Module 7

Spread Spectrum and Multiple Access Technique

Lesson 40

Multiple Access Techniques and Cellular CDMA

After reading this lesson, you will learn about

- ***Basic multiple access techniques;***
- ***Use of Code Division Multiple Access (CDMA) in cellular mobile communications***

An important use of the concept of spread spectrum in wireless communication systems is to allow multiple users occupy the same transmission band for simultaneous transmission of signals without considerable interference. The three basic multiple access techniques are briefly mentioned below:

a) Frequency Division Multiple Access (FDMA):

This classical technique has been in use in conventional telephone systems and satellite communication systems. Every user gets a certain frequency band assigned and can use this part of the spectrum to perform its communication. If only a small number of users is active, not the whole resource (frequency-spectrum) is used. Assignment of the channels can be done centrally or by carrier sensing in a mobile. The latter possibility enables random-access.

b) Time Division Multiple Access *(TDMA):*

Every user is assigned one or a set of well-defined time-slots within a 'Time Frame'. A transmitting user sends its own data only in the designated time-slot(s), and waits for the remaining time-frame duration till it gets another time-slot in the next time frame. Precise time synchronization among all users is an important and necessary feature of TDMA multiple access strategy. Usually, a central unit controls the synchronization and the assignment of time-slots.

c) Code Division Multiple Access (*CDMA) / Spread Spectrum Multiple Access (SSMA):*

One or more unique spreading codes are assigned to each user for accessing the RF bandwidth simultaneously for transmission and reception of signals. The spreading codes, assigned to all participating users, are carefully chosen to ensure very low cross-correlation among them. This ensures that the signals from undesired transmitters appear as noise (with no or very poor correlation with the desired signal after dispreading operation). CDMA / SSMA does not need very precise time synchronization among the users and hence, random-access is protocols can be implemented relatively easily.

In the following section, a brief account of CDMA scheme, used in cellular mobile communications, is presented.

Cellular CDMA

Mobile telephony, using the concept of cellular architecture, has been very popular world wide. Such systems are built based on accepted standards, such as GSM (Global System for Mobile communication) and IS-95(Intermediate Standard-95). Several standards of present and future generations of mobile communication systems include CDMA as an important component which allows a satisfactorily large number of users to communicate simultaneously over a common radio frequency band.

Cellular CDMA is a promising access technique for supporting multimedia services in a mobile environment as it helps to reduce the multi-path fading effects and interference. It also supports universal frequency reuse, which implies large teletraffic capacity to accommodate new calling subscribers. In a practical system, however, the actual number of users who can simultaneously use the RF band satisfactorily is limited by the amount of interference generated in the air interface. A good feature is that the teletraffic capacity is 'soft', i.e. there is no 'hard' or fixed value for the maximum capacity. The quality of received signal degrades gracefully with increase in the number of active users at a given point of time.

It is interesting to note that the quality of a radio link in a cellular system is often indicated by the Signal-to-Interference Ratio (SIR), rather than the common metric 'SNR'. Let us remember that in a practical system, the spreading codes used by all the simultaneous users in a cell have some cross-correlation amongst themselves and also due to other propagation features, the signals received in a handset from all transmitters do not appear orthogonal to each other. Hence, the signals from all users, other than the desired transmitter, manifest as interference. In a practical scenario, the total interference power may even momentarily exceed the power of the desired signal. This happens especially when the received signals fluctuate randomly (fading) due to mobility of the users. Fading is a major factor degrading the performance of a CDMA system. While large-scale fading consists of path loss and shadowing, small-scale fading refers to rapid changes in signal amplitude and phase over a small spatial separation.

The desired signal at a receiver is said to be 'in outage' (i.e. momentarily lost) when the SIR goes below an acceptable threshold level. An ongoing conversation may get affected adversely if the outage probability is high or if the duration of outage (often called as 'fade duration') is considerable. On the other hand, low outage probability and insignificant 'average fade duration' in a CDMA system usually implies that more users could be allowed in the system ensuring good quality of signal.