**Module 3—WAN Technologies**
**W/ Professor Messer**

**T1/E1 && T3/E3/DS3**:
http://www.professormesser.com/network-plus/n10-005/t1-e1-and-t3-e3-ds3/
**+Questions:**

1. A T1 line employs what type of multiplexing?
    a. Time-division multiplexing, it chooses which signal to transmit based on time
2. When entering a building, what type of media does T1 line most likely use?
    a. Twisted pair cabling
3. With what type of media would a T3 likely use when it enter a building?
    a. Coaxial, with BNC connectors

**Satellite, ISDN, Cable, DSK, and Dialup:**
http://www.professormesser.com/n10-005/satellite-isdn-cable-dsl-and-dialup/
+Questions:

1. How does the cost of non-terrestrial communications compare with conventional terrestrial networking?
    a. Non-terrestrial communications tend to be much higher because the technologies that it runs on are much more expensive.
2. Other than cost, what is the significant disadvantage of satellite communications?
    a. Latency, from a networking perspective, the latency is incredibly high for satellite comms.
3. What does the A in "ADSL" represent?
    a. Asymmetric, which indicates that the download speed is different from the upload speed.
4. What type of media would an ADSL use when it enter a building?
    a. Uses standard telephone lines
5. What type of DSL is capable of speeds of up to 100Mbit/s?
    a. VDSL—Very High Bitrate DSL.

**Circuit Switching and Packet Switching**
http://www.professormesser.com/n10-005/circuit-switching-and-packet-switching/
+Questions:

1. Which technology, circuit or packet switching, is most like the technology utilized by POTS?
    a. Circuit Switching
2. What is the major criticism of circuit switching?
    a. It is very inefficient use of resources, can only be used for one connection and not shared.
3. Why is packet switching considered more efficient than circuit switching?
    a. Data is grouped into packets for easier transfer, the media is shared on the network, and it is more efficient for sharing the connection.

**Transmission Media, Speed, and Distance**
http://www.professormesser.com/n10-005/transmission-media-speed-and-distance/
+Questions:

1. What are the three major WAN cable types?
    a. Coax, Twisted Pair, Fiber Optic
2. When was coax cable patented?
    a. 1880's
3. What type of cable is typically used in a local area network?
    a. Twisted Pair
4. What purpose does the twist in TWP copper cable server?
    a. To reduce electromagnetic interferences
5. What type of cabling would you use for very long distance and very high speed runs?
    a. Fiber Optic
6. When you use fiber optic cables, what are two conventional cabling operations that require extra care?
    a. It must be terminated properly, and be careful not to bend fiber optic at a high radius.

**+Notes**

**+ T1/E1 && T3/E3/DS3**

- T1, called T-Carrier Level 1, has been around for some time
  - Uses Time-division Multiplexing
    - Has digital signals coming through and it decides which channel is going to be used based on time, and it moves around each channel in a time division method
      - A standard that is used in North America, Japan, and South Korea
  - It has 24 separate channels
    - Runs at 1.544 Mbit/s line rate (speed)
      - 64 kbit/s per channel

- E1, E-Carrier Level 1, is the European version of T1
  - Has 32 separate channels
    - Runs at 2.048 Mbits/s line rate (speed)
      - Still 64 kbit/s per channel
  - Still uses Time-division Multiplexing

- T3, called T-Carrier Level 3
  - It's the next level up
  - Comes into a facility using COAX, with BNC connectors
    - Higher level signals
    - Different from T1, which comes in Twisted-Pair
  - T3 is often referred to as DS3,
    - DS3 is referring to the DATA that is passing through a T3 connections
  - T3 = 28 T1 Circuits
    - 28 * 24 = 672 T1 Channels
    - 44.736 Mbit/s line rate (speed)
- E3, E-Carrier Level 3…
  - E3 = 16 E1 Circuits
    - 16 * 32 = 512 E1 Channels
    - 33.368 Mbit/s line rate (speed)
- T3/E3 are typically placed into a major data center to increase total throughout

**+ Satellite, ISDN, Cable, DSK, and Dialup**

- Satellite—connects directly from facility up to a satellite, and back down to the service provider
  - Non-terrestrial communication, connecting through space
  - Higher cost relative to terrestrial networking—the cost of getting satellites into orbit
    - 5Mbit/s down, 1Mbit/s up
  - Advantages: Available for remote sites that are difficult to network through terrestrial media
    - In the middle of nowhere… on a cruise… not worried about local connectivity
  - Disadvantages:
    - High latency
      - 250 ms up, 250 down… Half of a second to send one packet
        - Real-time applications are significantly impacted…
        - Convenience shop credit card authentication is okay…
    - You have to be able to see the satellite…
      - High frequencies—2Ghz
      - Rain Fade—after a bad storm, the clouds can affect connection
        - Satellites can't see you…
      - Line of sight—absolutely clear view of Dish and Satellite
- ISDN—Integrated Services Digital Network
  - Allowed for Voice and Data over a single standard phone line (home, business, building, etc)

    - Smaller version of ISDN: BRI—Basic Rate Interface (2B+D Connection)
        - 2B refers to Two 64 kbit/s bearer (B) channels
            - Allowed for up to 128 kbit/s throughput
        - D refers to One 16 kbit/s signaling (D) channel
            - Channel specifically used for signaling
                - Making sure the connection is brought up and making sure it's torn down at the end
    - In larger environments: PRI—Primary Rate Interface
        - For higher throughput, or many more connections
        - Delivered over a T1 or E1 line, transmitting ISDN signals
            - T1—23B + D
            - E1—30B + D + alarm channel
        - Commonly used as connectivity from the PSTN to large phone systems (PBX)
- ADSL—Asymmetric Digital Subscriber Line
    - Uses telephone lines to provide these connections
    - Called Asymmetric because download speed is faster than the upload speed (Asymmetric)
    - Limited by how far the signal can travel over a phone line
        - 10,000 foot limitation from the central line
    - 24 Mbit/s downstream // 3.5Mbit/s upstream
- SDSL—Symmetric Digital Subscriber Line
    - Never really caught on, was never standardized
    - Allowed for the same download and upload speeds
- VDSL—Very High Bitrate DSL
    - More popular/catching on
    - A possible range of 4Mbit/s up to 100Mbit/s connection speed
- Cable—Cable Modem/Data on the Cable Network
    - DOCSIS—Data Over Cable Service Interface Specification
        - The standard to send data over cable
    - Allow high-speed networking
        - 4 Mbit/s through 100 Mbit/s
    - Multiple Services supported
        - Data, Voice, and Television
- Dialup—network with voice telephone lines
    - It's a legacy system
    - Run over standard analog frequencies
    - 56 kbit/s modems
        - With compression, up to 320 kbit/s
            - Theoretical maximum
    - It's relatively slow, difficult to scale

**+Circuit Switching && Packet Switching**

- Circuit Switching—circuit is established between endpoints before data passes
    - Like a phone call
    - Nobody else can use the circuit, it's an inefficient use of resources
        - Like a T1, the connection is always there, use it or not…
        - You pay a lot more.
    - Used in POTS, PSTN, T1/E1/T3/E3, ISDM
- Packet Switching—Data is grouped into packets || Cheaper (SONET, ATM, DSL, Cable, Wireless)
    - Voice, data, video, etc… like a network || Can use shared media (many can use, efficient)

+Transmission Media, Speed, and Distance

- Network Media—nothing happens unless the media works
    - OSI Layer 1, the physical layer
    - Things to consider when building a network:

        - Media (types of cables/interfaces)
        - Speed
        - Distance
- Three types of cables:
    - Coax, twisted pair, fiber
        - Usually picking one…
- Coax—Copper wire that is placed inside very heavy and thick cables
    - It was patented in the 1880's
    - Can carry signals over long distances
        - Not so much so today, we use fiber
    - Disadvantage:
        - Signal leakage and ground loops
            - Other copper-related interface issues
- Twisted-pair Copper—good for local area connections
    - Many copper wires, all twisted together to create pairs
        - Effectively it creates a way to cancel interference that might hit the wire from one place to another
    - Early telegraph lines had a twist to cancel interference
    - Very thing, very flexible, very inexpensive
    - Tight specification for bend radius and pulling tension
        - Relatively fragile to install
- Optic Fiber—communicating through light
    - Technology demonstrated in 1840's
    - Can travel very long distance communication
        - Kilometers at high speeds
    - Not susceptible to EMI
        - Not interference, electrical or magnetic
            - Only need to worry about the brightness of light
    - Must be terminated properly
        - Watch the bend radius, or you'll lose a lot of light/signal