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5 authors, including:


Ahmed Al Amin
University of Michigan


Tania Khadem
University of Science and Technology Chittagong


Md. Delwar Hossen
Uttara University


Md. Shoriful Islam
Brigham Young University

Analysis of Modulation and Coding Scheme for 5th Generation Wireless Communication System

Ahmed Al Amin,
Senior Lecturer
Department of Electrical & Electronic Engineering
Uttara University
Dhaka, Bangladesh
shaon04@gmail.com

Devashish Basak
Department of EEE
Khulna University of Engineering andTechnology (KUET) Khulna, Bangladesh

Tania Khadem
Department of Electrical& Electronic Engineering
Chittagong University of Engineering and TechnologyChittagong, Bangladesh

Md. Delwar Hossen
Assistant Professor
Department of Electrical & Electronic Engineering
Uttara University
Dhaka, Bangladesh
mddelwar1@yahoo.com

Md. Shoriful Islam
Lecturer
Department of Electrical & Electronic Engineering
Uttara University
Dhaka, Bangladesh
shoriful.eee@gmail.com

Abstract— **Advancing in communication technology, 5th Generation Wireless Communication System is playing a significant role. The 5th Generation wireless communication system involves different types of coding and modulation schemes for the better performances and efficient outputs. This paper analyzes the different coding schemes and modulation techniques and compares between them. The performances have been compared between the Turbo and Viterbi Coding Schemes. And the modulation techniques have been compared between QPSK and QAM modulation techniques. The QAM modulation scheme will be used for the users closer to the BTS (Base Transceiver Station). And QPSK modulation technique will be used for the users closer to the border of the cells. For both of the modulation techniques, both the coding schemes have been used and performances have been compared. Finally for all the modulation schemes, Viterbi Coding techniques (Convolutional Encoding and Viterbi Decoding) have proved its efficient performances in use.**

Index Terms- **QAM, QPSK, LTE, Turbo coding, Viterbi Coding, Convolutional encoding.**

I. INTRODUCTION

5th Generation Wireless Communication system is projected to be implemented within 2020. The most demanding feature of the 5th Generation Wireless Communication System is its high transmission and data rate. To accommodate data rate in Gigabit Range by 5th Generation Wireless Communication system, the main challenging factor is finding the perfect modulation and coding scheme. The modulation schemes are used in different ways. Such as, for the users nearer to the Base Transceiver Station (BTS), QAM (Quadrature Amplitude Modulation) modulation technique has been applied. Because, it can provide high data rate in case of High SNR (Signal to Noise Ratio) as the SNR is high closer to the BTS. And, QPSK () modulation scheme is used for the users closer to the border of the cell as there the value of SNR is low (QPSK modulation scheme provides high data rate in case of low SNR values). To increase the data rate by decreasing the BER (Bit Error Rate), researchers have to find a proper coding scheme. Viterbi Coding which consists of Convolutional Encoding and Viterbi Decoding, have been used in comparison with Turbo Coding. The comparison proves the efficient performances of Viterbi coding dominating the Turbo Coding Scheme. In addition, BPSK modulation techniques also have been analyzed for different types of coding. Hence, the Bit Error Rate (BER) has also been analyzed with different coding techniques.

II. RELATED STUDY

A. Evolution of 5G

Depending upon the different level of maturity of the underlying technology, the evolution of wireless telephone technologies can be divided into various generations. No demarcation is represented by such classifications into generations. However such generations are commonly agreed by both industry and academia and as a result it has become an unwritten standard. The data rate of 1G, 2G and 3G are almost history nowadays and by attaining data rates up to 7.2Mbps UMTS based 3G technologies have raised themselves to 3.5G with HSDPA (High Speed Downlink Packet Access). They have already implemented 4G through the 3GPP (3rd Generation Partnership Projects) where they have a strong desire achieve data rates in the order of 100Mbps downlink and 50 Mbps Uplink. Almost all the developed country has already converted their system in to 4G. Mainly in Europe 3GPP has given 4th Generation technology development efforts the brand name of Long Term Evolution or LTE whereas in North America similar effort is termed as UMB (Ultra-Mobile Broadband) by 3GPP2. [1] In different analysis papers the term 5G (5th generation mobile networks or fifth generation wireless systems) has been used. Right now, in any written document the term 5G hasn‟t been formally used rather different telecommunication firms or standardization bodies like 3GPP and WiMAX forums have been publicly utilizing it. All the researchers expected that around the year of 2020 5G would be implemented. The progress of their work is quite satisfied and it can be implemented before the expected date.[2]

[illegible]

Keys of 5G are

- ✓ In 5G there would be no limitation and it may be termed as REAL wireless world.
- ✓ In 5G there might be different additional options for instance there might be Multi-Media Newspapers and T.V programs would have clarity similar to HD T.V
- ✓ Internet protocol would be of version vi (IPv6) [2].

B. Architecture of 5G

With a view of providing hugely increased manageability as well as scalability and also substantial capabilities compared to those of previous generations in 5G era there should have been modification In the architecture of the mobile telecommunication. In order to achieve that a network control structure that is centralized software-based has been introduced. Also different legacy network (i.e 4G or 3G) can also deployed if the performance requirements of 5G is satisfied by the quality of service. [4] For using International Mobile Telecommunications (IMT) evolution as well as air interface technologies which is innovative the necessary solutions will be adaptive. The whole mobile ecosystem will be reshaped by technologies of network service and also functional virtualization. The generation of huge-scale services and applications has been facilitated by 5G.
The architecture of 5G has been illustrated below-

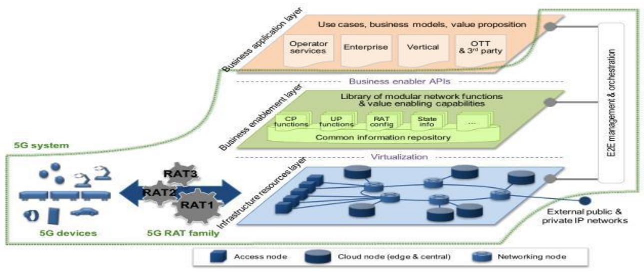

Figure 1: Architecture of 5G [5]

C. Challenges and requirements:

One of the biggest European Union 7th Framework Programmed (FP7) which consists 27 partners is termed as Mobile and wireless communications Enablers for the Twenty-twenty Information Society (METIS) [6-7]. The principal perspective of this society initiates foundation for 5G systems and also they working to achieve the standardization. Some test cases and also some aspects to address and illustrate the key requirements of 5G has been sorted out by METIS. The lists of aspects are:

- ✓ Splendidly fast‟
- ✓ It will render a great service when you are in crowd‟
- ✓ It will be the best experience that will follow you‟
- ✓ The connection will be very reliable and it will be in super real-time‟ and
- ✓ Things that are communicating are Ubiquitous‟ [8]

The number of challenges that 5G face to meet the expected key performance indicators (KPIs) are given below:

- Data rates should be around 1 to 10 GB/s so that it can support video that are high definition and also virtual reality applications.
- The latency time should be less than one millisecond with a view of supporting mobile control in real time also communications and applications which are from vehicle to vehicle.
- In order to ensure a delivery of services in a consistently seamless way there should be switching time which is rapid between different radio access technologies.
- The network systems of mobile should be expanded so that they can support applications of around tens of millions and also machines of hundreds of billions .[9]
- They should provide battery lifetime which is 10x times better for solutions which have low throughput like sensors.[10]
- Their capacity should be increased in the urban areas which are dense.
- They should be able to provide coverage in remote areas as well as airplanes.

D. Convolutional Encoding and Viterbi Decoding

Convolution code are commonly expressed by three parameters which are termed by (n,k,m). Here, n= number of bits which give output, k= number of bits in input and m= number of bits in memory register .It is code term of which the efficiency of convolution code is measure and expressed in the form of k/n. Some manufacturers use (n,k,L) instead of (n,k,m) where n and have the same meaning but L is termed as the constraint length of code and that‟s why it is called Constraint Length and here L=m+1.[11,12]. The convolutional encoder is illustrated by the following figure

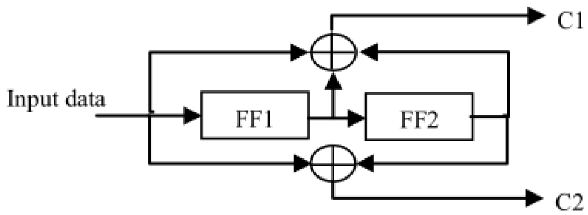

Figure 2: Convolutional encoder‟s block diagram of [13]

Where FF1 and FF2 are shift registers and they work as memory registers. The procedure of selecting which bit going to be added so that it can conceive the out bits is termed as generator polynomial for the bits of output. Here C1 and C2 are the generator polynomials and works as generator polynomials of two bits mudulo-2 adders. C1 and C2 can be of (111,101) where C1 = mod2 (FF1 + FF2+input bit). C2 = mod2 (FF2+ input bit.). A protection quality which is unique is expressed by the polynomials. In figure 3 encoder of code rate ½ is expressed and it symbolizes that 2 output bits are coded from each input bit. L is three here. The encoder has an output stream of C1 C2 C1 C2 C1 C2 and so on. There won't be any error corrected output if this stream is not followed and that"s why the bit synchronization has to be taken care of. Here we have considered that synchronized input bits are received by the decoder. The graphical ways to illustrate convolution coding is explained below

State Diagram

A state diagram for convolutional encoder is illustrated by fig 4. Corresponding to the binary contents which memory registers FF1 and FF2 consist the four states are shown by fig 3. Transition because of input of the information bit which is single is indicated by the lines that are joining states. „1" of the input bit is corresponded by the dashed lines and „0" of input transition bit is expressed by the dashed lines.

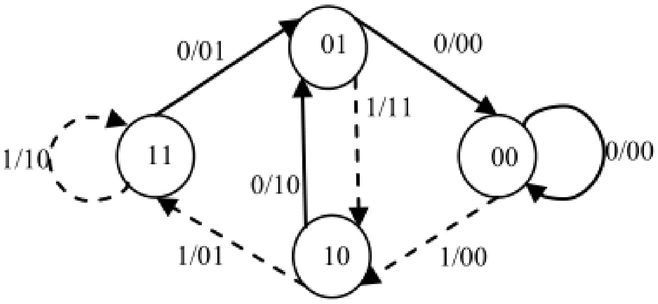

Figure 3: A (2, 1, 3) code's state diagram

The decoding which is maximum likelihood is the Viterbi algorithm's principle. It was Heller who first showed Viterbi decoding as a practical as well as efficient decoding technique for the case of short constraint length. But Viterbi algorithm is maximum likelihood and it was illustrated by Forney. [14] In order calculate the path metric as well as branch metric to the possible signal which is transmitted from received signal. An idea about trellis diagram is given in figure 5. The states which are possible are on vertical y-axis and discrete time is on horizontal x –axis. The constraints length of encoder is factor on which the number of states is dependent upon. The L which is constraint length is 3 and that"s why possible states are that is 4.Trace-back length (T) has a constraint length which is five to six times more. It is the state 0 at which the algorithm decoding started. It is desirable that the original sequence which has been sent is estimated when from channel a sequence of data is received. It is trellis by help of which this process be exemplified. At each time interval the states are shown by the bubble. The input bit „0" is represented by the solid line connecting dots that are shown in the diagram and the input bit „1" is expressed by the dotted line in the diagram.

E. Turbo Encoder and Decoder Structure

In figure 7 the structure of turbo encoder which is general is illustrated. For encoding the input bits which is similar two component codes are used but between the encoders there is an interleave situated. Normally for the component codes the methods of recursive systematic convolutional (RSC) codes have been used , but again there is a good possibility of achieving a fair performance if there is use of structure that has been seen in Fig. with other components that are aided. Good example of such codes are block codes, which are advocated by Hagenauer, Papke and Offer[16] and also by Pyndiah [17]. The turbo which is resultant i.e Bose–Chaudhuri–Hocquenghem (BCH) have been found in details in [18]. Here the center of concentration will be on the turbo encoder structure which is classic and which uses two RSC codes.

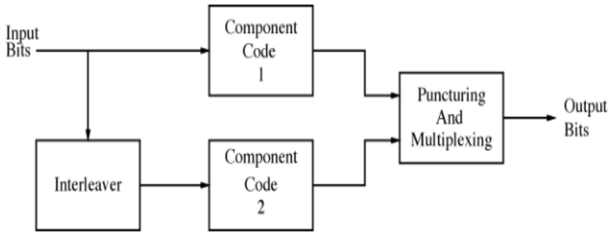

Figure 4: The schematic of Turbo encoder, Berrou et al, [19,20]

The general structure of iterative turbo decoder has been illustrated in figure 8 . In a structure which is analogous to that of encoder here the decoders are linked by the interleaves". There are three inputs in each decoder, The channel output bits are encoded quite systematically, from the component encoder which is associated the parity bits have been transmitted and from the other component decoders the information about the values which of bits which are likely have been concerned. This information is termed as priori information. Both information from the channel have to be exploited by the component decoders and this is called priori information.

III. Simulation and Results

In this paper Bit Error Rate (BER) of different modulation scheme along with coding techniques are analyzed. Here three modulation techniques such as BPSK, QPSK and QAM are analyzed along with two coding techniques such as turbo and convolution coding are analyzed.

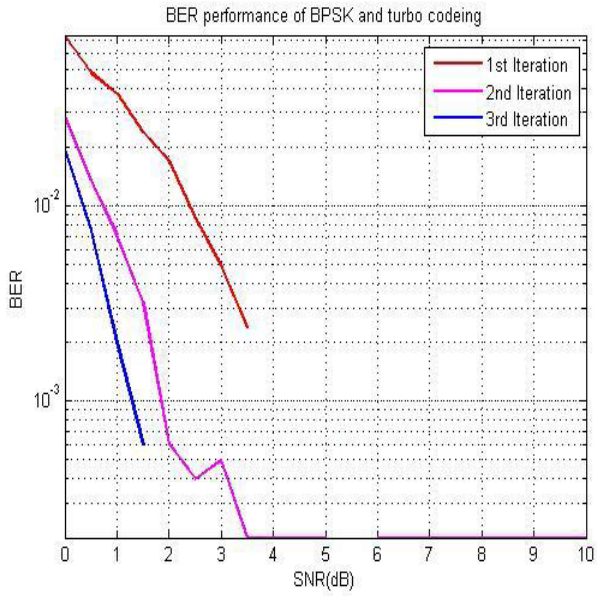

Figure 5: BER performance analysis of BPSK and turbo coding

Figure 5 shows that by turbo coding and BPSK modulation techniques for first iteration the BER is $10^{-2.9}$ for 3.5 dB SNR whereas for higher order iteration BER is much lower in case of lower SNR. But this BER is not much reasonable hence the standard BER is < 10^{-9} .

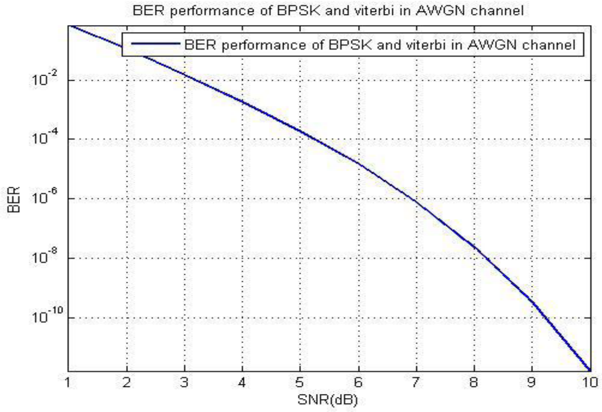

Figure 6: BER performance analysis of BPSK and convolutional coding

Figure 6 shows that in case of BPSK and convolutional coding BER is < 10^{-10} for 10 dB SNR. This shows much reasonable result for same modulation scheme and convolutional coding.

Figure 9-3: BER performance analysis of QAM and turbo coding

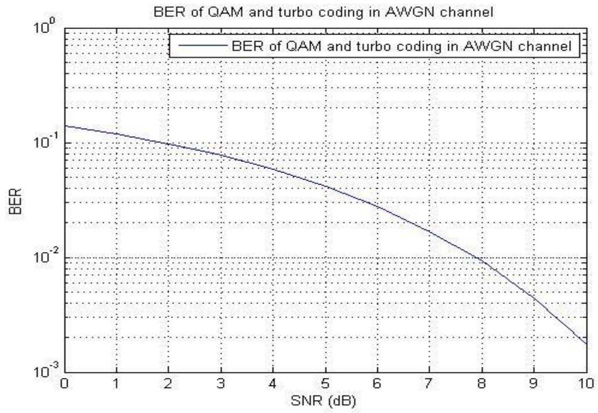

Figure 7 shows that in case of QAM and turbo coding BER is < $10^{-2.8}$ for 10 dB SNR. But this BER is much higher than the marginal level (< 10^{-9}).

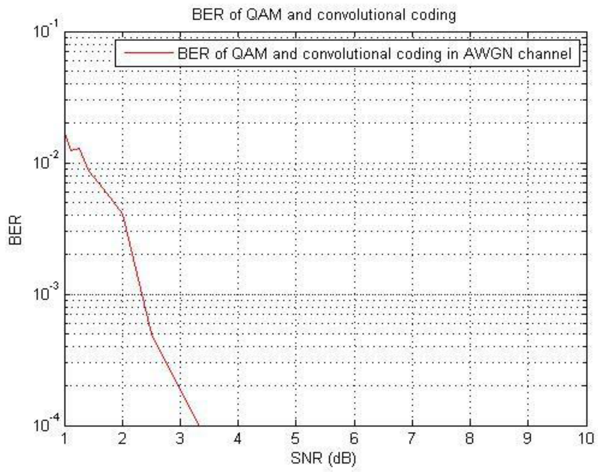

Figure 8: BER performance analysis of QAM and convolutional coding

Figure 8 shows that in case of QAM and turbo coding BER is < 10^{-4} for 3.2 dB SNR. This shows much reasonable result for QAM modulation scheme and convolutional coding. But this BER is much lower than the marginal level.

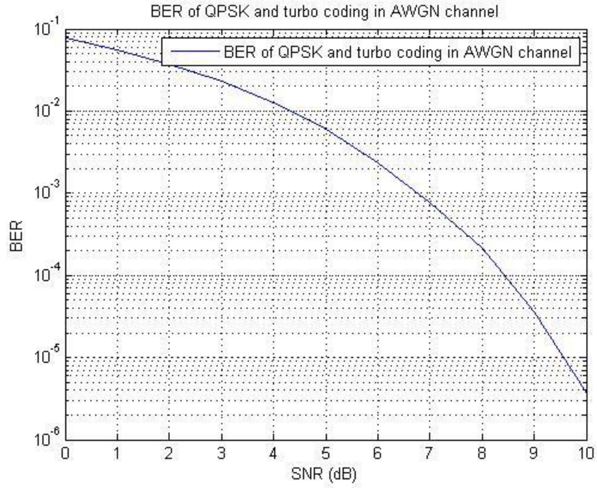

Figure 9: BER performance analysis of QPSK and turbo coding

Figure 9 shows that in case of QPSK and turbo coding BER is < $10^{-5.5}$ for 10 dB SNR. But this BER is much higher than the marginal level (< 10^{-9}).

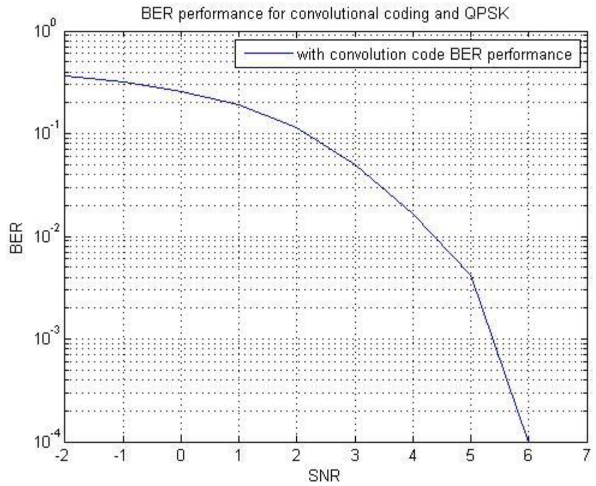

Figure 10: BER performance analysis of QPSK and convolutional coding.

Figure 10 shows that in case of QPSK and turbo coding BER is < 10^{-5} for 6 dB SNR. This shows much reasonable result for QAM modulation scheme and convolutional coding. But this BER is much lower than turbo coding. So in this proposed work QAM is proposed for the user near to the BTS and QPSK is proposed for the users who are situated in cell border. So for QAM and QPSK convolutional coding is a good solution for near and far user, moreover it provides higher BER in case of low SNR scenario.

IV. CONCLUSION

Adaptive modulation scheme have been proposed for 5th Generation Wireless Communication System. For this research work, the available options for adaptive modulation schemes are QPSK and QAM for the users closer to the border of the cells and closer to the BTS respectively. The objective was to find out the proper coding scheme for this adaptive modulation

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scheme to deduce the BER as well as to increase the data rate. By comparing the Viterbi Coding Scheme and Turbo Coding Scheme for adaptive modulation system it has been found that, Convolutional Coding Scheme proves to be more efficient than turbo coding in all kind of modulation schemes with any number of SNR (Signal to Noise Ratio).

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