Transmission Media of WAN

WAN Transmission

Communication between LANs over a WAN link will involve one of these technologies

- Analog
  - These use conventional telephone lines, with voice signaling (modem) technologies
- Digital
  - These use digital grade telephone lines, with digital technologies all the way
- Packet Switching
  - These use multiple sets of links between sender and receiver to move data

Analog

- **Dial-up line**
  - via public switched telephone network (PSTN)
  - requires modems which are slow
  - inconsistent quality of service
- **Dedicated line**
  - fast
  - reliable
  - expensive
  - service provider can implement line conditioning (a service that reduces delay and noise on the line, allowing for better transmissions) can make the leased lines even more reliable

Digital

- Digital Data Service (DDS) provide point-to-point synchronous communications at:
  - 2.4 Kbps
  - 4.8 Kbps
  - 9.6 Kbps or
  - 56 Kbps
- guarantees full-duplex bandwidth by setting up a permanent link from each endpoint
- 99% error free
- doesn't requires modem, requires bridge or router through a device called a CSU/DSU. This device translates standard digital signals a computer generates into bipolar digital signals used by synchronous communications
- Available in several forms:

	# of T channels	Speed
DDS		
T1	1	1.544 Mbps
T3	28	45 Mbps
T4	168	274.7 Mbps
Switched 56		56 Kbps

T1

- Point to point transmission => no switching
- uses two-wire pairs (1 pair to send, 1 to receive)
- full-duplex signal at 1.544 Mbps
- Used to transmit digital, voice, data and video signals
- multiplexing - signals from different source are collected into a component called a multiplexer and fed into one cable 8,000 times a second
- a T1 divides into 24 64 Kbps channels. Subscribers can lease one 64 Kbps channel known as a Fractional T-1.
    - each channel can transmit at 64 Kbps. This is called a DS-0
    - the whole 1.544 Mbps is known as DS-1
- Connecting a T1 line to your network is similar to a connecting a DDS or frame relay line. You will need a T1-compatible CSU/DSU, and a bridge or router. To distribute the T1's bandwidth between voice and data traffic, you will need a multiplexer/demultiplexer to combine voice and data signals for transmission, and separate them upon reception.

T3

- equivalent to 28 T-1 lines
- T3 and Fractional T-3 leased line service provides voice and data service from 6 Mbps to 45 Mbps
- REALLY expensive
- T-1 uses copper wire, while T-3 uses fiber optic cables or microwave transmission equipment.

Switched 56

- In reality, a Switched 56 line is nothing more than a circuit-switched version of a standard 56 Kbps DDS leased line. As customers pay only for connection time, resulting costs are usually significantly lower than those of a dedicated line.
- is a LAN to LAN digital dial-up service
- 56 Kbps
- used on demand => not dedicated => less expensive.
- Both ends must be equipped with a Switched 56 compatible CSU/DSU to dial-up another switched 56 site.

Packet Switching

- Switching (as in switched connections) refers to finding a path for data transmission across a number of potential links between sender and receiver. On the other hand, analog and digital connections require a fixed connection to exist, at least for the duration of each communication session. Switching methods include both circuit switching and packet switching. Essentially, when data is received on an incoming line, the switching device must find an appropriate outgoing line on which to forward it. These switching devices are usually called routers, based on the functions they perform.
- data package is broken into packers and each package is tagged with a destination address and other info.
- relayed through stations in a computer network

- data paths for individual packets depend on the best route at any given instant. The main point is that the small, individual packets are all take their own route to the destination, and an error in any one of them is easier to correct than a huge chunk of data
- These networks are sometimes called "any to any networks"
- Can use a virtual circuit
- logical connection between the sending computer and the receiving computer
- not actual cable, but bandwidth used on demand
- Can use a Switched Virtual Circuit to establish a connection over a specific route.
- Permanent Virtual Circuits allow the customer to pay for only the time that the line is used.

Advanced WAN

X.25

- speed peaks at 64 Kbps - Newer versions can be up to 2 Mbps
- a set of protocols incorporated in a packet-switching network
- uses switches circuits and routes as available to provide the best routing at any particular time. The situation is always changing.
- uses telephone lines - slow - MUCH error checking => this is a major disadvantage
- synchronous packet-mode host or other device and the public data network (PDN) over a dedicated or leased-line circuit
- DTC/DCE interface
- a PAD is also needed - Packet Assembler / Disassembler
- And X.25 gateway is needed between the LAN and the Public Data Network
- See pic on p. 595.

ISDN

- **Basic Rate (BRI)** is 3 data channels
    - 2 for 64 Kbps - 64 Kbps channels are known as B (Bearer) channels, carry voice, data or image
    - 1 for 16 Kbps - the 16 Kbps channel is D channel which carries signaling and link management data
    - This makes a total of 144 Kbps of bandwidth.
    - basic rate is called 2B+D
    - **The two B channels can be used together for 128 Kbps data stream**
- **Primary Rate (PRI)** ISDN takes **the entire bandwidth of a T1 link** by providing
    - 23 B Channels at 64 Kbps
    - 1 D Channel at 64 Kbps
- ISDN is a **dial-up service**, not dedicated, not bandwidth on demand
- Right now, ISDN is about 5 times as fast as the fastest modem
- You can transmit voice and data with ISDN

Frame Relay

- Like X.25 Frame Relay is a packet-switching technology
- uses variable-length packets
- It establishes a logical path that's called a Permanent Virtual Circuit (PVC) between end-points. PVCs take fixed paths, so a PVC is the equiva-lent of a dedicated line in a packet-switched network. The path is fixed, so network nodes don't have to waste time calculating routes. Frame relay connections operate at speeds between 56 Kbps and 1.544 Mbps because they use PVCs, and there is no built-in error checking.
- again, the PVC transmits at Data Link Layer. Because Frame Relay uses a PVC, the entire path from end to end is known => faster because no fragmentation or reassembly or best path routing is needed
- can supply bandwidth on demand
- over digital leased-line
- Frame relay connections to a network require you to use a frame relay-compatible CSU/DSU to create the physical connection to the WAN, and a router or bridge to move traffic from the LAN to the WAN, and the WAN to the LAN, as needed.
- in summary, Frame relay costs less than a dedicated line or an ATM connection and provides data transmission rates of up to 1.544 Mbps over conventional or fiber optic media.

ATM

- fixed-sized packets over broadband and baseband LANs or WANs
- 155 Mbps to 622 Mbps or more
- ATM can accommodate voice, data, fax, realtime video, CD-quality audio, imaging, and multimegabit data transmission.
- ATM is like frame relay because it assumes noise-free lines and leaves error checking to devices at either end of a connection. Also, ATM creates a PVC between two points across an ATM network as part of setting up a communication session.
- ATM Technology
    - broadband cell relay method that transmit data in 53-byte cells rather than in variable-length frames. This uniform cell size is a big factor for speed => uniformity is easier to switch, route and buffer.
    - cell consists of 48 bytes of application info and 5 bytes of ATM header data => a consistent uniform package
- in theory, up to 1.2 Gigabits per second, but can transmit normally at 155 Mbps
- can be used in LANs and WANs
- hardware like routers, bridges have to be ATM compatible
- switches are multiport hubs
- Any media type is OK
    - media recommended
    - T3 (45 Mbps)
    - FDDI (100 Mbps)
    - fiber channel (155 Mbps)
    - OC3 SONET (155 Mbps)
- ATM can even interface with frame relay and X.25.

About Optical Carrier Levels, T-Carrier Rates, And More
The Optical Carrier rating level for standard ATM technologies is cus-tomarily abbreviated as OC-n, where n is a multiplier applied to the basic OC level 1 rate (OC-1) of 51.84 Mbps. OC-1 describes the basic transmission rate for SONET communications. Table 10.1 (seen later in this chapter) summarizes most of the WAN service types that we cover in this chapter, along with their common abbreviations, basic characteristics, maximum throughput rates, and associated transmission technologies.

Fiber Distributed Data Interface (FDDI)

- 100 Mbps token passed ring network that uses Fiber optic cable
- used for Metropolitan Area Networks (MAN) to connect within the same city so this isn't really a WAN technology
- 100 km (62 miles) max. length => not really a WAN technology
- FDDI uses fiber optic cable to serve as
  - "backend network" that handle file transfer
  - serve as a backbone for other low capacity LANs
  - LANs that require large bandwidth
    - Video
    - CAD
    - CAM

- **Token Passing**
  - not the same as token passing in 802.5
  - here a computer can transmit as many frames as it can produce within a predetermined time before letting the token go. When it is finished transmitting, it lets the token go.
  - Because the computer releases the token when it's finished, there may be several frames on the ring at once.
  - FDDI is not like a regular Token Ring network because more than one computer at a time can transmit a token so that multiple tokens can circulate on the ring at any one time.
  - This is why FDDI is faster than regular Token Ring 802.5 => 802.5 only allows one token at a time to transmit.

- **Topology**
  - Dual-ring
    - primary ring is for traffic; a redundant second ring for backup
    - when the primary ring breaks down, the secondary ring reconfigures itself and flows in the opposite direction
    - REDUNDANCY is one of the key features of this technology.
  - 500 computers max.
  - more than one computer can transmit at a time - they share the bandwidth; for example, when 10 computers transmit, each does so at 10 Mbps
  - there must be a repeater every 2 Kms or less
  - computers connected to both rings are CLASS A stations and help to reconfigure the network if the first ring fails. CLASS B stations are only connected to the one, primary ring.

    - FDDI can have point-to-point links to a hub => it can be set up using a star ring topology

- **Beaconing**
    - all computers on an FDDI network are responsible for monitoring faults in the network
    - a computer that detects a fault sends a signal called a BEACON onto the network. If it sees it's upstream neighbour is sending a beacon it stops. This goes on until the only computer sending a beacon is the one directly downstream from the faulty computer. This process stops when a beaconing computer receives its own beacon => this means the beacon made it around the ring

- **Media**
    - FDDI uses fiber-optic. This means
        - immune to electromagnetic interference
        - secure because fiber optic doesn't emit a signal that can be monitored and cannot be tapped
        - able to transmit long distances before needing a repeater
    - FDDI on copper wire is called CDDI => can be done, but it has FAR less distance

Synchronous Optical Network (SONET)

- SONET is a fiber optic WAN technology used to deliver voice, data, and video at speeds in multiples of 51.84 Mbps
- The basic OC-1 level specifies a data rate of 51.84 Mbps, and is based on the DS1 basic rate defined for SONET. The most common level is OC-3 or 3 x 51.84 Mbps or 155.52 Mbps. OC-3 is the most common SONET implementation in use today, even though the specification defines OC-48 at 2.48 Gbps.
- uses fiber-optic
- Summary: SONET is a fiber optic WAN technology used to deliver voice, data, and video at speeds up to 622 Mbps, and beyond.

Switched Multimegabit Data Service (SMDS)

- Switching service that provides data transmission in the range between 1.544 Mbps (T1 or DS1) to 45 Mbps (T3 or DS3).
- Connectionless service that, like ATM, uses fixed-length 53 bytes cells.
- Like ATM and frame relay, it provides no error checking, leaving that up to devices at the connection points.
- IEEE 802.6 (MAN) specification.
- is a dual bus topology that forms a ring that is not closed

Other WAN Tidbits:

- E1 (European Trunk Line) is the T-1 digital equivalent
- The transmission rate is 2.048 Mbps
- See table p. 199 Exam Cram for other tidbits, most of which have been noted here

Network Troubleshooting

Planning

- Prevention and a proactive program of preventative maintenance are the best approaches to avoid problems.
- Policies and procedures should be determined during the network planning stages and should include;
    - Backing up the network.
    - Planning security.
    - Standardization of hardware and software.
    - Upgrade maintenance.
    - Documentation which may include;
        - map of the network
        - server information and backup schedules
        - software information
        - telephone numbers of vendors and tech support
        - copies of service agreements
        - record of problems and solutions

Network Utilities

- The ISO identifies five areas of network management;
    1. Accounting management
    2. Configuration management
    3. Fault management
    4. Performance management
    5. Security management

1. **Network Monitoring**
    - Can be performed with Performance Monitor in NTServer.
    - A baseline should be established under normal conditions for future reference.

Troubleshooting Methodology

2. Set the problem's priority.
3. Identify the problem's symptoms.
4. Develop a list of possible causes.
5. Test to isolate the cause.
6. Study the results of the test to identify a solution.

Tools

- **Digital Volt Meter (DVM)**
    - another name is a Volt /Ohm Meter
    - checks for resistance on cables, terminators and barrel connectors
        - cables and barrel connectors should provide 0 resistance
        - terminators in 10Base2 and 10Base5 networks should provide 50 ohms of resistance
    - Use as a continuity checker for cables.
    - a continuity check can reveal a short where:
        - two parts of the same cable are exposed and touching
        - part of cable is touching another conductor such as metal surface

Time-Domain Reflectometer (TDR)

- Sends sonar-like pulses down the cable to identify any kind of a break, short or imperfection that might affect performance
- can locate a break within a few feet of the actual separation in the cable

Advanced Cable Testers

- Work at OSI layers 2, 3, and 4 and can display more complex information.
- can indicate if a particular cable or NIC is causing problems
- Can display:
    - Message and error frame counts
    - Excess collisions
    - congestion errors
    - beaconing

Oscilloscopes

- measures signal voltage per unit of time
- Can identify
    - breaks,
    - shorts,
    - bends
    - opens (breaks in the cable)
    - and attenuation data.

Network Monitors

- Software that tracks all or part of network traffic.

Protocol Analyzers

- Can perform packet capture, decoding and transmission in real-time.
- Most useful network analysis tool.
- They look inside the packet to identify problems
- They have a TDR in them
- they can
    - identify the most active computers
    - identify computers sending error-filled packets
    - identify, view and filter certain types of packets
    - help analyze network trends
    - check various components, connections by generating test packets
    - set up alerts like Performance Monitor

Support Resources

- Microsoft TechNet
- BBS's
- User Groups
- Periodicals
- Internet
- Microsoft Network

Common Troubleshooting Situations

- Cable and other physical layer problems.
- Power fluctuations.
- Upgrades
- Changes in client computer configuration.

- Server crashes.
- Poor network performance resulting from some change or user application.