



Lecture (07)

Fundamentals of WANs (I)

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Agenda

- What is WAN?
- What is MAN?
- OSI layer1 of WANs
- Circuit switching services
- Packet-Switching Services

What is WAN?

- LAN standards and protocols define how a network between two devices operates, these devices are relatively close together.
- Term *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?

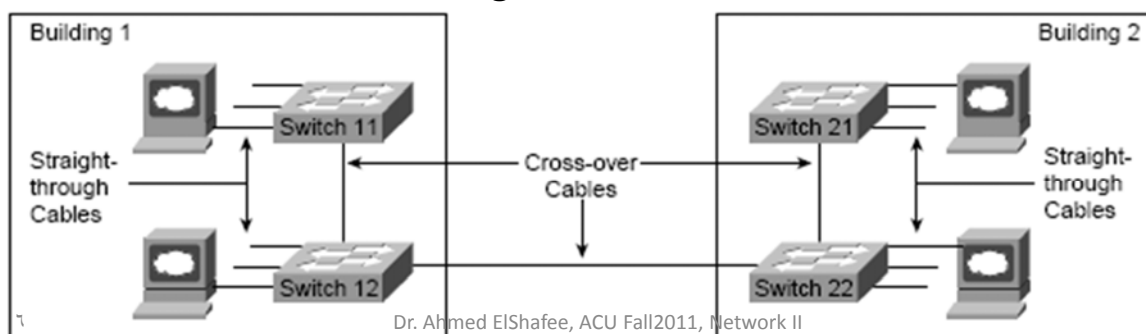
- Besides LANs and WANs, the term *metropolitan-area network (MAN)* is sometimes used for networks that extend between buildings and through rights-of-ways.
- The term typically implies a network that does not reach as far as a WAN, generally in a metropolitan area.
- The distinctions between LANs, MANs, and WANs are not sharp—there is no set distance that means a link is a LAN, MAN, or WAN link.



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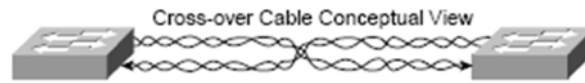
OSI layer1 of WAN

- 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.

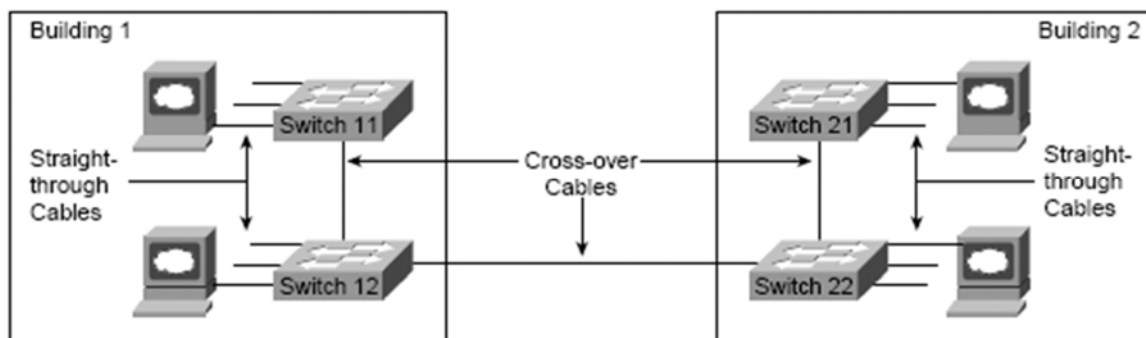


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OSI layer1 of WAN (2)



- 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 “Telco”*
- In many countries, the telephone company is still a government-regulated or government-controlled monopoly

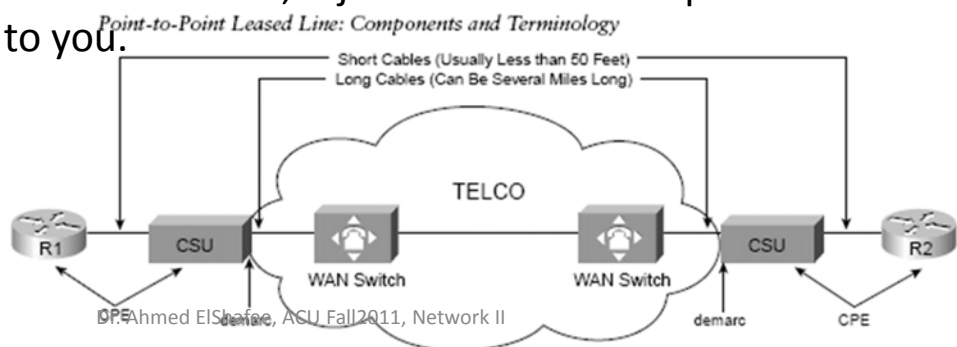
OSI layer1 of WAN (5)

- 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)

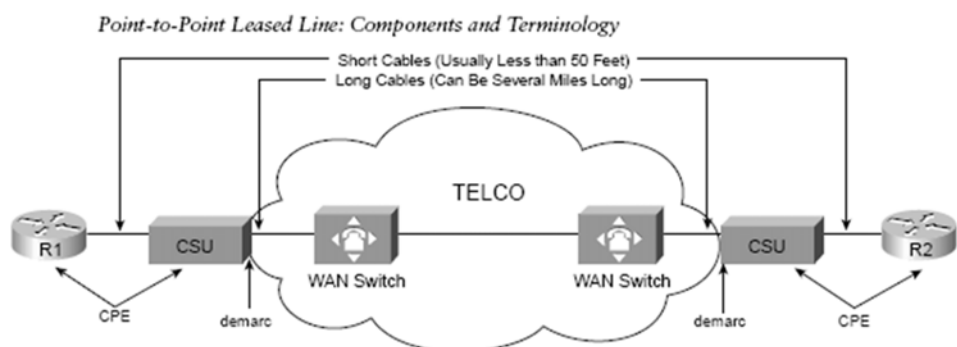
WAN Connections from the Customer Viewpoint

- Below figure presents WAN leased line acts as if the telco gave you two twisted pairs of wires between the two sites on each end of the line.
- Telco 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.



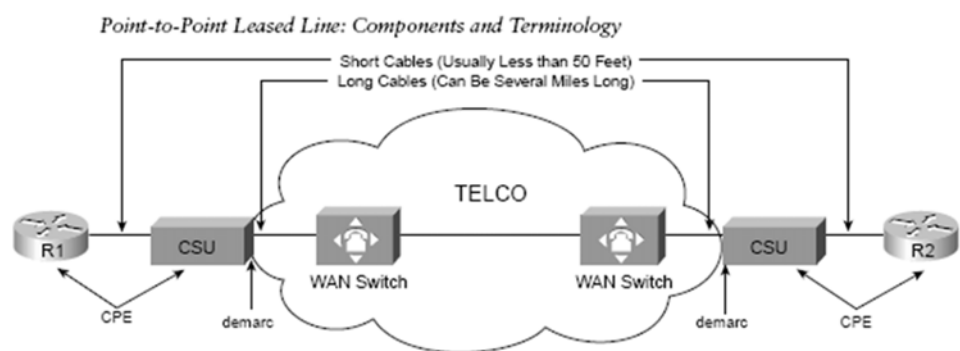
OSI layer1 of WAN (7)

- 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 equipments 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)

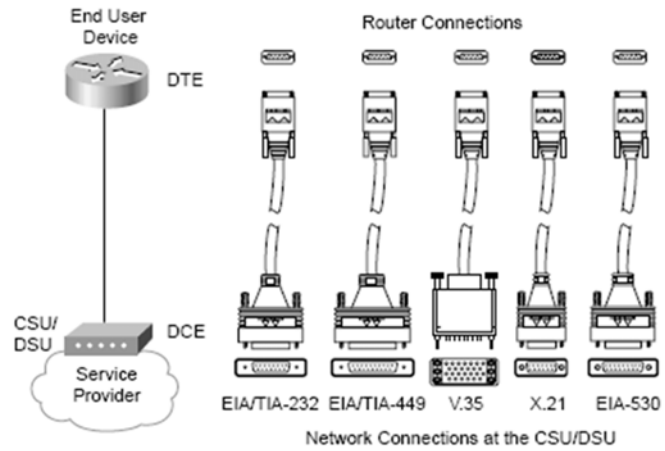
- synchronous serial interfaces
- asynchronous serial interfaces

Most common serial WAN links are synchronous

OSI layer1 of WAN (10)

1. Router 2 CSU

Serial Cabling Options



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

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OSI layer1 of WAN (11)

2. CSU to CO

- The cable between the CSU/DSU and the telco 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 (12)

- The cables and physical connector types each have differing limits on the speed of serial data transmission.
- Generally, the shorter the length of the cable is, the closer it can get to the maximum speed allowed for that cable and connector

Maximum Speeds for Various Cables

Data (bps)	Distance (Meters) EIA/TIA-232	Distance (Meters) EIA/TIA-449, V.35, X.21, EIA-530
2400	60	1250
4800	30	625
9600	15	312
19,200	15	156
38,400	15	78
115,200	3.7	—
T1 (1.544 Mbps)	—	15

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OSI layer1 of WAN (13)

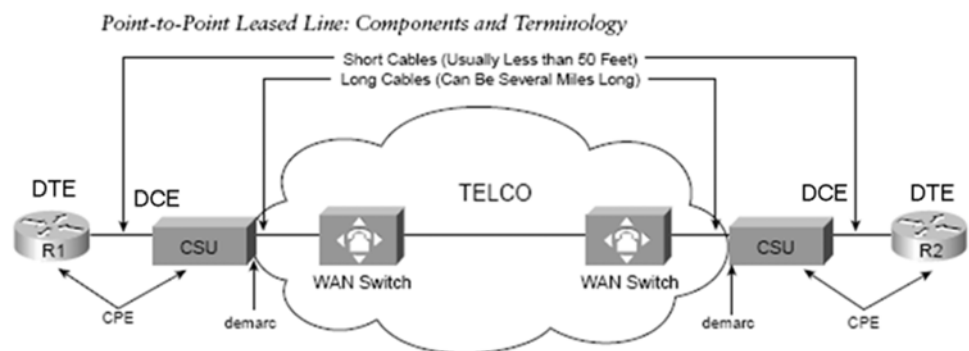
Clock Rates, DCE, and DTE

- 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 telco, 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 telco installs the new line into the customer premises, and the line can be connected to the CSU/DSUs

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OSI layer1 of WAN (14)

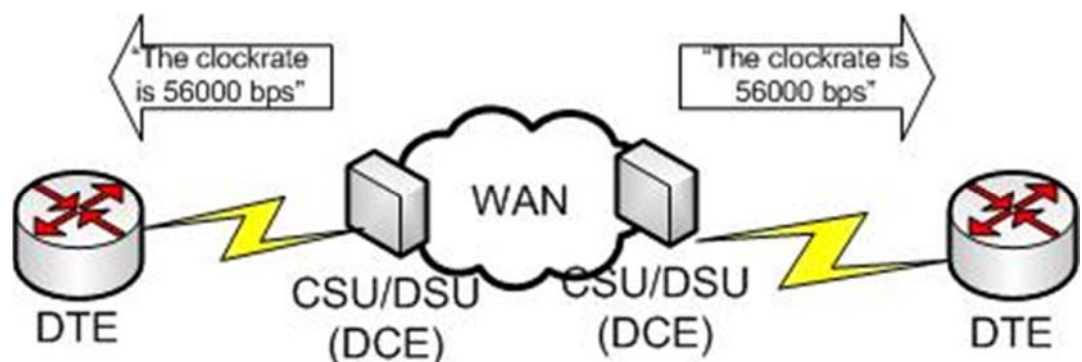
- *clock rate, bandwidth, link speed* all refer to the same thing
- One of the most important issue is that the two CSU/DSUs are configured to operate at that same speed.
- To do so, one device provides a clocking signal to the other device which simply react, sending and receiving data at the correct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



19

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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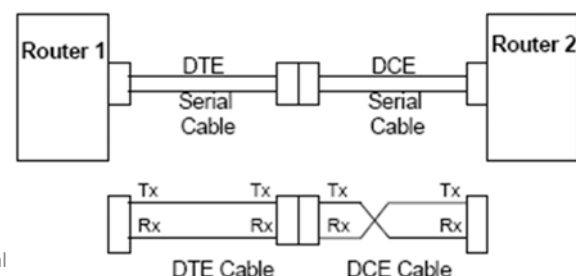
OSI layer1 of WAN (16)

- 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)

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 home 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 Telcos**
- So, years ago, the telcos 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 telcos starting selling data services—in other words, leased lines.
- The phone companies could sell a DS0 service at 64 kbps.
- telco 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 telcos do not use that bit, so they can offer the full 64-kbps channel.

OSI layer1 of WAN (21)

- Then Telco 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

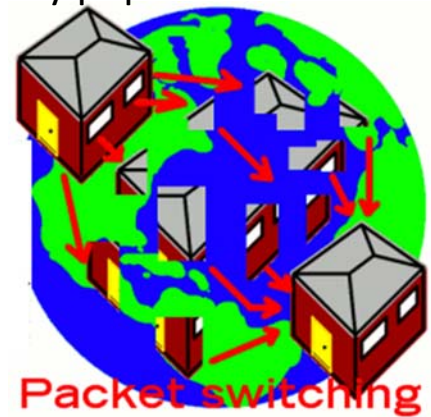
Circuit switching services

- All covered topics till name belongs to point to point serial leased line.
- Which means there is a dedicated direct path between two ends (WAN switches, Routers,...)



Packet switching services

- In a packet-switched service, physical WAN connectivity exists, similar to a leased line.
- However, the devices connected to a packet-switched service can communicate directly with each other, using a single connection to the service.
- Two types of packet-switching service are very popular today—Frame Relay.



Thanks,
C U Next Week isA,.....