A Survey of Different Modulation Technique in 5G MIMO Network

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Abstract—This The definition of the next generation of wireless communications, so-called 5G networks, is currently underway. Among many technical decisions, one that is particularly fundamental is the choice of the physical layer modulation format and waveform, an issue for which several alternatives have been proposed by previous research. . QAM is used extensively as a modulation scheme for digital telecommunication systems arbitrarily high spectral efficiencies can be achieved with QAM by setting a suitable constellation size, limited only by the noise level and linearity of the communications channel. The comparative merits of OFDM and FBMC/OQAM have been well investigated over the last few years but mostly, from a purely physical layer point of view and largely neglecting how the physical layer performance translates into user-relevant metrics at the upper-layers. Orthogonal frequency division multiplexing (OFDM) and orthogonal frequency division multiple access (OFDMA) have been the modulation format and multiple access strategy of choice in the downlink of Long Term Evolution (LTE)/LTE-Advanced cellular network standards because of a number of advantages they offer [3]. This paper aims at presenting a comprehensive comparison survey of modulation formats in terms of practical network indicators, such as goodput, delay, fairness, and service coverage, and under operational conditions that can be envisaged to be realistic in 5G deployments.

Index Terms—Modulation, QAM, 5G, OFDM, MIMO, signals.

I. INTRODUCTION

Multiple-input multiple-output (MIMO) transmission techniques have been widely studied over the past decade due to their advantages over single antenna systems such as improved data rate and energy efficiency. Spatial modulation (SM), which is based on the transmission of information bits by means of the indices of the active transmit antennas of a MIMO system [1], is one of the promising MIMO solutions towards spectral and energy-efficient next generation communications systems [2]. SM has attracted significant attention by the researchers over the past few years [3, 4] and it is still a hot topic in wireless communications [5]. OFDM with index modulation (OFDM-IM) [6] is a novel multicarrier transmission technique which has been proposed as an alternative to classical OFDM. Inspiring from the SM concept, in OFDM-IM, index modulation techniques are applied for the indices of the available subcarriers of an OFDM system.

In OFDM-IM scheme, only a subset of available subcarriers are selected as active according to the information bits, while the remaining inactive subcarriers are set zero. In other words, the information is transmitted not only by the data symbols selected from M-ary signal constellations, but also by the indices of the active subcarriers. Unlike classical OFDM, the number of active subcarriers can be adjusted in the OFDM-IM scheme, and this flexibility in the system design provides an interesting trade-off between error Particularly, in [7] we employed such a technique to assess the performance of FBMC and CP OFDM signals in terms of uncoded Bit Error Ratio (BER) versus Signal to Noise Ratio (SNR) in a high speed scenario. Orthogonal Frequency Division Multiplexing (OFDM), we have to explain why the multi-carrier transmission scheme was chosen in the first place. A multi-carrier transmission scheme subdivides the available channel bandwidth into several parallel sub-channels that are called subcarriers can be adjusted in the OFDM-IM scheme, and this flexibility in the system design provides an interesting trade-off between error Performance and spectral efficiency. Furthermore, it has been shown that OFDM-IM has the potential to achieve a better error performance than classical OFDM for low-to-mid spectral efficiency values. Due to its adjustable number of active subcarriers, OFDM-IM can be a possible candidate not only for high speed wireless communications systems but also for machine-to-machine (M2M) communications systems which require low power consumption.

II. OFDM ADVANTAGES

The following advantages can be listed for an OFDM-based access scheme, such as OFDMA and SC-FDMA that are used for the Downlink and Uplink in LTE, respectively [8].

Spectral Efficiency

Spectral efficiency means to utilize the available spectrum as efficient as possible. OFDM is a special case of a multi-carrier transmission. Instead of just dividing the spectrum into subcarrier and separating them by introducing guard bands these carriers overlap but are orthogonal due to the nature of the pulse shaping. That makes OFDM very spectrum efficient.

Robustness against multi-path propagation and low complexity receiver.

The long symbol duration and required introduction of a Cyclic Prefix to overcome potential Inter-Symbol Interference (ISI) due to multi-path propagation of the radio channel allows the use of a one-tap equalizer approach at the receiver side.

Multiple user scheduling advantage.

Using Orthogonal Frequency Division Multiplexing Access (OFDMA) as access scheme allows not just separation of multiple user in the frequency domain by assigning one or multiple Resource Blocks1 (RB) to an individual users, but also a scheduling of these resources in the time domain based on fixed Transmit Time Interval (TTI) of 1 ms. For the uplink (SC-FDMA) it is important to ensure proper synchronization of individual users at the receiving side. As an example, LTE uses the concept of Timing Advance (TA).

III. WORKING PRINCIPLE OF MIMO

Traditional radio system either does nothing to combat multipath interference, relying on the primary signal to muscle out the interfering copies or employ mitigation techniques. One technique uses a no. of antennas to capture the strongest signal at each moment in time. All techniques assume that the multipath signal is harmful and strive it to limit the damage [9,10].

1) On the contrary MIMO takes advantage of multipath propagation (direct and reflected signals).
2) MIMO uses multiple antennas to transmit multiple parallel signals.
3) In an urban environment, signals will bounce off trees, high rise buildings and reach the receiver through different path.
4) Receiver end uses an algorithm / DSP to sort out the multiple signals to produce one signal having originally transmitted data.
5) Multiple data streams are transmitted in a single channel at the same time and at the receiver multiple radios collect the multipath signal.
6) MIMO OFDM uses IFFT in the transmitter and FFT in the receiver.
7) MIMO increase range, throughput, and reliability.

Advantages of MIMO

The advantages of MIMO are as follows:-

1) **Capacity:** MIMO systems outclass traditional communication systems in terms of capacity as was discussed earlier. They have considerably high spectral efficiency compared to systems like BPSK, 16-QAM,etc. One of the primary motivations behind the development of MIMO is the rapidly increasing demand of higher data rates.
2) **SNR:** Because of the increased antenna array gain, MIMO systems have a higher signal to noise ration. Several antennas at both the transmitter and receiver used in MIMO systems create multiple independent channels for sending multiple data streams, thereby increasing signal power considerably relative to the noise without requiring additional bandwidth.
3) **Reliability:** MIMO enhances link reliability in challenging propagation conditions. Even when the signal strength is low and fading poses problems for traditional systems, MIMO has lower bit error rate.
4) **Throughput:** The bandwidth available increases since multiple signals use same bandwidth as they can utilize different paths which a signal may follow to reach a device. This results in an increased throughput because more users can be served on the same band.
5) **Datarate:** MIMO provide a wireless alternative to cable and digital subscriber line (DSL) for last mile broadcast and is used in mobile Worldwide Interoperability for Microwave Access (WIMAX) system. It provides high speed mobile data and telecommunication services for 4G and Long Term Evolution (LTE).
6) **Security:** MIMO systems have positional accuracy, i.e. they work accurately in a very precise antenna arrangement. Thus, they provide increased security because if someone wished to intercept the transmitted signals, they would need to be at the same location as the receiver.

Disadvantages of MIMO

The disadvantages of MIMO are follows:-

1) **Complex:** The most disadvantageous aspect of MIMO systems is their complexity compared to traditional antennas. This means that faults or problems are be harder to diagnose and more likely to occur.
2) **Multiple Antennas:** The underlying idea of MIMO framework demands multiple antennas for

reducing error rate, which in turn makes the system much larger in size than traditional systems. This can also be a problem in a social context, since antennas may seem unsightly.

3) **More expensive:** As a result of the complexity and the number of antennas used, MIMO systems are far more expensive than traditional communication systems.

4) **Location:** The location of smart antennas needs to be considered for optimal operation. Since fading and scattering provide for the better accuracy of MIMO systems, they need to be placed in areas crowded with buildings. Placing antennas in crowded public places is a pretty hard, if not an impossible task.

IV. QUADRATURE AMPLITUDE MODULATION

Quadrature Amplitude Modulation (QAM) [11] is both an analog and a digital modulation scheme. It conveys two analog message signals, or two digital bit streams, by changing (modulating) the amplitudes of two carrier waves, using the amplitude-shift keying (ASK) digital modulation scheme or amplitude modulation (AM) analog modulation scheme. The two carrier waves, usually sinusoids, are out of phase with each other by 90° and are thus called quadrature carriers or quadrature components hence the name of the scheme. The modulated waves are summed, and the resulting waveform is a combination of both Phase Shift Keying (PSK) and amplitude-shift keying (ASK), or (in the analog case) of phase modulation (PM) and amplitude modulation. In the digital QAM case, a finite number of at least two phases and at least two amplitudes are used. PSK modulators are often designed using the QAM principle, but are not considered as QAM since the amplitude of the modulated carrier signal is constant. QAM is used extensively as a modulation scheme for digital telecommunication systems arbitrarily high spectral efficiencies can be achieved with QAM by setting a suitable constellation size, limited only by the noise level and linearity of the communications channel. QAM is being used in optical fiber systems as bit rates increase; QAM16 and QAM64 can be optically emulated with a 3-path interferometer.

V. 5G OVERVIEW

There is still a dramatic increase in the number of users who subscribe to mobile broadband systems every year. More and more people crave faster Internet access on the move, trendier mobiles, and, in general, instant communication with others or access to information. More powerful smart phones and laptops are becoming more popular nowadays, demanding advanced multimedia capabilities [12]. This has resulted in an explosion of wireless mobile devices and services. Moreover, cellular service providers are facing continuously increasing demand for higher data rates, larger network capacity, high spectral efficiency, higher energy efficiency, and higher mobility required by new wireless application. 4G networks have just about reached the theoretical limit on the data rate with current technologies and therefore are not sufficient to accommodate the above issues. In this sense, we need groundbreaking wireless technologies to solve the above issues caused by trillions of wireless devices, and researchers have already started to investigate beyond 4G (B4G) or 5G wireless techniques. 5G is expected to enhance not only the data transfer speed of mobile networks but also the scalability, connectivity, and energy efficiency of the network. It is assumed that by 2020, 50 billion devices will be connected to the global IP network, which would appear to present a challenge [7]. When the number of devices connected to the Internet passes tens or hundreds of billions in the coming decade, the offloading of networked data on unlicensed bands will play a critical role in network load balancing, providing guaranteed bit rate services and a reduction in control signaling. Hence it is important that 5G will provide seamless compatibility with dense heterogeneous networks to satisfy the high demand of real-time traffic, so that end users will experience smooth connectivity to the network. In 5G To achieve 1000× speed enhancement, the first step is to use the mm-wave (with a wavelength on the order of millimeters) spectrum (3–300 GHz range) as the carrier frequency together with opportunistic traffic offloading onto an unlicensed spectrum (5 GHz Wi-Fi). The current cellular licensed carrier spans from the saturated 750 MHz to the 2600 MHz spectrum.

VI. LITERATURE SURVEY

The research work done in field of 5G with MIMO is mentioned in this section to reduce BER and S/N ratio.

In this paper [13] gives a clear thought of the error performance of 4QAM-OFDM, 8QAM-OFDM & 16QAM-OFDM system over AWGN channel & Rayleigh fading channel. It is observed from the simulation results that has the signal power is increases the error rate decreases in both AWGN & Rayleigh fading channel but error rate increases as the value of modulation scheme *M* increases. The error rate in Rayleigh fading channel is also higher than the AWGN channel for same signal. So to provide a reliable communication along with the high data rate, there should be a tradeoff between modulation order and signal power. Designing high performance wireless communication system basically depends on the effect of channel environment. Channel estimation is a method of characterizing the effect of the physical medium on the input data stream.

In this paper [14] proposed model of LTE-Advanced based on the structure of LTE/SAE where the architecture of it represents a challenge in the future of wireless broadband. The LTE/SAE presents an advanced radio interfacing with main improvement upcoming from using of Orthogonal Frequency Division Multiplexing (OFDM) with compound antenna technique. These technologies previously exist and in employment in WiMAX as itemized in IEEE 802.16. LTE-A should be more intelligent technology that interconnects the entire world without limits. We refer to this goal as enabling the 4A paradigm: “any rate, anytime, anywhere, affordable”. The wireless broadband will soon become readily available to everybody.

In this paper [15], we focus on COTS-based LTE technologies which are mature, proven reliable and robust, easily deployable, and scalable. COTS-based LTE products are reducing costs and increasing connectivity to improve C4I capabilities on the battlefield. Long Term Evolution (LTE), commonly marketed as 4G LTE, is a wireless high-speed communications networks and portable communications devices such as smart phones, tablets, and laptop computers, and other mobile devices. The LTE and LTE-A are referred to as System Architecture Evolution (SAE). The main goal of SAE is to provide seamless Internet Protocol (IP) connectivity between the User Equipment (UE) and the Packet Data Network (PDN) with reduced latencies and improved performance using fully optimized for packet-based networks.

In this paper [16] proposed the hybridization of MIMO-OFDM wireless system with 2x2, 4x4, and 8x8 antenna configurations over Rayleigh fading channel has been developed, evaluated using data rate and BER. The system model that represents the physical phenomenon of the hybridized MIMO-OFDM system has been developed around a transmitter which consists of convolution encoder, interleaver, QAM modulator, serial to parallel converter, inverse fast fourier transform, cyclic prefix, different antenna configurations. The Rayleigh fading channel with AWGN is used as wireless channel to form the faded signal. The faded signal output of the channel serves as input to the transmitter which consists of 2, 4, and 8 receive antenna, synchronized for proper synchronization, cyclic prefix removal, fast fourier transform, parallel to serial converter, QAM demodulator, de-interleaver and decoder, all for proper processing to retrieve the signal.

This paper [17] proposed the basic principles of these two promising schemes, Spatial Modulation (SM) and OFDMIM, which are still waiting to be explored by many experts, and review some of the recent interesting results in Index Modulation (IM) techniques. Furthermore, discuss the implementation scenarios of IM techniques for next generation wireless networks and outline possible future research directions. Particularly, we shift our focus to generalized, enhanced, and quadrature IM schemes and the application of IM techniques for massive multi-user MIMO (MU-MIMO) and cooperative communications systems. The receiver of the SM scheme has two major tasks to accomplish: detection of the active transmit antenna for the demodulation of the index selecting bits and detection of the data symbol transmitted over the activated transmit antenna for the demodulation of the bits mapped to M-ary signal constellation. Unfortunately, the optimum maximum likelihood (ML) detector of SM has to make a joint search over all transmit antennas and constellation symbols to perform these two tasks.

In this paper [18] is actually covered a Index Modulation technique is in a comprehensive manner by covering not only the basic principles and variants of Index Modulation (IM) but also reviewing the most recent as well as promising advances in this field. More specifically, we put the emphasis on three emerging forms of IM like Spatial modulation (SM), Channel Modulation CM and OFDM-IM.IM schemes have the ability to transfer the saved transmission energy from the inactive transmit entities to the active ones, and this results in an improved error performance compared to the traditional schemes that use the same total transmission energy. From another perspective, IM schemes have the ability to convey information in a more energy efficient way by deactivating some of the main elements of the system, while still exploiting them for data transferring purposes. Finally, since IM comes up with new dimensions for conveying digital information, the spectral efficiency of the considered communication system can be increased effectively without increasing the hardware complexity.

In this paper [19] proposed the new modulations for orthogonal MA can be adopted to reduce out-of-band leakage while meeting the diverse demands of 5G networks. Non-orthogonal MA is another promising approach that marks a deviation from the previous generations of wireless networks. By utilizing non orthogonality, we have convincingly shown that 5G networks will be able to provide enhanced throughput and massive connectivity with improved spectral efficiency. In addition to the aforementioned approaches to reduce the leakage of OFDM signals, some new types of modulations have also been proposed specifically for 5G networks. For example, to deal with high Doppler spread in eV2X scenarios, transmit data can be modulated in the delay-Doppler domain.

In this paper [20], we described the turbo decoder structure using iterative decoding process to produces the soft estimated output. We have implemented the SOVA 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. The performance of system is relatively improved with SOVA decoding algorithm of turbo codes in terms of decoding delay and computational complexity. The turbo codes have been shown to perform significantly better when increasing both the frame size and number of iterations.

In this paper [21], we have proposed a new algorithm for adaptive channel equalization in MIMOOFDM systems and also presented a bit error rate analysis of this algorithm with the much popular Zero Forcing (ZF) equalizer and optimally ordered MMSE equalizer for Rayleigh fading channels employing BPSK modulation scheme. The difference in propagation time delays of the signal images in MIMO-OFDM systems causes a delay spread at the receiver end. This causes Inter Symbol Interference (ISI). ISI has been a determining factor in high bit error rates in MIMO-OFDM systems. The proposed approach shows that the FRLS equalizer showed much better BER performance than the ZF equalizer but was at par with the MMSE equalizer. There was a significant difference between the BER performance of FRLS and ZF equalizer

VII. CONCLUSION & FUTURE WORK

The proper communication in network is shows the better data receiving. In this graph the performance of 4-QAM (4 point constellation), 8QAM and 16 QAM with QAM with MIMO_LTE is measured and observe that the MIMO performance is better than the pure QAM technique of signaling. In this survey we focus on work done on LTE, MIMO, OFDM in 5G as the underlying waveform were analyzed. Potential 5G Waveform Candidates were introduced and compared to OFDM in terms of spectral regrowth, peak-to-average power ratio (PAPR), carrier frequency offset and presence of noise. The spectral advantages in terms of out-of-band emission of the discussed 5G waveform candidates are more or less vanished when the signal is amplified and thus experience the non-linear behavior and characteristic of the RF front-end, in particular the power amplifier.

In future we improve the bandwidth utilization is improves that shows the better throughput performance. The channel utilization is improves because of that SNR ratio of proposed scheme provides better results of packets receiving and minims drop in network. The Bit Error Rate of digital signals are minimizes in high data rate of 5G. The 5G network having data rate more than 100 Mbps and for this rate handling sufficient amount of bandwidth is required. MIMO with LTE is the right choice to deliver different data through same bandwidth channel. The multiple antennas are carry multiple signals and also the each antenna is contain own bandwidth capacity to sending and receiving signals in MIMO. Due to that proposed scheme is provides better performance than pure QAM.

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