An Extensive Review on Performance Evaluation of MIMO LTE System

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Abstract - Demands for the higher transmission rates in a reliable way is increased as wireless networks start to offer video and voice transmission in addition to the data transmission. Thus, recently, next-generation wireless networks have emerged to offer higher transmission rates with less transmission errors through the use of multiple antennas. Multiple antenna systems increase the reliability and spectral efficiency of the system through the use of diversity techniques and SM scheme, respectively. Diversity techniques are widely used to reduce the effect of multi-path fading. The probability of all the replicas of the same information symbol experiencing the same fading decreases as the number of diversity branches increase. In a basic transmit diversity scheme is developed for two transmit antennas, while in the diversity gain is increased with using more than two antennas and employing orthogonal codes. This work reviews on the performance evaluation strategies of MIMO system using LTE technology.

Keywords - Mobile Communication, 4G mobile communication, Long Term Evolution, MIMO OFDM modulation, Wireless networks.

I. INTRODUCTION

The mobile and wireless communication systems in the late 20th century have radically changed the life of human being, especially in the economical and social aspects. In addition to the more traditional services such as speech, video, and data, the pervasive use of wireless communication systems can also provide other services to improve the quality of life, including health care, home automation, etc. Nevertheless, the main challenge in designing and operating a wireless communication system is to be able to provide a high throughput transmission with good reliability under limited radio spectrum, interference, and time variation of the wireless channel. With the rapidly growing demand for various services of the next-generation wireless communication systems, such as high-speed wireless Internet access and wireless television, the requirements for high data transmission rates and reliable communications over wireless channels become even more pressing. In fact, the past decades have witnessed explosive interest and development from both industry and research community in the design of wireless communication systems to increase the data transmission, improve reliability and optimize power consumption. Such interest and development promise to continue for years to come.

Modern communication systems are an important part of our day to day life. Especially, wireless communication systems such as mobile phone, wireless local area network (WLAN), Bluetooth, etc., provide the freedom for users to roam and to communicate from anywhere at any time. The next generation broadband wireless communication systems are expected to provide wireless multimedia services such as high-speed Internet access; multimedia message services (MMS) and mobile computing. In this case, the wireless communication system designers face a number of challenges which include the limited availability of the radio frequency spectrum and a complex time-varying wireless channel environment. In addition, meeting the increasing demand for high data rates, better quality of service (QoS), fewer dropped calls, longer battery life and higher network/user capacity paves the way for innovative techniques that improve spectral efficiency and link reliability.

Wireless systems are already ubiquitous in providing connection between people or devices, irrespective on their location. In recent years, the worldwide spread of digital cellular systems has modified the way people communicate, making it possible to access multimedia contents and to exchange information almost anywhere. The "anywhere, anytime" paradigm finds application not only for business and personal communication, but is also a promising means to build a telecommunication network in developing countries where no legacy infrastructure is present. For the near future, it is expected that different wireless networks and systems will coexist, furnishing the end user with the possibility to transparently connect to the service that best serves his needs. Various access technologies range from satellite systems that provide low bit rate but global coverage to hot spot access points with high bit rate and coverage limited to a few hundred meters. In such a scenario, with an ever increasing number of wireless services to be allocated within a limited frequency resource, it is of vital importance to develop spectrally efficient transmission technologies at the physical layer. The main impediment to this task is the nature of the propagation within the wireless medium that is characterized by random power and phase fluctuations

Since the advent of digital wireless communication, there has been much debate within the standardization bodies on what is the best radio interface to be implemented for different propagation environments and services. For instance, second generation cellular systems in Europe have preferred the TDMA technology in order to grant access to the spectral resource to multiple users, whereas in the United States the preferred choice has been CDMA. More recently, most of the discussion has focused on whether time-domain or multicarrier transmission has the most desirable properties within an adverse propagation environment such as indoor or urban outdoor. Amidst these debates, in the mid 90's, the seminal works of Telatar and Foschini shed light on an novel technology that promised an increase of the bandwidth efficiency to a level that could not be achieved by any other known technique. According to this technology, multiple antennas are deployed at both the transmitter and receiver side, forming a so called MIMO (that stands for Multiple Input Multiple Output) system.

From these early reports, MIMO systems have become a major research topic for both the Information Theory and Signal Processing communities. Ten years later, many questions have been answered but, as discussed below, there are still many important open issues. Addressing these aspects in a successful way is of utmost importance in making the promise of MIMO technology become reality

II. MIMO SYSTEM

The MIMO systems has multiple transmit antenna (Tx) and multiple receive antenna (RArix), where the transmission is over the same frequency and is widely used in wireless LAN networks (3G Americas 2009), which enhances LTE networks by offering good data rates and overall capacity to fulfill the promise in 3G and in 4G technologies. Outdated communications require additional conditions in order to have noise free communications but MIMO works well under rich scattering conditions, where the signals bounce around the environment, take different Tx paths to reach user equipment at different times to achieve better results. For this, telecom companies are more concentrated on SNR and good scattering environment for each signal. MIMO technology is most commonly implemented using an approach called single input, multiple outputs (SIMO) by employing antenna techniques. This adds to receive diversity and also in the method of multiple inputs single output (MISO) to provide variety in transmission. The techniques of SIMO are found since few decades but MISO techniques are used in most advanced cellular networks today. The techniques involve processes to boost the signal to noise (SNR) ratio for compensating degradations in the signal. Since RF signals pass through both Tx and Rx it weakens gradually due to disturbance from RF signals which minimizes SNR. This is especially found in concentrated environments, where the RF signal continuously finds objects to change its path and degrade the signal. The loss in SNR can be compensated by multiple antenna systems. These systems combine different fading characteristics with signals because the route is different from each antenna. Multiple paths in Tx and Rx are taken by the methods SIMO and MISO to accomplish SNR gain (Ghosh et al, 2010). This is possible since different antennas send the same signal in a different manner and these signals attain NR gains. The SNR increases connection range to boost data rates by employing modulation schemes namely 16QAM or 64QAM instead of QPSK (Quadrant Phase Shift-Keying). The full benefits of LTE are achieved by the effect of throughput in MIMO technology. The configuration of multiplicative effect of throughput in MIMO is shown in figure 2.1.

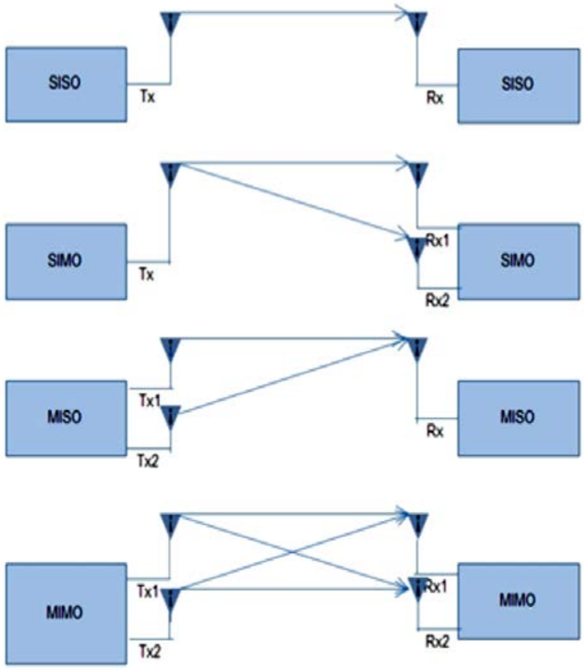

Figure 2.1 MIMO Configurations.

For instance, if $2x2\ (Tx = 2, Rx = 2)$ antenna configuration is required in order to achieve full benefits of LTE. The $2x2$ configuration is effective because it doubles throughput for both the users. Throughput gains in MIMO are obtained by the following conditions:

- Designing the node according to MIMO settings
- Ensure that the user equipment is able to take full advantage of multipath conditions that are present
- Exploiting best scattering conditions.

In this way customer satisfaction is improved in MIMO systems. MIMO offers extended benefits in multiuser scenarios in the context of superior performance in terms of data rates in 3G wireless networks. Extensive research indicates that multi-user MIMO (MUMIMO) can be achieved in real time to have significant performance gains in existing wireless networks.

III. LITERATURE REVIEW

SR.NO.	TITLE	AUTHORS	YEAR	METHODOLOGY
1	Adaptive Digitization and Variable Channel Coding for Enhancement of Compressed Digital Mobile Fronthaul in PAM-4 Optical Links	F. Lu *et al*	2017	LTE-A and 5G introduced advanced wireless technologies
2	Low cost implementation of software defined radio for improved transmit quality of 4G signals	G. C. Tripathi, P. Jaraut, M. Rawat and L. N. Reddy,	2015	digital pre-distortion algorithm for a low cost FPGA based platform
3	System-level throughput evaluation of multiuser MIMO using enhanced codebook considering user mobility in LTE-Advanced downlink	Y. Ma, Y. Jiang, Y. Kakishima, S. Nagata, Y. Kishiyama and T. Nakamura	2014	LTE-Advanced downlink, multiuser (MU)-MIMO transmission with closed-loop precoding matrix indicator
4	Wireless communication through Long Term Evolution (LTE) over satellite channel by using MIMO-OFDM model	M. M. Hasan and S. M. Sagar	2013	OFDM in aggregation to quadrature phase shift keying (QPSK) with Turbo Coding using 2×2 MIMO
5	LTE/LTE-A signal compression on the CPRI interface	B. Guo, W. Cao, A. Tao and D. Samardzija	2013	Cloud Radio Access Network (C-RAN)
6	Capacity of a Cellular Network with D2D Links	S. Ferrante, Q. Zhang and B. Raghothaman,	2013,	Cellular controlled direct UE to UE (User Equipment) communications
7	Comparison of MAC protocols between WiMAX and LTE	Zhongmin Li, Lu Gao and Min Liu	2010	OFDM technology and MIMO technology

F. Lu et al. , [1] The standardization and development of LTE-A and 5G introduced advanced wireless technologies including multiple-input multiple-output (MIMO) and carrier aggregation (CA), which require multiple wireless carriers to be delivered to and from each remote radio head (RRH). The common public radio interface (CPRI) as the mainstream standard in mobile fronthaul (MFH) with on-off keying (OOK) based optical links cannot fulfill the capacity and efficiency requirement. Instead, using compressed CPRI in a high-speed pulse-amplitude modulation-4 (PAM-4) link is actively researched and demonstrated. In this exploration, propose and demonstrate adaptive digitization and channel coding based on these compression and capacity boosting technologies. Depending on the optical link condition, the digitization bits and channel coding rates can be adaptively and dynamically changed to achieve the lowest error vector magnitude (EVM) of wireless carriers. By separating digitization bits into high-bits and low-bits, the coding overhead can be different between groups, while still keeping the same bit rate per wireless carrier. Based on existing digital MFH Infrastructure, the proposed scheme can significantly improve the capacity and sensitivity in the PAM-4 based compressed digital MFH. Capacity gains from 30% to 68%, sensitivity improvement of 2 to 9-dB, and significant EVM improvements are demonstrated experimentally, comparing with other compressed CPRI MFH solutions.

G. C. Tripathi, P. Jaraut, M. Rawat and L. N. Reddy, [2] this exploration presents the development and implementation of digital pre-distortion algorithm for a low cost FPGA based platform. The targeted setup is implemented using AD9361 and FPGA based processing boards Xilinx Zynq 7000 to provide wideband, high performance, highly integrated RF transceiver, which is well suited for wireless communications infrastructure, defense electronics systems, RF test equipment, instrumentation and general software-defined radio platforms. The FPGA based setup is reconfigurable as (1 × 1) SISO or (2 × 2) MIMO transmitters. For transmitter branch, digital predistortion has been implemented and results are reported for ZX60-2522M power amplifier from Mini-Circuits and 4G LTE signal implementation having input power of 10dBm and operating range of 0.5 to 2.5

GHz. The platform provides a flexible wireless research tool with the implementation of SDR solutions.

Y. Ma, Y. Jiang, Y. Kakishima, S. Nagata, Y. Kishiyama and T. Nakamura, [3] In LTE-Advanced downlink, multiuser (MU)-MIMO transmission with closed-loop precoding matrix indicator (PMI) selection and use of interference suppression ability of mobile station (MS) receiver are promising technologies to improve spectrum efficiency. In this exploration, investigate the throughput performance of a proposed MU-MIMO codebook that contains amplitude control information in addition to the phase control information. In system-level simulations, the impacts of the MS speed on the closed-loop control and the difference in the MIMO receiver capabilities for inter-user interference suppression are evaluated considering the overhead for different transmission modes (TMs). The simulation results show that the minimum mean square error (MMSE) receiver for inter-user interference suppression is necessary to obtain stable MU-MIMO performance gains irrespective of the MS mobility. The results also show that LTE TM 9, i.e., dynamic switching between single-user (SU)-MIMO and MU-MIMO, combined with the proposed codebook improves cell-average (cell-edge) throughput performance by approximately 10% (20%), compared to TM 4 with the Release 8 4-Tx codebook.

M. M. Hasan and S. M. Sagar, [4] this exploration is intended for verifying the implementation of Long Term Evolution (LTE) over satellite in Forward Link. Recent developments in wireless communication such as MIMO technique that allow improving the received signal quality and capacity, in combination with OFDM makes the signals more robust against delay spread in frequency selective channel. A dual satellite Orthogonal Frequency Division Multiplexing and Multiple-Input and Multiple-Output (OFDM-MIMO) model is considered which provides a handy and robust resource over satellite channel for this purpose. It is OFDM in aggregation to quadrature phase shift keying (QPSK) with Turbo Coding using 2×2 MIMO as specified for LTE 5 MHz BW, transmitted with satellite power delay profile has analyzed in terms of Bit Error Rate (BER). Spatial multiplexing and diversity are the two features that MIMO provides which has also been investigated. The investigation has been conducted considering downlink transmission over satellite forward link over dual-satellite 2×2 MIMO channel.

B. Guo, W. Cao, A. Tao and D. Samardzija, [5] the Centralized, Cooperative, Cloud Radio Access Network (C-RAN) is a next-generation wireless access network architecture based on centralized processing, collaborative radio, and real time cloud infrastructure. In this architecture, different access technologies (Global System for Mobile Communications (GSM)/Time Division Synchronous Code Division Multiple Access (TD-SCDMA)/Wideband Code Division Multiple Access (WCDMA)/Long Term Evolution (LTE)) can be supported on the same hardware platform in a baseband pool system, which can largely reduce system costs. Long Term Evolution (LTE) and Long Term Evolution-Advanced (LTE-A), which are based on Orthogonal Frequency Division Multiplexing (OFDM) and multiple input multiple output (MIMO) technologies, are regarded as the main wireless access technologies in the evolution from 3G to 4G. A variety of novel technologies such as multi-antenna MIMO, carrier aggregation (CA), and coordinated multipoint have been introduced in LTE/LTE-A to improve system performance, especially in the C-RAN architecture. However, one of the technical challenges for the C-RAN architecture is the fiber bandwidth required for data transmission between the remote radio unit (RRU) and the baseband unit (BBU). Propose using a low-latency baseband signal compression algorithm to solve this problem by reducing the fiber data rate. Using the characteristics of the LTE signal data, remove the redundancy in the spectral domain. Also leverage block scaling in conjunction with using a linear or nonlinear (non-uniform) quantizer to minimize quantization error. This algorithm effectively reduces the amount of data transmitted between the BBU and RRU, and facilitates the deployment of LTE in the C-RAN architecture. Verified the robustness of the algorithm via simulations and lab tests. The proposed algorithm yields good system performance at a 1/2 compression rate and at a 1/3 compression rate in a practical propagation environment.

S. Ferrante, Q. Zhang and B. Raghothaman, [6] Cellular controlled direct UE to UE (User Equipment) communications represent a rich area for research and development that includes topics such as public safety, new social applications, as well as enhancing cellular coverage and capacity. Much of the work is motivated by the growth in wireless data demand, and the expected explosion of new uses of cellular technology. Our study extends the traditional cellular topology to enable direct path links (DPLs) between UEs for local discovery and communication, referred to as device-to-device communication. Local traffic offloading can be used for social networking, wireless gaming, machine type communication, as well as for public safety. Present system throughput results using Monte Carlo simulation techniques for a system which enables the DPLs. Our results indicate that the mean system capacity could be improved by more than 200% by using direct path UE communications as an enhancement to traditional cellular systems, such as LTE.

Zhongmin Li, Lu Gao and Min Liu,[7] WiMAX based on series of IEEE 802.16 standards and 3GPP LTE are the two important development directions of next generation broadband wireless communication. In physical layers, in order to transmit high speed data flow in limited bandwidth, they both use the OFDM technology and MIMO technology to enhance system capacity and frequency spectral efficiency, avoid inter symbol interference, and improve system performance. But, they have more different methods in design of MAC protocols and sublayer allocation of MAC functions. In this exploration, firstly introduce the MAC protocols in WiMAX 16e and 3GPP LTE Release 8. Then compare their MAC functions in control plane and data plane, and provide the comparison chart of MAC functions between WiMAX and LTE. It shows that they both provide the MAC basic functions though they have various differences in realization mechanism and function division.

IV. PROBLEM STATEMENT

LTE has peak data rate limitations, its maximum due to number of component carriers. The spectrum usage efficiency also has been improved. In order to achieve these very high data rates it is necessary to increase the transmission bandwidth over that has been used by the first releases of LTE. Multi carrier scheduling can also be used to schedule users in a carrier that is experiencing less interference, thus improving throughput. Similarly, carrier aggregation can be used with inter-cell interference coordination techniques to ensure that users are scheduled in a manner that will generate less interference with surrounding cells. Different values are stated as LTE performance that depends on parameters such as system bandwidth, multi antenna schemes, FDD or TDD operation, etc. The maximum data rate of LTE varies from 100 Mbps to 300 Mbps. Physical channels and reference signals are mapped to these resources. By calculating the overhead of reference signals that actually do not carry information to higher layers and control channels that convey control information, there can determine the number of resource elements allotted for data transmission. Based on different modulation schemes, code rates, and number of antenna ports, the throughput for data channels can be calculated.

V. CONCLUSION

As many bits are transported in parallel, the transmission speed on each subcarrier can be much lower than the overall resulting data rate. This is important in a practical radio environment in order to minimize the effect of multipath fading created by slightly different arrival times of the signal from different directions. In this work has given a brief of MIMO using LTE. LTE with MIMO due to its enhanced data throughput is gaining widespread deployment with mobile communication providers. In this work the LTE systems with MIMO is examined. MIMO systems in their transmission utilize multiple antennas to transmit and receive signals based on same frequency. Wireless networks already use MIMO, The LTE frame is analyzed for its performance downgrade in different conditions.

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