4.1.MULTIPLE ACCESS TECHNIQUES

Multiple access techniques are used to allow a large number of mobile users to share theallocated spectrum in the most efficient manner.

➔ As the spectrum is limited, so the sharing is required to increase the capacity of cell orover a geographical area by allowing the available bandwidth to be used at the same time by different users.

➔ And this must be done in a way such that the quality of service doesn't degrade within the existing users.

MULTIPLE ACCESS TECHNIQUES FOR WIRELESS COMMUNICATION

➔ In wireless communication systems it is often desirable to allow the subscriber to sendsimultaneously information to the base station while receiving information from the base station.

➔ A cellular system divides any given area into cells where a mobile unit in each cell communicates with a base station.

➔ The main aim in the cellular system design is to be able to increase the capacity of the channel i.e. to handle as many calls as possible in a given bandwidth with a sufficient level of quality of service.

➔ There are several different ways to allow access to the channel. These includes mainly the following:

1. Frequency division multiple-access (FDMA)
2. Time division multiple-access (TDMA)
3. Code division multiple-access (CDMA)

1) FREQUENCY DIVISION MULTIPLE ACCESS

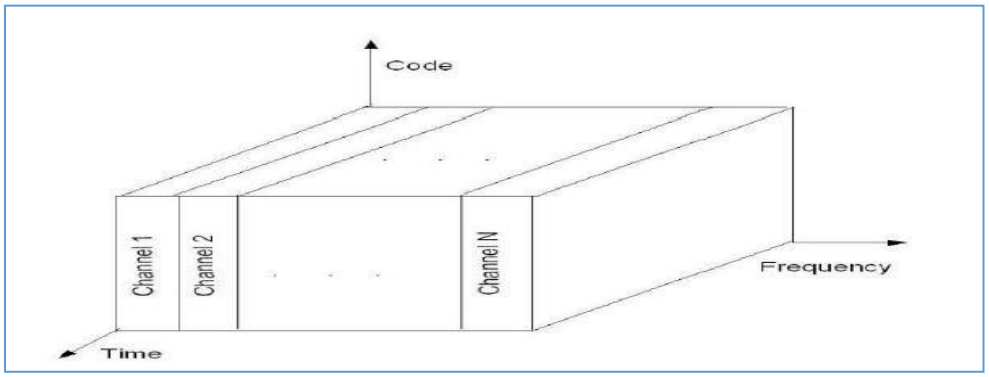

Figure : The basic concept of FDMA.

➔ This was the initial multiple-access technique for cellular systems in which each individual user is assigned a pair of frequencies while making or receiving a call as shown in Figure.
➔ One frequency is used for downlink and one pair for uplink. This is called frequency division duplexing (FDD).
➔ That allocated frequency pair is not used in the same cell or adjacent cells during the call so as to reduce the co channel interference.
➔ Even though the user may not be talking, the spectrum cannot be reassigned as long asa call is in place.
➔ Different users can use the same frequency in the same cell except that they must transmit at different times. The features of FDMA are as follows:
➔ The FDMA channel carries only one phone circuit at a time. If an FDMA channel is not in use, then it sits idle and it cannot be used by other users to increase share capacity.
➔ After the assignment of the voice channel the BS and the MS transmit simultaneously and continuously.
➔ The bandwidths of FDMA systems are generally narrow i.e. FDMA is usually implemented in a narrow band system The symbol time is large compared to the average delay spread.
➔ The complexity of the FDMA mobile systems is lower than that of TDMA mobile systems. FDMA requires tight filtering to minimize the adjacent channel interference.

FDMA/FDD in AMPS

➔ The first U.S. analog cellular system, AMPS (Advanced Mobile Phone System) is basedon FDMA/FDD.
➔ A single user occupies a single channel while the call is in progress, and the single channel is actually two simplex channels which are frequency duplexed with a 45 MHz split.
➔ When a call is completed or when a handoff occurs the channel is vacated so that another mobile subscriber may use it.
➔ Multiple or simultaneous users are accommodated in AMPS by giving each user a unique signal.
➔ Voice signals are sent on the forward channel from the base station to the mobile unit, and on the reverse channel from the mobile unit to the base station.
➔ In AMPS, analog narrowband frequency modulation (NBFM) is used to modulate the carrier.

FDMA/TDD in CT2

➔ Using FDMA, CT2 system splits the available bandwidth into radio channels in the assigned frequency domain.
➔ In the initial call setup, the handset scans the available channels and locks on to an unoccupied channel for the duration of the call.
➔ Using TDD(Time Division Duplexing), the call is split into time blocks that alternate between transmitting and receiving.

FDMA and Near-Far Problem

➔ The near-far problem is one of detecting or filtering out a weaker signal amongst stronger signals.

➔ The near-far problem is particularly difficult in CDMA systems where transmitters share transmission frequencies and transmission time.

➔ In contrast, FDMA and TDMA systems are less vulnerable. FDMA systems offer different kinds of solutions to near-far challenge.

➔ Here, the worst case to consider is recovery of a weak signal in a frequency slot next tostrong signal.

➔ Since both signals are present simultaneously as a composite at the input of a gain stage,the gain is set according to the level of the stronger signal; the weak signal could be lostin the noise floor. Even if subsequent stages have a low enough noise floor to provide

2) TIME DIVISION MULTIPLE ACCESS

➔ In digital systems, continuous transmission is not required because users do not use theallotted bandwidth all the time.

➔ In such cases, TDMA is a complimentary access technique to FDMA. Global Systemsfor Mobile communications (GSM) uses the TDMA technique.

➔ In TDMA, the entire bandwidth is available to the user but only for a finite period of time. In most cases the available bandwidth is divided into fewer channels compared toFDMA.

➔ The users are allotted time slots during which they have the entire channel bandwidth at their disposal, as shown in Figure

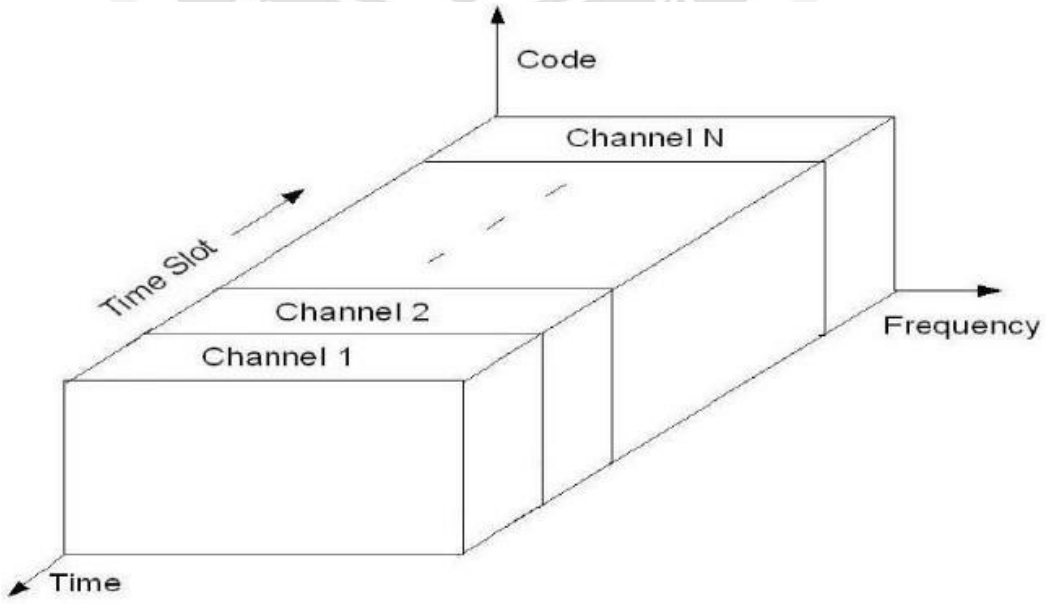

Figure : The basic concept of TDMA.

➔ TDMA requires careful time synchronization since users share the bandwidth in the frequency domain. The number of channels are less, inter channel interference is almost negligible.
➔ TDMA uses different time slots for transmission and reception. This type of duplexingis referred to as Time division duplexing (TDD).

- The features of TDMA includes the following:

a. TDMA shares a single carrier frequency with several users where each users makes use of non overlapping time slots.
b. The number of time slots per frame depends on several factors such as modulation technique, available bandwidth etc.
c. Data transmission in TDMA is not continuous but occurs in bursts. This results in low battery consumption since the subscriber transmitter can be turned OFF when not in use. Because of a discontinuous trans- mission in TDMA the handoff process is much simpler for a subscriber unit, since it is able to listen to other base stations during idle time slots.
d. TDMA uses different time slots for transmission and reception thus duplexers are not required.

➔ TDMA has an advantage that is possible to allocate different numbers of time slots perframe to different users.
➔ Thus bandwidth can be supplied on demand to different users by concatenating or reassigning time slot based on priority.

TDMA/FDD in GSM

➔ GSM is widely used in Europe and other parts of the world. GSM uses a variation of TDMA along with FDD.
➔ GSM digitizes and compresses data, then sends it down a channel with two other streams of user data, each in its

3) CODE DIVISION MULTIPLE ACCESS

➔ In CDMA, the same bandwidth is occupied by all the users, however they are all assigned separate codes, which differentiates them from each other shown in Figure
➔ CDMA utilize a spread spectrum technique in which a spreading signal (which is uncorrelated to the signal and has a large bandwidth) is used to spread the narrow band message signal.

Direct Sequence Spread Spectrum (DS-SS)

➔ This is the most commonly used technology for CDMA. In DS-SS, the message signal is multiplied by a Pseudo Random Noise Code.

- Each user is given his own codeword which is orthogonal to the codes of other users and in order to detect the user, the receiver must know the codeword used by the transmitter.

- There are, however, two problems in such systems which are discussed in thesequel.

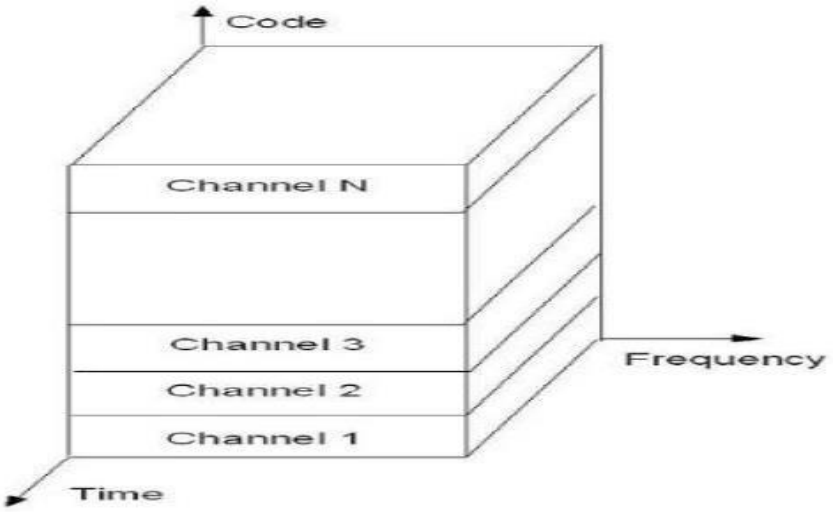

Figure : The basic concept of CDMA.

CDMA and Self-interference Problem

➔ In CDMA, self-interference arises from the presence of delayed replicas of signal dueto multipath.

➔ The delays cause the spreading sequences of the different users to lose theirorthogonality, as by design they are orthogonal only at zero phase offset.

➔ Hence in despreading a given user's waveform, nonzero contributions to that user'ssignal arise from the transmissions of the other users in the network.

➔ This is distinct from both TDMA and FDMA, wherein for reasonable time or frequencyguardbands, respectively, orthogonality of the received signals can be preserved.

CDMA and Near-Far Problem

➔ The near-far problem is a serious one in CDMA. This problem arises from the fact thatsignals closer to the receiver of interest are received with smaller attenuation than are signals located further away.

➔ Therefore the strong signal from the nearby transmitter will mask the weak signal fromthe remote transmitter.

➔ In TDMA and FDMA, this is not a problem since mutual interference can be filtered. In CDMA, however, the near-far effect combined with imperfect orthogonality betweencodes (e.g. due to different time sifts), leads to substantial interference.

➔ Accurate and fast power control appears essential to ensure reliable operation ofmultiuser DS-CDMA systems.