Data Communications

DCF255

Lecture 7 | Switching and Routing

Agenda

- Data Link Layer
  - Logical Link Layer
  - Media Access Layer

- Switched Networks
  - Circuit and Packet Switching

- Switch and Router Operation

- MLPS Networks

- VoIP Networks

Data Link Layer

2 Layers: MAC and LLC

Data Link Layer

- The data is actually divided into two layers
  - Logical Link Layer
  - Media Access Layer

- Logical Link Layer designed for older Ethernet 802.2 and is used by some LAN/WAN technologies. Not used by modern Ethernet 802.3

- Media Access Layer is used by shared networks and is based on the CSMA/CD protocol

| Data Link Layer | Logical Link Layer |
| | Media Access Layer |
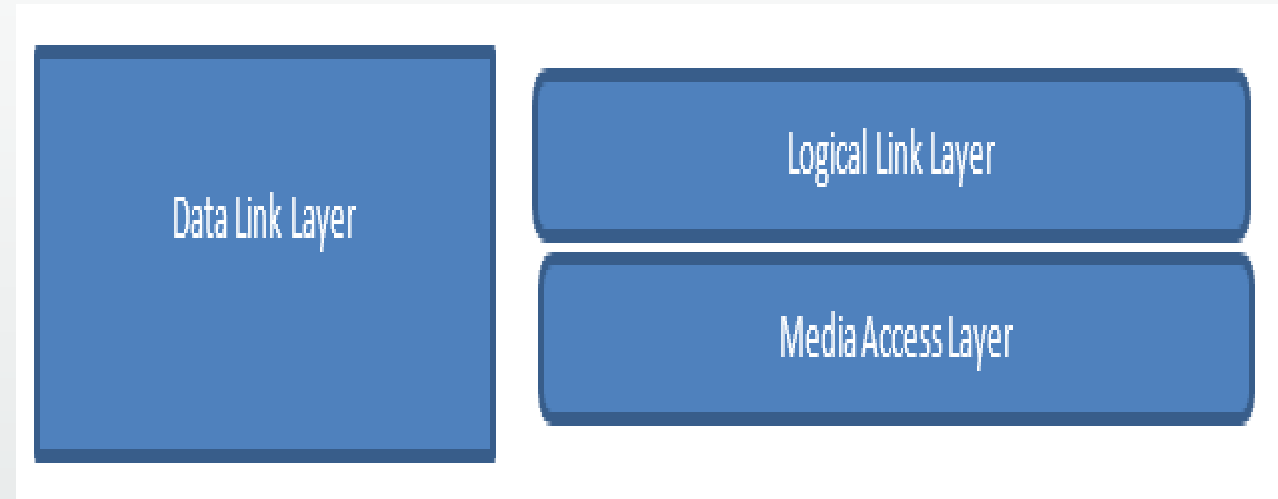
Media Access Layer

- The media access layer controls who can send on a shared medium based on protocol CSMA/CD

CSMA/CD

- CS – each computer NIC listens to the noise level on the line, when the noise is low, it sends data
- MA – nothing preventing 2 computers to send data at the same time, if they do, collision and data is lost
- CD – each computer NIC listens to the noise level and if it detects a spike in noise, a collision has occurred. Both devices stop sending. Special packet sent to delete transmission
  - Each computer then waits a random amount of time and resends the data

How collision can be detected?
- detecting voltage level on the line
- detecting /energy power level
- detecting simultaneous transmission & reception
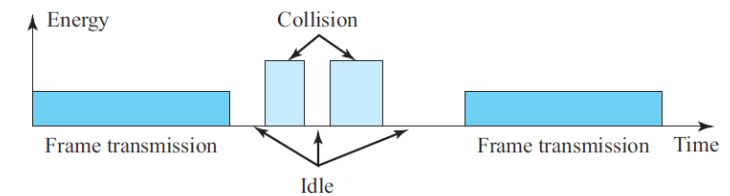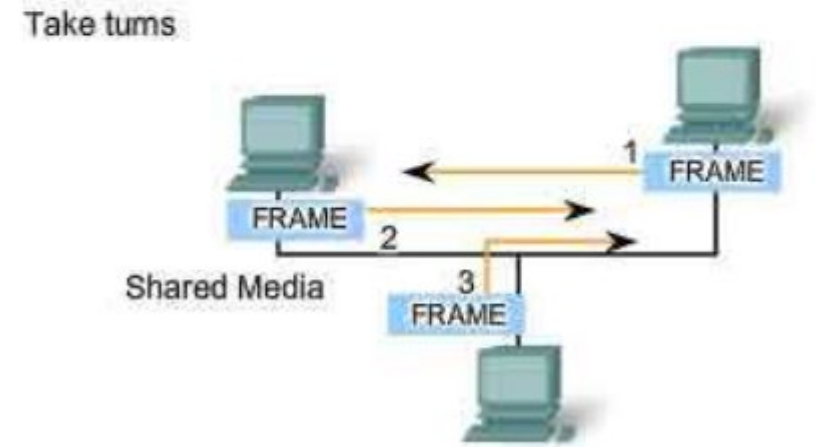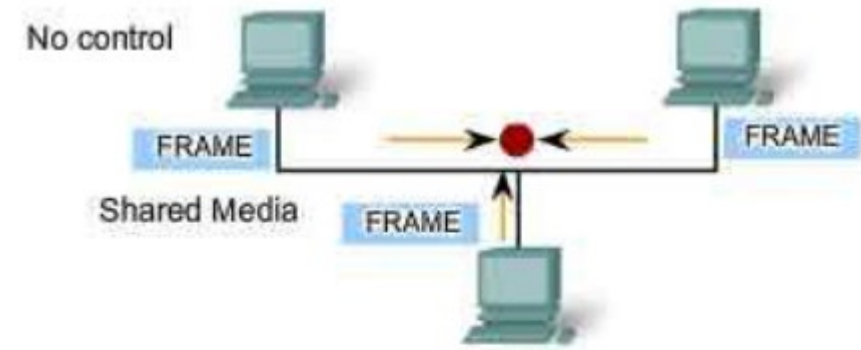
- **CSMA/CD not used on switched Ethernet because each device has a dedicated path.**
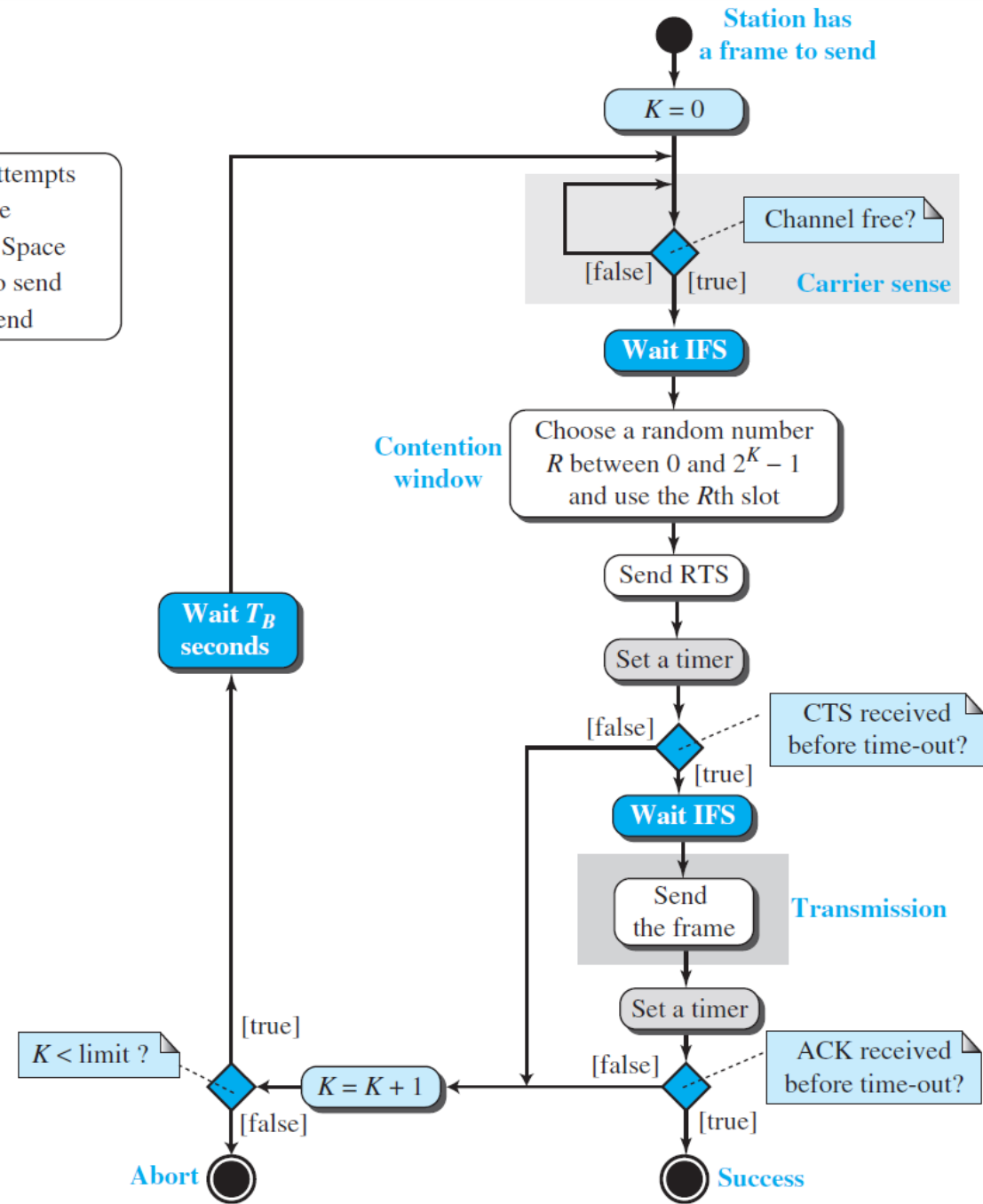
CSMA/CA

CSMA/CA uses three strategies: the **interframe space (IFS)**, **contention window**, and **acknowledgments**

- The station ready to transmit a frame, senses the medium by checking the energy level at the carrier frequency.
- **IFS**-First, collisions are avoided by deferring transmission even if the channel is found idle. When an idle channel is found, the station does not send immediately. It waits for a period of time called the *interframe space* or *IFS*.
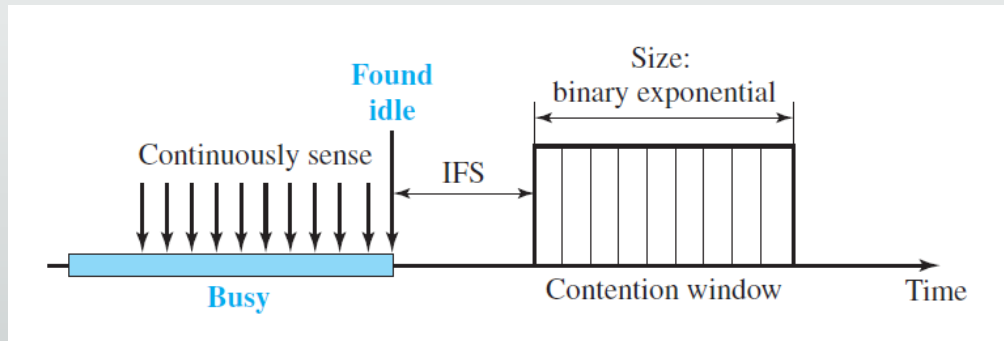
Legend
K: Number of attempts
T_B: Backoff time
IFS: Interframe Space
RTS: Request to send
CTS: Clear to send

Station has a frame to send

$K = 0$

Channel free?

[false] [true] **Carrier sense**

Wait IFS

Contention window

Choose a random number
R between 0 and $2^K - 1$
and use the Rth slot

Send RTS

Wait T_B seconds

Set a timer

CTS received before time-out?

[false] [true]

Wait IFS

Send the frame **Transmission**

Set a timer

ACK received before time-out?

[true]

$K < $ limit ? [false]

$K = K + 1$

[false]

Abort [false] [true] **Success**

CSMA/CA

- **Contention window-** is an amount of time divided into slots.
  - A station that is ready to send chooses a random number of slots as its wait time.
  - The number of slots in the window changes according to the binary exponential backoff strategy.
  - This means that it is set to one slot the first time and then doubles

- *Acknowledgment-* With all these precautions:
  - there still may be a collision
  - Data may also be corrupted during the transmission.

- The positive acknowledgment and the time-out timer can help guarantee that the receiver has received the frame.

Legend

K: Number of attempts
T_B: Backoff time
IFS: Interframe Space
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CTS: Clear to send
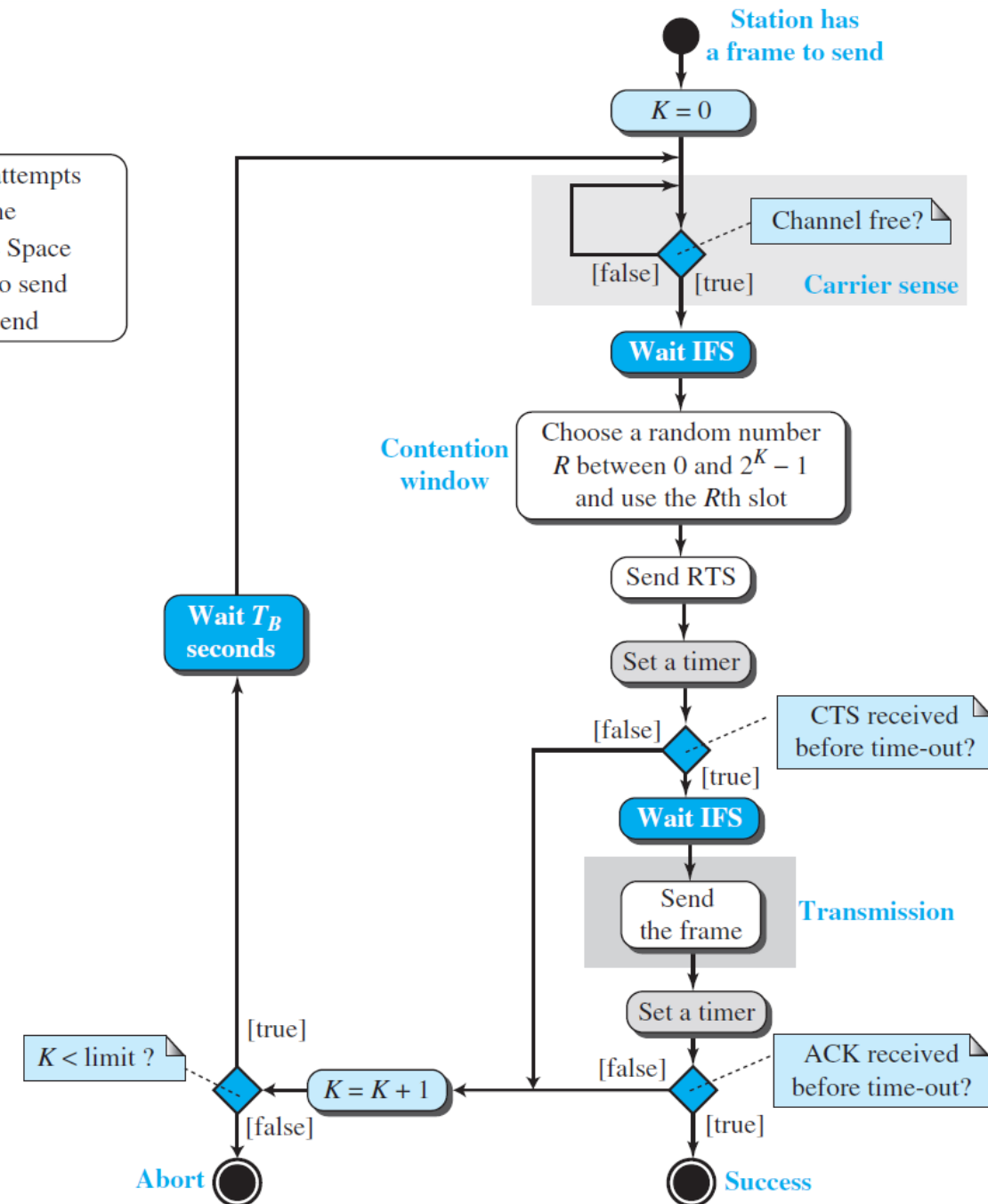
Switched Networks

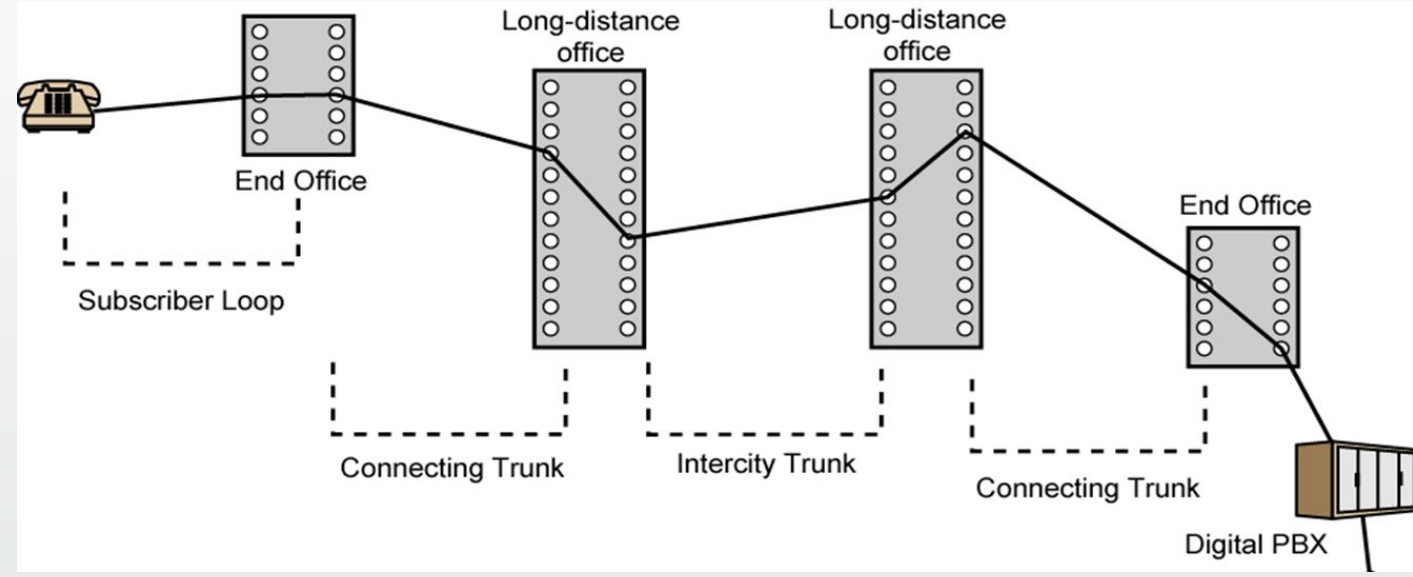Circuit Switched and Packet Switched

Switched Networks

- A switched network consists of a series of interlinked nodes, called switches.
- Switches are devices capable of creating temporary connections between two or more devices linked to it.
- In a switched network, some of these nodes are connected to the end systems (computers or telephones, for example). Others are used only for routing

- Switching is a method to move any type of data through the network using as switch hardware.
- The two fundamental techniques are:
  1. Circuit Switching
  2. Packet Switching
     - Datagram Switching
     - Virtual Circuits
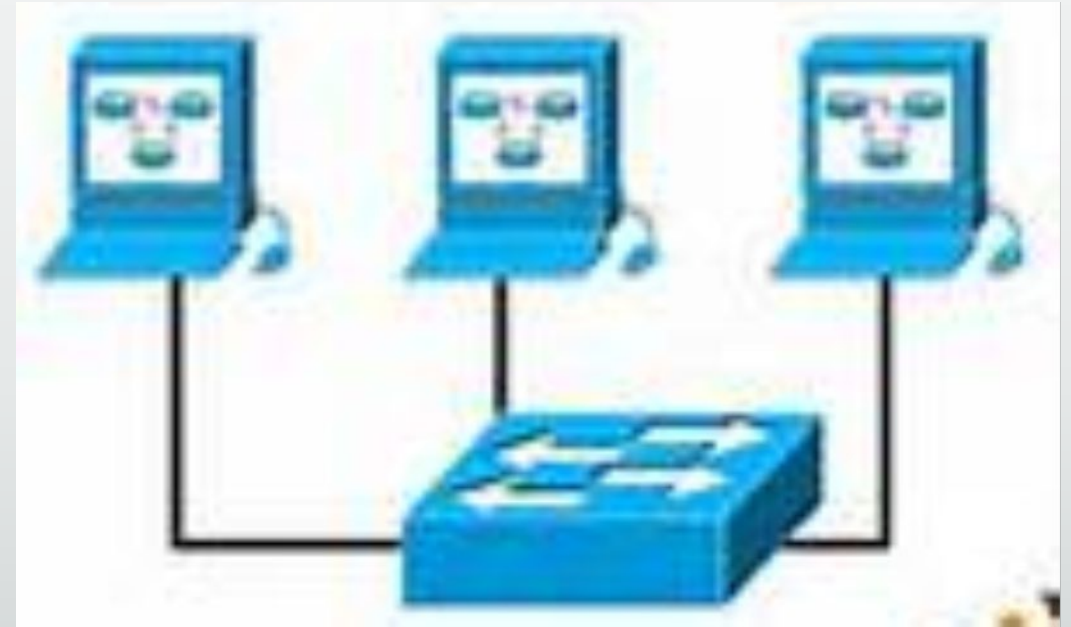
Circuit Switching

- Used by the PSTN when connecting land lines
- Dedicated circuit ideal for voice, live audio and videoconferencing
  - Temporary or Permanent Circuit
- Using circuit switching requires establishing a path, transmitting the data and disconnecting the circuit
- Other examples of circuit switched networks are: ISDN (Integrated Services Digital Network) , X.21, High-Speed Circuit-Switched Data (HSCSD) service in cellular systems such as GSM.
- Two types of switches used by circuit switched networks are: crossbar switch and multistage switch and they operate at the physical layer

Public switching telephone network (PTN)

Circuit Switching too inefficient to send data

Packet Switching

- Packet Switching most popular form of connection. Used on the Internet and Ethernet networks
- Large messages fragmented into smaller messages each one individually addressed
- On demand resource allocation. Faster with less congestion

Datagram switching (Network layer)
- Each packet is treated independently of other
- Packets may take different paths/routes to reach its destination
- Packets may arrive out of order
- There is no connection setup and tear down
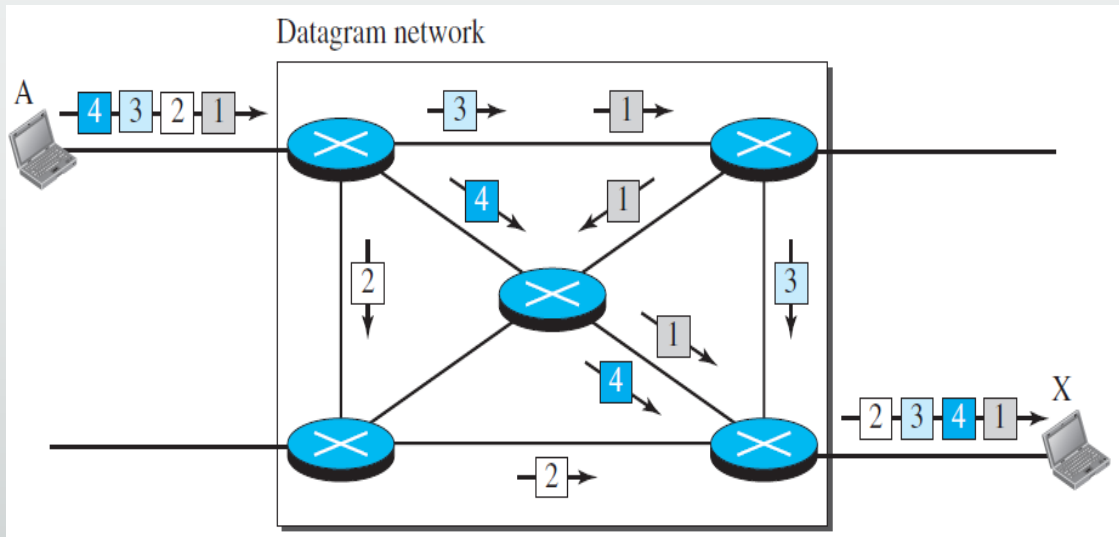
Virtual Circuits (Datalink layer)
- A combination of circuit switched and datagram switching
- A temporary circuit created as in circuit switching and and like datagram switching, data are packetized and each packet carries address in the header but the address has local jurisdiction i.e.; the address of the next switch
- All packets follow the same path to destination
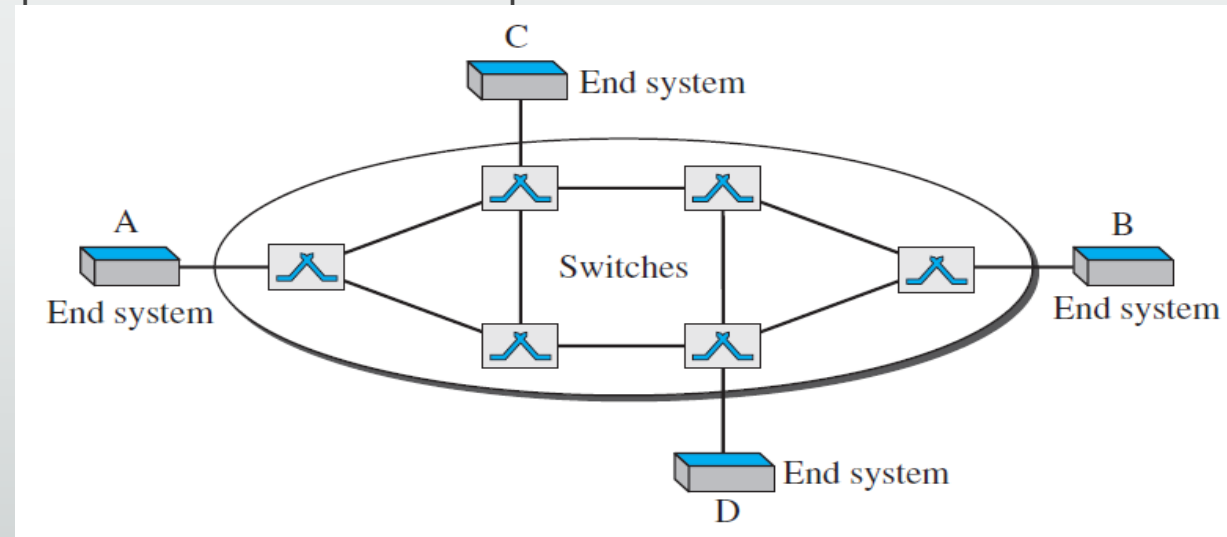
Packet Switching

Note:

The term "Packet-Switching" is a misnomer because on single network frames are switched and on internets packets are routed. Unfortunately, data communications do not have terminology police to ensure consistent use of terms. Thus, Packet-Switching is a generic term for fragmentation of large messages into smaller ones which are independently addressed and sent across a link. The term is correctly used when referring to how the Internet routes packets, the term is never used on single networks or internets.

Frames are switched across single networks ------- Packets are routed across internets

Switch Operation

Across single switched network

Switch

- A **switch** is a networking hardware that connects devices on a computer network by using packet switching to receive and forward data to the destination device.
- Switches forward frames based on MAC address.
- The switches port copies the MAC address of the device attached to it

- Much faster than routers and improve performance when collisions or broadcast traffic slow network down
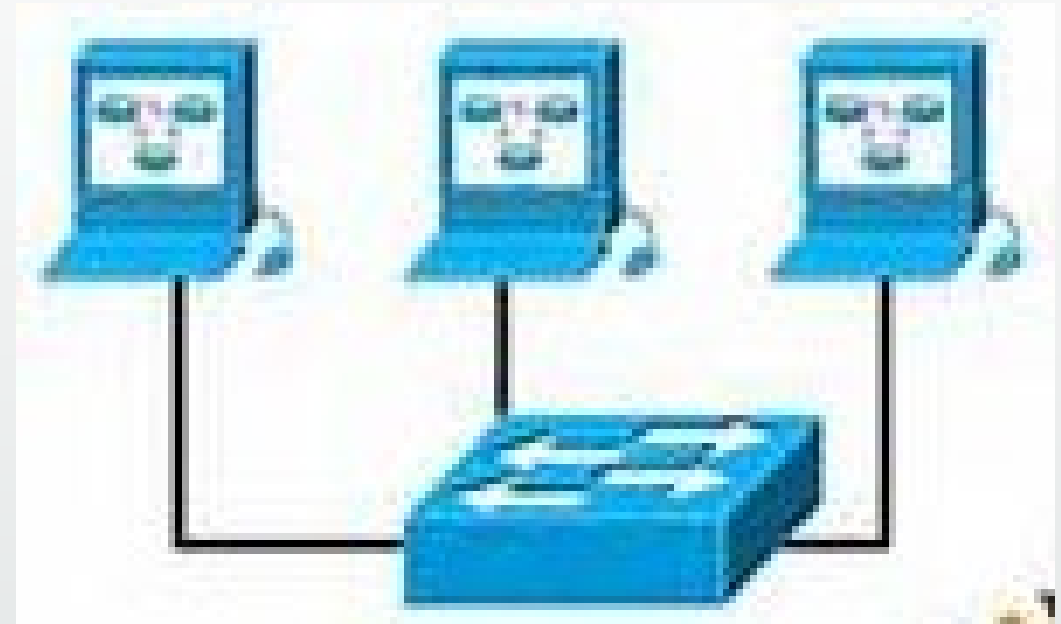
Note: Circuit switching also uses switching hardware that use to connect users for voice communication (both analog and digital), and it is different from layer 2 and layer 3 switches used by packet switching networks.

Switch Operation

- **Host A needs to send frame to Host B**

- **2 different paths CDF or CEF**

- **Switch uses its switching table**

- **For Host B use send to Switch E**

- **Switches only know their neighbour**

- Process repeated at each switch across each physical link.
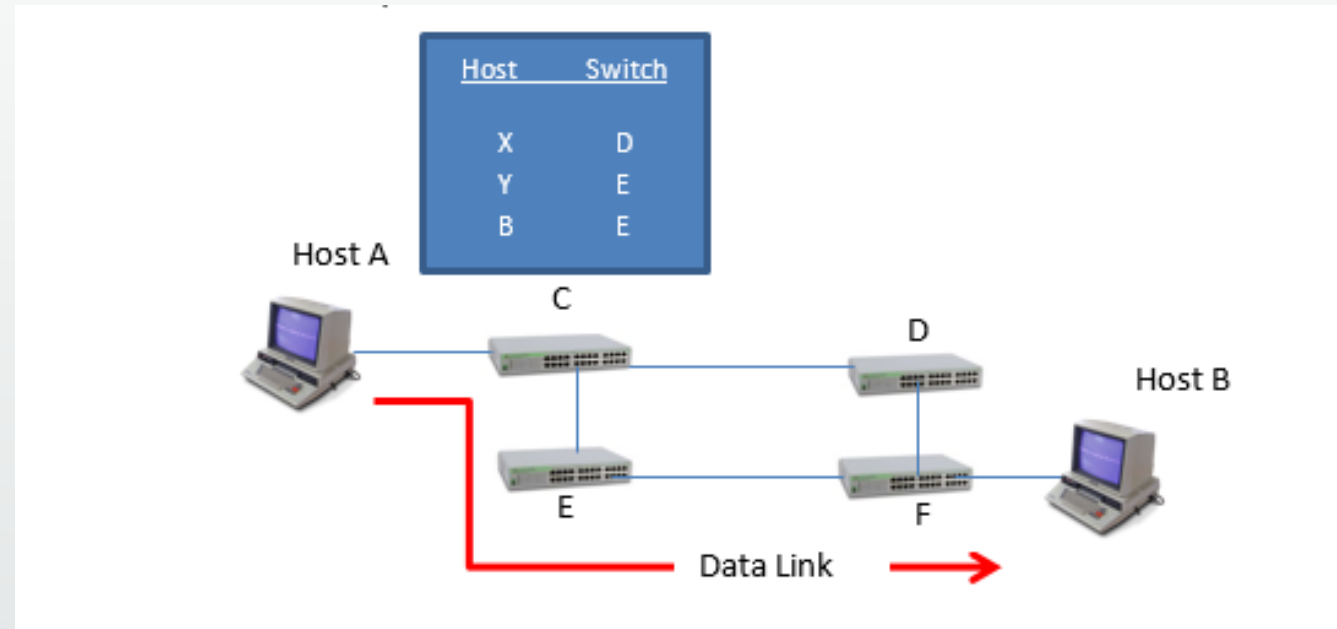
The path across a single network is called a "Data-Link"

Router Operation

Across internets

Router Operation

- A router is a more complex device than a switch and must determine the best path for a packet among many paths
- Router is an internet layer device that connects multiple IP networks to exchange packets between them
- Switches are organized in a hierarchical manner so there is only one path
- Routers are organized in a "mesh" manner with many alternate paths
- Router maintains routing table for finding the best path to the destination of incoming data packet
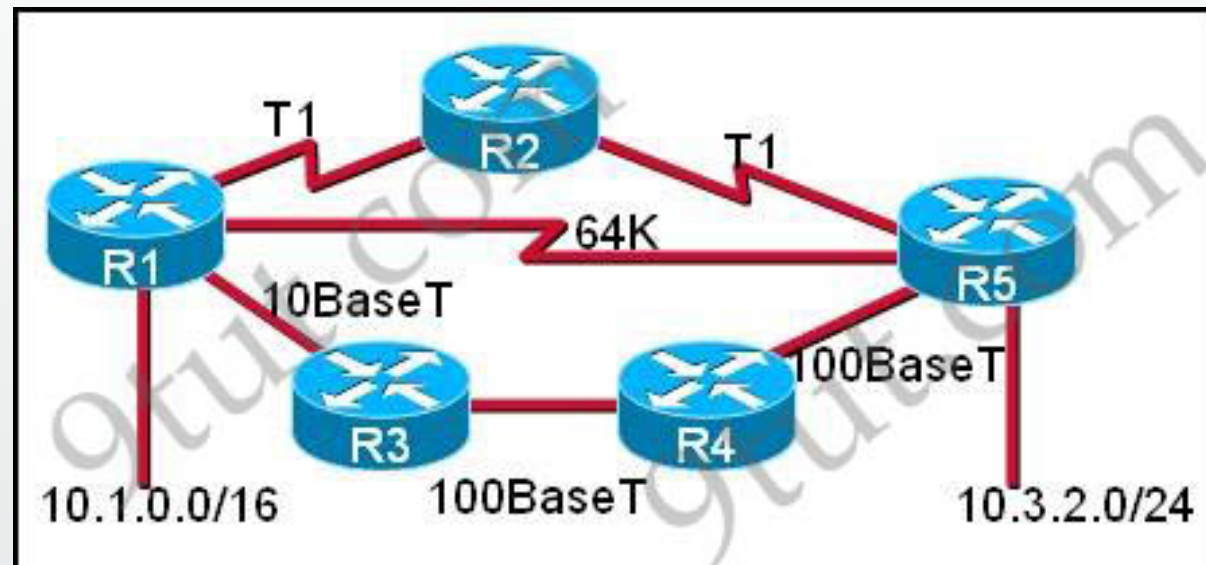
Router Operation

- How the router makes a the forwarding decision will depend on the routing protocol

- Follow 3 steps:

1. AND IPv4 address with subnet mask to find the destination network

2. Compare destination network with each line in its routing table. Best match is longest match.

3. Multiple matching addresses metric used to choose best match,
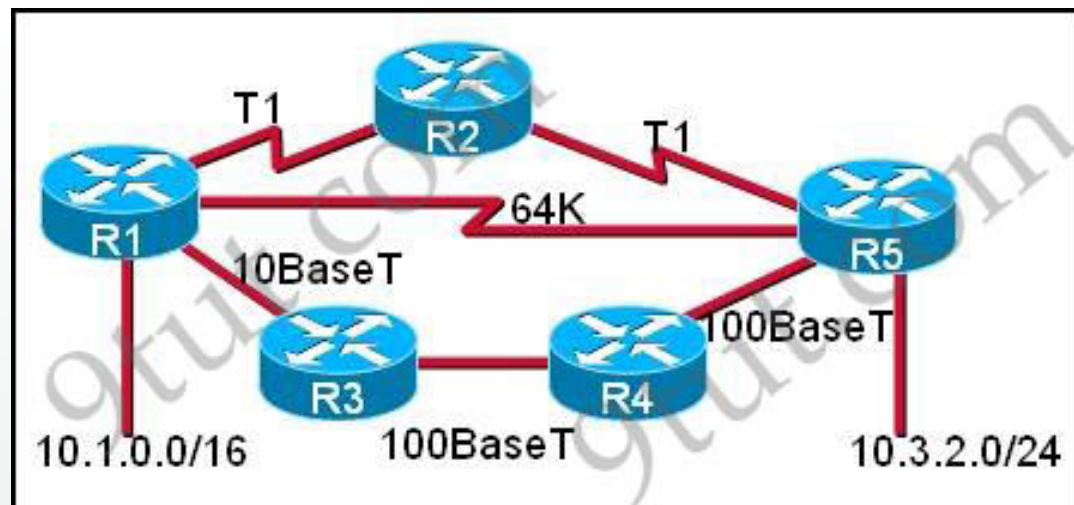
Subnet mask divides the IP address into a network address and host address. One part identifies the host (computer), the other part identifies the network to which it belongs.
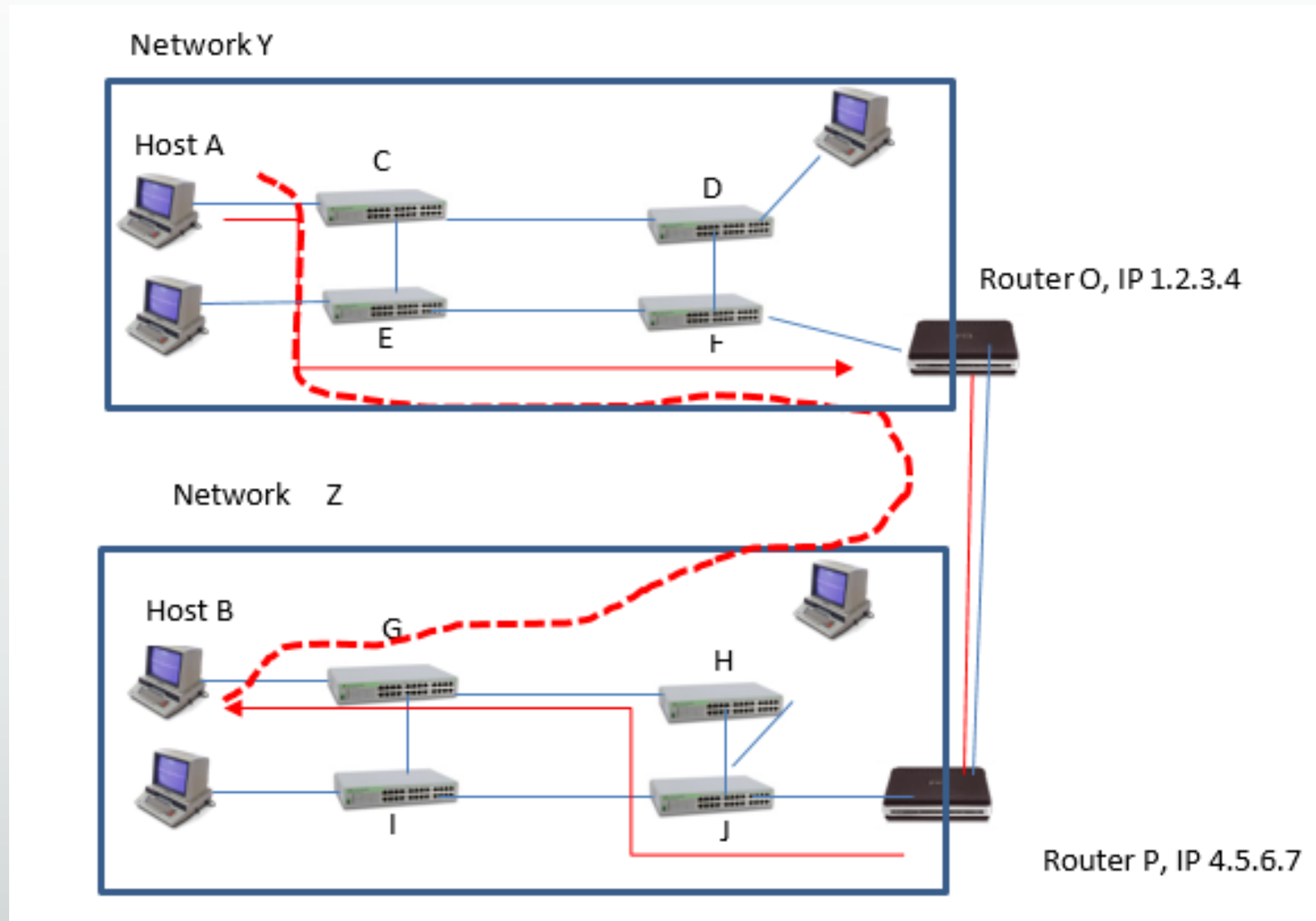
Suppose an ip address of a computer is *205.16.37.39/28.* The network address is :

205	.	16	.	37	.	39

11001101 . 00010000 . 00100101 . 00100111

255	.	255	.	255	.	240

11111111 . 11111111 . 11111111 . 11110000

_____

205	.	16	.	37	.	32

Switch and Router Operation

A Case Study

Switch\Router Operation; Case Study

Switch\Router Operation; Case Study

Type	Number	Description
Physical Links	9	AC,CE,EF,FO, OP,PJ,JH,HG, GB
Data Links	3	AO,OP,PB
Frames	3	AO,OP,PB
Packet	1	AB
Route	1	AB
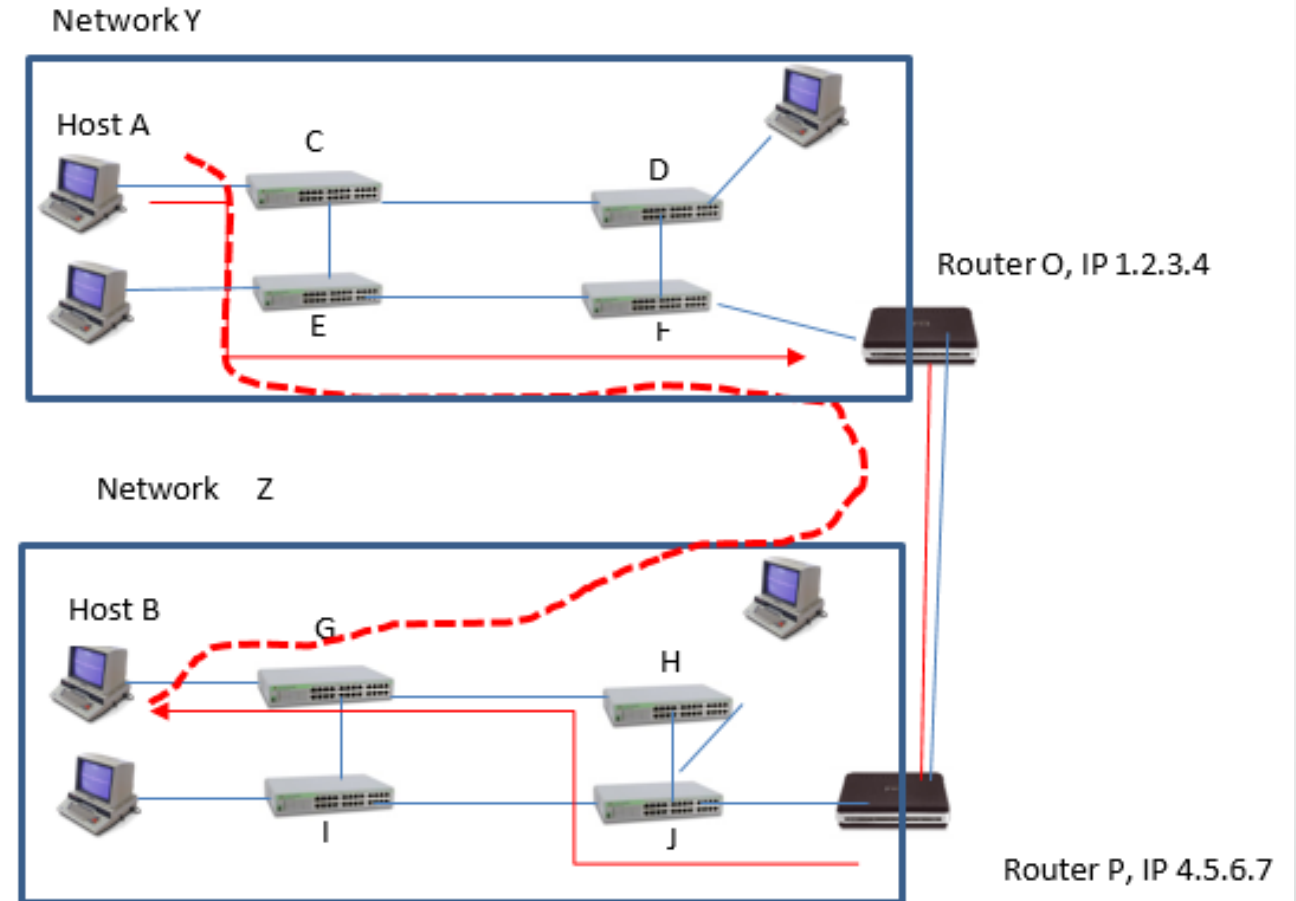
Packets are routed across internets. Frames are switched across single networks.

Network Virtualization

What is it and the benefits
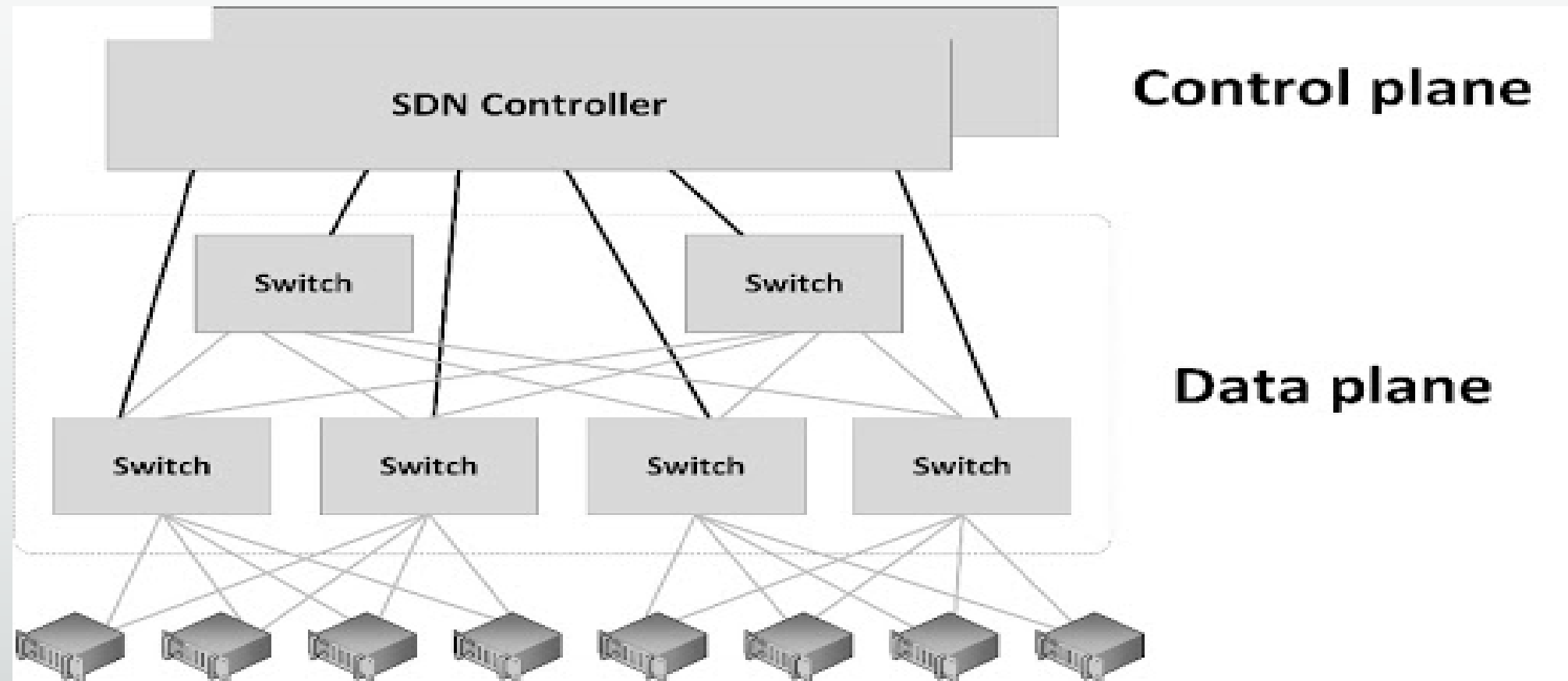
What is a Network Virtualization (NV)?

- Traditional Network devices:
  - Control Plane and Data Plane are in same hardware
  - All the network devices were controlled separately

- Network Virtualization:
  - Control Plane and Data Plane are separated
  - All Control Planes are centralized virtually on a server under software development network (SDN)
  - The network administrator can manage, add, modify the networking activities very fast
  - Improved cloud networking and security.

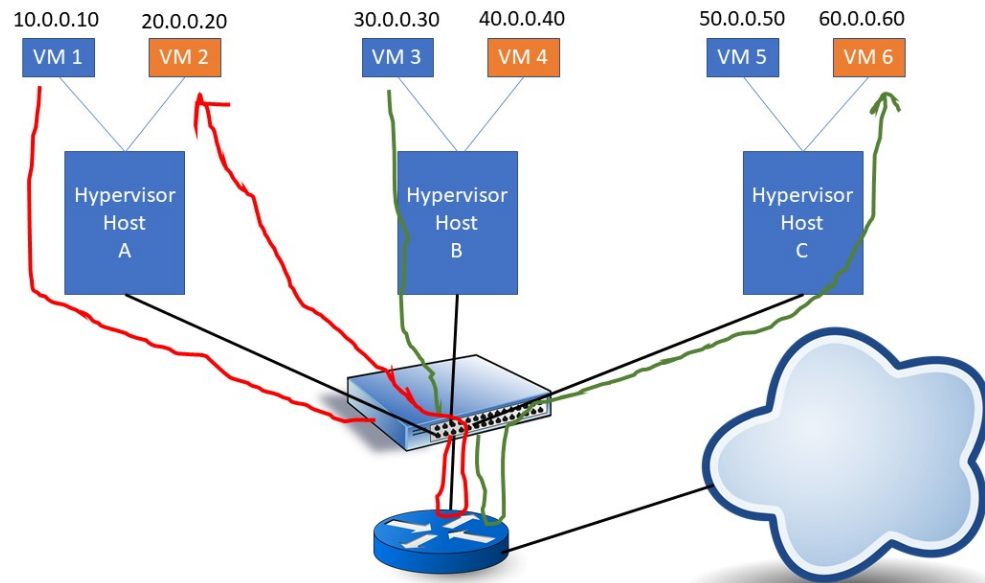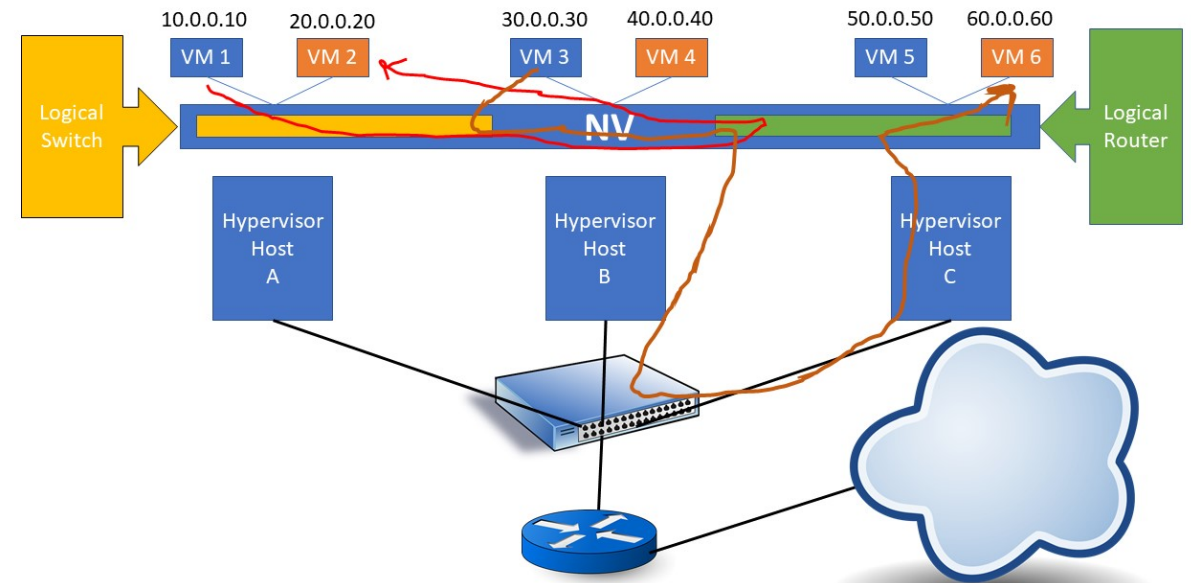# Traditional Network vs Network Virtualization
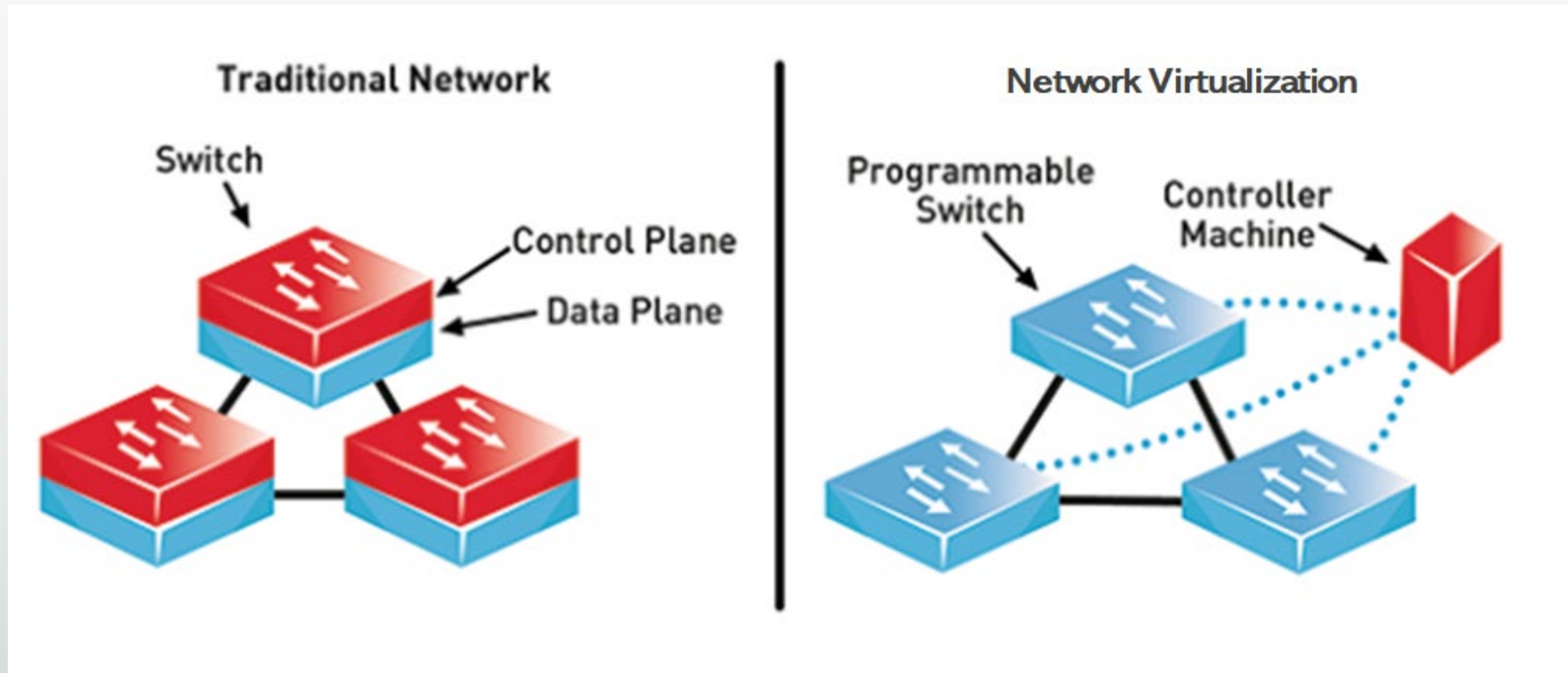
NV Control Plane and Data Plane

Example of Network Virtualization

Traditional Network

Network Virtualization

Network Virtualization (NV) Benefites

- Increase the time of network supplying from weeks to minutes

- By using automation in NV instead of manual processing, it achieves greater efficiency in network operation.

- Network workloads can be placed and moved separately of the physical topology

- As security in the data center or cloud networking, NV improved networking security.
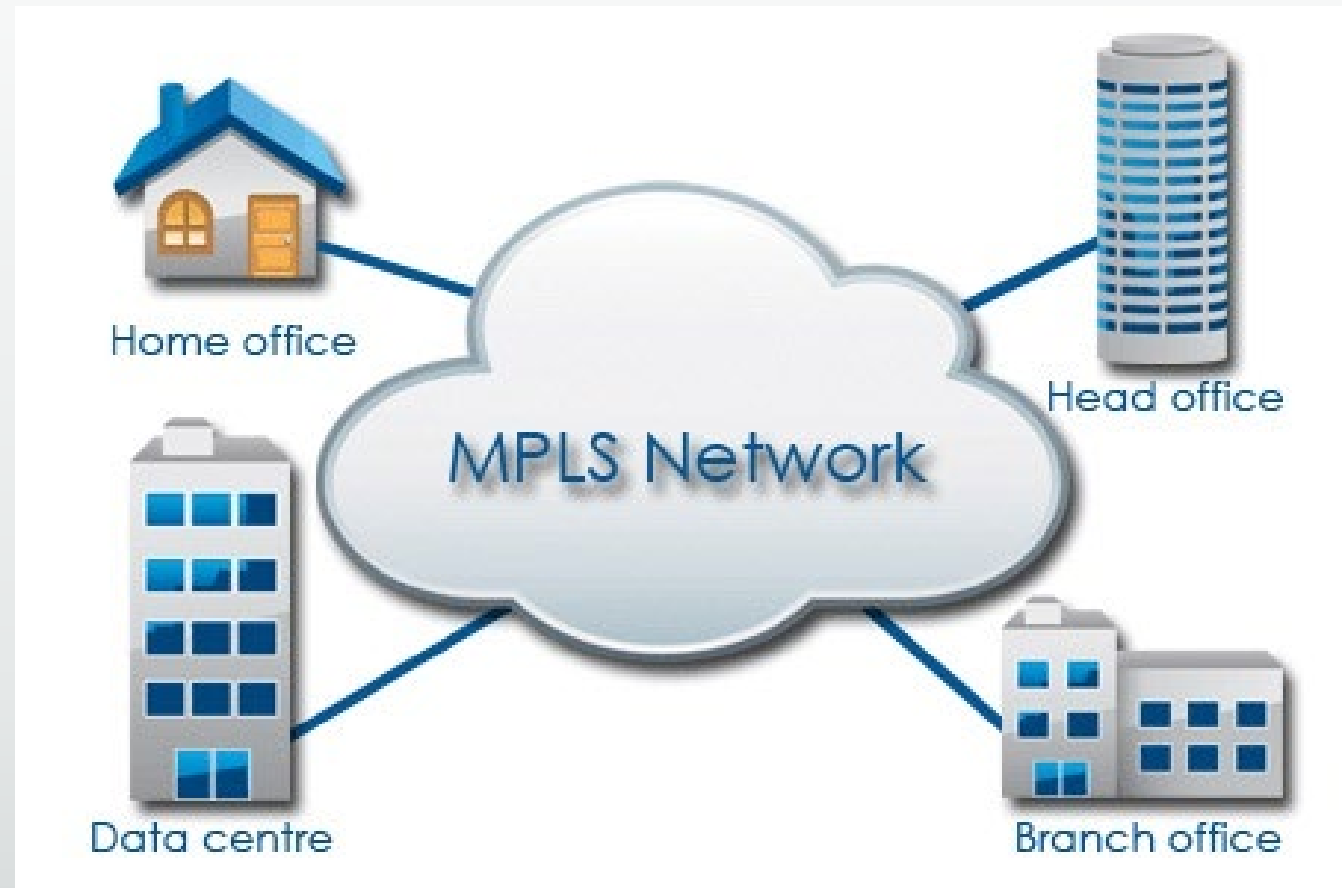
MPLS

Data Networks

MPLS

- MPLS networks have switches that function at layer 3

  Routing slow must pass packet to Internet layer to read IP address

- Add MAC address to frame to pass frame to next link

- Must recalculate the FCS

- MLPS simplifies routing by making it more like switching

MPLS

- Site A wants to send a packet to Site D

- Calculate the best route called "label-switched path"

- Path assigned unique address

- New MLPS header added between LAN header and IP header with new address

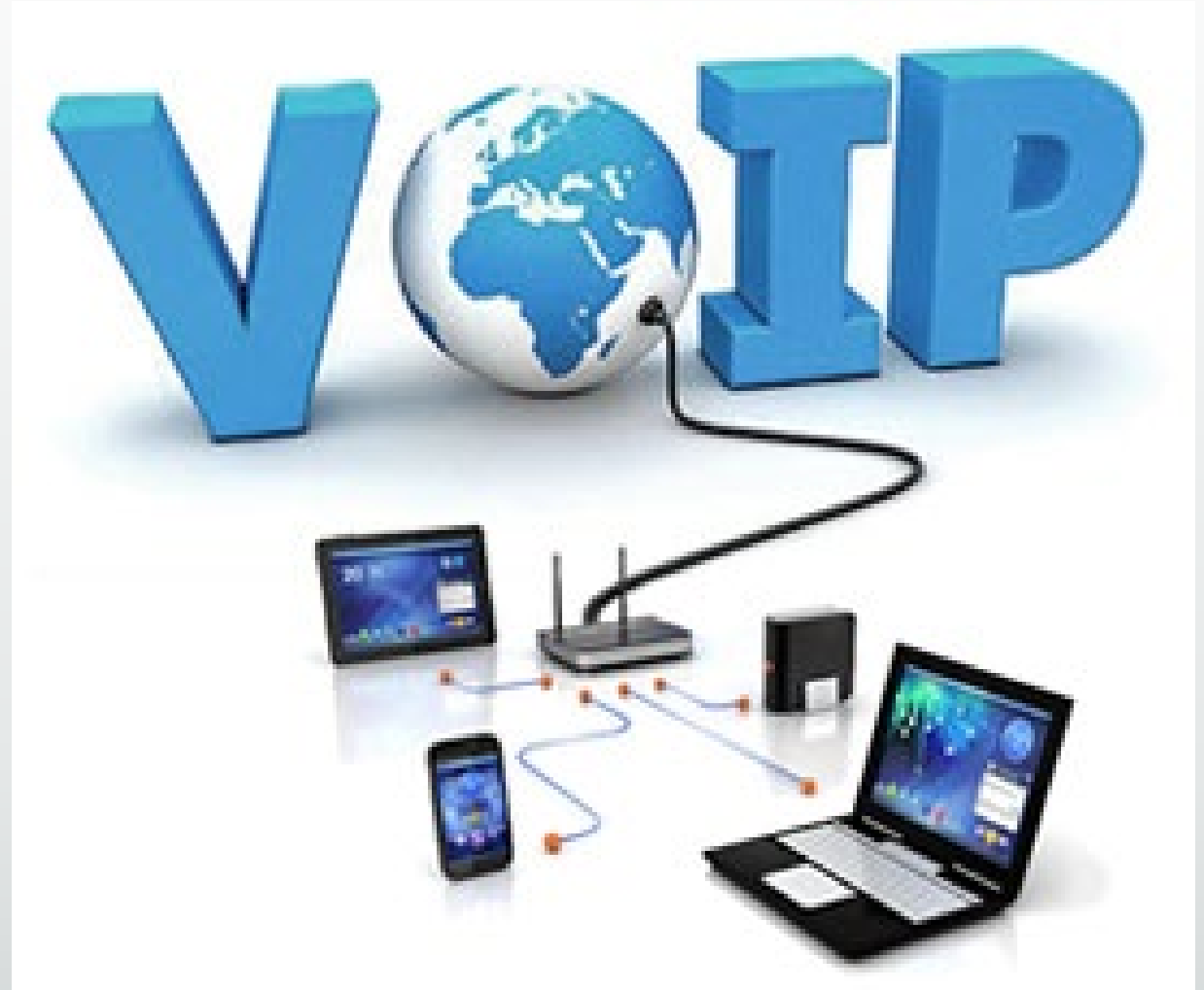- Each address is unique within the data network
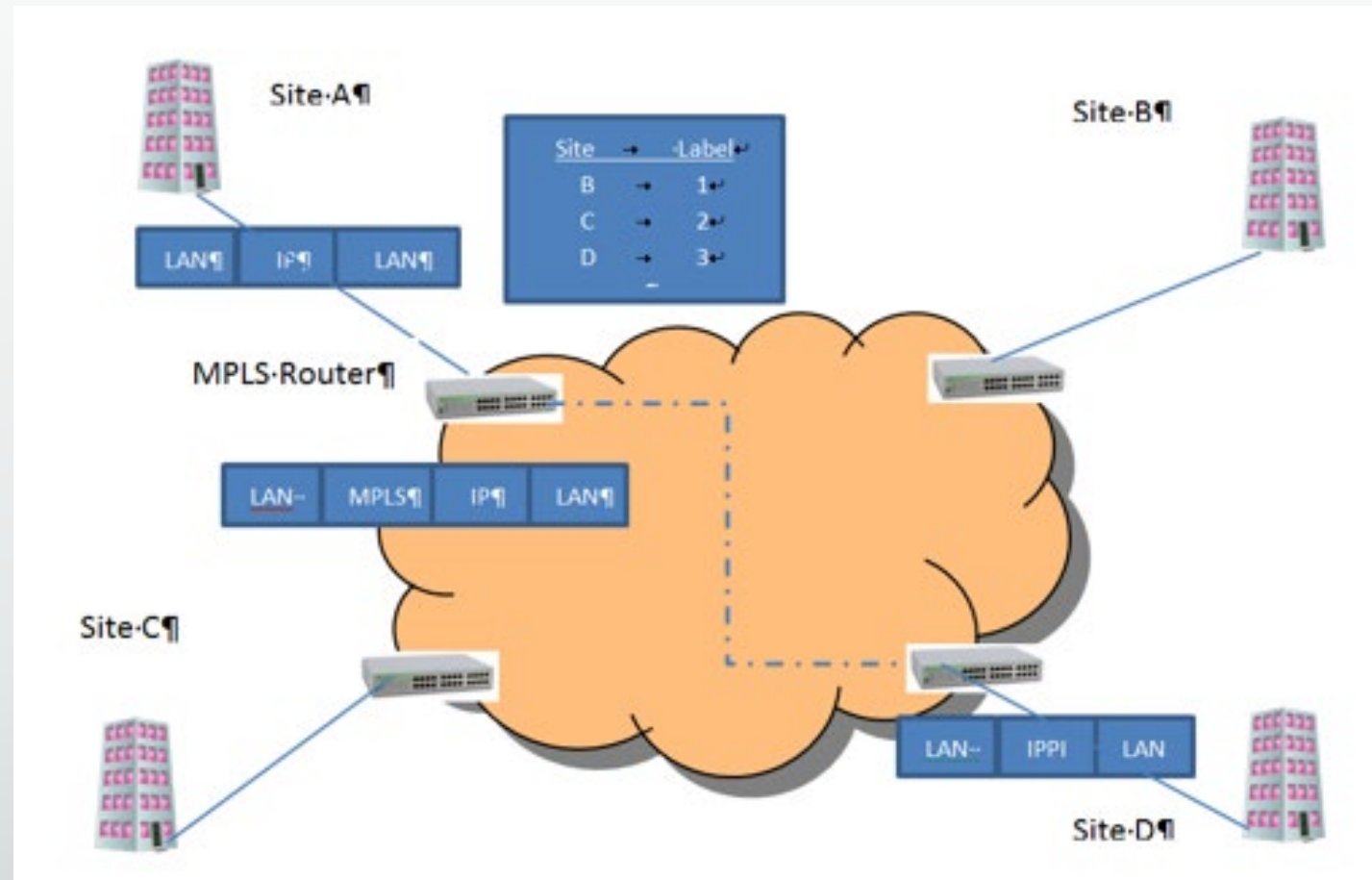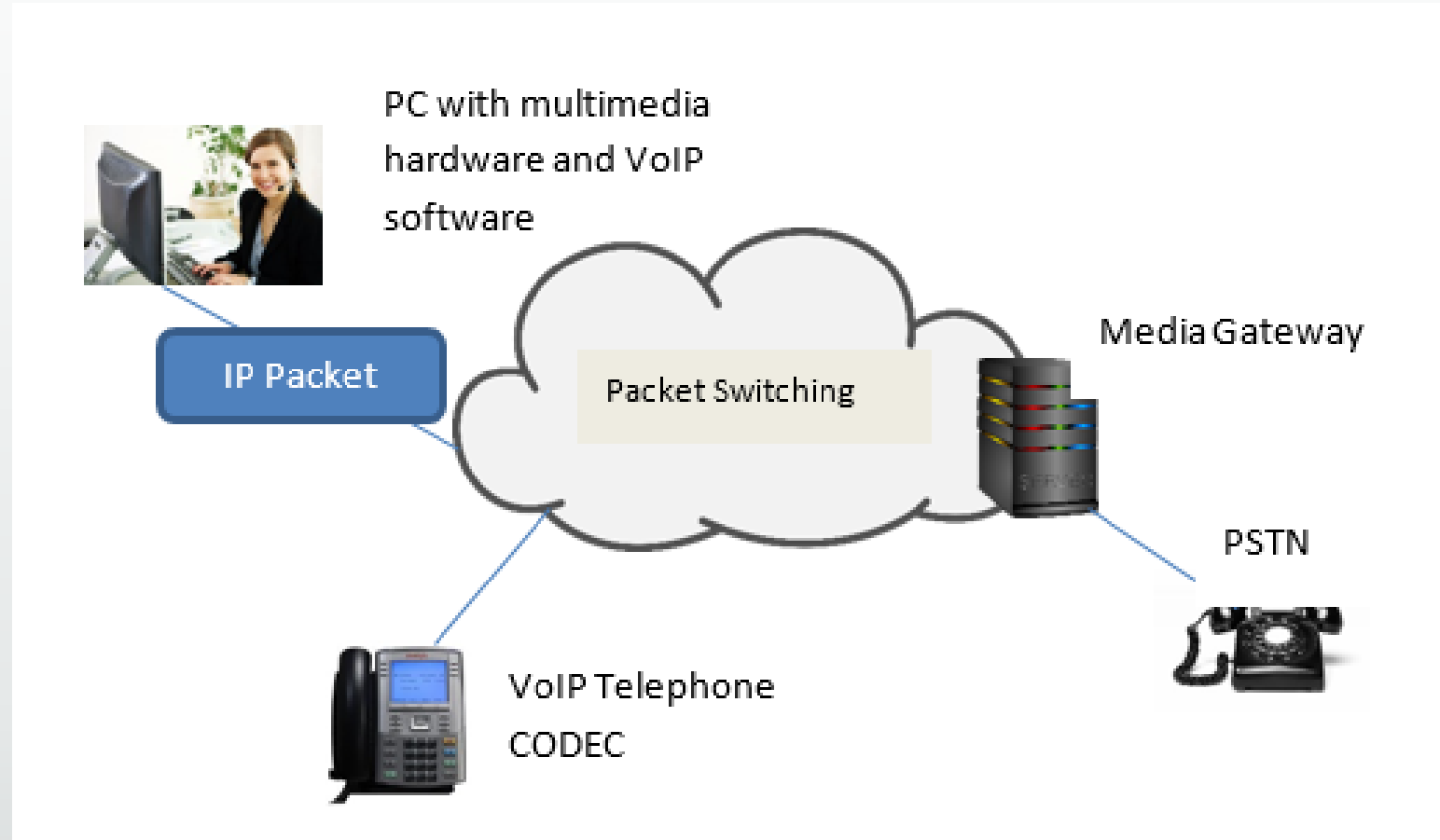
VoIP

Networks

VoIP

- VoIP applications growing in the business sector

- Business deals with one network

- Increases mobility

- Increases worker collaboration

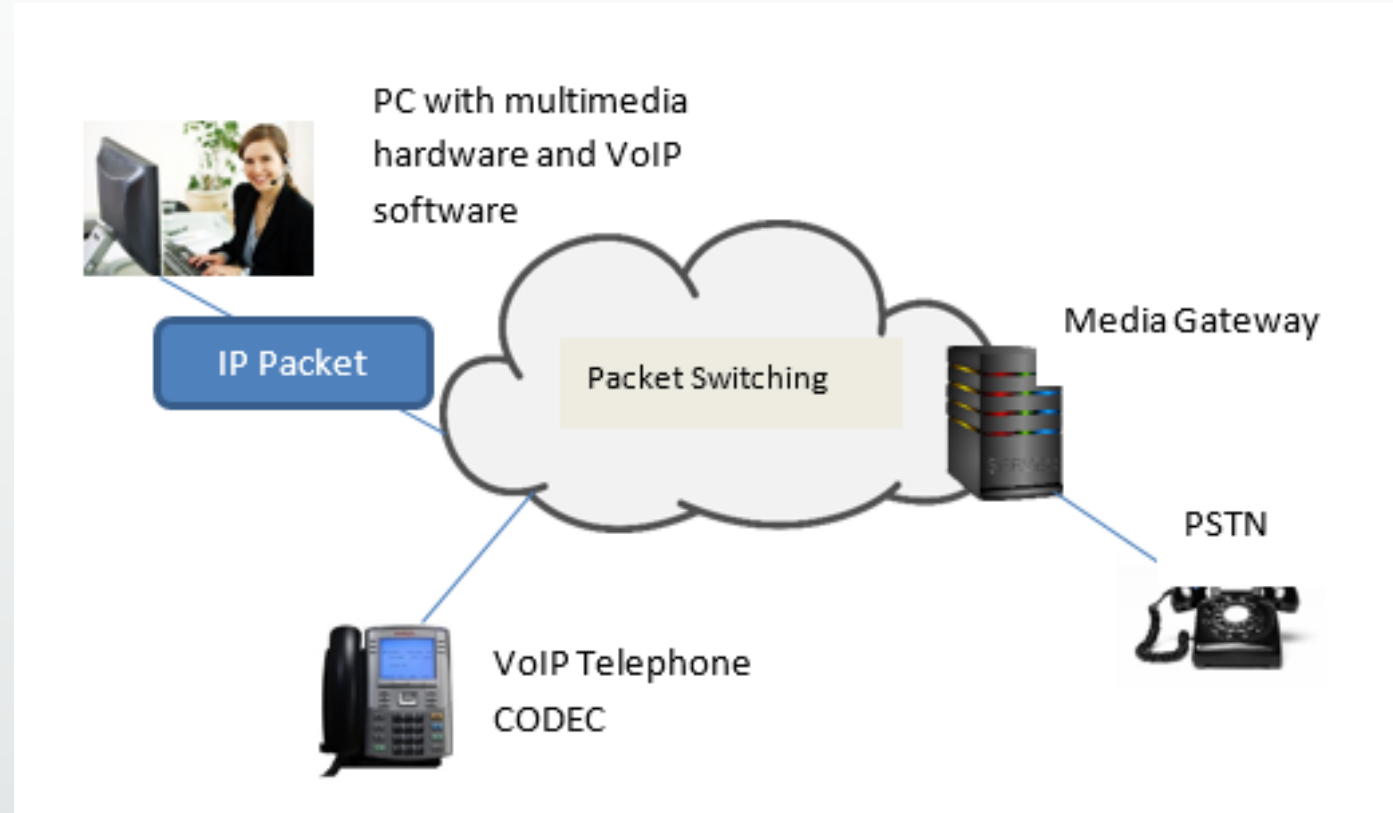- Improves customer relations

VoIP Applications : Client\Server Architecture

- **Client**
  - PC with speakers, microphone and VoIP software
  - or IP-enabled Phone with VoIP software
- Built-in CODECS to convert digital IP packet to analog voice

PC with multimedia hardware and VoIP software

IP Packet

Packet Switching

Media Gateway

PSTN

VoIP Telephone CODEC

VoIP Applications: Client\Server Architecture
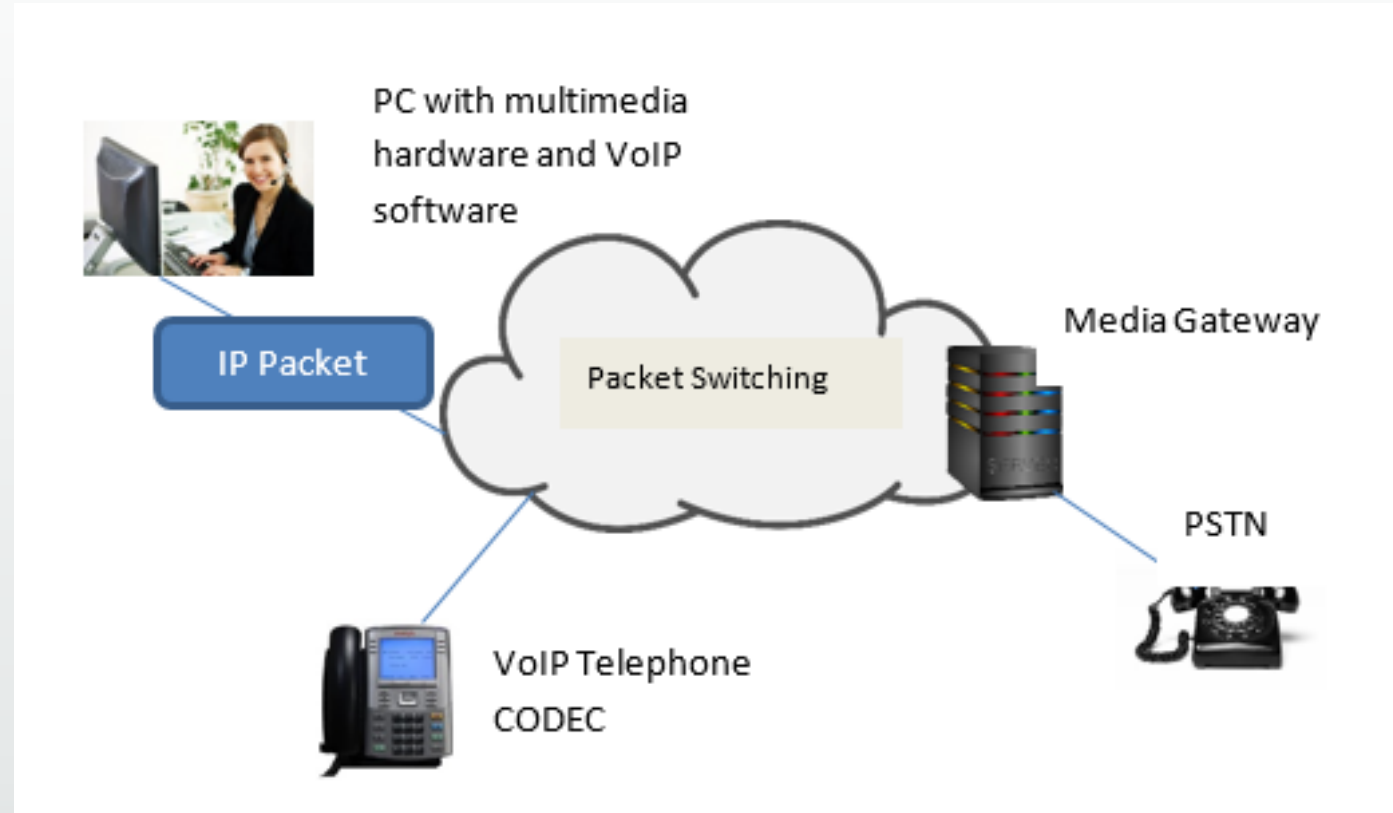
- **Server**
  - Two signaling protocols H.323 and SIP
  - SIP newer Internet standard and replace H.323 in time
- Server service offered by all Telcos, Cable companies and 3rd party providers

PC with multimedia hardware and VoIP software

IP Packet

Packet Switching

Media Gateway

PSTN

VoIP Telephone CODEC

OfficeSIP is an Open Source Server Service which can be installed on Windows

VoIP Applications: Client\Server Architecture

- VoIP require real time transmission TCP to slow
- UDP is used lower overhead than TCP
- Combined with RTP (real time protocol)
  - Adds a header between the UDB header and application message
  - Header adds a sequence number and timestamp to avoid jitter

PC with multimedia hardware and VoIP software

IP Packet

Packet Switching

Media Gateway

PSTN

VoIP Telephone CODEC

Programming VoIP Applications

- Use prebuilt SDK kits to build:
  - Softphone
  - VoIP gateway server
  - PBX system
- Saves development time

- Common kit for Windows is **Ozeki VoIP SIP SDK**

  - http://www.voip-sip-sdk.com/p_24-ozeki-voip-sip-sdk-quick-start-guide-voip.html

- Cross Platform kit is Asterisk which is open source, free to use and can be modified
  - to http://www.asterisk.org/get-started

Summary

1. The data link layer is divided into two sub layers: Logical Link Control and the Media Access Control. The former is used by older Ethernet and some other technologies. The latter is used by wireless Ethernet which shares bandwidth

2. The protocol of the MAC sublayer is CSMA/CD. This protocol controls when and how hosts send data and respond to collisions. A variation of this protocol called CSMA/CA is used for wireless Ethernet to avoid collisions and having to retransmit

3. Switches are layer 2 devices and forward frames based on the MAC address. Routing are layer 3 devices and forward packets based on the IP address. Routing is more complicated and slower than switching because routers are connected to meshes and must determine the best route among alternate paths. Switches work in a hierarchical fashion and only have one path to the destination

4. MPLS is a new technology which basically makes router work like switches. A MPLS is currently being used as a MAN technology to make routing faster

5. VoIP applications are growing in the business world because they combine data and voice into one network which lowers cost. VoIP applications also increase mobility and improve customer satisfaction. Writing VoIP applications should be done with prebuilt SDK kits such as Ozeki for Windows and Asterisk for cross platform applications

References

- Data Communication and Networking 5/e By Behrouz Forouzan

- Data and Computer Communications 7/e William Stallings