Characteristics & design constraints of CDMA:

Characteristics of CDMA. Based on the preceding analysis of the DS-CDMA system, we can summarize some properties of DS-CDMA as follows:

a. *Universal frequency reuse* – As CDMA achieves the orthogonality among the transmitted signals from the mobile users by using the orthogonal, or approximately orthogonal, PN sequences in spreading the signals, the total frequency bandwidth allocated to the system can be reused from cell to cell. As a result, we achieve the minimum cell cluster size ($N = 1$) and maximum frequency reuse. This significantly reduces the complexity of frequency planning in cellular system design;

b. *Soft handoff* – Because of the universal frequency reuse, a mobile user can simultaneously communicate with several nearby base stations using the same frequency band and the same spreading signal in each link. When the mobile user is at the cell boundary, it can establish a connection with the new base station before terminating the connection with the old base station. This will improve handoff performance;

c. *High transmission accuracy* – With spread spectrum, as discussed in Chapter 4, we can use Rake receivers to mitigate the fading dispersive channel impairments and, therefore, improve transmission accuracy, especially during soft handoff;

d. *Soft capacity* – As in practice, the PN sequences are not truly orthogonal, MAI will degrade the transmission BER performance. The maximum number of users that can be supported in each cell depends on the required quality of service (QoS) and is limited by MAI, to be discussed in Subsection 6.4.3. As a result, unlike TDMA and FDMA, there is no hard limit on the number of users in each cell. During peak traffic hours, if the users can tolerate a lower QoS to a certain degree, the system can accommodate more users to satisfy the high service demands in that period;

e. *Flexibility* – As CDMA is interference limited, if a user does not transmit, it does not generate any interference with other active users and, therefore, does not use the system resources. This feature translates to a high resource utilization via statistical multiplexing for on-off voice traffic and bursty data traffic. Even though TDMA can make use of the traffic activity factor to increase resource utilization, with CDMA it is easier to implement the statistical multiplexing. In addition, CDMA has more flexibility than TDMA in supporting multimedia services (with various time-varying traffic rates).

The advantages of the CDMA systems are not achieved without paying a price. First, CDMA requires stringent power control to achieve high capacity. For example, with voice services, the cell capacity is maximized when the signals received at the base station from all the mobiles in the cell have the same minimum power level. Second, with a large processing gain, the maximum transmission rate in each code channel (using a unique PN sequence in the signal spreading) is limited as compared with TDMA. This limitation can be overcome by parallel transmissions of information from/to one mobile user, with each transmission using a unique PN sequence. Third, the CDMA systems operate at a high chip rate and require accurate PN synchronization at the receiver. The complexity of the transmitter and (Rake) receiver is higher than that of TDMA and FDMA systems.