Media

•Media is the "stuff" on which voice and data transmissions are carried.

•The characteristics of media have a direct bearing on the speed, accuracy and distance at which traffic can be carried.

Copper Wire

- Electrical properties of copper cabling create resistance and interference problems with transmissions.
- Signals weaken the further they are transmitted via copper. Because it is electric, resistance within the copper media slows down the signal or flow of current. The electrical property of copper cabling is the key factor that limits the speed of transmission

Copper Wire

Electrical Interference

- Another factor that limits the use of copper wiring is electrical interference.
- Signals sent over copper wire are direct current electrical signals.
- Signals near these signals can introduce interference and noise into the transmission.
  - Manufacturing areas, near copiers, magnetic sources, and radio and TV station transmissions.

Unshielded Twisted Pair

(UTP)

- This type of cable is used extensively by LECs to provide the local loop between the customer and the CO.
- Insulated wire pairs from 6 to as many as 2700 can be bundled together to form a single cable.
- Because the wires in these cables are insulated, they can be buried, thus eliminating the need for above ground support.

Twisted Pair

- Twisted Pair cables are suitable for transmitting signals with bit rates of up to 10 Mb/s over relatively short distances.
- Shielded twisted pair cables can carry even higher bit rates over greater distances and are far less susceptible to electromagnetic interference.

Twisted Pair Wire

Crosstalk

- Within homes and business, crosstalk is another example of "leaking" electrical transmissions.
  - In homes with two lines, one line can often hear the faint conversation on the other line if the wires are too close to each other.
- To protect against "leaking" - twist each copper wire of a two-wire pair.
  - Noise induced into each wire of the twisted pair is canceled at the twist in the wire.

Copper Wire
Cat 5 Twisted Pair

- Twisted pair cabling and connection components used inside buildings are rated by the EIA/TIA (Electronics Industry Association/ Telecommunications)
  - In 1992, these standards were published such that unshielded twisted pair could be used to transmit data within buildings at 100 MBPS.
- Organizations typically install Cat 5 for both voice & data.
- 10BaseT, 100BaseT and 1000BaseT are Ethernet standards for networking on twisted pair copper wire

Coaxial Cable

- Coaxial cable is suitable for carrying high bit rate signals over distances ranging from 100 to 500 meters, depending upon the cable type.
- The center conductor is effectively shielded from noise and interference and signal losses due to both "skin effect" and radiation are greatly reduced.
- Skin effect is tendency for electrons to travel along the outside of the copper cable

Copper Review

•The oldest form of transmission medium still in use today.

•Today, the primary use of copper is between the customer premise and the central office. Copper wire is also used for inside wiring.

•Found on poles or laid beneath the ground.

•Some disadvantages of Copper Wire are: Heavy, Expensive, Limited Band Width (DS-3), 30-year Lifespan, Easy To Tap, Fraud, Needs Repeaters every 3-30 miles.

Fiber Optic Cabling

- Fiber lines are immune to electrical interference.
- Signals are transmitted by light waves (generated by a laser) rather than electrical signals. There is no electricity present in the transmissions.

Fiber Optics
Anatomy

- Core
  - The narrower the core, the faster and further a light signal can travel without errors and repeaters.
- Cladding
  - The core is surrounded by cladding which keeps the light contained within the core to prevent the light signal from dispersing (spreading & losing strength)
- Casing (acrylate)
  - Protects the fiber from environmental hazards such as rain, dust, scratches and snow.

Fiber Optics
Benefits

- Security
  - Resistant to taps; does not emit electromagnetic signals, therefore, to tap fiber strands, the strands have to be physically broken and listening devices spliced into the break.
- Small Size
  - Less duct space required; individual strands of fiber are the size of a human hair. Duct size is particularly significant under city streets where underground conduit is at capacity, filled with copper.
    - AT&T would issue canoe paddles to their installers!

Fiber Optics
Benefits

- Single conductor fiber
  - Weighs 9 times less than coaxial cable
- Low attenuation
  - Less fading or weakening of signals over distance
- No sparking hazards
  - in flammable areas
- High bandwidths
  - Suitable for new high-speed transmission speeds such as SONET and ATM

Fiber Optics
Disadvantages

- Costs
  - Termination, components and connector costs are higher than for copper wiring.
  - Specialized equipment is required to terminate fiber cables within buildings.
  - Specialized equipment is also needed to test and splice fiber and to convert electrical signals to light pulses and visa versa.

Fiber Optics
Disadvantages

- More care
  - Fiber is not as flexible as twisted pair in bending around corners. One should "loop" it around 90° turns.
- To the Curb/Into Buildings
  - Local electrical power is required. This adds extra expense.
- Training
  - Specialized technicians, who may be paid at higher levels, are often required to work with and test fiber cabling.

Fiber Optics
IXC

- Many IXC networks are now fully fiber. The added expense is justified because of their greater capacity and higher speeds.
- Telephone companies can lay fewer strands of fiber in less space than heavier copper requiring many more pairs to achieve the same capacity as fiber.
- Signals can travel further, in the range of 30 miles, on fiber without the use of repeaters to strengthen a faded signal.

Fiber Optics
Uses

- Individual organizations use fiber
  - For the riser, between floors within a building portion of their networks
  - In campus environment, for cable runs between buildings.
- Other places
  - All IXC, ISP and Electric Utility networks
  - LEC - between central offices, to neighborhood wire centers
  - From LEC and IXC to office buildings
  - For undersea cable runs between continents
  - In backbone CATV networks (between the cable company headbands and neighborhood wire centers)

Types of Fiber
Single-Mode

- The combined widths of the core and cladding are as wide as a strand of hair.
- Single-mode is smaller, more expensive and carries signals faster than multimode fiber.
  - Multi-mode fiber has multiple paths for reflected light within the glass cable (which means the glass is less pure, thus causing problems with signal propagation)
- Used for cable runs longer than two kilometers (1.24 miles)
  - IXC, Cable companies, ISP and Transoceanic cabling.

Types of Fiber
Single-mode

- The small core of the fiber keeps the light signal from bouncing across the diameter of the core of the fiber.
- Can be run for 50 miles without the use of a repeater.
- This also increases the expense.
  - Cost of splicing and connecting it to patch panels and other devices.
  - Less room for error - leak or disperse out of the core.

Fiber
Components

- When fiber networks are interfaced with devices that transmit electrical signals, the electrical signals must be converted to light pulses.
- Transmitters (light source transducers) are either LED (light-emitting diodes) or lasers.
- Lasers send faster pulses and are more expensive than LED. LED's are commonly used with multimode fiber. Lasers are used with single-mode fiber.

Fiber
Components (cont.)

- At the receiving end, the detectors that change light pulses into electrical signals are either PINs (Positive Intrinsic Negative) or APDs (Avalanche PhotoDiodes).
- LEDs and PINs are used in applications with lower bandwidth and distance requirements. Lasers and APDs are used with single-mode fiber.

Error Rates

- In wireless (airwaves)
  - 1 in 10^3 bits (1 in 1,000)
- In copper
  - 1 in 10^7 bits (1 in 10,000,000)
- In optical fiber
  - 1 in 10^{11} bits (1 in 100,000,000,000)

Terrestrial Microwave

- Terrestrial microwave (radio) transmission can be employed in remote areas where more traditional cable facilities would be impractical, or too expensive.
- This media can provide point-to-point links over long distances. It is limited to line-of-sight and can be adversely effected by man-made structures and weather conditions.
- Provided at speeds of 45 MBPS (T3 or DS3)

Microwave
Frequencies

- FCC has divided the frequencies
  - 1 - 23 GHz - private users and common carrier provided communication services for revenue generation.
  - 1 - 12 GHz - Long-haul (up to 30 miles)
  - 18 - 23 GHz - Short-haul microwave systems (several hundred feet to 15 miles)
  - Above 23 GHz were designed for military radar applications and some specific commercial applications. Now PCS.

Terrestrial Microwave

- The primary components of microwave technology are tower, Transmitter/Receiver, Antenna and wave guides or feeder cables.
- Microwave signals are usually thought of as constituting a beam or shot of energy.
- Microwave signals only travel in straight lines.
- In terrestrial microwave systems, towers are placed 3 to 35 miles apart.
  - Some disadvantages of Microwave are: Signal Loss; Radio Interference; Environmental Factors: rain, temperature inversions, birds, planes; Sun Spots & Solar Flares.

Satellite

- Satellite transmission is employed in areas where land-based transmission facilities would be impractical, or too expensive.
- Communications satellites are usually placed in orbits that are "geocentric or geostationary".
  - This means that they complete one revolution in the same time as the Earth. A satellite would appear to be stationary when viewed from a point on Earth.
  - This feature is necessary for point-to-point transmission between two Earth stations.

- The first satellite, *Telstar*
  - Launched by AT&T in 1962 and had only twelve voice circuits.
- INTELSAT VI
  - Launched in 1989 by the ITSO (International Telecommunications Satellite Organization) which is owned and operated under a treaty with 112 countries.
  - Can carry 120,000 simultaneous phone calls plus three television channels.

- INTELSAT satellites carry 2/3 of the world's international telephone service and almost all international television transmissions.
- In 1984, the PAS (Pan American Satellite Corporation was established and became INTELSAT's first competitor.
  - The PAS 1 serves continental US, Central and South America, the Caribbean and Western Europe.

Satellites

- Domestic satellites launched by US organizations included COMSAT (a government-regulated private organization), AT&T, Satellite Business Systems, Western Union, GTE, REC and GE American Satellite.

Satellites
Components

- uplink/downlink
- transponder - a microwave repeater that receives, amplifies, and reconverts uplink signals and retransmits them back to the antenna to downlink them to earth stations.
- Footprint - can range from several hundred to several thousand miles in width, depending on the applications