Trends in mobile communications

Marian Dorin Pîrloagă,Ph.D Aspirant,Military Technical Academy-Bucharest,Romania,pirloaga.marian@yahoo.com

Abstract. In this paper i describe some principals technics used in mobile communications in order to improve performance and increase data transmission rate, especially inMIMO-OFDM systems combining techniques MIMO and OFDM. One of the advantages of OFDM is the flexibility concerning modulation and multiple access techniques. Adaptive subcarrier allocation and adaptive modulation being applied to the OFDM-FDMA and OFDM-TDMA, respectively, are considered.Ofdm makes efficient use of the spectrum by allowing overlap.By dividing the channel into narrowband flat fading subchannels, OFDM is more resistant to frequency selective fading than single carrier systems are.He using adequate channel coding and interleaving one can recover symbols lost due to the frequency selectivity of the channel.The channel equalization becomes simpler than by using adaptive equalization techniques with single carrier systems.It is possible to use maximum likelihood decoding with reasonable complexity.OFDM is computationally efficient by using FFT techniques to implement the modulation and demodulation functions.Is less sensitive to sample timing offsets than single carrier systems are.Provides good protection against co channel interference and impulsive parasitic noise.

One of possible application of OFDM is the combination with antenna array at the transmitter and receiver to increase the diversity gain or to exchange the system capacity on time variant and frequency selective channels,resulting in MIMO configuration.

Keywords: MIMO,OFDM,spatial diversity,channels,multiusers,multiplexing

1.Introduction

Wireless communication have a high density of hyperlinks that allow the reader to immediately study the details of specific issues. Cellular and cordless phones rapidly became mass-market consumer products. There were about 250 Million subscribers in the year 2010, and a market of 500 to 600 Million handhelds per year. Around that year many operators invested Billions of Euros on spectrum for Third Generation (3G) systems, such as UMTS. However, the insight that these could only be recouped over periods of rapid growth for ten years or more may have accelatered the malaise in the telecomm markets after 2010.Products for enhanced communication services, such as data, electronic mail, high resolution digital video or even full multimedia communication entered the market. Services such as the GSM Short Message Service greatly extent the capabilities of pagers. I-mode is a successful text and multimedia service in Japan, and Europe is betteing on WAP: The Wireless Application Protocol. The projected growth of the number of Internet users to 500 Million worldwide indicates potential when wireless and computing technologies are merged. The revolutionary development of such systems appeared is focussed towards large capacity, better quality, more bandwidth, wider coverage, lower power consumption and more services. This development remains a technical challenge, with many issues still to be resolved. Multiple Input Multiple Output technology that uses multiple antennas to provide gains in channel robustness and throughput. New technologies needed to be developed to enable MIMO to be fully implemented. New levels of processing were needed to allow some of the features of spatial multiplexing as well as to utilise some of the gains of spatial diversity.The 3 G network problems are the following limitations:limited transmiting power,fluctuation in wireless link duet o fading and the scarcity of spectrum.MIMO can implements a new architecture for next generation systems[1].

2.MIMO -Multiple Input Multiple Output basics

A channel may be affected by fading and this will impact the signal to noise ratio. In turn this will impact the error rate, assuming digital data is being transmitted. The principle of diversity is to provide the receiver with multiple versions of the same signal. If these can be made to be affected in different ways by the signal path, the probability that they will all be affected at the same time is considerably reduced. Accordingly, diversity helps to stabilise a link and improves performance, reducing error rate.Several different diversity modes are available and provide a number of advantages:

-Time diversity***:*** Using time diversity, a message may be transmitted at different times, e.g. using different timeslots and channel coding.

-Frequency diversity***:*** This form of diversity uses different frequencies. It may be in the form of using different channels, or technologies such as spread spectrum / OFDM.

-Space diversity : Space diversity used in the broadest sense of the definition is used as the basis for MIMO. It uses antennas located in different positions to take advantage of the different radio paths that exist in a typical terrestrial environment.

MIMO is effectively a radio antenna technology as it uses multiple antennas at the transmitter and receiver to enable a variety of signal paths to carry the data, choosing separate paths for each antenna to enable multiple signal paths to be used.

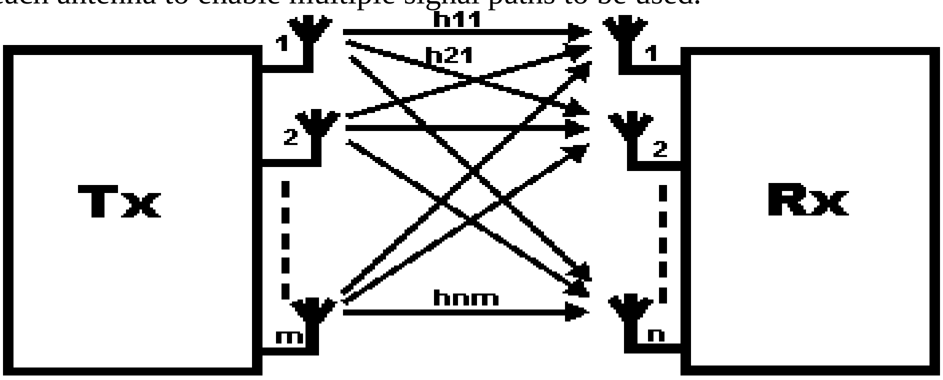


Fig.1General Outline of MIMO system

MIMO systems employ multiple antennas at both the transmitter and receiver as shown in figure 1.They transmit data x1;x2;…….xn on different transmit anetnnas simultaneouslyand in the same frequency band.At the receiver ,MIMO decoders use m>n antennas.Assuming N receives antennas,and representing the signalreceived by each antennaas will have:

S1=h11 x1+ h12 x2+……+h1N xN

S2=h21 x1+ h22 x2+…….+h2N xN

………………………………………………..

SN=hN1 x1+hN1 x2+………Hnn xN

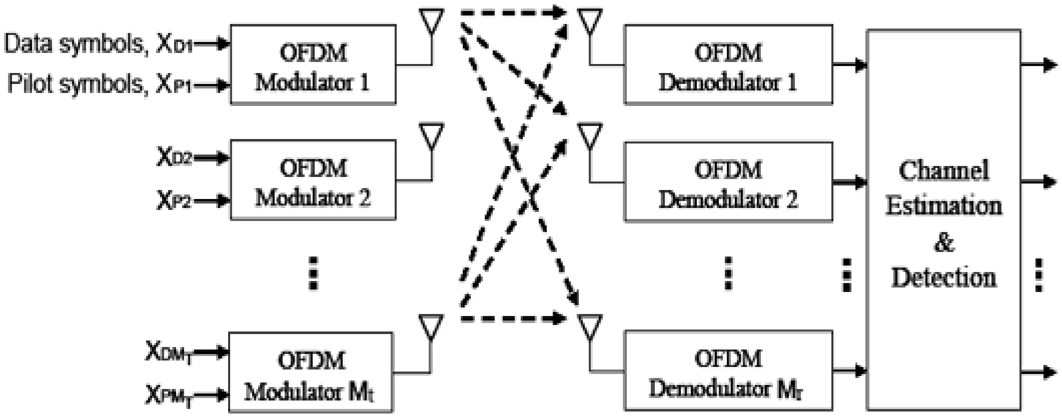
One of the core ideas behind MIMO wireless systems space-time signal processing in which time (the natural dimension of digital communication data) is complemented with the spatial dimension inherent in the use of multiple spatially distributed antennas, i.e. the use of multiple antennas located at different points. Accordingly MIMO wireless systems can be viewed as a logical extension to the smart antennas that have been used for many years to improve wireless[2].

It is found between a transmitter and a receiver, the signal can take many paths. Additionally by moving the antennas even a small distance the paths used will change. The variety of paths available occurs as a result of the number of objects that appear to the side or even in the direct path between the transmitter and receiver. Previously these multiple paths only served to introduce interference. By using MIMO, these additional paths can be used to advantage. They can be used to provide additional robustness to the radio link by improving the signal to noise ratio, or by increasing the link data capacity.

As a result of the use multiple antennas, MIMO wireless technology is able to considerably increase the capacity of a given channel while still obeying Shannon's law. By increasing the number of receive and transmit antennas it is possible to linearly increase the throughput of the channel with every pair of antennas added to the system. This makes MIMO wireless technology one of the most important wireless techniques to be employed in recent years. As spectral bandwidth is becoming an ever more valuable commodity for radio communications systems, techniques are needed to use the available bandwidth more effectively. MIMO wireless technology is one of these techniques.

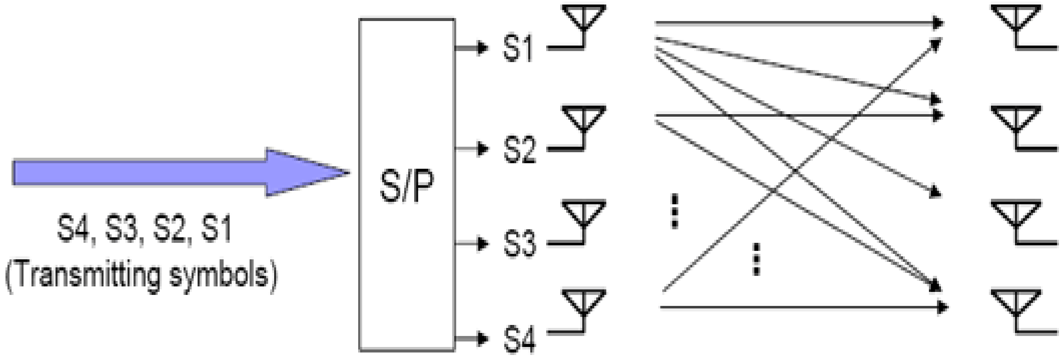
3.MIMO combined with OFDM

Orthogonal Frequency Division Multiplexing (OFDM) is one of the most promising physical layer technologies for high data rate wireless communications due to its robustness to frequency selective fading, high spectral effciency, and low computational complexity. OFDM can be used in conjunction with a Multiple-Input Multiple-Output (MIMO) transceiver to increase the diversity gain and/or the system capacity by exploiting spatial domain. Because the OFDM system effectively provides numerous parallel narrowband channels, MIMO-OFDM is considered a key technology in emerging high-data rate systems such as 4G, IEEE 802.16, and IEEE 802.11n.

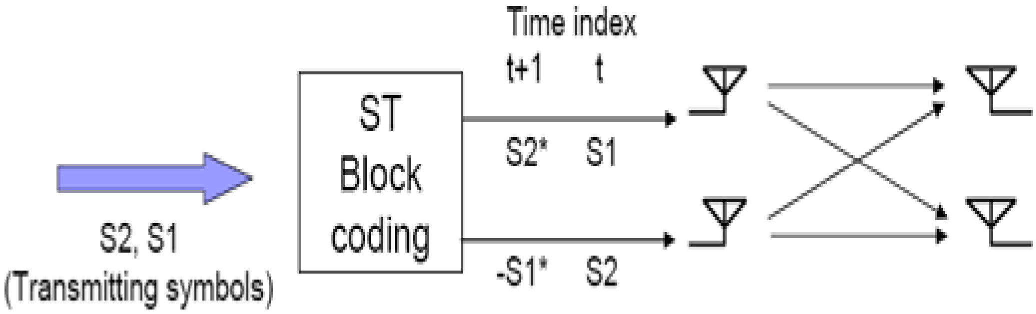


MIMO communication uses multiple antennas at both the transmitter and receiver to exploit the spatial domain for spatial multiplexing and/or spatial diversity.

Spatial multiplexing has been generally used to increase the capacity of a MIMO link by transmitting independent data streams in the same time slot and frequency band simultaneously from each transmit antenna, and differentiating multiple data streams at the receiver using channel information about each propagation path.



In contrast to spatial multiplexing, the purpose of **spatial diversity** is to increase the diversity order of a MIMO link to mitigate fading by coding a signal across space and time so that a receiver could receive the replicas of the signal and combine those received signals constructively to achieve a diversity gain.



A MIMO-OFDM systems combines MIMO and OFDM techniques and transmits independent OFDM modulated data from multiple antennas simultaneously.Orthogonal frequency division multiplexing(OFDM)is a mult-carrier transmission techniquie and a method for high speed bi-directional wireless data communication.OFDM reduced the required bandwidth and keeping the modulated signals orthogonal,in finnaly do not interfere with each other. In [3] the capacity of conventional MIMO, MIMOOFDM and spread MIMO-OFDM in presence of multipath is studied. Spread MIMO-OFDM is MIMO with OFDM and CDMA i.e. above MIMO-OFDM a spreading code is used in the signal. In the single user case the results showed that capacity for the conventional MIMO without ISI is the highest and they state that it is the upper bound of capacity limit. MIMO-OFDM and spread MIMO-OFDM give more capacity than conventional MIMO in presence of multipath and based on their results MIMO-OFDM and spread MIMOOFDM would be similarly impacted by multipath. This seems reasonable since OFDM with long enough cyclic prefix is a powerful mean to mitigate multipath.

In multiuser channel spread MIMO-OFDM provides more capacity than the other schemes. Figures 2 from [3] present the results of that paper.

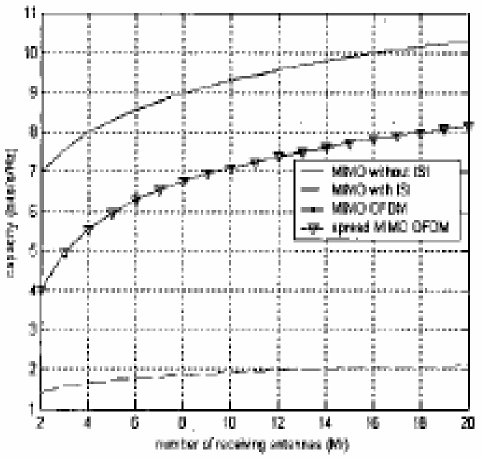


Fig. 2 Channel capacity versus number of receive antennas at Mt=2, SNR=15 dB, L=5

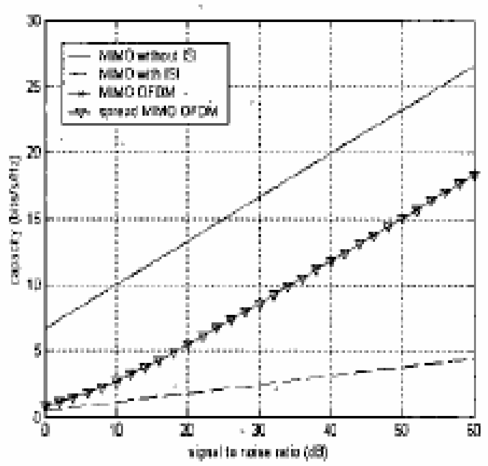


Fig. 3 Channel capacity versus signal to noise ratio at Mt=Mr=10, L=5

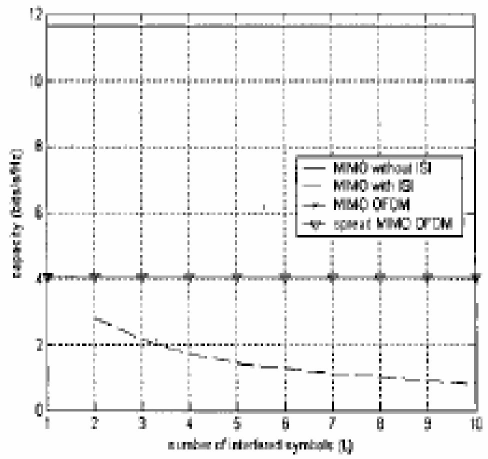


Fig.4 Channel capacity versus number of interfered symbols at Mt=Mr=10, SNR=15 dB

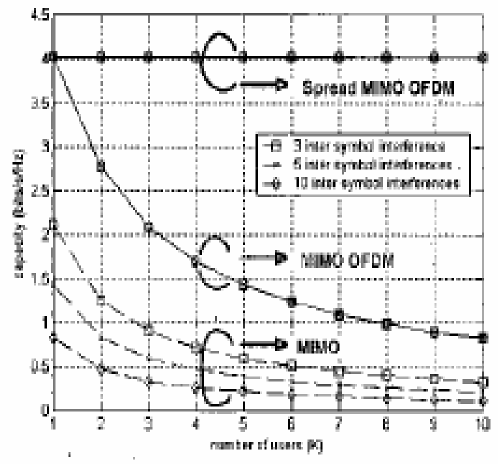


Fig.5 Average capacity rate per user versus number of users at Mt=Mr=10, SNR=15 dB

Fig 2.*The results of multiusers channel capacity*

In MIMO-OFDM systems, channel state information (CSI) is essential at the receiver in order to coherently detect the received signal and to perform diversity combining or spatial interference suppression. The channel is very important to the performance of diversity schemes, and more variable channels give more diversity. Thus, in order to attain accurate CSI at the receiver, pilot-symbol-aided or decision-directed channel estimation must be used to track the variations of the frequency selective fading channel. Among the various resources in MIMO multicarrier systems the power assignment is related to the accuracy of the channel estimation. Pilot symbols facilitate channel estimation, but in addition to consuming bandwidth, they reduce the transmitted energy for data symbols per OFDM symbol under a fixed total transmit power condition. This suggests a tradeoff between the system capacity and the accuracy of the channel estimation in MIMO-OFDM systems according to the power allocation when the total transmit power is fixed.

In order to model the MIMO-OFDM system in a graphical and fast simulation, we have developed the MIMO-OFDM simulator in the LabVIEW simulation package from National Instruments. By using this simulator, one can see the bit errror rate (BER) performance of the system and the channel capacity lower bound according with three different types of pilot patterns[5].

4. Conclusions

MIMO and MIMO-OFDM are very hot topics of current research. The information-theoretic performance limits, particularly in the multiuser context and space time code and receiver design have attracted significant research interest.

The MIMO-OFDM systems has the following advantages:higher transmition rate,coverage for long distance,diversity gain,reduced interference.MIMO can combine with CDMA and to achieved the benefits as WLAN's to cellular products.

OFDM is a good method for high speed and biderectional wireless data communication and has the following advanteges:

-makes efficient use of the spectrum by allowing overlap.

-by dividing the channel into narrowband flat fading subchannels, OFDM is more resistant to frequency selective fading than single carrier systems are.

-eliminates ISI and IFI through use of a cyclic prefix.

-using adequate channel coding and interleaving one can recover symbols lost due to the frequency selectivity of the channel.

-channel equalization becomes simpler than by using adaptive equalization techniques with single carrier systems.

-it is possible to use maximum likelihood decoding with reasonable complexity.

-OFDM is computationally efficient by using FFT techniques to implement the modulation and demodulation functions.

-is less sensitive to sample timing offsets than single carrier systems are.

-OFDM provides good protection against cochannel interference and impulsive parasitic noise.

5.References

[1]Heath W.,Trends in broadband cellular communication,The wireless networking communications group

[2] http://www.radio-electronics.com/info/antennas/mimo/multiple-input-multiple-output-technology-tutorial.php

[3] P. Uthansaku M.E. Bialkows "Multipath signal effect on the capacity of MIMO, MIMO-OFDM and spread MIMO-OFDM" Microwaves, Radar and Wireless Communications, 2004. MIKON-2004. 15th International Conference on , Volume: 3 , 17-19 May 2004 Pages:989 – 992

[4]Lizhong Zheng,Diversity and multiplexing:a fundamental tradeoff in multiple-antenna channels.IEEE transactions on information Theory,vol 49,no 5 May

[5] http://users.ece.utexas.edu/~jandrews/molabview.html

[6]University of California,Los Angeles,Introduction to MIMO and MIMO-OFDM