

Analysis of a MIMO-OFDM Wireless Communication System Using a Binary Power Control Scheme with Radio Channel Uncertainties

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Abstract Here a novel binary power control scheme is presented with radio channel uncertainty which includes path loss, Rayleigh fading, shadowing coefficient, and interference from other users to analyse the performance of MIMO-OFDM wireless communication system. From bit error rate (BER) point of view a two tier system with adjacent interference is taken into account to guarantee QoS. The main objective of this system is to optimize energy efficiency with QoS. Taking both energy efficiency and quality of service (QoS) an energy efficient binary power control with BER constraint algorithm is presented. The performance of this system is analyzed and results of the same are presented to show the effectiveness of the system presented.

Keywords: wireless communication, power control, MIMO-OFDM, bit error rate, quality of service

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1. Introduction

With rapid development of information and communication technologies (ICT), the energy consumption has grown up to 163 PJ i.e. two billion litres of diesel is used by the tower stations emitting around 32.9 millions tones of CO₂ [1,2] and is around 2% of worldwide CO₂ emission. With the recent spectrum reframing from 900MHz to 1800 MHz and ongoing 3G, upcoming 4G roll outs, the subscriber base is consistently increasing and is currently more than one billion. This growth will require 1,00,000 more towers to ensure network availability [2]. The rapid increase in number of users is causing burden on network operators from economical perspectives. The main contributing sectors within the ICT industry include the energy requirements of PCs and monitors (40%), data centres about 23% and, fixed & mobile telecommunications contribute about 24% of the total emissions. A typical communications company spends nearly 1% of its revenues on energy which for large operators may amount to hundreds of crores of rupees [3]. To overcome these economical and environmental challenges raised by energy consumption, ICTs are moving towards green wireless communication approach. These in terms are shifting towards energy efficient designs in all stages of cellular networks while guaranteeing user's QoS. The green wireless communication explores energy savings of cellular networks in hardware design and manufacture, node deployment, and network operation and management [4,5]. A holistic approach was proposed for component

link and network level energy savings in cellular networks [4]. These efforts include reductions in the electricity required to power network elements, integration of renewable energy sources such as solar and wind, more energy efficient practices for network operations and a greater focus on recycling and reuse of network equipment. Since energy consumption is closely related to network utilization and life time [6], the network-level energy efficiency is believed to be one of the promising optimization targets. Furthermore, for most power allocation schemes, the acquisition for the perfect centralized knowledge of channel state information (CSI) is a great challenge [7] to tackle this difficulty; a binary power control (BPC) scheme which leads to a simpler or even distributed solution for performance optimization was proposed [8]. However in many power control algorithms channel gain is considered as a random variable [9] in spite of considering various influencing factors as path loss, shadowing and fading effect [10]. The detailed theory on this topic can be found in [11,12]. In the proposed algorithm a two tier system with the channel interference is considered. Based on these parameters the channel state information (CSI) is obtained and power allocation is done with either P_{max} or P_{min} .

The system presented in this paper is analysed using MATLAB. Section 2 presents the system model of the proposed wireless system. Binary power control scheme is presented in Section 3. Section 4 presents the performance analysis of entire system and discussions on the measured results are also presented there. Finally, conclusions of this study are presented in Section 5.

2. System Model

Figure 1 shows the model of proposed MIMO-OFDM wireless communication system with base station B_T located at the center of the cell with a protection distance of D and first tier mobile unit (receiving M_T) with a distance of $(D-R)$ and second tier mobile units with $(D+R)$ distance.

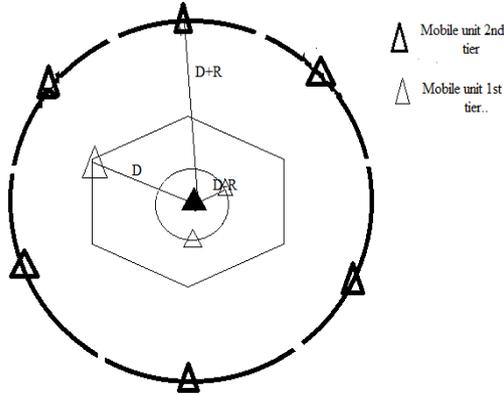


Figure 1. Proposed system model

Each of the signal travelling form transmitting antenna undergoes several radio channel uncertainties like path loss, shadowing coefficient, multipath fading coefficient, and interference from other users. Assuming all these parameters the received signal is given by [13]

$$S = \frac{wz_i^2}{R_{i\sigma_r}} p_i \tag{1}$$

For first tier mobile unit it is given by

$$S = \frac{wz_i^2}{(D-R)\sigma_r} p_i \tag{2}$$

For second tier mobile unit it is given by

$$S = \frac{wz_i^2}{(D+R)\sigma_r} p_i \tag{3}$$

Where R is the distance between base station and user i , z is the Rayleigh fading coefficient, w is lognormal coefficient, and σ_r is the path loss coefficient.

Energy efficiency optimization is carried out by defining energy efficiency which is the ratio of channel capacity to the total power transmission with reference to Shannon capacity limit

$$\eta = \frac{\text{channel capacity}}{\text{total power transmittd}} \tag{4}$$

$$\eta = \frac{\sum_{i=1}^N \log_2(1 + \frac{S_i}{n_o})}{P_{total}} \tag{5}$$

Where S_i is the received signal and n_o is the AWGN in wireless sub-channel.

Here BPSK modulation scheme to investigate BER performance is adopted and is given by [13]

$$P_{BER} = \frac{1}{2} e^{-\frac{\epsilon_b}{N_o}} \tag{6}$$

3. Binary Power Control Scheme

Binary power control is a power control scheme with only two allowable power values, usually 0 or P_{max} . Hence, a link can either transmit at a full power or be switched off completely. Binary power control (BPC) has the advantage of leading towards simpler or even distributed power control algorithms. Moreover, the binary power control scheme is formulated as [14]

$$P_{min} \leq P \leq P_{max} \tag{7}$$

Assuming this scheme, the number of subchannels are divided into two subsets one with minimum transmission power (MP_{min}) and other with maximum transmission power (MP_{max}). However, total number of channels used are N and subchannels are grouped into M . The wireless subchannel with maximum power is given by [13]

$$P_{max-1} = \frac{P_{max\text{total}}}{M} \tag{8}$$

And, energy efficiency is as given in [13],

$$\eta = \frac{\sum_{i=1}^M \log_2(1 + \frac{wz_i^2}{R_{i\sigma_r}} p_{max-1})}{P_{max\text{total}}} \tag{9}$$

4. Performance Analysis

Based on the above discussed constraints i.e. firstly the subchannels are ordered digressively according to channel state information (CSI). Then the subchannels will either be allocated with P_{max} or P_{min} . After this the process of determining BER is carried out. This average bit error rate is compared with the threshold value (b) to guarantee the QoS. Typical values of radio channel uncertainties are listed in Table 1.

Table 1. Different parameters considered in EEBPCB algorithm

Sr.No.	Parameter	Typical values
1	No Of Subchannels	8-128
2	Total Transmitted Power	0.6-1.0
3	Bandwidth(Hz)	1MHz
4	Cell radius(m)	1-500
5	Path loss Coefficient	3.8-4.1(2-4).
6	Protection Distance(d)	50m
7	Spectrum Efficiency(n_o)	0.1w

From Figure 2 it is observed that for increase in number of subchannels in EEBPCB, the energy efficiency gets increased in comparison with average power control algorithm presented in [15].

Figure 3 shows the energy efficiency comparison of EEBPCB algorithm and average power control algorithm [16] as a function of total transmitted power. Here, as the signal power increases, the energy efficiency of MIMO-OFDM system goes on reducing. However, EEBPCB algorithm shows high efficiency for different power ratings in comparison with average power control algorithm [16].

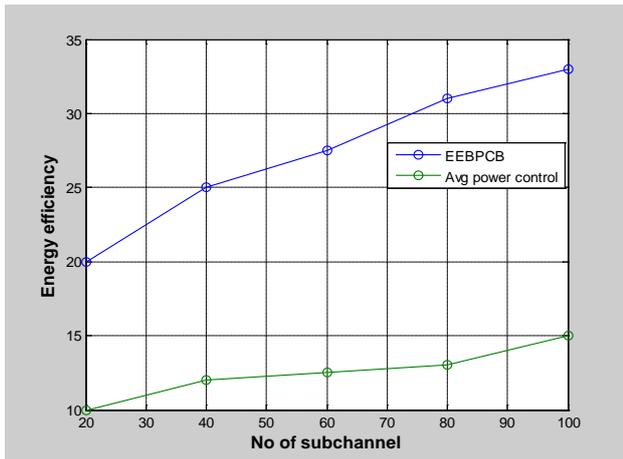


Figure 2. Energy efficiency comparison for EEBPCB and average power control algorithm for different no of subchannels

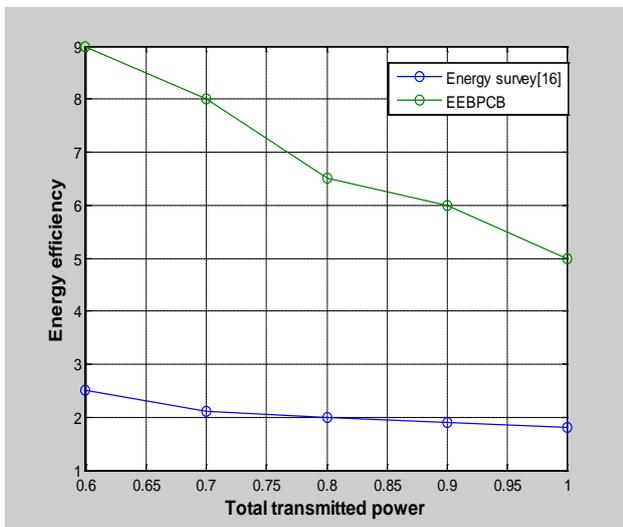


Figure 3. Energy efficiency comparison for EEBPCB and average power control algorithm with different transmitted power

In another effort, bit error rate comparison of EEBPCB and EBPCB [13] as a function of different path loss coefficients is presented in Figure 4. However, for both the schemes the bit error rate is ascending with path loss coefficients. In case of EEBPCB algorithm there is a marginal loss in average bit error rate as compared with EBPCB.

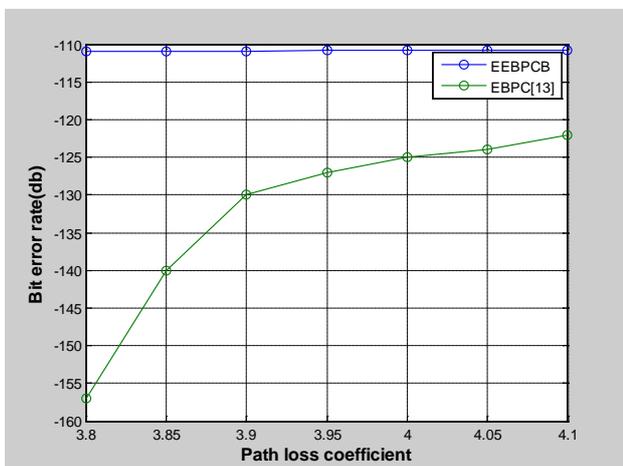


Figure 4. Bit error rate comparison of EEBPCB and EBPCB as a function of different path loss coefficients

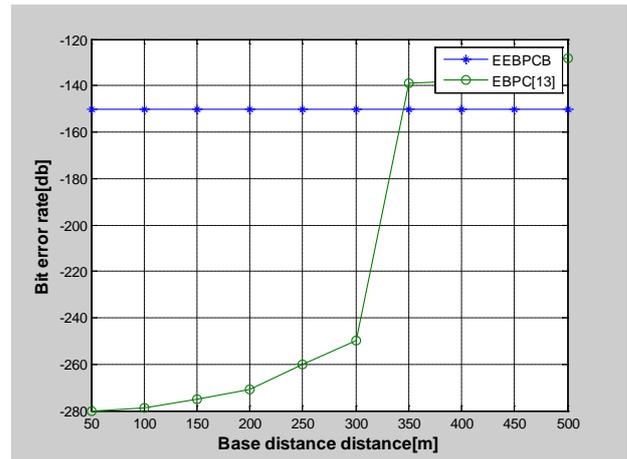


Figure 5. Bit error rate comparison of EEBPCB and EBPCB with distance from base station

Figure 5 shows bit error rate comparison of EEBPCB and EBPCB [13] as a function of distance from base station. In EEBPCB algorithm we have considered different interference scenarios from other users i.e. the distance from the base station is equal to 50m (D), greater than 50m(D+R), and less than 50m (D-R). From the results presented here it is shown that the BER is nearly constant for all cases considered.

5. Conclusions

The performances of MIMO-OFDM wireless communication system considering radio channel uncertainties have been analysed. The exact impact of the proposed system interns of energy efficiency, average bit error rate has been fully investigated under different scenarios like number of channels, total transmission power, distance from the base station, and path loss coefficients. Results presented show that energy efficiency of proposed system model is better than the other techniques mentioned, also the BER is nearly constant for varying distance from the base station.

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