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ADAPTIVE MIMO OFDM BIT ERROR RATE IMPROVEMENT USING DIFFERENT MODULATION TECHNIQUES

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Abstract: Digital communication using multiple-input–multiple output (MIMO), sometimes called a "volume-to-volume" wireless link, has recently emerged as one of the most significant technical breakthroughs in modern communications. The technology figures prominently on the list of recent technical advances with a chance of resolving the bottleneck of traffic capacity in future Internet-intensive wireless networks. Perhaps even more surprising is that just a few years after its invention the technology seems poised to penetrate large-scale standards-driven commercial wireless products and networks such as broadband wireless access systems, wireless local area networks (WLAN), third-generation (3G)1 networks and beyond .This work will present an overview of recent progress in the area of multiple-input–multiple-output (MIMO) space–time coded wireless systems. After some background on the research leading to the discovery of the enormous potential of MIMO wireless links, we will highlight the different classes of techniques and algorithms will propose which attempt to realize the various benefits of MIMO including spatial multiplexing and space–time coding schemes. These algorithms will often derived and analyzed under ideal independent fading conditions. We will present an adaptive MIMO OFDM using channel modeling and measurements, leading to a better understanding of actual MIMO gains. Finally, the work will address current questions regarding the integration of MIMO links in practical wireless systems and standards in terms of BER. This work concerns the application which deals with MIMO-related research that are entering in a maturing stage and with recent measurement campaign results further demonstrating the benefits of MIMO channels, the standardization of MIMO solutions in third generation wireless systems (and beyond) has recently begun, mainly in for a such as the International Telecommunications Union and the 3GPPs. Several techniques, seen as complementary to MIMO in improving throughput, performance and spectrum efficiency are drawing interest, especially as enhancements to present 3G mobile systems, e.g., high-speed digital packet access (HSDPA) These include adaptive modulation and coding, hybrid ARQ, fast cell selection, transmit diversity.
Keywords: MIMO, HSDPA, OFDM, BER

I. INTRODUCTION

Worldwide Interoperability for Microwave Access (Wi-Max) is an emerging global broadband wireless system based on IEEE 802.16 standard. It is a new wireless OFDM-based technology that provides high quality broadband services long distances based on IEEE.802.16 wireless (Metropolitan Area Network) MAN air interface standard to fixed, portable and mobile users[1,2]. Wi-Max promises to combine high data rate services with wide area coverage (in frequency range of 10 – 66 GHz (Line of sight) and 2 -11 GHz (Non-Line of Sight)) and large user densities with a variety of Quality of Service (QoS) requirements. Wi-Max can provide broadband wireless access (BWA) up to 30 miles (50 km) for fixed station and 3 to 10 miles (5-15 km) for mobile stations with theoretical data rates between 1.5 and 75 Mbps per channel. The new standards for Wi-Max are being developed for expanding the mobility further with enhanced coverage, performance and higher data rates (of the order of 100 Mb/s) in a Wi-Max Network. The Wi-Max standard air interface incorporates the meaning of both the medium access control (MAC) and the physical (PHY) layers for the endorser station and base station while the entrance system operability is characterized by the Wi-Max Forum, an association comprising of administrators and part and gear producers. As the essential capacity of Wi-Max PHY layer is the genuine physical transportation of information. The primary execution turns out to be all the more difficult when portable situations are experienced in remote channel. Keeping in mind the end goal to accomplish most extreme execution at low BER, high information rate transmission (both in settled and versatile situations) and high ghastly productivity with assortment of QoS needs IEEE 802.16d/e standard backings assortment of PHY layer instruments with an assortment of components. The adaptability of the PHY empowers the framework planners to tailor their framework as per their prerequisites.

II. SIMULATION MODEL

We have designed physical layer of Wi-Max model following the IEEE Wi-Max Standards using Simulink/matlab platform. In this model various IQ mapping schemes are considered in presence of fading channel to understand the performance of modulation schemes at different SNR.First of all we studied the model performance in presence of AWGN channel only without the effect of any kind of fading. Figure 1 shows the Wi-Max model having AWGN channel here the performance is evaluated using three criteria. These criteria are Bit error rate scatter plot and signal spectrum scope.

Model 1: Physical layer model without fading:

In figure 1 the input is provided by binary data generated from MAC layer in packet data unit format. In MAC PDU block the generated data could be predefined integers or random integers. These inputs are arrays of 35x1 sizes generating repetitively. The generated inputs are attached with 6 byte MAC header and passed to randomizer in binary packets. These MAC PDUs (packet data units) are transmitted at the end from physical layer and we have connected AWGN channel to introduce white noise in transmitted signal.

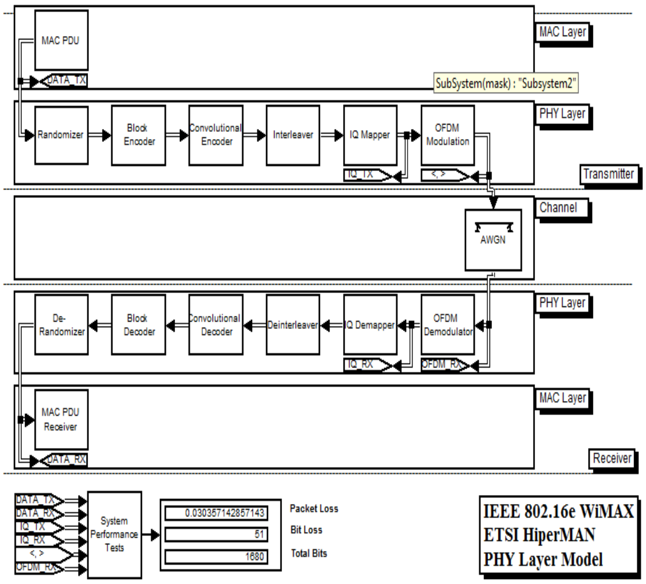

Figure 1: Simulink model for Wi-Max Physical layer without fading

1 MAC PDU (MAC address):

Medium access control protocol data units are a package of data (group of data bits) that contain header, connection address and data protocol information that is used to control and transfer information across a type of medium (such as a radio channel). The Wi-Maxsystem MAC PDUs contains a header, which holds the connection identifier along with control information. MAC PDUs may also have payload of data and error checking bits (CRC) bits after the header (e.g. user data). A MAC PDU header contains a header type, encryption control field, payload type and error checking (CRC) code.

Fig 2 MAC PDU

2. Randomizer:

Randomization is the first process carried out in the physical layer after the data packet is received from the higher layers.Each burst in Downlink and Uplink is randomized. Randomizer operates on a bit bybit basis.

The purpose of the scrambled data is to convert long sequences of 0's or 1's in a random sequence to improve the coding performance. The main component of the data randomization is a Pseudo Random Binary Sequence generator which is implemented using Linear Feedback Shift Register.

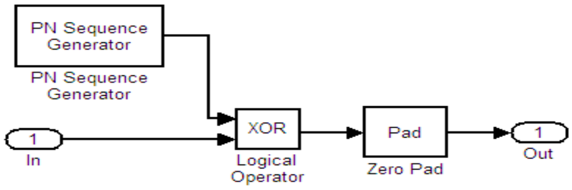

Fig: 3Randomiser

3. PN Generator:

Generate a pseudorandom noise (PN) sequence using a linear feedback shift register (LFSR). The LFSR is implemented using a simple shift register generator (SSRG, or Fibonacci) configuration.

4. PAD (MASK) (LINK):

Append or prepend a constant value to the input along the specified dimensions. Truncation occurs when the specified output dimensions are shorter than the corresponding input dimensions.

5. Block Encoder:

Using this block we get the data in coding form.

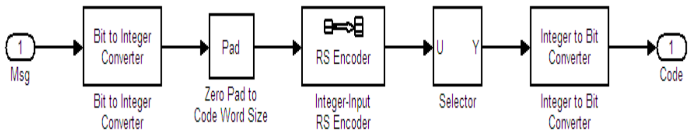

Fig: 4 Block Encoder

III. RESULTS

Transmit Diversity vs. Receive Diversity-

Using diversity reception is a well-known technique to mitigate the effects of fading over a communications link. However, it has mostly been related to the receiver end. In [1], Alamouti proposes a transmit diversity scheme that offers similar diversity gains, using multiple antennas at the transmitter. This was conceived to be more practical as, for example, it would only require multiple antennas at the base station in comparison to multiple antennas for every mobile in a cellular communications system.This section highlights this comparison of transmit vs. receive diversity by simulating coherent binary phase-shift keying (BPSK) modulation over flat-fading Rayleigh channels. For transmit diversity, we use two transmit antennas and one receive antenna (2x1 notationally), while for receive diversity we employ one transmit antenna and two receive antennas (1x2 notationally).The transmit diversity system has a computation complexity very similar to that of the receive diversity system.The resulting simulation results show that using two transmit antennas and one receive antenna provides the same diversity order as the maximal-ratio combined (MRC) system of one transmit antenna and two receive antennas.Also observe that transmit diversity has a 3 dB disadvantage when compared to MRC receive diversity. This is because we modelled the total transmitted power to be the same in both cases. If we calibrate the transmitted power such that the received power for these two cases is the same, then the performance would be identical. The theoretical performance of second-order diversity link matches the transmit diversity system as it normalizes the total power across all the diversity branches.

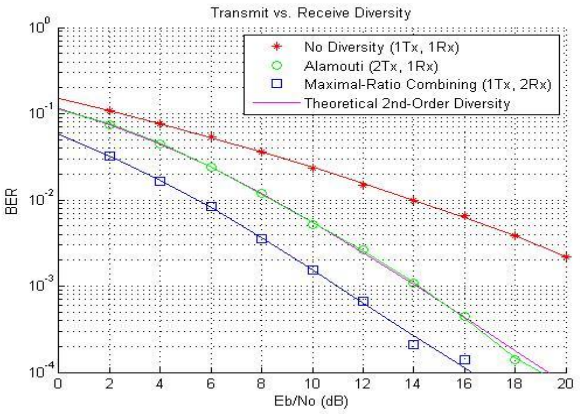

Figure 5: BER Performance at different MIMO coding schemes for 1x2 or 2x1 sytems.

Orthogonal Space-Time Block Coding and Further Explorations: We present some performance results for orthogonal space-time block coding using four transmit antennas (4x1 system) using a half-rate codeas per [4].We assume the system to offer a diversity order of 4 and will compare it with 1x4 and 2x2 systems, which have the same diversity order also. To allow for a fair comparison, we use quaternary PSK with the half-rate G4 code to achieve the same transmission rate of 1 bit/sec/Hz.Since these results take some time to generate, we load the results from a prior simulation. The functional script OSTBC4M.m,OSTBC4M.m is included, which, along with MRC1M.m,MRC1M.m and OSTBC2M.m,OSTBC2M.m, was used to generate these results. The user is urged to use these scripts as a starting point to study other codes and systems. As expected, the similar slopes of the BER curves for the 4x1, 2x2 and 1x4 systems indicate an identical diversity order for each system. Also observe the 3 dB penalty for the 4x1 system that can be attributed to the same total transmitted power assumption made for each of the three systems. If we calibrate the transmitted power such that the received power for each of these systems is the same, then the three systems would perform identically. Again, the theoretical performance matches the simulation performance of the 4x1 system as the total power is normalized across the diversity branches.

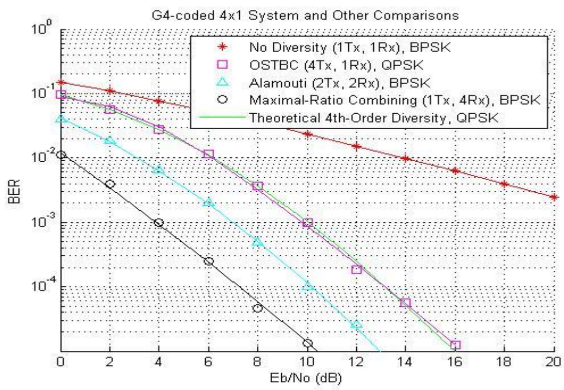

Figure 6: BER performance at different MIMO coding schemes for higher order diversity.

Algorithm is developed to determine the modulation type and rate as per the channel noise. The algorithm is initialized at the given constraints of bandwidth, sampling factor, guard band size. The bandwidth , g , fs factor, that are used MIMO OFDM systems are-

Bandwidth = max 20 Mhz

Guard band Tg = Td/8

Sampling factor fs = n.BW

After initializing the programme sampling factor is decided for the given sampling factor provide by user

fs = 22.7 Mhz

Ts = Tb + Tg

Using the guard band, sampling time and bandwidth the algorithm decides the total data, useful data, and guard data. The algorithm determines the index of cyclic prefix at which data at particular address is to inserted in the OFDM block. Prior to applying inverse FFT over the modulation symbols. The algorithm applies following precoding schemes.

Randomization - Randomizer operates on a bit by bit basis. The purpose of the scrambled data is to convert long sequences of 0's or 1's in a random sequence to improve the coding performance.Interleaving - Interleaving is done by spreading the coded symbols in time before transmission.Galois Field is widely used to represent data in error control coding and is denoted by GF(2m).

Trellis - The number of bits removed is dependent on the code rate used.

Table 1: The algorithm chooses following modulation type and rate at different SNR.

Modulation	Coding Rate	Receiver SNR threshold (db)
BPSK	1/2	6.4
QPSK	1/2	9.4
QPSK	3/4	11.2
QAM-16	1/2	16.4
QAM-16	3/4	18.2
QAM-64	1/2	22.7
QAM-64	3/4	24.4

On entering the b.w = 8, G = 1/4 the algorithm gives the values. Using above algorithm as we enter different values of Vw, G and SNR(db).We can generate parameters for different modulation schemes that can be adapted during generation of data by applying MIMO OFDM. The table below describe the result obtained as the parameter for MIMO OFDM data generation plateform at different channel condition.

Proposed Algorithm Results:

After discussion and analysis of MIMO systems of data coding and transmission and OFDM performance at different modulation scheme we are going to describe the results that are obtained for MIMO OFDM system by using the adaptive modulation strategy that estimates the channel SNR from the pilot symbols and cyclic prefix values and then from the

estimated SBR the algorithm decides the modulation scheme that can be most suitable for minimum BER values. The MIMO OFDM configuration that has been used is:
Choice for modulation scheme is from 1 to 5 each choice represents:
1:Adaptive Modulation
2:BPSK
3:QPSK
4:16QAM
5:64QAM

Number of Tx antennas Mt=2
Number of Rx antennas Mr=2
Guard band ration out off total OFDM block,G=1/4
Delay spread of channel, DS=5
Number of subcarriers, L=120;
Bandwidth,B=5x10 6 Hz
Signal to noise ratio is varied in dB as =[6.5 10 15 20 25 30 35 40]

The value of SNR is varied for different choice of modulation to record the effect of the noise on modulated data.
ifBPSKbitsper symbol=1
elseifOPSKbitsper symbol=2
elseif16QAMbitspersymbol=4
elseif64 QAM bitspersymbol=6
Random binary data is generated for Mt transmitters and pilot data is inserted thereafter the cyclix prefix is added.Initially a random data stream is generated having size of Nsym*Nfft= 6144 samples with 6 (Nsym) OFDM blocks with 1024(Nfft) size of each block. The transmitted signal is has length extra then the generated block due to addition of cyclic prefix block. Since CP length is 128 thus the transmitted signal block will have length as Nfft+CP. Thus a Tx array is initialized to store transmitted data with size Nsym*(Nfft+CP)= 6912.

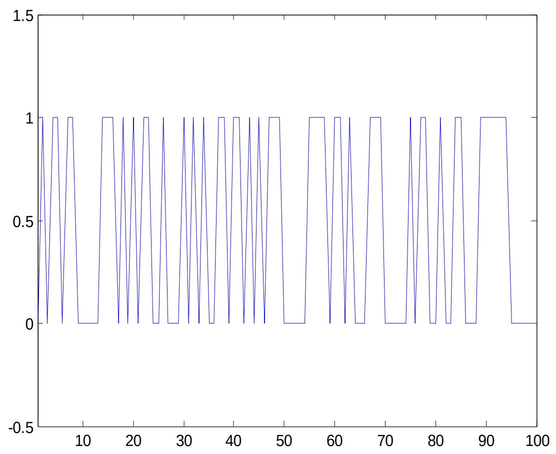

Figure 7: Initial 100 samples of generated binary data.

After generating the binary data modulation is applied on the data for example if we apply BPSK then we will get two values of same magnitude but opposite phases as shown in figure2. .

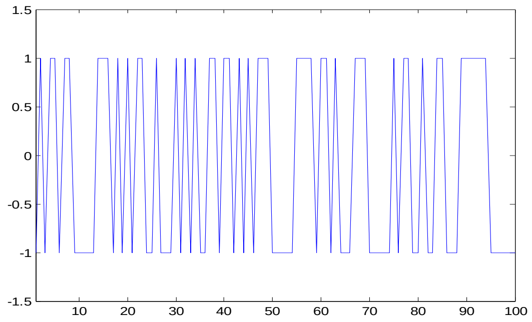

Figure 8 : Initial 100 samples of BPSK modulated binary data.

After applying the modulation the data is subdivided into blocks of size NFFT and then ifft is applied on each block. After applying ifft the last CP samples are replicated in initial of each block to generate the transmitted data block. Thus the OFDM block matrix is of size 1024 after adding CP it Tx block has size of 1152 samples. Noise is added to the Tx blocks at different SNR values and after that frequency offset is created and the data array is saved as the received block.

Table 5.2: The values of parameter chosen by adaptive modulation scheme for different Bandwidth and SNR.

B.W./SNR → ↓		**7**	**10**	**15**	**20**	**25**
20	**Cyclic prefix**	¼	¼	**1/8**	**1/4**	**1/8**
		Modulation scheme BPSK Coding rate1/2 CPselect=193 to 256,1 to 256 CPremove=65 to 320 Input size=88 Sampling frequency=22.7	Modulation scheme QPSK Coding rate 1/2 CPselect=193 to 256, 1 to 256 CPremove=65 to 320 Input size=184 Sampling frequency=22.7	Modulation scheme QPSK Coding rate 3/4 CPselect=225 to 256,1 to 256 CPremove=33 to 288 Input size=280 Sampling frequency=22.7	Modulation scheme 16-QAM coding rate 3/4 CPselect=193 to 256, 1 to 256 CPremove= 65 to 320 Input size=568 Sampling frequency=22.7	Modulation scheme 64-QAM coding rate 3/4 CPselect=225 to 256,1 to 256 CPremove=33 to 288 Input size=856 Sampling frequency=22.7
10	**Cyclic prefix**	**1/8**	**1/8**	**1/8**	**1/8**	**1/4**
		Modulation scheme BPSK Coding rate 1/2 CPselect=225 to 256 CPremove= 33to 288 Input size=88 Sampling frequency=-11.3	Modulation scheme QPSK Coding rate 1/2 CPselect=225 to 256,1 to 256 CPremove=33 to 288 Input size=184 Sampling frequency= 11.3	Modulation scheme QPSK Coding rate 3/4 CPselect=225 to 256,1 to 256 CPremove=33 to 288 Input size=280 Sampling frequency=11.3	Modulation scheme 16-QAM Coding rate 3/4 CPselect=225 to 256,1 to 256 CPremove=33 to 288 Input size=568 Sampling frequency=11.3	Modulation scheme 64- QAM Coding rate 3/4 CPselect=193 to 256,1 to 256 CPremove=65 to 320 Input size=856 Sampling frequency=11.3
5	**Cyclic prefix**	¼	**1/8**	**1/4**	**1/4**	**1/8**
		Modulation scheme BPSK coding rate 1/2 CPselect=193 to 256,1 to 256 CPremove=65 to 320 Input size=88 Sampling frequency=5.76	Modulation scheme QPSK Coding rate 1/2 CPselect=225 to 256, 1 to 256 CPremove=33 to 288 Input size=184 Sampling frequency=5.76	Modulation scheme QPSK Coding rate 3/4 CPselect=193 to 256,1 to 256 CPremove=65 to 320 Input size=280 Sampling frequency=5.76	Modulation scheme 16-QAM Coding rate 3/4 CPselect=193 to 256,1 to 256 CPremove=65 to 320 Input size=568 Sampling frequency=5.76	Modulation scheme 64- QAM coding rate 3/4 CPselect=225 to 256,1 to 256 CPremove=33 to 288 Input size=856 Sampling frequency=5.76

The report generated by code is given below:
choose cyclic prefix to overcome delays spreads
,1/4 for longest delay spread ,1/8 for long delay spreads ,
1/16 for short delays spreads ,1/32 for very small delay spread channels
cSNR =6.500000000000000
Modulation scheme of BPSK with Coding rate 1/2 is chosen
modscheme =Adaptive Modulation
choose cyclic prefix to overcome delays spreads
,1/4 for longest delay spread ,1/8 for long delay spreads ,
1/16 for short delays spreads ,1/32 for very small delay spread channels
cSNR =10
Modulation scheme of QPSK with Coding rate 1/2 is chosen
modscheme =Adaptive Modulation
choose cyclic prefix to overcome delays spreads
,1/4 for longest delay spread ,1/8 for long delay spreads ,
1/16 for short delays spreads ,1/32 for very small delay spread channels
cSNR =15
Modulation scheme of QPSK with Coding rate 3/4 is chosen
modscheme =Adaptive Modulationchoose cyclic prefix to overcome delays spreads,1/4 for longest delay spread ,1/8 for long delay spreads ,
1/16 for short delays spreads ,1/32 for very small delay spread channels
cSNR = 20
Modulation scheme of 16-QAM with Coding rate 3/4 is chosen
modscheme =Adaptive Modulation
choose cyclic prefix to overcome delays spreads
,1/4 for longest delay spread ,1/8 for long delay spreads ,
1/16 for short delays spreads ,1/32 for very small delay spread channels
cSNR =25
Modulation scheme of 64-QAM with Coding rate 3/4 is chosen
modscheme =Adaptive Modulation
choose cyclic prefix to overcome delays spreads
,1/4 for longest delay spread ,1/8 for long delay spreads ,
1/16 for short delays spreads ,1/32 for very small delay spread channels
cSNR = 30
Modulation scheme of 64-QAM with Coding rate 3/4 is chosen
modscheme =Adaptive Modulation
choose cyclic prefix to overcome delays spreads
,1/4 for longest delay spread ,1/8 for long delay spreads ,
1/16 for short delays spreads ,1/32 for very small delay spread channels
cSNR =35
Modulation scheme of 64-QAM with Coding rate 3/4 is chosen
modscheme =Adaptive Modulation
choose cyclic prefix to overcome delays spreads
,1/4 for longest delay spread ,1/8 for long delay spreads ,
1/16 for short delays spreads ,1/32 for very small delay spread channels
cSNR = 40
Modulation scheme of 64-QAM with Coding rate 3/4 is chosen
modscheme =Adaptive Modulation

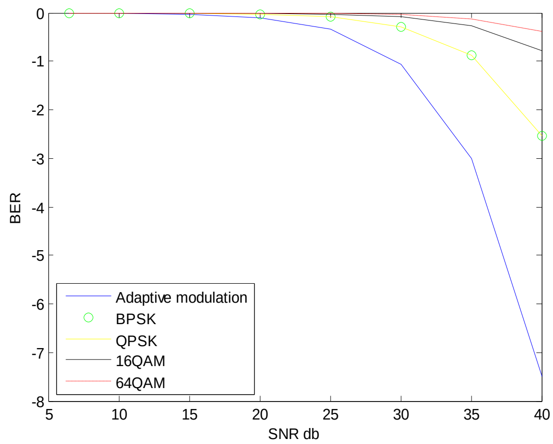

Figure 7 : Performance evaluation of CP based channel estimation and correction in terms of BER at different modulation for MIMO OFDM systems.

IV. CONCLUSION

Transmit Diversity vs. Receive Diversity-
Using diversity reception is a well-known technique to mitigate the effects of fading over a communications link. However, it has mostly been related to the receiver end. In [1], Alamouti proposes a transmit diversity scheme that offers similar diversity gains, using multiple antennas at the transmitter. This was conceived to be more practical as, for example, it would only require multiple antennas at the base station in comparison to multiple antennas for every mobile in a cellular communications system.
This section highlights this comparison of transmit vs. receive diversity by simulating coherent binary phase-shift keying (BPSK) modulation over flat-fading Rayleigh channels. For transmit diversity, we use two transmit antennas and one receive antenna (2x1 notationally), while for receive diversity we employ one transmit antenna and two receive antennas (1x2 notationally).
The transmit diversity system has a computation complexity very similar to that of the receive diversity system.The resulting simulation results show that using two transmit antennas and one receive antenna provides the same diversity order as the maximal-ratio combined (MRC) system of one transmit antenna and two receive antennas.
Also observe that transmit diversity has a 3 dB disadvantage when compared to MRC receive diversity. This is because we modelled the total transmitted power to be the same in both cases. If we calibrate the transmitted power such that the received power for these two cases is the same, then the performance would be identical. The theoretical performance of second-order diversity link matches the transmit diversity system as it normalizes the total power across all the diversity branches.

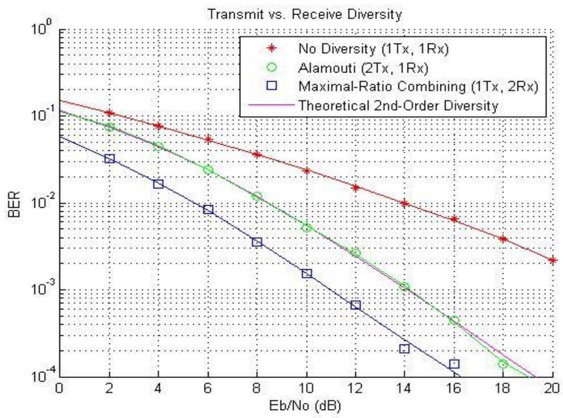

Figure 9: BER performance at different MIMO coding schemes for 1x2 or 2x1 sytems.

Orthogonal Space-Time Block Coding and Further Explorations:

We present some performance results for orthogonal space-time block coding using four transmit antennas (4x1 system) using a half-rate codeas per [4].

We assume the system to offer a diversity order of 4 and will compare it with 1x4 and 2x2 systems, which have the same diversity order also. To allow for a fair comparison, we use quaternary PSK with the half-rate G4 code to achieve the same transmission rate of 1 bit/sec/Hz.

Since these results take some time to generate, we load the results from a prior simulation. The functional script OSTBC4M.m,OSTBC4M.m is included, which, along with MRC1M.m,MRC1M.m and OSTBC2M.m,OSTBC2M.m, was used to generate these results. The user is urged to use these scripts as a starting point to study other codes and systems.

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Also observe the 3 dB penalty for the 4x1 system that can be attributed to the same total transmitted power assumption made for each of the three systems. If we calibrate the transmitted power such that the received power for each of these systems is the same, then the three systems would perform identically. Again, the theoretical performance matches the simulation performance of the 4x1 system as the total power is normalized across the diversity branches.

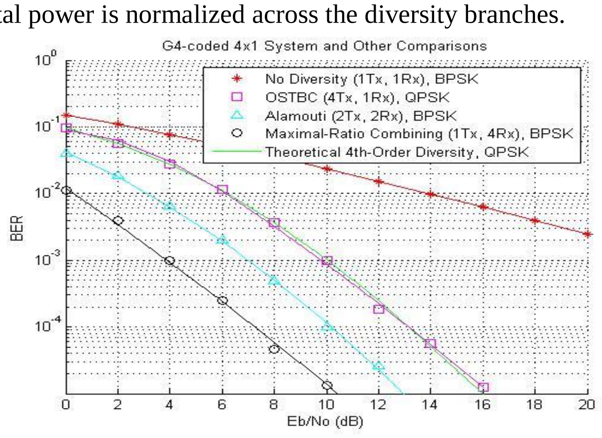

Figure 10:BER performance at different MIMO coding schemes for higher order diversity.

Algorithm is developed to determine the modulation type and rate as per the channel noise. The algorithm is initialized at the given constraints of bandwidth, sampling factor, guard band size. The bandwidth , g , fs factor, that are used MIMO OFDM systems are-

Bandwidth = max 20 Mhz

Guard band Tg = Td/8

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Galois Field is widely used to represent data in error control coding and is denoted by GF(2m).

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Table 2: The algorithm chooses following modulation type and rate at different SNR.

Modulation	Coding Rate	Receiver SNR threshold (db)
BPSK	½	6.4
QPSK	½	9.4
QPSK	3/4	11.2
QAM-16	½	16.4
QAM-16	¾	18.2
QAM-64	½	22.7
QAM-64	¾	24.4

On entering the b.w = 8, G = 1/4 the algorithm gives the values. Using above algorithm as we enter different values of Vw, G and SNR(db).We can generate parameters for different modulation schemes that can be adapted during generation of data by applying MIMO OFDM. The table below describe the result obtained as the parameter for MIMO OFDM data generation plateform at different channel condition.

Proposed Algorithm Results:

After discussion and analysis of MIMO systems of data

coding and transmission and OFDM performance at different modulation scheme we are going to describe the results that are obtained for MIMO OFDM system by using the adaptive modulation strategy that estimates the channel SNR from the pilot symbols and cyclic prefix values and then from the estimated SBR the algorithm decides the modulation scheme that can be most suitable for minimum BER values. The MIMO OFDM configuration that has been used is:
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5:64QAM

Number of Tx antennas Mt=2
Number of Rx antennas Mr=2
Guard band ration out off total OFDM block,G=1/4
Delay spread of channel, DS=5
Number of subcarriers, L=120;
Bandwidth,B=5x10 ^{6} Hz
Signal to noise ratio is varied in dB as =[6.5 10 15 20 25 30 35 40]

The value of SNR is varied for different choice of modulation to record the effect of the noise on modulated data.
ifBPSKbitsper symbol=1
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Random binary data is generated for Mt transmitters and pilot data is inserted thereafter the cyclix prefix is added.Initially a random data stream is generated having size of Nsym*Nfft= 6144 samples with 6 (Nsym) OFDM blocks with 1024(Nfft) size of each block. The transmitted signal is has length extra then the generated block due to addition of cyclic prefix block. Since CP length is 128 thus the transmitted signal block will have length as Nfft+CP. Thus a Tx array is initialized to store transmitted data with size Nsym*(Nfft+CP)= 6912.

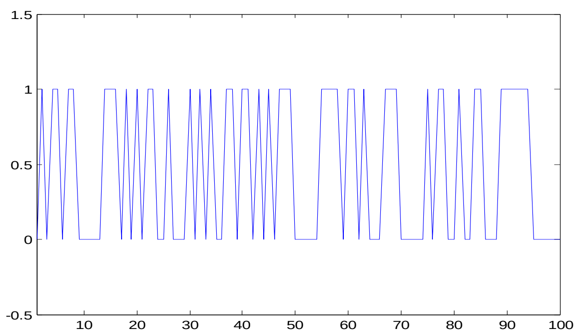

Figure 11 : Initial 100 samples of generated binary data.
After generating the binary data modulation is applied on the data for example if we apply BPSK then we will get two values of same magnitude but opposite phases as shown in figure2. .

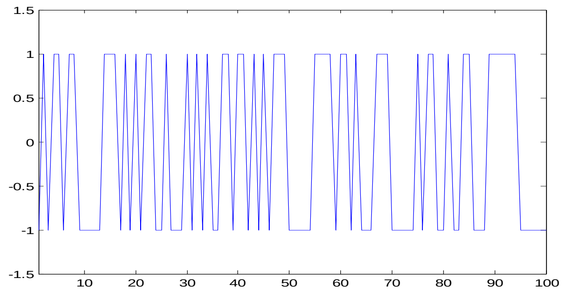

Figure 12: Initial 100 samples of BPSK modulated binary data.

After applying the modulation the data is subdivided into blocks of size NFFT and then ifft is applied on each block. After applying ifft the last CP samples are replicated in initial of each block to generate the transmitted data block. Thus the OFDM block matrix is of size 1024 after adding CP it Tx block has size of 1152 samples. Noise is added to the Tx blocks at different SNR values and after that frequency offset is created and the data array is saved as the received block.

Table 3: The values of parameter chosen by adaptive modulation scheme for different Bandwidth and SNR.

B.W./SNR →		7	10	15	20	25
20	**Cyclic prefix**	¼	¼	**1/8**	**1/4**	**1/8**
		Modulation scheme BPSK Coding rate1/2 CPselect=193 to 256,1 to 256 CPremove=65 to 320 Input size=88 Sampling frequency=22.7	Modulation scheme QPSK Coding rate 1/2 CPselect=193 to 256, 1 to 256 CPremove=65 to 320 Input size=184 Sampling frequency=22.7	Modulation scheme QPSK Coding rate 3/4 CPselect=225 to 256,1 to 256 CPremove=33 to 288 Input size=280 Sampling frequency=22.7	Modulation scheme 16-QAM coding rate 3/4 CPselect=193 to 256, 1 to 256 CPremove= 65 to 320 Input size=568 Sampling frequency=22.7	Modulation scheme 64-QAM coding rate 3/4 CPselect=225 to 256,1 to 256 CPremove=33 to 288 Input size=856 Sampling frequency=22.7
10	**Cyclic prefix**	**1/8**	**1/8**	**1/8**	**1/8**	**1/4**
		Modulation scheme BPSK Coding rate 1/2 CPselect=225 to 256 CPremove= 33to 288 Input size=88 Sampling frequency=-11.3	Modulation scheme QPSK Coding rate 1/2 CPselect=225 to 256,1 to 256 CPremove=33 to 288 Input size=184 Sampling frequency= 11.3	Modulation scheme QPSK Coding rate 3/4 CPselect=225 to 256,1 to 256 CPremove=33 to 288 Input size=280 Sampling frequency=11.3	Modulation scheme 16-QAM Coding rate 3/4 CPselect=225 to 256,1 to 256 CPremove=33 to 288 Input size=568 Sampling frequency=11.3	Modulation scheme 64-QAM Coding rate 3/4 CPselect=193 to 256,1 to 256 CPremove=65 to 320 Input size=856 Sampling frequency=11.3
5	**Cyclic prefix**	¼	**1/8**	**1/4**	**1/4**	**1/8**
		Modulation scheme BPSK coding rate 1/2 CPselect=193 to 256,1 to 256 CPremove=65 to 320 Input size=88 Sampling frequency=5.76	Modulation scheme QPSK Coding rate 1/2 CPselect=225 to 256, 1 to 256 CPremove=33 to 288 Input size=184 Sampling frequency=5.76	Modulation scheme QPSK Coding rate 3/4 CPselect=193 to 256,1 to 256 CPremove=65 to 320 Input size=280 Sampling frequency=5.76	Modulation scheme 16-QAM Coding rate 3/4 CPselect=193 to 256,1 to 256 CPremove=65 to 320 Input size=568 Sampling frequency=5.76	Modulation scheme 64-QAM coding rate 3/4 CPselect=225 to 256,1 to 256 CPremove=33 to 288 Input size=856 Sampling frequency=5.76

The report generated by code is given below:
choose cyclic prefix to overcome delays spreads,1/4 for longest delay spread ,1/8 for long delay spreads , 1/16 for short delays spreads ,1/32 for very small delay spread channels cSNR =6.500000000000000
Modulation scheme of BPSK with Coding rate 1/2 is chosen
modscheme =Adaptive Modulation choose cyclic prefix to overcome delays spreads ,1/4 for longest delay spread ,1/8 for long delay spreads , 1/16 for short delays spreads ,1/32 for very small delay spread channels cSNR =10
Modulation scheme of QPSK with Coding rate 1/2 is chosen
modscheme =Adaptive Modulation
choose cyclic prefix to overcome delays spreads
,1/4 for longest delay spread ,1/8 for long delay spreads ,
1/16 for short delays spreads ,1/32 for very small delay spread channels
cSNR =15
Modulation scheme of QPSK with Coding rate 3/4 is chosen
modscheme =Adaptive Modulationchoose cyclic prefix to overcome delays spreads,1/4 for longest delay spread ,1/8 for long delay spreads ,
1/16 for short delays spreads ,1/32 for very small delay spread channels
cSNR = 20
Modulation scheme of 16-QAM with Coding rate 3/4 is chosen
modscheme =Adaptive Modulation
choose cyclic prefix to overcome delays spreads
,1/4 for longest delay spread ,1/8 for long delay spreads ,
1/16 for short delays spreads ,1/32 for very small delay spread channels
cSNR =25
Modulation scheme of 64-QAM with Coding rate 3/4 is chosen
modscheme =Adaptive Modulation
choose cyclic prefix to overcome delays spreads
,1/4 for longest delay spread ,1/8 for long delay spreads ,
1/16 for short delays spreads ,1/32 for very small delay spread channels
cSNR = 30
Modulation scheme of 64-QAM with Coding rate 3/4 is chosen
modscheme =Adaptive Modulation
choose cyclic prefix to overcome delays spreads
,1/4 for longest delay spread ,1/8 for long delay spreads ,
1/16 for short delays spreads ,1/32 for very small delay spread channels
cSNR =35
Modulation scheme of 64-QAM with Coding rate 3/4 is chosen
modscheme =Adaptive Modulation
choose cyclic prefix to overcome delays spreads
,1/4 for longest delay spread ,1/8 for long delay spreads ,
1/16 for short delays spreads ,1/32 for very small delay spread channels
cSNR = 40
Modulation scheme of 64-QAM with Coding rate 3/4 is chosen
modscheme =Adaptive Modulation

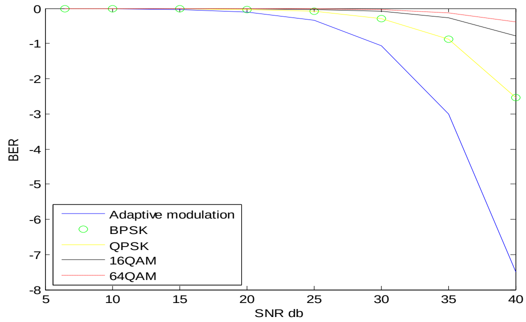

Figure 13 : Performance evaluation of CP based channel estimation and correction in terms of BER at different modulation for MIMO OFDM systems.

CONCLUSION MIMO-OFDM is getting popularity as an important technique in wireless data communications and telemetry because of its advantages that includes very large degree of bandwidth efficiency, better linkage quality of service, simple and flexible adaptive channel equalization, and high level of resistance towards the frequency selective multipath fading and distortion. In addition to these advantages, MIMO OFDM is facing challenges of low quality of performance due to caused by some undesirable effects because of channel fading and distortion that destroys the orthogonality among the subcarriers and causes error in the detection of OFDM block symbol data. Consequently the bit error rate (BER) of the MIMO-OFDM blocks after receiving at receiver end hence due to this it also degrades the channel estimation accuracy.

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