



Lecture (08)

Fundamentals of WANs (II)

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Agenda

- OSI Layer 2 of WANs
- ATM & SONET WAN

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).
- The two most popular data-link protocols used on multi-points-to-multi points link is
 - Frame Relay

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.

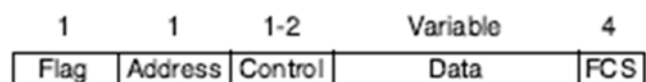
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OSI Layer 2 of WANs (4)

- HDLC defines framing that includes an
 1. address field, a
 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

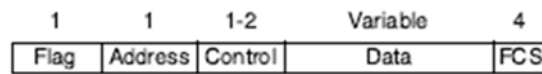


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OSI Layer 2 of WANs (5)

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.

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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

- Only CISCO routers uses this function.
- 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.

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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 (generic control) per link and one CP 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 control protocols 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 as Cisco's default on serial links.
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.

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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.

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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.

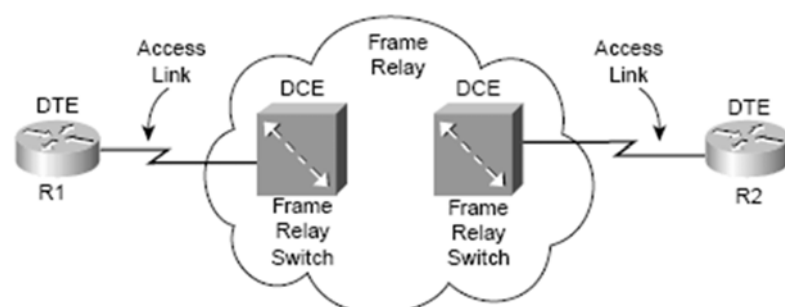
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OSI Layer 2 of WANs (16)

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

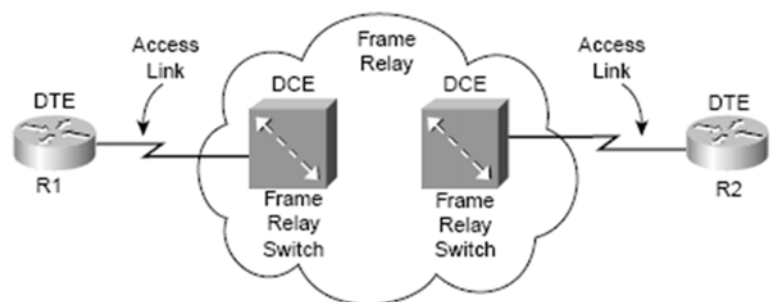


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OSI Layer 2 of WANs (17)

- 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



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OSI Layer 2 of WANs (18)

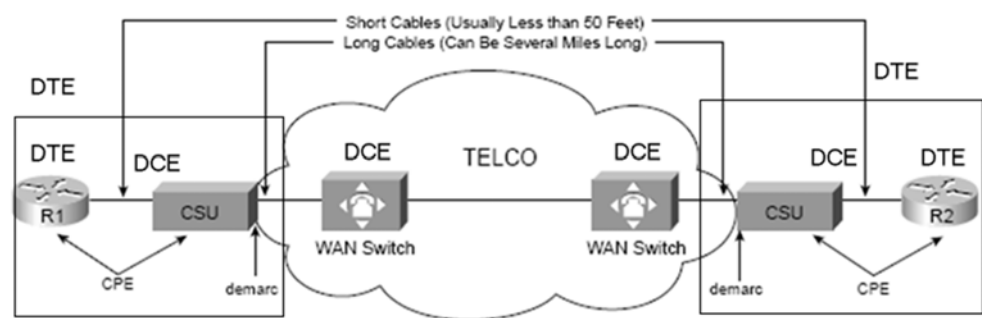
- Each frame header holds an address field called a data-link connection identifier (DLCI).
- The WAN switch forwards the frame, based on the DLCI, through the provider's network until it gets to the router on the other side of the network.
- so that it's called packet switching service, and that's the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

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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.*

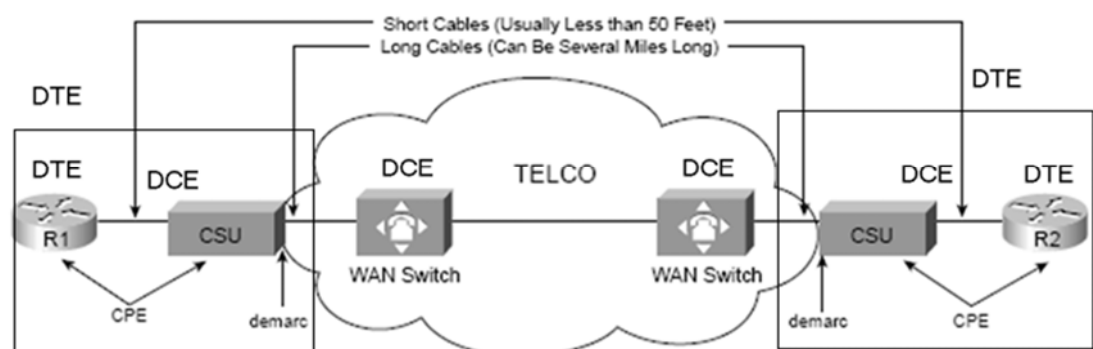
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OSI Layer 2 of WANs (20)

- 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.

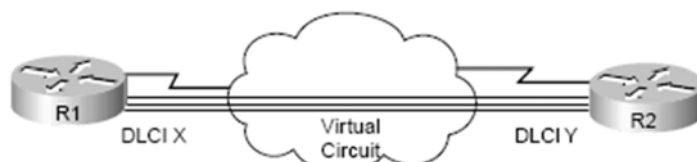
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OSI Layer 2 of WANs (21)

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

Frame Relay PVC Concepts

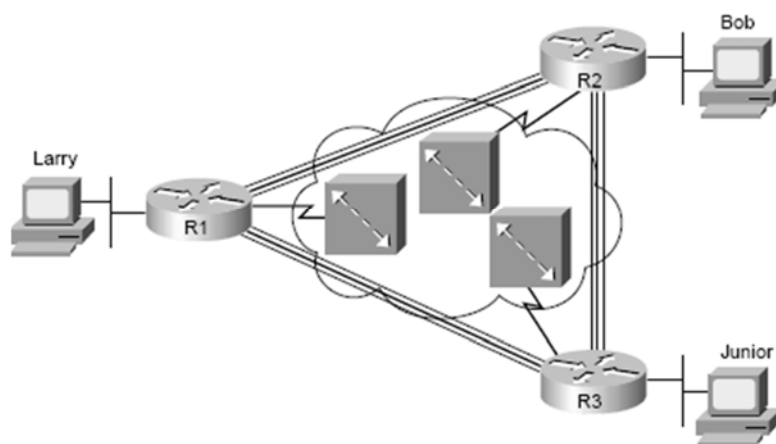


- When R1 needs to forward a packet to R2, it encapsulates the Layer 3 packet into a Frame Relay header and trailer and then sends the frame.
- R1 uses a Frame Relay address called a DLCI in the Frame Relay header.

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.

ATM & SONET WAN

ATM and SONET

- Asynchronous Transfer Mode (ATM) and Synchronous Optical Network (SONET) together provide the capability for a telco to provide high-speed services for both voice and data over the same network.
- SONET defines a method for transmitting digital data at high speeds over optical cabling, and ATM defines how to frame the traffic, how to address the traffic so that
- DTE devices can communicate, and how to provide error detection.
- In short, SONET provides Layer 1 features, and ATM provides Layer 2 features over SONET.

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ATM & SONET WAN (2)

SONET

- The motivation behind SONET was to allow the phone companies of the world to connect their COs with high-speed optical links.
- SONET provides the Layer 1 details of how to pass high-speed data over optical links.

• *optical carrier (OC) represents the prefix in the names for SONET*

SONET Link Speeds

Optical Carrier	Speed*
OC-1	52 Mbps
OC-3	155 Mbps
OC-12	622 Mbps
OC-48	2.4 Gbps
OC-192	9.6 Gbps
OC-768	40 Gbps

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*Speeds rounded to commonly used values

ATM & SONET WAN (3)

- Optical cabling has fiberglass in the middle, with a light signal being sent over the fiberglass.
- Outside the United States, the term *Synchronous Digital Hierarchy (SDH)* represents the same standards as SONET.

ATM & SONET WAN (4)

ATM

- ATM has a wide variety of applications, but its use as a WAN technology has many similarities to Frame Relay.
- When using ATM, routers connect to an ATM service via an access link to an ATM switch inside the service providers network.
- For multiple sites, each router would need a single access link to the ATM network, with a VC between sites as needed.
- ATM can use permanent VCs (PVCs) like Frame Relay.

ATM & SONET WAN (5)

- Differences between ATM and Frame Relay
- First, ATM relies on SONET for Layer 1 features instead of the traditional twisted-pair specifications such as T1 and DS0
- ATM does not forward frames—it forwards *cells*.
- Packets and frames can vary in size, but ATM cells are always a fixed 53-bytes in length.
- ATM cells contain 48 bytes of payload and a 5-byte header.
- The header contains two fields
 - *Virtual Path Identifier (VPI)* and
 - *Virtual Channel Identifier (VCI)*.
- that together act like the DLCI for Frame Relay by identifying each VC.

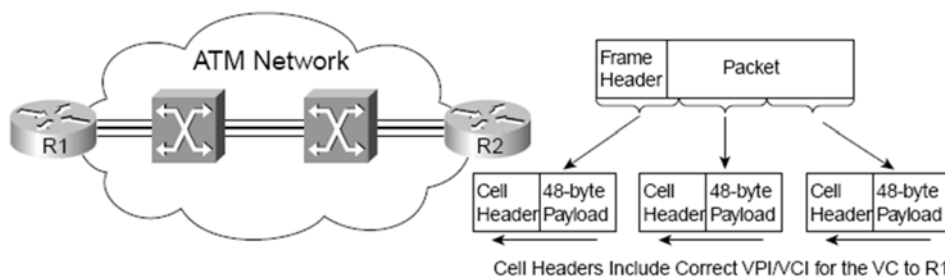
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ATM & SONET WAN (6)

- Relay switches forward frames based on VPI/VCI pair.

ATM Segmentation and Reassembly



- R2 takes the packet, adds a data-link header appropriate for ATM, and then also segments the frame into cells before sending any data.
- R2 takes the first 48 bytes of the frame and puts them in the payload field of a new cell. Next, it takes the next 48 bytes and puts them in another cell, and so on.

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ATM & SONET WAN (7)

- The cell header includes the correct VPI/VCI pair so that the ATM switches in the ATM network know to forward the cells to R1.
- R1 actually reverses the segmentation process after receiving all the cells—a process called *reassemble*.
- *The entire concept of segmenting a frame into cells, and reassembling them, is called segmentation and reassembly (SAR).*

ATM & SONET WAN (8)

- Because of its similar function to Frame Relay, ATM also is considered to be a type of packet switching service.
- However, because it uses fixed-length cells, it more often is called a *cells witching* service.

ATM & SONET WAN (9)

Terms Describing Types of WAN Connections

Dedicated Circuit	Another Term for a Leased Point-to-Point Line
Packet switching	Service in which each DTE device connects to a telco using a single physical line, with the possibility of being able to forward traffic to all other sites. The telco switch makes the forwarding decision based on an address in the packet header.
Frame switching	In concept, it is identical to packet switching. However, when the protocols match OSI Layer 2 more than any other layer, it is called frame switching. Frame Relay is a frame-switching technology.
Cell switching	In concept, it is identical to packet switching. However, because ATM DTEs break frames into small, fixed-length cells, these services are also called cell switching. ATM is a cell-switching technology.
Circuit switching	A circuit is a point-to-point link between only two sites, much like a leased line. However, circuit switching refers to the process of dialing, setting up a circuit, and then hanging up—in other words, the circuit is switched on and off. Dialed lines using modems and ISDN, as covered in Chapter 15, are examples of circuit switching.

Thanks,
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