Class 4 ((Communication and Computer Networks))

Lesson 3... Transmission Media, Part 2 / Wireless

Abstract

Unguided media transport electromagnetic waves without using a physical conductor. This type of communication is often referred to as wireless communication. Signals are normally broadcast through free space and thus are available to anyone who has a device capable of receiving them. The objective of this lesson is to make the student more familiar with some techniques used in wireless communication.

Key points;

Introduction

For unguided media, transmission and reception are achieved by means of an antenna. For transmission, the antenna radiates electromagnetic energy into the medium (usually air), and for reception, the antenna picks up electromagnetic waves from the surrounding medium. There are basically <u>two types of configurations</u> for wireless transmission: **directional** and **omnidirectional**.

For the directional configuration, the transmitting antenna puts out a focused electromagnetic beam; the transmitting and receiving antennas must therefore be carefully aligned.

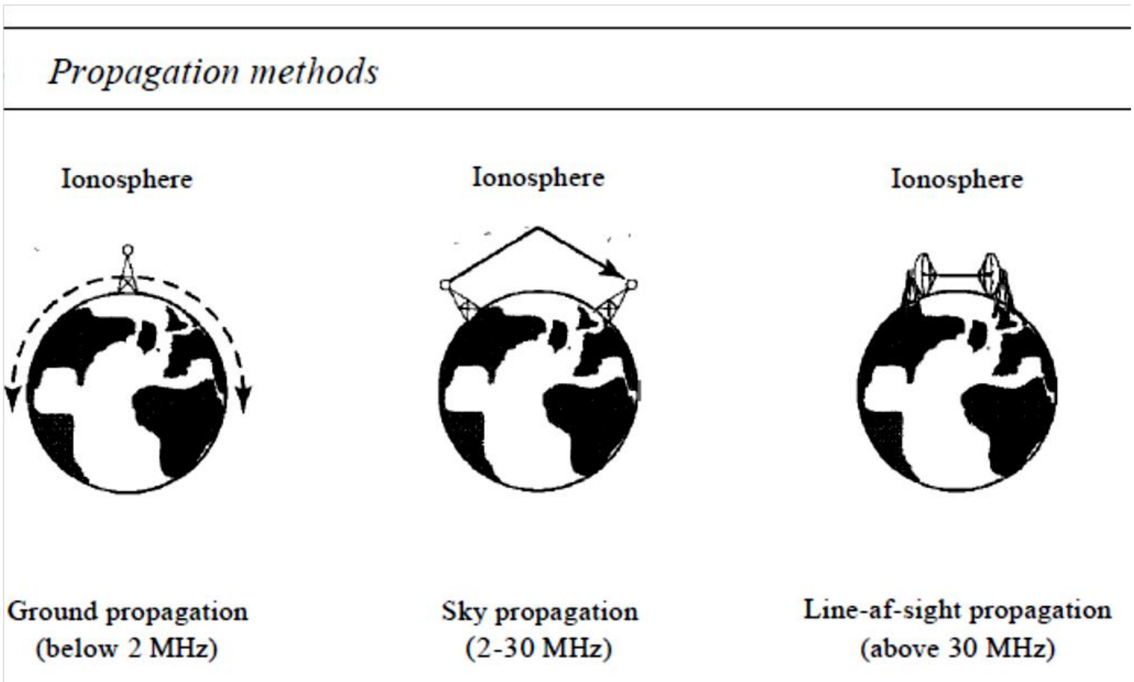
In the omnidirectional case, the transmitted signal spreads out in all directions and can be received by many antennas. In general, the higher the frequency of a signal, the more it is possible to focus it into a directional beam.

Three general **ranges of frequencies** are of interest in our discussion of wireless transmission. Frequencies in the range of about **2 GHz to 40 GHz** are referred to as **microwave frequencies**. At these frequencies, highly directional beams are possible, and **microwave is quite suitable for point-to-point transmission**. Microwave is also used for satellite communications.

Frequencies in the range of **30 MHz to 1 GHz** are suitable for omnidirectional applications. We will refer to this range as the broadcast radio range.

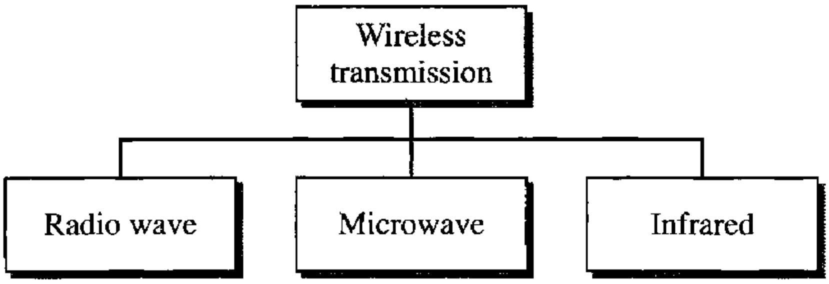
Another important frequency range, for local applications, is the infrared portion spectrum. This cover, roughly, from 3 X 10^{11} to 2 X 10^{14} Hz. Infrared is useful to local point-to-point and multipoint applications within confined areas, such as a single room.

Unguided signals can travel from the source to destination in several ways: **ground propagation**, **sky propagation**, and **line-of-sight propagation**, as we will see in the next sections.



Wireless transmission waves

We can divide wireless transmission into three broad groups: radio waves, microwaves, and infrared waves. See Figure below,



Radio Waves

Although there is no clear-cut between radio waves and microwaves, electromagnetic waves ranging in frequencies between 3 kHz and 1 GHz are normally called **radio waves**; waves ranging in frequencies between 1 and 300 GHz are called **microwaves**.

Radio waves, for the most part, are omnidirectional. This means that the sending and receiving antennas do not have to be aligned. A sending antenna sends waves that can be received by any receiving antenna. The omnidirectional property has a disadvantage too. The radio waves transmitted by one antenna are susceptible to interference by another antenna that may send signals using the same frequency or band.

Radio waves, particularly those of low and medium frequencies, can penetrate walls. This characteristic can be both an advantage and a disadvantage. It is an advantage because, for example, an AM radio can receive signals inside a building. It is a disadvantage because the radio wave band is relatively narrow, just under 1 GHz, compared to the microwave band. When this band is divided into subbands, the subbands are also narrow, leading to a low data rate for digital communications.

Almost the entire band is regulated by authorities. Using any part of the band requires permission from the authorities.

Microwaves

Electromagnetic waves having frequencies between 1 and 300 GHz are called microwaves. Microwaves are unidirectional. When an antenna transmits microwave waves, they can be narrowly focused. This means that the sending and receiving antennas need to be aligned. The unidirectional property has an obvious advantage. A pair of antennas can be aligned without interfering with another pair of aligned antennas.

The following describes some characteristics of microwave propagation:

- Microwave propagation is line-of-sight.
- Very high-frequency microwaves cannot penetrate walls.
- The microwave band is relatively wide, almost 299 GHz

Terrestrial Microwave

The antenna is fixed rigidly and focuses a narrow beam to achieve line-of-sight transmission to the receiving antenna.With no intervening obstacles, the maximum distance between antennas conforms to:

$$d = 7.14\sqrt{Kh}$$

where *d* is the distance between antennas in kilometers, *h* is the antenna height in meters, and K is an adjustment factor accounts for the fact that microwaves are bent or refracted with the curvature of the earth and will, hence, propagate farther than the optical line of sight. A good rule of thumb is K = 4/3. For example, two microwave antennas at a height of 100 m may be as far as 7.14 X = 82 km apart.

To achieve long-distance transmission, a series of microwave relay towers is used; point-to-point microwave links are strung together over the desired distance.

The primary use for terrestrial microwave systems is in long-haul telecommunications service, as an alternative to coaxial cable or optical fiber. The microwave facility requires far fewer amplifiers or repeaters than coaxial cable over the same distance, but requires line-of-sight transmission. Microwave is commonly used for both voice and television transmission.

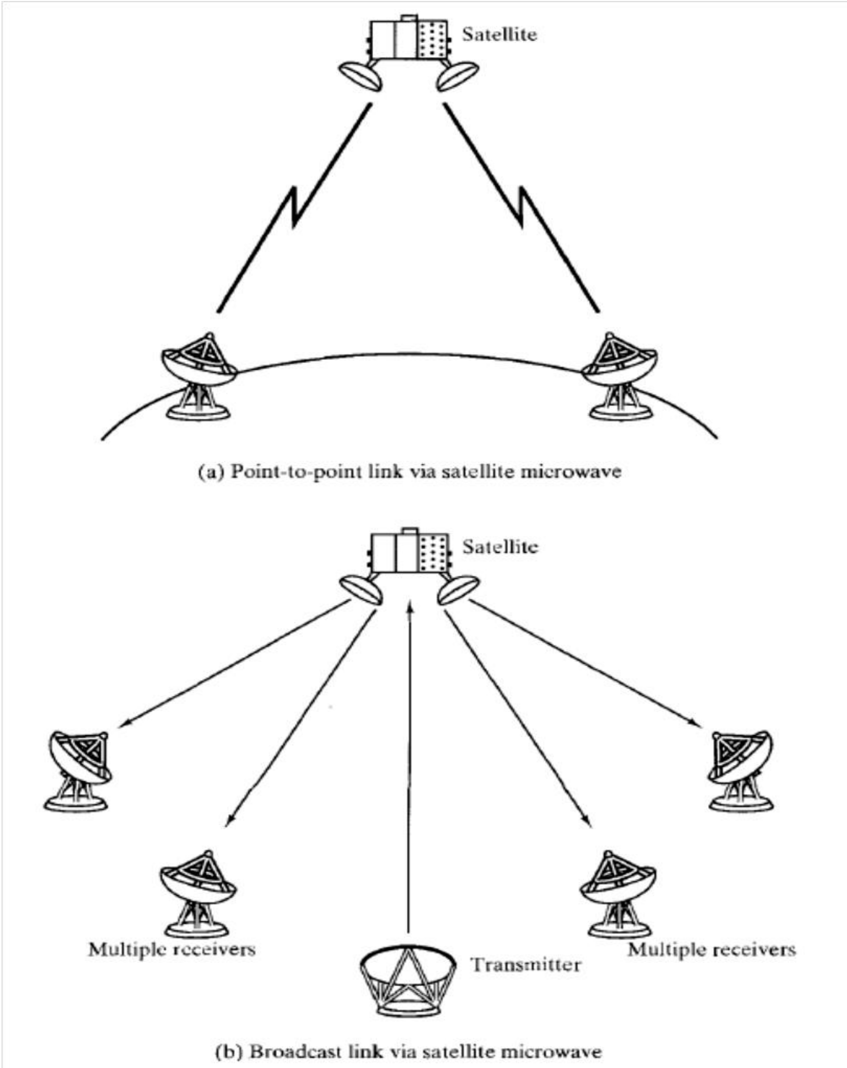
Another increasingly common use of microwave is for short point-to-point links between buildings; this can be used for closed-circuit TV or as a data link between local area networks.

Repeaters or amplifiers, then, may be placed farther apart for microwave systems-10 to 100 km is typical. Attenuation increases with rainfall, the effects of which become especially noticeable above 10 GHz. Another source of impairment is interference.

Satellite Microwave

A communication satellite is, in effect, a microwave relay station. It is used to link two or more ground-based microwave transmitter/receivers, known as earth stations, or ground stations. The satellite receives transmissions on one frequency band (uplink), amplifies or repeats the signal, and transmits it on another frequency (downlink). A single orbiting satellite will operate on a number of frequency bands, called transponder channels, or simply transponders.

Figure below depicts, in a general way, two common configurations for satellite communication. In the first, the satellite is being used to provide a point-to-point link between two distant ground-based antennas. In the second, the satellite provides communications between one ground-based transmitter and a number of ground-based receivers.



To remain stationary, the satellite must have a period of rotation equal to the earth's period of rotation.

The communication satellite is a technological revolution as important as fiber optics. Among the most important applications for satellites are

Television distribution

Long-distance telephone transmission

Private business networks

The optimum frequency range for satellite transmission is 1 to 10 GHz. Below 1 GHz, there is significant noise from natural sources, including galactic, solar, and atmospheric noise, and human-made interference from various electronic devices.

Above 10 GHz, the signal is severely attenuated by atmospheric absorption and precipitation. Most satellites providing point-to-point service today use a frequency bandwidth in the range 5.925 to 6.425 GHz for transmission from earth to satellite (uplink) and a bandwidth in the range 3.7 to 4.2 GHz for transmission from satellite to earth (downlink). This combination is referred to as the 416 GHz band.

The 12/14 GHz band has been developed (uplink: 14 to 14.5 GHz; downlink: 11.7 to 12.2 GHz). At this frequency band, attenuation problems must be overcome. However, smaller and cheaper earth-station receivers can be used. It is anticipated that this band will also saturate, and use is projected for the 19/29 GHz band (uplink: 27.5 to 31.0 Ghz; downlink: 17.7 to 21.2 GHz). This band experiences even greater attenuation problems but will allow greater bandwidth (2500 MHz versus 500 MHz) and even smaller and cheaper receivers.

Infrared

Infrared waves, with frequencies from 300 GHz to 400 THz (wavelengths from 1 mm to 770 nm), can be used for short-range communication. Infrared waves, having high frequencies, cannot penetrate walls. This advantageous characteristic prevents interference between one system and another; a short-range communication system in one room cannot be affected by another system in the next room. When we use our infrared remote control, we do not interfere with the use of the remote by our neighbors. However, this same characteristic makes infrared signals useless for long-range communication. In addition, we cannot use infrared waves outside a building because the sun's rays contain infrared waves that can interfere with the communication.