SPREAD SPECTRUM COMMUNICATIONS – INTRO

Multiple Access:

Scenario : Multiple Users want to talk at the same time in the same geographical area

Example : 4 people want to talk at the same time in our locality using the same available resource (as in GSM)

Problem : How to allow different users share the same resources ?

Solutions : Divide them separately in time or in frequency or in combination of both or using separate codes

Dividing the users in Frequency Domain: – FDMA

FDMA – Frequency Domain Multiple Access is a technique in which the users share the same resources but at different frequencies.

Advantages of FDMA

- No Inter Symbol Interference (ISI)
- Simple to design
- Easier synchronization

Disadvantages of FDMA

Frequency reuse is a problem in FDMA. We cannot allocated indefinite number of frequencies to the ever growing number of users.Since the spectrum is limited in bandwidth, a limited set of frequencies (Absolute Radio-Frequency Channel Number- ARFCN as in GSM) is reused over a

given area. Need to take care of co-channel interference when using frequency reuse technique High Q filters are required at the receiver side to separate the frequency content of each allocated spectrum, or large guard bands are required to separate each users.

Dividing the users in Time Domain : – TDMA

TDMA – Time Domain Multiple Access is a technique in which the users share the same resources but at different time slots.The time slots are so small that it is impossible for users to perceive the service disruptions.

Advantages of TDMA

- No need for High Q filters
- Suitable for digital data like PCM (Pulse coded modulation) data

Disadvantages of TDMA

- Need for tight synchronization circuits and guard time between time slots
- Equalizers are needed to cancel ISI effects.
- Susceptible to interference and multi-path effects.

Dividing the Users using codes: CDMA (Code Division Multiple Access)

Spread Spectrum Techniques:

The strict requirements of FDMA and TDMA are overcome by using spread spectrum techniques. Spread Spectrum techniques does not require high Q analog filters,frequency reuse,guard bands (as in FDMA) and equalizers,strict synchronization circuits,guard time (as in TDMA).

Advantages:

- Low power spectral density however the transmitted bandwidth requirement is higher than the other two techniques.
- Privacy due to use of separate codes for each users
- Possibility of jamming the signal is very very low
- Reduced multi-path effects
- Immune to interference effects

There exist different techniques to spread a signal: Direct-Sequence (DS), Frequency-Hopping (FH), Time-Hopping (TH) and Multi-Carrier CDMA (MC-CDMA). It is also possible to make use of combinations of them.

Direct-Sequence (DS) spread sprectrum:

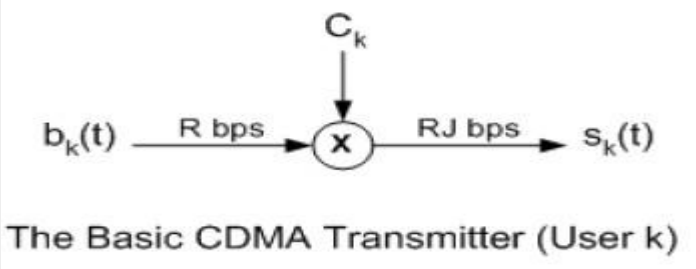
In DS spread spectrum technique, the user data is spread over much higher bandwidth by multiplying with a maximum length PN sequence called chips.Always the user data rate (Rb) is relatively low compared to the rate of the PN sequence (called “chip rate” – Rc).The spread signal looks like a noise when transmitted over a radio interface.

“Spreading Factor” or “Processing Gain” determines number of users that can be allowed in a spread spectrum system,the amount of multi-path effect reduction, the difficulty to jam or detect a signal etc. It is defined as the ratio of chip rate to the user data rate. Higher the spreading factor, greater the capability to detect a user data. Spreading factor may also be considered as a “gain” and is known as “Processing Gain” given by 10log10(chip rate/user rate).

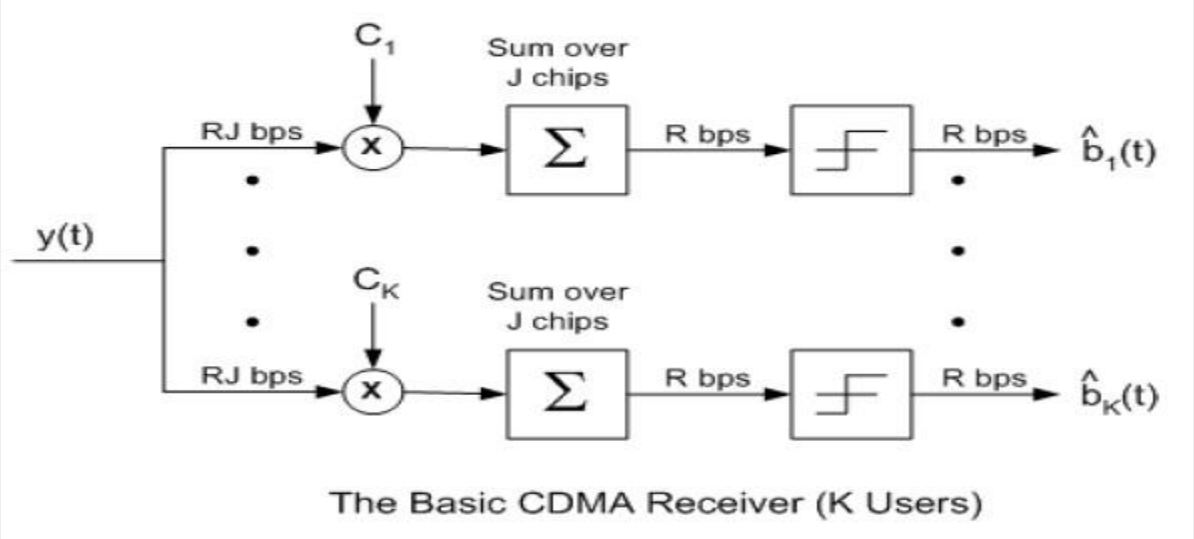
If the processing gain of a CDMA system is 20dB and if a Eb/N0 ratio of 5dB is needed at the receiver for satisfactory operation , the signal-to-interference ratio can be as low as -15dB,

the user signal can still be recovered from the received signal (in presence of the interference signal). This is because the de-spreading benefits from the processing gain of 20dB.

In a typical WCDMA system, the chip rate is 3.84×10^6 chips/second (3.84 Mcps) and the user data rate is 12.2 Kbps, which equates to a processing gain of 10log(3.84M/12.2K)=24.9dB.



A Basic CDMA Transmitter



A Basic CDMA Receiver

Source: http://www.gaussianwaves.com/2010/09/spread-spectrum-communications-intro/