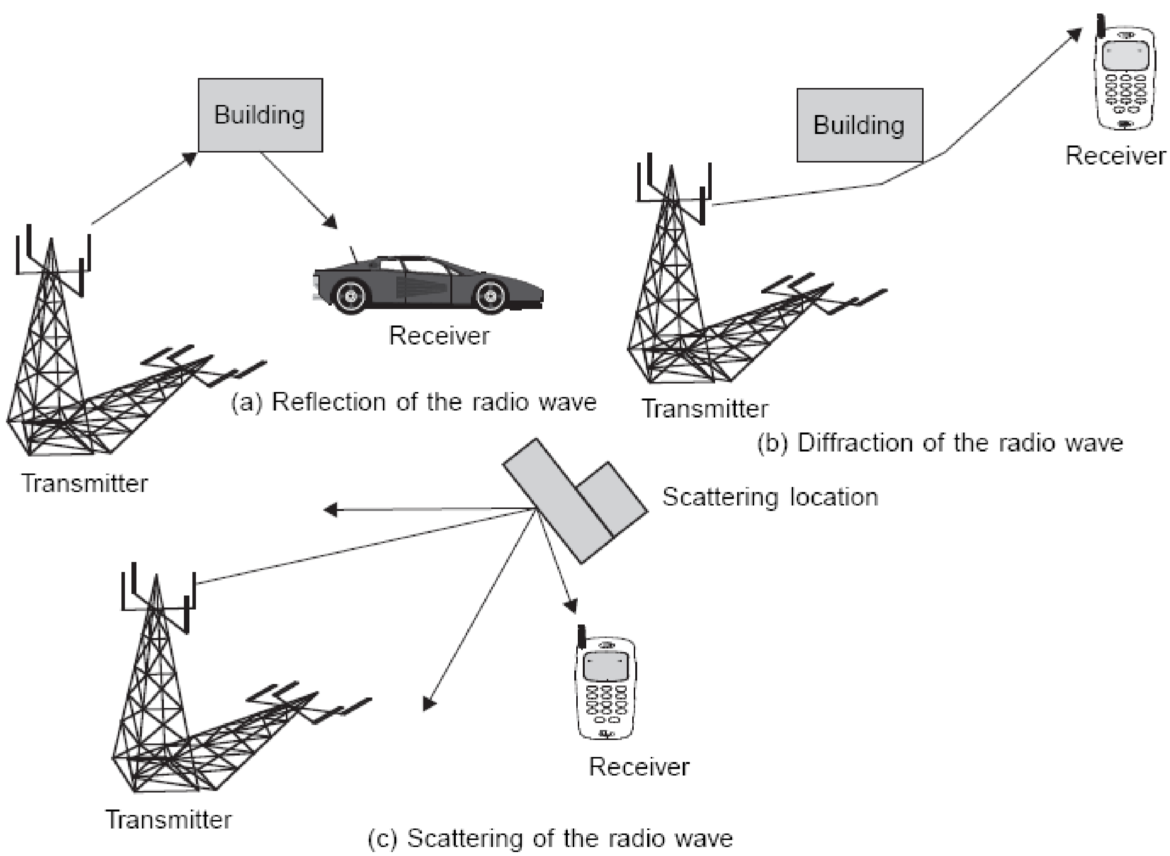
Radio Propagation and Propagation Path-Loss Models

Exponential growth of mobile communications has increased interest in many topics in radio propagation. Much effort is now devoted to refi ne radio propagation path-loss models for urban, suburban, and other environments together with substantiation by fi eld data. Radio propagation in urban areas is quite complex because it often consists of refl ected and diffracted waves produced by multipath propagation. Radio propagation in open areas free from obstacles is the simplest to treat, but, in general, propagation over the earth and the water invokes at least one refl ected wave. For closed areas such as indoors, tunnels, and underground passages, no established models have been developed as yet, since the environment has a complicated structure. However, when the environmental structure is random, the Rayleigh model used for urban area propagation may be applied. When the propagation path is on line of sight, as in tunnel and underground passages, the environment may be treated either by the Rician model or waveguide theory. Direct wave models may be used for propagation in a corridor. In general, radio wave propagation consists of three main attributes: refl ection, diffraction and scattering (see Figure 3.1) [2]. *Refl ection* occurs when radio wave propagating in one medium impinges upon another medium with different electromagnetic properties. The amplitude and phase of the refl ected wave are strongly related to the medium's instrinsic impedance, incident angle, and electric fi eld polarization. Part of the radio wave energy may be absorbed or propagated through the refl ecting medium, resulting in a refl ected wave that is attenuated. *Diffraction* is a phenomenon by which propagating radio waves bend or deviate in the neighborhood of obstacles. Diffraction results from the propagation of wavelets into a shadowy region caused by obstructions such as walls, buildings, mountains, and so on. *Scattering* occurs when a radio signal hits a rough surface or an object having a size much smaller than or on the order of the signal wavelength.



This causes the Signal energy to spread out in all directions. Scattering can be viewed at the receiver as another radio wave source. Typical scattering objects are furniture, lamp posts, street signs, and foliage. In this chapter, our focus is to characterize the radio channel and identify those parameters which distort the information-carrying signal (i.e., base band signal) as itpenetrates the propagation medium. The several empirical models used for calculating path-loss are also discussed.

Applied wireless transmission techniques

The basic part of any digital communication system is the communication channel. This is the physical medium that carries information bearing signals from the *source* of the information to the *sink*. In a radio system the communication channel is the propagation of radio waves in free space (see Figure 4.1). As discussed in Chapter 3, radio waves in free space are subjected to fading. In nearly all communication systems some equipment is required to convert the information- bearing signal into a suitable form for transmission over the communication channel and then back into a form that is comprehensible to the end-user. This equipment is the *transmitter* and *receiver*. The receiver does not only perform the inverse translation to the transmitter, but it also has to overcome the distortions and disturbances (see Chapter 3) that occur over the communication channel. Thus, it is often more diffi cult to design the receiver than the transmitter. Speech coding, forward-error-correcting (FEC) coding, bit-interleaving, diversity, equalization, and modulation play important roles in a communication system, particularly in a radio system (see Chapters 7, 8, and 9). The transmitter for a radio system consists of antenna, RF section, encoder, and modulator. An *antenna* converts the electrical signal into a radio wave propagating in free space. The *RF section* of the transmitter generates a signal of suffi cient power at the required frequency. It typically consists of a power amplifi er, a local oscillator, and an up-converter. However, generally the RF section only amplifi es and frequency-converts a signal (see Figure 4.2). At the input of the transmitter the user interface interacts and converts the information into a suitable digital data stream. The information source can be analog (such as speech) or discrete (such as data). Analog information is converted into digital information through the use of sampling and quantization. Sampling, quantization, and encoding techniques are called formatting and source coding. The *source encoder* and *modulator* bridge the gap between the digital data and electrical signal required at the input to the RF section. The encoder converts the data stream into a form that is more resistant to the degradations introduced

Baseband Systems

Source information may contain either analog, textual, or digital data. *Formatting* involves sampling, quantization, and encoding. It is used to make the message compatible with digital processing. *Transmit formatting* transforms source information into digital symbols. When data *compression* is used in addition to formatting, the process is referred to as *source coding*. Figure 4.3 shows a functional diagram that primarily focuses on the formatting and transmission of baseband (information bearing) signals. The receiver with a detector followed by a signal decoder performs two main functions: (1) does reverse operations performed in the transmitter, and (2) minimizes the effect of channel noise for the transmitted symbol.

Messages, Characters, and Symbols

During digital transmission the characters are fi rst encoded into a sequence of bits, called a *bit stream* or *baseband signal*. Groups of b bits form a fi nite symbol set or word M (_ 2b) of such symbols [14,17]. A system using a symbol set size of M is referred to as an *M-ary system*. The value of b or M is an important initial choice in the design of any digital communication system. For b _ 1, the system is called a *binary system*, the size of symbol set M is 2, and the modulator uses two different waveforms to represent the binary "1" and the binary "0" (see Figure 4.4). In this case, the symbol rate and the bit rate are the same. For b _ 2, the system is called

Pulse Amplitude Modulation (PAM)

Pulse amplitude modulation [6] is a process that represents a continuous analog signal with a series of discrete analog pulses in which the amplitude of the information signal at a given time is coded as a binary number. PAM is now rarely used, having been largely superseded by pulse code modulation (PCM). Two operations involved in the generation of the PAM signal are:

1. Instantaneous sampling of the message signal $s(t)$ every T_s seconds, where f = $1/T_s$ is selected according to the sampling theorem.
2. Lengthening the duration of each sample obtained to some constant value T. These operations are jointly referred to as *sample and hold*. One important reason for intentionally lengthening the duration of each sample is to avoid the use of an excessive channel bandwidth, since bandwidth is inversely proportional to pulse duration. The Fourier transform of the rectangular pulse $h(t)$ is given as Using fl at-top sampling of an analog signal with a sample-and-hold circuit such that the sample has the same amplitude for its whole duration introduces *amplitude distortion* as well as a *delay*. This effect is similar to the variation in transmission frequency that is caused by the fi nite size of the scanning aperture in television. The distortion caused by the use of PAM to transmit an analog signal is called the *aperture effect*. The distortion may be corrected by use of an *equalizer*. The equalizer decreases the in-band loss of the reconstruction fi lter as the frequency increases in such a manner to compensate for the aperture effect. The amount of equalization required in practice is usually small. For T/T_s _ 0.1, the amplitude distortion is less than 0.5%, in which case the need or equalization may be omitted altogether

Pulse Code Modulation

Pulse code modulation (PCM) [13] is a digital scheme for transmitting analog data. It converts an analog signal into digital form. Using PCM, it is possible to digitize all forms of analog data, including full-motion video, voice, music, telemetry, etc. To obtain a PCM signal from an analog signal at the source (transmitter) of a communications circuit, the analog signal is sampled at regular time intervals. The sampling rate is several times the maximum frequency of the analog signal. The instantaneous amplitude of the analog signal at each sample is rounded off to the nearest of several specifi c, predetermined levels (quantization). The number of levels is always a power of 2. The output of a pulse code modulator is a series of binary numbers, each represented by some power of 2

bits. At the destination of the communications circuit, the pulse code modulator converts the binary numbers back into pulses having the same quantum levels as those in the modulator. These pulses are further processed to restore the original analog waveform. When pulse modulation is applied to a binary symbol, the resulting binary wave form is called a *pulse code modulation* waveform. When pulse modulation is applied to a nonbinary symbol, the resulting waveform is called *M-ary pulse modulation* waveform. Each analog sample is transmitted into a PCM word consisting of groups of b bits. The PCM word size can be described by the number of quantization levels that are used for each sample. The choice of the number of quantization levels, or bits per sample, depends on the magnitude of quantization distortion that one is willing to tolerate with the PCM format. In North America and Japan, PCM samples the analog waveform 8000 times per second and converts each sample into an 8-bit number, resulting in a 64 kbps data stream. The sample rate is twice the 4 kHz bandwidth required for a toll-quality voice conversion

Source : http://nprcet.org/e%20content/Misc/e-Learning/ECE/IV%20year-VIII%20semester/EC1016%20WIRELESS%20NETWORKS.pdf