- In the second generation those which use TDMA- technology mobile assisted handoffs used are called MAHO. Wherein, every mobile station measures the received power to the surrounding base stations and continually reports these values to the corresponding base stations.
- Handoff is initiated when the signal strength of a neighbouring base station exceeds that of the current base stations. So attempt is made to hook on to a stronger signal at any point of time.

Soft handoff:
The ability to make a choice between the instantaneous received signals from different base stations is called *Soft handoff*. CDMA uses soft handoff approach.

8.6. Multiple access schemes

Simultaneous access to communication resources for many subscriber from widely different locations on earth is always preferred. Such a capability is called "Multiple Access".

The purpose of multiple access is to permit sharing of the communication resources by a large number of subscribers (users) seeking to communicate with each other. It is also desired that the sharing of the communication resources should be accomplished without causing serious interference to each other.

There are three basic types of multiple access techniques. They are

1. Frequency Division Multiple Access (FDMA)
2. Time Division Multiple Access (TDMA)
3. Code Division Multiple Access (CDMA)

8.6.1. FDMA

In this FDMA technique, disjoint frequency sub-bands are allocated to different users on a continuous time basis. In TDMA, guard bands are introduced as buffer zones between the allocated adjacent channel bands as shown in the figure below. This is done for avoiding interference between users.

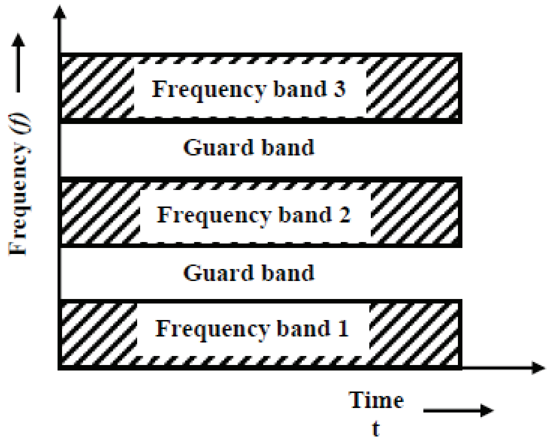

Fig: 8.11 Frequency division multiple access

In FDMA, the user should occupy the available time slot fully, but in small different frequency slot.

Channels can be assigned to the same frequency at all times (pure FDMA). Sometimes frequencies are changed according to a certain pattern (FDMA combined with TDMA). Frequency Division Multiplexing (FDM) is often used for simultaneous access to the medium by a base station and a mobile station in cellular networks. Here, the two partners typically establish a duplex channel. The signals from the base station to the mobile station and vice versa are separated using different frequencies. This method is called as Frequency Division Duplex (FDD). Both the partners have to know the frequencies in advance or otherwise they cannot listen into the medium. The two frequencies are also known as uplink (i.e.,) from mobile station (or mobile unit) to base station and as downlink (i.e.,) from base station to mobile station.

For explaining FDMA, let us consider a mobile phone network based on the GSM standard for 900 MHz. The basic frequency allocation scheme for GSM is fixed. All uplinks use the band between 890 and 915 MHz and all downlinks use the band between 935 and 960 MHz. Both the uplink and downlink have been allocated 25 MHz for a total of 50 MHz. The total number of channels in FDMA is 124 and each channel is 200 KHz. The duplex separation is 45 MHz.

According to FDMA, the base station allocates a certain frequency for up and down link to establish a duplex channel with the mobile unit.

Up and down links have a fixed relation. If the uplink frequency is $f_u = \mathbf{890}MHz + (n \times \mathbf{0.2}MHz)$,

the downlink frequency is $f_d = f_u + \mathbf{45}MHz$.

i.e. $f_d = \mathbf{890}MHz + (n \times \mathbf{0.2}MHz) + \mathbf{45}MHz = \mathbf{935}MHz + (n \times \mathbf{0.2}MHz)$ for a certain channel n.

This shows the use of FDM for multiple access and duplex according to a predetermined scheme.

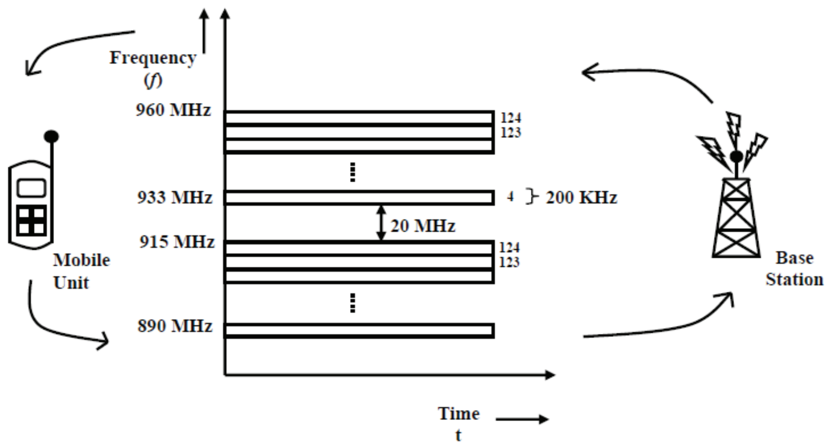

Fig: 8.12 FDD/FDMA system

8.6.2. TDMA

In the TDMA technique, each user is allocated the full spectral occupancy but only for a short duration of time called a time slot. Buffer zones in the form of guard band are inserted between the assigned time slots as shown below to avoid interference between users.

An alternative to FDMA is the TDMA technique. In TDMA, each user has access to the entire authorized radio frequency spectrum for a short time for transmitting messages. Every user shares the authorized frequency spectrum with all other users who have time slot allocations at other pre assigned times.

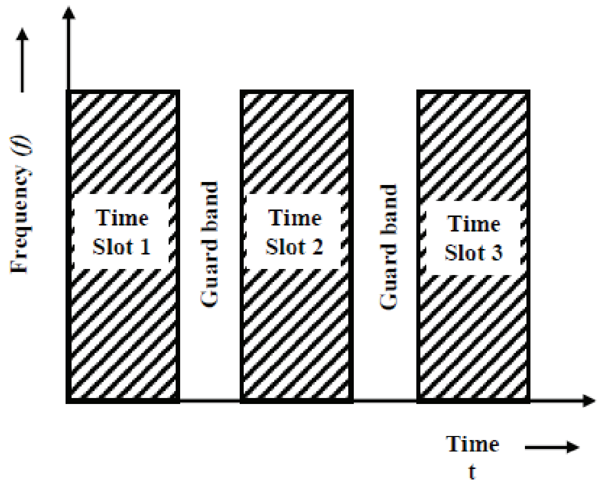

Fig: 8.13 Time division multiple access

Depending upon the allocation of available radio spectrum, TDMA technique is divided into two types. They are

1. Narrow band TDMA
2. Wide band TDMA

When available frequency spectrum is only partially allocated to a particular user group, the access method is called as Narrow band TDMA.

When the entire available frequency spectrum is allocated to each user during the users time slot, this access method is called as Wide band TDMA.

It is important here to note that listening to different frequencies at the same time is quite difficult but listening to many channels separated in time at the same frequency is simple. This is the basic concept behind the TDMA technique.

In the TDMA technique, TDM patterns are used to implement multiple access and a duplex channel between a base station and mobile station as shown in the figure below. The TDMA technique is used in DECT cordless phone system. Allocation of different time slots for uplink and downlink using the same frequency is called Time Division Duplex (TDD).

The figure shows the time division multiplexing for multiple access and duplex operation. As shown in the figure 8.14, the base station uses one out of 12 time slots for downlinks where as the mobile station uses one out of 12 time slots for uplink. Hence the uplink and down link systems are separated by time slot. In addition up to 12 different mobile stations can use the same frequency without causing interference to others. In the above example (i.e., DECT cordless phone system) the access pattern is repeated every 10ms (i.e.,) till each time a slot has a duration of 417µs. This repetition ensures access to the medium every 10ms. Thus TDM is allocating time slots for channels in a fixed pattern which results in a fixed bandwidth and is the typical solution for any wireless phone system.

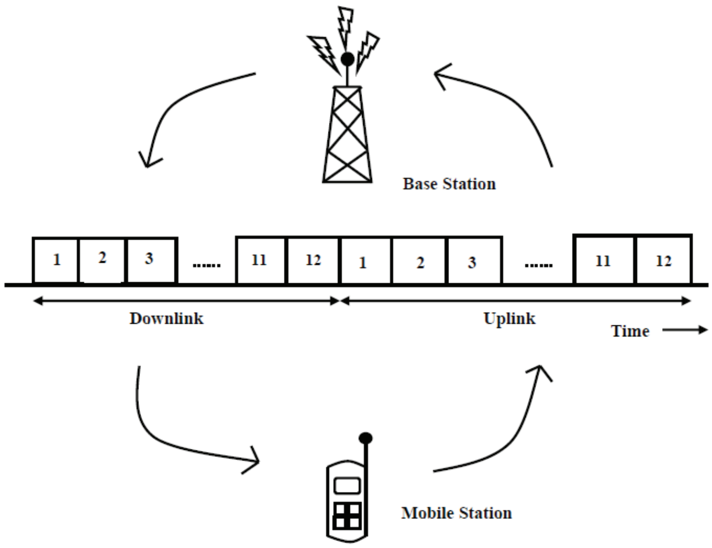

Fig: 8.14 TDD/TDMA scheme

In this TDMA technique, there is need for synchronization in the time domain between the sender and the receiver. This synchronization can be done by using a fixed pattern (i.e., allocating a certain time slot for a channel) or by using a dynamic allocation scheme.

8.6.3. CDMA

Codes with certain characteristics can be applied to the transmission to enable the use of Code Division Multiplexing (CDM). CDMA use the codes to separate different users in code space and to enable access to a shared medium without interference.

CDMA technique is an hybrid combination of FDMA and TDMA as illustrated in the figure.

Frequency hopping

In this technique, during each successive time slot, the frequency bands assigned to the users are recorded in an essentially random manner.

For example, during time slot 1, user 1 occupies frequency band 1, user 2 occupies frequency band 2 user 3 occupies frequency band 3 and so on. During time slot 2, user 1 hops to frequency band 3, user 2 hops to frequency band 1 and user 3 hops to frequency band 2 and so on. Such arrangement is called “frequency hopping”.

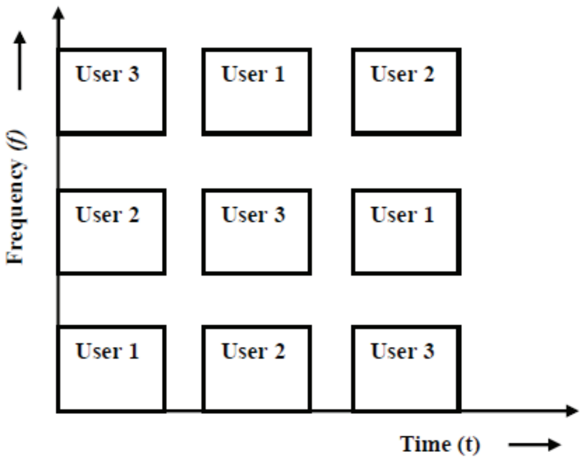

Fig: 8.15 Code division multiple access

In the CDMA technique, frequency hopping mechanism can be implemented through the use of a pseudo-noise (PN) sequence which is a cyclic code with noise like characteristics.

An important advantage of CDMA over both FDMA and TDMA is that it can provide for “secure communications”.

In CDMA, each user is provided with an individual distinctive pseudo-noise (PN) code. In the absence of mutual correlation, within the same mobile cell, a large number of independent users can transmit at the same time and in the same radio bandwidth. The receiver decorrelates (despread) the information and regenerates only the desired data sequence.

Here, each mobile unit transmits its data source along with the uncorrelated pseudo-noise code in the same radio frequency bandwidth at the same time as the other mobile transmitters. The base station receiver receives all the signals and the adaptive power circuitry at the base station ensures that all the received signals at the base station have the same power. The base station receiver decorrelate (despread) and demodulate the independent messages from the mobile transmitter.

The main problem arising in CDMA is how to find 'good' codes and how to separate the signal from the noise generated by other signals and the environment.

The following theoretical example explains the basic function of CDMA.

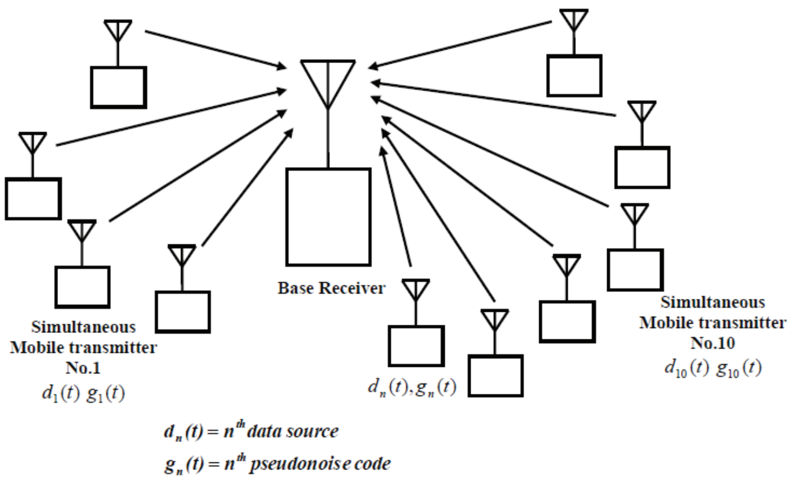

Fig: 8.16 CDMA access mechanisms

Two senders A and B want to send data CDMA assign the following key sequence key A_K = 010011, key B_K = 110101. Let us assume that sender A sends the bit $A_d = 1$ and B sends the data bit $B_d = 0$. For illustration let us code a binary 0 as -1 and as a binary 1 as +1.

Both the senders spread their signal using their keys as chipping sequence. The term spreading refers to the simple multiplication of the data bit with the whole chipping sequence.

Sender A then sends the signal A_s as,

$A_s = A_d * A_k = (+1) * (-1, +1, -1, -1, +1, +1)$

$= (-1, +1, -1, -1, +1, +1)$

Sender B then sends the signal

$B_s = B_d * B_k = (-1) * (+1, +1, -1, +1, -1, +1)$

$= (-1, -1, +1, -1, +1, -1)$

Both the signals are then transmitted simultaneously using same frequency and thus the signals get super imposed in space.

(i.e.,) Assume any error occuring from environmental noise.

Neglecting interference from other senders and environmental noise and assuming that the signals have the same strength at the receiver, the signal received at the receiver is given by

$C = A_g + B_g = (-2, 0, 0, -2, +2, 0)$

The receiver now wants to receive data from sender A and therefore tunes into the code of A (i.e.,) it applies A's code for despreading as,

$C * A_k = (-2, 0, 0, -2, +2, 0) * (-1, +1, -1, -1, +1, +1)$

$= (2+0+0+2+2+0)$

$= 6$

As the result is much larger than 0, the receiver detects as binary 1.

If the receiver wants to receive data from sender B, then it applies B's code for despreading as,

$C * B_k = (-2, 0, 0, -2, +2, 0) * (+1, +1, -1, +1, -1, +1)$

$= (-2+0+0-2-2+0)$

$= -6$

As the result is negative, the receiver detects as binary 0.

In this case assume noise and interference are introduced, it is difficult for the receiver to detect the original data bits.

8.6.4. Comparison of FDMA, TDMA and CDMA

Sl. No.	Approach	FDMA	TDMA	CDMA
1.	Idea	Segment the frequency band in to disjoint sub-bands	Segment the sending time into disjoint time slots, either fixed or	Spread the spectrum using orthogonal codes

			demand driven patterns	
2.	Terminals	Every terminal has its own frequency, uninterrupted	All terminals are active for short periods of time on the same frequency	All terminals can be active at the same place at the same moment, uninterrupted
3.	Signal Seperation	Done by means of filtering in the frequency domain	Done by means of synchronization in the time domain	Done by means of using codes and special receiver
4.	Advantages	Simple and robust	Fully digital and very flexible	Flexible, less planning needed & soft handoff
5.	Disadvantages	Inflexible frequencies are a scare (rare) resource	Need for the guard space and the synchronization is difficult	Receiver have higher complexity, Needs more complicated power control for the seders
6.	Comment	Typically combined with TDMA and SDMA	Standard in fixed mobile networks, together with FDMA & SDMA	Higher complexity and this will be integrated with FDMA/TDMA