

Cross-Layer Optimization for Energy-Efficient Communications for Adaptive MIMO System.

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ABSTRACT

In this paper, we propose a mechanism which used to switch between single inputs multiple outputs and multiple input multiple output with maximum of two transmit antennas to reduce energy consumption at mobile terminals. when a base station is underutilized then to conserve mobile terminal energy slow down transmission rates so there need to have one crossover point on the transmission rate and below that SIMO is more efficient than MIMO when circuit power is considered but Crossover point is increases with circuit power, channel correlation and the number of receiver antennas these all the factors increase the potential energy savings in mode switching. We recommend an adaptive mode switching algorithm which combined with rate selection according to user perceived performance is acceptable that maintain a user's target throughput and also conserve mobile terminal energy. Simulations under dynamic loads confirm that the recommended technique can reduce the transmission energy and also enables an effective tradeoff between energy conservation and file transfer delay.

Keyword: - Energy conservation, energy efficiency, throughput, MIMO, antenna, adaptive switching mechanism, transmission rate, power, cross-layer design.

1. INTRODUCTION

Energy efficiency is much unfavorable for mobile terminals which supports high speed connection such as WiMAX (Worldwide interoperability for microwave access) or 3GPP-LTE (3rd generation partnership project) so there is higher energy consumption because of high transmission rate. At mobile terminals display or CPU these are key energy consuming components out of which power consumption due to RF transmission is one of the main source to battery consumption which is about 60% in time division multiple access phones [1]. The main concept is to reducing the uplink transmission energy of mobile terminals to reduce battery energy consumption.

Provisionally improbable voice service which requires to support constant bit rate, data services (i.e. uploading of files, emails or pictures) and allows mobile terminals some freedom in making full use of delay-tolerance to save energy. When the base station traffic variation is less which is apparently due to reducing user populations and traffic loads so there is a easy way to save energy at mobile terminals is to make full use of spare capacity but actually even though file transfer delays would be longed and the transmission power reduced aggressively thus the transmission energy is reduced. We say this as the energy-delay tradeoff.

To address the circuit power problem in MIMO systems it is to found out a crossover point on transmission rate or spectral efficiency in which below that crossover point SIMO is more energy efficient than MIMO but this focus on the case where N_t (transmission antennas) = 2 at the mobile terminal but this is the most practical assumption given by antenna configurations of the IEEE802.16m standard [1] so we propose an adaptive switching mechanism to switch between MIMO and SIMO to save energy. The main idea is ease when the system transmission rate below that crossover point then the MT operates with single input multiple output at low spectral efficiency to reduce energy consumption but when congested transmission rate above that crossover point then the mobile terminal operates with multiple input multiple output at high spectral efficiency to increase throughput but this is depends on adaptive way considering two point which is channel variations and dynamic network traffic. Circuit power is the main factor to considered in determining the crossover point but we will see that there are two other factors also affects the crossover point that is channel correlation and the number of receive antennas which makes mode switching more useful.

2. LITERATURE SURVEY

MIMO and OFDM are main techniques in current third generation (3G) and future fourth generation (4G) wireless high speed systems such as the Third Generation Partnership Project Long Term Evolution (3GPP LTE) and Worldwide Interoperability for Microwave Access (WiMAX). Previous research on MIMO and OFDM mainly focuses on to increase network capacity or spectral efficiency but rarely considered energy consumption. Thus there is need to design energy efficient schemes with MIMO and OFDM to is very much Important. This literature survey provides an overview on the state of art on this point while covering cross layer optimization techniques for energy efficient in wireless networks.

2.1. Multiple Input Multiple Output

MIMO can give diversity gain and multiplexing gain. Mainly diversity gain provides different path for sending signal hence it is achieved by sending signals that contains the same information through different paths between transmitter antennas and receiver antennas. Multiplexing gain can be achieved by transmitting in different information signal through the spatial channels parallel. This both factors help to increase network throughput and also used to reduce energy consumption at MT's. The causes of diversity gain and multiplexing gain on energy efficiency (EE) in MIMO transmission in wireless sensor networks (WSN) is explored. In MIMO, more is the transmission antenna will consume more circuit power so MIMO scheme is not always more energy efficient than single input single output (SISO). All signal processing blocks at the transmitter antenna and the receiver antenna is considered in an energy consumption model of MIMO.

The trade-off between transmission power and circuit power consumption to obtain higher energy efficiency (EE) in MIMO systems is considered. The adaptive MIMO switching technique based on the available CSI (channel state information) can achieve improvement in energy efficiency. The Co-operative MIMO and data aggregation strategies are combined to increase energy consumption in wireless sensor Networks. The problem of energy-efficient MIMO precoding is considered for a point to point communication system with multiple antenna terminals at mobile terminal. The power given in wireless ad-hoc networks is configured as a non co- operative to increase EE and a link switch off mechanism reduce co-channel interference to improve EE.

In many practical systems user terminals are usually contains with only one antenna. Thus traditional MIMO cannot be implemented. To overcome the limitation multiuser MIMO (MU- MIMO) which is also called virtual MIMO has been proposed. For distributed transmission and information processing multiple users co-operate in MU-MIMO so local information exchange is not dispensable for MU MIMO and this have more power consumption as compared to single user MIMO(SU-MIMO). It is also proved that even when the local energy consumption for co-operation is considered MU-MIMO is still more energy-efficient than SISO over a certain transmission distance and it is also shown to increase EE constellation size should have to optimized.

2.2. Orthogonal Frequency Division Multiple Access (OFDMA)

Orthogonal frequency division multiple access (OFDMA) scheme will be the superior multiple access scheme for high speed wireless networks and OFDMA multiple access technology is used in both accepted 4G standards . This multiple access scheme (OFDMA) is classify by its simplicity and which also gives high spectral efficiency. This multiple access scheme is achieved by allocating different sets of orthogonal sub-carriers to different users. The use is that subcarriers can be adaptively given to the users that experience high signal to noise ratio(SNR) hence system capacity can be highly increased. This type of scheme is called as multi-user diversity scheme.

OFDMA systems multi-user diversity can be used to increase network capacity and also to reduce energy consumption at MT's. When a good channel is allocated to the particular user then the transmit power can be significantly decreased. Based on the above observation an optimal subcarrier and power allocation algorithms minimizing the total transmit power and increases energy efficiency. The optimal resource allocation scheme is used to reduce the transmit power compared with conventional schemes if circuit power consumption is not considered. The effect of transmission rate, transmit power and circuit power consumption on the EE in OFDMA systems is analyzed where flat fading channels are considered. It is also showed that EE increases with the channel gain as well as the number of sub channels by decreasing with the circuit power consumption.

2.3 Cross-layer Optimization

Cross-layer design is another key approach to reduce energy consumption. The design requirements for energy efficiency across the medium access network and application layers. A comprehensive discussion of energy-efficient cross layer design in the time, frequency and spatial domains. Each layer of the protocol stack is dependable on other layers. Cross layer strategies can significantly reduce power consumption through resource allocation schemes and adaptive transmission corresponding to service environment dynamics and traffic. From the previously strategies it is also see that cross-layer design gives a key role in reducing the energy consumption for networks having MIMO and OFDMA transmission schemes.

Cross-layer design contains low design margins also it is leads to higher algorithm complexity. As a result, significant computational overhead is increased to obtain the optimal solution. From the margin adaptive optimization problem which has key role at reducing the overall transmitting power of users have an individual rate constraints in realistic OFDMA systems is NP-hard. Moreover three suboptimal approaches (problem splitting, relaxation constraint and heuristics) have been given in to obtain optimal solutions. The cross-layer optimization reduces energy consumption by considering signaling overhead.

3. PROPOSED APPROACH

This section describes rate selection process and adaptive mode switching algorithm for multiple users in time varying MIMO channels. The algorithm is given as Conserving User Terminals Energy (CUTE). The CUTE algorithm solve two objectives that is achieving a target user-perceived throughput and saving energy but the key idea is very simple to accordance to their users throughput history and channel variation user switch between SIMO and MIMO adaptively. In given total system time is divided into equal sized frames and a frame is given as the time period in which all users are taken an equal fraction of time according to temporally fair scheduling and Round robin scheduling.

3.1 Working of the System

Working of proposed system as given below-

3.1.1 Rate selection

Suppose $n(t)$ is number of users that uses the uplink time varying channel for an equal fraction of time. Suppose $r_{i,z}(t)$ be file transmission rate of user i belonging to transmission mode $z \in \{m, s\}$ and $c_{i,z}(t)$ is maximum transmission rate hence transmission rate is calculated by the MIMO channel matrix H and the output power P_0 . Since we made practical assumption that users use the channel in fair way and each user is only allocated a fraction of time frame $1/n(t)$ and $c_{i,z}(t)/n(t)$ should be given as the maximum achievable transmission rate of user i . let $q_i(t)$ defines as the target rate of a particular user which is given by user since file transmission are delay-tolerant. Users can decide their own target rate according to their performance by considering their preferences between energy savings and high speed transmission. If For example a user with sufficient battery

resource so user prefer fast transmission but another user with low battery so user prefer slow transmission to make use of energy-delay trade-off to save energy and also note that the target rate ($q_i(t)$) should be independent of z so the transmission rate is given by

$$r_{i,z}(t) = \min \left[\max [e_{i,z}(t), q_i(t)], \frac{c_{i,z}(t)}{n(t)} \right] \quad (1)$$

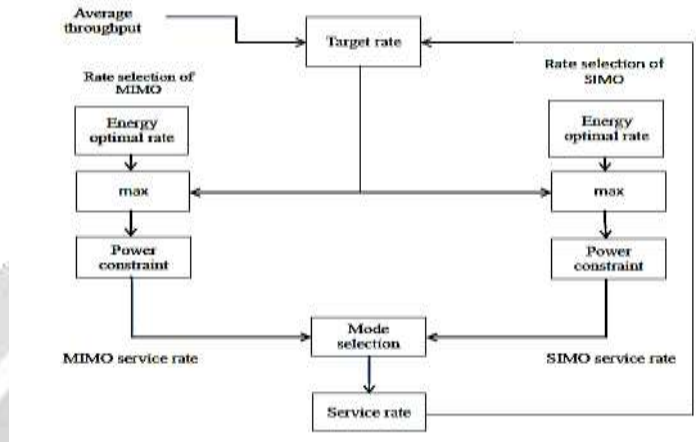


Fig-1: Flow chart of the CUTE algorithm.

3.1.2 Mode switching

Suppose that $r_{i,z}(t)$ transmission rate is given. $1/n(t)$ fraction of time frame is given to each user then the instantaneous rate is given by $r_{i,z}(t)*n(t)$ to achieve transmission rate and the corresponding transmission power is given by $f_{i,z}(n(t)*r_{i,z}(t))$. So the average energy per bit is calculated by using $f_{i,z}(n(t)*r_{i,z}(t))/n(t)*r_{i,z}(t)$ and according to minimum energy per bit, the transmission mode selected [2] is given by

$$\hat{z}_i = \arg \min_{z \in \{m,s\}} \frac{f_{i,z}(n(t)r_{i,z}(t))}{r_{i,z}(t)} \quad (2)$$

3.1.3 Target rate

Suppose that user i in system wants to obtain a throughput q_i . Since it mainly focus on best effort traffic which is tolerant to transmission rate variation so there is no need to achieve q_i instantaneously. Instead it considers achieving q_i on average. Based on averaging of $r_i(t)$ let define the average transmission rate $\bar{r}_i(t)$ observed by user i in time frame t is given as $\bar{r}_i(t) = \bar{r}_i(t-1)*\nu + r_i(t)*(1-\nu)$ where $0 < \nu < 1$ corresponds to averaging weight in the past. We specify a target rate $q_i(t)$ to satisfy $q_i = \bar{r}_i(t-1)q_i(t)(1-\nu)$ so $q_i(t)$ is given by [2].

$$q_i(t) = \frac{q_i - \bar{r}_i(t-1)\nu}{1-\nu} \quad (3)$$

3.1.4 Energy-optimal rate $e_{i,z}(t)$:

We calculate the energy optimal transmission rate is defined by $e_{i,z}(t)$ and by using $f_z(r)$ and idling power consumption P_{idle} , as that which reduces the energy required per bit during a time frame t hence it is given as

$$e_{i,z}(t) = \arg \min_r \left(\frac{1}{n(t)} f_{i,z}(n(t)r) + \frac{n(t)-1}{n(t)} p_{idle} \right) \frac{1}{r} \quad (4)$$

so user i consumes $f_{i,z}(n(t))$ power for $1/n(t)$ fraction of time and idle for $n(t)-1/n(t)$ fraction of time.

4. RESULTS OF CUTE ALGORITHM

In CUTE algorithm, we calculated the average energy consumption per file transfer versus the average delay. Users are assumed to experience $N_r \times 2$ spatially correlated Rayleigh fading channels.

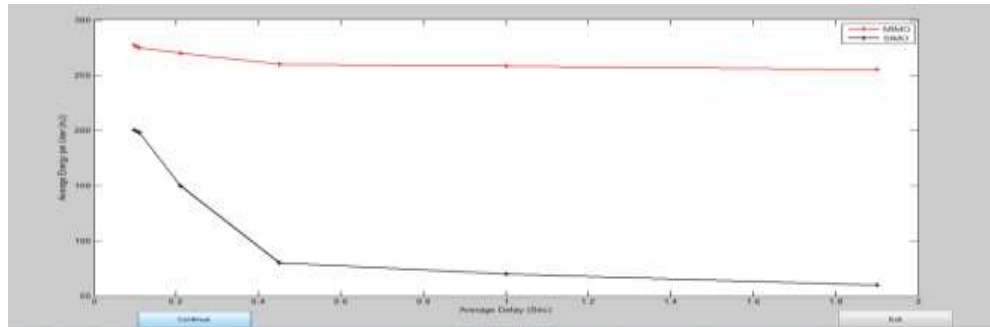


Fig-4.1 Energy-delay tradeoff curves without circuit and idling power. Zero forcing receiver for MIMO, $N_r=2$, $N_t=2$, traffic load = 2.51Mbps, $r_{\max} = 8.35$ Mbps.

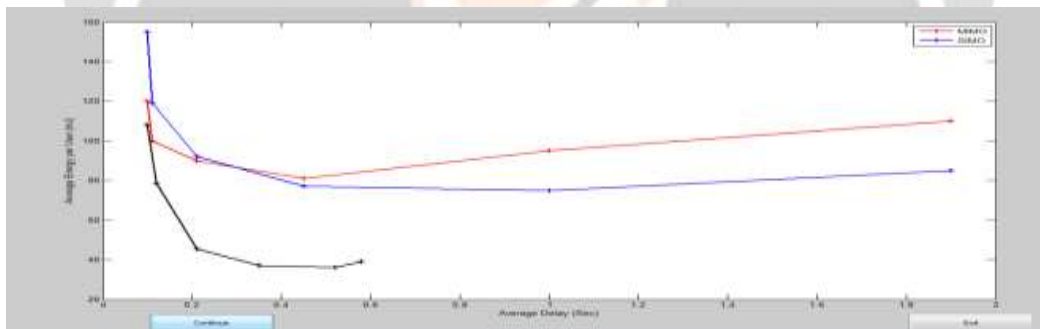


Fig-4.2 Energy-delay trade-off curves with circuit and idling power, zero forcing receiver for MIMO, $N_r = 4$, $N_t = 2$, traffic load = 3.70Mbps, $r_{\max} = 12.34$ Mbps.

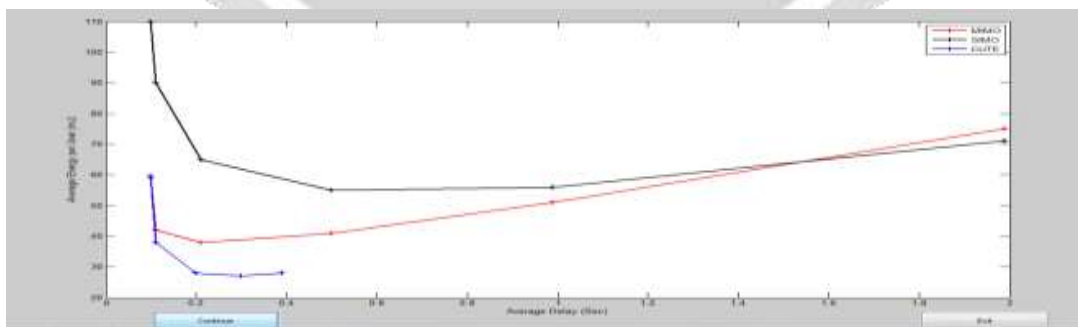


Fig-4.3 Energy-delay tradeoff curves with circuit and idling power: zero forcing receiver for MIMO, $N_r = 8$, $N_t = 2$, traffic load $\rho = 4.51$ Mbps, $r_{\max} = 15.04$ Mbps.

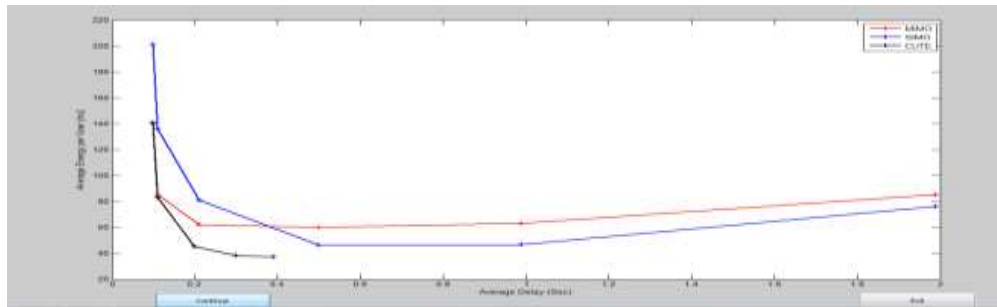


Fig-4.4 Energy-delay tradeoff curves based on energy-opportunistic scheduling (circuit and idling power included) ideal receiver for MIMO, $N_r = 2$, $N_t = 2$, traffic load $\rho = 2.51\text{Mbps}$, $r_{\max} = 8.36\text{Mbps}$, $v = 0$.

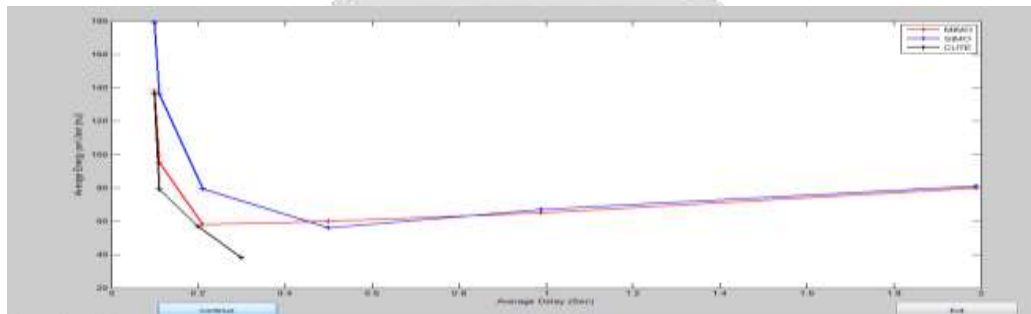


Fig-4.5 Energy-delay tradeoff curves with circuit and idling power: ideal receiver for MIMO, $N_r = 2$, $N_t = 2$, traffic load $\rho = 2.51\text{Mbps}$, $r_{\max} = 8.36\text{Mbps}$

5. APPLICATION

1. Slow down transmission speed when a base station is underutilized.
2. Reduce the transmission energy.
3. To increase network throughput.
4. To reduce energy consumption

6. CONCLUSION

Switching transmission mode between MIMO and SIMO Significant energy-saving is being saved under dynamic loads condition. Due to multiplexing gains MIMO is more energy efficient than SIMO but it is not when circuit power taken in to account. This is because circuit power can be superior at low transmission rates and MIMO consumes more circuit power as it contain more antennas than SIMO and adaptive Mode switching saves more energy in case of MIMO.



Receive antennas requires the adaptive mode switching because the energy efficiency of MIMO is reduces due to channel correlation. In doing this it considered the effect of idling power consumption to address the energy optimal transmission rates and also solved the mode switching problem by considering with rate selection.

The CUTE algorithm exhibited significant energy savings and eliminated the undesirable operating points with additional delay and energy consumption so CUTE algorithm achieve the significant rate for particular user according to their need while considering energy consumption factor for that transmission speed and gives significant throughput.

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BIOGRAPHIES

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