Adaptive modulation OFDM LTE

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Abstract. Long Term Evolution (LTE) is the new upgrade path for carrier with both GSM/UMTS networks and CDMA2000 networks. The LTE is targeting to become the first global mobile phone standard regardless of the different LTE frequencies and bands use in other countries barrier. Adaptive Modulation and Coding (AMC) is used to increase the network capacity or downlink data rates. Various modulation types are discussed such as Quadrature Phase Shift Keying (QPSK), Quadrature Amplitude Modulation (QAM). Spatial multiplexing techniques for 4×4 MIMO antenna configuration is studied. With channel station information feedback from the mobile receiver to the base station transmitter, adaptive modulation and coding can be applied to adapt to the mobile wireless channels condition to increase spectral efficiencies without increasing bit error rate in noisy channels. In High-Speed Downlink Packet Access (HSDPA) in Universal Mobile Telecommunications System (UMTS), AMC can be used to choose modulation types and forward error correction (FEC) coding rate.

1. Introduction

Long Term Evolution (LTE) is a standard for wireless data communications technology and an evolution of the GSM/UMTS standards. The goals of LTE was to increase the capacity and the speed of wireless data networks by utilizing a new Digital Signal Processing (DSP) techniques and modulations. Adaptive modulation and coding is used to increase the network capacity or data rates [1]. Network architectures used to redesign significantly reduce transfer latency compared to the 3G architectures. The LTE wireless interface is incompatible with 2G and 3G networks, so that it must be operated on a separate wireless spectrum. The physical layer is simulated using Matlab. Channel Quality Information estimation is used to improve the data rates and bit error rate (BER). Various modulation types are discussed.

Increasing broadband multi-media services including VoIP, mobile TV, audio and video streaming, video conferencing, FTP and internet access require larger wireless cellular network and reliability.

Multiple-Input-Multiple-Output (MIMO) antenna systems can provide enormous capacity by spatial multiplexing [2], [3]. The performance of a MIMO system is highly dependent on the characteristics of the matrix channel. Link adaptation can be employed to any time varying systems to improve the transmission throughput by dynamically changing transmission parameters. Therefore the combination of link adaptation and MIMO is promising to realize higher spectral efficiency and higher

throughput for mobile communication systems [4].

Fixed modulation cannot make maximum use of information transfer rate to suit changing channel conditions within given bandwidth allocation. Spectral efficiency is the average data rate per bandwidth unit Hertz per cell. Tradeoffs are required in designing mobile communication systems. For a given bandwidth allocation, spectral efficiency can be increased by increasing data rate using higher order modulation or larger multiple-input-multiple-output MIMO techniques. However, this can increase the probability of error in noisy channel

The problem is to search feasible solution to increase spectral efficiency by matching modulation and coding to conditions on the radio link. Spatial multiplexing techniques for 4×4 MIMO antenna configuration is studied. With channel station information feedback from the mobile receiver to the base station transmitter, adaptive modulation and coding can be applied to adapt to the mobile wireless channels condition to increase spectral efficiencies without increasing bit error rate in noisy channels.

2. System description

2.1. Adaptive Modulation

Modulation is the approach by which a carrier wave has the ability to convey the message or digital signal. There are three essential methods to this: amplitude, frequency and phase shift keying. More bits per symbol or period can be encoded using a high order of modulation. Distinctive order modulation permits to send more bits per symbol and in this way attain higher

throughputs or better spectral efficiencies [5]. The utilization of adaptive modulation (AM) permits a wireless system to pick the highest order modulation upon the channel conditions.

2.2. Adaptive modulation and coding

Nowadays, Adaptive Modulation and Coding (AMC) which is a key innovation to progressively respond to the channel change of fading channels [6]. The quintessence of the plan is that, with accessible channel state information (CSI) estimation at the transmitter, link adaptation is empowered by the AMC for compelling usage of the available channel capacity for resulting transmissions while provisioning focused on at the receiver in fighting remote channel fluctuations.

3. Simulation results
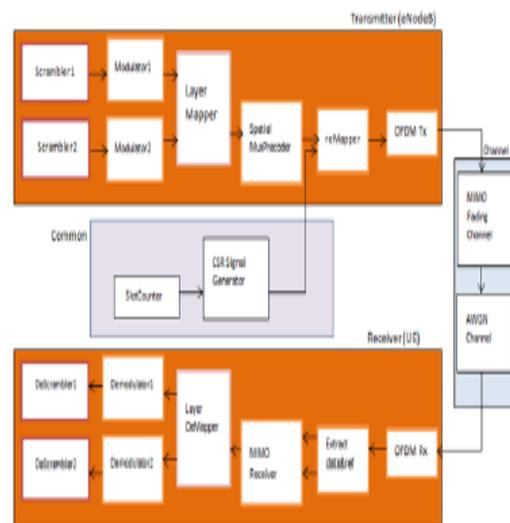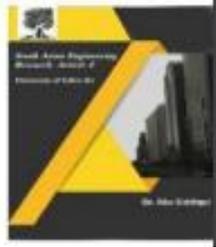
3.1. Adaptive Modulation

Figure 1. Physical Downlink Shared Channel Processing.

Figure 1 shows the physical downlink shared channel processing (PDSCH). The Downlink Physical Channel processing using spatial multiplexing codebook-based

transmission by firstly scrambling the transport channel encoded bits by a bit-level scrambling sequence. This depends on the physical layer cell identity and ensures the randomization of cells. Secondly, the data modulation is converting the scrambled bits into complex modulated symbols. Layer Mapping is then used to map the complex modulated symbols received. The numbers of layers are same as the number of transmitted antennas. After that, Codebook-based precoding is used to precode the modulated symbols per layer. Then, the resource antenna used to map the precoded symbols are transmitted on each antenna and mapped to the resource elements of the resource blocks available for the transmission. Then, the Cell specific reference signal (CSR) is used to specify number of antenna in a cell and utilized for channel estimation at the receiver. Then, for the resource element carrying the reference signal for an antenna, the corresponding resource elements in other antennas have null transmissions. It permits the CSR signals to transmit without interference from the other antenna transmissions. Then, OFDM transmission is used to create the complex-valued time-domain OFDM signal per antenna from the fully populous resource grid, using the OFDM Modulator block. Then, in the MIMO channel, the higher mobility profiles are avoided as the closed-loop spatial multiplexing mode would be appropriate to high data rate and low mobility situations. Lastly is the Receiver UE processing that comprise of OFDM receiver and MIMO receiver.

The following will cover the channel quality indicator (CQI) channel-state report effect to change the modulation scheme in the subframe. Hence, to understand the design trade-offs, there will be comparison on: firstly, baseline –no adaptation, secondly, random selection of adaptation mode, and lastly adaptive modulation –CQI based.

Figure 2 shows the spectrum of user data acquired from the receive antenna. The receive signal shows the effects of frequency-selective fading effectively balanced by the close-loop spatial multiplexing used in transmission mode. Figure 3 demonstrate the pattern diagrams before (first column) and after (second column) equalization of information achieved from the receive antenna. The receive cluster signal shows that the equalizer can reduce the consequence of fading channel and produce pattern that more closely represents that of the 16QAM constellation.
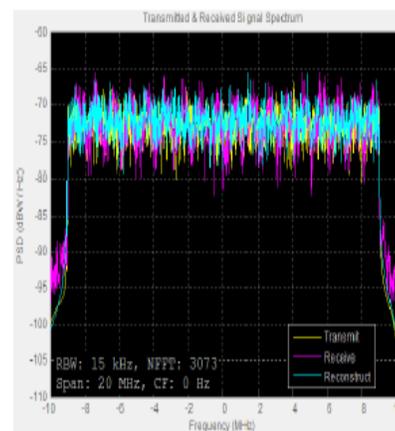

Figure 2. Adaptive modulation based on CQI feedback, MIMO 4x4 antenna: transmitted and received signal spectrum, Power Spectrum Density (PSD) (dB) versus Frequency (MHz).
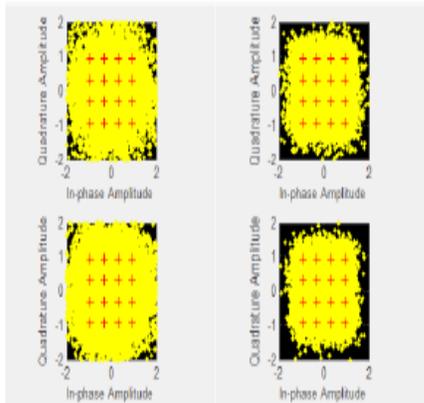
Figure 3. Adaptive modulation based on CQI feedback, MIMO 4x4 antennas: pattern diagram before and after equalization, left (before equalization), right- (after equalization).

Table 1 summarize the results for Adaptive Modulation MIMO 4. Table 1 shows that for fixed modulation, a higher modulation order produces higher data rate at the cost of higher BERs. As the modulation change to lower modulation order QPSK, it shows a lower data rate and lower BERs. Moreover, when randomly selecting the modulation scheme with no consideration of channel quality, both the average data rate and the BER are average value.

Table 1. Adaptive modulation MIMO 4×4.

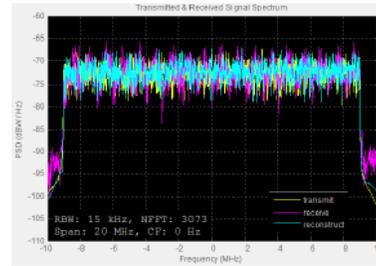| Type of Modulation	Average Data Rate (Mbps)	Modulation Rate	Coding Rate	Bit Error Rate (BER)
QPSK	57.34	2	0.5	0.00001
16QAM	112.4	4	0.5	0.12183
64QAM	157.43	6	0.5	0.21584
Random selection	102.214	2 or 4 or 6	0.5	0.11461
Adaptive Modulation	99.24	2 or 4 or 6	0.5	0.11239

Figure 4. Adaptive modulation and coding based on CQI feedback, MIMO 4x4 antennas: transmitted and received signal spectrum, PSD (dB) versus Frequency (MHz).
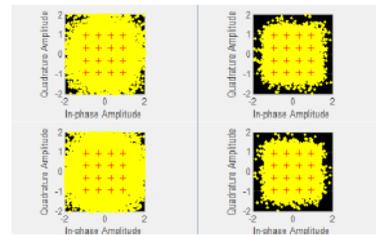

Figure 5. Adaptive modulation and coding based on CQI feedback, MIMO 4x4 antennas: pattern diagram before and after equalization, left (before equalization), right (after equalization).

Table 2. Adaptive modulation and coding MIMO 4×4.

Type of Modulation	Average Data Rate (Mbps)	Modulation Rate	Coding Rate	Bit Error Rate (BER)
QPSK	57.34	2	0.5	0.00001
16QAM	112.4	4	0.5	0.12183
64QAM	157.43	6	0.5	0.21584
Random selection	130.91	2 or 4 or 6	0.4958	0.18133
Adaptive Modulation and Coding	85.83	2 or 4 or 6	0.39-0.5	0.08375

Overall, the CQI estimation techniques have been implemented and It also proves that AMC can

increase data rate or spectra efficiency and reduce bit error rate better compared to fixed modulation.

The user data rates and efficiency spectrum can be altered by using the selection measures for link

adaptation. The main objective of LTE to experience high speed and high capacity can be easily

achieved by using these techniques thus providing a faster and better performance.

4. Conclusion

Adaptive Modulation and Coding can increase data rate or spectra efficiency and reduce BER better
compared to fixed modulation.

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