Lecture (05) Network Access layer fundamentals II LAN, & WAN

By:

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Agenda

- Recent Ethernet Standards (cont,..)
  - Fast Ethernet
  - Gigabit Ethernet
- Ethernet Addressing
- Ethernet Framing
- What is WAN?
- What is MAN?
- OSI layer1 of WANs
- OSI Layer 2 of WANs

Recent Ethernet Standards

- More recently created alternatives, areFast Ethernet and Gigabit Ethernet
- Fast Ethernet most likely being used on the desktop and Gigabit Ethernet being used between networking devices or on servers.
- Additionally, 10 Gb provides yet another improvement in speed and performance

Fast Ethernet

- Fast Ethernet, as defined in IEEE 802.3u, retains many familiar features of 10-Mbps IEEE 802.3 Ethernet variants.
- The age-old CSMA/CD logic still exists, but it can be disabled for full-duplex point-to-point topologies in which no collisions can occur.
- The 802.3u specification calls for the use of the same old IEEE 802.3 MAC and 802.2 LLC framing for the LAN headers and trailers.
- A variety of cabling options is allowed—unshielded and shielded copper cabling as well as multimode and single-mode fiber.

Fast Ethernet (2)

Key features

1. higher bandwidth
2. auto negotiation, allows an Ethernet card or switch to negotiate dynamically to discover whether it should use either 10 or 100 Mbps

- many Ethernet cards and switch ports are called 10/100 cards or ports today because they can autonegotiate the speed.
- The endpoints autonegotiate whether to use half duplex or full duplex as well.
- If autonegotiation fails, it settles for half-duplex operation at 10 Mbps.

Fast Ethernet (3)

Recommendations

- for devices that rerely move, such as servers and switches, you should configure the LAN switch and the device to use the identical desired setting instead of depending of autonegotiation
- using autonegotiation for switch ports connected to end-user devices because these devices are moved frequently relative to servers or other network devices, such as routers.

Gigabit Ethernet

- The IEEE defines Gigabit Ethernet in standards 802.3z for optical cabling and 802.3ab for electrical cabling.
- Gigabit Ethernet retains many familiar features of slower Ethernet variants.
- CSMA/CD still is used and can be disabled for full-duplex support.
- uses of the same old IEEE 802.3 MAC and 802.2 LLC framing for the LAN headers and trailers
- The most likely place to use Gigabit is between switches, between switches and a router, and between a switch and a server.

Gigabit Ethernet (2)

- Gigabit Ethernet differs from the slower Ethernet specifications in how it encodes the signals onto the cable.
- Gigabit Ethernet is obviously faster, at 1000 Mbps, or 1 Gbps.

Ethernet Addressing

Terms:

- Ethernet LAN addressing identifies either individual devices or groups of devices on a LAN
- *Term unicast addresses, or individual addresses, is used because it identifies an individual* LAN interface card.
- While terms *broadcast, multicast, refers to a group addresses.*

Ethernet Addressing (2)

How dose it work?

- For instance, imagine that Fred and Barney are on the same Ethernet, and Fred sends Barney a frame.
- Fred puts his own Ethernet MAC address in the Ethernet header as the source address and uses Barney's Ethernet MAC address as the destination.
- When Barney receives the frame, he notices that the destination address is his own address, so Barney processes the frame.
- If Barney receives a frame with some other device's unicast address in the destination address field, Barney simply does not process the frame.

Ethernet Addressing (3)

IEEE standard MAC addresses:

- The IEEE requires globally unique unicast MAC addresses on all LAN interface cards.
- manufacturers encodes the MAC address onto the card, usually in a ROM chip.
- The first half of the address identifies the manufacturer of the card -*organizationally unique identifier (OUI)-.*
- the second half of the address being assigned a number that this manufacturer has never used on another card.

Ethernet Addressing (4)

Group addresses

- The IEEE defines two general categories of group addresses for Ethernet:

1. **Broadcast addresses** have a value of FFFF.FFFF.FFFF (hexadecimal notation). The broadcast address implies that all devices on the LAN should process the frame. Ethernet Data-Link Protocols
2. **Multicast addresses**—are used to allow a subset of devices on a LAN to communicate. Some applications need to communicate with multiple other devices.

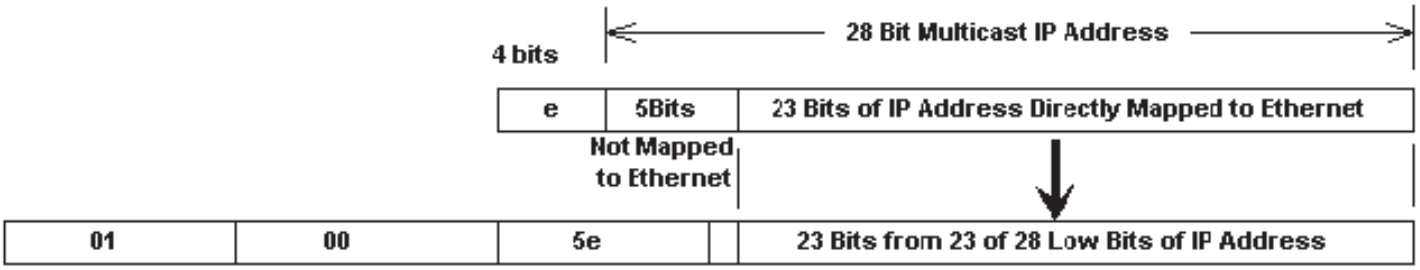
Ethernet Addressing (5)

- When we use a switch to connect hosts, multicast messages are actually forwarded to all hosts on the hub or the switch.
- As you should know, devices actually use MAC addresses to communicate on the local network segment.
- When the device on the local segment needs to send a multicast message, it will use a frame with a special MAC address.
- Special multicast addresses in the MAC address begin with 01-00-5E.
- The remaining portion of the MAC address is a modified format of the multicast IP address.

- When the switch receives the frame with the multicast MAC address, it will forward the frame out all ports to all connected devices.
- In this case, even devices that are not members of the original IP multicast group will see the frame.
- However, devices that don't belong to the IP multicast group will not process the frame since they will check the destination IP address

- An IP multicast address is in the range 224.0.0.0 through 239.255.255.255.
- In hexadecimal that is E0.00.00.00 to EF.FF.FF.FF. To be a multicast address, the first three bits of the most significant byte must be set and the fourth bit must be clear.
- In the IP address, there are 28 bits for multicasting.
- Therefore there are 5 multicasting bits that cannot be mapped into an Ethernet data packet.
- The 5 bits that are not mapped are the 5 most significant bits.

IP to Ethernet Multicast Address Mapping



- The 28 IP multicast bits are called the multicast group ID.
- A host group listening to a multicast can span multiple networks.

Ethernet Addressing (6)

Summary:

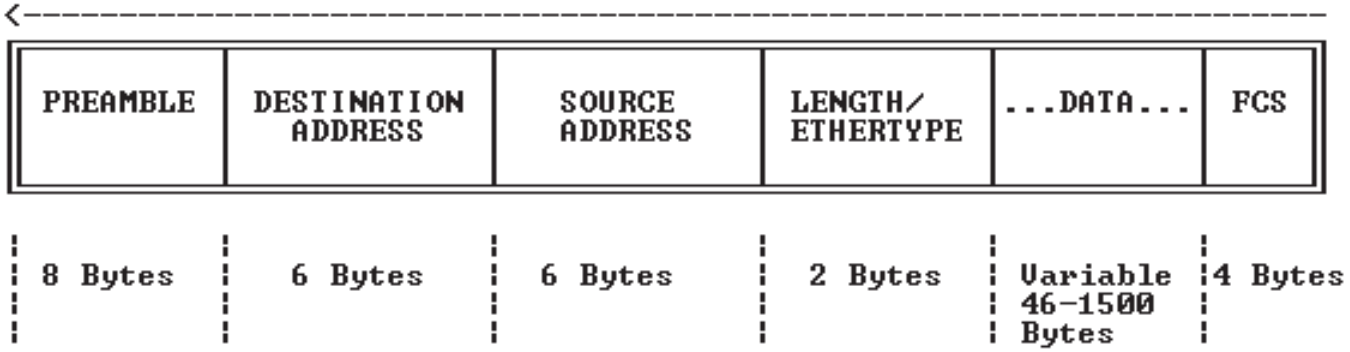
LAN MAC Address Terminology and Features

LAN Addressing Terms and Features	Description
MAC	Media Access Control. 802.3 (Ethernet) and 802.5 (Token Ring) are the MAC sublayers of these two LAN data-link protocols.
Ethernet address, NIC address, LAN address, Token Ring address, card address	Other names often used instead of MAC address. These terms describe the 6-byte address of the LAN interface card.
Burned-in address	The 6-byte address assigned by the vendor making the card. It usually is burned into a ROM or EEPROM on the LAN card and begins with a 3-byte organizationally unique identifier (OUI) assigned by the IEEE.
Unicast address	Fancy term for a MAC that represents a single LAN interface.
Broadcast address	An address that means "all devices that reside on this LAN right now."
Multicast address	Not valid on Token Ring. On Ethernet, a multicast address implies some subset of all devices currently on the LAN.

Ethernet Framing

Definition:

- Framing defines the meaning behind the bits that are transmitted across a network.
- Which refers to the definition of the fields assumed to be in the data that is received.



Ethernet Framing (2)

Real life example:

- For instance, if Fred is sending data to Barney over an Ethernet.
- Fred put Barney's Ethernet address in the Ethernet header so that Barney would know that the Ethernet frame was meant for Barney.
- The IEEE 802.3 standard defines the location of the destination address field inside the string of bits sent across the Ethernet .

Ethernet Framing (3)

Maximum transmission unit (MTU)

- The IEEE 802.3 specification limits the data portion of the 802.3 frame to a maximum of 1500 bytes.
- The Data field was designed to hold Layer 3 packets; the term *maximum transmission unit (MTU) defines the maximum Layer 3 packet that can be sent over a* medium.
- Because the Layer 3 packet rests inside the data portion of an Ethernet frame, 1500 bytes is the largest IP packet allowed over an Ethernet.

Ethernet Framing (4)

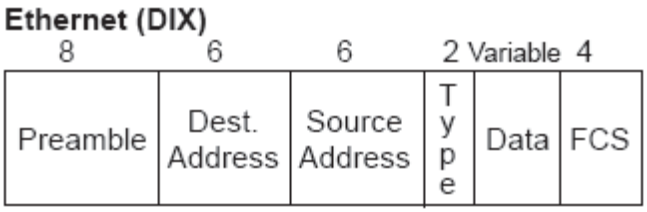
Identifying the Data Inside an Ethernet Frame

There are three type of Ethernet frame

1. Ethernet DIX (early version of Ethernet by DEC, IBM, and Xeoreox)
2. IEEE Ethernet 802.3
3. IEEE Ethernet with SNAP header (*Subnetwork Access Protocol*)

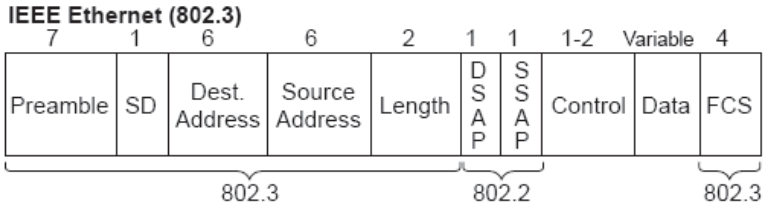
Ethernet Framing (5)

1. Ethernet DIX



Ethernet Framing (6)

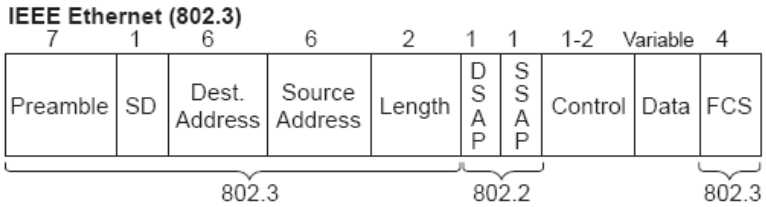
2. IEEE Ethernet (802.3)



Why?

- when the IEEE created 802.2 (Logical Link Control (LLC)), it saw the need for a protocol type field that identified what was inside the field called “data” in an IEEE Ethernet frame.
- The IEEE called its Type field the destination service access point (DSAP).

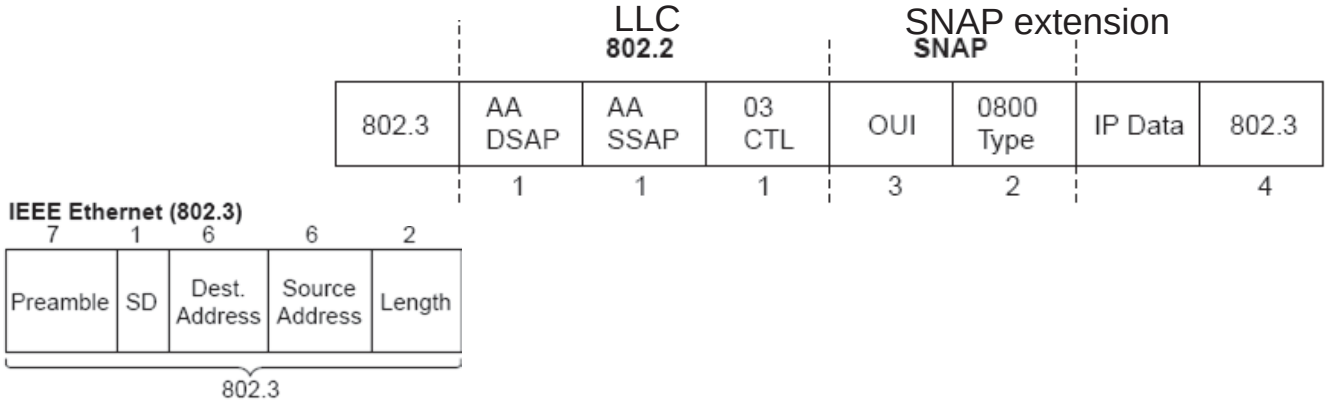
Ethernet Framing (7)



- When the IEEE first created the 802.2 standard, anyone with a little cash could register favorite protocols with the IEEE and receive a reserved value with which to identify those favorite protocols in the DSAP, and SSAP field.
- For instance, Novell registered IPX and was assigned hex E0 by the IEEE.
- However, the IEEE did not plan for a large number of protocols—and it was wrong.
- As it turns out, the 1-byte-long DSAP field is not big enough to number all the protocols.

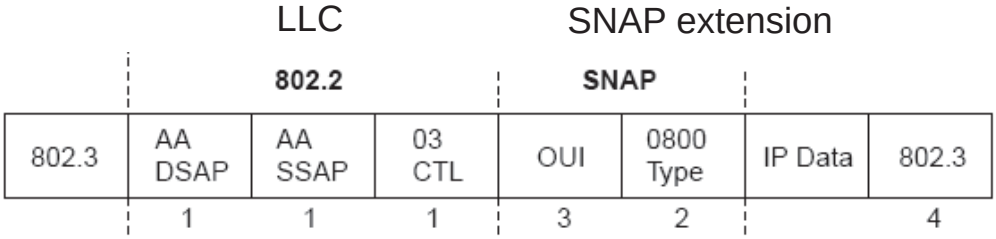
Ethernet Framing (8)

3. IEEE Ethernet with SNAP header



- To accommodate more protocols, the IEEE allowed the use of an extra header, called a *Subnetwork Access Protocol (SNAP) header*
- *OUI : IEEE Organizationally Unique Identifier*

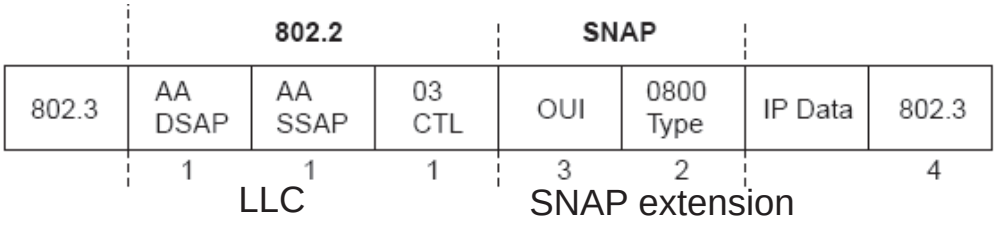
- To identify that type of header, the DSAP, & SSAP field is AA, which implies that a *SNAP header follows the 802.2 header, and the SNAP* header includes a 2-byte protocol type field.
- Which is used for the same purpose as the DSAP field, but because it is 2 bytes long, all the possible protocols can be identified.



IEEE802.2 Logical Link Control (LLC)

Ethernet Framing (9)

- For instance, in Figure, the SNAP type field has a value of 0800, signifying that the next header is an IP header



- IEEE Organizationally Unique Identifier (OUI) followed by a 2-octet protocol ID.
- If the OUI is hexadecimal 000000, the protocol ID is the Ethernet type (Ether Type)

Ethernet Framing (10)

Other Examples

- Some examples of values in the Ethernet Type and SNAP Protocol fields are 0800 for IP and 8137 for NetWare.
- Examples of IEEE SAP values are E0 for NetWare, 04 for SNA, and AA
- Interestingly, the IEEE does not have a reserved DSAP value for TCP/IP; SNAP headers must be used to support TCP/IP over IEEE Ethernet.

Ethernet Framing (11)

Headers summary:

Protocol Type Fields in LAN Headers

Field Name	Length	LAN Type
Ethernet Type	2 bytes	DIX Ethernet
802.2 DSAP and SSAP	1 byte each	IEEE Ethernet, IEEE Token Ring, ANSI FDDI
SNAP Protocol	2 bytes	IEEE Ethernet, IEEE Token Ring, ANSI FDDI

What is WAN?

- LAN standards and protocols define how a network between two devices operates, these devices are relatively close together.
- Team *local refers to LAN*
- WAN standards and protocols define how to network between devices that are relatively far apart—in some cases, even thousands of miles apart—
- Term *wide-area refers to WAN.*

What is WAN? (2)

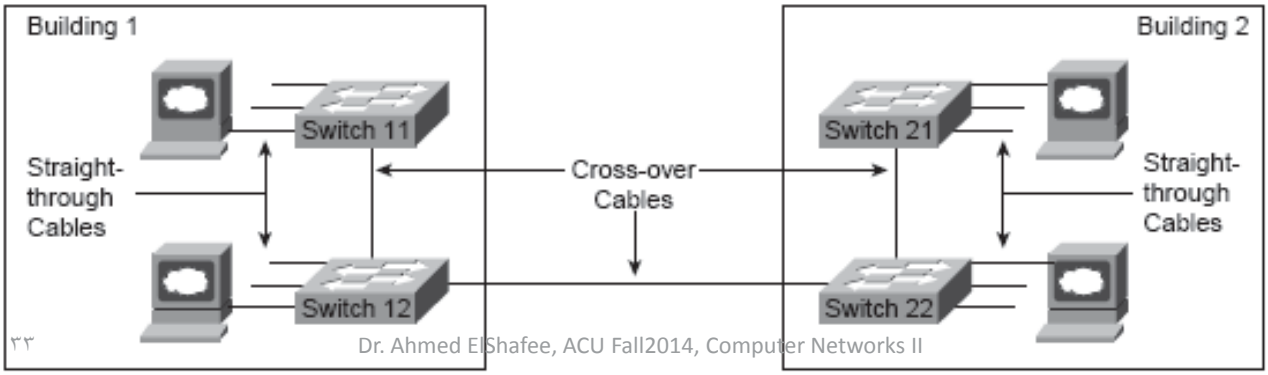
- LANs tend to reside in a single building or possibly among buildings in a campus using optical cabling approved for Ethernet.
- WAN connections typically run longer distances than Ethernet, across town or between cities.
- Often, only one or a few companies even have the rights to run cables under the ground between the sites.
- So, the people who created WAN standards needed to use different physical specifications than Ethernet to send data 1000 km or more (WAN).

What is MAN?

- Besides LANs and WANs, the term *metropolitan-area network (MAN) is* sometimes used for networks that extend between buildings and through rights-of-ways.
- The term typically implies a network that does not reach as far as a WAN, generally in a metropolitan area.

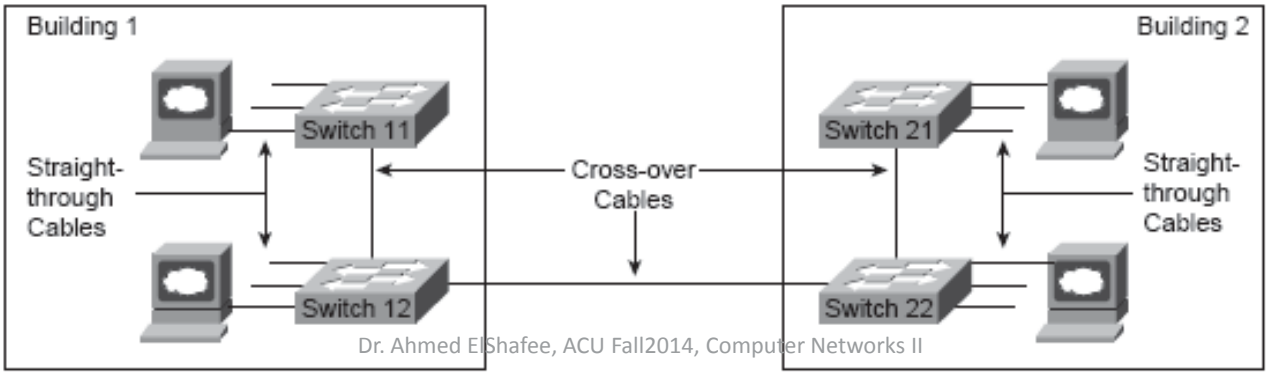
OSI layer1 of WAN

- The OSI physical layer defines the standards and protocols used to create the physical network and to send the bits across that network.
- A point-to-point WAN link acts like a trunk between two Ethernet switches in many ways.
- Below figure shows a LAN with two buildings and two switches in each building.



OSI layer1 of WAN (2)

- the trunk links between the switches uses Ethernet network layer protocol, which uses a twisted pair of wires to transmit and another twisted pair to receive, to reduce electromagnetic interference.



OSI layer1 of WAN (3)

- Now imagine that the buildings are 1000 KMs apart instead of right next to each other.
- You are immediately faced with two problems:

1. Ethernet does not support any type of cabling that allows an individual trunk to run for 1000 KMs
2. Even if Ethernet supported a 1000 KMs trunk, you do not have the rights of way needed to bury a cable over the 1000 KMs of real estate between buildings.

OSI layer1 of WAN (4)

- To create such long links, or circuits, the actual physical cabling is owned, installed, and managed by a company that has the right of way to run cables under streets.
- Because a company that needs to send data over the WAN circuit does not actually own the cable or line, it is called a *leased line.*
- *Companies that can provide leased WAN lines typically started* life as the local telephone company called “Telecom”
- In many countries, the telephone company is still a government-regulated or government-controlled monopoly

OSI layer1 of WAN (5)

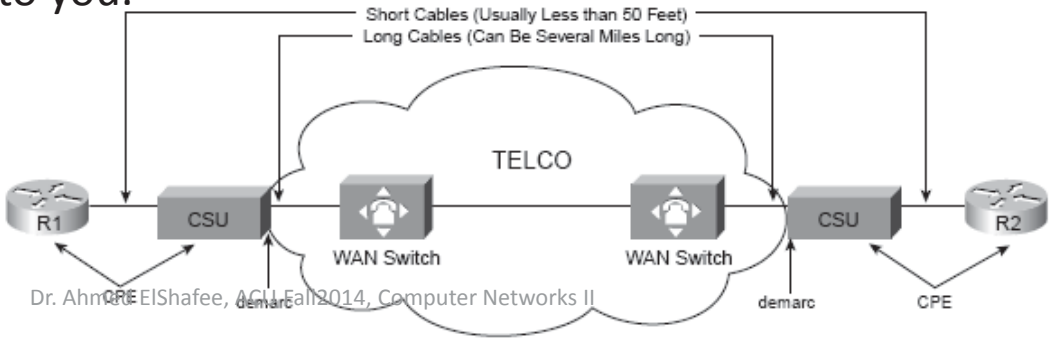
- Point-to-point WAN links provide basic connectivity between two points.
- It is similar to what you would have if you made a phone call between two sites but you never hung up.
- The two devices on either end of the WAN circuit could send and receive bits between each other any time they want, without needing to dial a phone number.
- It is called a *leased circuit or leased line because you have* the exclusive right to use that circuit, as long as you keep paying for it.

OSI layer1 of WAN (6)

WAN Connections from the Customer Viewpoint

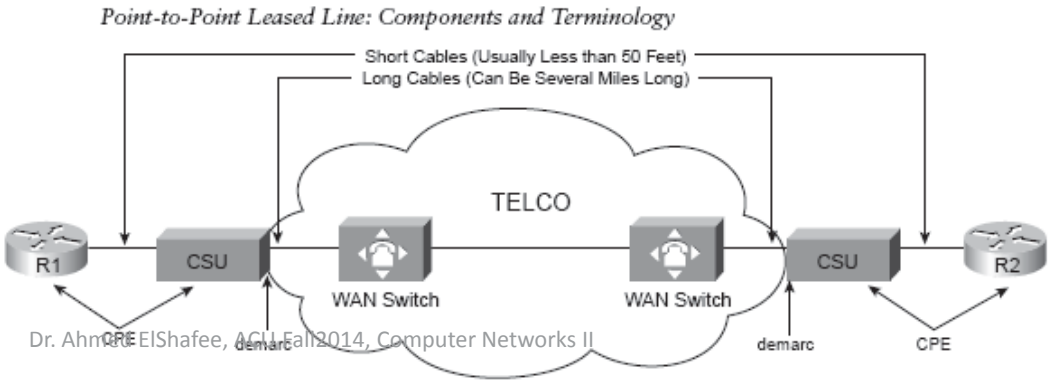
- Below figure presents WAN leased line acts as if the Telecom gave you two twisted pairs of wires between the two sites on each end of the line.
- Telecom has built a large network already and even runs extra cables from the local central office (CO) to your building.
- When you ask for leased line, it just dedicate some pre-installed line to you.

Point-to-Point Leased Line: Components and Terminology



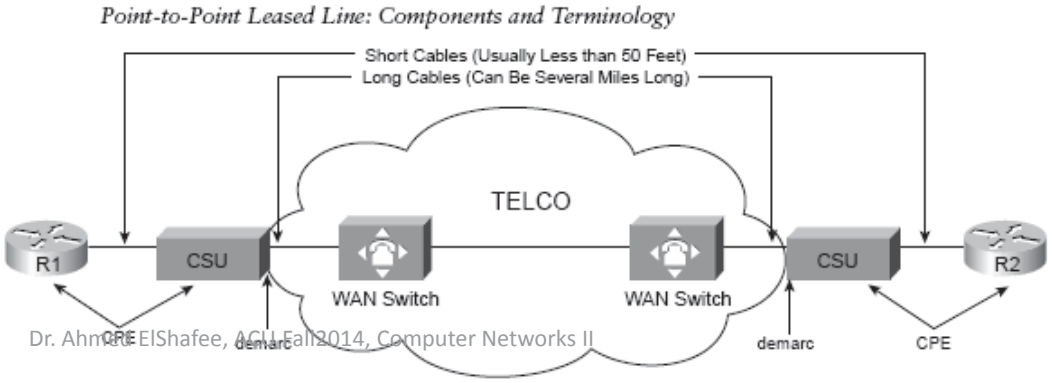
OSI layer1 of WAN (7)

- Typically routers are connected to Channel Service Unit or Digital Service Unit "CSU/DSU" using short cable.
- In other cases router comes with internally integrated CSU
- Router + CSU called CPE "*customer premises equipment*" which refers to equipment in customer side.



OSI layer1 of WAN (8)

- A direct line is connected from CSU to nearest CO connecting to WAN switch.
- The same happened in the other end.
- Between WAN switches, there may be different COs, and different WAN switches uses different technologies.



OSI layer1 of WAN (9)

WAN Cabling Standards

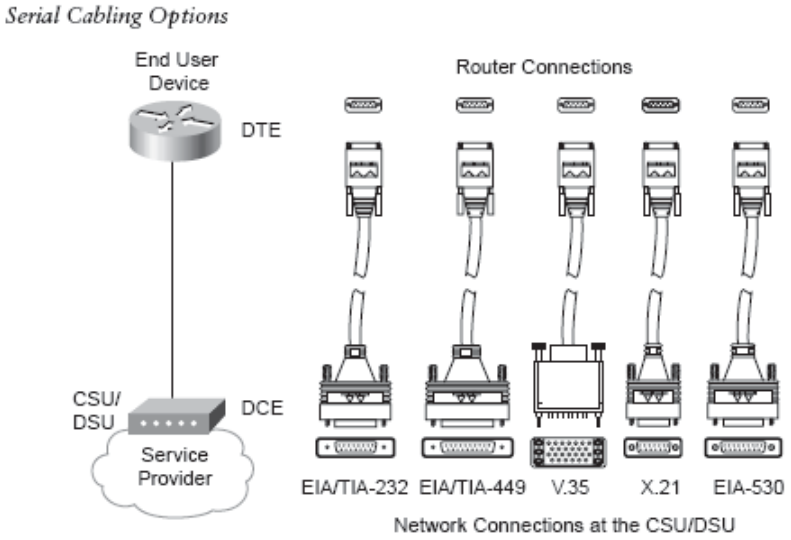
There are two type of WAN links (serial links)

- synchronous serial interfaces
- asynchronous serial interfaces

Most common serial WAN links are synchronous

OSI layer1 of WAN (10)

1. Router 2 CSU



WAN Interface Cable Standards

Standard Connectors (Into CSU/DSU)	Standards Body	Number of Pins on the Connector
EIA/TIA-232	TIA	25
EIA/TIA-449	TIA	37
EIA/TIA-530	TIA	25
V.35	ITU	34
X.21	ITU	15

OSI layer1 of WAN (11)

2. CSU to CO

- The cable between the CSU/DSU and the Telecom CO typically uses an RJ-48 connector to connect to the CSU/DSU;
- the RJ-48 connector has the same size and shape as the RJ-45 connector used for Ethernet cables.

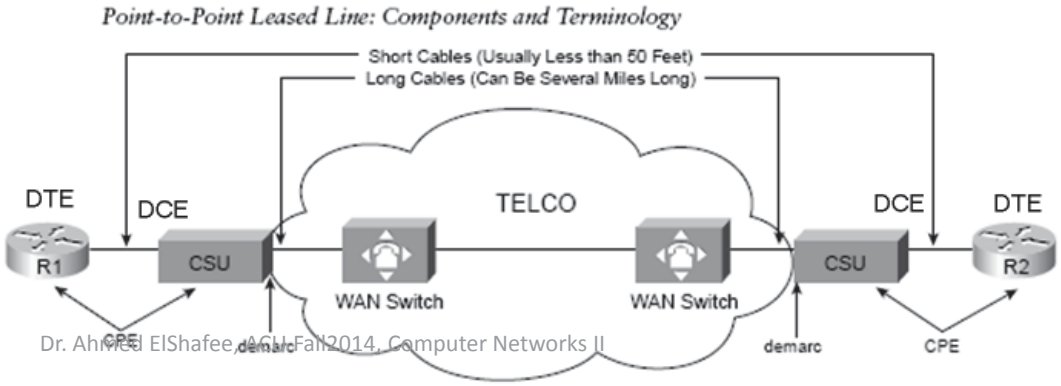
OSI layer1 of WAN (13)

Clock Rates, DCE, and DTE

- When a network engineer needs to add a point-to-point leased line between two routers, he contacts a service provider and orders the circuit.
- As part of that process, the customer specifies how fast the circuit should run, in kilobits per second (kbps).
- While the circuit is being set up by the Telecom, the engineer purchases two CSU/DSUs, installs one at each site, and configures each CSU/DSU.
- He also cables each router to the respective CSU/DSU using the cables shown in the previous section.
- Eventually, the Telecom installs the new line into the customer premises, and the line can be connected to the CSU/DSUs

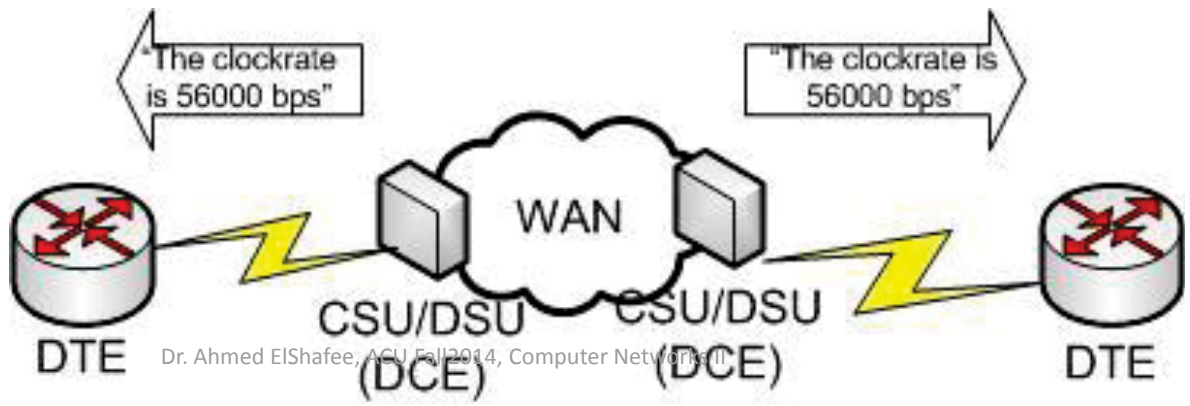
OSI layer1 of WAN (14)

- *clock rate, bandwidth, link speed* all refer to the same thing
- One of the most important isssue is that the two CSU/DSUs are configured to operate at that same speed.
- To do so, one device provides a clocking signal to the other device which simply react, sending and receiving data at the correct rate.



OSI layer1 of WAN (15)

- The device that provides clocking, typically the CSU, is considered to be the *data communications equipment (DCE).*
- The device receiving clocking, typically the router, is referred to as *data terminal equipment (DTE).*



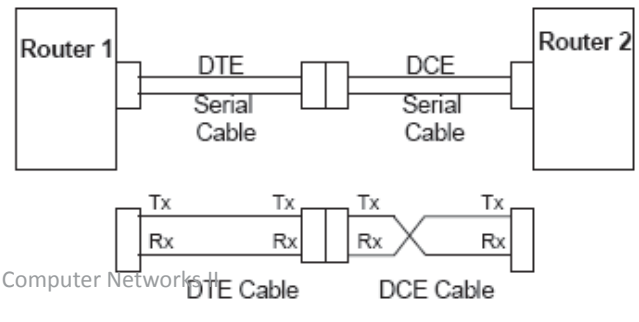
OSI layer1 of WAN (16)

- So when network engineer buys a serial cable for his router, he may buy
  - DCE cable if his router acts as DCE device
  - DTE cable if his router acts as DTE device (typical)

OSI layer1 of WAN (18)

Back-to-back serial link

- You can buy two routers, a DTE serial cable for one router, and a DCE serial cable for the other and connect the two cables together.
- The router with the DCE cable in it can be configured to provide clocking— meaning that you do not need a CSU/DSU. So, you can build a WAN in your network lab,(The DCE cable has a female connector, and the DTE has a male connector, so they can be connected.)



OSI layer1 of WAN (19)

- **Link Speeds Offered by Telecoms**
- So, years ago, the Telecoms of the world developed a standard for sending voice using digital transmissions.
- Digital signaling inside their networks allowed for the growth of more profitable data services, such as leased lines.
- They used Pulse Code Modulation
- PCM defines that an incoming analog voice signal should be sampled 8000 times per second, and each sample should be represented by an 8-bit code.
- So, 64,000 bits were needed to represent 1 second of voice.

OSI layer1 of WAN (20)

- So the baseline transmission speed was 64 kbps because that was the necessary bandwidth for a single voice call.
- The term *digital signal level 0 (DS0) refers to the standard for a single 64-kbps line.*
- Later the Telecoms starting selling data services—in other words, leased lines.
- The phone companies could sell a DS0 service at 64 kbps.
- Telecom decided to just sell 7 of every 8 bits that could be sent over a DS0—and 7/8 of 64 kbps is 56 kbps. (ECC)
- Today many Telecoms do not use that bit, so they can offer the full 64-kbps channel.

OSI layer1 of WAN (21)

- Then Telecom starts duplicating DS0 to offer wider band width

WAN Speed Summary

Type of Line	Name of Signalling Type	Bit Rate
56	DS0*	56 kbps
64	DS0	64 kbps
T1	DS1	1.544 Mbps (24 DS0s, plus 8 kbps overhead
T3	DS3	44.736 Mbps (28 DS1s, plus management overhead)
E1	ZM	2.048 Mbps (32 DS0s)
E3	M3	34.064 Mbps (16 E1s, plus management overhead)
J1	Y1	2.048 Mbps (32 DS0s; Japanese standard)

*DS0, with 1 robbed bit out of 8

OSI Layer 2 of WANs

- WAN protocols used on point-to-point serial links provide the basic function of data delivery across that one link.
- The two most popular data-link protocols used on point-to-point links are
  - High-Level Data Link Control (HDLC) and
  - Point-to-Point Protocol (PPP).

OSI Layer 2 of WANs (2)

1. HDLC

HDLC performs OSI Layer 2 functions,

- **Arbitration—**Determines when it is appropriate to use the physical medium
- **Addressing—**Ensures that the correct recipient(s) receives and processes the data that is sent
- **Error detection—**Determines whether the data made the trip across the physical medium successfully
- **Identifying the encapsulated data—**Determines the type of header that follows the datalink header

OSI Layer 2 of WANs (3)

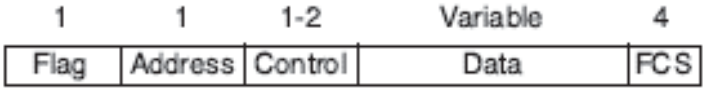
1. Arbitration

- HDLC is very simple as compared with Ethernet
- Ethernet uses CSMA/CD algorithm arbitrates
- point-to-point serial link, each router can send over the four-wire (two-pair) circuit at any time, so there is no need for any kind of a arbitration.

OSI Layer 2 of WANs (4)

- HDLC defines framing that includes an
  1. address field,
  2. frame check sequence (FCS) field,
  3. And a protocol type field.
- These three fields in the HDLC frame help provide the other three functions of the data link layer.

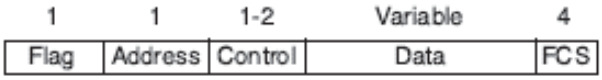
HDLC Framing



OSI Layer 2 of WANs (5)

2. Addressing

HDLC Framing



- HDLC defines a 1-byte address field, although on point-to-point links, it is not really needed.
- In the past HDLC was used for a multidrop circuit.
- With a multidrop circuit, one central site device could send and receive frames with multiple remote sites.
- HDLC defined the address field to identify the different remote sites on a multidrop link.
- Now HDLC used for point to point links so address is not used, routers insert decimal 3 into address field.

OSI Layer 2 of WANs (6)

3. Error Detection

- HDLC performs error detection just like Ethernet—it uses an FCS field in the HDLC trailer. And just like Ethernet, if a received frame has errors in it, the frame is discarded, with no error recovery performed by HDLC.

4. Identifying the encapsulated data

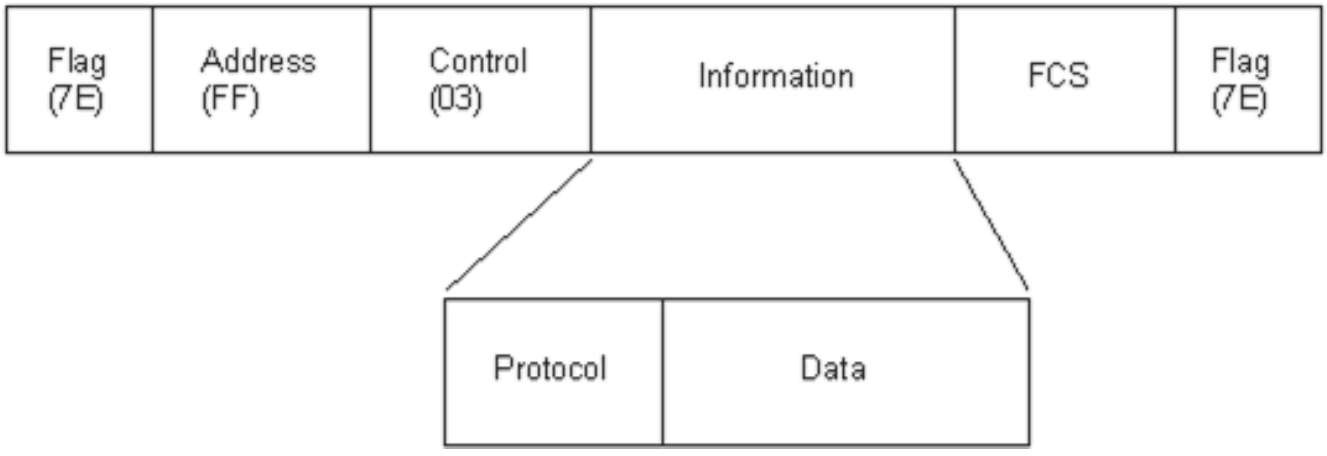
- HDLC performs the function of identifying the encapsulated data just like Ethernet as well.
- When a router receives an HDLC frame, it wants to know what type of packet is held inside the frame.

OSI Layer 2 of WANs (7)

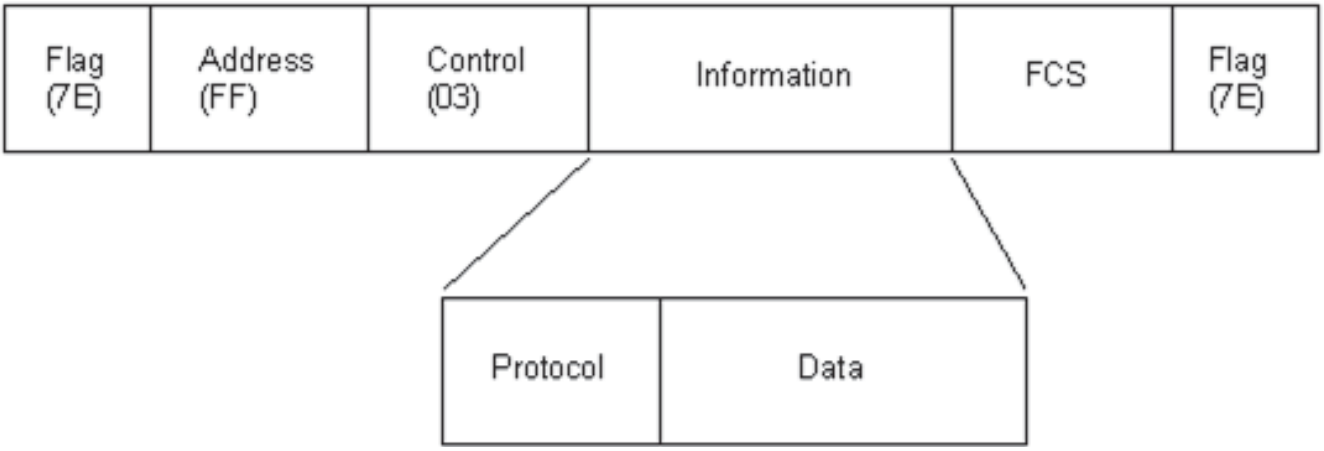
2. Point-to-Point Protocol

Comparing the basics, PPP behaves exactly like HDLC

1. There is an address field, but the addressing does not matter.



2. PPP does discard errored frames that do not pass the FCS check.
3. And PPP uses a 2-byte Protocol Type field—although PPP's Protocol Type field is defined by the protocol



OSI Layer 2 of WANs (8)

- PPP-unique features fall into two main categories:

1. Those needed regardless of the Layer 3 protocol sent across the link
2. Those specific to each Layer 3 protocol

- Each link that uses PPP has one LCP (link control protocol) per link and one CP (control protocol) for each Layer 3 protocol defined on the link.

OSI Layer 2 of WANs (9)

Link Control Protocol (LCP),

- focuses on the features that apply regardless of the Layer 3 protocol used.
- LCP performs most of its work when the line comes up, so it has a lot more work to do with dialed links, which come up and down a lot, versus leased lines, which hopefully seldom fail.

OSI Layer 2 of WANs (10)

PPP LCP Features

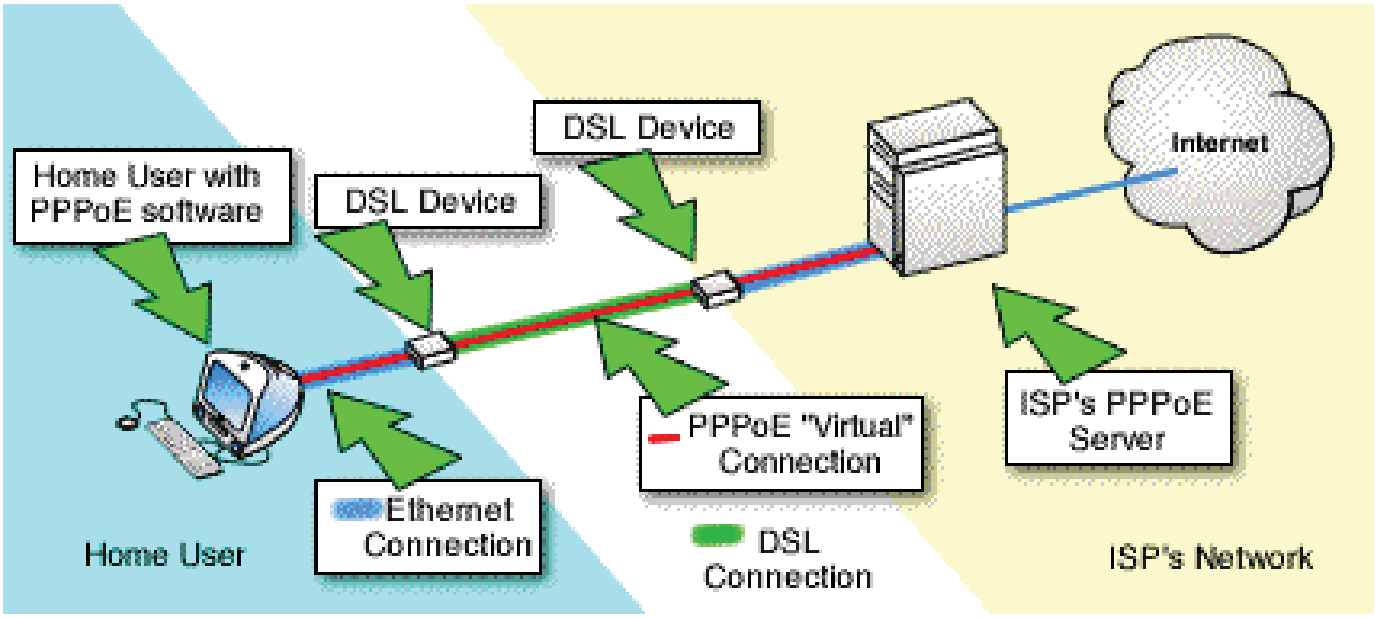
Function	LCP Feature	Description
Error detection	Link quality monitoring (LQM)	PPP can take down a link based on the percentage of errors on the link using LQM.
Looped link detection	Magic number	The telco might reflect the data that a router sends it back to the router, to test a circuit. PPP uses a feature called magic numbers to detect a looped link and takes down the link.
Multilink support	Multilink PPP	This allows multiple parallel serial links to be connected between the same two routers, balancing traffic across the links.
Authentication	PAP and CHAP	Particularly useful for dial-up links, PPP initiates an authentication process to verify the identity of the device on the other end of the serial link.

OSI Layer 2 of WANs (11)

IP Control Protocol (IPCP) (type of LC)

- provides for IP address assignment over a PPP link.
- When a user dials a new connection to an ISP using a modem, PPP typically is used, with IPCP assigning an IP address to the remote PC.

- If a router is configured for IPX, AppleTalk, and IP on a PPP serial link, the router configured for PPP encapsulation automatically tries to bring up the appropriate controlprotocols for each Layer 3 protocol.



OSI Layer 2 of WANs (12)

3. Other Point-to-Point WAN Data-Link Protocols

- WAN data-link protocols can be compared relative to two main attributes.

1. First, some protocols do support multiprotocol traffic by virtue of having a defined protocol type field.
2. Also, some protocols actually perform error recovery—so when the receiving end notices that the received frame did not pass the FCS check, it causes the frame to be resent.

OSI Layer 2 of WANs (13)

List of WAN Data-Link Protocols

Protocol	Error Correction?	Type Field?	Other Attributes
Synchronous Data Link Control (SDLC)	Yes	No	SDLC supports multipoint links. It assumes that an SNA header occurs after the SDLC header.
Link Access Procedure Balanced (LAPB)	Yes	No*	LAPB is used mainly with X.25.
Link Access Procedure on the D Channel (LAPD)	No	No	LAPD is used by ISDN lines for signaling to set up and bring down circuits.
Link Access Procedure for Frame Mode Bearer Services(LAPF)	No	Yes	This is a data-link protocol used over Frame Relay links.
High-Level Data Link Control (HDLC)	No	No*	HDLC serves o
Point-to-Point Protocol (PPP)	Supported but not enabled by default	Yes	PPP was meant for multiprotocol interoperability from its inception, unlike all the others.

OSI Layer 2 of WANs (14)

- **Synchronization**
- Both of HDLC and PPP are synchronous.
- Synchronous means sending and receiving ends uses the same clock.
- it is expensive to build devices that truly can operate at exactly the same speed.
- So, the devices operate at close to the same speed and listen to the speed of the other device on the other side of the link.
- One side makes small adjustments in its rate to match the other side.

WAN Terminology

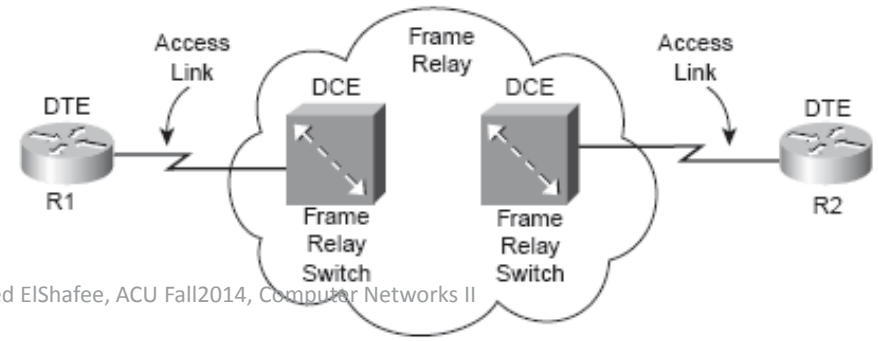
Term	Definition
Synchronous	The imposition of time ordering on a bit stream. Practically, a device tries to use the same speed as another device on the other end of a serial link. However, by examining transitions between voltage states on the link, the device can notice slight variations in the speed on each end and can adjust its speed accordingly.
Asynchronous	The lack of an imposed time ordering on a bit stream. Practically, both sides agree to the same speed, but there is no check or adjustment of the rates if they are slightly different. However, because only 1 byte per transfer is sent, slight differences in clock speed are not an issue. A start bit is used to signal the beginning of a byte.
Clock source	The device to which the other devices on the link adjust their speed when using synchronous links.
DSU/CSU	Data service unit/channel service unit. Used on digital links as an interface to the telephone company in the United States. Routers typically use a short cable from a serial interface to a DSU/CSU, which is attached to the line from the telco with a similar configuration at the other router on the other end of the link.
Telco	Telephone company.
Four-wire circuit	A line from the telco with four wires, comprised of two twisted-pair wires. Each pair is used to send in one direction, so a four-wire circuit allows full-duplex communication.
T1	A line from the telco that allows transmission of data at 1.544 Mbps.
E1	Similar to a T1, but used in Europe. It uses a rate of 2.048 Mbps and 32 64-kbps channels.

OSI Layer 2 of WANs (16)

Frame Relay

- Frame Relay networks are multi-access networks, which means that more than two devices can attach to the network, similar to LANs.
- To support more than two devices, the protocols must be a little more detailed.

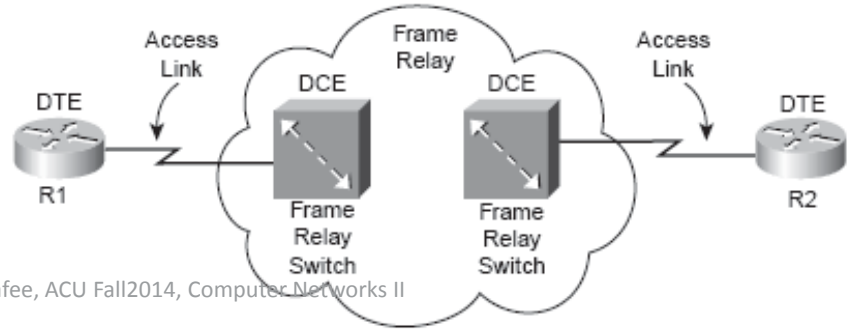
Frame Relay Components



OSI Layer 2 of WANs (17)

- Frame Relay uses the same Layer 1 features as a point-to-point leased line.
- For a Frame Relay services, a leased line is installed between each router and a nearby Frame Relay switch; these links are called *access links.*
- The access links run the same speeds and use the same signaling standards as do point-to-point leased lines.

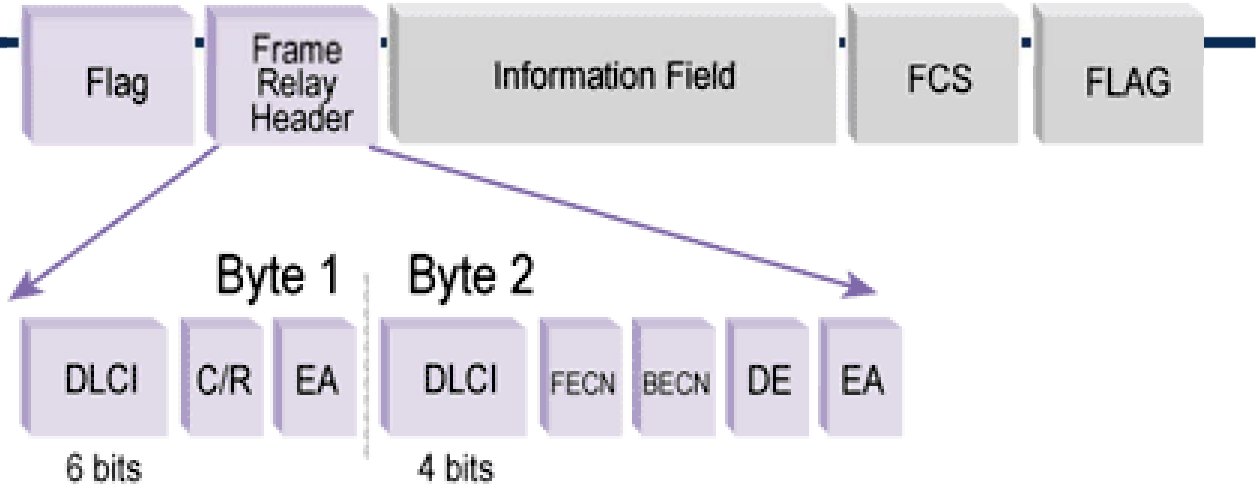
Frame Relay Components



OSI Layer 2 of WANs (18)

- Each frame header holds an address field called a data-link connection identifier (DLCI).
- The WAN switch forwards the frame, based on the DLCI, through the provider's network until it gets to the router on the other side of the network.
- so that it's called packet switching service, and that's the main difference between point2point and frame relay.

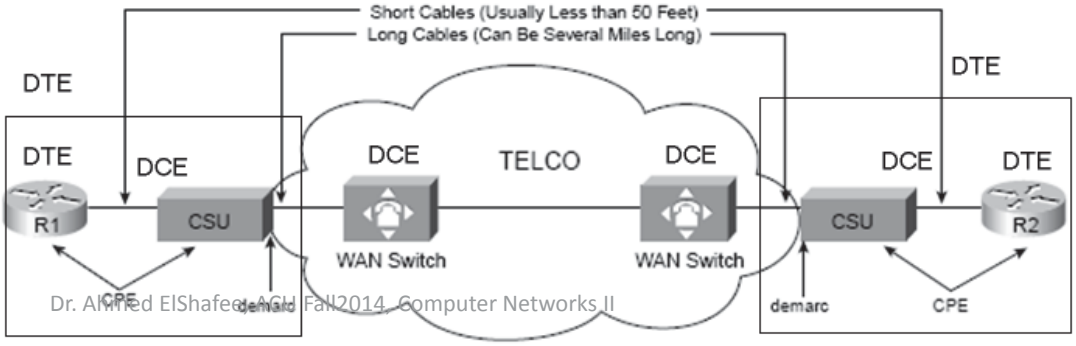
-



DLCI: Data link connection identifier
C/R: Command/response field bit
FECN: Forward explicit congestion notification
BECN: Backward explicit congestion notification
DE: Discard eligibility indicator
EA: Address extension bit (allows 3- or 4-byte header)

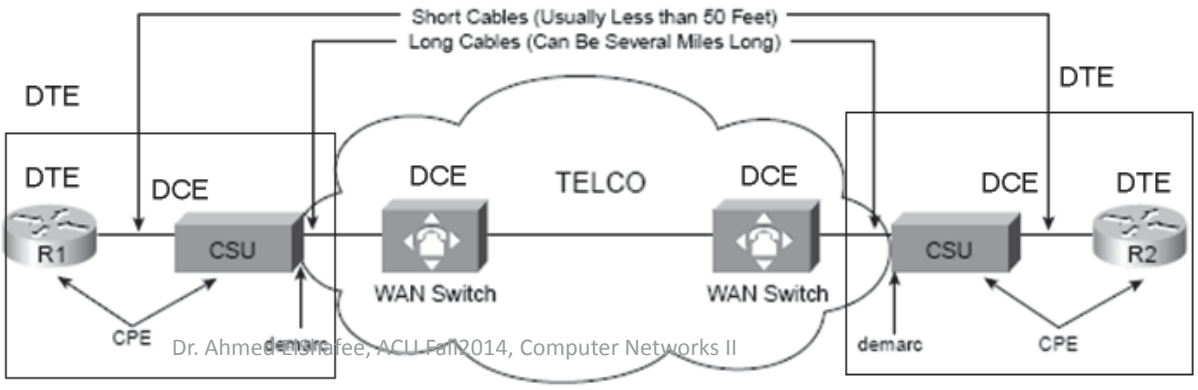
OSI Layer 2 of WANs (19)

- Frame Relay protocols resemble OSI Layer 2 protocols; the term usually used for the bits sent by a Layer 2 device is *frame*
- the Frame Relay switches are called DCE, and the customer equipment—routers, in this case—are called DTE
- *DCE refers to the device providing the service, and the term DTE refers to the device* needing the frame-switching service.



OSI Layer 2 of WANs (20)

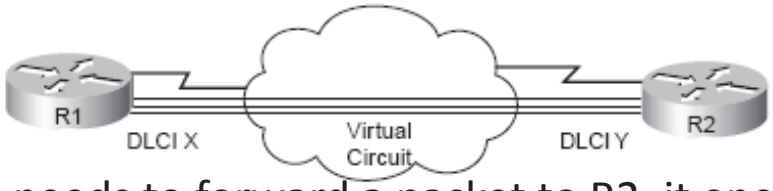
- At the same time, the CSU/DSU provides clocking to the router, so from a Layer 1 perspective, the CSU/DSU is still the DCE and the router is still the DTE.
- It's just two different uses of the same terms.



OSI Layer 2 of WANs (21)

- The logical path between each pair of routers is called a Frame Relay *permanent virtual circuits (PVCs).*

Frame Relay PVC Concepts

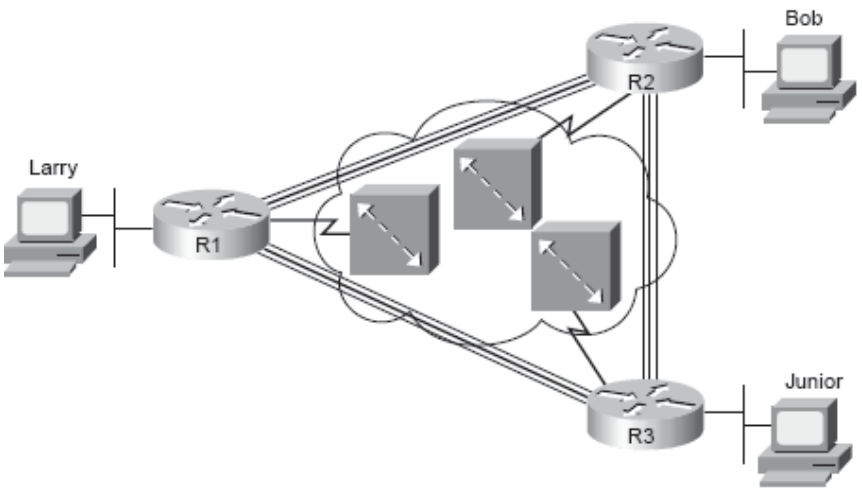


- When R1 needs to forward a packet to R2, it encapsulates the Layer 3 packet into a Frame Relay header and trailer and then sends the frame.
- R1 uses a Frame Relay address called a DLCI in the Frame Relay header.

OSI Layer 2 of WANs (22)

- Permanent virtual circuit (PVC) is the main feature of frame relay over p2p
- Figure shows connecting 3 sites using 3 leased lines and 3 frame relay switches

Typical Frame Relay Network with Three Sites



OSI Layer 2 of WANs (23)

- In the example, both VCs terminating at R1 use the same access link.
- So, with large networks with many WAN sites that need to connect to a central location, only one physical access link is required from the main site router to the Frame Relay network.
- If point-to-point links were used, a physical circuit, a separate CSU/DSU, and a separate physical interface on the router would be required for each point-to-point link.
- So, Frame Relay enables you to expand the WAN but add less hardware to do so.

OSI Layer 2 of WANs (24)

- Frame Relay is designed with the concept of a *committed information rate (CIR).*
- *Each VC has a CIR, which is a guarantee by the provider* that a particular VC gets at least that much bandwidth.
- You can think of CIR of a VC like the bandwidth or clock rate of a point-to-point circuit, except that it's the minimum value—you can actually send more, in most cases.


Thanks,..
See you next week (ISA),…