Literature Review on Physical Layer of WiMAX

Anurag Mehto[1], Deepti Dave[2]

[1]M-Tech Research Scholar, [2] Asst. Prof. & Research Guide

Dept. of Computer Science & Engineering, IES Institute of Technology & Management, Bhopal

Abstract: In this research paper we have studied and analyzed the Physical Layer of WiMAX as our base work. The main issue of this work is to study implement the efficient WiMAX technology. An application of dynamic programming is widely used for estimation and detection problems in digital communications and signal processing. It is used to detect signals in communication channels with memory, and to decode sequential error-control codes that are used to enhance the performance of digital communication systems. The viterbi algorithm is also used in speech and character recognition tasks where the speech signals or characters are modeled by hidden Markov models. The basics of the viterbi algorithm as applied to systems in digital communication systems, and speech and character recognition. It also focuses on the operations and the practical memory requirements to implement the viterbi algorithm in real-time. A forward error correction technique known as convolutional coding with viterbi decoding was explored. In this project, the basic viterbi decoder behavior model has been analyzed theoretically. The convolutional encoder, BPSK and AWGN channel may be implemented in Matlab. The theory of viterbi algorithm is introduced based on convolutional coding. The application of viterbi algorithm in the continuous-phase frequency shift keying (CPFSK) is presented. Analysis for the performance is made and compared with the conventional coherent estimator.

Keywords:-Physical Layer of WiMAX (Worldwide Interoperability for Microwave Access) system.

I. INTRODUCTION

The physical (PHY) layer of WiMAX is based on the IEEE 802.16-2004 and IEEE 802.16e-2005 standards and was designed with much influence from Wi-Fi, especially IEEE 802.11a. Although many aspects of the two technologies are different due to the inherent difference in their purpose and applications, some of their basic constructs are very similar. Like Wi-Fi, WiMAX is based on the principles of orthogonal frequency division multiplexing (OFDM), which is a suitable modulation/access technique for non–line-of-sight (NLOS) conditions with high data rates.

In WiMAX, the various parameters pertaining to the physical layer, such as number of subcarriers, pilots, guard band and so on, are quite different from WiFi, since the two technologies are expected to function in very different environments. The IEEE 802.16 suite of standards (IEEE 802.16-2004/IEEE 802-16e-2005) [3, 4] is defined within its scope four PHY layers , any of which can be used with the media access control (MAC) layer to develop a broadband wireless system. The PHY layers defined in IEEE 802.16 are:

Wireless MAN SC, a single-carrier physical(PHY) layer intended for frequencies beyond 11GHz requiring a LOS condition. This PHY layer is part of the original 802.16 specifications. Wireless MAN SCa, a single-carrier PHY for frequencies between 2GHz and 11GHz for point-to-multipoint operations.Wireless MAN OFDM [8], a 256-point FFT-based OFDM physical layer for point-to-multipoint operations in non-LOS conditions at frequencies between 2GHz and 11GHz. This PHY layer, finalized in the IEEE 802.16-2004 specifications, has been accepted by WiMAX for fixed operations and is often referred to as fixed WiMAX.

Wireless MAN OFDMA[8], a 2,048-point FFT-based OFDMA PHY for point-to-multipoint operations in NLOS conditions on frequencies between 2GHz and 11GHz. In the IEEE 02.16e-2005 specifications, this PHY layer has been modified to SOFDMA [9] (scalable OFDMA), where the FFT size is variable and can take any one of the following values: 128, 512, 1,024, and 2,048.. Smaller FFT size is given to lower bandwidth channels, while larger FFT size to wider channels. The variable. FFT size allows for optimum operation/implementation of the system over a wide range of channel bandwidths and radio conditions. This PHY layer has been accepted by WiMAX for mobile and portable operations and is also referred to as mobile WiMAX.

II. ARCHITECTURE OF WIMAX PHYSICAL LAYER BASEBAND PROCESSOR

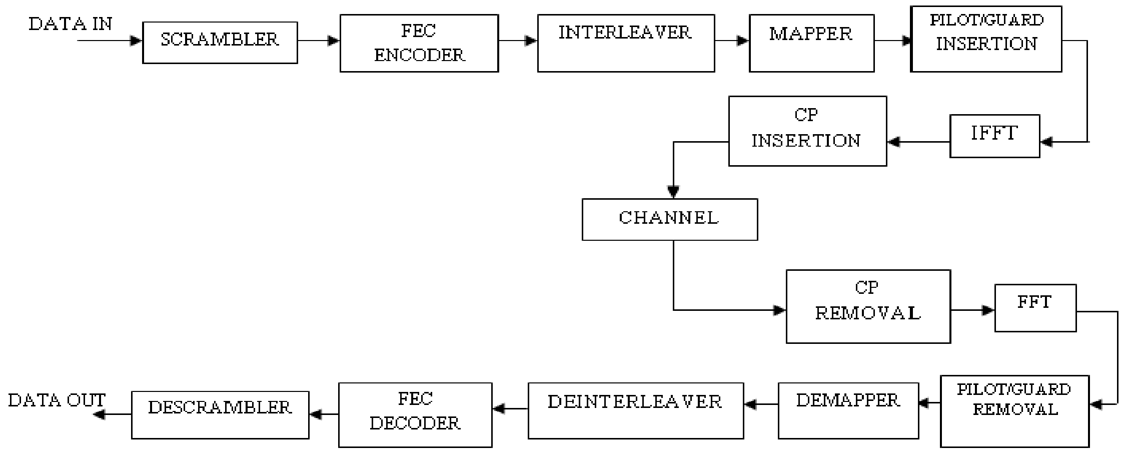

Fig. 1 WiMAX PHY Layer Baseband processor

III. SYSTEM MODEL

The OFDM symbol threats the source symbols to perform frequency-domain into time-domain. If we chose the N number of subcarriers for the system to evaluate the performance of WiMAX the basic function of IFFT receives the N number of sinusoidal and N symbols at a time. The output of IFFT is the total N sinusoidal signals and makes a single OFDM symbol. The mathematical model of OFDM symbol defined by IFFT which would be transmitted as given bellow:

$$x_n = \left(\frac{1}{n}\right)\sum_{k=0}^{N-1} x^k e^{2\pi.\frac{jkn}{N}} \qquad \text{N}= 0,1,2 \ldots\ldots N-1$$

Cyclic prefix insertion

To maintain the frequency orthogonality and reduce the delay due to multipath propagation, cyclic prefix is added in OFDM signals. To do so, before transmitting the signal, it is added at the beginning of the signal. In wireless transmission the transmitted signals might be distorted by the effect of echo signals due to the presence of multipath delay. The ISI is totally eliminated by the design when the CP length L is greater than the multipath delay. After performing Inverse Fast Fourier Transform (IFFT) the CP will be added with each OFDM symbol.

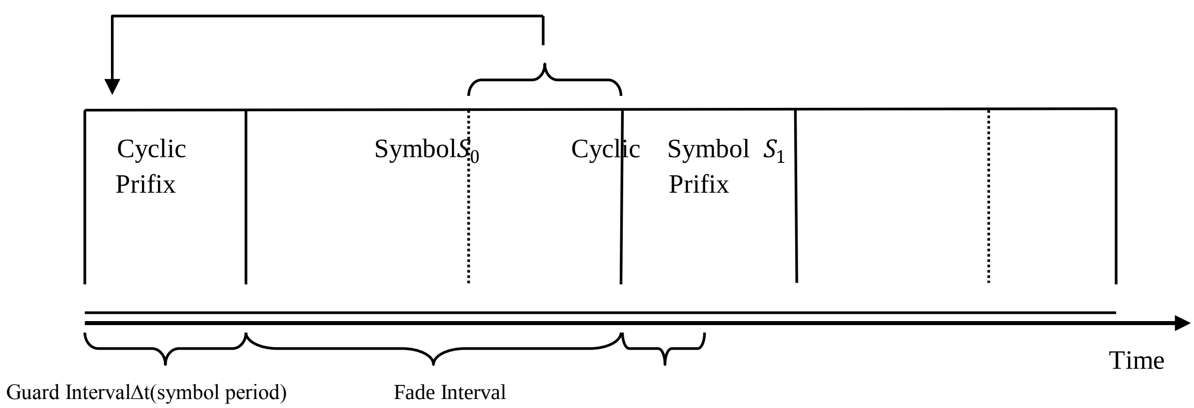

Fig. 2 Cyclic prefix insertion

MAP AND MLSI

MAP and MLSE can be both viewed as a derivation from the BAYES Estimation. In BAYES criterion, two notations are made: The priori probabilities (denoted as P (H0) and P (H1)) The cost to each possible decision (denoted as Cij), i, j = 0, 1, as the cost associated with the decision Di given that the true hypothesis is Hj.

Hence, the decision rule resulting from the BAYES criterion is:

$$\frac{f \quad Y/H_1\,(Y/H_1) >^{H_1} P_0(C_{10} - C_{00})}{f \quad Y/H_0\,(Y/H_0) <^{H_0} P_1(C_{01} - C_{11})}$$

In MAP, let the costs

$$Cii \;=\; 0, i \;=\; 0, 1$$

$$Cij \;=\; 1, i, j \; and \; i, j \;=\; 0, 1$$

Hence, minimizing the risk is equivalent to minimizing the probability of error. Then, the decision rule is reduced to

$$P(H_1/y)\frac{>^{H_1}}{<^{H_0}}P(H_0\;/\;y)$$

In MLSE, let

$$P_0(C_{10} - C_{00}) = P_1(C_{01} - C_{11})$$

It yields:

$$P(y \quad /H_1)\frac{>^{H_1}}{<^{H_0}}P(y\;/\;H_0)$$

IV. LITERATURE REVIEW

In year of 2014 Kene, J.D.; Kulat, K.D., [1] in the study of Turbo code provides relatively better performance as compare to convolution codes at lower Signal to Noise Ratio. Turbo code offers an outstanding coding gain very close to Shannon limit over an AWGN channel to achieve maximum throughput particularly for WiMAX application. The objective of this paper is to Study the Mobile WiMAX system performance by implementing the turbo codes using Soft Output Viterbi Algorithm (SOVA). Turbo decoder is optimized by modifying the SOVA that contributed to the system performance optimization. For different transmission conditions,

BER performance has been simulated and compared to the conventional Log-MAP decoding algorithm. The performance of mobile WiMAX system has also been tested for the effect of various Decoding algorithms, Frame size and Code rates.

In year of 2013 Chaput, E.; Verloop, M.; Beylot, A.-L.; Baudoin, C., [2] Investigated on Satellite Digital Video Broadcasting is deeply changing: the next generation is dedicated to packet based communications and introduces (like many modern physical layers: WiMax, HSDPA) fade mitigation techniques leading to variable throughput. Such tremendous changes need to be taken into account and the scheduling entity needs to be revisited. The purpose of this paper is to investigate utility function based algorithms. Such techniques have already been studied but never within this context. Dvb-s2 frames can encapsulate numerous ippackets; can offer variable payload length as well as variable transmission time, because of acm techniques. A more general approach is needed to encompass theses properties. As a consequence, the number of solutions among which a scheduler has to find the better is increased. They will then show that the algorithm implemented is an important issue.

In year of 2012 Garitselov, O.; Mohanty, S.P.; Kougianos, E.; Okobiah, O., [3] In the study With CMOS technologies progressing deeper into the nano-scale domain the design of analog and mixed-signal components is becoming very challenging. The presence of parasitic and the complexity of calculations involved create an enormous challenge for designers to keep their design within specifications when reaching the physical layout stage of the design process. This paper proposes a novel ultra-fast design flow that uses mimetic-based optimization algorithms over neural-network based non-polynomial metamodels for design-space exploration. A new heuristic optimization algorithm which is based on mimetic algorithms and artificial bee colony optimization is introduced. The design flow relies on a multiple-layer feed forward neural network metamodel of the nano-CMOS circuit.The physical design aware neural network are trained and used as metamodel to predict frequenc ,locking time and power of a PLL circuit . Using a CMOS PLL circuit it is shown that the proposed design flow is flexible and robust while it achieves optimal design to two different wireless specifications, WiMax and MMDS. Experimental results show that the proposed approach is 2.4 × faster than the swarm based optimization over the same meta models.

In year of 2011 Bhattacharyya, B.; Misra, I.S.; Sanyal, S.K., [4] In the study of, a complete novel and unique concept of Adaptive Cyclic Prefix (ACP) is proposed for IEEE 802.16e-WiMAX Physical Layer (PHY) using a Simulink-VSA based simulation model. Implementation of ACP algorithm provides a better QoS in the form of lowest average error for low channel SNR condition, compared to the existing Fixed Cyclic Prefix (FCP) in WiMAX. MATLAB plays the crucial part for implementing ACP, while the WiMAX PHY Layer scenario is created within Simulink workspace. By measuring Error Vector Magnitude (EVM) and Relative Constellation Error (RCE) in Vector Signal Analyzer (VSA), a significant improvement is obtained in average error performance with respect to varying Channel SNR for ACP compared to FCP.

Simulation results also show that ACP is efficient enough to be used for each of the modulation and coding specified for a WiMAX system, making it an easy alternative to the standard Adaptive Modulation and Coding (AMC). Finally exhaustive simulation results have been included in support to the success of the algorithm.

In year of 2010 Constantinescu, M.; Borcoci, E.; Rasheed, T., [5] Investigated on the context of micro and macro-mobility capabilities defined by IEEE 802.16e/WiMAX standards, the paper presents the simulation campaign undertaken to identify the sets of configuration parameters having a major impact on the handover process for the IEEE 802.16e mobile station. Simulation results could then be used to construct a database for guiding some cross-layer optimization algorithms deciding upon handover trigger, in order to increase the handover performance, from the application point of view.

V. PROBLEM FORMULATION

The problem with Viterbi decoder behavior model, convolutional encoder, BPSK(Binary Phase Shift Keying) and AWGN channel work in MATLAB in the previous work. The BER was tested to evaluate the decoding performance. The application of Viterbi Algorithm in the Continuous-Phase Frequency Shift Keying (CPFSK) has been presented. Analysis for the performance is made and compared with the conventional coherent estimator and the complexity of the implementation of the Viterbi decoder in hardware device the main issue of this research work is to implement the RTL level model of Viterbi decoder. The RTL Viterbi decoder model includes the BranchMetric block, the Add-Compare-Select block, the trace-back block, the decoding block and next state block. With all done, we further understand about the Viterbi decoding algorithm.

VI. PROPOSED METHODOLOGY

Since the Log-MAP decoding algorithm needs relatively large number of iterations to achieve the expected BER performance at low SNR, it leads to excessive time delay and computational complexity for deciding the system performance. The overall system complexity increases with the number of iterations carried out. In order to achieve expected BER at relatively low system complexity, another sub-optimum algorithm that is suitable for turbo decoding is the Soft Output Viterbi Algorithm (SOVA) [11]. It is a modified Viterbi Algorithm (VA) that produces the most likely path sequence for a reliability value of each estimated bit. The operation of SOVA decoding algorithm is based on the classical process of the Viterbi Algorithm, followed by an updating rule to produce soft outputs on the estimated bit sequence. With the updating rule, VA finds the survivor path that has the smallest path metric between all the metrics of paths that enter each state. The path metric is the summation of all the branch metrics of a state sequence. The SOVA considers only two path sequences to update its soft output, namely the survivor and the concurrent path sequences. A first attempt to improve the SOVA has been implemented with two proposed modifications, so as to connect its soft output and to follow a Gaussian distribution. With the first modification, the extrinsic information is normalized by multiplying with a correcting factor c that depends on the variance of the decoder output, where as the second modification (that is less effective) is done the correlation in the decoder input is eliminating by inserting two more correcting coefficients. In this study, we described the turbo decoder structure using iterative decoding process to produces the soft estimated output. We have implemented the SOVA [11] decoding algorithm for testing the performance of turbo decoder. We have simulated the physical layer of mobile WiMAX for Log-MAP and SOVA decoding algorithm of turbo codes and compared the BER performance for the same parameters of PHY layer. The BER performance of these algorithms is tested with Binary Phase Shift Keying (BPSK) modulation scheme. The channel is considered as an Additive White Gaussian Noise (AWGN) channel.

VII. CONCLUSION

In this research work we have prepared the literature review on convolutional coding, that is a coding scheme often employed in deep space communications and recently in digital wireless communications. Viterbi decoders are used to decode convolutional codes. Viterbi decoders employed in digital wireless communications are complex in its implementation and dissipate large power. We investigated and study the design of Viterbi. By building the convolutional encoder and Viterbi decoder in the behavior model, we found that MATLAB simulation results can give us a light on its performance.we find the Viterbi decoding algorithm is mature error correct system. This is based WiMAX PHY Layer baseband processing blocks which contain transmitter chain blocks and transmitter chain blocks for data communication purpose. As the future work, some of the remaining blocks from both the chain blocks can be implemented according to IEEE 802.16 standards, and then the complete system can be integrated to make the complete system.

ACKNOWLEDGEMENT

I would like to express my gratitude towards the researchers for making their resources available for my research topic i.e. “Literature Review of Physical Layer of WiMAX” and professors of IES Institute of Technology And Management for their valuable guidance.

REFERENCES

[1] Kene, J.D.; Kulat, K.D., "WiMAX physical layer optimization by implementing SOVA Decoding algorithm," *Circuits, Systems, Communication and Information Technology Applications (CSCITA), 2014 International Conference on*, vol., no., pp.179, 183, 4-5 April 2014.

[2] Chaput, E.; Verloop, M.; Beylot, A.-L.; Baudoin, C., "Utility function based packet scheduling over DVB-S2," *Communications (ICC), 2013 IEEE International Conference on* , vol., no., pp.4288,4292, 9-13 June 2013.

[3] Garitselov, O.; Mohanty, S.P.; Kougianos, E.; Okobiah, O., "Metamodel-assisted ultra-fast memetic optimization of a PLL for WiMax and MMDS applications," *Quality Electronic Design (ISQED), 2012 13th International Symposium on* , vol., no., pp.580,585, 19-21 March 2012.

[4] Bhattacharyya, B.; Misra, I.S.; Sanyal, S.K., "Optimization of error performance in a WiMAX transceiver using novel Adaptive Cyclic Prefix strategy," *Computer and Information Technology (ICCIT), 2011 14th International Conference on* , vol., no., pp.245,250, 22-24 Dec. 2011.

[5] Constantinescu, M.; Borcoci, E.; Rasheed, T., "WiMAX Handover Conditions Evaluation towards Enhancement through Cross-Layer Interaction," *Telecommunications (AICT), 2010 Sixth Advanced International Conference on* , vol., no., pp.422,427, 9-15 May 2010.

[6] Kooti, H.; Bozorgzadeh, E.; Shenghui Liao; LichunBao, "Reconfiguration-aware spectrum sharing for FPGA based software defined radio," *Parallel & Distributed Processing, Workshops and Phd Forum (IPDPSW), 2010 IEEE International Symposium on* , vol., no., pp.1,4, 19-23 April 2010.

[7] Morsy, K.E.; Nafie, M.H.; Digham, F.F.; Elezabi, A.Y., "Time-Based Demand-Constrained Cross-Layer Resource Allocation for Wireless Networks," *Communications (ICC), 2010 IEEE International Conference on* , vol., no., pp.1,5, 23-27 May 2010.

[8] Nandula, S.; Giridhar, K., "On synchronization algorithms for OFDMA based wireless MAN system," Telecommunications and Malaysia International Conference on Communications, 2007. ICT-MICC 2007. IEEE International Conference on , vol., no., pp.515,519, 14-17 May 2007.

[9] Dong Li; Penghui Wei; Xiaolong Zhu, "Novel Space-Time Coding and Mapping Scheme in SCFDMA Systems," Personal, Indoor and Mobile Radio Communications, 2007. PIMRC 2007. IEEE 18th International Symposium on , vol., no., pp.1,4, 3-7 Sept. 2007.

[10] YousiZheng; XiaofengZhong; Lei Wan; Jianfeng Kang, "A frequency domain scheduling algorithm for IEEE 802.16 OFDMA systems," *Wireless and Optical Communications Networks, 2009. WOCN '09. IFIP International Conference on* , vol., no., pp.1,5, 28-30 April 2009.

[11] Soft Output Viterbi Algorithm (SOVA) in Continuous-Phase Frequency Shift Keying Hailun Tan; Digital Telecommunications, 2006. ICDT '06. International Conference on 2006 Page(s):5 - 5

[12] G. David Forney, J., Maximum-Likelihood Sequence Estimation of Digital Sequences in the Presence of Intersymbol Interference. IEEE, Trans, Inf. Theory, 1972.

[13] Viterbi, A.J., Error bounds for convolutional codes and an asymptotically optimum decoding algorithm. IEEE Trans. Information Theory, 1967. 13(2): p. 260-269.

[14] G. David Forney, J., The Viterbi Algorithm. Proceedings of IEEE, 1973.61(3).

[15] Proakis, J.G., Digital Communications: McGraw Hill.

[16] Zhigang Cao, Y.Q., Communication Theory: Tsinghua University Press.

[17] Piret, P., Convolutional Codes, an algebraic approach: MIT Press.

[18] Chari, M.J.R.a.S., Demodulation of Cochannel FSK Signals Using Joint Maximum likelihood Sequence Estimation. IEEE, Trans., 1993. 2: p. 1412 - 1416

[19] Narkat, M., Signal Detection and Estimation: Artech House.

[20] Dai, M., Information Theory: Tongji University Press.

[21] Jun Horikoshi, K.K.a.T.O. Error Performance Improvement of Bandlimited QTFSK Assisted by an Efficient Coded Modulation and Viterbi Sequence Estimation. In IEEE, Trans, Infomation. Theory. 1994.

[22] Rappaport, T.S., Wireless Communications, Principles and Practice: Prentice Hall.

[23] M. G. Pelchat, R. C. Davis, and M. B. Luntz, “Coherent demodulation of continuousphase binary FSK signals,” iPnr oc. Inl.Telemetry Conf. (Washington, D. C., 1971).

[24] R. de Buda, "Coherent demodulation of frequency-shift keying with low deviation ratio," IEEE Trans. Commun. Technol., vol. COM-20, pp. 429-435, June 1972.

[25] A. J. Viterbi, "Error bounds for convolutional codes and an asymptotically optimum decoding algorithm," IEEE Trans. Inform. Theory, vol. IT-13, pp. 260-269, Apr. 1967.