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A Review MIMO-OFDM Systems for LTE Environment

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ABSTRACT: This paper nowadays, the requirements in terms of communication are increasing exponentially and getting more diverse. The transmission data rates must be high while maintaining very good quality of service (QoS) despite the very hostile propagation channels. Generally, transmissions that are carried out on mobile radio channels are selective both in time and frequency. To overcome the channel selectivity and allows high transmission data rates, the Long Term Evolution (LTE) standard makes use of the Multiple Input Multiple Output-Orthogonal Frequency Division Multiplexing (MIMO-OFDM) technique. By implementing this technique in the context of mobile transmission, new approaches for time and frequency.

Keywords*:* Multiple-Input Multiple-Output (MIMO), Long Term Evolution, quality of service.

I. INTRODUCTION

In wireless communication system many techniques are used for the transmission of signals like TDMA, CDMA, FDMA and OFDM. In TDMA (Time Division Multiplexing Access) the information is transmitted into time slots so in each slot only one user is allowed to either transmit or receive. In FDMA (Frequency Division Multiplexing Access) individual channel are assigned to individual user, each user is allocated a unique frequency band. In CDMA (Code Division Multiplexing Access) many users may transmit simultaneously but then near-far problem occurs [1]. OFDM has attracted lot of attention in the field of wireless communications. OFDM is a multicarrier modulation technique [2] which is widely used for transmission of signals over the wireless channels. The prime advantage of OFDM is its ability to cope with the severe channel conditions like attenuation, interference and multipath fading without complex equalization filters. OFDM has been adopted in several wireless standards such as DVB-T (Digital Video Broadcasting-Terrestrial), DVB-T2, ISDB-T (Integrated Services Digital Broadcasting for Microwave Access), LTE (Long Term Evolution) and others [3]. OFDM is also in demand for short range communications. Now a days the demand of high speed communication has increased. To achieve the high speed and reliable communication MIMO channels are introduced [4]. MIMO channels provide higher spectral efficiency as compare to SISO (Single Input Single Output), SIMO (Single Input Multiple Output) and MISO (Multiple Input Single Output) channels [5]. Wi-Fi, LTE and many other radio and wireless technologies are using MIMO wireless technology to provide increased link capacity and spectral efficiency. MIMO can increase the diversity gain and also improves the system capacity of time variant and frequency selective channels [6]. Channel estimation is a challenging problem in the wireless systems. The transmitted signal travels to the receiver by undergoing many unknown effects that may corrupt the signal [6]. In wireless communication the transmitted signal arrives at the receiver along multiple paths. Channels are random in nature due to which it is hard to predict the channel. In MIMO channels the precision and speed convergence of the channel estimator affect the performance of receiver.

II. MIMO-OFDM

In Modern communication systems MIMO channels are a

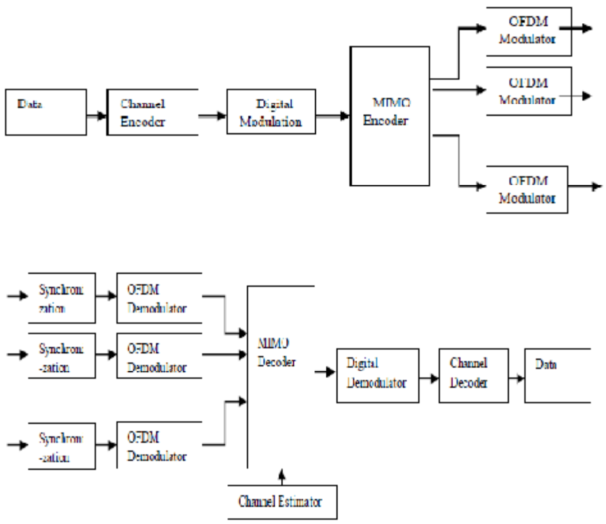

Fig. 1. Block Diagram of MIMO-OFDM System.

Combined with OFDM to provide robustness [7] and high spectral efficiency [8]. MIMO-OFDM playing an important role in current and future wireless communications [9]. It combines MIMO which multiplies capacity by transmitting different signals over multiple antennas and OFDM which divides the radio channel into a large number of closely spaced sub channels to provide more reliable communication at high speed. It provides the highest capacity and data throughput. MIMO technology is the most significant method which is employed to improve the signal to noise ratio for wireless technologies. MIMO systems are combine with OFDM to ensure that the signals are transmitted orthogonally with each other. OFDM necessitates time and frequency synchronization to sustain its orthogonality between subcarriers and also resistive to frequency offset which can be caused either by Doppler shift due to relative motion between the transmitter and receiver or by the difference between the frequencies of the local oscillator at the transmitter and receiver[6]. MIMO-OFDM is the foundation for most advanced wireless communication and mobile broadband network standards. It is said to be future of 4G and 5G broadband communications. information correctly, the receiver must be able to estimate the channel frequency response[8]. The main aim of channel estimation scheme is that data received at the receiver should be same as the data transmitted from the transmitter. In MIMO-OFDM many techniquesWireless communications have evolved very rapidly. The rapid growth in the number of new subscribers, the development of different global technologies and wireless standards, the demand in the new, better quality, low cost services as well as higher data rates are the main motivations for the evolution in the wireless communications. The communication over wireless channel has three fundamental distinctions from the wireline communication [9,7]. First is the large-scale and small-scale fading, second is the interference between the transmitter receiver pairs, and third is the user mobility in the network. The presence of fading, interference and mobility makes the design of wireless communication system challenging. The convectional design focusing on the reliability of the connection needs to mitigate the fading and multipath effects. Modern wireless system design focusing on the spectral efficiency gains from the rich multipath environment by means of utilizing spatial diversity through the Multiple–Input Multiple–Output (MIMO) communications. The MIMO system as a system with multiple antennas at the transmitter and the receiver theoretically allows linear growth of the link capacity. The capacity is proportional to the rank of MIMO channel [16]. While high spectral efficiency can be obtained through spatial multiplexing, many other MIMO system benefits such as improved signal quality and coverage can be achieved via spatial diversity, beam forming, space time coding and interface cancellation [3]. However, all the gains can not be achieved simultaneously due to their dependence on antenna configuration and scattering environment. Multi–carrier modulation such as Orthogonal Frequency Division Multiplexing (OFDM) is currently the most prominent technology Since it is mitigating inter-symbol interference and enhancing system capacity, it is also well suitable for MIMO channel transmission. Furthermore, it facilitates using very simple equalization even in very broadband communications. By combining MIMO system with OFDM technique the desired system requirements, such as good coverage in non-line-of-sight environment, reliable transmission, high peak data rates as well as high spectral efficiency, may be fulfilled [5].

Multi-stream multi-carrier wireless transmission has been already standardized in IEEE 802.11n WLAN, IEEE 802.16 WMAN, IEEE 802.16WiMAX as well as in 3GPP Long Term Evolution (LTE) and it will be the key transmission technology for the future 4G broadband wireless communication networks. The aspects of MIMO–OFDM technology, such as multi–antenna configuration, sub-carrier scheduling and optimization, large number of resource elements, need to be taken into account in the design of physical level, system level as well as interaction between link and system level called Link-to-System (L2S) interface. The evaluation of the quality of a radio link involving specific characteristics like spacial pre- and postprocessing, synchronization, channel estimation, channel coding, modulation is done at a link level. The system level aims at evaluating the entire wireless network performance while taking into account terminal mobility, intercell interference, scheduling, handover, link adaptation in several typical deployment scenarios. The purpose of L2S interface is to determine the performance of radio link in terms of packet or block error rate in order to adapt transmission modes at the system level. The system level requirement of accurately estimating the performance of each link using link level simulations in a reasonable time cannot be fulfilled. Hence, there is a demand for a simple and efficient L2S interface model that accurately predicts link error probability for MIMO–OFDM system with a large number of frequency, time and space resource quality measures. The L2S interface model has to provide a system level quality measure, called effective Signal-to-Interference-and-Noise-Ratio (SINR), for link error prediction based on instantaneous channel and interference conditions. Additionally, the effective SINR can be used to evaluate the system level performance based on a capacity criterion and taking into account the impact of adaptive modulation and coding, Hybrid–Automatic Repeat reQuest (hybrid-ARQ, HARQ) and mobility. On the system level MIMO–OFDM transmission of many Radio Resource Management (RRM) functions and in particular dynamic rank adaptation. Rank adaptation is the procedure to adapt number of MIMO streams, for each user according to the rank of MIMO channel experienced by the mobile terminal [100]. Dynamic rank adaptation allows fast adaptation to varying channel conditions, and consequently, brings either MIMO multiplexing or diversity gains. The prediction of the transmission mode based on maximum total expected throughput is time demanding. More efficient rank adaptation algorithm achieving the same system performance is required to achieve MIMO multiplexing and diversity gains. sure, since the effective SINR is heavily used on the system level as a quality measure of a radio link. By establishing the distribution of effective SINR allows to utilize the performance measure with confidence in different scenarios and to analyze the impact of link adaptation and retransmissions on the performance. Additionally, the problem of optimizing radio resource management and in particular rank adaptation is addressed in this thesis. The goal is to develop computationally efficient dynamic rank adaptation methods that provide speed up in CPU time without any loss in the system performance. MIMO mode in 3GPP LTE downlink network, as it is a baseline transmission method in 3GPP LTE. The performance studies are conducted by using analytical tools as well as fully dynamic system level simulations in realistic scenarios. The proposed algorithms can be used in the standardization process of next generation wireless communications in order to understand the expected performance of the system. contributes to the design and optimization of L2S interface and to the performance evaluation of multi-carrier multi-stream transmission on the system level The technique of data is also applied for 4G, WiMAX 802.16 systems, with which low bit error rate can be achieved. The necessity of knowing the channel state information in is achieved by conveying the information from the receiver side to the transmitter side. This channel state information will be used to encode the data. If the channel state information conveyed is perfect, the system capacity will be improved significantly by techniques. But since the feedback channel also requires a bandwidth, this reduces the channel capacity. Hence one of the drawbacks of this technique is that in certain cases the reduction in the channel capacity is observed. Also the channel state information conveyed may not be proper always, because of the delay in feed backing the information from the receiver side to the transmitter side. Because of all this reasons, designing a proper feedback channel and codebook is essential for improving the performance of systems [8].

For a 2 x 2 MIMO system, four paths can exist between the transmit and receive antennas. This may include a direct line of sight (LOS) component and or the other component due to the multipath caused due to the reflection, scattering and diffraction from the environment. If the signal to interference noise ratio is very low for the received bit stream, it is difficult to demodulate the transmitted bit streams in the MIMO system. By including precoding in the transmission of the bit streams, the signal reception in the receive antennas can be improved. Different precoding schemes for spatial multiplexing or transmit diversity techniques have been proposed in [7] [8]. In this paper, we analyse the techniques in spatial multiplexing MIMO systems. The concepts of transmit beamforming is done here in which multiple beams are transmitted simultaneously. The complex weighting matrices for 4 x 4 antenna configurations are specified in [9]. In a 2 x 2 configuration, the signals are generated by the multiplication of the weighting matrix '***F***' with the input signals. performance obtained for a 2 x 2 MIMO-OFDM system with and without is given. And finally the paper is concluded Long Term Evolution (LTE), is a standard for radio communications of high-speed data transmission for mobile phones and data business [11]. It is based on the Global System for Mobile communications (GSM)/ Enhanced Data rate for GSM Evolution (EDGE) and Universal Mobile Telecommunications System (UMTS)/ High-Speed Packet Access (HSPA) network technologies, increasing the capacity and speed using new modulation techniques [1, 2]. Orthogonal frequency-division multiplexing (OFDM) and multiple-input multiple-output (MIMO) are the key technologies of LTE. MIMO technology can significantly increase channel capacity and spectrum efficiency without occupying any more bandwidth. Signal detection algorithms are studied in this thesis: Zero-Forcing (ZF) detector, Minimum Mean Square Error (MMSE) detector, Maximum Likelihood (ML) detector, QR decomposition with M-algorithm maximum likelihood detector (QRM-MLD) and Sphere Decoding (SD) detector. The results of the study show that the optimal signal detector is superior to other signal detectors on bit-error-rate (BER) performance. The BER performance in a correlated MIMO-OFDM For growing voice and data services, it raises a higher demand of the transmission rate, transmission performance and data throughput. To achieve this, it is not enough only to use more spectrum resources, the space resources of the wireless signal should be used as well. That is using multiple antennas to transmit and receive the signal. Due to scattering in the wireless communication environment, reflection and diffraction caused by the multipath fading is a major factor in the deteriorating performance of wireless communication systems. Diversity has been an effective technology. Common sources of diversity are time diversity, frequency diversity and space diversity [3]. Space diversity technique does not require extra time and bandwidth. LTE is a standard for radio communications of high-speed data transmission for mobile phones and data business [1]. It is based on the GSM/EDGE and UMTS/HSPA network technologies, increasing the capacity and speed using new modulation techniques [1, 2]. OFDM and MIMO are key technologies of LTE. MIMO technology can significantly increase channel capacity and spectrum efficiency without occupying more bandwidth. MIMO communications system uses multiple antennas of both transmitting end and receiving end, the data throughput and the spectrum utilization can grow exponentially to meet the requirements of high transmission rate, high transmission performance and high data throughput, MIMO improves communications system performance by full use of space diversity. Meanwhile, OFDM has been widely considered in the academia and industry. OFDM is an efficient multi-carrier transmission technology. It converts high speed serial data streams to relatively low transmission rate of symbols on a group of sub channels by serial/parallel conversion. In OFDM, each subcarrier is orthogonal to each other. In frequency domain, the responses of the sub channels overlap. Thus OFDM can provide higher spectrum utilization than normal frequency division multiplexing system. As one of the key technologies of LTE, signal detection algorithms are studied in this thesis. After nearly a decade of efforts, MIMO systems and related technologies have developed greatly, but there are still some shortcomings. With the continuous improvement of transmission speed, with increasing numbers of antennas, and higher and higher modulation order, the tradeoff between complexity and performance of the MIMO system should be studied. Approaching the capacity of multi-antenna system needs to have a good detection technology. However, the MIMO system not only brings a huge capacity, but also produces great complexity for the received signal detection. It is the objective of this paper to investigate MIMO-OFDM detectors for LTE. Five signal detection algorithms are studied: ZF detection, MMSE detection, ML detection, QRM-MLD and SD detection. ZF [3] and MMSE [3] are simple and have low complexity but the performance is not ideal.

ML [3] detection has the optimal detection performance. However, because of it searches through all possible points in the signal space, if the number of transmit antennas is greater than four or modulation constellation is larger than QPSK, the complexity will reach a very high level [13]. ML is thus difficult to implement in practical applications. The current study focused on the signal detection algorithm is in two areas: to enhance the performance of the linear detector and to reduce the complexity of ML algorithm. QRM-MLD [17] and SD [5] detector are the detectors reduce the complexity of ML algorithm. SD detector do not search all the points as ML detector. It limits the search area into a sphere for the center is the actual received point **y**. Thus the points need to be searched are reduced. The range of search is far less than ML detector; therefore it significantly reduces the computational complexity. QRM-MLD is based on QR decomposition and ML algorithm. This detection algorithm approximately obtains the ML detection performance.

CONCLUSIONS

In this paper Review the performance of a MIMO – OFDM LTE, systems is analyses by BPSK, QPSK, 16 PSK and 16 QAM for a 2 x 2 MIMO OFDM system. It was seen that the bit error rate performance obtained is better In the modulation schemes used the BER performance of BPSK was found to be better than QPSK, 16 PSK and 16 QAM for the same SNR. Although the performance was found to be increasing, still there is a scope for further improvement in BER performance with lower SNR. This needs to be tested with more number of antennas and for varying channel conditions.3GPP engineers named the technology "Long Term Evolution" because it represents the next step (4G) in a progression from GSM, a 2G standard, to UMTS, the 3G technologies based upon GSM. LTE provides significantly increased peak data rates, with the potential for 100 Mbps downstream and 30 Mbps upstream, reduced latency, scalable bandwidth capacity, and backwards compatibility with existing GSM and UMTS technology. Future developments to could yield peak throughput on the order of 300 Mbps.The upper layers of LTE are based upon TCP/IP, which will likely result in an all-IP network similar to the current state of wired communications. LTE will support mixed data, voice, video and messaging traffic. LTE uses OFDM (Orthogonal Frequency Division Multiplexing) and, in later releases, MIMO (Multiple Input Multiple Output) antenna technology similar to that used in the IEEE 802.11n wireless local area network (WLAN) standard. The higher signal to noise ratio (SNR) at the receiver enabled by MIMO, along with OFDM, provides improved coverage and throughput, especially in dense urban areas.LTE is scheduled to be launched commercially in 2010 by Verizon Wireless and AT&T Wireless. T-Mobile and Alltel have also announced plans to roll out 4G capabilities based on LTE. These networks will compete with Clearwire's WiMAX for both enterprise and consumer broadband wireless customers. Outside of the US telecommunications market, GSM is the dominant mobile standard, with more than 80% of the world's cellular phone users. As a result, HSDPA and then LTE are the likely wireless broadband technologies of choice for most users. Nortel and other infrastructure vendors are focusing significant research and development efforts on the creation of LTE base stations to meet the expected demand. When implemented, LTE has the potential to bring pervasive computing to a global audience, with a wire-like experience for mobile users everywhere.

REFERENCES

[1] "An Introduction to LTE". 3GPP LTE Encyclopedia. Retrieved December 3, 2010.

[2] "Long Term Evolution (LTE): A Technical Overview". Motorola. Retrieved July 3, 2010.

[3] J.G. Proakis, "Digital Communications, Fourth Edition", McGraw-Hill Book Co., New York (2011).

[4] Hiroyuki Kawai, Kenichi Higuchi, Noriyuki Maeda, Member, Mamoru Sawahashi, "Adaptive Control of Surviving Symbol Replica Candidates in QRM-MLD for OFDM MIMO multiplexing", IEEE Journal on Selected Areas in Communications, Vol.24, No. 6, June 2006

[5] B.Hassibi and H.Vikalo, "On the sphere-decoding algorithm I.Expected complexity." IEEE Transactionson Signal Processing, v01.53, No.8, Part 1, PP. 2806—28 18, Aug. 2005. Comparison of different MIMO-OFDM signal detectors for LTE

[6] Yong Soo Cho, Jaekwon Kim, Won Young Yang, Chung G. Kang, "MIMO-OFDM Wireless Communications with MATLAB", John Wiley & Sons (Asia) Pte Ltd., 2010.

[7] L. N. Trefethen and D. Bau, Numerical Linear Algebra (SIAM, 1997).

[8] Rai Jain, "Channel Models: A Tutorial", ACM, February 21, 2007.

[9] D. Shiu, G.J. Foschini, M.J. Gans, J.M. Kahn, Fading Correlation and Its Effect on the Capacity of Multielement Antenna Systems, *IEEE Transactions on Communications,* vol **48**, pp. 502-513, 2000.

[10] J. Kermoal, L. Schumacher, K.I. Pedersen, P. Mogensen, F. Frederiksen, A Stochastic MIMO Radio Channel Model With Experimental Validation, *IEEE Journal on Selected Areas Communications,* vol **20**, pp. 1211-1226, 2002.

[11] K. Yu, M. Bengtsson, B. Ottersten, D. McNamara, P. Karlsson, M. Beach, Modeling of Wide-Band MIMO Radio Channels Based on NLoS Indoor Measurements, *IEEE Transactions on Vehicular Technology,* vol **53**, pp. 655-665, 2004.

[12] Eduardo Lopez-Estraviz, Valery Ramon, Andre Bourdoux, Liesbet Van der Perre, "Symbol Based Search Space Constraining for Complexity/Performance Scalable Near ML Detection in Spatial Multiplexing MIMO OFDM Systems", *IEEE ICC, 2009.*

[13] K. J. Kim and J. Yue, "Joint channel estimation and data detection algorithms for MIMO-OFDM systems," in *Proc. 36th Asilomar Conf. Signals, Syst*., Compute., Nov. 2002, pp. 1857–1861.

[14] Kim, J., Kim, Y., and Kim, K. (2007) "Computationally efficient signal detection method for next generation mobile communications using multiple antennas." *SK Telecommun. Review*, **17**(1C), 183–191.

[15] Viterbo, E. and Boutros, J. (1999) Auniversal lattice code decoder for fading channels. *IEEE Trans. Info. Theory,* **45**(5), 1639–1642.

[16] Hochwald, B.M. and Brink, S. (2003) Achieving near-capacity on a multiple-antennas channel. *IEEE Trans. Commun.,* **51**(3), 389–399.

[17] A. Wiesel, X. Mestre, A. Pagés, and J. R. Fonollosa. Efficient implementation of sphere demodulation. In Proc. SPAWC'03, April.