# Spread Spectrum in Mobile Computing

Spread spectrum is a technique used for wireless communications in telecommunication and radio communication. In this technique, the frequency of the transmitted signal, i.e., an electrical signal, electromagnetic signal, or acoustic signal, is deliberately varied and generates a much greater bandwidth than the signal would have if its frequency were not varied.

In other words, "Spread Spectrum is a technique in which the transmitted signals of specific frequencies are varied slightly to obtain greater bandwidth as compared to initial bandwidth."

Now, spread spectrum technology is widely used in radio signals transmission because it can easily reduce noise and other signal issues.

## Reasons to use Spread Spectrum

* Spread spectrum signals are distributed over a wide range of frequencies and then collected and received back to the receiver. On the other hand, wide-band signals are noise-like and challenging to detect.
* Initially, the spread spectrum was adopted in military applications because of its resistance to jamming and difficulty intercepting.
* Now, this is also used in commercial wireless communication.
* It is most preferred because of its useful bandwidth utilization ability.

## Usage of Spread Spectrum

There are many reasons to use this spread spectrum technique for wireless communications. The following are some reasons:

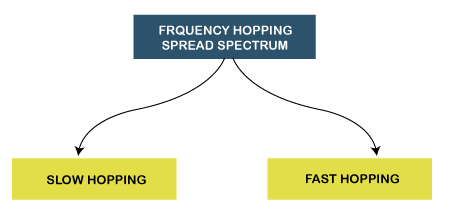
* It can successfully establish a secure medium of communication.
* It can increase the resistance to natural interference, such as noise and jamming, to prevent detection.
* It can limit the power flux density (e.g., in satellite down links).
* It can enable multiple-access communications.

## Types of Spread Spectrum

Spread Spectrum can be categorized into two types:

* Frequency Hopping Spread Spectrum (FHSS)
* Direct Sequence Spread Spectrum(DSSS)

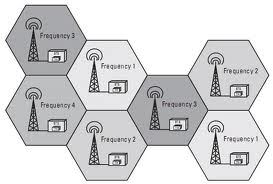
**The Frequency Hopping Spread Spectrum or FHSS can also be classified into two types:**



* **Slow Hopping:** In slow hopping, multiple bits are transmitted on a specific frequency or same frequency.
* **Fast Hopping:** In fast hopping, individual bits are split and then transmitted on different frequencies.

**https://www.youtube.com/watch?v=FHkpKJhpwPg**

**Digital Cellular System and Multiple Access Scheme:**  
**Cellular Fundamentals :**  
The area served by mobile phone systems is divided into small areas known as the cell . Each cell contains the base station that communicates with mobiles in the cell by transmitting and receiving signals on radio links. The transmission from the base station to a mobile is typically referred to as downstream, forwardlink, or the down link. Corresponding terms for the transmission from a mobile to the base are upstream, reverse-link, and up link. Each base station is associated with a mobile switching center (MSC) that connects the calls to & from the base to mobiles in other cells and the public switched telephone network. A typical setup depicting a group of base stations to a switching center. In this section terminology associated with cellular systems is introduced with a brief description to understand how  
these systems work.

[](https://i0.wp.com/blog.oureducation.in/wp-content/uploads/2013/06/cellular.jpg?ssl=1)

**CDMA:**  
The CDMA scheme is a direct sequence (DS), spread-spectrum method. It uses linear modulation with  
wideband pseudonoise (PN) sequences to generatethe signals. These also known as the codes, spread  
the spectrum of the modulating signal over the large bandwidth, simultaneously reducing spectral  
density of the signal. Thus, various CDMA signals occupy the same bandwidth and appear as noise to  
each other. More details on DS spread-spectrum may be found .  
In the CDMA scheme, each user is assigned an individual code at the time of the call initiation. These code  
are used both for spreading signal at time of transmission and the despreading the signal at the time  
of reception. Cellular systems using CDMA schemes use the FDD, thus employing 2 frequency channels  
for forward and the reverse links.

**In CDMA systems:**  
If a user doesn’t has anything to send, it causes less interference to the other users of the system  
Typically, each user needs to transmit less than half the time  
Since the interference limited, this doubles capacity.  
CDMA have overcome most cynicism to dominate worldwide wireless voice market  
• What about the data services? Scheduling vs. thee Inteference Averaging  
• CDMA appears to be an underdog for the 4 Generation , but still may win  
• Ongoing research on CDMA  
Increase the capacity by joint decoding Applying CDMA to other applications: the optical CDMA, the ad hoc networks, the dense wireless LANs “MultiCDMA”:multicarrier CDMA, multiple antenna CDMA, multicode CDMA.

**Drawbacks of CDMA:**  
1 . Tight synchronization is required to use the orthogonal codes, that then break in a multipath channel anyway  
2. The Quasi orthogonal codes cause the self interference, that dominates the performance in most CDMA systems  
3. Near far problem is the serious hindrance, requiring fast & accuratepowercontrol   
4. And for all this, the required bandwidth is now J times larger than it was previous , so there doesn’t appear to be a capacity gain.  
**GSM:**  
The GSM standard was developed as a replacement for first generation (1G) analog cellular networks, & the originally described digital, circuit switched network optimized for the full duplex voice telephony. These were expanded over the time to include the data communications, 1st by circuit switched transport, then the packet data transport via GPRS (General Packet Radio Services) and EDGE (Enhanced Data rates for GSM Evolution or EGPRS).  
Several open-source software projects exist that provide certain GSMfeatures:  
•gsmd daemon by Openmoko.  
• OpenBTS develops a Base transceiver station  
• The GSM Software Project aims to build a GSM analyzer for less than $1000.  
• OsmocomBB developers intend to replace the proprietary baseband GSM stack with a free software implementation.

<https://www.youtube.com/watch?v=Mg1NnzBB4Wo>

<https://www.youtube.com/watch?v=r-RxGQuZLio&list=RDCMUCrJ1Ty_WsV3hxcXlbXyBfUA&index=2>

Diversity

<https://www.youtube.com/watch?v=YU0VjIBbbn0>

# Diversity techniques and spatial multiplexing

The wireless communication environment is very hostile. The signal transmitted over a wireless communication link is susceptible to fading (severe fluctuations in signal level), co-channel interference, dispersion effects in time and frequency, path loss effect, etc. On top of these woes, the limited availability of bandwidth posses a significant challenge to a designer in designing a system that provides higher spectral efficiency and higher quality of link availability at low cost.

Previous article in this series: [Introduction to Multiple Antenna Systems](https://www.gaussianwaves.com/2014/08/introduction-to-multiple-antenna-systems/)

Multiple antenna systems are the current trend in many of the wireless technologies that is essential for their performance (you will even see it in your future hard disk drives as ***Two Dimensional Magnetic Recording (TDMR)*** technology). ***Multiple Input Multiple Output systems (MIMO)*** improve the spectral efficiency and offers high quality links when compared to  traditional ***Single Input Single Output (SISO)*** systems. Many theoretical studies ***[1-2]*** and communication system design experimentations ***[3-5]*** on MIMO systems demonstrated a great improvement in performance of such systems.

## Techniques for improving performance

Spatial Multiplexing techniques ***[6]***, example – BLAST***[7]*** yields increased data rates in wireless communication links. Fading can be mitigated by employing receiver and transmit diversity (Alamouti Scheme ***[8]*** , Tarokh et. al***[9]***) , there by improving the reliability of the transmission link. Improved coverage can be effected by employing coherent combining techniques – which gives array gain and increases the signal to noise ratio of the system. The goals of a wireless communication system are conflicting and a clear balance of the goals is needed for maximizing the performance of the system.

The following text concentrates on two of the above-mentioned techniques – diversity and spatial multiplexing.

## MIMO classification with respect to antenna configuration

In MIMO jargon, communication systems are broadly categorized into four categories with respect to number of antennas in the transmitter and the receiver, as listed below.

● SISO – Single Input Single Output system –***1*** Tx antenna , ***1*** Rx antenna  
● SIMO – Single Input Multiple Output system – ***1*** Tx antenna, N_R Rx antennas (N_R > 1)  
● MISO – Multiple Input Single Output system – N_T Tx antennas, ***1*** Rx antenna (N_T > 1)  
● MIMO – Multiple Input Multiple Output system – N_T Tx antennas, N_R Rx antennas (N_T, N_R > 1)

## Diversity and Spatial-Multiplexing

Apart from the antenna configurations, there are two flavors of MIMO with respect to how data is transmitted across the given channel. Existence of multiple antennas in a system, means existence of different propagation paths. Aiming at improving the reliability of the system, we may choose to send same data across the different propagation (spatial) paths. This is called ***spatial diversity***or simply***diversity***. Aiming at improving the data rate of the system, we may choose to place different portions of the data on different propagation paths (**spatial-multiplexing**). These two systems are listed below.

● MIMO – implemented using ***diversity techniques*** – provides ***diversity gain*** – Aimed at ***improving the reliability***  
● MIMO – implemented using ***spatial-multiplexing techniques*** – provides ***degrees of freedom*** or ***multiplexing gain*** – Aimed at ***improving the data rate*** of the system.

## Diversity:

As indicated, two fundamental resources available for a MIMO system are diversity and degrees of freedom. Let’s see what these terms mean

In diversity techniques, **same information** is sent across independent fading channels to combat fading. When multiple copies of the same data are sent across independently fading channels, the amount of fade suffered by each copy of the data will be different. This guarantees that at-least one of the copy will suffer less fading compared to rest of the copies. Thus, the chance of properly receiving the transmitted data increases. In effect, this improves the reliability of the entire system. This also reduces the co-channel interference significantly. This technique is referred as inducing a “**spatial diversity**” in the communication system.

Consider a SISO system where a data stream ***[1, 0, 1, 1, 1]*** is transmitted through a channel with deep fades. Due to the variations in the channel quality, the data stream may get lost or severely corrupted that the receiver cannot recover.The solution to combat the rapid channel variations is to add independent fading channel by increasing the number of transmitter antennas or receiver antennas or the both.