Transmission Media

Parts of this lecture's notes were adapted from Wikipedia's "Transmission Medium" (http://en.wikipedia.org/wiki/Wide_area_network), "Optical Fiber" (http://en.wikipedia.org/wiki/Optical_fiber), and "Physical Media" (http://en.wikipedia.org/wiki/Physical_media).

1. Transmission Media

A transmission medium is a material substance (solid, liquid, gas, or plasma) that can propagate energy waves. For example, the transmission medium for sound received by the ears is usually air, but solids and liquids may also act as transmission media for sound.

A transmission medium can be classified as a:

- linear medium, if different waves at any particular point in the medium can be superposed;
- bounded medium, if it is finite in extent, otherwise unbounded medium;
- uniform medium or homogeneous medium, if its physical properties are unchanged at different points; and
- isotropic medium, if its physical properties are the same in different directions.

Electromagnetic radiation can be transmitted through an optical media, such as optical fiber, or through twisted pair wires, coaxial cable, or dielectric-slab waveguides. It may also pass through any physical material that is transparent to the specific wavelength, such as water, air, glass, or concrete. Sound is, by definition, the vibration of matter, so it requires a physical medium for transmission, as do other kinds of mechanical waves and heat energy.

Transmission and reception of data is performed in four steps:

- the data is coded as binary numbers at the sender end;
- a carrier signal is modulated as specified by the binary representation of the data;
- at the receiving end, the incoming signal is demodulated into the respective binary numbers; and
- decoding of the binary numbers is performed.

A physical medium in data communications is the transmission path over which a signal propagates. Many transmission media are used as communications channels.

For telecommunications purposes in the United States, Federal Standard 1037C transmission media are classified as one of the following:

- guided (or bounded): waves are guided along a solid medium, such as a transmission line; and
- wireless (or unguided): transmission and reception are achieved by means of an antenna.

2. Copper Wire

One of the most common physical mediums used in networking is copper wire. Copper wire is currently the most commonly used type of physical media due to the abundance of copper in the world, as well as its ability to conduct electricity. Copper wire can carry signals over long distances using relatively low amounts of power. Most copper wires used in data communications today have eight strands of copper organized in unshielded twisted pairs, or UTP. The wires are twisted around one another because it reduces electrical interference from outside sources. In addition to UTP, some wires use shielded twisted pairs (STP), which reduce electrical interference even further. The way copper wires are twisted around one another also has an effect on data rates. Category 3 cable (Cat3) has three to four twists per foot and can support speeds of 10 Mbit/s. Category 5 cable (Cat5) is newer and has three to four twists per inch, which results in a maximum data rate of 100 Mbit/s. In addition, there are category 5e (Cat5e) cables, which can support speeds of up to 1,000 Mbit/s, and more recently, category 6 cables (Cat6), which support data rates of up to 10,000 Mbit/s (or 10 Gbit/s).

3. Optical Fiber

Another example of a physical medium is optical fiber, which has emerged as the most commonly used transmission medium for long-distance communications. An optical fiber is a flexible, transparent fiber made of glass (silica) or plastic, slightly thicker than a human hair. It can function as a waveguide to transmit light between the two ends of the fiber. Optical fibers are widely used in fiber-optic communications, which permits transmission over longer distances and at higher bandwidths (data rates) than other forms of communication. Four major factors favor optical fiber over copper – data rates, distance, installation, and cost. Optical fiber can carry huge amounts of data compared to copper. It can be run for hundreds of miles without the need for signal repeaters, in turn, reducing maintenance costs and improving the reliability of the communication system because repeaters are a common source of network failures. Glass is lighter than copper allowing for less need for specialized heavy-lifting equipment when installing long-distance optical fiber. Optical fiber for indoor applications cost approximately a dollar a foot, the same as copper.

Optical fibers typically include a transparent core surrounded by a transparent cladding material with a lower index of refraction. Light is kept in the core by total internal reflection. This causes the fiber to act as a waveguide. Multimode and single-mode are two types of commonly used optical fiber. Fibers that support many propagation paths or transverse modes are called multimode fibers (MMF), while those that only support a

single mode are called single-mode fibers (SMF). Multimode fibers use LEDs as the light source, generally have a wider core diameter, and are used for short-distance communication links (about 2 kilometers) and for applications where high power must be transmitted. Single-mode fibers are used for most communication links longer than 1,050 meters and can carry signals over distances of tens of miles.

Joining lengths of optical fiber is more complex than joining electrical wire or cable. The ends of the fibers must be carefully cleaved and then spliced together, either mechanically or by fusing them with heat. Special optical fiber connectors for removable connections are also available.

4. Coaxial Cable

Yet another example of a physical medium is coaxial cables, often called coax. Introduced in the mid-1920s, coax was the second transmission medium to be put forward. Coaxial cables have two different layers surrounding a copper core. The innermost layer has an insulator. The next layer has a conducting shield. These are both covered by a plastic jacket. Coaxial cables are used for microwaves, televisions, and computers. In the center of a coaxial cable is a copper wire that acts as a conductor where the information travels. The copper wire in coax is thicker than that in twisted-pair, and it is also unaffected by surrounding wires that contribute to electromagnetic interference, so it can provide higher transmission rates than the twisted-pair. The center conductor is surrounded by plastic insulation, which helps filter out extraneous interference. This insulation is covered by a return path, which is usually braided-copper shielding or aluminum foil type covering. Outer jackets form a protective covering for coax; the number and type of outer jackets depend on the intended use of the cable (e.g., whether the cable is supposed to be strung in the air or underground, whether rodent protection is required, etc.).

The two most popular types of coaxial cabling are used with Ethernet networks. Thinnet is used on Ethernet 10BASE2 networks and is the thinner, more flexible of the two. Unlike a thicknet, thinnet uses a British naval connector (BNC) on each end to connect to computers. Thinnet is part of the RG-58 family of cable with a maximum cable length of 185 meters and transmission speeds of 10 Mbit/s. Thicknet coaxial cabling is used with Ethernet 10BASE5 networks, has a maximum cable length of 500 meters, and transmission speeds of 10 Mbit/s. It's expensive and not commonly used; although, it was originally used to directly connect computers. The computer is connected to the transceiver at the cable from the attachment unit interface of its network card using a drop cable. Maximum thicknet nodes are 100 on a segment. One end of each cable is grounded.

5. Wireless Media

Wireless media may carry surface waves or skywaves, either longitudinally or transversely, and are so classified. In both forms, communication is achieved through

electromagnetic waves. With guided transmission media, the waves are guided along a physical path; examples of guided media include phone lines, twisted pair cables, coaxial cables, and optical fibers. Unguided transmission media are methods that allow the transmission of data without the use of physical means to define the path it takes. Examples of this include microwave, radio, or infrared. Unguided media provide a means for transmitting electromagnetic waves but do not guide them; examples are propagation through air, vacuum, and seawater.

The term *direct link* is used to refer to the transmission path between two devices in which signals propagate directly from transmitters to receivers with no intermediate devices, other than amplifiers or repeaters used to increase signal strength. This term can apply to both guided and unguided media.

A transmission may be simplex, half-duplex, or full-duplex. In simplex transmission, signals are transmitted in only one direction; one station is a transmitter and the other is the receiver. In the half-duplex operation, both stations may transmit, but only one at a time. In full duplex operation, both stations may transmit simultaneously. In the latter case, the medium is carrying signals in both directions at the same time.