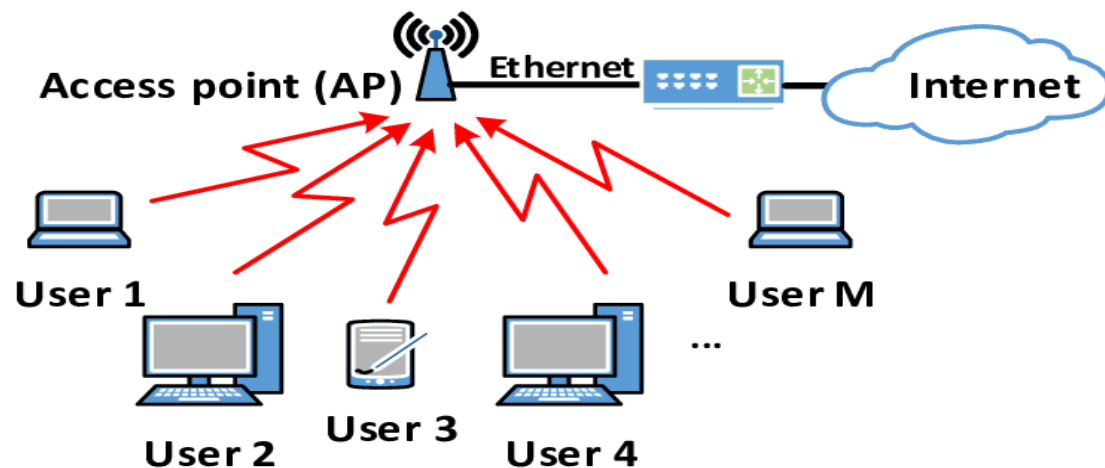# CHAPTER 3

WIRELESS NETWORK
AND
WAN TECHNOLOGIES

Compiled by: Tsegaye B.

Wireless LAN?

- A wireless LAN or WLAN is a wireless local area network that uses radio waves as its carrier.

- To give a network connection to all users in a building or campus, the last link with the users is wireless.

- The backbone network usually uses cables

Wireless-LAN

- A WLAN is a wireless computer network that links two or more devices using a wireless distribution method within a limited area such as a home, school, computer laboratory, or office building.

- This gives users the ability to move around within a local coverage area and yet still be connected to the network.

Wireless-LAN

- A WLAN can also provide a connection to the wider Internet.

- Wireless LANs have become popular for use in the home, due to their ease of installation and use.

- They are also popular in commercial complexes that offer wireless access to their customers (often without charge).

Common Topologies

- Ad-hoc Wireless LAN

- Infrastructure Wireless LAN

ad hoc WLAN

- ad hoc networks are self-organizing networks without any centralized control
- Suited for temporary situations such as meetings and conferences.
- A Basic Service Set (BSS) without an AP is called as Ad hoc network.
- **ad hoc** wireless nodes communicate directly with one another using the same radio frequency.
- The physical size of the network is determined by the maximum reliable propagation range of the radio signals.
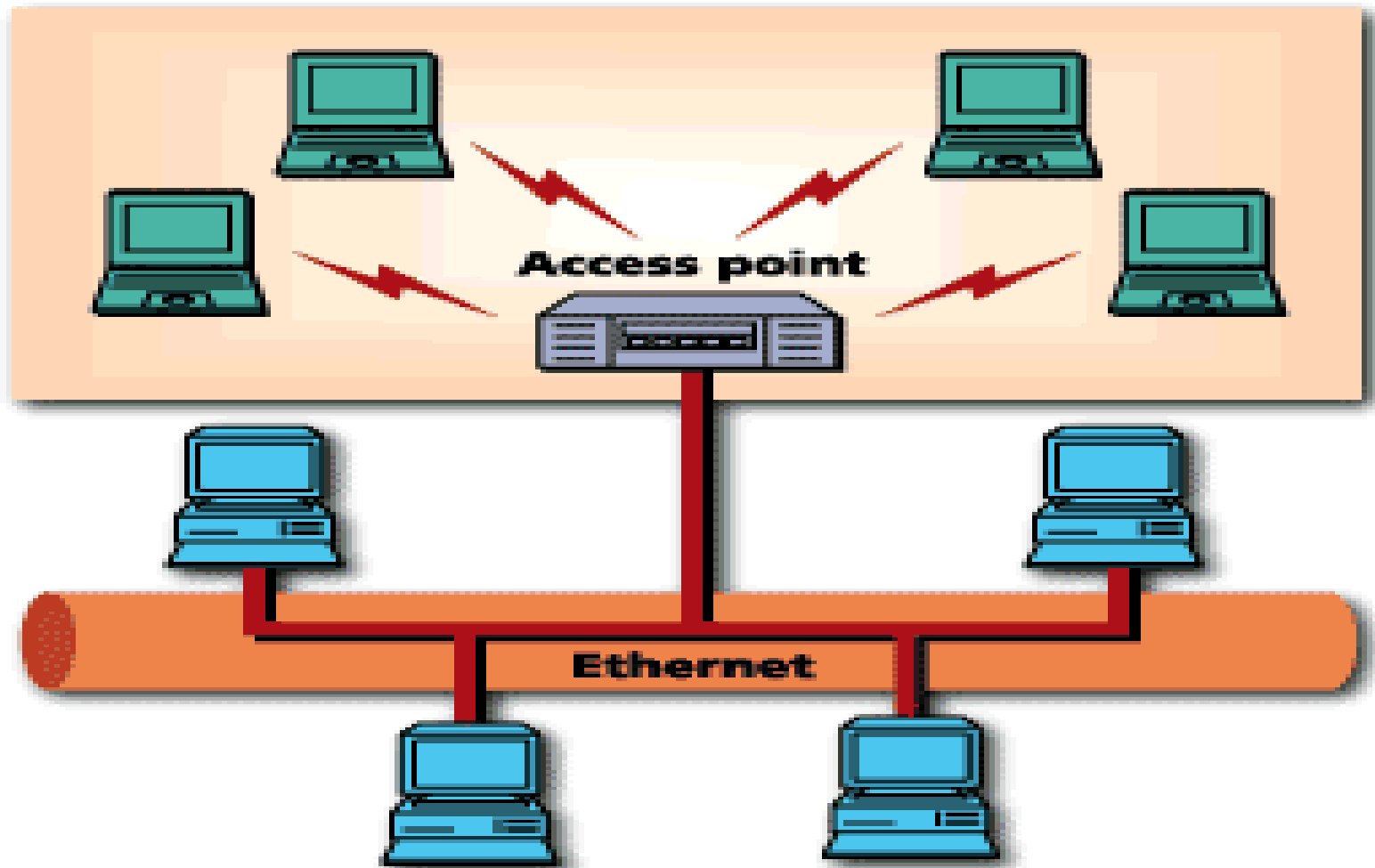
Ad-Hoc Wireless LAN
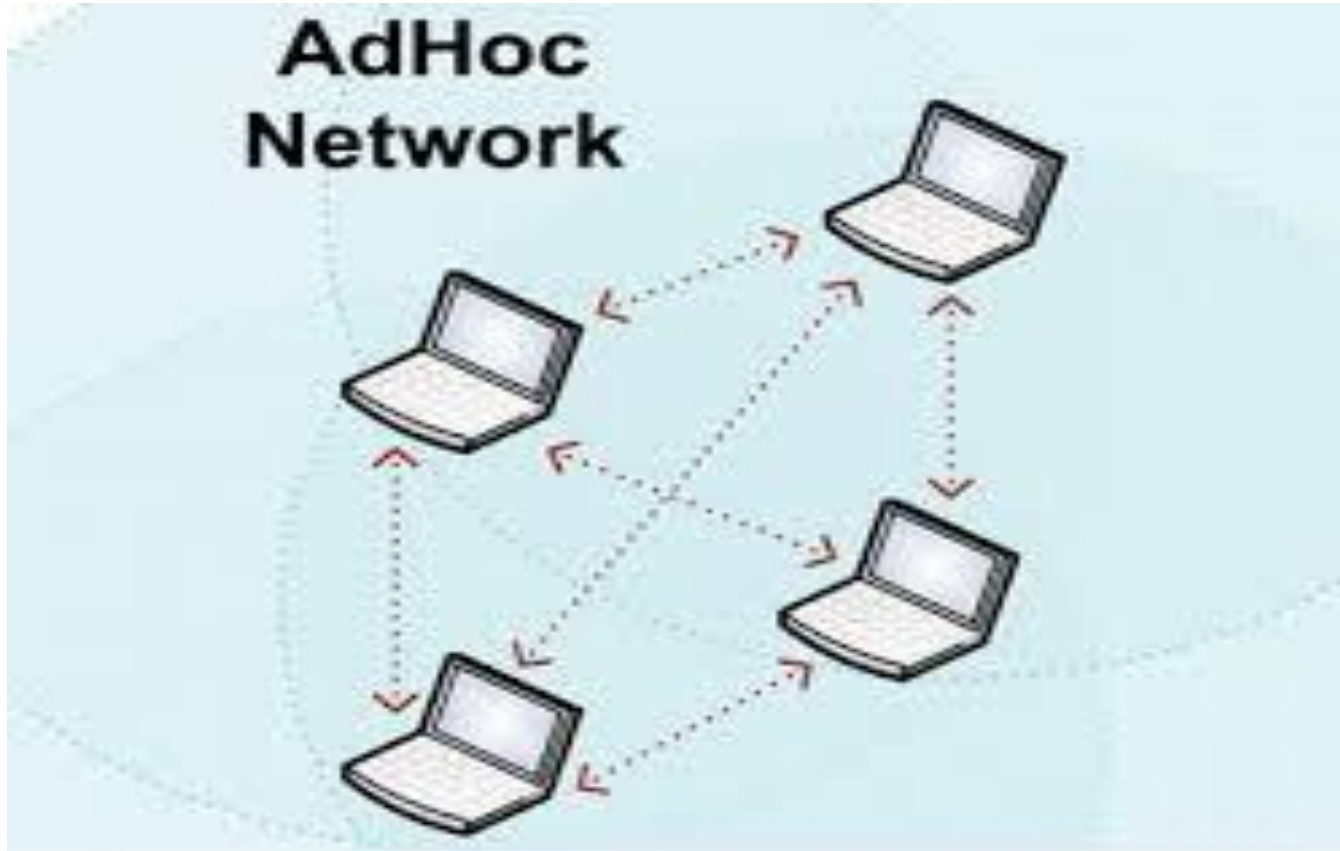
Infrastructure Wireless LAN

- The wireless LAN connects to a wired LAN. There is a need of an **Access Point** (AP) that bridges wireless LAN traffic into the wired LAN. The AP can also act as a repeater for wireless nodes, effectively doubling the maximum possible distance between nodes.

- **Infrastructure mode** is an 802.11 networking framework in which devices communicate with each other by first going through an Access Point (AP)
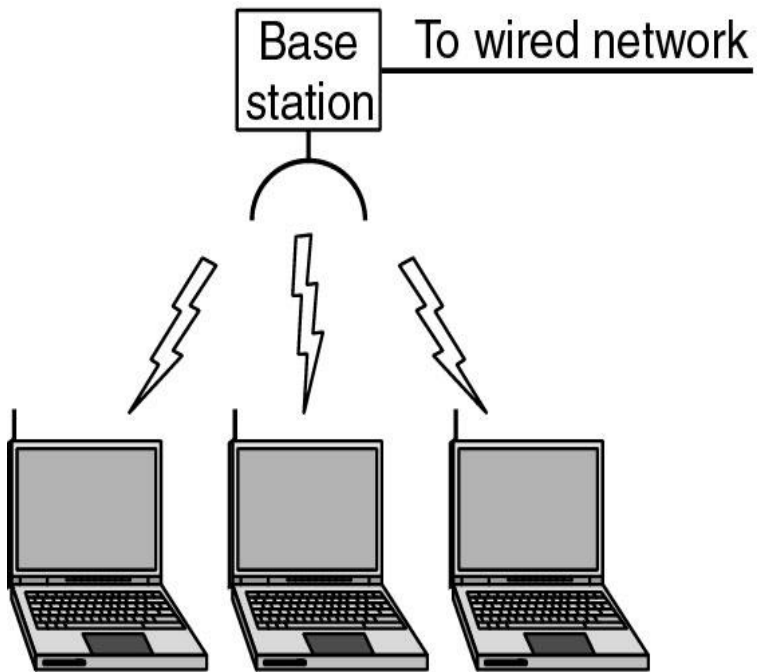
Infrastructure Wireless LAN

- In the area of wireless computer **networking**, a **base station** is a radio receiver/transmitter that serves as the hub of the WLAN, and may also be the gateway between a wired **network** and the wireless **network**. It typically consists wireless router

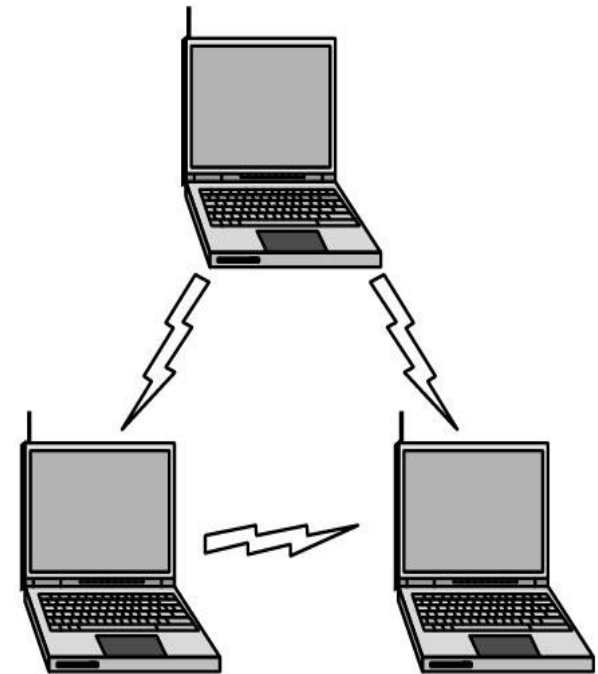- Base station network is connected to the Wired Internet. Other nodes can be fixed or mobile

Network Infrastructure

Access point

Ethernet

Common Topologies-WLANs

Base station — To wired network

(a)

Infrastructure WLAN .

(b)

Ad hoc WLAN.

11

How do wireless LANs work?

- A WLAN serves the same purpose as a wired one — to link a group of computers

- WLAN uses the same networking protocols and supporting most of the same applications.

- Wireless networks operate using radio frequency (RF) technology, a frequency within the electromagnetic spectrum associated with radio wave propagation

How are WLANs Different?

➢They use specialized physical and data link protocols

➢They integrate into existing networks through Access Points (AP) which provide a bridging function

➢They let you stay connected as you roam from one coverage area to another

➢They have unique security considerations

➢They have specific interoperability requirements

➢They require different hardware

➢They offer performance that differs from wired LANs.

Physical and Data Link Layers WLAN

Physical Layer:

- The wireless **NIC** takes **frames** of data from the data link layer, scrambles the data in a predetermined way, then uses the modified data stream to modulate a **radio carrier signal**.

Data Link Layer:

- Uses **C**arriers-**S**ense-**M**ultiple-**A**ccess with **C**ollision **A**voidance (CSMA/CA). **CSMA/CA** in computer networking, is a network multiple access method in which carrier sensing is used, but nodes attempt to avoid collisions by transmitting only when the channel is sensed to be idle

Integration With Existing Networks

- Wireless Access Points (APs) - a small device that bridges wireless traffic to your network.

- Access point is designed to broadcast a **wireless** signal that computers can detect and "tune" into.

- Most access points bridge wireless LANs into Ethernet networks

Integration With Existing Networks
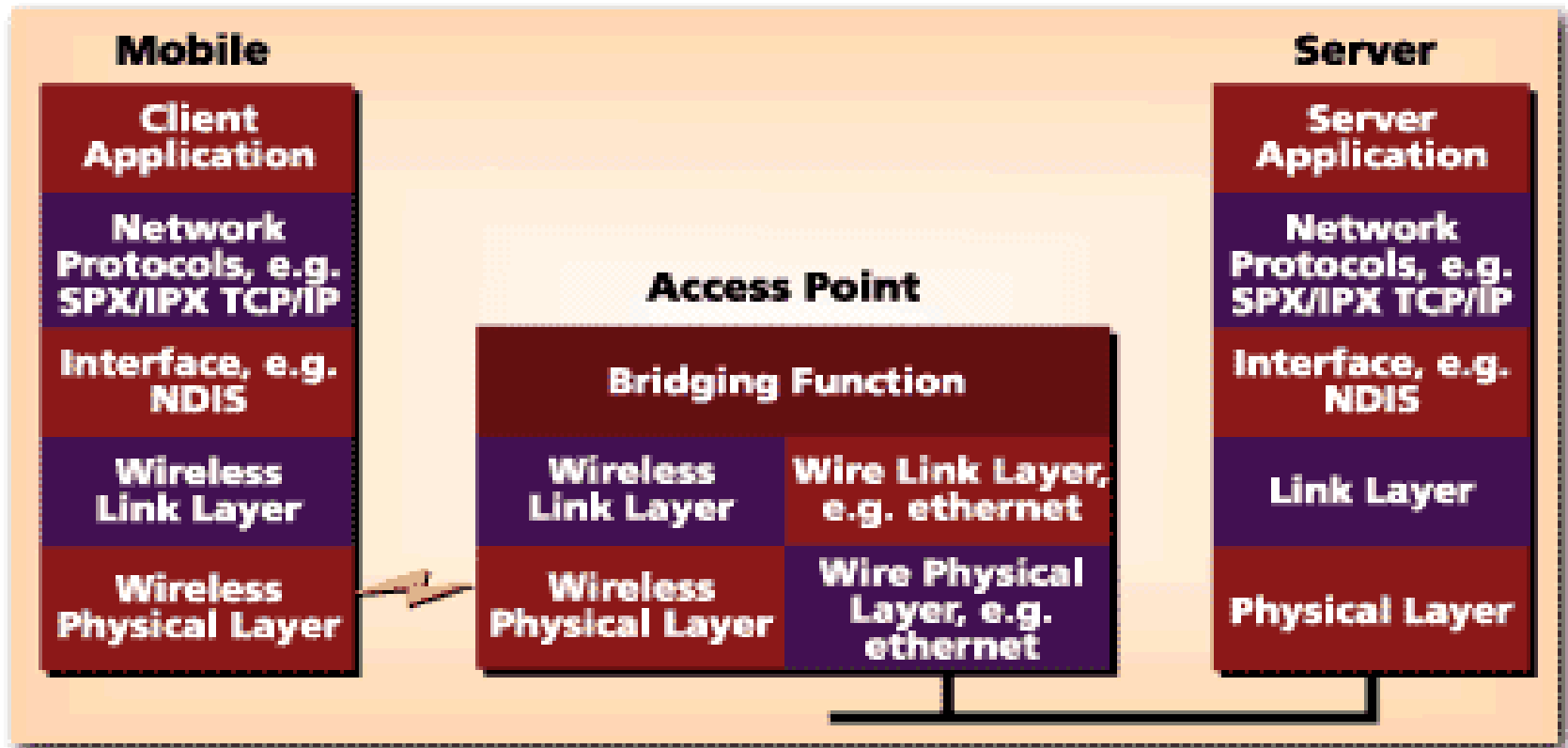
Roaming

Roaming refers to the ability for a **cellular** customer to automatically make and receive voice calls, send and receive data, or access other services, including home data services, when travelling outside the geographical coverage area of the home **network**.
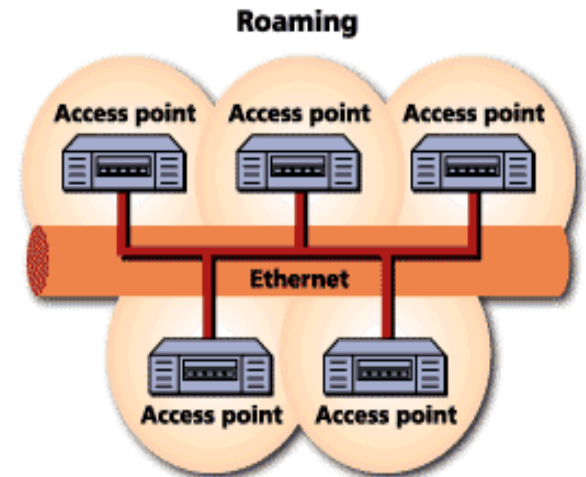
- Users maintain a continuous connection as they roam from one physical area to another
- Mobile nodes automatically register with the new access point.
- Methods: DHCP, Mobile IP

WLAN Security

- The IEEE 802.11 standard specifies optional security called "***Wired Equivalent Privacy***" whose goal is that a wireless LAN offer privacy equivalent to that offered by a wired LAN.

- The standard also specifies optional authentication measures.

- Common standard encryption schemes are
  - Wired Equivalent Privacy (WEP)
  - Wi-Fi Protected Access (WPA)
  - Wi-Fi Protected Access 2 (WPA2)

18

Interoperability

- Before the IEEE 802.11, interoperability was based on cooperation between vendors.

- IEEE 802.11 only standardizes the physical and Medium Access Control layers.

- Vendors must still work with each other to ensure their IEEE 802.11 implementations interoperate

- Wireless Ethernet Compatibility Alliance (WECA) introduces the Wi-Fi Certification to ensure cross-vendor interoperability of 802.11b solutions

Architecture

Stations

- All components that can connect into a wireless medium in a network are referred to as stations (STA). All stations are equipped with wireless network interface controllers (WNICs). Wireless stations fall into two categories: wireless access points, and clients. APs, normally wireless routers, are base stations for the wireless network. They transmit and receive radio frequencies for wireless enabled devices to communicate with. Wireless clients can be mobile devices such as laptops, personal digital assistants, IP phones and other smartphones, or non-portable devices such as desktop computers, printers, and workstations that are equipped with a wireless network interface.

Basic service set (BSS)

- BSS is a set of all stations that can communicate with each other at physical layer. Every BSS has an identification (ID) called the BSSID, which is the MAC address of the access point servicing the BSS.

- There are two types of BSS: Independent BSS (IBSS), and infrastructure BSS. An independent BSS (IBSS) is an ad hoc network that contains no access points, which means they cannot connect to any other basic service set.

Architecture

Independent basic service set

- An IBSS is a set of STAs configured in ad hoc (peer-to-peer)mode.

Extended service set

- An extended service set (ESS) is a set of connected BSSs. Access points in an ESS are connected by a distribution system. Each ESS has an ID called the SSID which is a 32-byte (maximum) character string.

Distribution system

- A distribution system (DS) connects access points in an extended service set. The concept of a DS can be used to increase network coverage through roaming between cells.

- DS can be wired or wireless. Current wireless distribution systems are mostly based on WDS or MESH protocols, though other systems are in use.

Hardware

- Wireless router (AP)

- Wire-based connections:

- Wireless NIC: with antenna

- ISA Card with external antenna connected by cable.
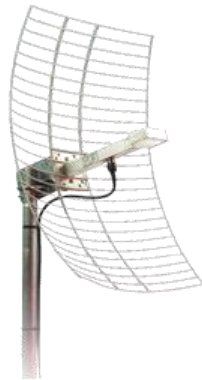
- Handheld terminals /computers with wireless NIC

Hardware

CISCO Aironet 350 series

Wireless Handheld Terminal

Semi Parabolic Antenna

BreezeCOM AP

Wireless Technology Standards

- Most modern WLANs are based on IEEE 802.11 standards and are marketed under the Wi-Fi brand name.

- **IEEE 802.11** is a set of media access control (MAC) and physical layer specifications for implementing wireless local area network (WLAN) computer communication in the 900 MHz and 2.4, 3.6, 5, and 60 GHz frequency bands.

Wireless Technology Standards

- A family of wireless LAN (WLAN) specifications developed by a working group at the Institute of Electrical and Electronic Engineers (IEEE)

- Versions:

  - 802.11a
  - 802.11b
  - 802.11g
  - 802.11e
  - 802.11f
  - 802.11i

802.11 - Transmission

- Most wireless LAN products operate in unlicensed radio bands
  - 2.4 GHz is most popular
  - Available in most parts of the world
  - No need for user licensing
- Most wireless LANs use spread-spectrum radio
  - Resistant to interference, secure

802.11a

- Ultra-high spectrum efficiency
  - 5 GHz band
  - More data can travel over a smaller amount of bandwidth
- High speed
  - Up to 54 Mbps
- Less interference
  - Fewer products using the frequency
    - 2.4 GHz band shared by cordless phones, microwave ovens, Bluetooth, and WLANs

802.11b

- operates in 2.4GHz band.

- Its speed is 11 Mbps.

- It covers up to 300 feet distance.

- It normally installed in both business and homes

- deployed in "hot spots" such as hotels, airports and Starbucks.

802.11g

- 802.11g is a high-speed extension to 802.11b
  - Compatible with 802.11b
  - High speed up to 54 Mbps
  - 2.4 GHz
- offering greater performance (that is, speed and range) and remains today's most common wireless networking technology

Performance

- **802.11a** offers speeds with a theoretically maximum rate of 54Mbps in the 5 GHz band

- **802.11b** offers speeds with a theoretically maximum rate of 11Mbps at in the 2.4 GHz spectrum band

- **802.11g** is a new standard for data rates of up to a theoretical maximum of 54 Mbps at 2.4 GHz.

Choose the right technology

- Usually IEEE 802.11b or 802.11a

- 802.11b offers interoperability

- 802.11a offers higher data rates (up to 54 mbps)
  - Higher throughput per user.
  - Limited interoperability.

Access Point Placement and Power

- Typically – mounted at ceiling height.

- Between 15 and 25 feet (4.5m to 8m)

- The greater the height, the greater the difficulty to get power to the unit.

- Solution: consider devices that can be powered using CAT5 Ethernet cable (CISCO Aironet 1200 Series).

- Access points have internal or external antennas

Antenna Selection and Placement

- Permanently attached.

- Remote antennas connected using an antenna cable.

- Coax cable has a high signal loss, should not be mounted more than a 1 or 2 meters away from the device.

- Placement: consider building construction, ceiling height, obstacles.

- Different materials (cement, steel) have different radio propagation characteristics.

Connecting to the Wired LAN

- Consider user mobility

- If users move between subnets, there are challenges to consider.

- OSes like Windows XP and 2000, Linux support DHCP to obtain the new IP address for the subnet. Certain applications such as VPN will fail.

- Solution: access points in a roaming area are on the same segment.

The Site Survey

- Helps define the coverage areas, data rates, the precise placement of access point.

- Gather information:
 - diagramming the coverage area and measuring the signal strength

WAN Technologies

- A WAN is a data communications network that covers a relatively broad geographic area and that often uses transmission facilities provided by common carriers, such as telephone companies.

- WAN technologies generally function at the lower three layers of the OSI reference model:

  - Network layer

  - Data link layer

  - Physical layer
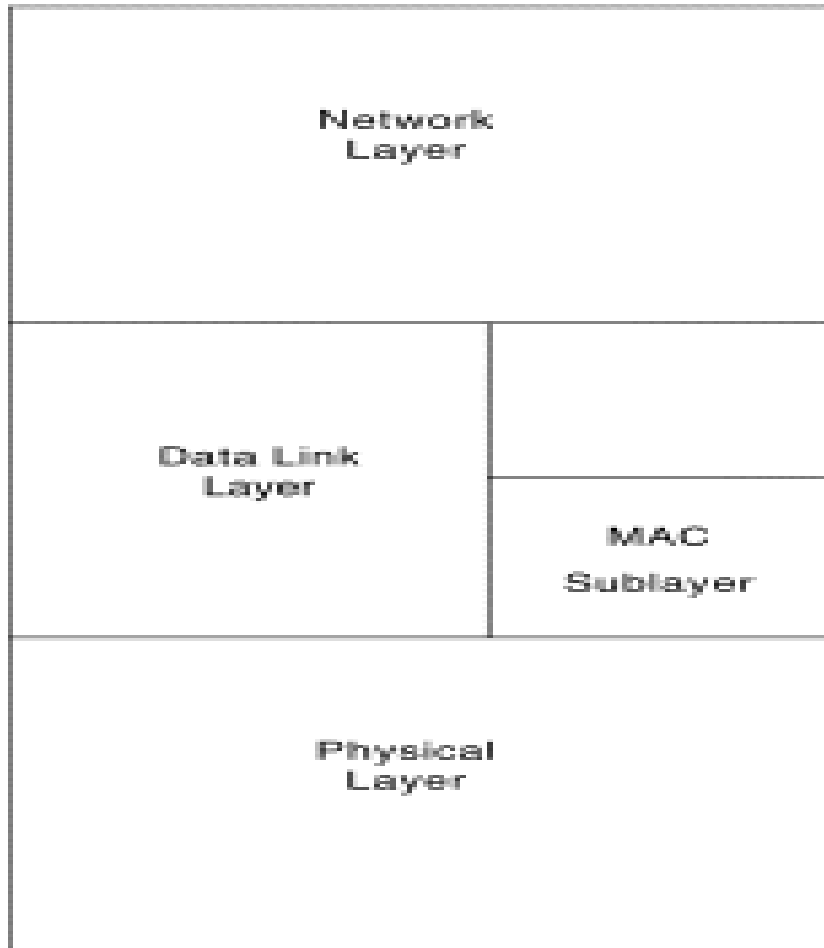
WAN Technologies
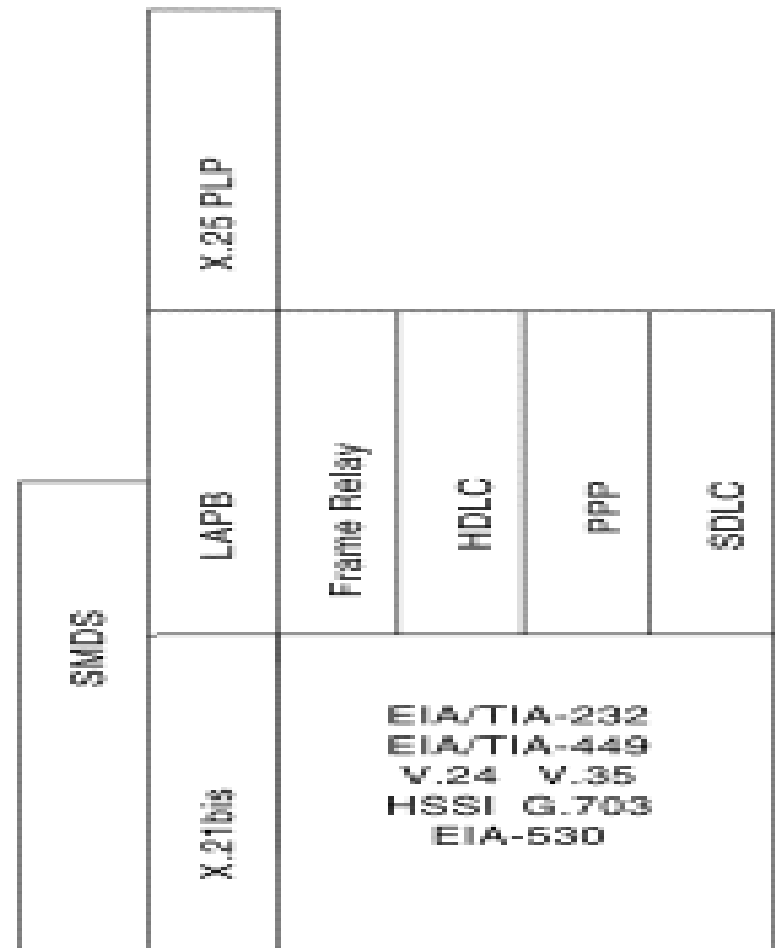
WAN Connection Devices

- Customer Premises Equipment (CPE)
- Data Communication Equipment (DCE)
- Data Terminal Equipment (DTE)
- Local Loop
- Central Office (CO)
- Toll Network
- CSU/DSU

CPE- Customer Premises Equipment

- Also called customer-provided equipment
- The subscriber either owns the CPE or leases the CPE from the service provider
- A subscriber in this context is a company that arranges for WAN services from the service provider
- CPE generally refers to devices such as telephones, routers, network switches, residential gateways

DTE- Data Terminal Equipment

- End systems that communicate across the WAN technologies
- The customer devices that pass the data from a customer network or host computer for transmission over the WAN
- The DTE connects to the DCE through the local loop
- They are usually terminals, personal computers or network hosts and are located on the premises of individual subscribers.

DCE-Data Communication Equipment

- Also called Data Circuit Terminating Equipment
- DCE consists of devices that put data on the local loop
- DCE provides an interface to connect subscribers to a communication link on the WAN cloud
- DCE is a communication devices such as modems and packet switches that provide the interface between the DTE devices and the carriers facilities.

Local Loop

- The actual copper or fiber cable that connects the CPE to the central office (CO) of the service provider.
- The local loop is sometimes called the last-mile

Central Office (CO)

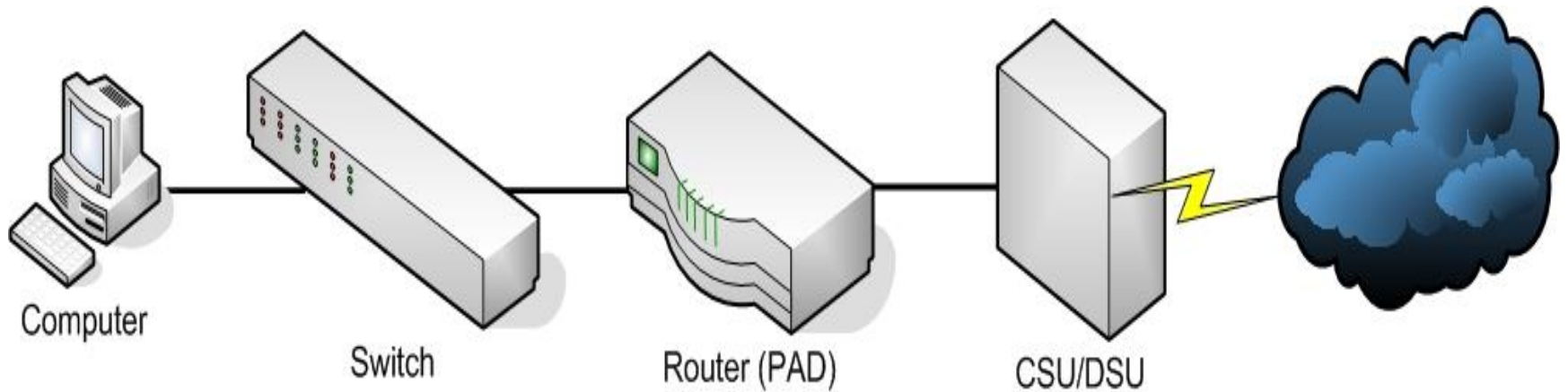- The CO is the local service provider facility or building that connects the CPE to the provider network
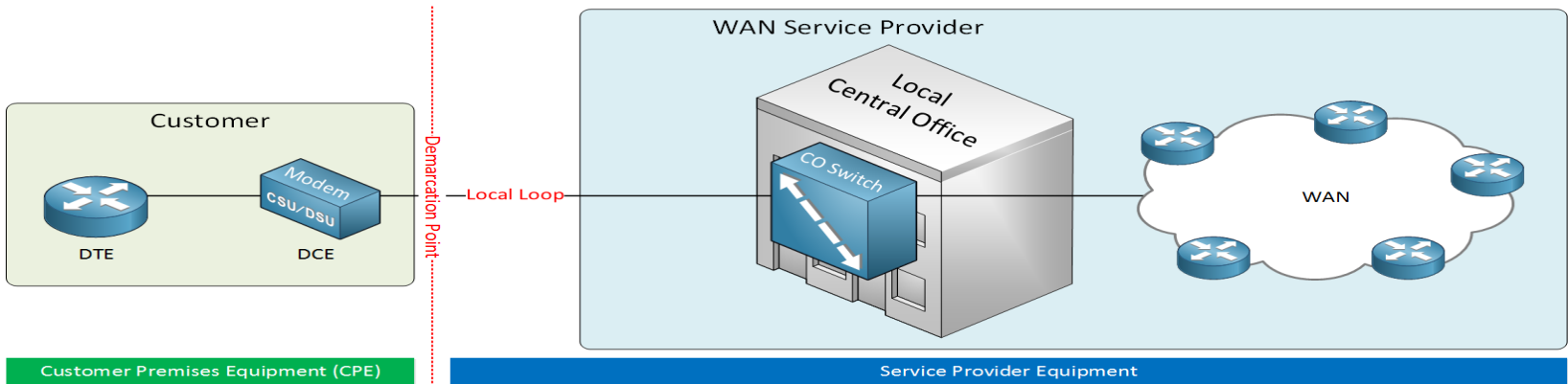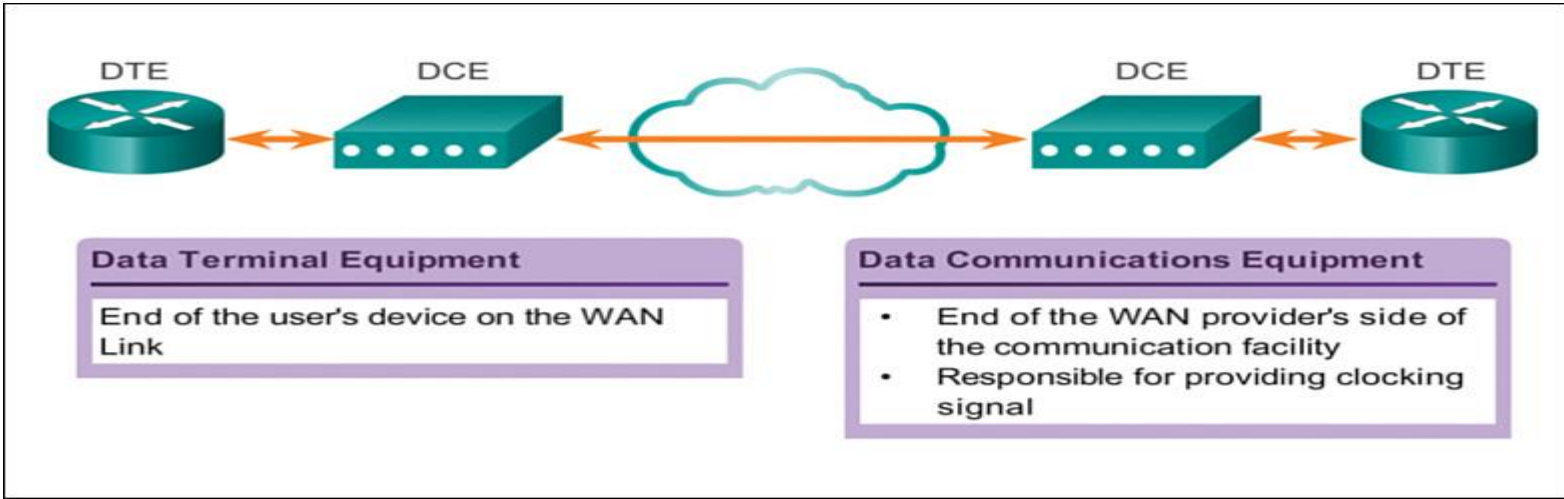
Toll Network

- This consists of all digital, fiber optic communication lines, switches, routers and other equipment inside the WAN provider network

Devices in WAN technology

- **CSU/DSU-Channel Service Unit/Digital Service Unit**
  - A CSU/DSU is a digital-interface device that adapts the physical interface on a DTE device to the interface of DCE device in a switched-carrier network.
  - The CSU/DSU terminates the digital signals at customer location.
  - CSU/DSU is required to prepare data traffic for digital lines
  - Can be used by a router to connect to digital line
- **WAN Switch**
  - a multiport internetworking device used in service provider networks

Devices in WAN technology

Computer — Switch — Router (PAD) — CSU/DSU

Data Terminal Equipment

End of the user's device on the WAN Link

Data Communications Equipment

- End of the WAN provider's side of the communication facility
- Responsible for providing clocking signal

Other WAN Devices

- Dialup modem

- Access Server

- Broadband modem

- Router

- Core Router

Switching in WAN Technology

Circuit Switching

- a circuit switched network is one that establishes a dedicated circuit or channel between nodes and terminals before the users may communicate

- Circuit switching dynamically establishes a dedicated virtual connection for voice or data between a sender and a receiver

- Before communication can start, it is necessary to establish the connection through the network of the service provider

- The two most common types of circuit switched networks
  - The Public Switched Telephone Network (PSTN)
  - The Integrated Service Digital Network (ISDN)

Circuit Switching

ISDN Network

Circuit-Switched Connection
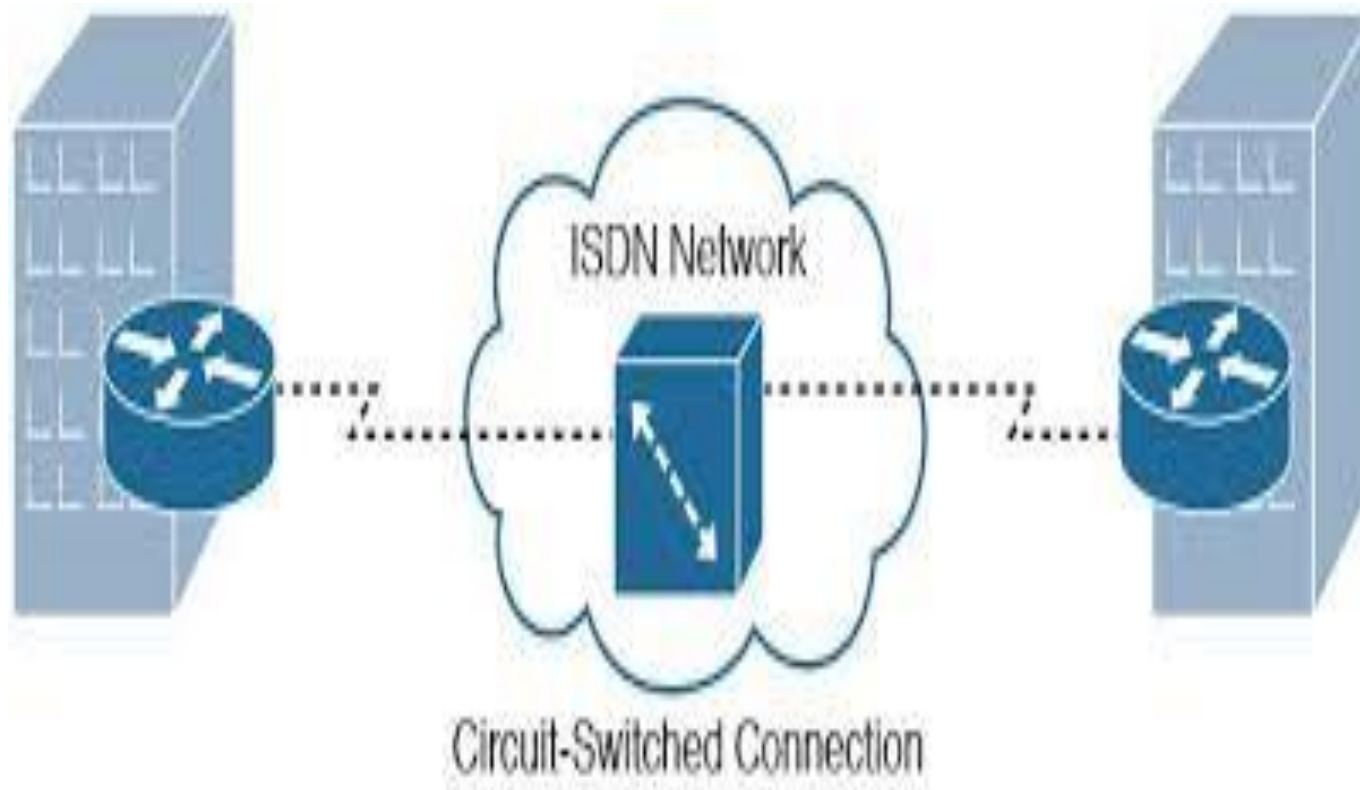
Switching in WAN Technology

Packet Switching

- Packet switching splits traffic data in to packets that are routed over a shared network

- Packet switched network do not require a circuit to be established

- The switches in packet switched network (PSN) determine the links that packets must be sent over based on the addressing information in each packet

- Two approaches in this link determination
  - Connectionless system
  - Connection oriented system

Switching in WAN Technology

Packet Switching

- Packet-switched networks move data in separate, small blocks (packets) based on the destination address in each packet.

- When the circuit is established temporarily while a packet is travelling through it, and then breaks down again, it is called a virtual circuit (VC)

- Because the internal links between the switches are shared between many users, the cost of packet switching network is lower than that of circuit-switching network

Switching in WAN Technology

- Packet switching is a **WAN technology** in which users share common carrier resources.

- Packet-switching networks include
  - Asynchronous Transfer Mode (ATM),
  - Frame Relay,
  - Switched Multimegabit Data Services (SMDS), and
 - X.25

Packet Switching
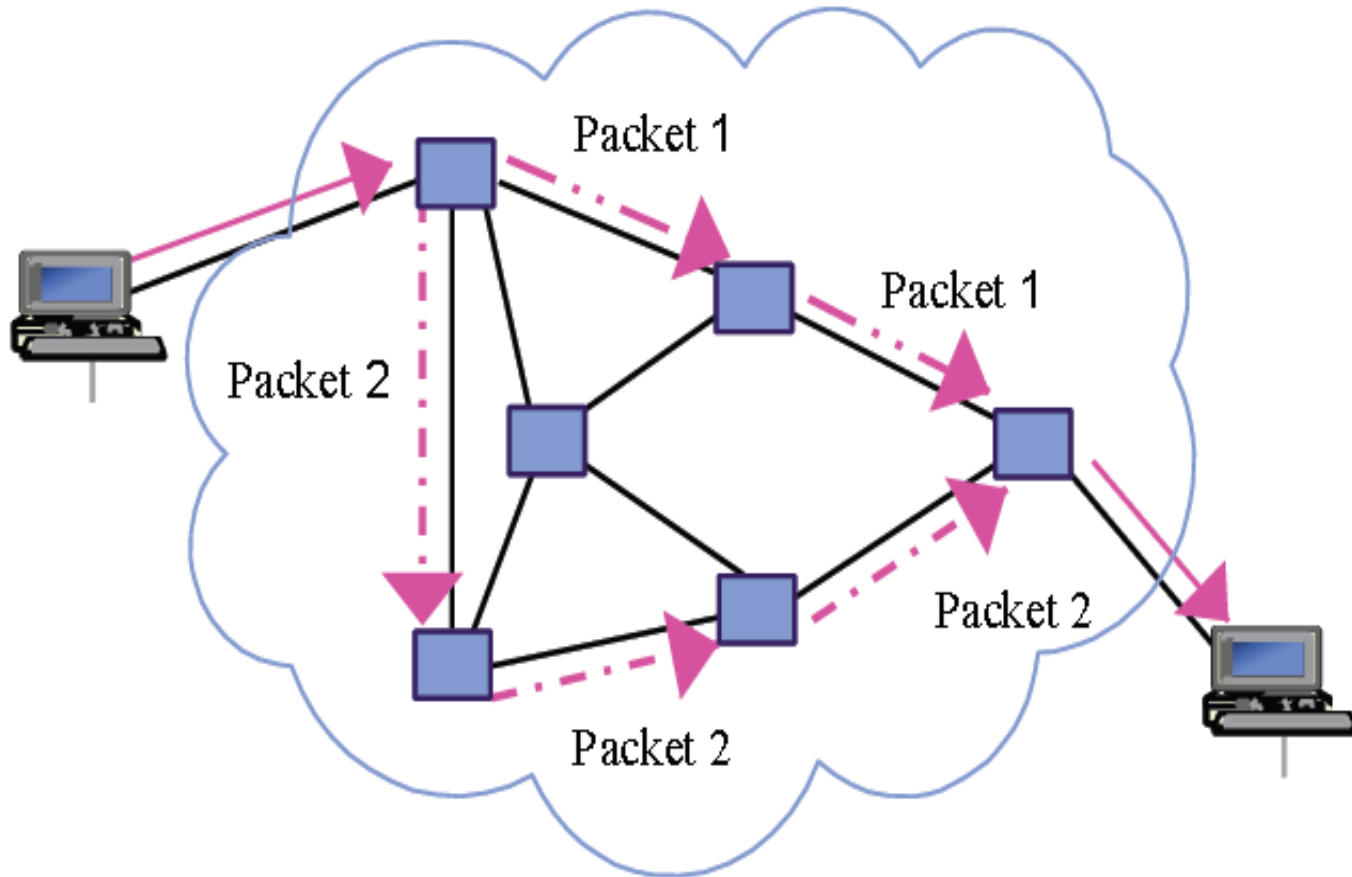
WAN Technologies

✓PPP-Point-to-Point Protocol

✓ISDN

✓ATM

✓Frame relay

✓DSL

✓X.25

PPP-Point-to-Point Protocol

- PPP link provides a pre-established WAN communications path from the customer sites through the provider network to a remote destination.

- PPP lines are usually leased from a carrier and are called leased lines because its established path is permanent and fixed for each remote network reached through the carrier facilities

- PPPs commonly used as a layer 2 protocol on dedicated Leased lines.

- PPP is communications protocol used to establish a direct connection between two routers without any host or any other networking device in between.

Point to point protocol (PPP)

2811
RouterA

2811
RouterB
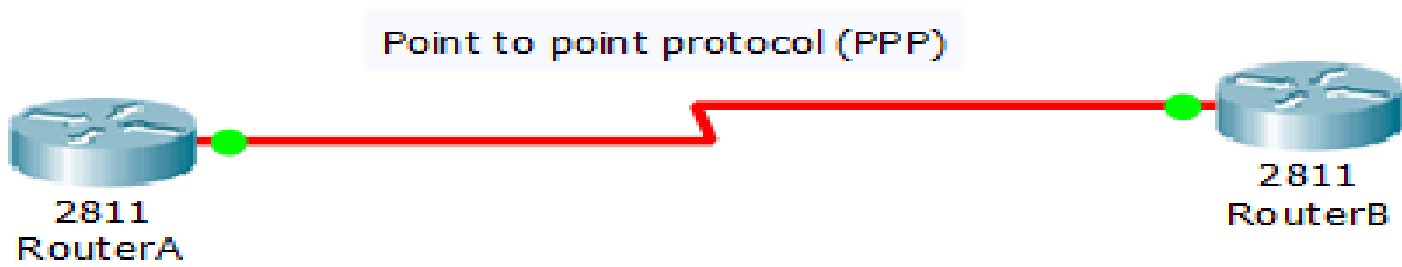
ISDN-Integrated Services Digital Network

- ISDN is a set of communication standards for simultaneous digital transmission of voice, video, data, and other network services over the traditional circuits of the public switched telephone network (PSTN).

- Prior to ISDN, the telephone system was viewed as a way to transport voice, with some special services available for data.

- The key feature of ISDN is that it integrates speech and data on the same lines, adding features that were not available in the classic telephone system.

Integrated Services Digital Network

- ISDN is a circuit-switched telephone network system which provides a better voice quality than an analog phone can provide.
- ISDN supports multiple channels
  - B (Bearer) channels for 64 Kbps channels on a single connection
  - D (Delta or data) channel for 64 Kbps signaling data
- ISDN is faster than telephone line connections
- ISDN is consisting of ISDN switches

Integrated Services Digital Network

- The ISDN standards define several kinds of access interfaces, such as:

  - Basic Rate Interface (BRI)

    - Offers a two 64 Kbps B channels with 16 Kbps D channels

  - Primary Rate Interface (PRI)

    - Offers a 1.472 Mbps data path over B channel and a 64 Kbps D channel

  - Narrowband ISDN (NISDN),

  - Broadband ISDN (BISDN)
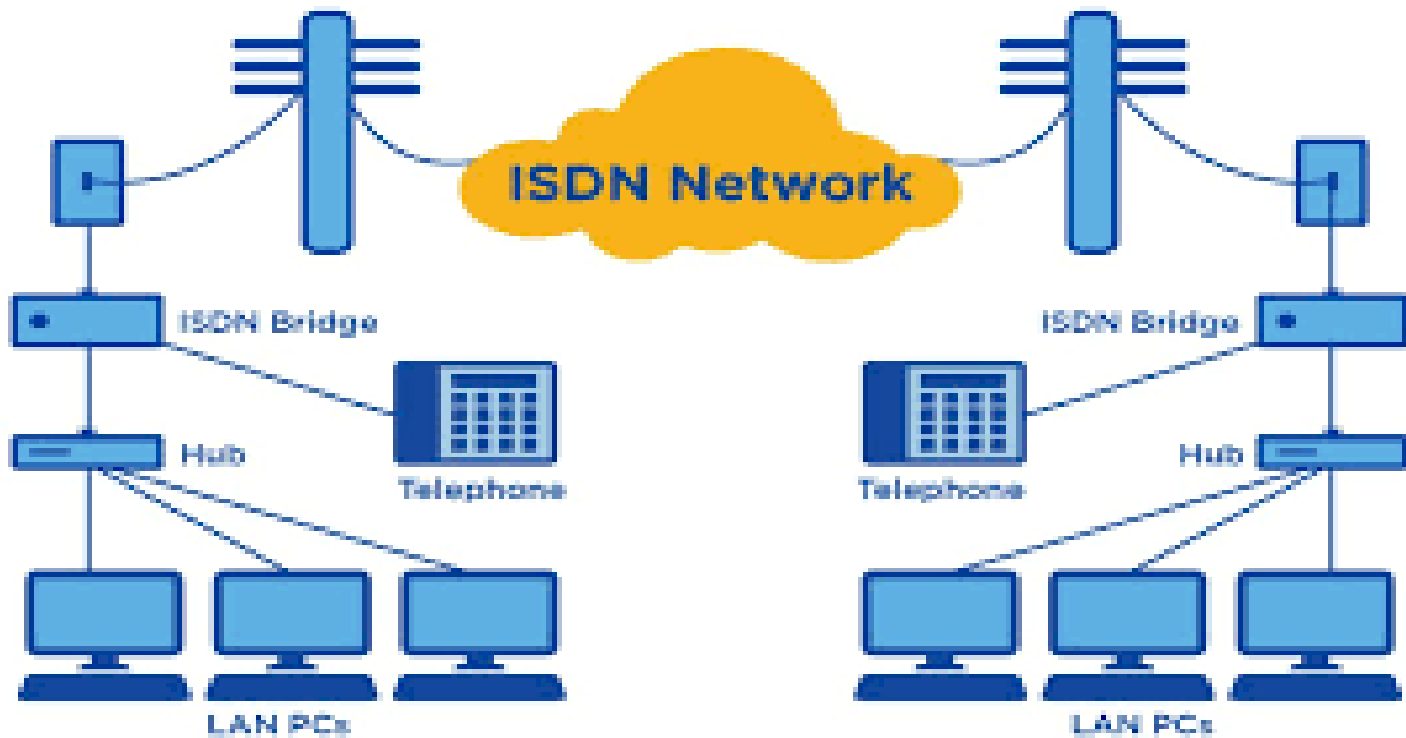
Frame Relay

- Intended to be an intermediate solution for the demand of high bandwidth networking

- uses a protocol that works at the data link layer of the OSI

- A number of DTE can communicate over a single physical connection

- Each DTE is identified by a single Data link connection identifier (DLCI)

- Relatively low cost and widespread availability compared to leased lines

- Frame relay sites are connected via virtual circuits (VC)
  - VC are either Point to point or point to multipoint connection

Frame Relay

- High performance WAN protocol
  - Higher degree of connectivity
- Does not provide error checking for packets
- Employs packet switching technology
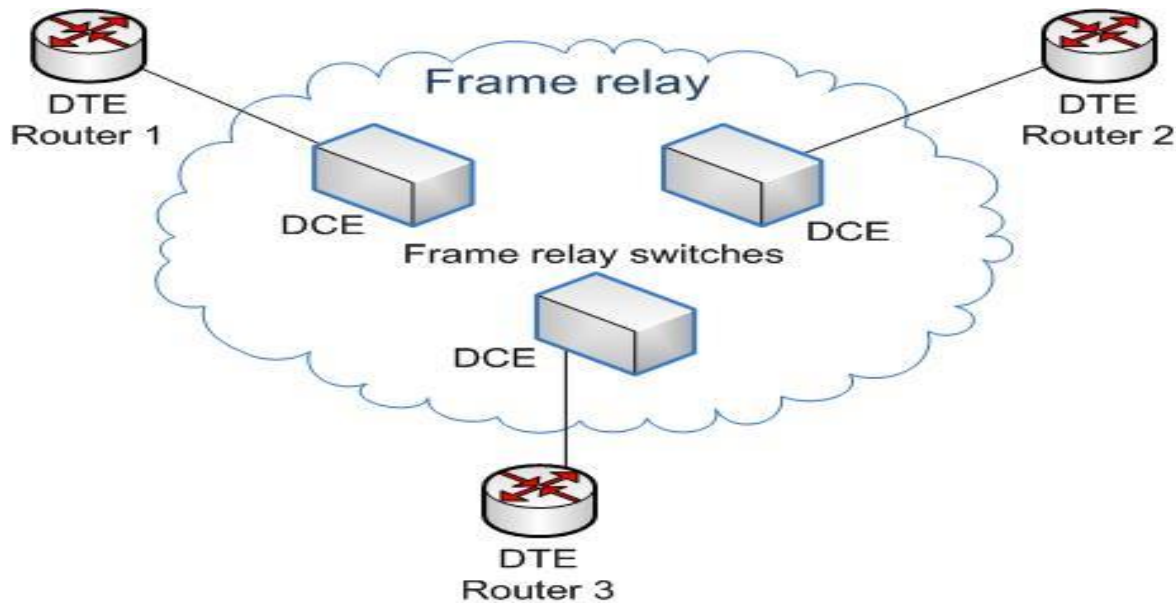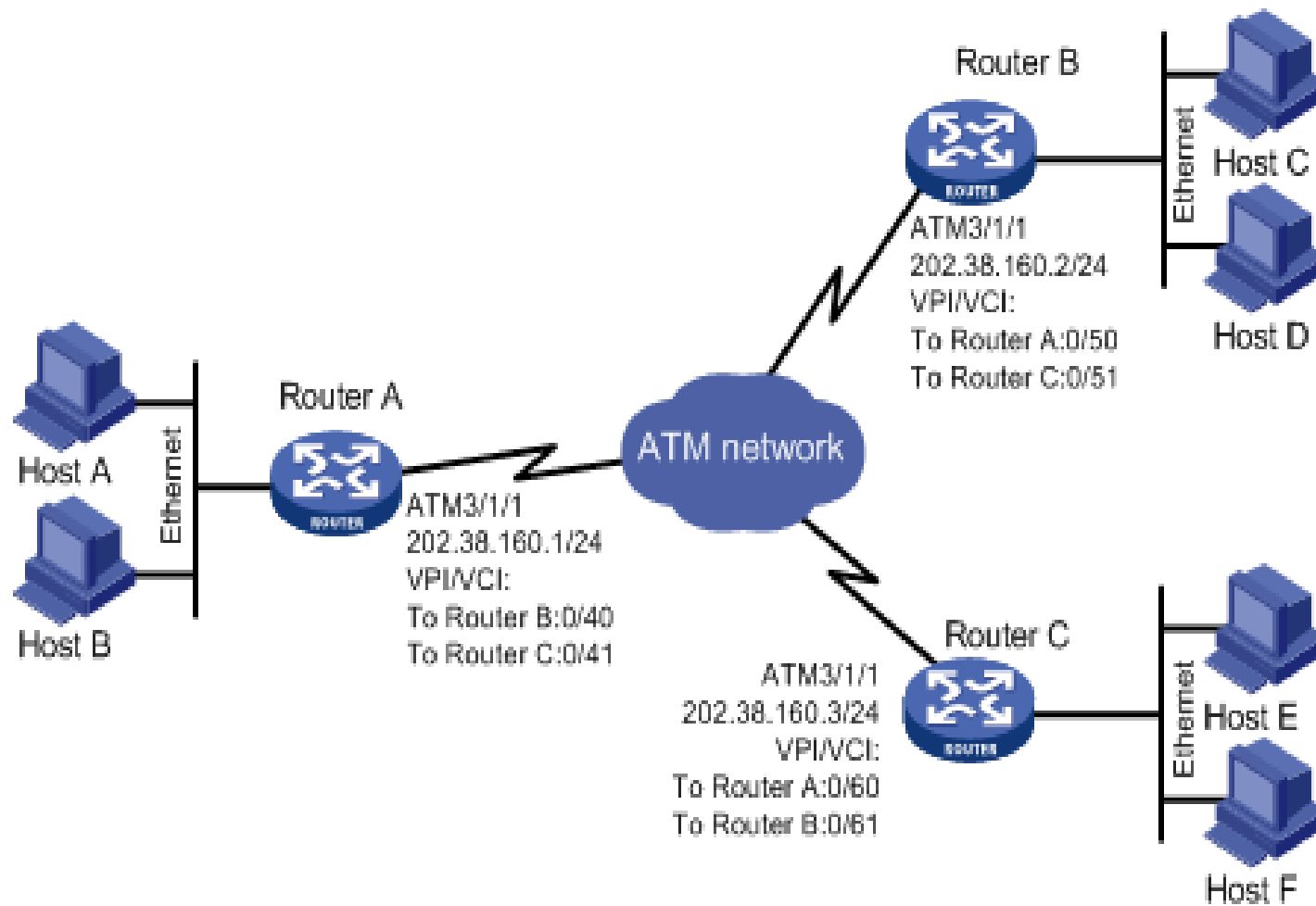
ATM -Asynchronous Transfer Mode

- ATM is a telecommunications standards for carriage of a *complete range* of user traffic including voice, data, image, text and video signals.

- ATM was developed to meet the needs of the *Broadband* Integrated Services Digital Network (B-ISDN).

- ATM works at the three lowest layers of the reference model: network layer, data link layer, and physical layer

- ATM is a core protocol used over the
  - Public switched telephone network (PSTN) and
  - Integrated Services Digital Network (ISDN)

ATM -Asynchronous Transfer Mode

- ATM provides a *permanent shared network* technology that offered very low latency and jitter at much higher bandwidths.

- ATM has data rates beyond 155 Mbps.

- As with the other shared technologies, such as X.25 and Frame Relay, diagrams for ATM WANs look the same.

- A typical ATM line needs almost 20% greater bandwidth than Frame Relay to carry the same volume of network layer data.

ATM-Asynchronous transfer mode

- ATM is a connection-oriented packet switching technique in which a virtual circuit must be established between two endpoints before the actual data exchange begins.
- These virtual circuits(VC) may be
  - Permanent Virtual Circuit (PVC): dedicated connections that are usually preconfigured by the service provider
  - Switched Virtual Circuit (SVC): set up on a per-call basis using signaling and disconnected when the call is terminated.
- ATM eventually became dominated by Internet Protocol

Router B

Host C

Host D

ATM3/1/1
202.38.160.2/24
VPI/VCI:
To Router A:0/50
To Router C:0/51

Router A

Host A

Host B

Ethernet

ATM network

ATM3/1/1
202.38.160.1/24
VPI/VCI:
To Router B:0/40
To Router C:0/41

Router C

ATM3/1/1
202.38.160.3/24
VPI/VCI:
To Router A:0/60
To Router B:0/61

Host E

Host F

DSL (Digital Subscriber Line)

- DSL technology is a broadband technology that uses existing twisted-pair telephone lines to transport high-bandwidth data to service subscribers.

- The term xDSL covers a number of similar yet competing forms of DSL technologies.

- DSL technology allows the local loop line to be used for
  - Normal telephone voice connection and
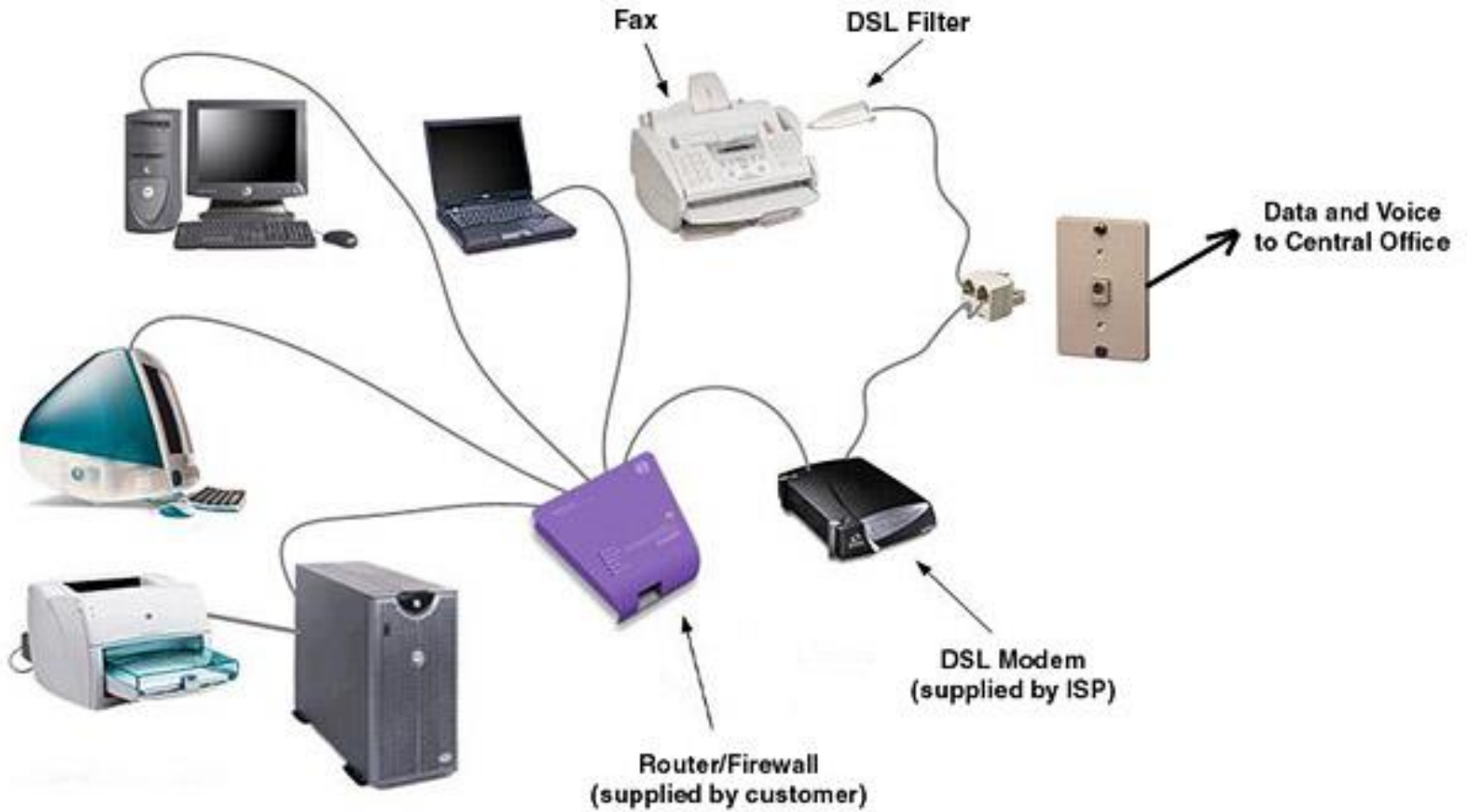 - instant network connectivity.

DSL (Digital Subscriber Line)

- The two basic types of DSL technologies are
  - Asymmetric (ADSL)
  - Symmetric (SDSL).
- All forms of DSL service are categorized as ADSL or SDSL and there are several varieties of each type.
- ADSL service provides higher download speed or downstream bandwidth to the user than upload bandwidth speed.
- SDSL service provides the same capacity in both directions.

DSL (Digital Subscriber Line)

- Asymmetric DSL
  - Maximum distance to DSLAM: 18,00 feet
  - Voice and Data on the same line
  - Downstream: up to 8 Mbps
  - Upstream: up to 1.544 Mbps

- Symmetric DSL
  - Maximum distance to DSLAM: 12.00 feet
  - No simultaneous voice and data on the same line
  - Downstream: 1.168 Mbps
  - Upstream: 1.168 Mbps

- Very high bit rate DSL
  - Downstream: up to 52 Mbps and Upstream: up to 12 Mbps

DSL

Fax

DSL Filter

Data and Voice
to Central Office

DSL Modem
(supplied by ISP)

Router/Firewall
(supplied by customer)

X.25

- The first of these packet-switched networks was standardized as the X.25 group of protocols.

- X.25 provides a low bit rate shared variable capacity that may be either switched or permanent circuites.

- X.25 is a network-layer protocol and subscribers are provided with a network address.

- Virtual circuits can be established through the network with call request packets to the target address. The resulting SVC is identified by a channel number.

- X.25 technology is no longer widely available as a WAN technology

- Frame Relay has replaced X.25 at many service provider locations.

X.25

X.25 NETWORK
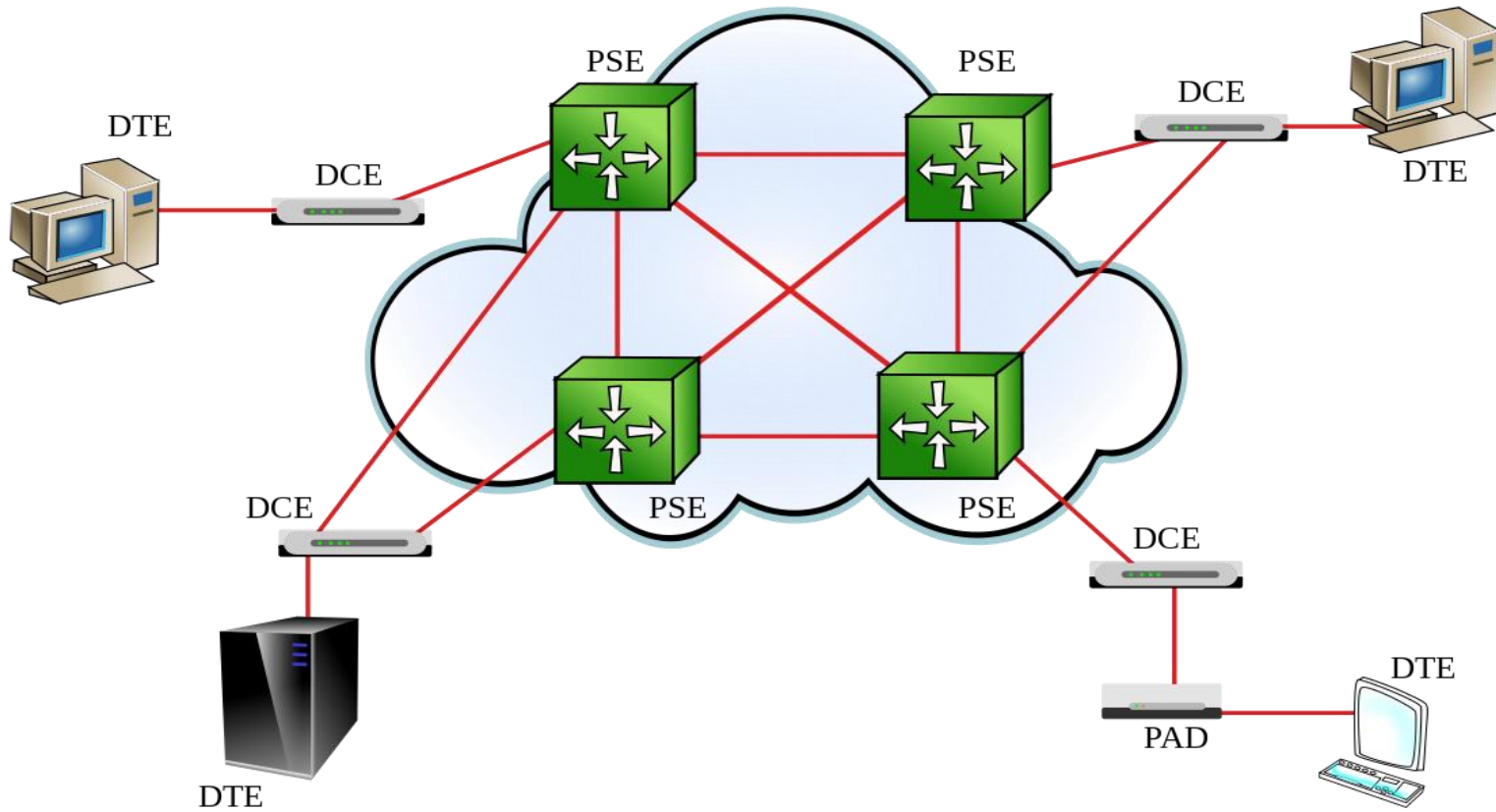
Other WAN Technologies

Reading Assignment
- Synchronous Optical Network (SONET)
- MPLS- Multiprotocol Label Switching
- VPN- Virtual Private Network
- SDLC protocol
- POTS
- HDLC
- SMDS
- LAPB
- T1
- E1
- T3
- E3