Lecture (06)
Network Access layer fundamentals III LAN, & WAN
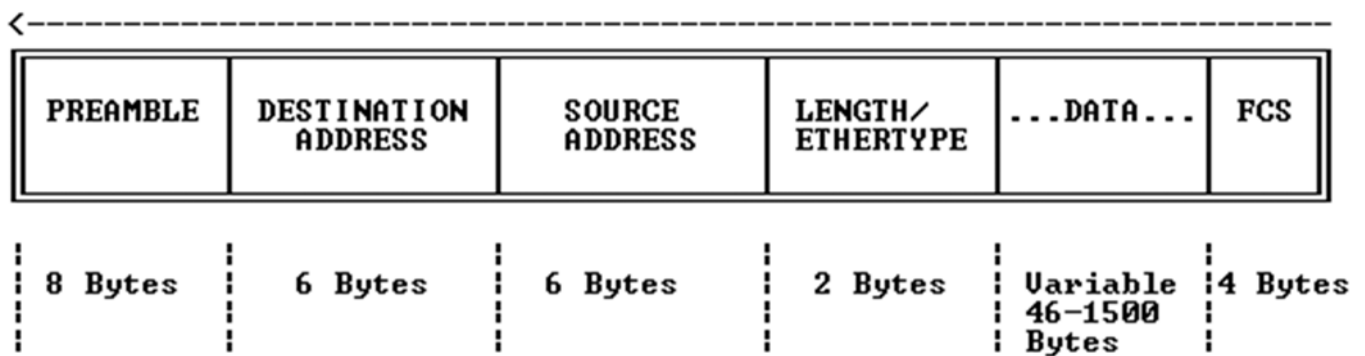
By:

Dr. Ahmed ElShafee

Agenda

- Ethernet Framing
- What is WAN?
- What is MAN?

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.

PREAMBLE	DESTINATION ADDRESS	SOURCE ADDRESS	LENGTH/ ETHERTYPE	...DATA...	FCS
8 Bytes	6 Bytes	6 Bytes	2 Bytes	Variable 46-1500 Bytes	4 Bytes

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
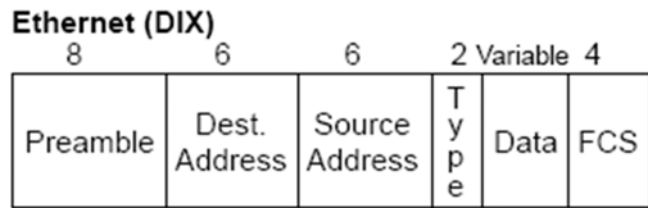
There are three type of Ethernet frame

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 (DIX)

8	6	6	2	Variable	4
Preamble	Dest. Address	Source Address	Type	Data	FCS

Ethernet Framing (6)

2. IEEE Ethernet (802.3)

IEEE Ethernet (802.3)

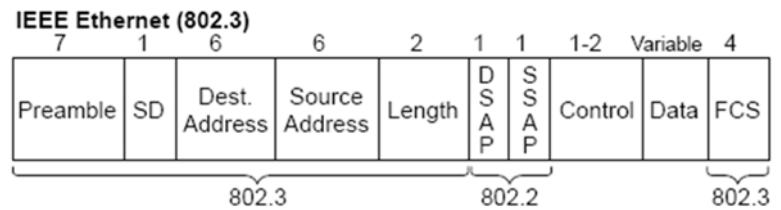| 7	1	6	6	2	1	1	1-2	Variable	4
Preamble	SD	Dest. Address	Source Address	Length	DSAP	SSAP	Control	Data	FCS

802.3   802.2   802.3
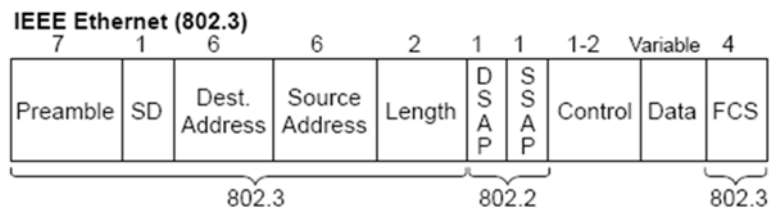
Why?

- 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 <u>destination service access point</u> (DSAP).

Ethernet Framing (7)

IEEE Ethernet (802.3)

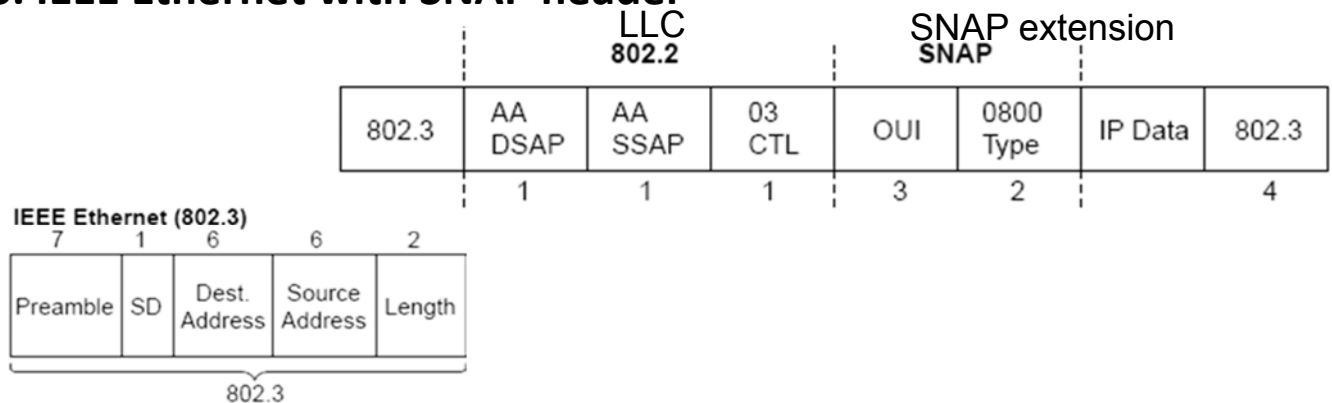| 7	1	6	6	2	1	1	1-2	Variable	4
Preamble	SD	Dest. Address	Source Address	Length	D S A P	S S A P	Control	Data	FCS

802.3 ← → 802.2 ← → 802.3

- 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 <u>DSAP</u>, and <u>SSAP</u> field.

- For instance, <u>Novell</u> registered <u>IPX</u> and was assigned hex <u>E0</u> by the IEEE.

- However, the IEEE did not plan for a large number of protocols—and it was wrong.

- As it turns out, the <u>1-byte-long DSAP</u> field is not big enough to number all the protocols.

Ethernet Framing (8)

3. IEEE Ethernet with SNAP header

	LLC 802.2			SNAP extension SNAP			
802.3	AA DSAP	AA SSAP	03 CTL	OUI	0800 Type	IP Data	802.3
	1	1	1	3	2		4

IEEE Ethernet (802.3)

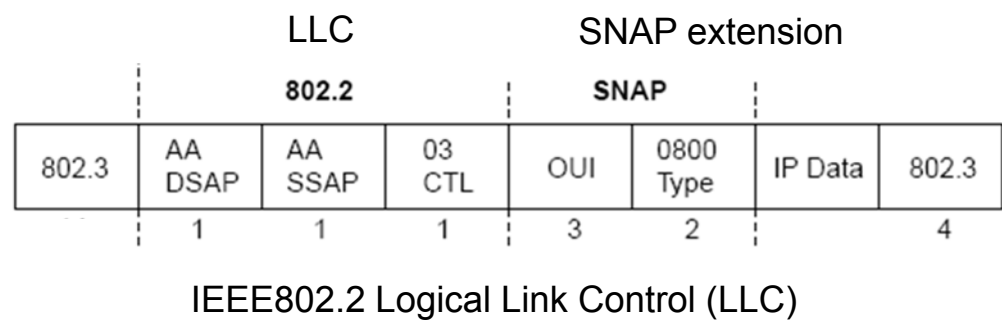| 7	1	6	6	2
Preamble	SD	Dest. Address	Source Address	Length

802.3

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

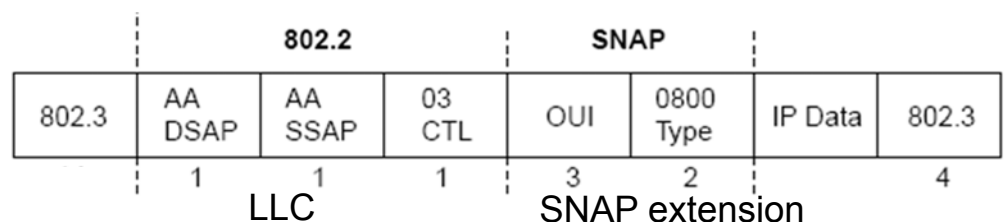- *OUI : IEEE Organizationally Unique Identifier*

- 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.

LLC   SNAP extension

802.3	AA DSAP	AA SSAP	03 CTL	OUI	0800 Type	IP Data	802.3
	1	1	1	3	2		4

802.2 — SNAP

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

802.3	AA DSAP	AA SSAP	03 CTL	OUI	0800 Type	IP Data	802.3
	1	1	1	3	2		4

802.2 — SNAP

LLC   SNAP extension

- 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,

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.*

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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).

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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.
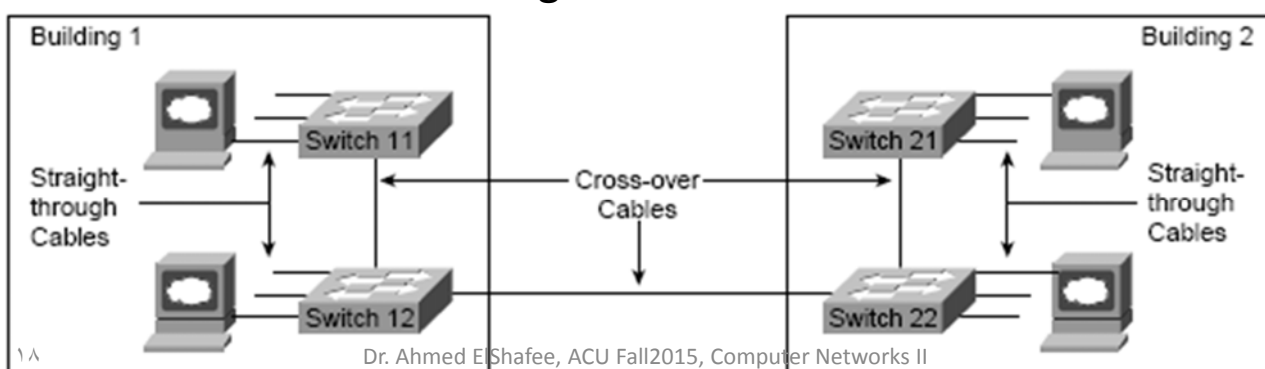
OSI layer1 of WAN

- 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.

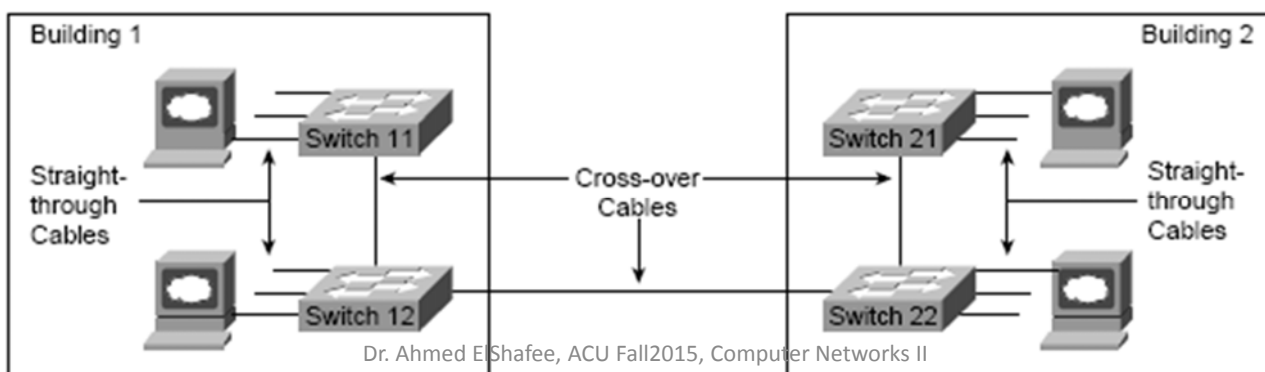- Below figure shows a LAN with two buildings and two switches in each building.

Building 1 | Switch 11 | Straight-through Cables | Cross-over Cables | Switch 21 | Straight-through Cables | Building 2

Switch 12 | Switch 22

OSI layer1 of WAN (2)

Cross-over Cable Conceptual View

- 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.

Building 1

Switch 11

Straight-through Cables

Cross-over Cables

Switch 12

Building 2

Switch 21

Straight-through Cables

Switch 22

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
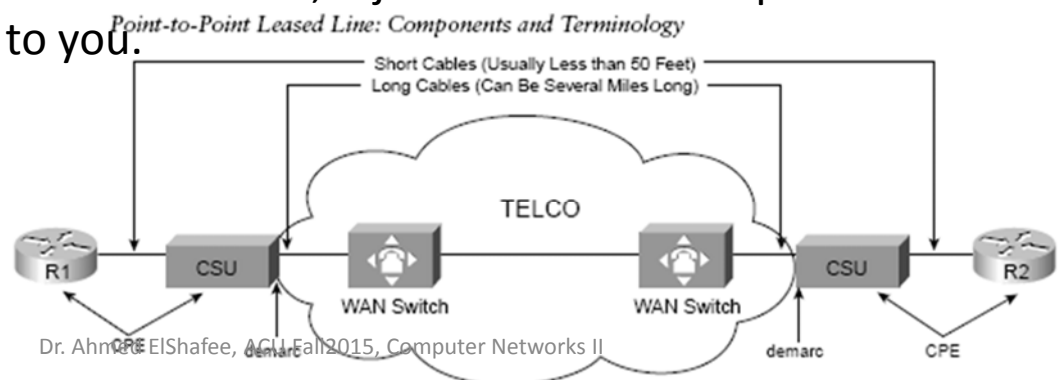
OSI layer1 of WAN (5)

- 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.
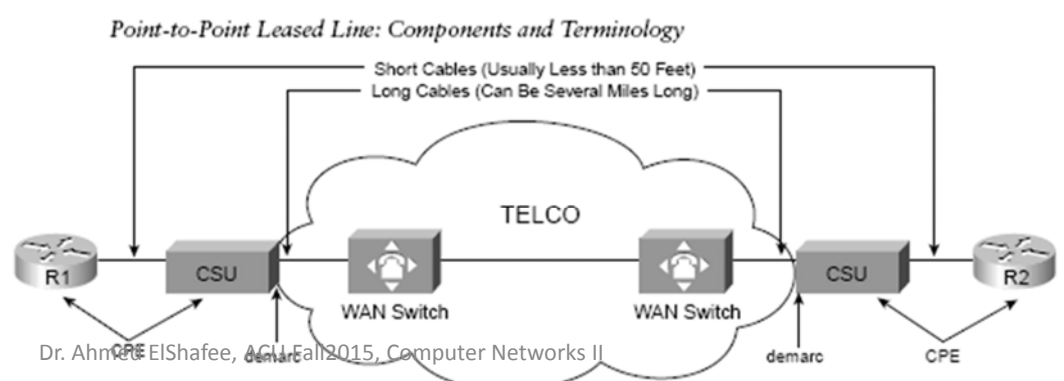
OSI layer1 of WAN (6)

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.

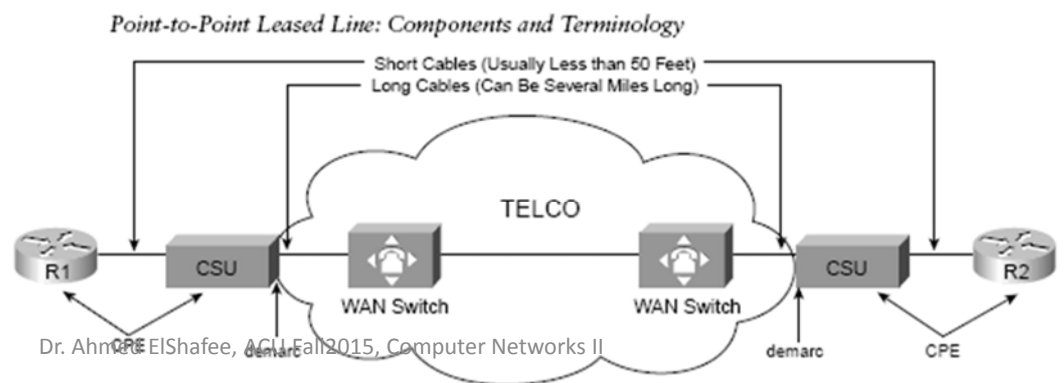- When you ask for leased line, it just dedicate some pre-installed line to you.

Point-to-Point Leased Line: Components and Terminology

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OSI layer1 of WAN (7)

- Typically routers are connected to <u>Channel Service Unit or Digital Service Unit "CSU/DSU"</u> using short cable.

- In other cases router comes with internally integrated CSU

- Router + CSU called <u>CPE</u> "*customer premises equipment"* which refers to equipment in customer side.

Point-to-Point Leased Line: Components and Terminology

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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.

Point-to-Point Leased Line: Components and Terminology

Short Cables (Usually Less than 50 Feet)
Long Cables (Can Be Several Miles Long)

TELCO

R1   CSU   WAN Switch   WAN Switch   CSU   R2

CPE   demarc   demarc   CPE

OSI layer1 of WAN (9)

WAN Cabling Standards

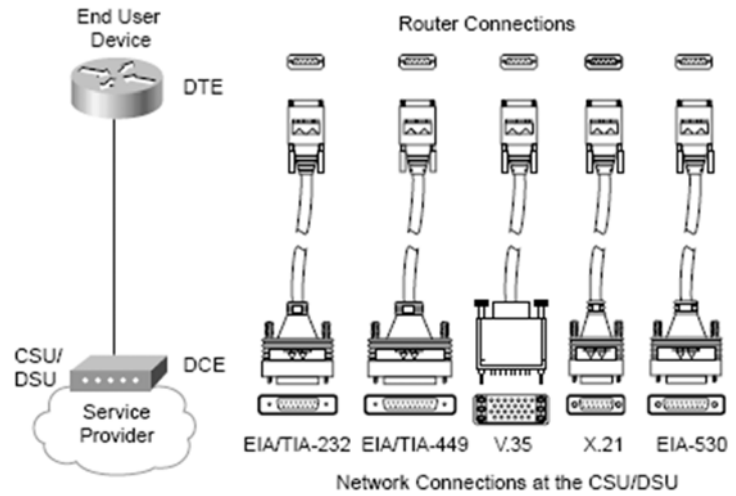There are two type of WAN links (serial links)

- synchronous serial interfaces

- asynchronous serial interfaces

Most common serial WAN links are synchronous

OSI layer1 of WAN (10)

1. Router 2 CSU

Serial Cabling Options

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

WAN Interface Cable Standards

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.

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

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- *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.


Point-to-Point Leased Line: Components and Terminology
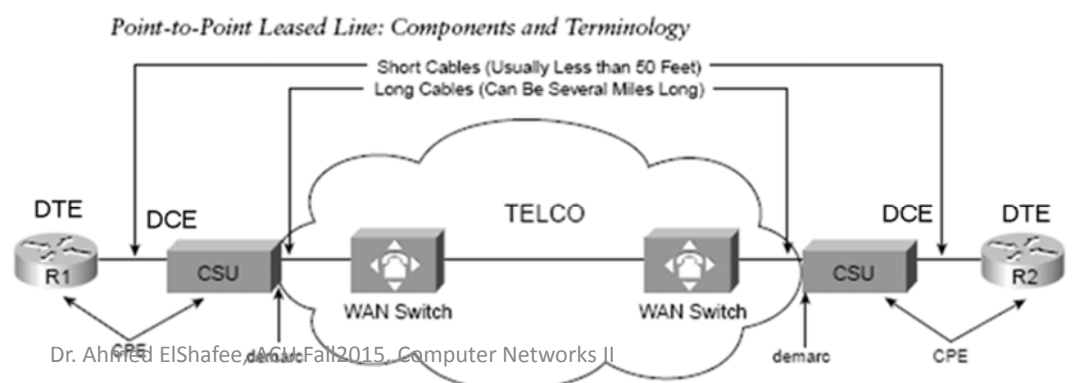
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OSI layer1 of WAN (15)

- 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)*.

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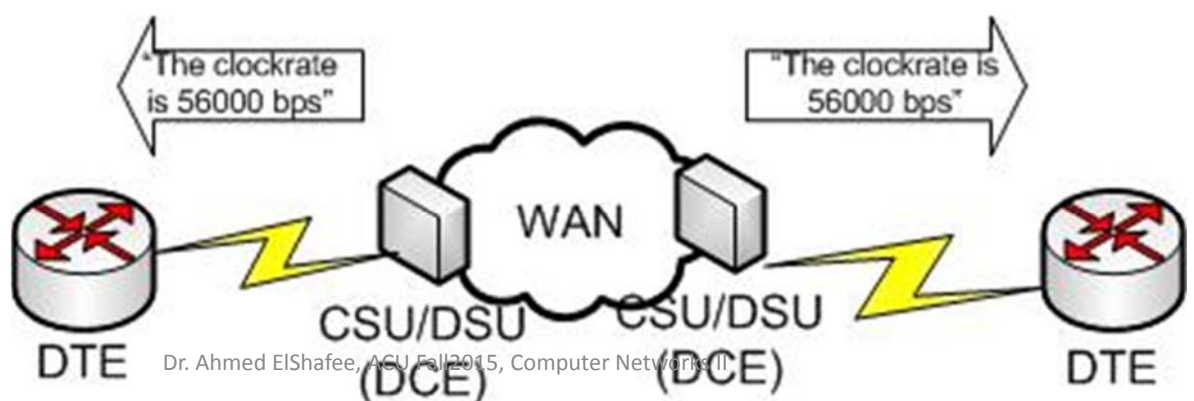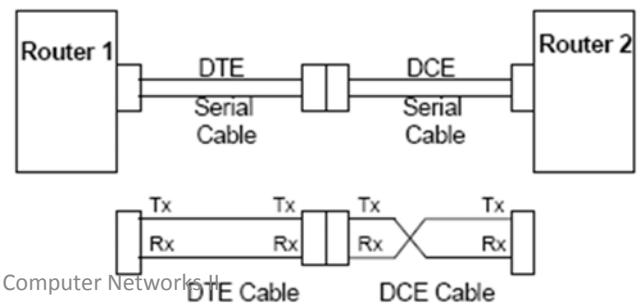

OSI layer1 of WAN (16)

- 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)

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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.)

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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.

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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.

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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

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Thanks,..

See you next week (ISA),...