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Comparative Study of Digital Modulation Techniques in WIMAX

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Abstract: - The migration to 4G networks will bring a new level of expectation to wireless communications. As after digital wireless revolution made mobile phones available for everyone, the higher speeds and packet delivery of 4G networks will make high quality multimedia available everywhere. The key to achieving this higher level of service delivery is a new air interface. Orthogonal Frequency Division Multiplexing (OFDM) is an alternative wireless modulation technology to CDMA. OFDM is a digital modulation and multiplexing technique. In this paper, we have discussed various digital modulation techniques such as BPSK (2bits), QPSK (4 bits), QAM, 16 QAM and 64 QAM. We have designed simulation environment in MATLAB with various configurations of OFDM technique. The main objective of our work is to measure Bit Error Rate with different modulation schemes and come to the best configuration to achieve better utilization of bandwidth. We have studied existing configurations with analog and digital modulation techniques and compared the results. The driving force behind the need to satisfy this requirement is the explosion in mobile telephone, Internet and multimedia services coupled with a limited radio spectrum.

Key Words:- **OFDM; 3G; 4G; BPSK; QPSK; Bit Error Rate (BER); WIMAX; QAM.**

I. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) is an alternative wireless modulation technology to CDMA. OFDM has the potential to surpass the capacity of CDMA systems and provide the wireless access method for 4G systems. OFDM is a modulation scheme that allows digital data to be efficiently and reliably transmitted over a radio channel, even in carriers. These carriers are regularly spaced in frequency, forming a block of spectrum. The frequency spacing and time synchronization of the carriers is chosen in such a way that the carriers are orthogonal, meaning that they do not cause interference to each other. This is despite the frequency (Frequency Division Multiplexing) and these carriers are orthogonal to each other, hence Orthogonal Frequency Division Multiplexing. In OFDM, usable bandwidth is divided into a large number of smaller bandwidths that are mathematically orthogonal using fast Fourier transforms (FFTs). Reconstruction of the band is performed by the inverse fast Fourier transform (IFFT). Carriers overlapping each other in the frequency domain. The name 'OFDM' is derived from the fact that the digital data is sent using many carriers, each of a different Attenuation is drop in signal power when transmitting from one point to another which is caused due to shadowing /slow fading and it can be avoided by splitting the signal into many small bandwidth carriers like OFDM does. This lead to small loss in carrier rather than complete loss. Delay spread is the time spread between the arrival of the first and last multipath signal seen by receiver. In digital system the delay spread can lead to inter-symbol interference. This can be minimized in many ways, one method is to reduce the symbol rate by reducing the data rate for each channel i.e. split the bandwidth into more channels by using frequency division multiplexing another is to use a coding scheme while is relevant to inter symbol interference such as CDMA. In this paper we have mainly focused on WIMAX technology and simulated it in Matlab (Simulink). Most users are keen to use wireless medium with greater speed and that is supported using the existing infrastructure. Many researches have been proved that WIMAX is answer for user's expectation and this paper will answer to all the questions regarding confusion on choosing the best modulation technique to use not only to get better utilization of available bandwidth but also how to minimize the BER. More information regarding WIMAX specification and advantages is explained in [1]. WIMAX at base level make use of OFDM and our research started with convenient model of OFDM and uses that model in WIMAX to get better result. Observation and conclusion regarding the same will be discussed in following sections.

II. PERFORMANCE EVALUATION OF OFDM

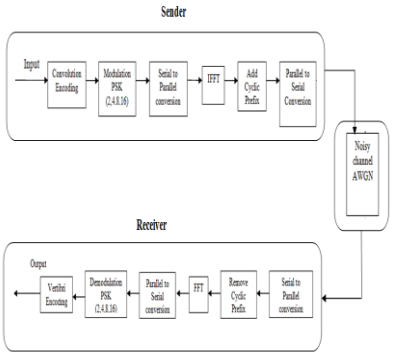

Fig 1: Block Diagram OFDM (Sender and Receiver)

OFDM is digital modulation as well as multiplexing technique. So we have chosen PSK as digital modulation technique. Different form of PSK such as BPSK (2-PSK), QPSK (4-PSK), 8-PSK and 16-PSK has been used to evaluate to find which modulation technique will be suitable to get maximum benefit from available network. For simulation the total number of bits that has been transferred is adjusted according to the modulation technique that has been used. For BPSK we have considered 12000 bits of data and increased the value to

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24000, 36000 and 48000 for QPSK, 8-PSK and 16-PSK respectively.

A. Steps Involved in Simulation:

1. Take input
   It can be random data, sine wave, cosine wave or sound input.
2. Encode the data
   Encode the data using Convolution Encoding technique.
3. Modulation
   The modulation techniques used in this project are 2-PSK, 4-PSK (QPSK), 8-PSK and 16-PSK. The output of this modulation technique is real and imaginary value. Only real part is taken into consideration. The real part is sent to next block for further processing.
4. OFDM modulation
   Convert serial data into parallel.
   Apply IFFT to the parallel data.
   Add cyclic prefix to the processed data.
   Convert parallel data to serial.
5. Send the signal
   Add noise to the carrier.
   Pass carriers through AWGN channel taking SNR=11db.
6. OFDM Demodulation
   Convert serial to parallel.
   Remove cyclic prefix.
   Apply FFT.
7. Demodulation
   Apply corresponding demodulation technique.
8. Decode the data
   Decoder for convolution encoding technique is Vertibri Decoder, which is used.
9. The received data is then checked with original input data and BER and Loss of bit is calculated.

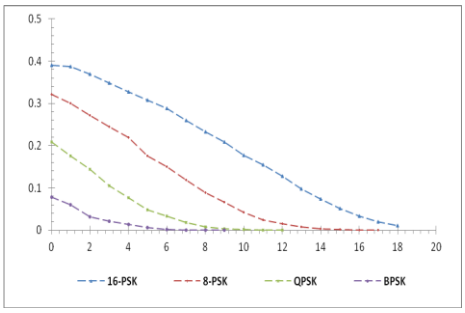

Fig 2: Plot of SNR value in dB to BER(X axis SNR & Y axis BER).

B.Out Come:

- As we increase the order of modulation throughput increases but BER value goes on increasing.
- If we consider only BER value into account and not the throughput then BPSK is the best modulation technique since number of error in even small SNR values are minimal as compared other modulation technique.
- Fig 2 clearly shows the comparative study of the simulated modulation techniques, from where we can conclude that in terms of BER, BPSK is the best where as if we take into consideration of throughput then 16-PSK is far better than other modulation techniques.

Mathematically it has been proved that as we go on increasing order of modulation throughput is almost doubled.

III. PERFORMANCE EVALUATION OF WIMAX

Steps involved in Simulation are as follows:

1. Generate random binary data.
2. Generate pulse for the same and randomize it.
3. Convert bits into integer.
4. Coding Technique
   i. R S Encoder
   ii. Convolution Encoder
5. Interleave
6. Modulation technique (Depending upon SNR value corresponding modulation technique is chosen). List of techniques are
   i. BPSK
   ii. QPSK
   iii. General QAM
   iv. 16-QAM
   v. 64-QAM
7. Multiplex the data (Assembler)
8. Apply IFFT
9. Adding Cyclic Prefix
10. Send data from Rayleigh fading channel and AWGN Channel.
11. Opposite of all the above explained steps is performed by Receiver
12. The Decoding techniques for encoder are as follows:
    i. R S Decoder for R S Encoder
    ii. Vertibri Decoder for Convolution Encoder
13. The Received data is then compared with original data to calculate BER.

A. Simulation Environment for WIMAX

WIMAX generally works between 1.25 to 20 MHz; this simulation can also be simulated in between these two values. The user can select the bandwidth and delay spread and SNR value and on basis of that corresponding modulation technique is chosen which can be changed (if user wants to) while playing simulation. The simulation is run for 2 mins and the result for No. of bits sent, Total number of Bit Error and BER can be viewed in System Performance test block. The comparative analysis for every modulation technique along with WiMAX module is given in following section (Observation 1-Observation2)

Observation-1

Channel Bandwidth=1.25 MHz

Delay=1/4

1. **Modulation technique=BPSK**
   Coding rate=1/2

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SNR	Total bit	Bit Loss	BER
7	6864	0	0

2. **Modulation technique=QPSK**
Coding rate=1/2

SNR	Total bit	Bit Loss	BER
7	1.435e+004	566	0.03944
9	1.435e+004	21	0.001392
10	1.435e+004	0	0

3. **Modulation Technique=QPSK**

Coding rate=3/4

SNR	Total bit	Bit Loss	BER
12	3.024e+004	1314	0.04345
14	3.024e+004	54	0.001786
15	3.024e+004	0	0

4. **Modulation Technique=16-QAM**

Coding rate=1/2

SNR	Total bit	Bit Loss	BER
13	2.782e+004	2663	0.09571
15	2.782e+004	359	0.0129
16.5	2.782e+004	35	0.001258
17.5	2.782e+004	4	0.0001438

5. **Modulation Technique=16-QAM**
Coding rate=3/4

SNR	Total bit	Bit Loss	BER
17	4.146e+004	1.2575e+004	0.3075
18.5	4.146e+004	4909	0.1184
20	4.146e+004	1987	0.04727
22.5	4.146e+004	146	0.003521

6. **Modulation Technique=64-QAM**
Coding rate=2/3

SNR	Total bit	Bit Loss	BER
23	5.472e+004	5865	0.01072
24	5.472e+004	2894	0.05289
26	5.472e+004	531	0.009704
28	5.472e+004	9	0.0001645

7. **Modulation Technique=64-QAM**
Coding rate=3/4

SNR	Total bit	Bit Loss	BER
24.5	8.902e+004	3.29e+004	0.3696
27	8.902e+004	2.118e+004	0.2379
30	8.902e+004	8302	0.09326
33	8.902e+004	3893	0.04373

Observation-2
Channel Bandwidth=6 MHz
Delay=1/4

1. **Modulation technique=BPSK**
Coding rate=1/2

SNR	Total bit	Bit Loss	BER
7	1.17e+004	0	0

2. **Modulation technique=QPSK**
Coding rate=1/2

SNR	Total bit	Bit Loss	BER
7	2.374e+004	907	0.0379
9	2.374e+004	25	0.00107
10	2.374e+004	0	0

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3. **Modulation Technique=QPSK**

Coding rate=3/4

SNR	Total bit	Bit Loss	BER
12	2.212e+004	795	0.0359
14	2.212e+004	54	0.002441
15	2.212e+004	0	0

4. **Modulation Technique=16-QAM**
Coding rate=1/2

SNR	Total bit	Bit Loss	BER
15	3.083e+004	377	0.01253
16.5	3.083e+004	45	0.00146
17.5	3.083e+004	4	0.00013

5. **Modulation Technique=16-QAM**
Coding rate=3/4

SNR	Total bit	Bit Loss	BER
18.5	4.487e+004	5270	0.11745
20	4.487e+004	2343	0.05222
23	4.487e+004	92	0.00205

6. **Modulation Technique=64-QAM**
Coding rate=2/3

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SNR	Total bit	Bit Loss	BER
23	9.576e+004	1.092e+004	0.114
26	9.576e+004	1055	0.01102
28	9.576e+004	115	0.001201

7. Modulation Technique=64-QAM
Coding rate=3/4

SNR	Total bit	Bit Loss	BER
24.5	1.079e+005	4.024e+004	0.3731
30	1.079e+005	8892	0.08240
33	1.079e+005	4865	0.04511

Out Come:

In WiMAX model we have analyzed BER value of different modulation techniques in different channel bandwidth with different SNR values. At the end of analysis we have concluded that as we increase channel bandwidth we get better throughput but BER increases. As we go up order of modulation BER increases for a given SNR value. As we go on increasing SNR value for a given modulation technique BER goes on decreasing. Thus at last of analysis we reached to the configuration where Bit Error rate is very less and throughput is more.

IV. CONCLUSION

This paper is only the comparative study of digital modulation techniques that can be used in OFDM which is core part of WIMAX model. After this study and comparing the table that we have observed we can come up with the combination of different encoding-decoding and modulation-demodulation techniques which will best suit with current expectation of end-user.

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