Transmission Media

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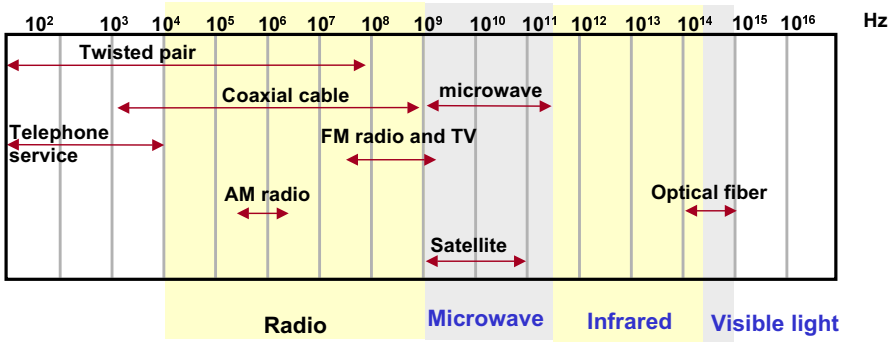
Type of Media

- **Guided Transmission Media**
  - **Conductive metal**
    - twisted pair, coaxial cable
  - **Glass or plastic**
    - fiber optic
- **Wireless transmission**
  - microwave, satellite

A conductive metal such as copper transmits data using electric current. A transparent glass or plastic such as fiber optic cable transmits data using light waves.

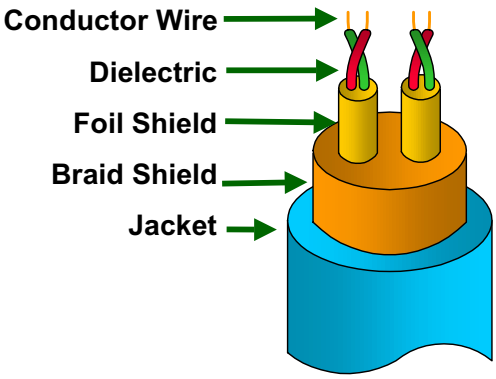
Wireless transmission requires no physical media but relies on electromagnetic waves such as those found in television and radio broadcasts. The waves radiate by inducing a current in a transmitting antenna and then travel through the air or free space. This type of media is such as microwave and satellite transmission.

Electromagnetic Spectrum



The picture above shows the electromagnetic spectrum and indicates the frequencies at which various guided media and unguided transmission techniques operate.

Twisted Pair



- Two varieties
  - unshielded
  - shielded

Since straight copper wires tend to act as antennas and pick up extraneous signal. The twisting helps reduce the amount of outside inferences.

Twisted pairs often are bundled together and wrapped in a protective coating. Each pair has twist length, reducing the interference between them (crosstalk).

Conductor Wire : Made of copper, copper treated with tin or silver, or aluminum or steel covered with copper.

Dielectric : Nonconductive material (such as polyethylene or Teflon)

Foil Shield : Made of polypropylene or polyester tape coated with aluminum on both sides (STP only).

Braid Shield : Flexible conductive wire braided around the dielectric. Braid may be made of aluminum or bare or treated copper.

Jacket : Made of polyvinylchloride or polyethylene for nonplenum cable; made of Teflon or Kynar for plenum cable.

Unshield Twisted-Pair (UTP)

- **Does not include any extra shielding around the wire pairs**
- **Ordinary telephone line and commonly used for local area network**
- **Least expensive, easy to work and simple to install**
- **Subject to external electromagnetic interference**
- **Limited length**

UTP is the primary choice for a 10BaseT and 100BaseT Ethernet network that uses UTP cabling at 10 Mbps and 100 Mbps respectively. Because it lacks shielding, UTP is not as good at blocking noise and interference as STP.

Shield Twisted-Pair Cable (STP)

- **Covered with a foil shield to reduce interference and crosstalk**
- **Better performance, but more expensive and difficult to work than UTP**

STP can handle high-speed transmissions. Cable itself is relatively expensive, can be quite bulky and heavy. STP is used in ARCnet and Token Ring networks.

Coaxial cable

- **Functionally grouped into**

Baseband
cable is dedicate for only one channel

Broadband
cable can carry several analog signals (at different frequencies) simultaneously.

Coaxial cable is popular for cable television transmissions and for creating LAN such as 10Basee operates at 10 Mbps .

RG-6 : drop cable for CATV, 75 Ω impedance.

RG-8 : thick Ethernet LAN (10Base5), 50 Ω.

RG-11 : main CATV truck, 75 Ω.

RG-58 : thin Ethernet (10base2), 50 Ω.

RG-59 : ARCnet, 75 Ω.

Optical Fiber

- **Light wave.**
- **High transmission rate.**
- **Immune to interference.**
- **Light weight.**

Fiber-optic cable or optical fiber provides a medium for signals using light rather than electricity. Light waves are immune to electromagnetic interference and crosstalk. Optical fiber can be used for much longer distances before the signal must be amplified. Data transmission using optical fiber is many times faster than with electrical methods.

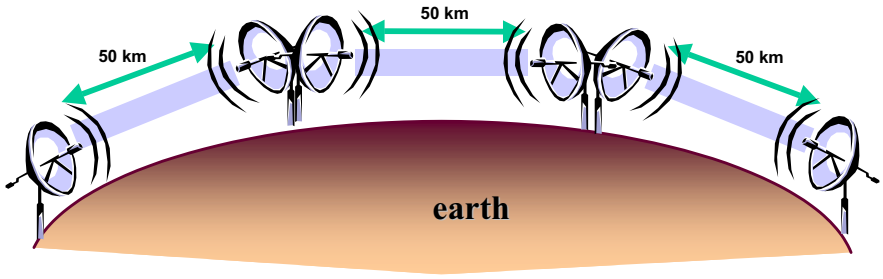
Microwave

- **Transmission between two ground stations**
- **Distance ≈ 50 km (depend on the height of antennas)**

direct line of sight transmission between two ground stations

microwave transmission tower

$D=7.14\sqrt{Kh}$; K=4/3

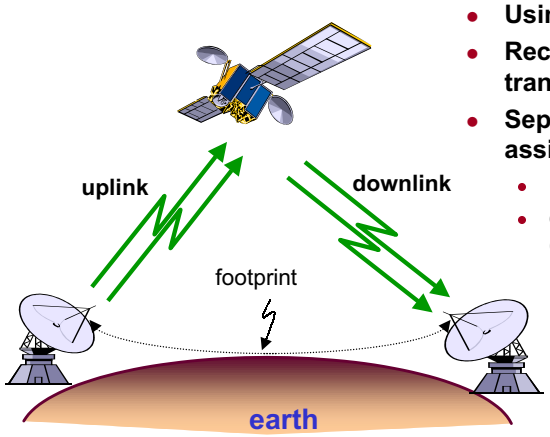


Microwave links are widely used to provide communication links when it is impractical or too expensive to install physical transmission media. Two properties of microwave transmission place restrictions on its use. First, microwaves travel in a straight line and will not follow the earth's curvature. Second, atmospheric conditions and solid objects interfere with microwaves. For example, they cannot travel through buildings.

Typical microwave distances before repeaters are necessary :

Frequency	Approx. distance
2-6 GHz	30 miles
10-12 GHz	20 miles
18 GHz	7 miles
23 GHz	5 miles

Satellites



- Using microwave
- Receive and retransmit using transponder
- Separate frequencies are assigned for
  - upward transmission (uplink)
  - downward transmission (downlink)

Satellite transmission is microwave transmission in which one of the stations is a satellite orbiting the earth. A microwave beam is transmitted to the satellite from the ground. This beam is received and retransmitted (relayed) to the predetermined destination. Receiver and transmitter in satellites is known as transponder.

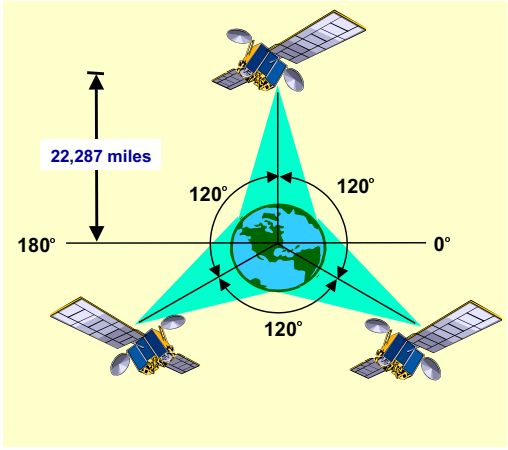
The optimum frequency range for satellite transmission is in the range 1 to 10 GHz. Below 1 GHz, there is significant noise from natural sources, atmospheric noise, and noise from electronic devices. Above 10 GHz, the signal is attenuated by atmospheric absorption.

Satellite Bands

Freq.	Band	uplink	downlink	use
4/6	C	5.925-6.425	3.7-4.2	commercial
7/8	X	7.9-8.4	7.9-8.4	military
11/14	Ku	14.0-14.5	11.7-12.2	commercial
20/30	Ka	27.5-30.5	17.7-21.2	military
20/44	Q	43.5-45.5	20.2-21.32	military

Satellite operates in specific frequency ranges. Bands are grouped in pairs such as 4/6 GHz, where the number refers to downlink /uplink frequencies. The above are example of primary bands. Normally there are many microwave bands assigned by letter : P, L, C, X, K, Q, V and W. Most of these bands have a subband such as Ku, Ka, Kt, Kp , Ce, Cz etc.

Geostationary Satellite



- **Remains in a fixed position relative to ground station.**
- **Used for communication purposed.**
- **Used 3 satellites to cover all over the earth except the polar extreme (latitudes > 81° north or south).**

Satellites moves across the sky, communication is possible for only a short time. As at dropped below the horizon, communication ceased until it later appeared above the other horizon.

To always provide communications, modern telecommunication satellites are positioned approximately 22,300 miles above the equator and arrange satellite's velocity synchronous with the earth's rotation. This is called *geostationary orbit*. Only three satellites are needed to provide coverage of the entire earth with small overlapping areas.

Kepler's third law

$P^2 = K \times D^3$

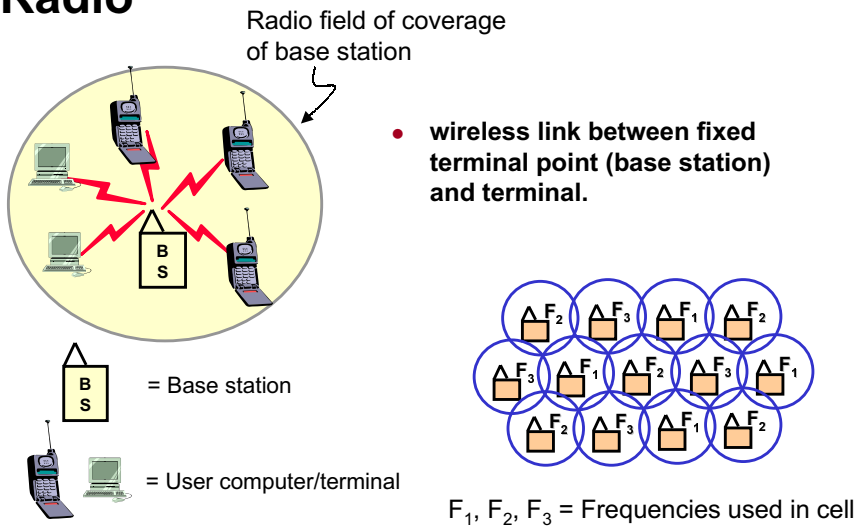
P = times to rotate = 24 hrs.

K = constant.

D = distance between satellite and earth's center.

D = 22,287 miles above the equator.

Radio



- **wireless link between fixed terminal point (base station) and terminal.**

A radio transmitter is placed at the fixed-wire terminal point; providing a wireless link between each terminal and central site. The coverage area of a base station is restricted by limiting its power output so that it provides only sufficient channels to support the total load in that area. Wider coverage is achieved by arraying multiple base stations in a cell structure.

Each base station operates using a different band of frequencies from its neighbors. Since the field of coverage of each base station is limited, it is possible to reuse its frequency band in other parts of the network. [Halsall]

Factor to select media

- **Cost**
- **Data rate & bandwidth**
- **Distance**

	Twisted pair	Coaxial	Optical fiber	Microwave	Satellite
Data rate	1-100 Mbps	10 Mbps	400-500 Mbps	200-300 Mbps	1-2 Mbps
interference	electrical	electrical	immune	solid object	atmospheric condition
distance	up to 1 mile (1-2 Mbps for 1 mile 10 Mbps for 100 m)	2-3 miles	20-30 miles	20-30 miles	unlimited

Different type of media have different manufacturing cost. In addition, devices to which they attach have various costs. Various media can support different data rate and bandwidth. Users choose a proper media for data rate need. The last factor is how long a media can carry data.