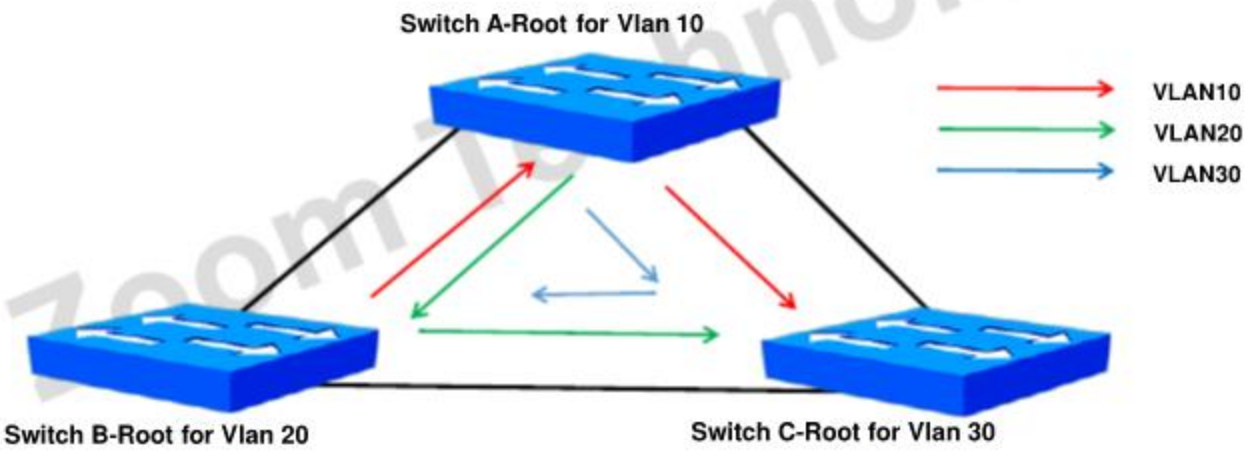
Rapid Spanning Tree Protocol (RSTP)

- This is the enhance version of STP (802.1w)
- Improved STP convergence .
- RSTP selection
  - Root bridge selection
  - Root port selection
  - Alternate port selection (Backup Root port)
  - Designated port selection
  - Backup port selection (Backup Designated port)

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Per-vlan Spanning Tree Protocol (PVST)

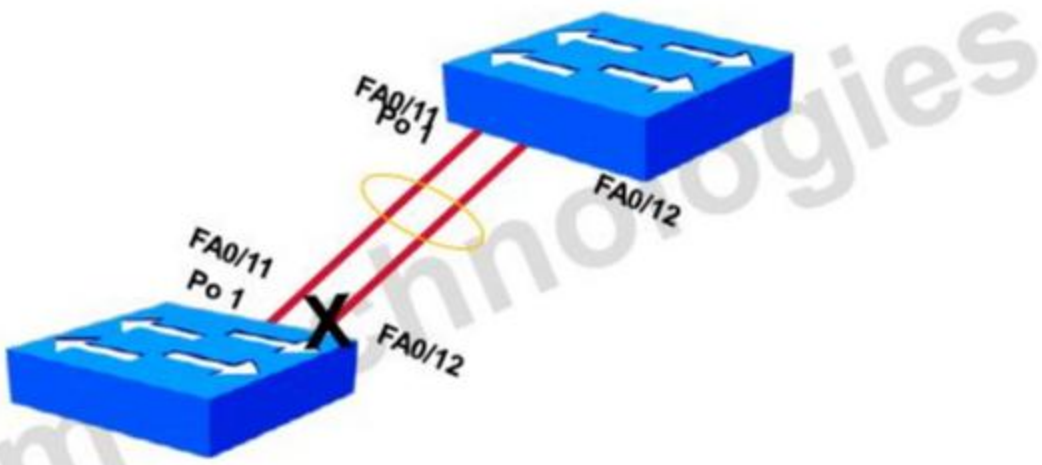
- PVSTP is a Cisco proprietary protocol.
- One STP instance for each VLAN.
- Separate Root switches, Root ports, and block ports for each VLAN.
- The traffic load can be balanced across the available links



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Switch Path



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EtherChannel

- An EtherChannel combines individual Ethernet ports into a single logical link, providing Redundancy and Load balancing.
- If one Ethernet port in EtherChannel fails, traffic previously sent over the failed Ethernet port will be sent through the other Active Ethernet ports within the EtherChannel
- EtherChannel can be used from Switch to Server, Switch to Router, Switch to Firewall and Switch to Switch.
- Load balancing happens based on mac address.
- Note:
  - Only similar physical ports (Ethernet or Fiber) can be bundled.
  - Maximum 8 links can be bundled per EtherChannel

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Etherchannel configuration

Etherchannel configuration

```
Switch(config)# interface fastethernet < no. >
Switch(config-if)# channel-group 1 mode on
```

Verification

```
Switch# show etherchannel
```

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Port Security

- Port Security is used to control network access based on the following:
  - MAC Address
  - Number of MAC Addresses per port
- If any violation takes place the following actions can be configured:
  - Shutdown
  - Restrict
  - Protect

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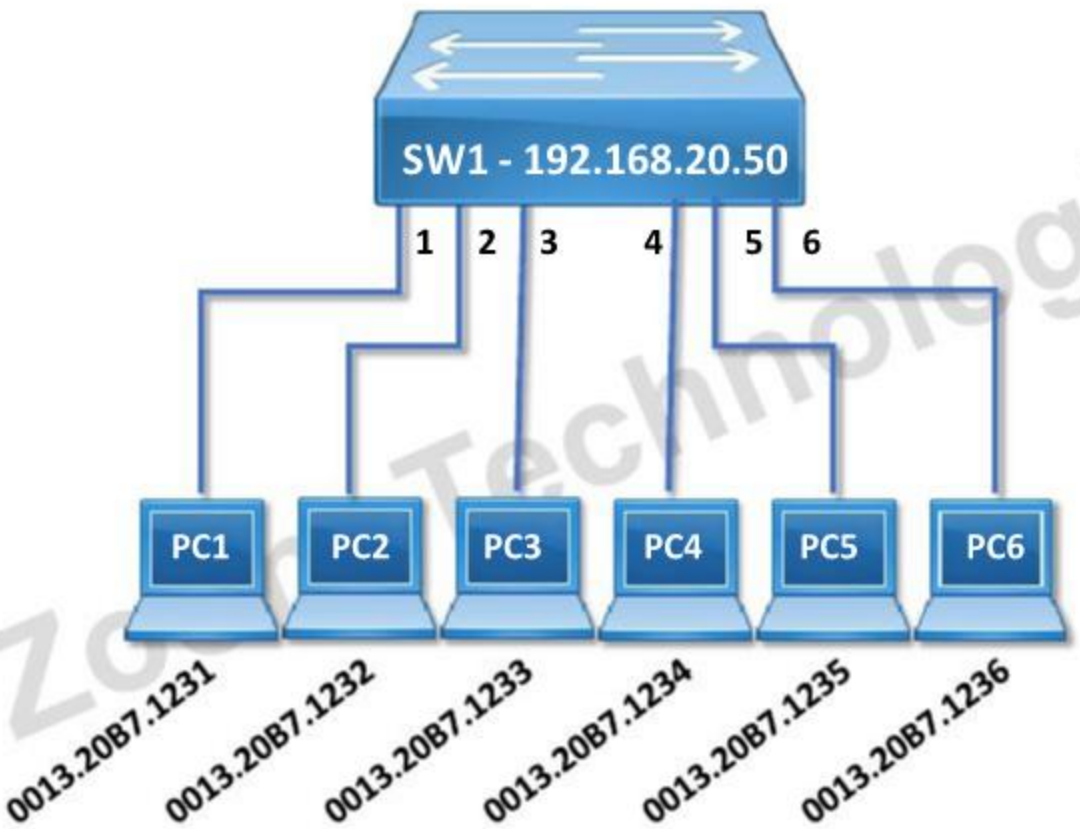
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Violation Modes

- Shutdown
  - The port becomes error disabled and the port LED turns off.
- Protect
  - Frames with unknown source MAC address are dropped. It does not notify that a security violation has occurred.
- Restrict
  - Frames with unknown source address are dropped. It gives a notification (log message) that security violation has occurred.

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Port-Security



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Port Security Configuration

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Configuring port security

```
switch(config)# interface  <interface type>  <interface number>
switch(config-if)# switchport  mode access
switch(config-if)# switchport port-security maximum <value>
switch(config-if)# switchport port-security mac-address <mac-address>
switch(config-if)# switchport port-security violation {protect|restrict|shutdown}
switch(config-if)# switchport  port-security
```

Verification

```
Switch# show  port-security
```

CCIE CCNP CCNA

Error Disable Recovery

ZOOM TECHNOLOGIES

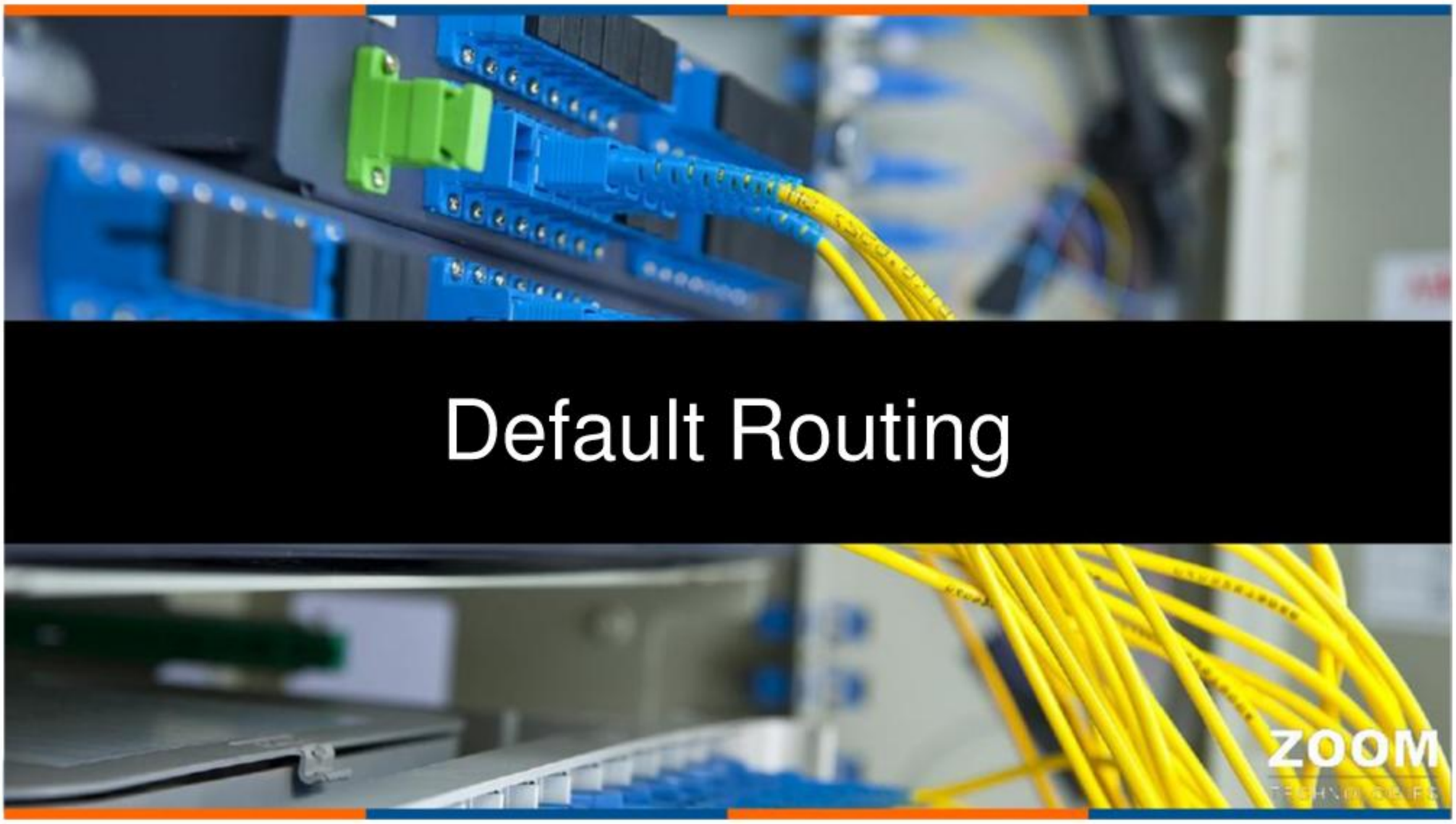
Configuring Error Disable Recovery

```
switch(config)# errdisable recovery cause psecure-violation
switch(config)# errdisable recovery interval <seconds>
```

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CCIE CCNP CCNA

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Default Routing

- A default route, or gateway of last resort, allows traffic to be forwarded, even without a specific route to a particular network.
- The default route is identified by all zeros in both the network and subnet mask (0.0.0.0 0.0.0.0)
- The default route is represented with S*

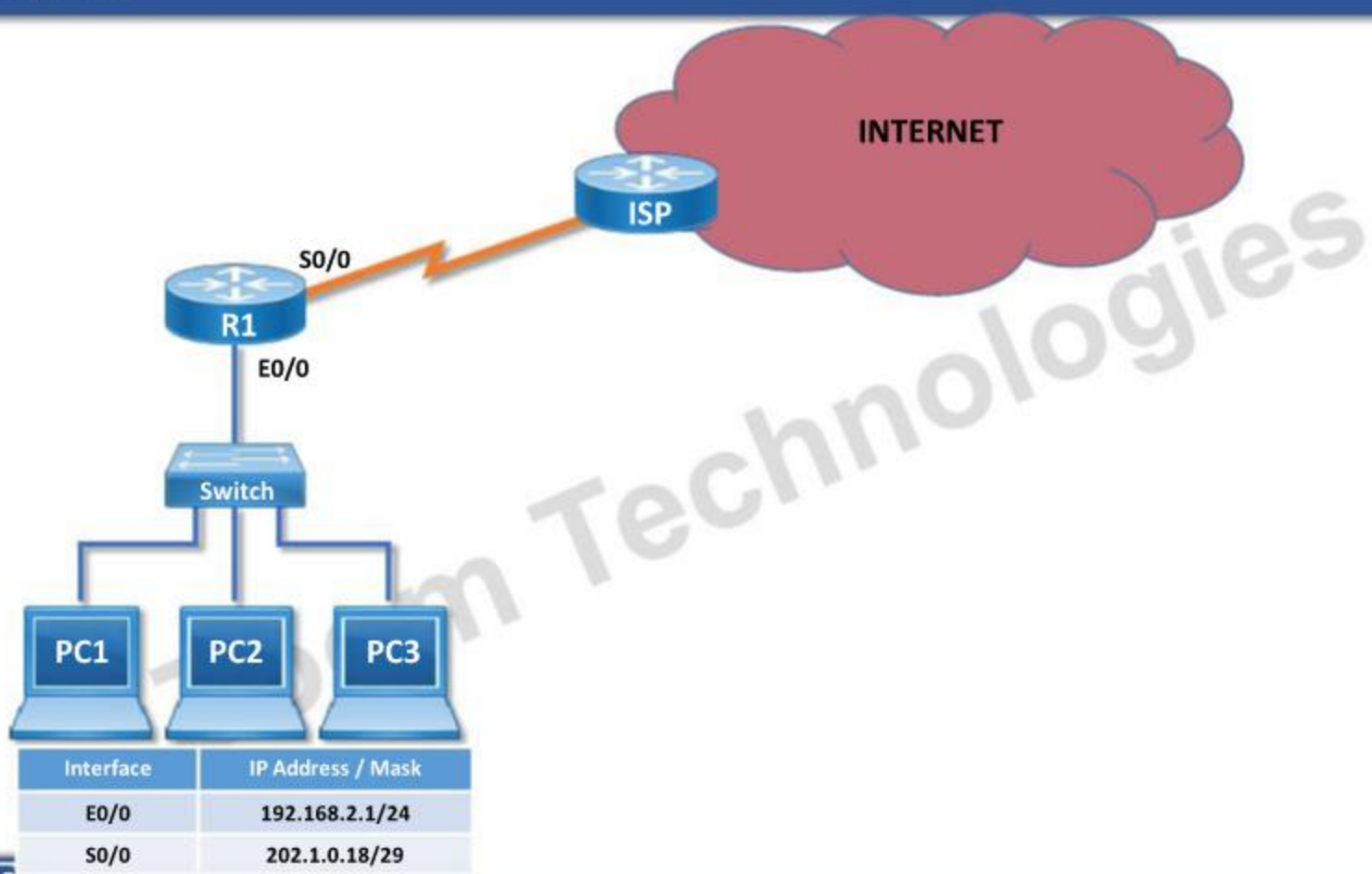
Configuring Default Routing

```
Router(config)# ip route 0.0.0.0 0.0.0.0 < Exit interface type & no. >
```

CCIE
CCNP
CCNA

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Example....



Interface	IP Address / Mask
E0/0	192.168.2.1/24
S0/0	202.1.0.18/29

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NAT

- NAT is a process of changing one IP into another
- NAT is used to save precious public IP addresses.
- NAT is usually used to translate private IP addresses to public IP addresses and vice versa
- It provides security
- Types of NAT
  - Static (one to one mapping)
  - Dynamic (many to many mapping)
  - PAT (many to one mapping)

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Private IP Address

- There are certain addresses in each class of IP address that are reserved for Private Networks. These addresses are called private addresses.
- These addresses are not Routable (or) valid on Internet.

Class A

10.0.0.0 to 10.255.255.255

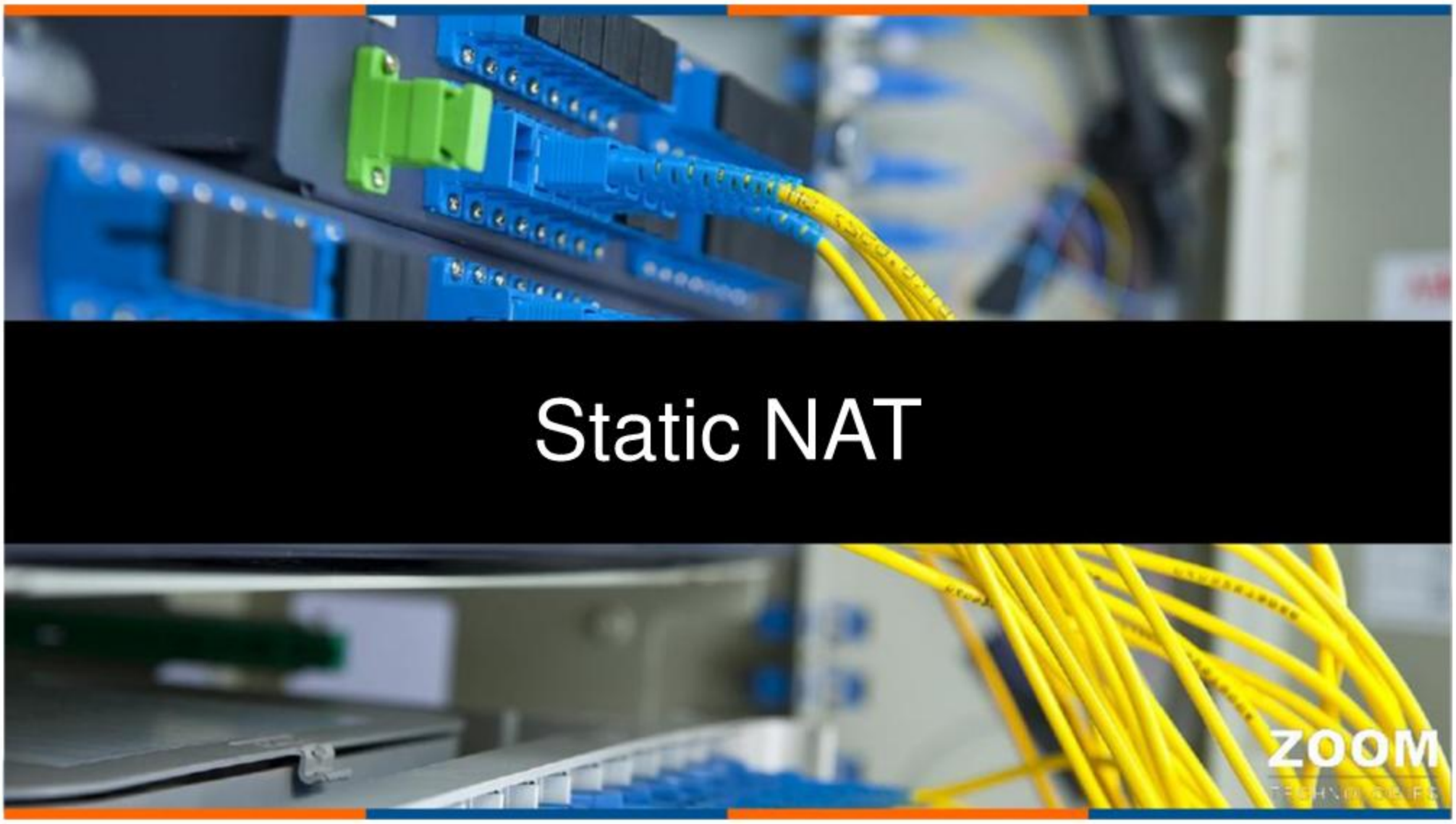
Class B

172.16.0.0 to 172.31.255.255

Class C

192.168.0.0 to 192.168.255.255

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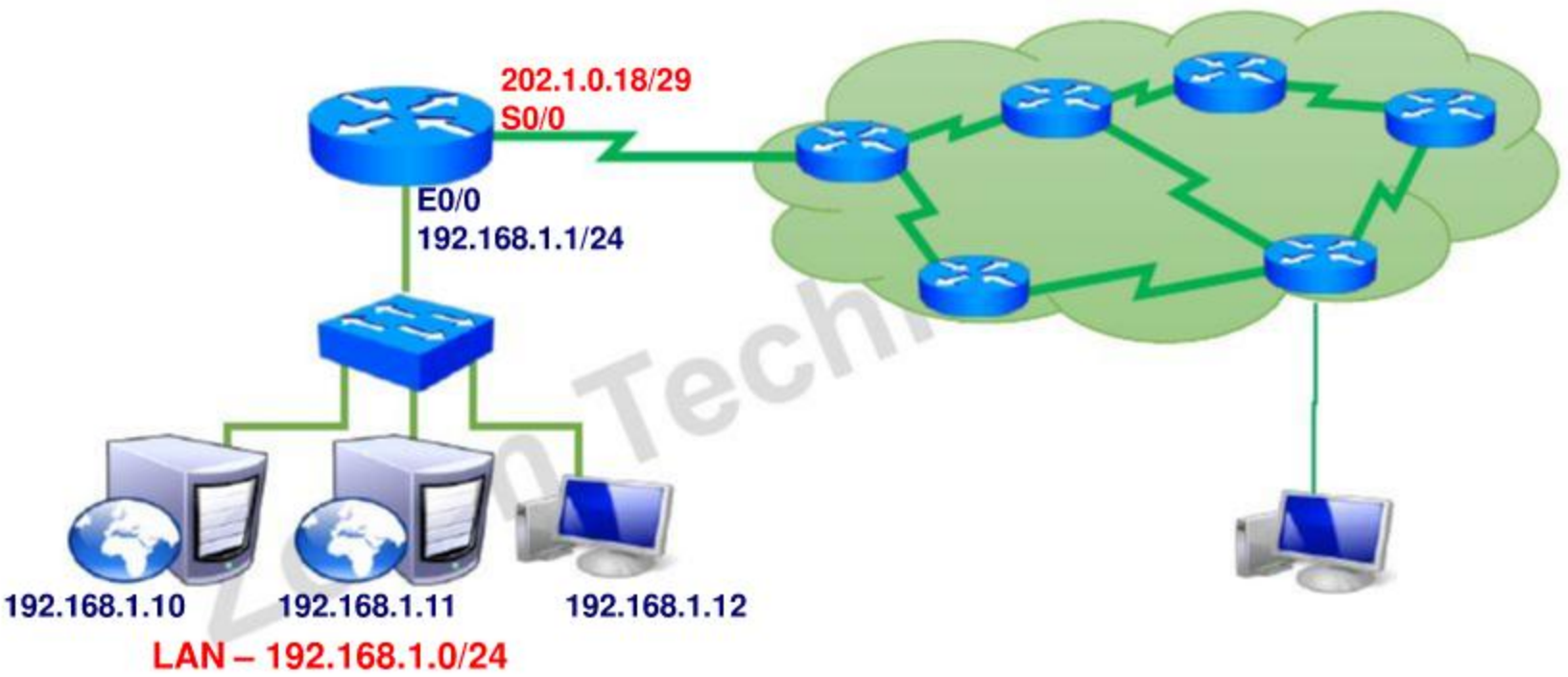
Static NAT

- One private IP address is mapped to one public IP address.
- Generally used for hosting public servers. (Internet to Server)
- Generally configured for inbound traffic.

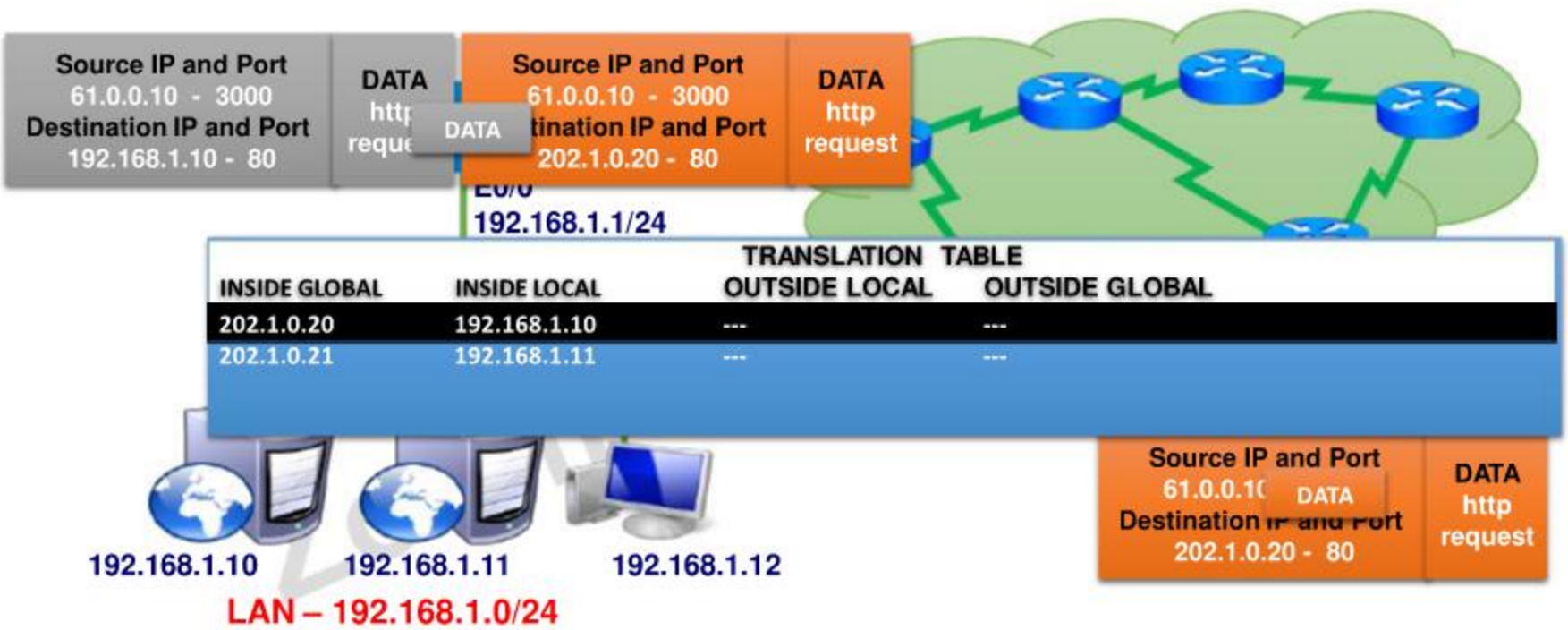
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Static NAT Configuration

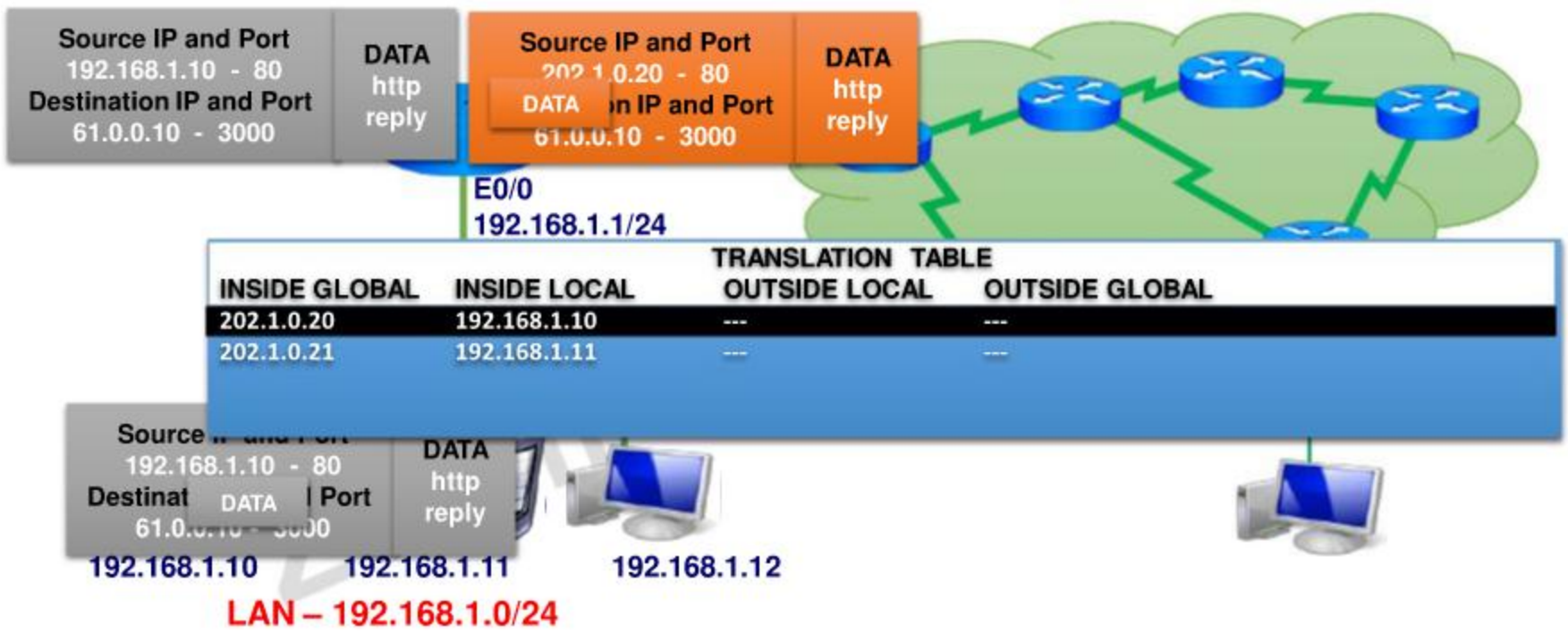


Static NAT



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Static NAT



Static NAT configuration

Defining NAT on Interfaces

```
Router(config)# interface  <interface type>  <interface number>
Router(config-if)# ip  nat   inside/outside
```

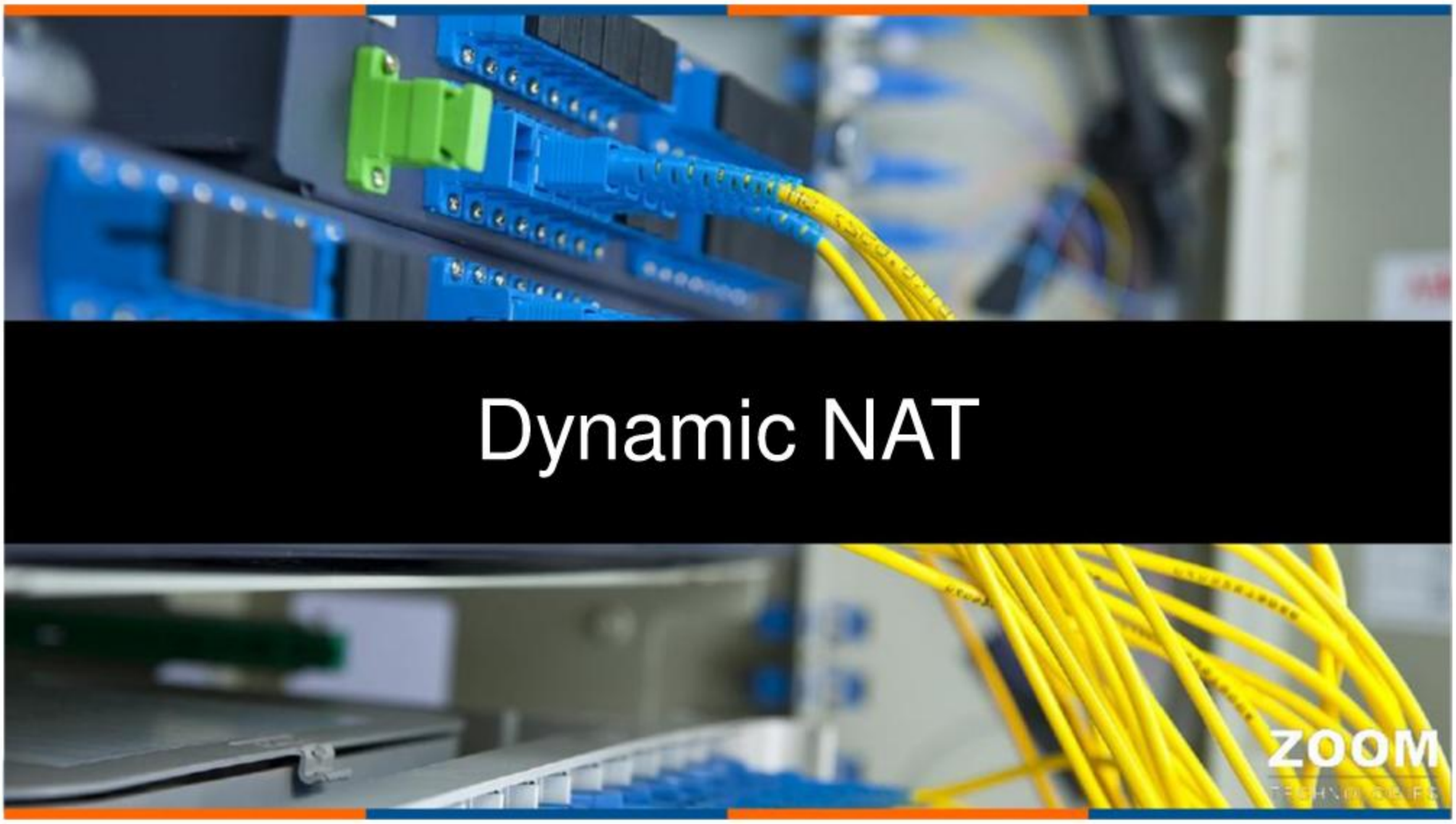
Configuring static NAT

```
Router(config)# ip  nat  inside  source static  <private ip>  <public ip>
```

Verification

```
Router# Show ip nat translations
```

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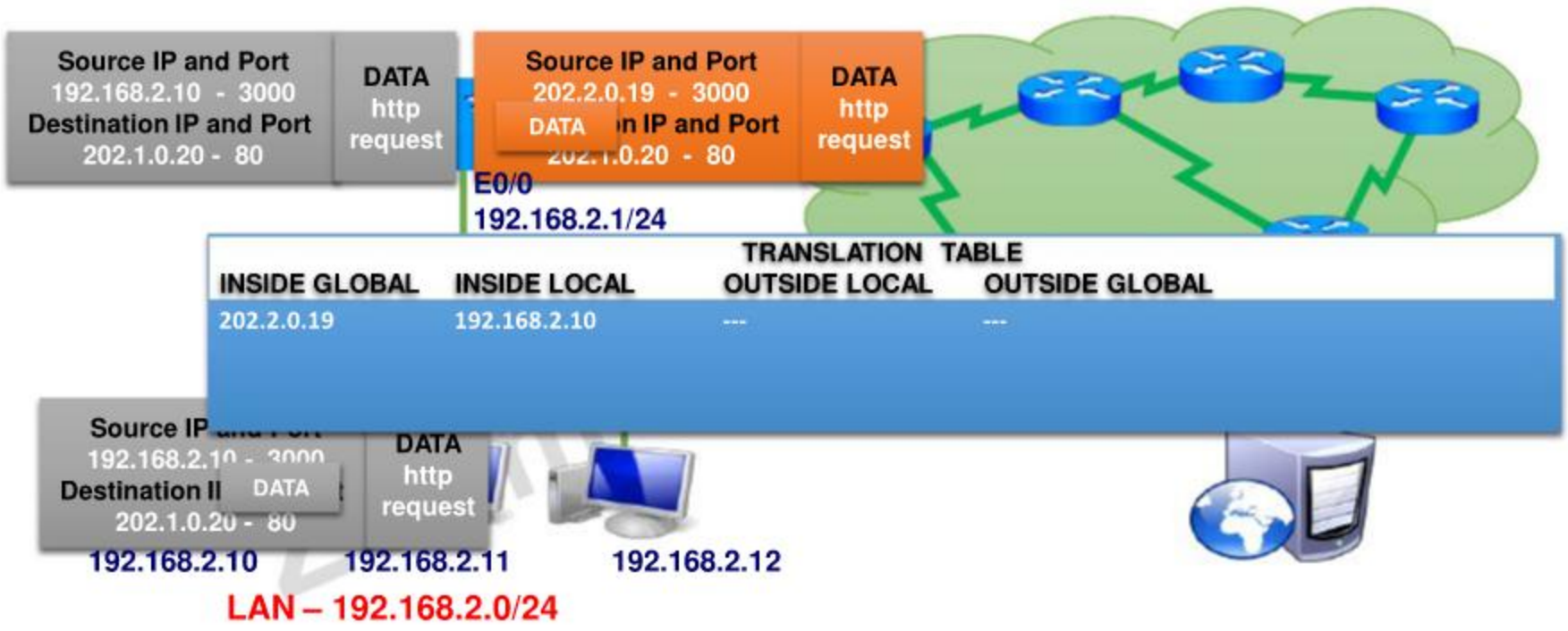
Dynamic NAT

- Many private IP addresses are mapped to many public IP addresses.
- Configured for outbound traffic. (LAN to Internet)
- Number of people who can connect to internet is equal to the number of public IP addresses

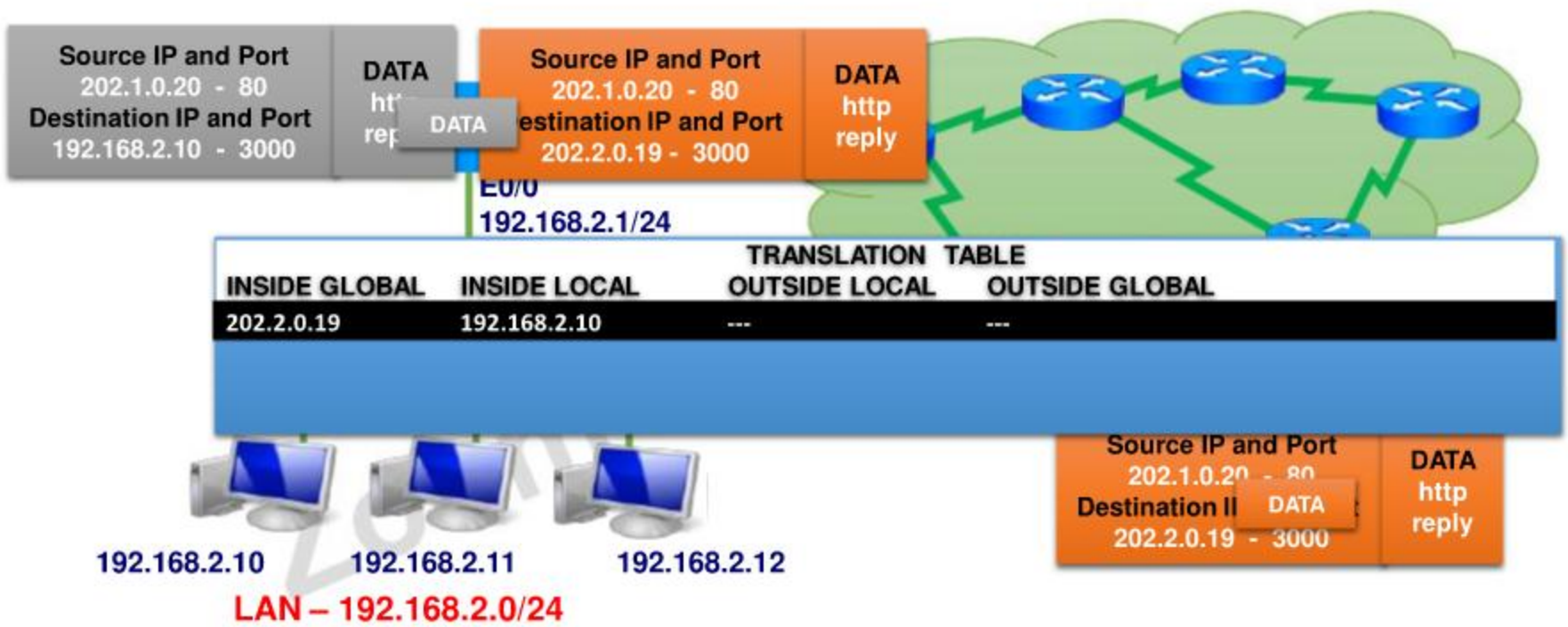
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Dynamic NAT

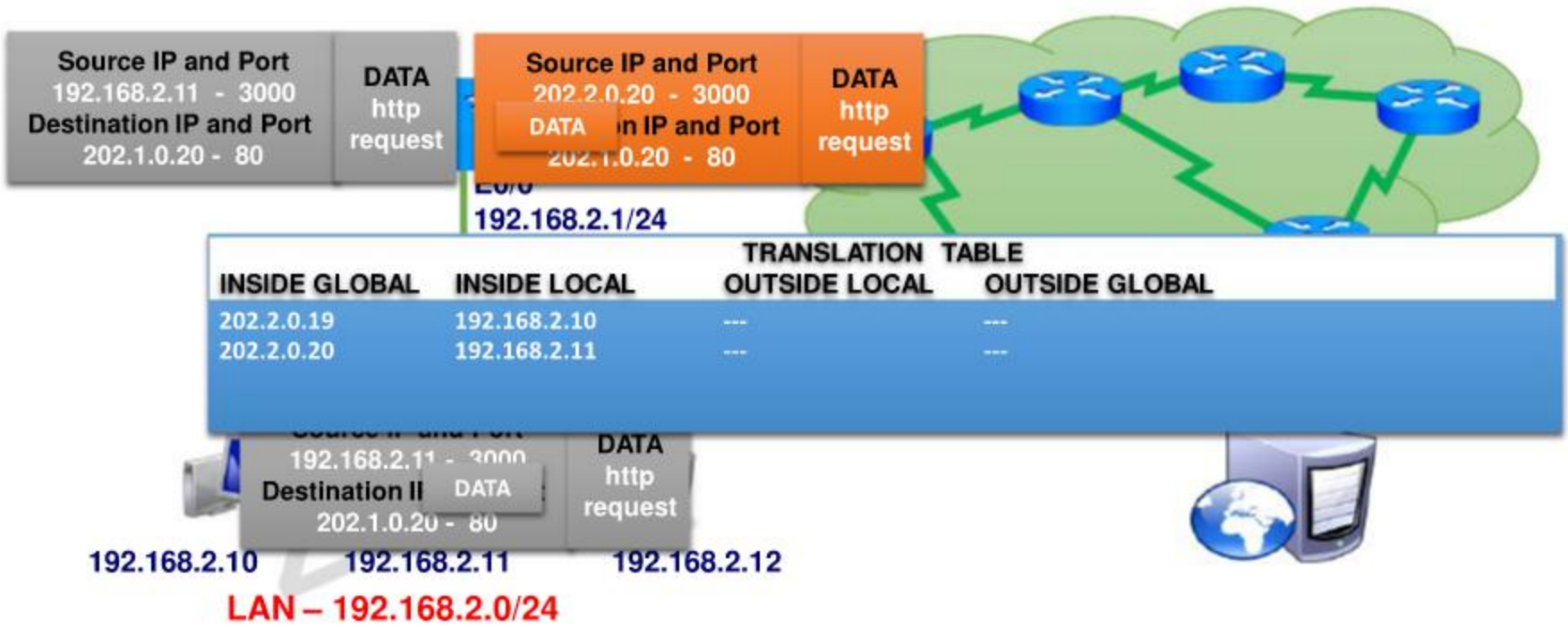


Dynamic NAT

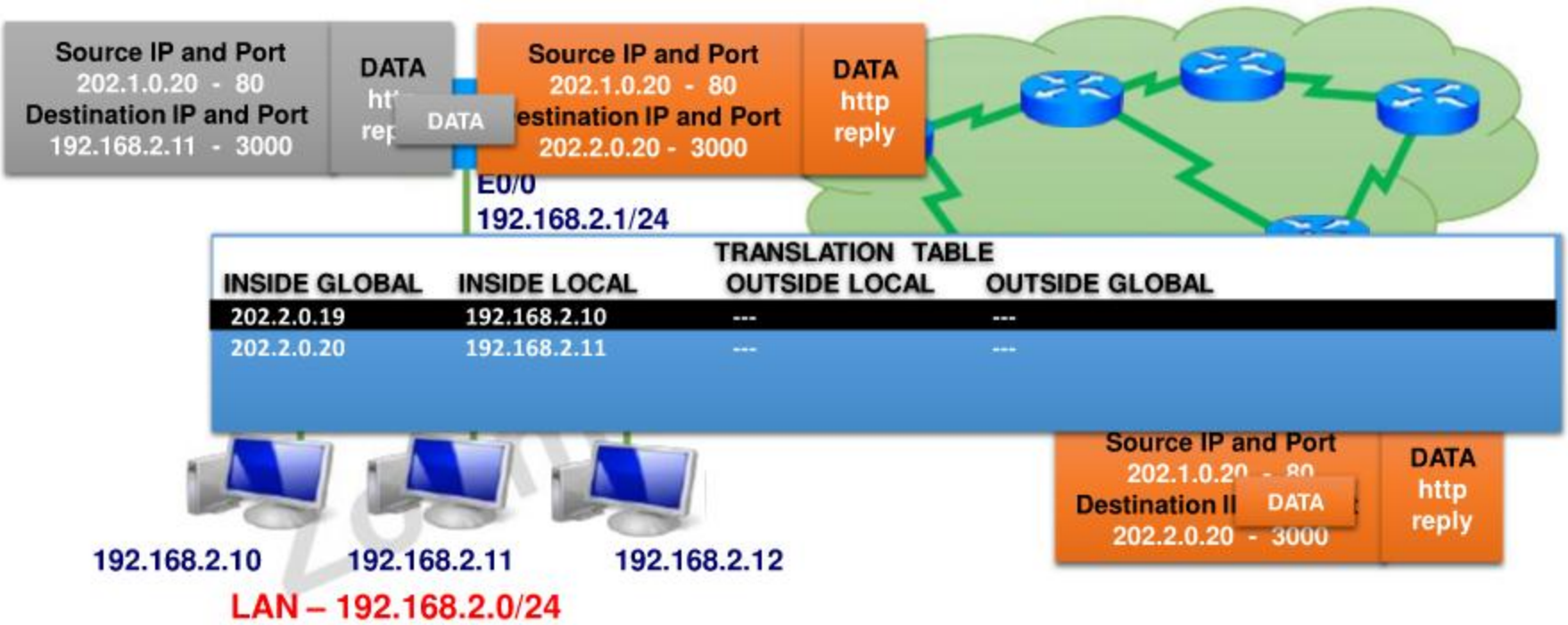


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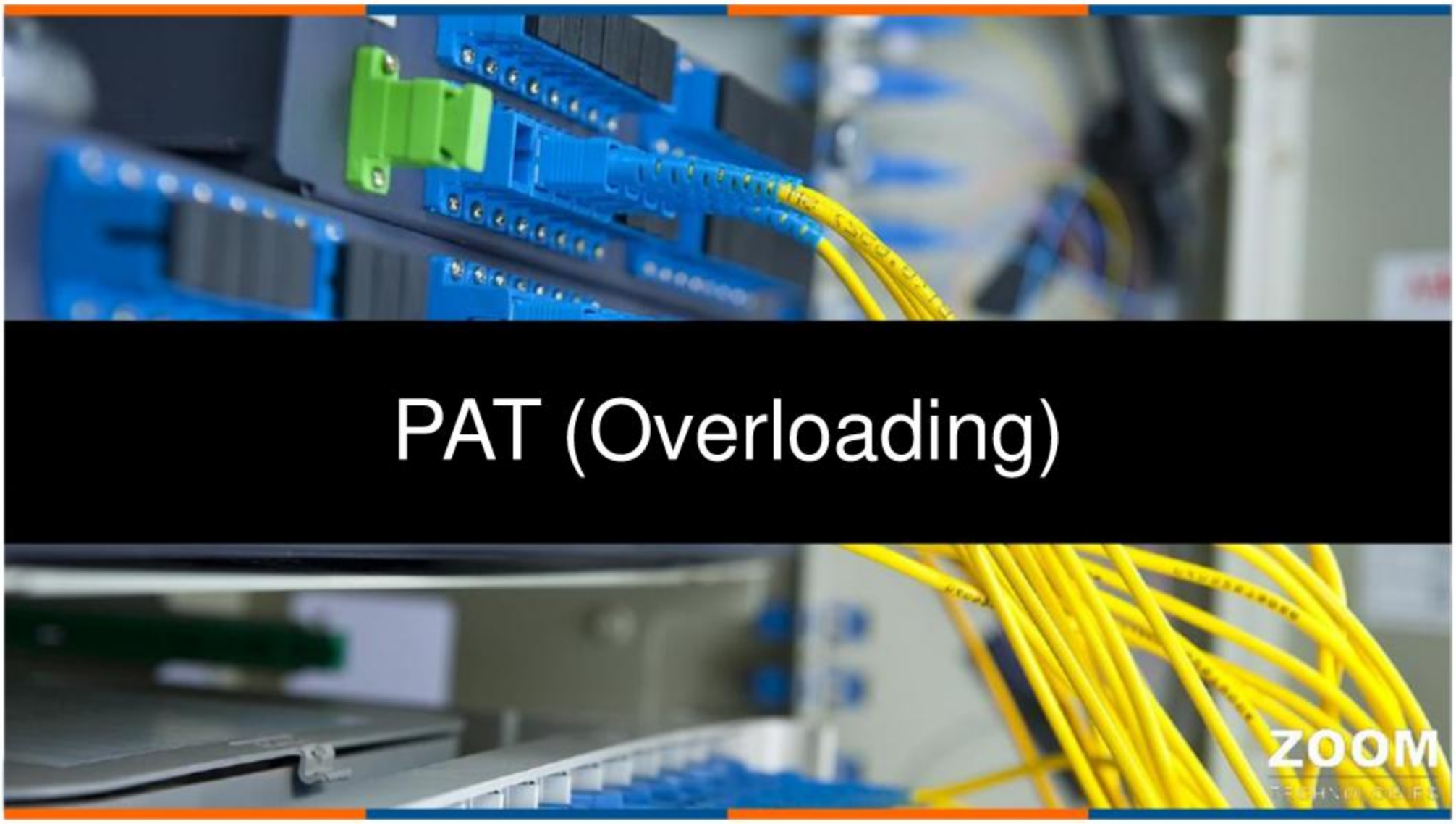
Dynamic NAT



Dynamic NAT



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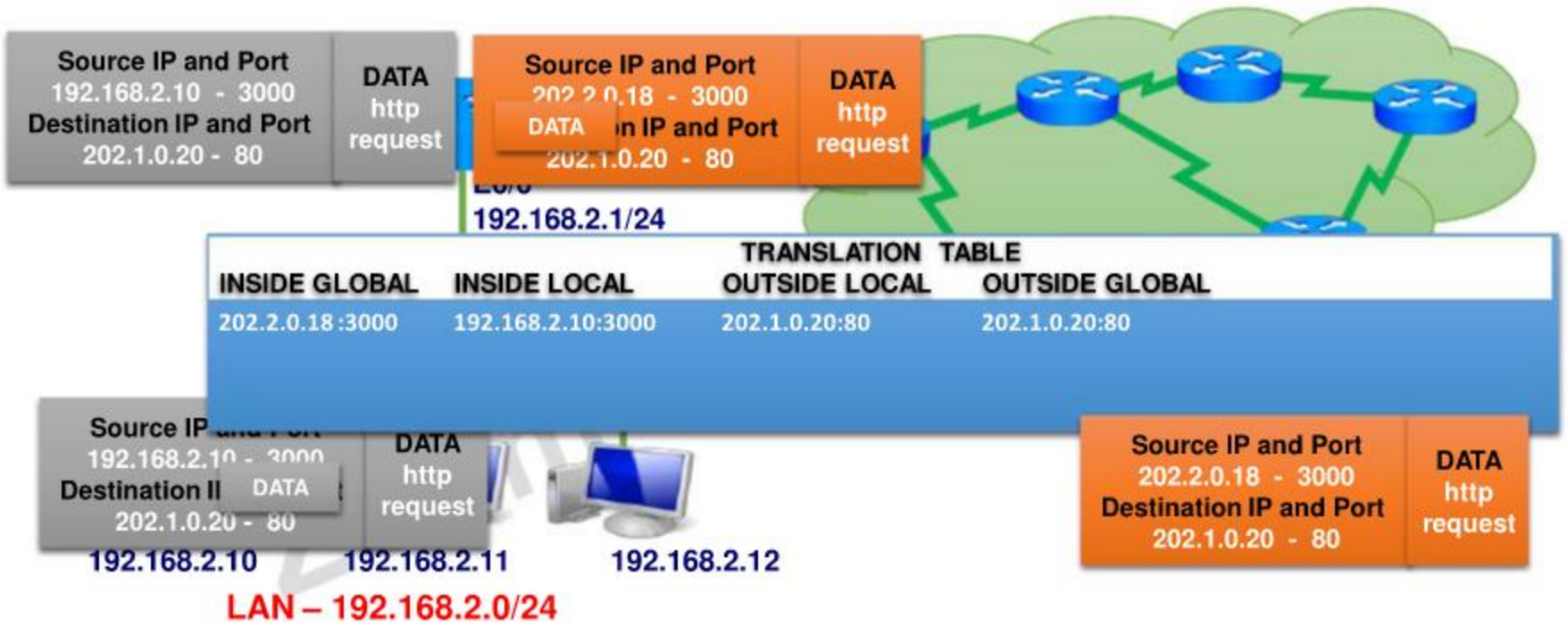


PAT(Overloading)

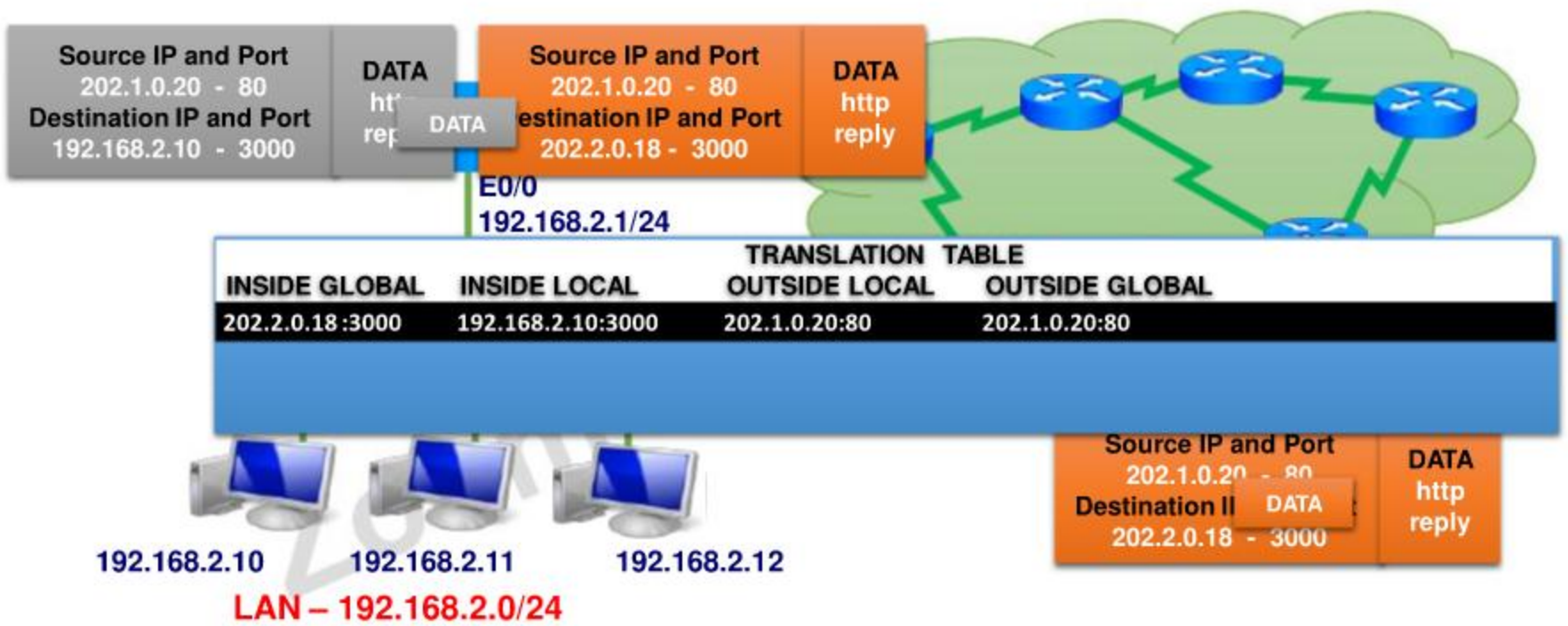
- Many private IP addresses are mapped to one public IP address.
- Configured for outbound traffic (LAN to Internet)
- All users can access Internet at the same time.

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PAT(Overloading)

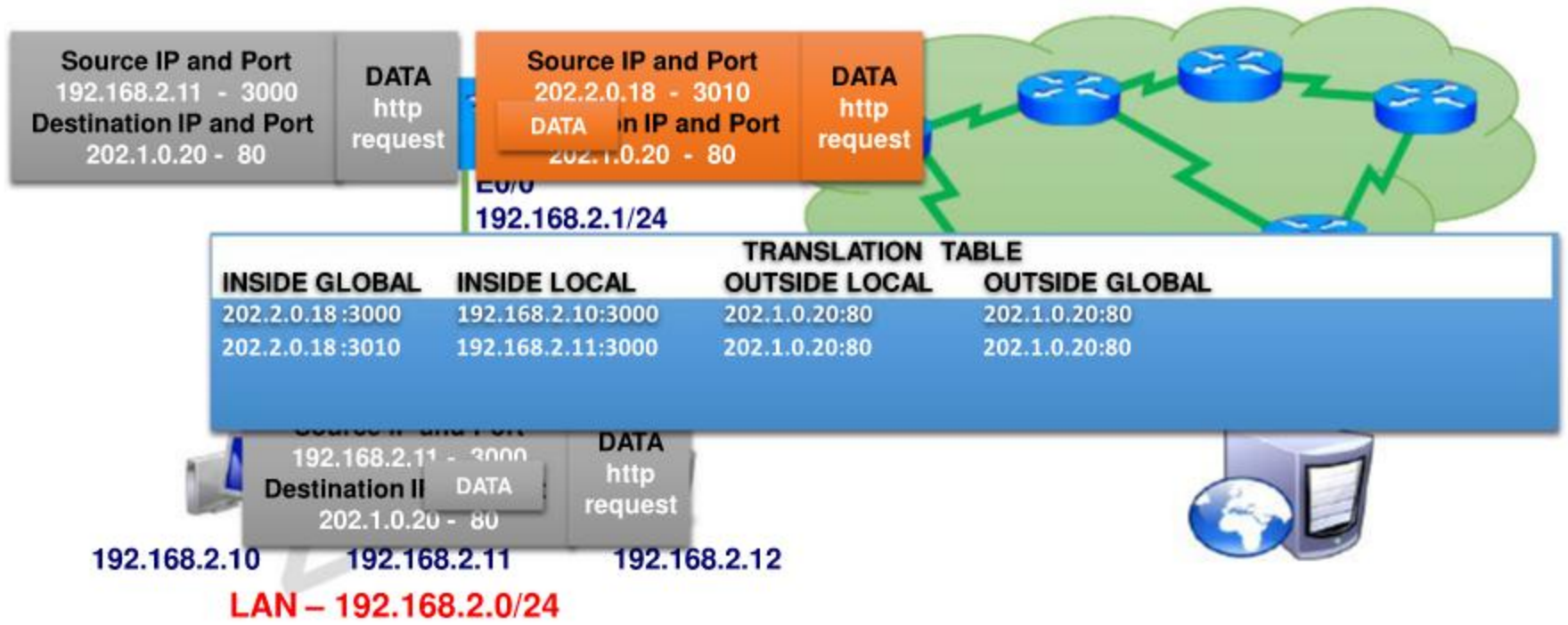


PAT(Overloading)

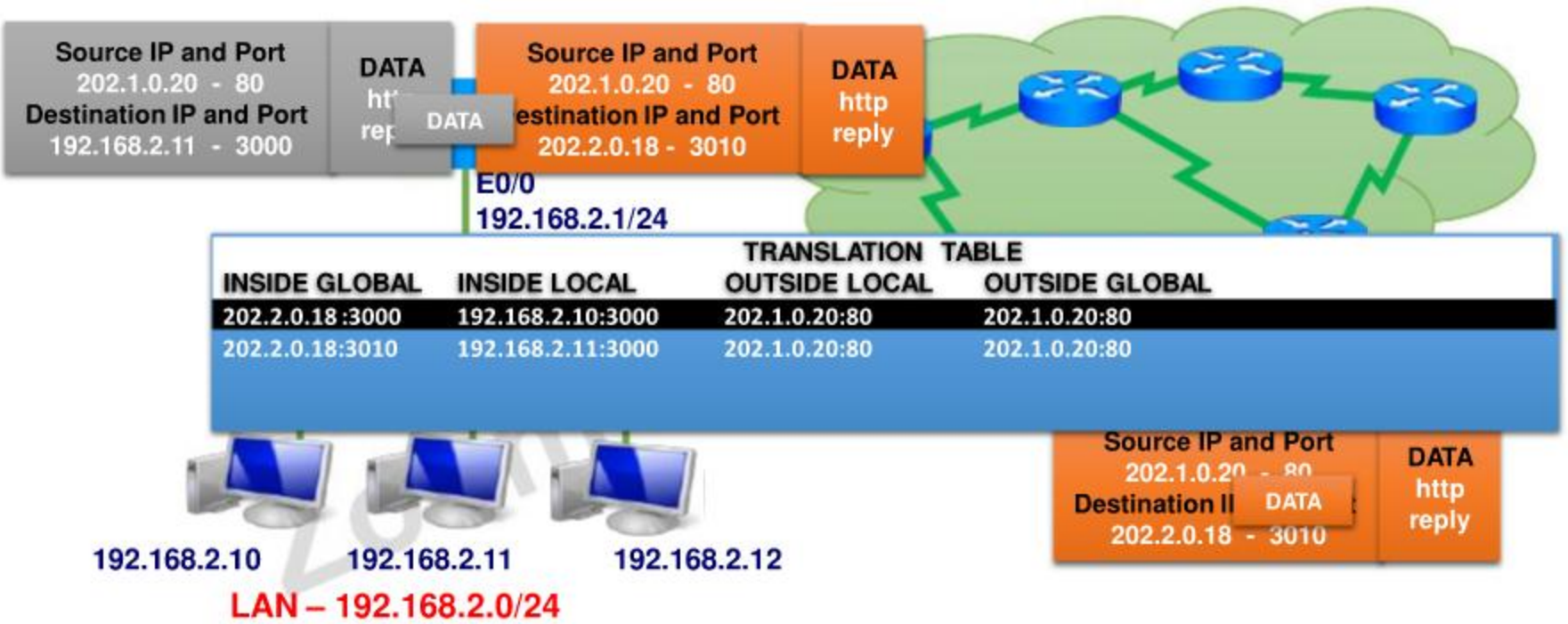


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PAT(Overloading)



PAT(Overloading)



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PAT configuration

Defining NAT on Interfaces

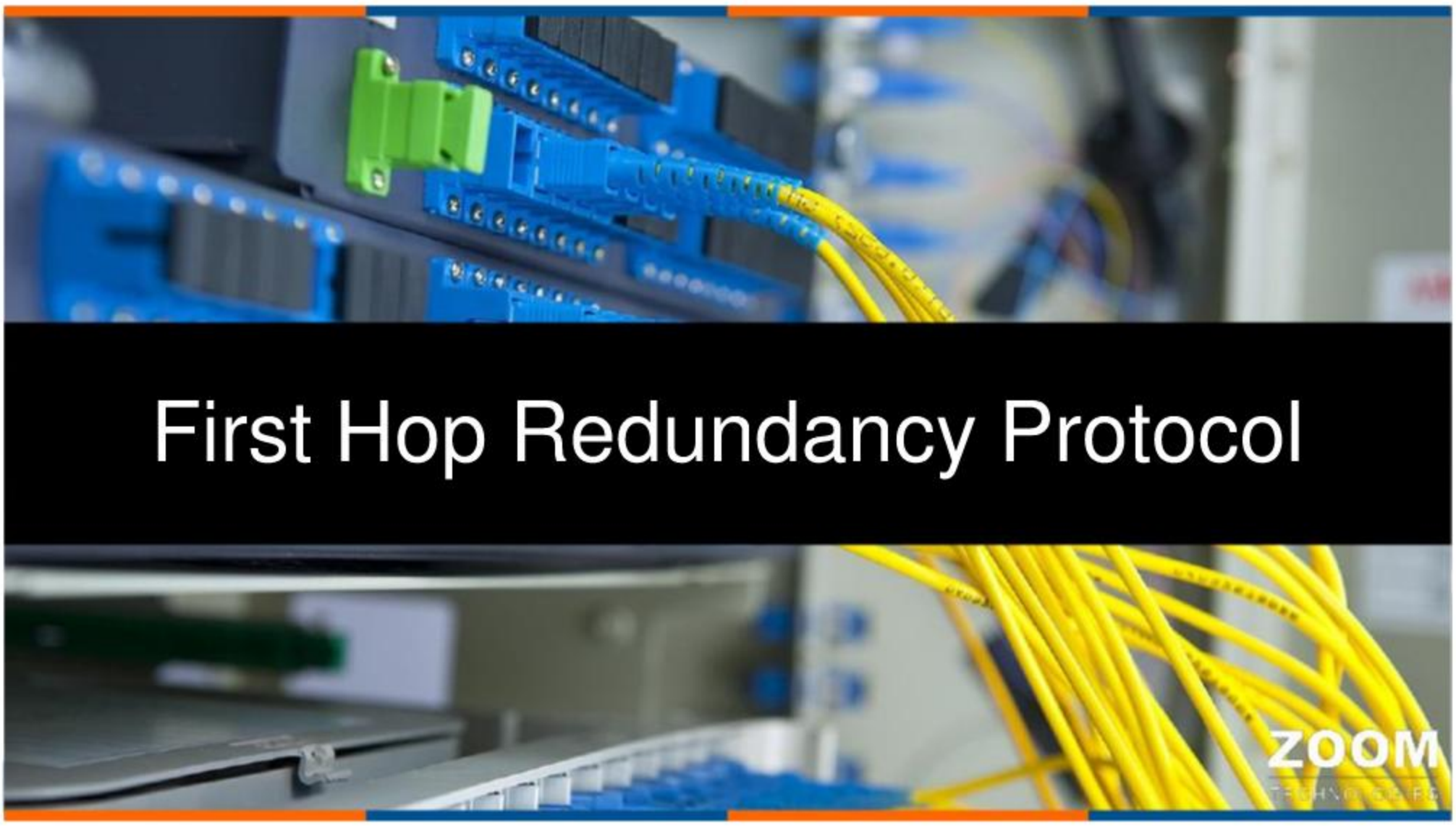
Router(config)# interface <interface type> <interface number>
Router(config-if)# ip nat inside/outside

Configuring PAT

Router(config)# ip nat inside source list <acl no.> interface < interface type >
< interface no. > overload

Verification

Router# Show ip nat translations



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FIRST HOP REDUNDANCY PROTOCOL

- First Hop Redundancy Protocols (FHRP) are a group of protocols that provide Default Gateway Redundancy if there is more than one path to the same Destination.
- The following are FHRP:
  - HSRP (Cisco Proprietary | RFC)
  - VRRP (IETF Standard)
  - GLBP (Cisco Proprietary)
- First Hop Redundancy Protocols enables two or more devices (Routers) to work together as a group. They share a common IP address called "Virtual IP address". This virtual IP address is configured as the default gateway address for the LAN hosts.

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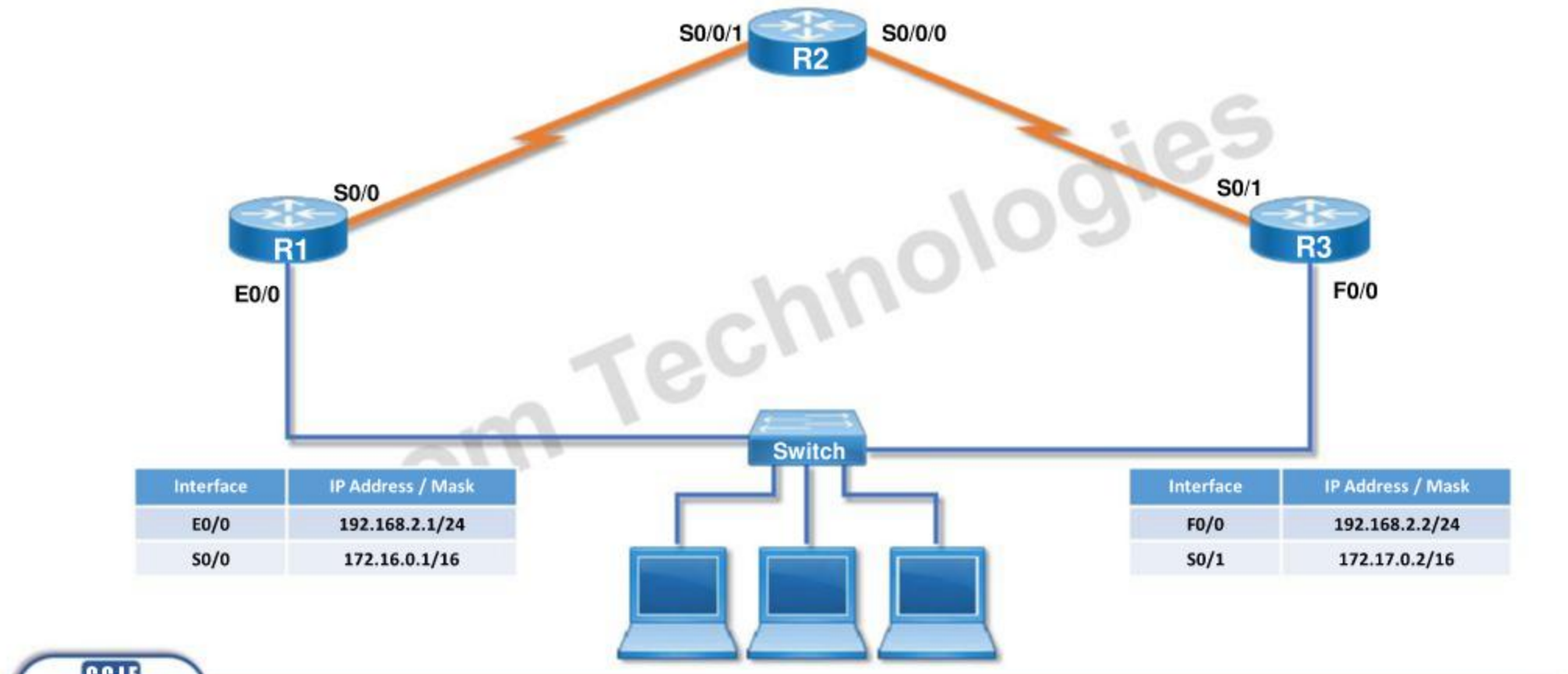
HSRP (Hot Standby Router Protocol)

- HSRP operates with an active/standby model
- HSRP allows two (or more) routers to cooperate, all being willing to act as the default router
- Only one router actively supports the end-user traffic, the other routers would be in an HSRP standby state
- The router with highest priority will be the Active router
- On all routers, default priority is 100
- If the priority is the same on all the routers, the router with highest IP address will be the Active router

Configuring HSRP

```
Router(config)# interface < interface  type > < no. >
Router(config-if)# standby 1 ip < virtual ip >
Router(config-if)# standby 1 priority < priority >
```

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Interface	IP Address / Mask
E0/0	192.168.2.1/24
S0/0	172.16.0.1/16

Interface	IP Address / Mask
F0/0	192.168.2.2/24
S0/1	172.17.0.2/16

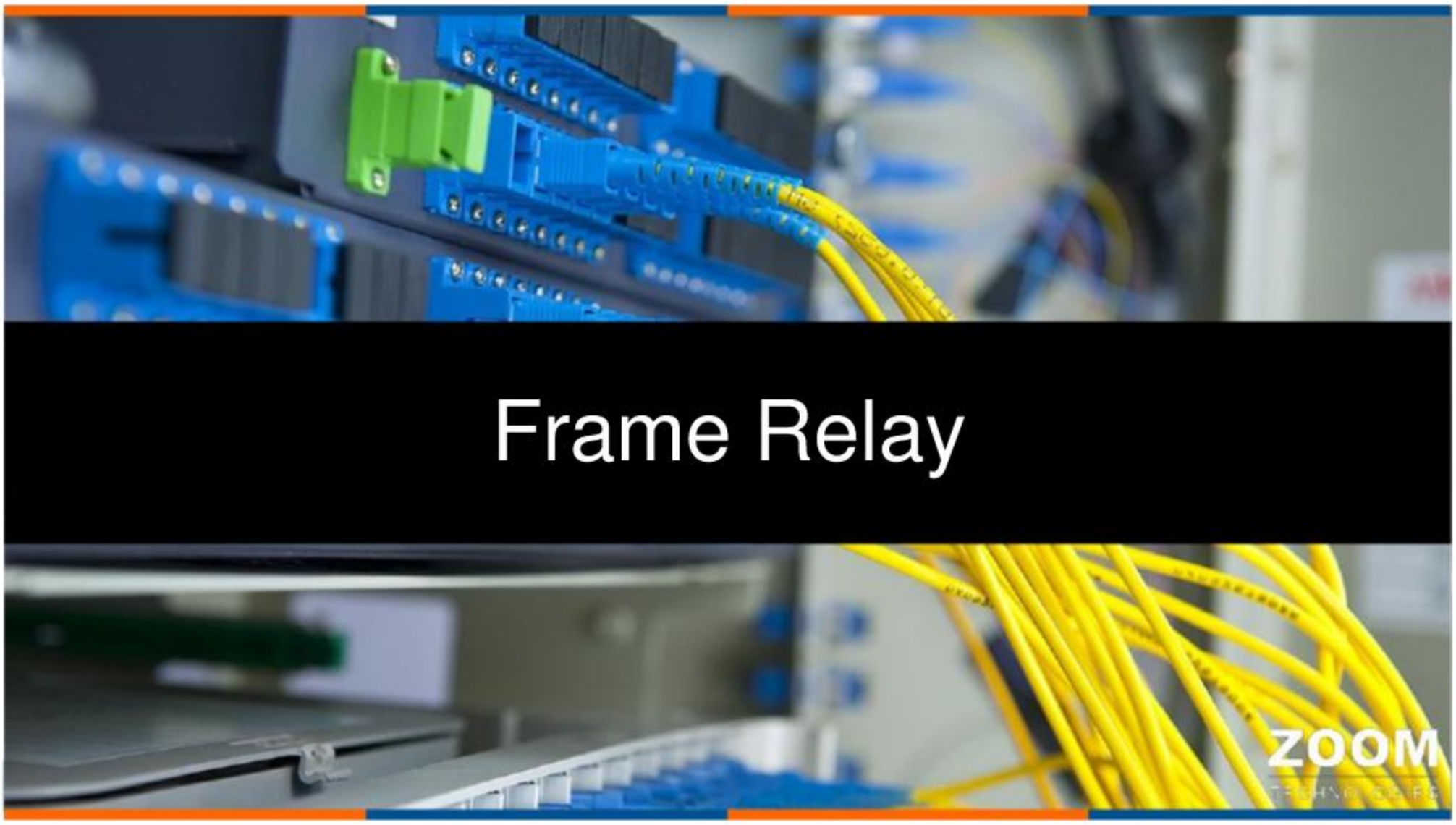


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Types of WAN Technologies

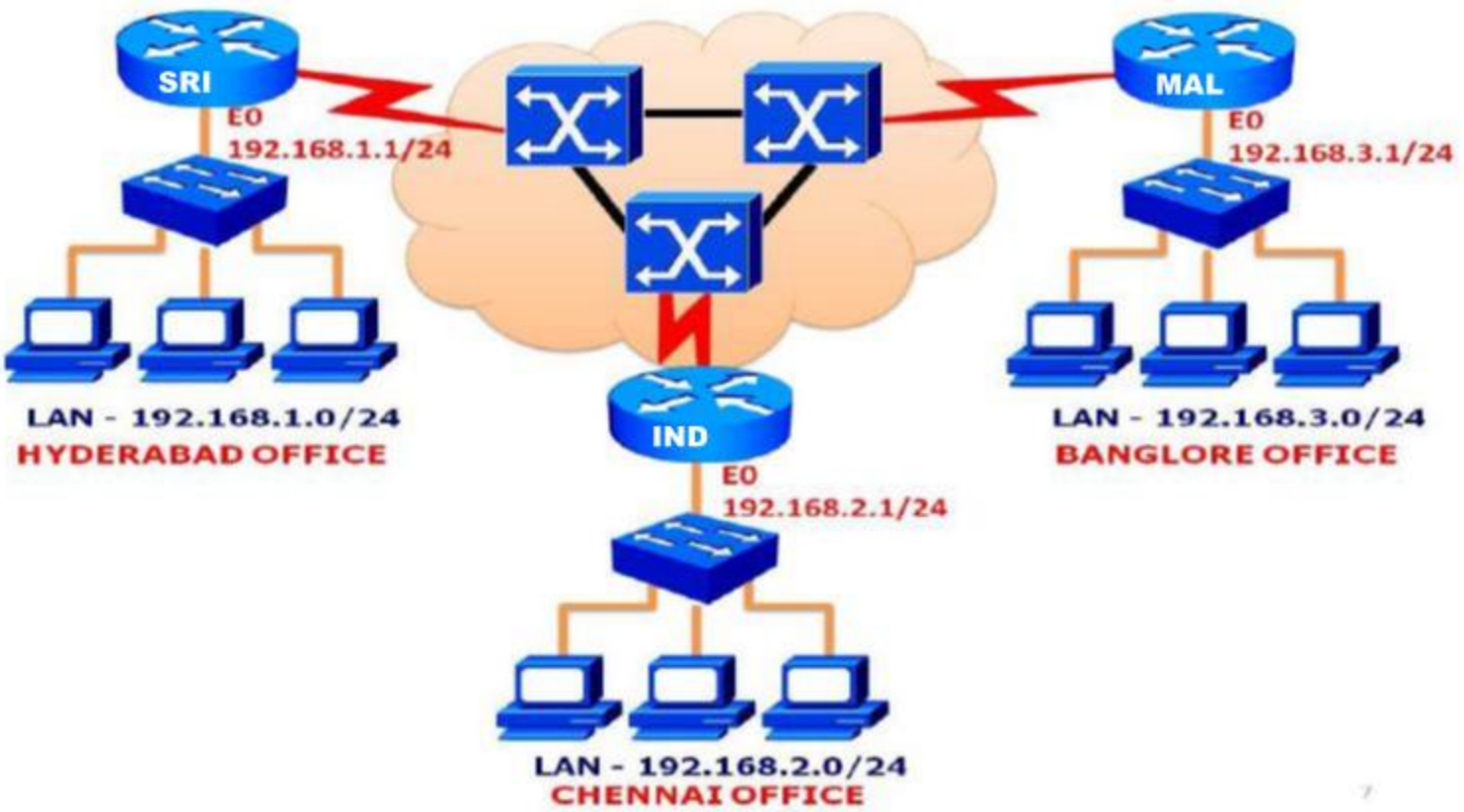
- Dedicated service
  - Leased Line
    - MLLN (Managed Leased Line Networks)
- Circuit switching
  - PSTN (Public Switched Telephone Networks)
  - ISDN (Integrated Services Digital Networks)
- Packet Switching
  - Frame-relay
  - MPLS (Multi Protocol Label Switching)
  - ATM (Asynchronous Transfer Mode)
- Broadband
  - DSL
  - Cable internet
- VSAT / MOBILE 3G or 4G / PPPoE

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Frame Relay Network Diagram



Advantages of Frame Relay

- Frame Relay uses logical circuits to make connections between sites.
- These logical circuits are referred to as Virtual Circuits (VCs).
- Only one serial interface of a Router is used to connect to multiple sites using virtual circuits.
- Uses Shared bandwidth
- VCs provide full duplex communication.

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Frame Relay Terminology

- Virtual circuits are of two types:
  - Permanent Virtual Circuits – PVCs
  - Switched Virtual Circuits –SVCs
- Permanent Virtual Circuit :
  - PVCs are similar to a leased line(dedicated).
  - Used when constant data need to be sent.
- Switched Virtual Circuit :
  - Also called as Semi-permanent virtual circuit(Dial-up).
  - Used when data has to be sent in small amounts and at periodic intervals.

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Frame Relay Terminology

- Local Management interface(LMI):
  - Works between the Router (DTE) and the Frame Relay switch (DCE).
  - It is a keepalive mechanism that provides status information about Frame Relay connectivity.
  - LMI standards : Cisco, ANSI, Q933a
  - It is Locally significant (it should be same between router and frame relay switch).

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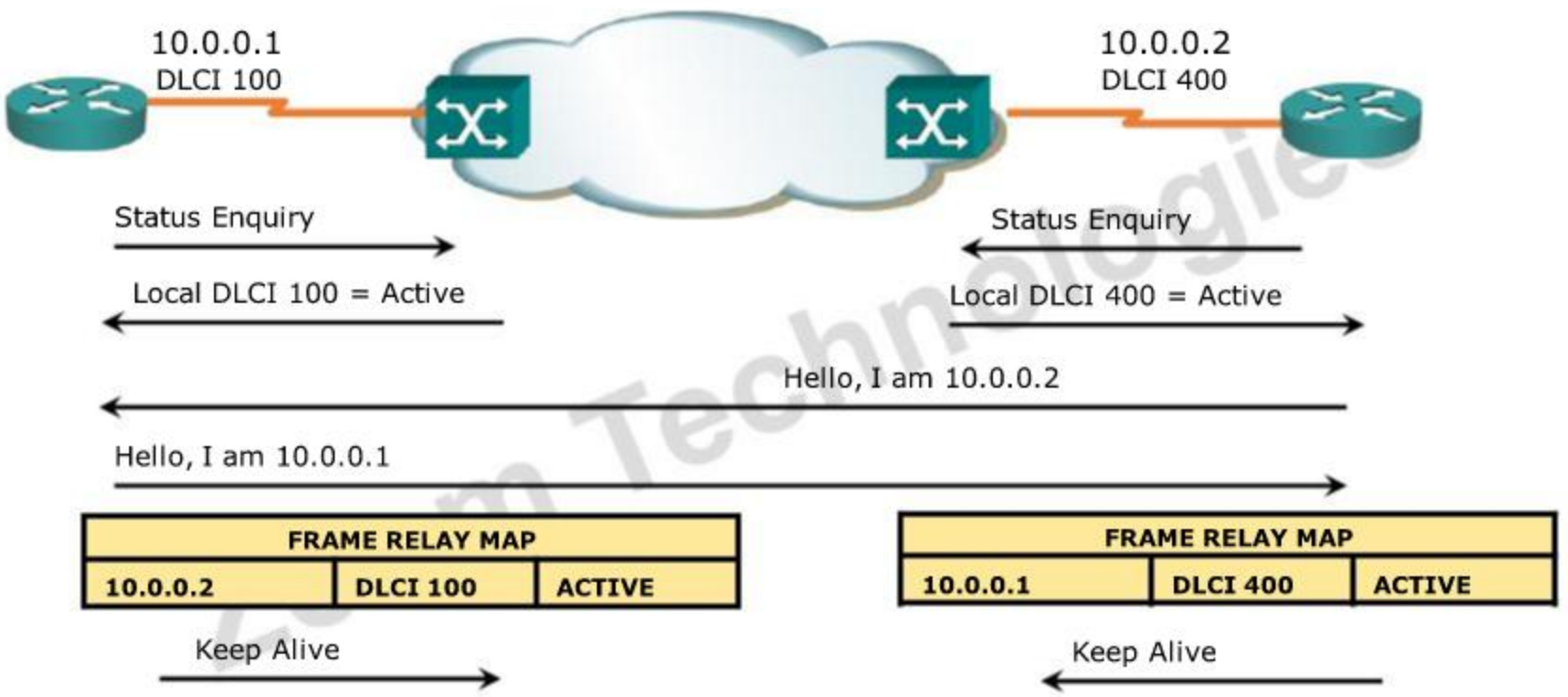
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Frame Relay Terminology

- Data Link Connection Identifier(DLCI) :
  - To identify each VC on a physical interface.
  - Each VC has a unique DLCI number(locally significant).
  - Frame relay switches use DLCI number to forward data to remote network.
  - Inverse ARP automatically maps DLCIs to next hop IP addresses, mapping can also be done manually.
  - DLCIs range from 16 to 1007 (these are assigned by service providers).

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LMI and Inverse ARP



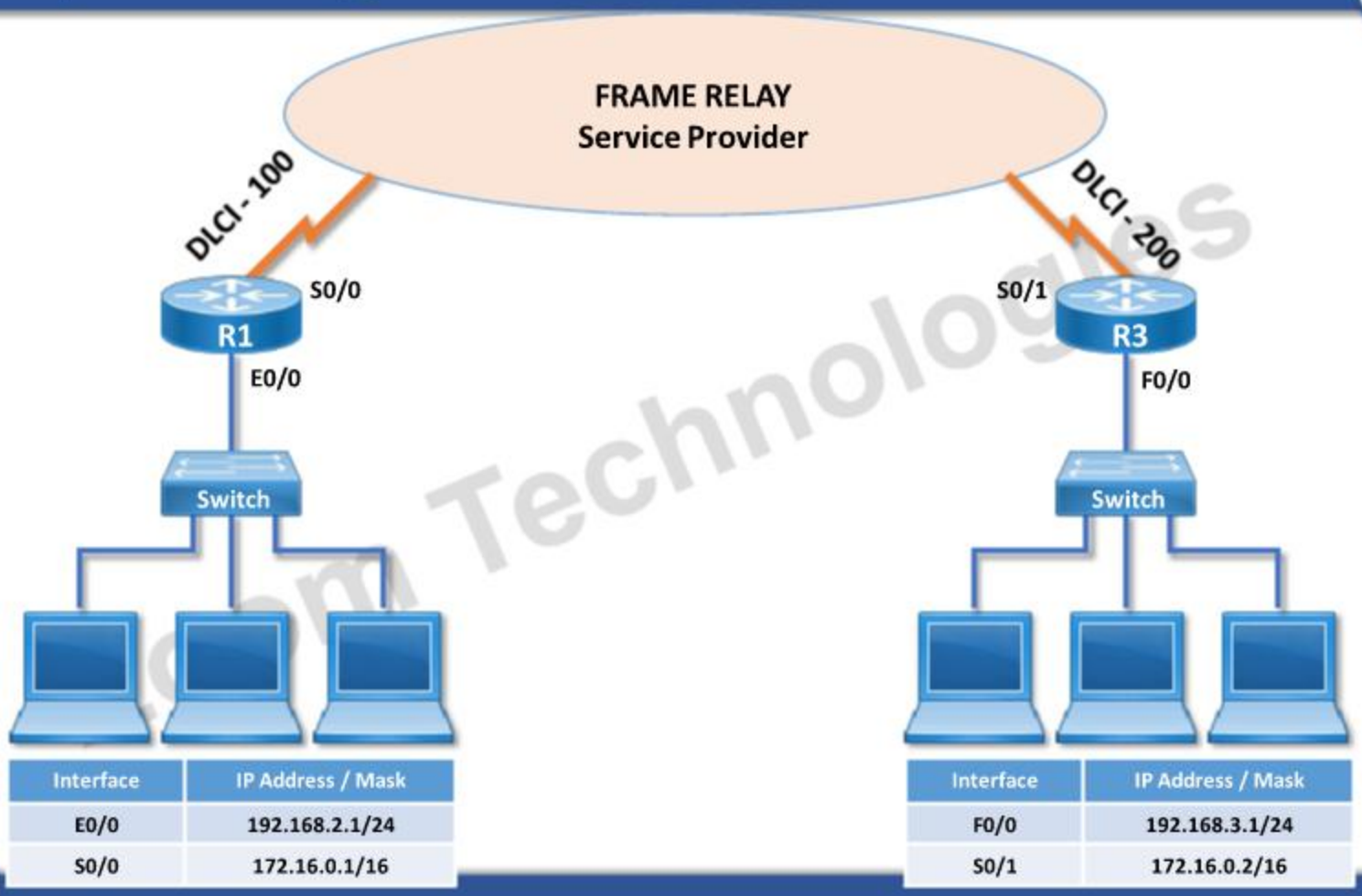
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Frame Relay Terminology

- **Committed Information Rate(CIR) :**
  - **Minimum bandwidth guaranteed by service provider.**
- **Burst Rate(BR) :**
  - **Also called excess information rate.**
  - **Excess data rate beyond the provider guaranteed(CIR).**

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Frame-Relay Network Diagram



Interface	IP Address / Mask
E0/0	192.168.2.1/24
S0/0	172.16.0.1/16

Interface	IP Address / Mask
F0/0	192.168.3.1/24
S0/1	172.16.0.2/16

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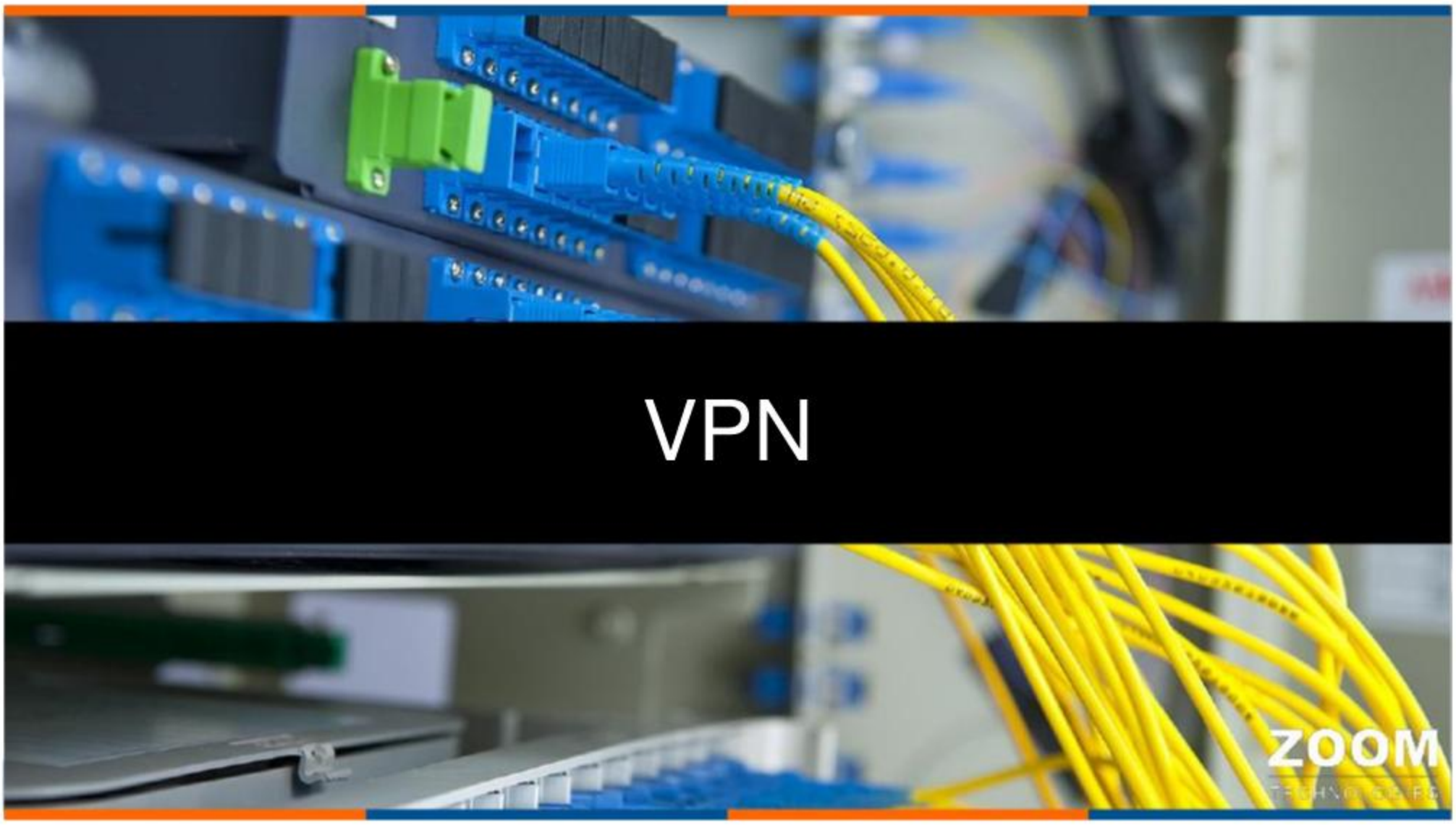
Frame Relay configuration

Configuring Serial interface

```
Router(config)# interface serial < no. >
Router(config-if)# ip address < address > < mask >
Router(config-if)# no shutdown
Router(config-if)# encapsulation  frame-relay
Router(config-if)# frame-relay  lmi-type  < lmi type >
Router(config-if)# frame-relay  interface-dlci  < dlci no >
```

Verification

```
Router# show  frame-relay map
Router# show  frame-relay pvc
```



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VIRTUAL PRIVATE NETWORK

- It provides a private communication channel over a public network.
- Provides security
- Provides point to point connectivity
- Scalability

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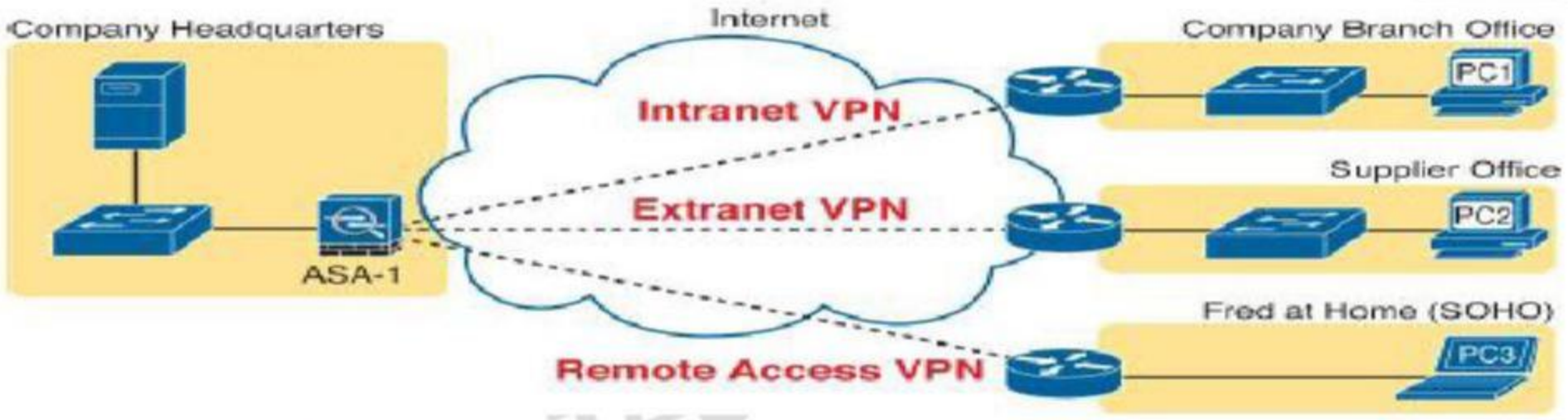
Features of VPN

- Confidentiality (Privacy)
  - Preventing anyone in the middle of the Internet (man in the middle) from being able to read the data
- Authentication
  - Ensuring that the sender of the VPN packet is a legitimate device and not a device used by an attacker
- Data integrity
  - Ensuring that the packet was not changed as the packet transited the Internet
- Anti-replay
  - Preventing a man in the middle from copying and later replaying the packets sent by a legitimate user for the purpose of pretending to be a legitimate user

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TYPES OF VPN



TYPE	TYPICAL PURPOSE
Intranet	A site to site VPN that connects all the computers at two sites of the same organization , usually using one VPN device at each site.
Extranet	A site to site VPN that connects all the computers at two sites of diffarent but partnering organisations, usually using one VPN device at each site.
Remote Access	Connecting idividual internet users to the enterprise network

Types of VPN

- **IPSEC VPN: IPSec defines how two devices, both connected to the Internet, can achieve the main goals of a VPN such as confidentiality, authentication, data integrity, and anti-replay.**
  - **IPSec uses encryption, encapsulating an IP packet inside an IPSec packet. De-encapsulation happens at the end of the tunnel, where the original IP packet is decrypted and forwarded to its intended destination.**

- **SSL VPN: The Secure Socket Layer (SSL) protocol serves as an alternative VPN technology to IPSec. In particular, today's web browsers support SSL as a way to dynamically create a secure connection from the web browser to a Web Server/Application Server, supporting safe online access to financial transactions.**

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GENERIC ROUTING ENCAPSULTION (GRE)

- GRE is a tunneling protocol that was originally developed by Cisco.
- GRE provides tunneling of non-IP traffic (IPX and Appletalk), and Multicast traffic (which is not done by IPSec).
- However, GRE provides only tunneling without any encryption.

NOTE: STATIC ROUTE SHOULD BE CONFIGURED TOWARDS REMOTE LAN NETWORK VIA TUNNEL INTERFACE

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GRE Tunnel Configuration

GRE TUNNEL Configuration

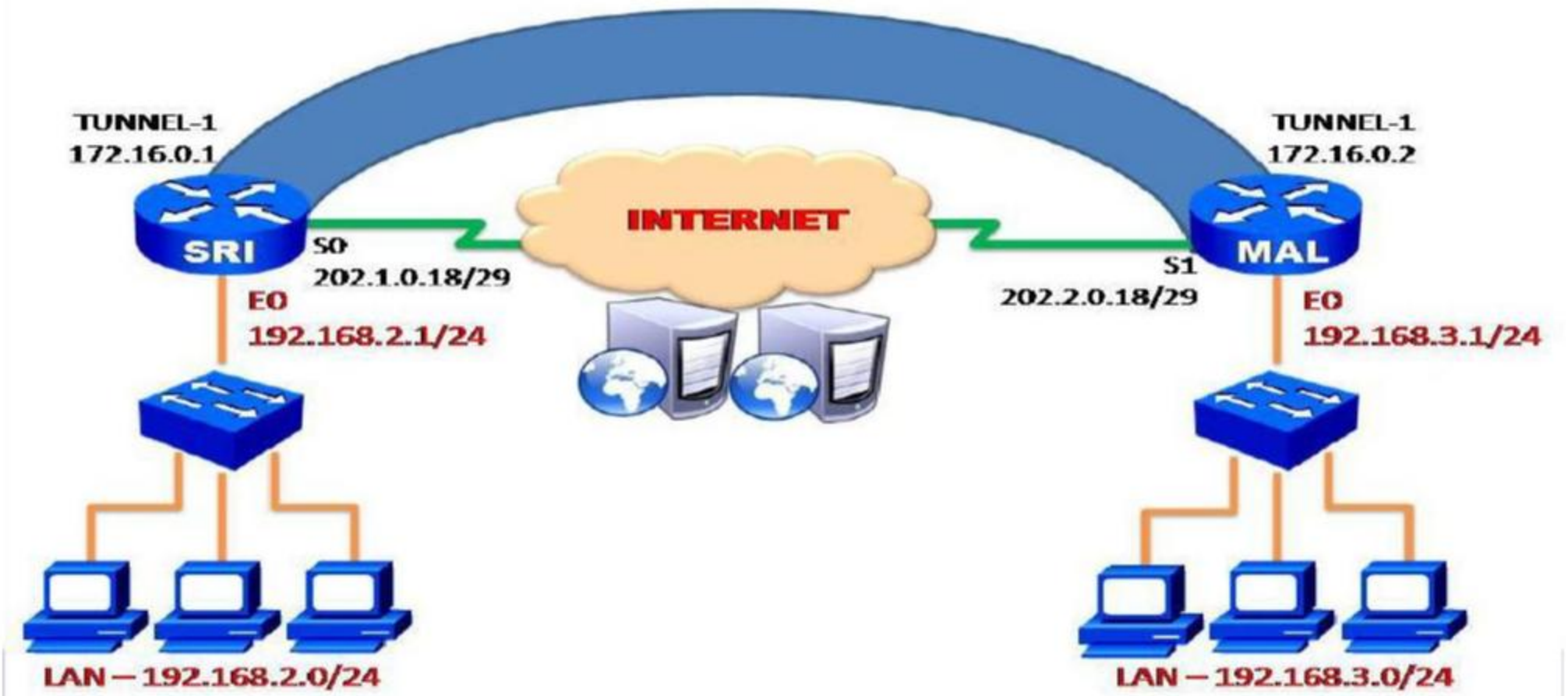
```
Router(config)# interface  tunnel  < no. >
Router(config-if)# ip  address  < address >   < subnet mask >
Router(config-if)# tunnel source < tunnel source ip address >
Router(config-if)# tunnel destination < tunnel destination ip address >
```

Verification

```
Router# Show interface tunnel < no. >
```

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Example





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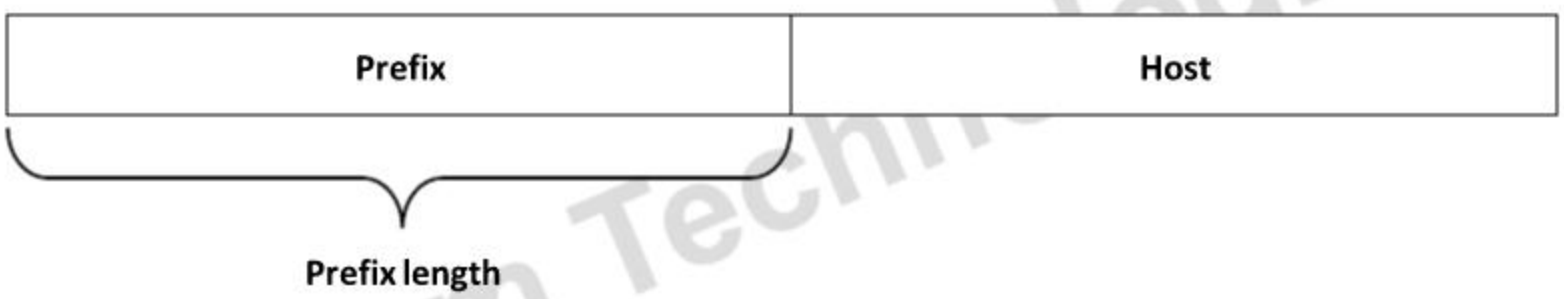
IPv6 Address

- IPv6 is a 128 bit address.
- It is represented as 32 hexadecimal numbers arranged in 8 quartets of 4 hexadecimal digit separated by a colon ":"
  - xxxx:xxxx:xxxx:xxxx:xxxx:xxxx:xxxx:xxxx
  - 2031:0000:0000:130f:0000:0000:09c4:1300
- Case insensitive for A,B,C,D,E and F.
- Leading zero in any quartet can be omitted.
- Successive fields of zeros can be represented as :: but only once in a address.

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IPv6 Address

- IPv6 is a flat addressing scheme i.e. it is not divided into classes.
- 2031:0000:0000:130f:0000:0000:09c4:1300/64



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IPv6 Address types

- Unicast
- Multicast
- Anycast

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Special Addresses

0:0:0:0:0:0:0:0	::	0.0.0.0 (any host)
0:0:0:0:0:0:0:1	::1	127.0.0.1 (Loopback)
2000::/3		Public IP addresses
FC00::/7		Unique Local
FE80::/10		Link local range
FF00::/8		Multicast range

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Host Configuration

MAC address of Local system



021C:C0FF:FE12:42EA

HOST portion of IPv6 address

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IPv6 Auto-configuration



2031:0000:0000:130f:021c:c0ff:fe12:42ea /64

Assigned by Router **Self MAC address + padded bits**

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Neighbor Discovery Protocol (NDP).

- ARP Replaced by Neighbor Discovery Protocol
- For IPv4, Address Resolution Protocol(ARP) discovers the MAC address used by neighbors

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NDP FUNCTIONS

- SLAAC : For Auto Configuration
- Router Discovery : To Identify the Router
- Duplicate Address Detection(DAD) : To Identify the IP conflicts
- Neighbor MAC Discovery : To get destination MAC Address

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NDP MESSAGES

- Router Solicitation (RS): It is a message generated by Client to Router, FF02::2(multicast address)
- Router Advertisement (RA):This is a response of Router Solicitation, FF02::1 (mulicast address)
- Neighbor Solicitation (NS): It is a request to discover Destination Client
- Neighbor advertisement (NA): It is a reply for Neighbor Solicitation message

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IPv6 Routing protocols

- Static
- RIPng
- OSPFv3
- EIGRPv6
- MP BGP

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IPv4/IPv6 co-existence

- Dual-stack
- Tunneling
- Translation (NAT –PT)

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Dual Stack

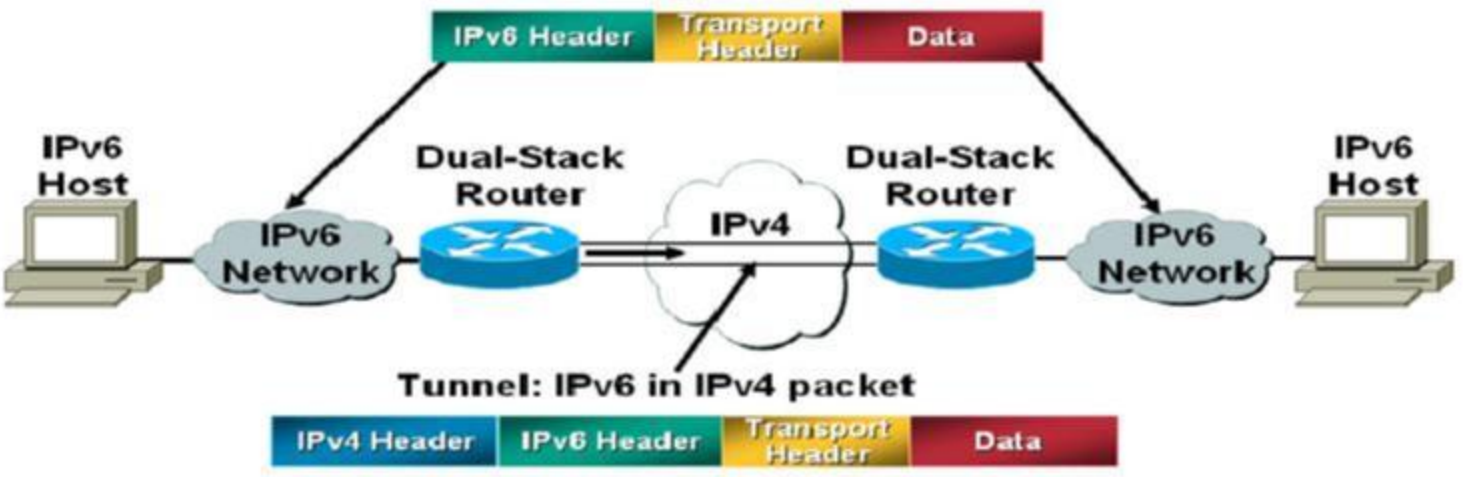
- Dual stack is process of configuring IPv4 and IPv6 address on the same interface.



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6to4 tunneling



NAT-PT

- Similar to static NAT in IPv4.
- Each IPv4 address is NATed to a IPv6 address.

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IPv6 Configuration



Interface	IP Address / Mask
G0/0	2001:1::1/64
G0/1	2001:3::1/64

Interface	IP Address / Mask
G0/0	2001:2::1/64
G0/1	2001:3::2/64

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BASIC OSPF v3 CONFIGURATION

- It is similar to OSPF v2 for IPv4
- OSPF v3 is for IPv6 Networks
- Similarities between OSPF V2 and OSPF V3
  - Both are Link State Protocols
  - Both use IPv4 address as Router Id
  - LSA flooding and aging mechanism
  - Basic packet types (LSAs)

OSPF v3 Configuration

```
Router(config)# ipv6 unicast-routing
Router(config)# ipv6 router ospf < P id >
Router(config-rtr)# router-id < ipv4 ip address >
Router(config-rtr)# exit
Router(config)# interface < interface type > < no. >
Router(config-if)# ipv6 ospf < P id > area < area id >
```



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EIGRP v6

- It is similar to EIGRP of IPv4
- EIGRP v6 is for IPv6 Networks

EIGRP v6 Configuration

```
Router(config)# ipv6 unicast-routing
Router(config)# ipv6 router eigrp < As no. >
Router(config-rtr)# no shutdown
Router(config-rtr)# router-id < ipv4 ip address >
Router(config-rtr)# exit
Router(config)# interface < interface type > < no. >
Router(config-if)# ipv6 eigrp < As no. >
```



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Cisco Discovery Protocol (CDP)

- It is a Cisco proprietary protocol.
- CDP is enabled by default in all Cisco devices.
- CDP advertisements are sent through all the ports by default.
- CDP Advertisement are sent every 60 seconds.
- CDP Advertisements are sent via multicast address 01:00:0c:cc:cc:cc.

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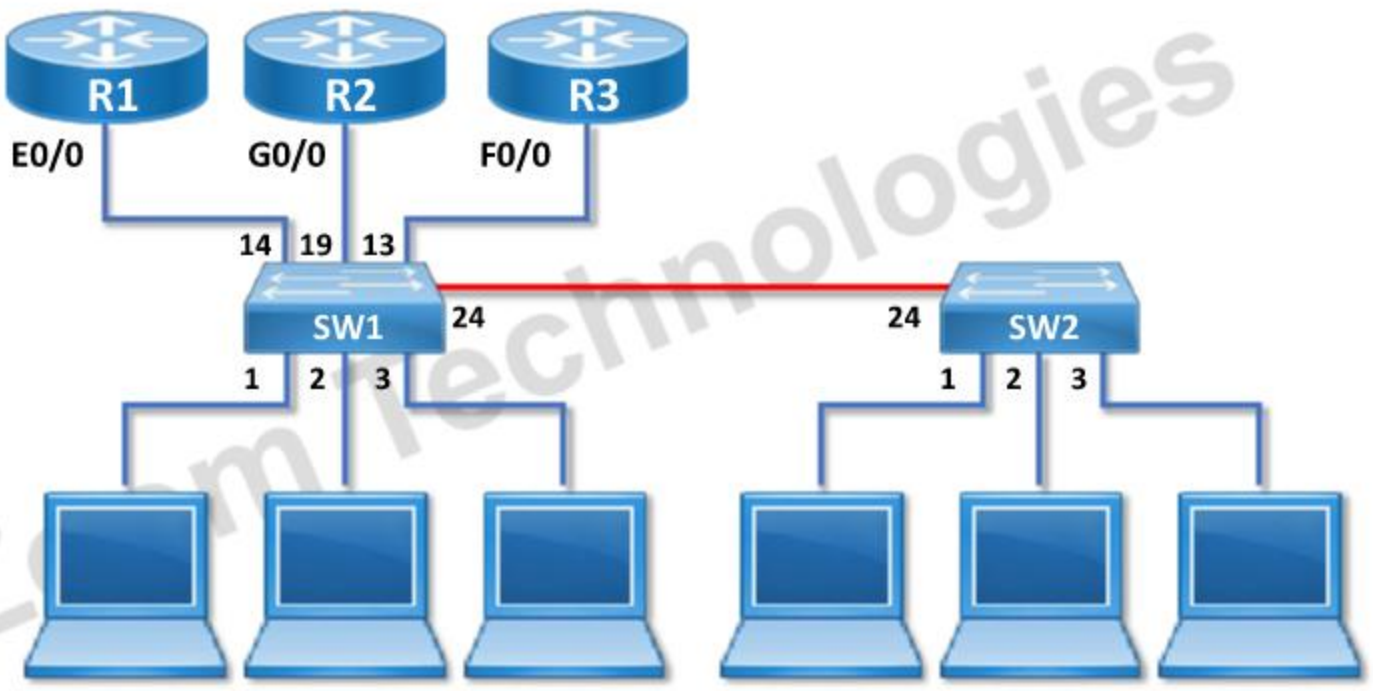
Advantages of CDP

- Once Layer 1 is active CDP sends the information to its active neighbors.
- It can be used for Layer 1, layer 2, layer 3 troubleshooting.
- Information advertised by CDP
  - Logical address (if defined)
  - Hostname
  - Hardware Platform
  - IOS Version
  - Interface Type and Interface Number of local and remote device connected.

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Example of CDP working



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Disadvantages Of CDP

- CDP can be used only between Cisco devices.
- Information about only directly connected neighbors can be known.

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DYNAMIC HOST CONFIGURATION PROTOCOL

- DHCP is used for dynamic IP address assignment to network devices / hosts
- DHCP server provides IP address, Subnet mask, Default gateway and DNS server IP address to DHCP clients.

Configuring DHCP

```
Router(config)#ip dhcp pool < name >
Router(config-dhcp)#network < network id > < subnet mask >
Router(config-dhcp)#default-router  < ip address >
Router(config-dhcp)#dns-server < ip address >
Router(config-dhcp)#lease < time >
Router(config-dhcp)#exit
Router(config)#ip dhcp excluded-address < start ip > < end ip >
```

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SSH (SECURE SHELL)

- Telnet is used to configure the Network devices.
- However Telnet sends data in plain text, so Telnet is not secure.
- SSH is used for secure remote login, it provides data encryption between host and network device.
- Cisco IOS should support encryption for running SSH.

Configuring SSH

```
Router(config)# hostname    xxxx
Router(config)# username xxxx password xxxx
Router(config)# ip domain-name  < name.com >
Router(config)# crypto key generate rsa
Router(config)# line vty 0 4
Router(config-line)# transport input ssh
Router(config-line)# login local
```

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Syslog

- Syslog is an application that stores Log information from Network devices.
- Syslog works with a Client/Server model.

- Syslog Client :
  - A network device that generates Log message and send the syslog server.

- Syslog Server :
  - A PC/Server that has the Syslog software installed and accepts and stores log messages.

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System Message Security Levels

Level	Level Name	Explanation
0	Emergency	The System may be unusable
1	Alert	Immediate action may be required
2	Critical	A critical event took place
3	Error	A router experienced an error
4	warning	A condition might warrant attention
5	Notification	A normal but significant condition occurred
6	Informational	A normal event occurred
7	Debugging	The output is a result of a debug command

Configuring Syslog

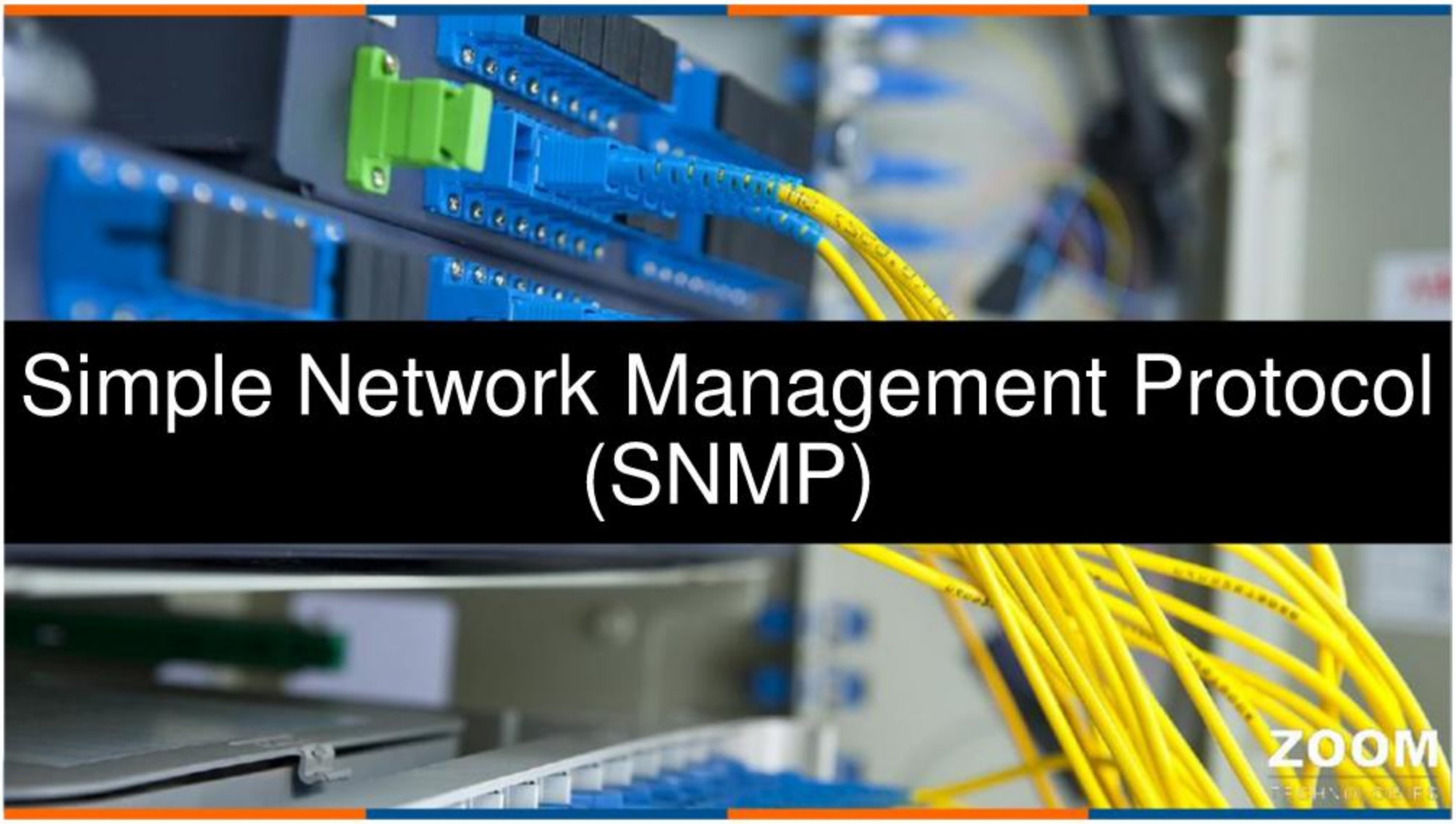
Configuring Syslog client

```
Router(config)#logging on
Router(config)#logging buffered
Router(config)#logging <syslog server ip>
```

Verification

```
Router#Show logging
```

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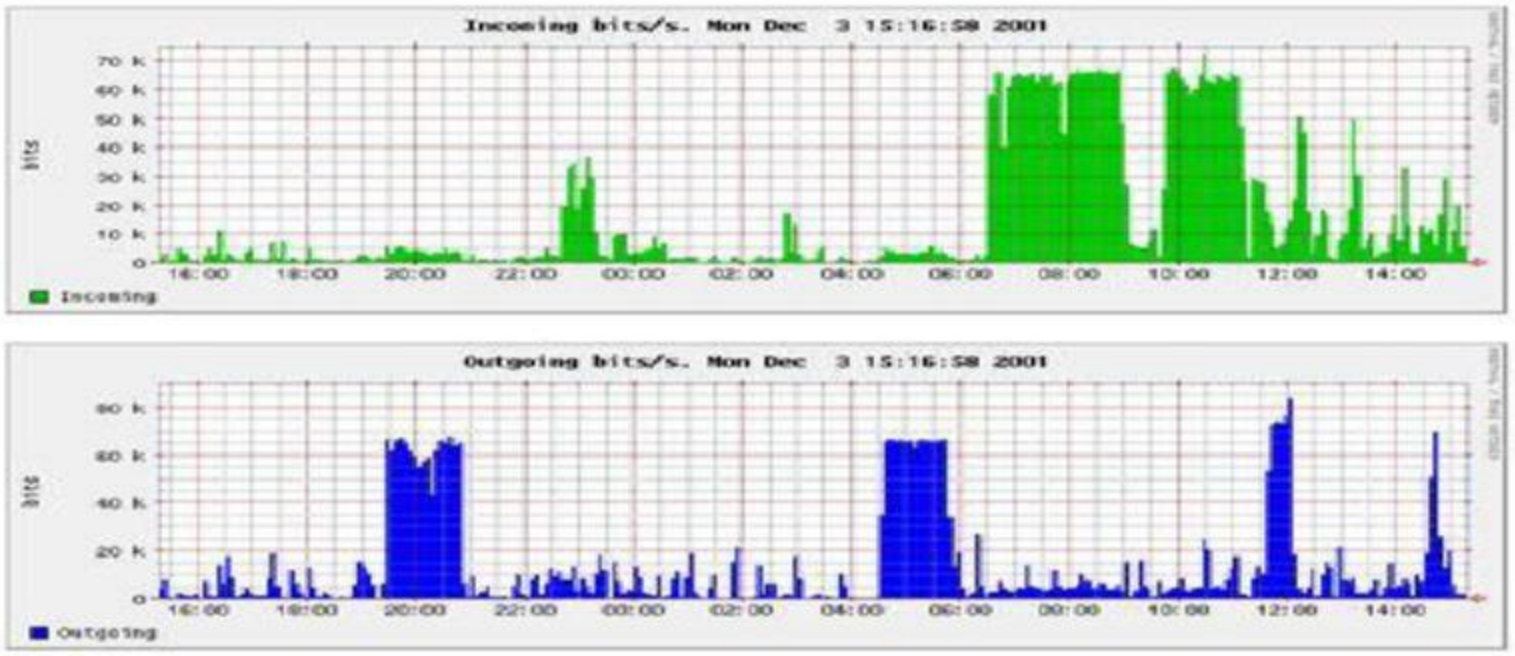
Simple Network Management Protocol (SNMP)

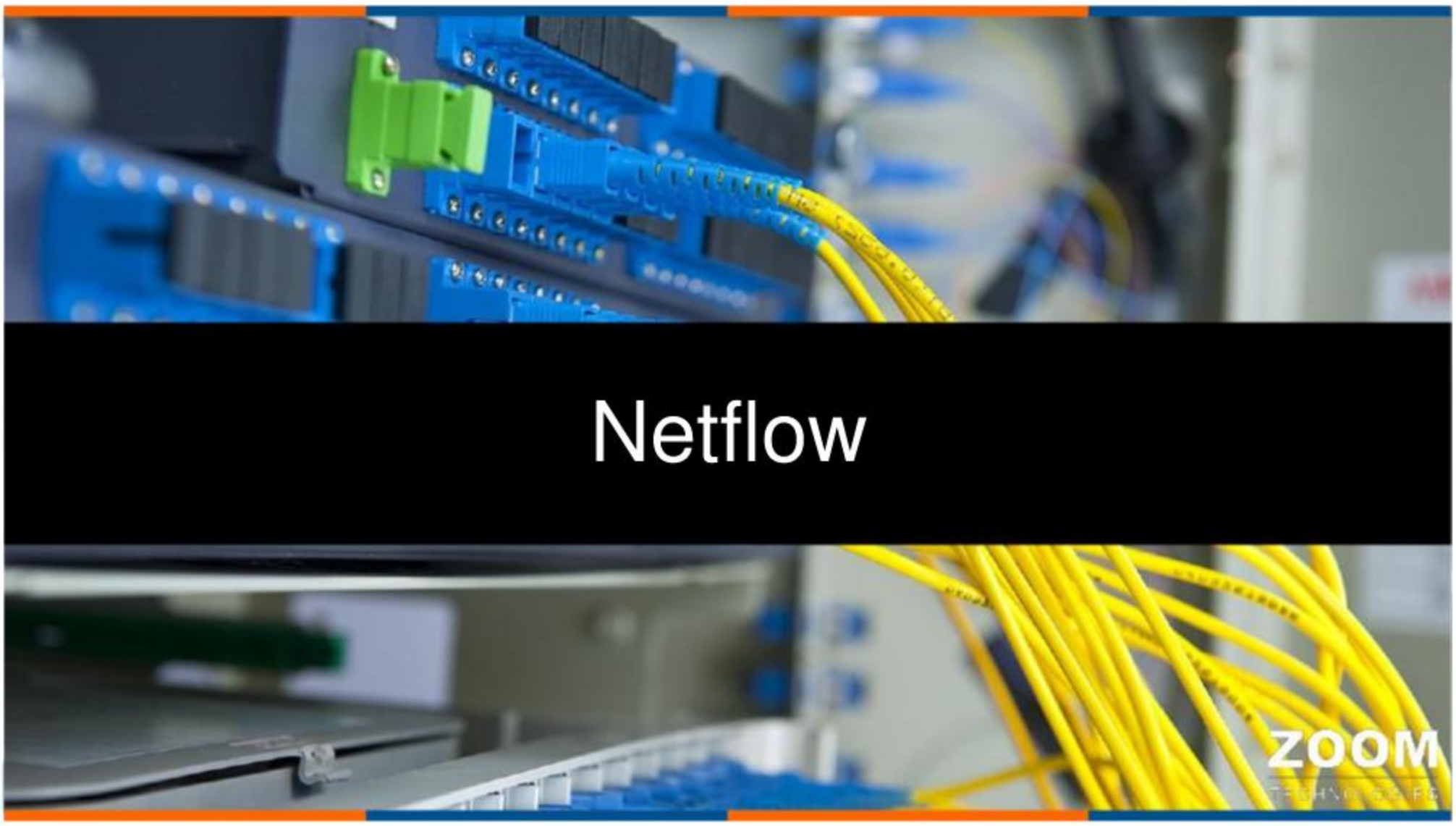
- SNMP is a standard TCP/IP protocol for Network Management.
- Supported by all Network devices (Routers, Switches, Firewalls, Servers, etc.)
- Network Administrators use SNMP to monitor and map network availability, performance, and errors.
- To read SNMP traps we need software like
  - Whatsup Gold
  - Cisco Works
  - HP Openview
  - IBM Tivoli
  - MRTG/PRTG

Note: Traps are the log messages generated by SNMP

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SNMP TRAFFIC MONITORING





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Netflow

- A Network flow is sequence of packets moving from source device to destination device
- In a flow the packets contain Source IP address, Destination IP address, Port information etc.
- Netflow is a service, configured in Routers and Switches.
- It allows Administrator to monitor the flow of different types of network traffic.
- All Switches and Routers support Netflow, however an appropriate IOS is required.

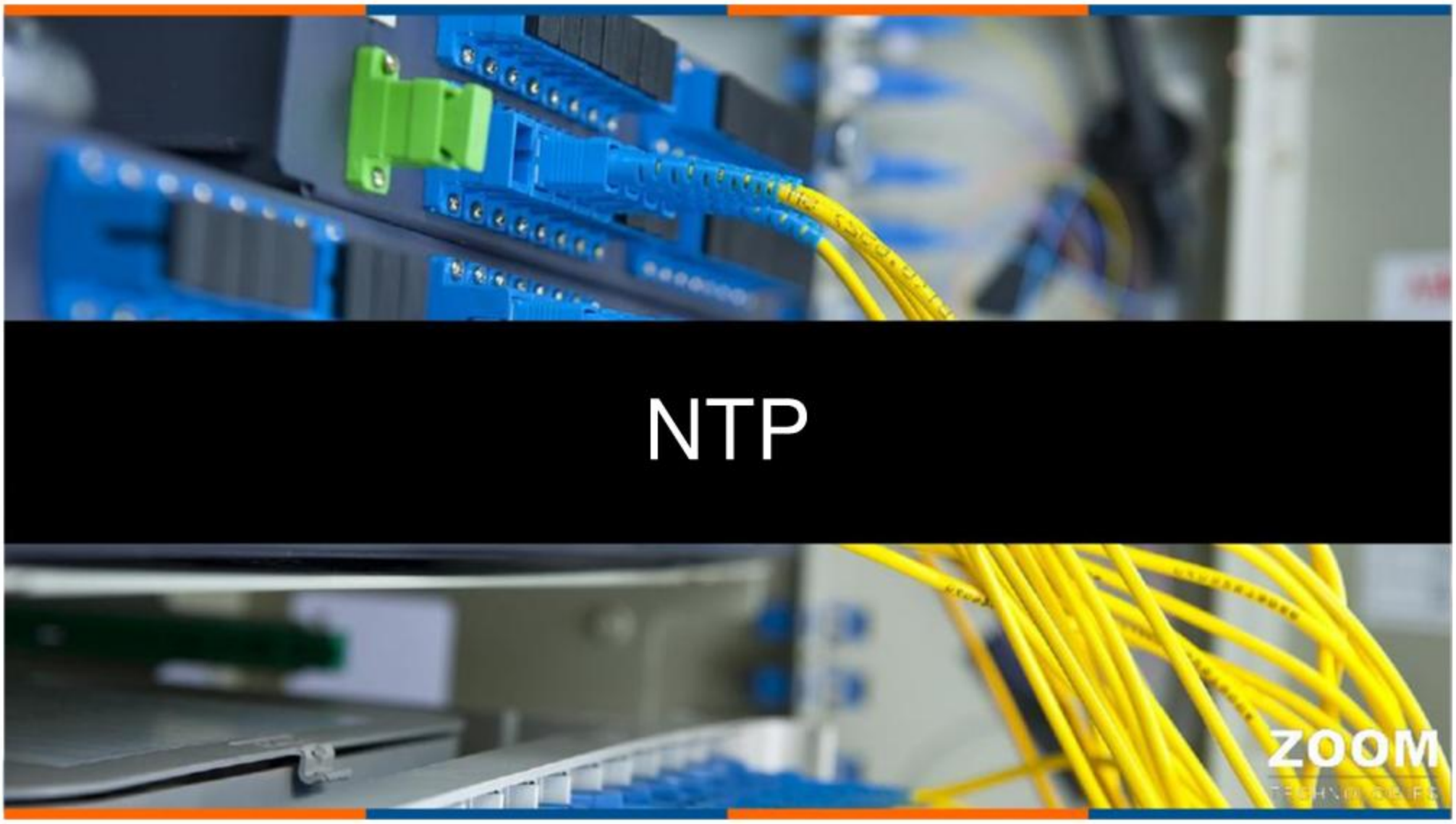
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Netflow

- Key advantages of Netflow
  - Application and network usage monitoring
  - Network productivity and utilization of network resources
  - Network anomaly and security vulnerabilities

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Network Time Protocol

- NTP is a Networking protocol designed to synchronize the clocks of computers over a network.
- NTP uses UDP port no: 123 for sending the NTP updates
- NTP uses different layers of Clock sources, each layer is called “Stratum”.
- NTP work as Client / Server model

Technologies

Configuring NTP on Router

Router(config)# ntp server < IP or Domain name of NTP server >

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Cisco IOS image

- Cisco provides IOS image for each Router and Switch series separately, the IOS image is available in different version, release and feature set.
- Cisco identifies major revisions to Cisco IOS software using the term version, with smaller changes to IOS being called a release.

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CISCO IOS Image naming Conventions

- A Cisco IOS image is a binary executable file of a feature set for specific platform .
- The name of Cisco IOS image represent the platform, features set, format, and other information of image file.



Naming Conventions Feature Set

- Base:
  - Entry level image (i.e.: IP Base, Enterprise Base).
- Services:
  - Addition of IP Telephony Service, MPLS, Net Flow, VoIP, VoFR, and ATM (i.e.: SP Services, Enterprise Services).
- Advanced
  - Addition of VPN, Cisco IOS Firewall, 3DES encryption, Secure Shell, Cisco IOS IPSec and Intrusion Detection Systems (i.e.: Advanced Security, Advanced IP Services).
- Enterprise
  - Addition of multi-protocols, including IBM, IPX, AppleTalk (i.e.: Enterprise Base, Enterprise Services).

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Licensing

- A Software license is provided by Cisco by specifying the product id, serial number, and PAK (Product activation key) of the device
- License will be received through email or in CD after ordering the IOS with required feature set.
- NOTE: By default we will get the license with the device which we order with required features. If we require extra features we have to order Product Activation Key from Cisco product License portal.

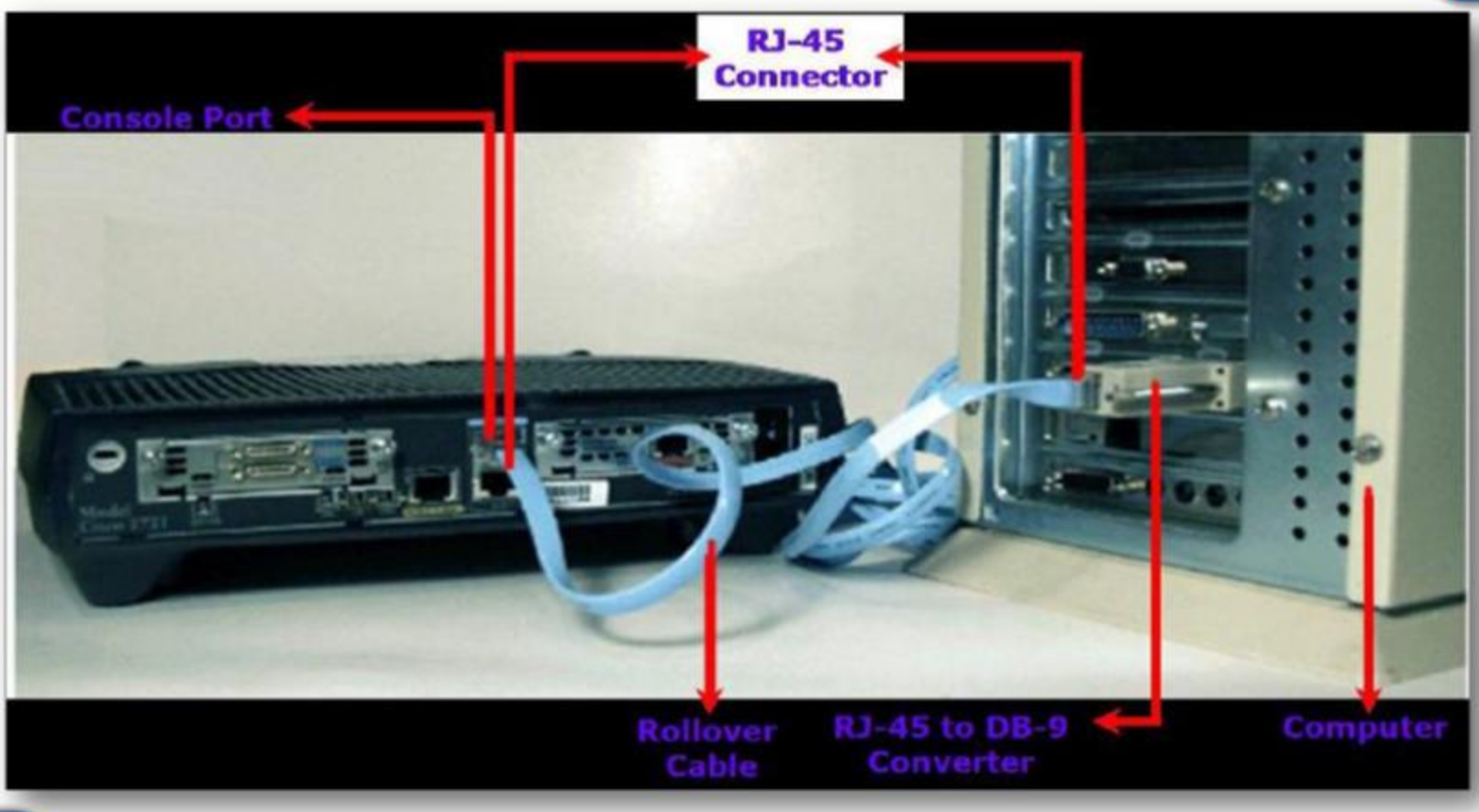
- License installation
- Copy the License in tftp server

```
Router # license install tftp:// <ip address of tftp>/license.lic
```

- Note: after successful installation of license reload the router



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- Connect the console cable from Router console Port to PC COM port
- Open the Emulation Software (Putty)
- Restart the Router
- Press Ctrl + Break to Enter into Rommon mode

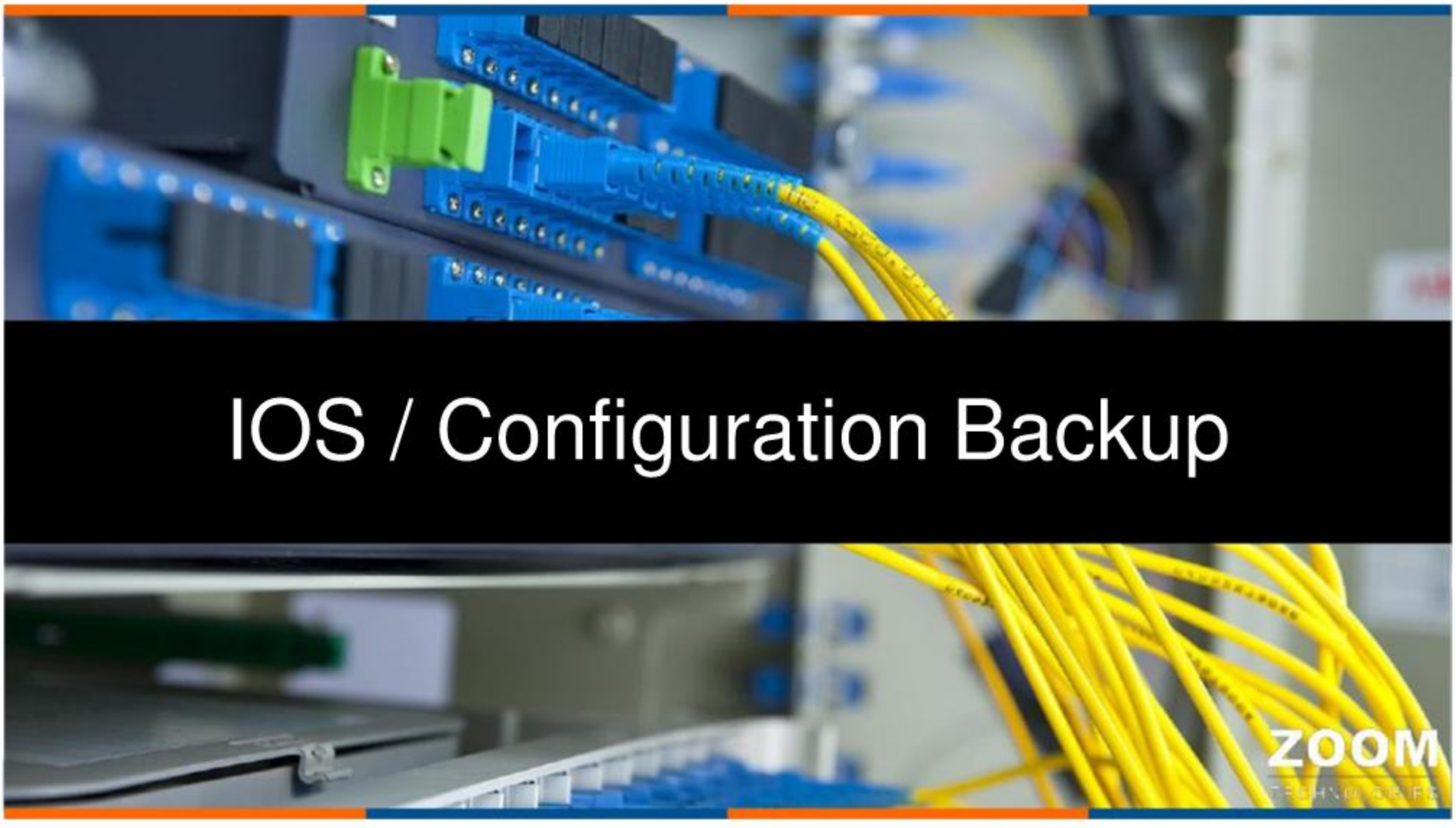
- Changing configuration register value in Modular Router

```
rommon1>confreg  0x2142
rommon2>reset
```

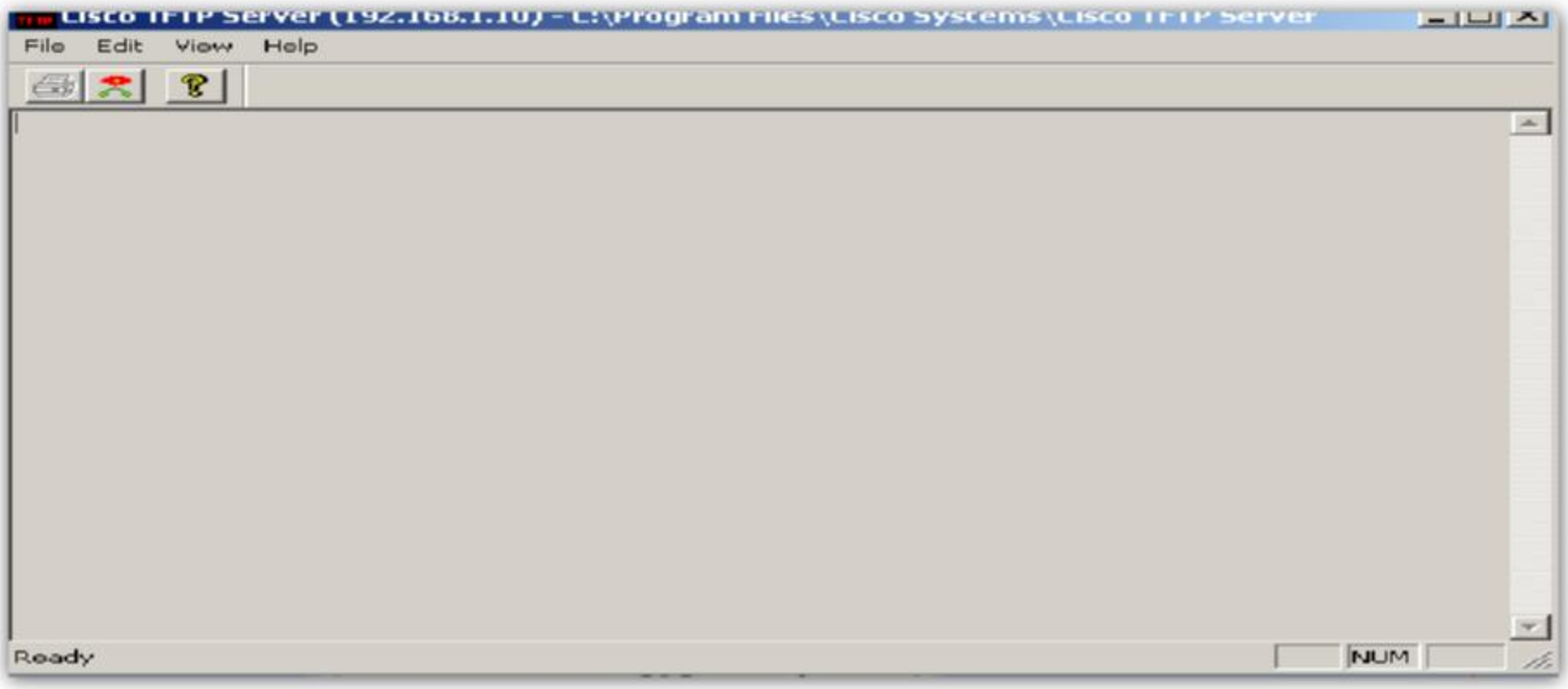
- Changing configuration register value in Fixed Router

```
>O/r  0x2142
>i
```

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Initial Configuration



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Backup of Startup-Configuration

```
Command Prompt
C:\>   telnet  192.168.2.1
Connecting    .....
================================
WELCOME  TO  SRILANKA
================================
User Access Verification
password :   ****
SRILANKA> enable
password :   ****
SRILANKA# copy startup-config  tftp
Address or name of remote host []? 192.168.2.10
Destination filename [startup-config]?
!!
713 bytes copied in 0.56 secs
SRILANKA#
```

Backup of IOS

```
Command Prompt
SRILANKA#  show  flash
System flash directory:
File  Length   Name/status
  1   8116916  c2600-io3s56i-mz.120-7.T.bin
[8116980 bytes used, 271628 available, 8388608 total]
8192K bytes of processor board System flash (Read/Write)

SRILANKA# copy flash: tftp:
Source filename []? c2600-io3s56i-mz.120-7.T.bin
Address or name of remote host []? 192.168.2.10
Destination filename [c2600-io3s56i-mz.120-7.T.bin]?
!!!
```

Restoring Startup-config

```
Command Prompt
SRILANKA#  copy tftp startup-config
Address or name of remote host []? 192.168.2.10
Source filename []? startup-config
Destination filename [startup-config]?
Accessing tftp://192.168.2.10/startup-config...
Loading startup-config from 192.168.2.10 (via Ethernet0/0): !
[OK - 713/1024 bytes]
[OK]
713 bytes copied in 9.439 secs (79 bytes/sec)
SRILANKA#
```

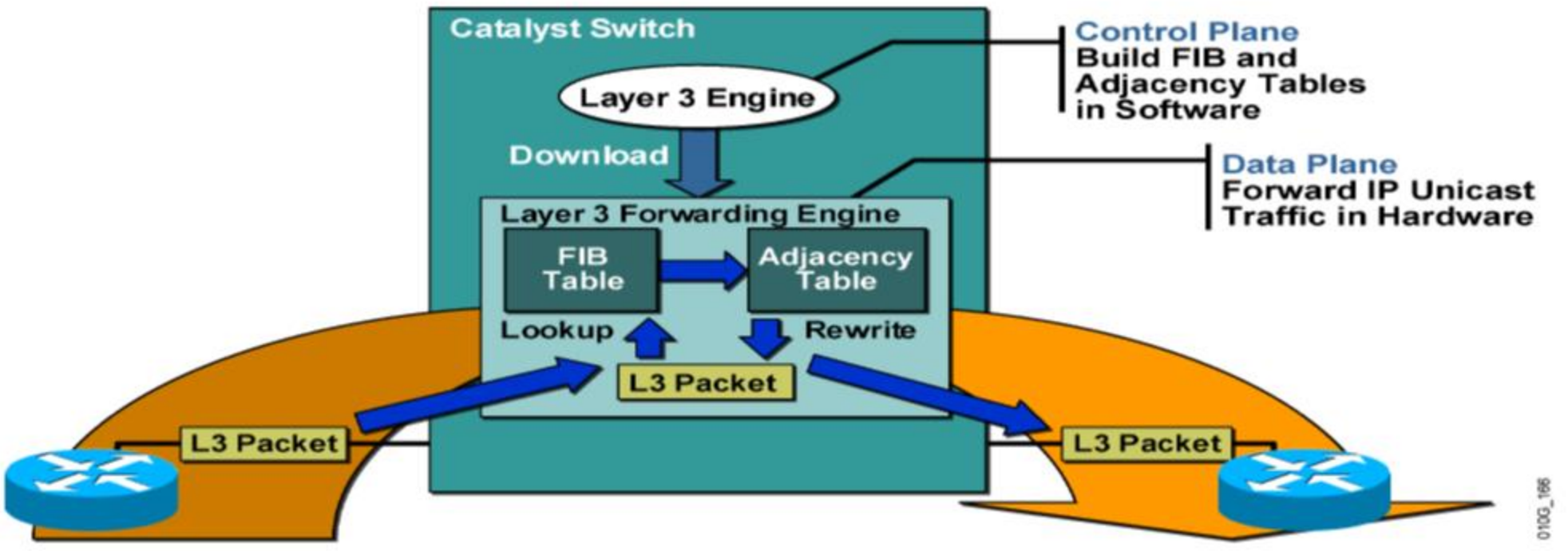
Restoring IOS

```
Command Prompt
SRILANKA# copy tftp flash
Address or name of remote host []?  192.168.2.10
Source filename []?c2600-io3s56i-mz.120-7.T.bin
Destination filename [c2600-io3s56i-mz.120-7.T.bin]?
Do you want to over write? [confirm]
Accessing tftp://192.168.2.10/c2600-io3s56i-mz.120-7.T.bin...
Erase flash: before copying? [confirm]
Erasing the flash filesystem will remove all files! Continue? [confirm]
Erasing device... eeeeeeeeeeeeeeeeeeeeeeeeeeeeeeee ...erased
Erase of flash: complete
Loading c2600-io3s56i-mz.120-7.T.bin from 192.168.2.10 (via Ethernet0/0):
!!!
```

Restoring IOS

```
Command Prompt
Loading c2600-io3s56i-mz.120-7.T.bin from 192.168.2.10 (via Ethernet0/0):
!!!
```

CEF



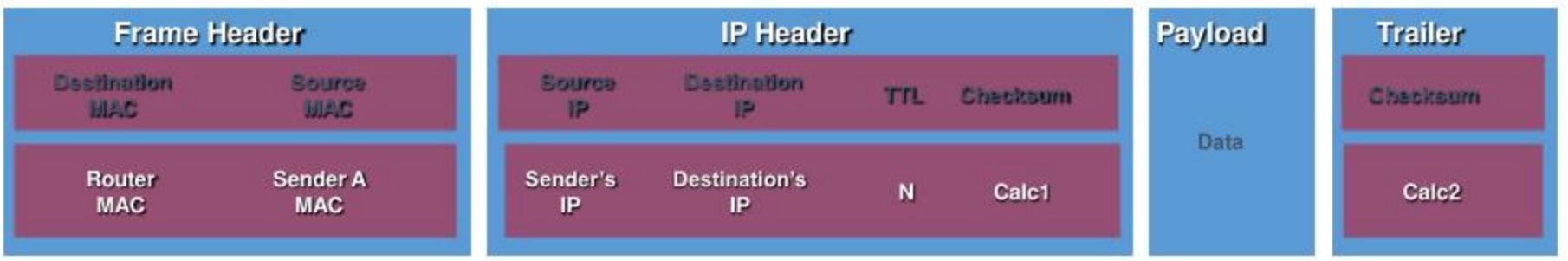
CEF

- Forward Information Base
  - FIB is like a routing table.
  - Its uses the most specific match for destination
  - FIB Maps Destination with Next hop IP address
  - FIB table is updated along with the Routing table
  - FIB work at hardware switching processes
- Adjacency Table
  - It maps layer 3(next hop IP) – layer 2 (MAC)

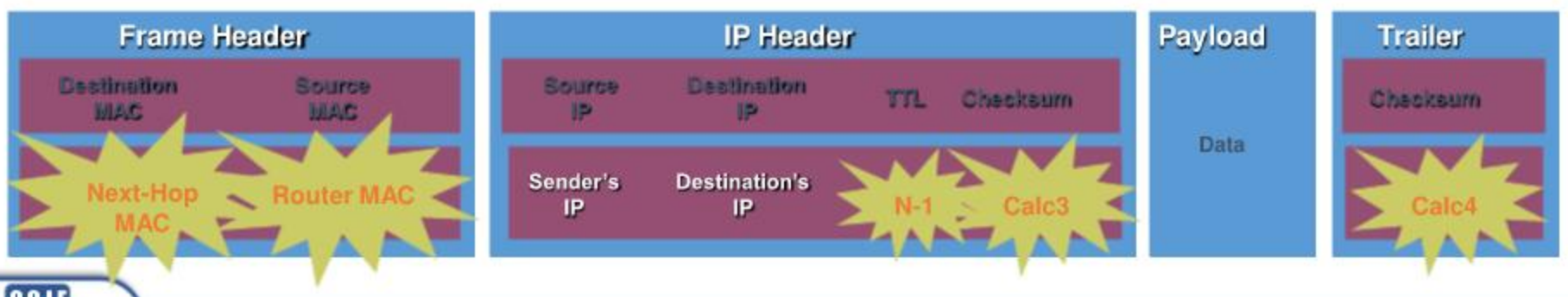
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Incoming IP Unicast Packet



Rewritten IP Unicast Packet



Displaying CEF Entries in the FIB

```
Switch# show ip cef
```

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MCSE-2012 Full Course

MICROSOFT CERTIFIED SOLUTIONS EXPERT

Practicals in real-time environment. Detailed curriculum with all 5 papers

Duration: 1 Month | 4 Hrs Per Day (starts on 15th & 30th of every month)

Batches: Morning: 8.30 to 10.30 • Afternoon: 2.00 to 4.00 • Evening: 7.30 to 9.30

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Cisco Routers with BSNL/TELCO MUX & Live Channelised E1

Duration: 1 Month | 4 Hrs Per Day (starts on 15th & 30th of every month)

Batches: Morning: 8.30 to 10.30 • Afternoon: 2.00 to 4.00 • Evening: 7.30 to 9.30

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Duration: 2 Weeks | 4 Hrs Per Day (starts on 15th & 30th of every month)

Batches: Morning: 8.00 • Afternoon: 1.30 • Evening: 7.00

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Free MCSE & CCNA Exam Practice Questions

Complete Package for Only

Fees: ₹ 5,900/-

+ 14% Service Tax

Duration: 3 Months
4 Hrs Per Day

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Course is mapped to EHCE course from US-Council (www.us-council.com)

(Pre requisite is CCNA / MCSE / LINUX)

Duration: 2 Weeks | 4 Hrs Per Day (starts on 15th & 30th of every month)

Batches: Morning: 7.30 or Evening: 6.00

Fees: ₹ 9,500/-
+ 14% Service Tax

100% GUARANTEED JOB ASSISTANCE

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CISCO CERTIFIED NETWORK PROFESSIONAL

Duration: 1 Month | 4 Hrs Per Day (starts on 15th of every month)

Batches: Morning: 7.30 • Afternoon: 2.00 • Evening: 6.00

- Labs on latest routers with IOS version 15.X

Monitoring, Diagnostics & Troubleshooting Tools

• PRTG • Wireshark • SolarWinds, etc.

Exam Practice Challenge Labs

Fees: ₹ ~~10,000/-~~

Introductory Special Offer

Fees: ₹ 5,500/-

+ 14% Service Tax

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Duration: 1 Month | 4 Hrs Per Day (starts on 15th of every month)

Batches: Morning: 7.30 • Evening: 6.00

- Individual Rack For Every Student
- Real time scenarios by 20+ years experienced CCIE certified industry expert who has worked on critical projects worldwide.

Written + Lab Exam Focus

FREE Full Scale 8 Hours Exam Lab Included

Unlimited Lab Access For 1 Year

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Fees: ₹ 2,500/-
+ 14% Service Tax

MICROSOFT PRIVATE CLOUD

Microsoft Certified Solutions Expert [MCSE] Private Cloud
Duration: 2 Weeks | 4 Hrs Per Day
Batches: (Contact the Counselors for the next available batch)

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+ 14% Service Tax

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Duration: 2 Weeks | 4 Hrs Per Day (starts on 15th & 30th of every month)
Batches: (Contact the Counselors for the next available batch)

Fees: ₹ 2,500/-
+ 14% Service Tax

CCNA SECURITY (Pre requisite is CCNA R&S)

CISCO CERTIFIED NETWORK ASSOCIATE - SECURITY
Duration: 2 Weeks | 4 Hrs Per Day (starts on 15th of every month)
Batches: Morning: 7.30 or Evening: 6.00

Fees: ₹ 7,500/-
+ 14% Service Tax

CCNP SECURITY (Pre requisite is CCNA Security at ZOOM)

CISCO CERTIFIED NETWORK PROFESSIONAL - SECURITY
Duration: 2 Weeks | 4 Hrs Per Day (starts on 30th of every month)
Batches: Morning: 7.30 or Evening: 6.00

Fees: ₹ 9,500/-
+ 14% Service Tax

CCIE SECURITY (Pre requisite is CCNA & CCNP Security at ZOOM)

CISCO CERTIFIED INTERNETWORK - SECURITY
Duration: 1 Month | 4 Hrs Per Day
Batches: (Contact the Counselors for the next available batch)

Fees:₹15,500/-
+ 14% Service Tax

VMware vSphere (Pre requisite is MCSE)

Duration: 1 Month | 4 Hrs Per Day (starts on 15th of every month)
Batches: Morning: 7.30 and Evening: 7.30

Fees: ₹ 4,950/-
+ 14% Service Tax

VMware vCloud (Pre requisite is VMware vSphere)

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Batches: Morning: 9.30 to 11.30

Fees: ₹ 2,500/-
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Duration: 2 Weeks | 4 Hrs Per Day
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We also offer the following courses (Contact the Counselors for the next available batch)

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