Energy Efficient Maximization in OFDM Multi-User MIMO Systems

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Abstract – The energy efficiency has become more important in MIMO wireless communication system in recent days. The antennas at each end of the communications circuit are combined to minimize errors and optimize data speed. In Multiple Input Multiple Output Time Division Duplexing (MIMO TDD), by assuming reciprocity property the downlink transmission is based on uplink channel estimation. When more uplink pilot power ensures more accurate channel estimation and better downlink performance, it achieves higher energy consumption of mobile users. Link adaptation scheme uses different modulation schemes for different communication link quality. From the result of MIMO TDD, it ensures high Bit Error Rate. MIMO schemes are usually incorporated into OFDM systems. The spatial and frequency resource can be jointly allocated to improve EE. However, the complexity of the joint design may be prohibitive. This system is effective, in addition to that it also needs simple algorithms like energy efficiency optimization power allocation (EEOPA) algorithm of multiuser multiple input and multiple output (MU-MIMO) systems in order to obtain a trade-off between complexity and performance.

Keywords — Energy efficiency, Link adaptation rate, multiuser MIMO (MU-MIMO), Multiple Input Multiple Output OFDM (MIMO-OFDM), Energy Efficiency Optimization Power Allocation (EEOPA)

I. INTRODUCTION

Multiple input multiple output (MIMO) wireless systems involve multiple transmit and receive antennas to increase the transmission data rate and to minimize errors. MIMO technology has attracted attention in communications, because it offers significant increases in data throughput and link range without additional bandwidth or increased transmit power. It achieves this goal by spreading the same total transmit power over the antennas to achieve an array gain that improves the spectral efficiency and to achieve a Diversity gain that improves the link reliability. In conventional wireless communications a single antenna is used at the source, and another single antenna is used at the destination. In some cases, this gives rise to problems with multipath effects. When an electromagnetic field (EM field) is met with obstructions such as hills, canyons, buildings, and utility wires, the wave fronts are scattered, and thus they take many paths to reach the destination. Usually, transmission between two antennas depends upon channel performance. Link adaptation has an important role in broadband wireless communication systems.

It refers to the concept of adjusting transmit parameters like modulation and coding rate according channel conditions. When the channel is good, higher-order modulation and higher code rates are chosen, while when the channel is bad, less efficient lower-order modulation and lower code rates are used. Channel performance is more important Link adaptation is a technique used to improve spectrum efficiency by adapting system parameters, such as modulation scheme and coding rate, according to the channel condition.

Motivated by the demand for improving the energy efficiency in mobile multimedia communication systems, various resource allocation optimization schemes aiming at enhancing energy efficiency have become one of the mainstreams in mobile multimedia communication systems, including transmission power allocation bandwidth allocation sub channel allocation etc. Multiple-input–multiple-output (MIMO) technologies can create independent parallel channels to transmit data streams, which improves spectral efficiency and system capacity without increasing the bandwidth requirement energy efficiency optimization power allocation.
(EEOPA) technologies eliminate the multipath effect by transforming frequency-selective channels into flat channels.

In [2], single input and single output (SISO) system with adaptive modulation technique is used to minimize total energy consumption for transmitting given number of bits in AWGN channel which has been investigated in this. It shows that it not always energy efficient by using the lowest modulation order when considering the circuit energy consumption. Energy efficient link adaptation for a single input multiple output (SIMO) is studied in [3]-[5]. In [6], uplink energy efficient transmission is considered in OFDMA systems, since mobile stations are battery powered. In [7], BS uses the zero-forcing precoder for assumption, in that the optimal power allocation maximizes the EE in the downlink of a multiuser multicarrier system is studied.

These studies [4]-[9] assumes the availability of channel side information (CSI). In practice, it is impossible to obtain perfect CSI because of channel estimation error and CSI cannot be obtained without additional cost. In [12], studied the EE of users in a time division duplexing (TDD) MU-MIMO system. Based on the estimate, the BS performs zero-forcing (ZF) beamforming and transmits data to users. Here, it will find optimal uplink pilot power for each user and shows that the average throughput of each user is independent from the pilot power of others. It proposes an iterative algorithm to find optimal uplink pilot power and downlink transmission rate that maximizes the EE of all users in the network.

Assume zero-forcing precoding at the BS due to its low-complexity linear precoding scheme and at high SNR, it performs optimal among all the linear precoders. Under imperfect CSI at the transmitter, SINR analysis is tractable when ZF precoder is employed. When assuming flat fading channel, the discussion on the tradeoffs between the uplink pilot power and downlink rate of user in a multiuser MIMO system can be simplified. Compare to uplink transmission, downlink transmission is more efficient.

The system consists of three parts:
- Uplink channel estimation
- Downlink effective channel estimation
- Downlink data transmission

In Fig 2. Each frame has T symbols and allocate Tup symbols for uplink channel estimation, Tdn symbols for downlink channel estimation and the rest are Ttr=T-Tup-Tdn symbols for downlink transmission.

**Multiuser MIMO Systems**

Multiuser MIMO (MU-MIMO) systems consist of multiple antennas at the base station BS and a single or multiple antennas at each UE. MU-MIMO enables space-division multiple access (SDMA) in cellular systems. When the individual streams are assigned to various users is said to be Multi User MIMO (MU-MIMO). This mode is particularly useful in the uplink because the complexity on the UE side can be kept at a minimum by using only one transmit antenna. The Block diagram for MU-MIMO is shown below:
Fig 3. MU-MIMO System

The uplink and the downlink of a MU-MIMO system represent two different problems which are discussed in the following text. The architecture diagram of MIMO-TDD system is given below:

- **UPLINK MU-MIMO SYSTEM**

Consider the uplink of a multicell multiuser MIMO where the channel experiences large-scale fading. The data detection is done by using the linear zero-forcing technique, assuming the base station (BS) has perfect channel state information. We derive new, exact closed-form expressions for the uplink rate, symbol error rate, and outage probability per user, as well as a lower bound on the achievable rate. This bound is very tight and becomes exact in the large-number-of-antennas limit. We further study the asymptotic system performance in the high signal-to-noise ratio (SNR) and large number of users per cell. We show that at high SNRs, the system is interference-limited and hence, we cannot improve the system performance by increasing the transmit power of each user. Instead, by increasing the number of BS antennas, the effects of interference and noise can be reduced, thereby improving the system performance.

- **DOWNLINK MU-MIMO SYSTEM**

Multiple antenna downlink channels have been the subject of a great deal of research for a number of years now, primarily motivated by the very significant capacity increase associated with multi-user MIMO techniques. In the downlink of a cellular-like system, a base station equipped with multiple antennas wishes to communicate with a number of terminals, each possibly equipped with multiple receive antenna. Under the assumption of perfect channel state information (CSI) at the transmitter and receivers, multi-user MIMO in the form of linear beamforming plus interference pre-cancellation (based on dirty-paper coding) is now known to achieve the capacity of the MIMO downlink channel.

- **LINK ADAPTATION**

Link adaptation or adaptive modulation, coding used to denote the matching of modulation coding and other signals on radio signals. For example, edge uses a rate adaptation algorithm that adapts the modulation and coding scheme (MCS) according to the quality of the radio channel, and thus the bit rate and robustness of data transmission. The process of link adaptation is a dynamic one and the signal and protocol parameters change as the radio link conditions change.

III. TERMINOLOGY

A. ZF-Beamforming

Zero-forcing Beamforming (ZF-BF) is a spatial signal processing in multiple antenna wireless devices. For downlink, the ZF-BF algorithm allows a transmitter to send data to desired users together with nulling out the
directions to undesired users and for uplink, ZF-BF receives from the desired users together with nulling out the directions from the interference user.

B. Pre-Processing

The input signal is used to voice signal. The voice signal information is converted into binary pattern and to given the process. The sampled data to be given to the process. Then to plot the sampled data signal. Data pre-processing is a data mining technique that involves transforming raw data into an understandable format. Real-world data is often incomplete, inconsistent, and/or lacking in certain behaviours or trends, and is likely to contain many errors. Data pre-processing is a proven method of resolving such issues. Data pre-processing prepares raw data for further processing. Data pre-processing is used database-driven applications such as customer relationship management and rule-based applications.

C. Uplink Channel Estimation

The pilot distribution defined in the LTE specifications and we focus on the polynomial modelling to estimate the channel for all the TDD symbols in a given resource block (RB). In particular, also-called double expansion modelling of the channel. We further analyze the structure of the channel matrix in the frequency domain as in but based on and order polynomial modelling and we derive an algorithm for the computation of ICI terms directly in the frequency domain without any need of estimating all the time domain modelling parameters. Finally, we propose a lower complexity all-infrequency domain estimator suitable especially for TDD systems.

D. Downlink Effective Channel Estimation

The Downlink estimation on known data, from either the transmitter or the receiver, placing over all the subcarriers or just over some of them, which is the case used in practice to reduce the overhead Pilot Symbol Assisted Modulation. The case of all pilots anyway is often used to simplify the treatment and to adapt this afterwards. The first approach for instance, to produce the estimate also on the sub-channels that don’t carry pilots, has to perform an interpolation over the whole bandwidth, knowing only the pilots estimates.

E. Downlink Data Transmission

Wave Propagation over the mobile radio channel has the most significant in a mobile communication system's performance. The problem is that it is not possible to exactly describe all occurring during transmission over the channel. Therefore, statistical methods are used to characterize the channel behaviour. They do not exactly predict the receive power level in a certain area, but give a probability for a certain channel state estimate. Dual Wi-Fi’s architecture ensures that AP’s do not contend with clients. Thus, a single AP on the channel operates collision-free and performs minimal medium. The received signal at the kth user,

\[ r_k = \sqrt{\beta_k} h_k^T u_k + \sum_{j=1, j \neq k}^{K} \sqrt{\beta_j} h_k^T u_j + n_k \]

The received signal has the signal power of the transmitted signal in the MIMO system is the combination of the signal noise and interferences. From system analysis, the existing system has high Bit Error Rate while using Time Division Duplexing Multiuser MIMO systems.

IV. PROPOSED SYSTEM

In order to reduce high Bit Error Rate in existing system can use Energy Efficiency Optimization Power Allocation algorithm. Optimization of power is also important for decreasing energy consumption for multi mobile devices. The design power consumption also increases when the higher capacity wireless links are designed designed to meet increasing demand from multimedia application. In addition, power optimization is also important for maximizing the battery life for mobile devices. The strength of the transmitting signal is based on channel performance, but in MIMO systems the downlink channel transmission is more effective compared to uplink channel transmission. The flow diagram of
energy efficiency optimization power allocation algorithm in Multiuser MIMO system is given below:

Fig 5. Architecture of EEOPA algorithm in Multiuser MIMO Systems

A. QAM Modulation

Quadrature Amplitude Modulation is a signal, in which two carriers shifted in phase by 90 degrees are modulated and the resultant output consists of both amplitude and phase variations. Both amplitude and phase variations are present it may also be considered as a mixture of amplitude and phase modulation. Motivation to the use of Quadrature Amplitude Modulation (QAM) comes from the fact that a straight amplitude modulated signal. QAM may exist either in analogue or digital formats. The analogue versions of QAM are typically used to allow multiple analogue signals to be carried on a single carrier. Digital formats of QAM are often referred as “Quantized QAM” and they are increasingly used for data communications often within radio communications systems. In the case of LTE Radio communications systems ranging from cellular technology through wireless systems including WiMAX, and Wi-Fi 802.11 use a variety of forms of QAM, and the use of QAM will only increase within the field of radio communications.

B. QAM Noise Margin

In radio communication systems, when higher order modulation rates are able to offer much faster data rates and higher levels of spectral efficiency for the radio communications system. The higher order modulation schemes are considerably less resilient to noise and interference. They sense the channel conditions and adapt the modulation scheme to obtain the highest data rate for the given conditions. As signal to noise ratios decrease errors will increase along with re-sends of the data, thereby slowing throughput. While using lower order modulation scheme, the link can be made more reliable with fewer data errors and re-sends it. From figure 7, it shows SNR & BER calculation by using Energy efficiency optimized power allocation algorithm. Figure 6 shows Rayleigh cdf with signal 1 as shown below:

Fig 6. Rayleigh cdf with sig=1.00

Fig 7. SNR & BER calculation

In QAM, various flavors may be used when data-rates beyond those offered by 8-PSK are required by a radio communications system. This is because QAM achieves a greater distance between adjacent points in the I-Q plane by distributing the points more evenly.
V. CONCLUSION

In this paper, an energy-efficiency model is proposed for MIMO-TDD mobile multimedia communication. An energy-efficiency optimization scheme is presented based on the sub channel grouping method, in which the complex multichannel joint optimization problem is simplified into a multi target single-channel optimization problem. A closed-form solution of the energy efficiency optimization is derived for MIMO-TDD mobile multimedia communication systems. The EE of users in a TDD MU-MIMO system. We have derived the closed-form expression of the average throughput and shown that the average throughput of the $K$th user is independent of the uplink pilot powers of the other users. Therefore, each user can maximize its EE independently. From simulation analyses, the existing system has high Bit Error Rate. In future, it can overcome by using Energy Efficiency Optimized Power Allocation (EEOPA) algorithm can guarantee the required QoS with high energy efficiency in MIMO-OFDM mobile multimedia communication systems.

REFERENCES