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A Cross-layer approach for Energy Efficient Wireless Communication

Mr. Amol Bendmali, Prof. M. S. Kakade, Prof. Mrs. S. O. Rajankar

***Abstract*— In this paper, we propose a mechanism which used to switch between single input multiple output 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.**

***Index Terms*— MIMO, energy conservation, spare capacity, adaptive switching mechanism, transmission rate, cross-layer design.**

I. INTRODUCTION

Energy efficiency is much unfavourable for mobile terminals which supports high speed connection such as WiMAX (Worldwide interoperability for microwave access) or 3GPP-LTE (3^{rd} 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 (e.g. uploading of files, pictures or emails) RF transmission energy of mobile terminals to reduce battery energy consumption.

Providentially 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 i.e. slow down file transmission rate as long as the user recognized performance is acceptable 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 *Nt* (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 usuful.

II. 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.

A. MIMO

MIMO can gives 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 archieved by transmitting in different information signal through the spatial channels parallel. This both factors helps to increase network throughput and also used to reduce energy consumption at MT's. In MIMO, more is the transmission antenna will consume more circuit power so

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Amol Bendmali, electronics and telecomm., pune university/Sinhgad College of engineering/Pune, India.
Prof. M. S. Kakade, electronics and telecomm., pune university/Sinhgad College of engineering/Pune, India.
Prof. Mrs. S. O. Rajankar, electronics and telecomm., pune university/Sinhgad College of engineering /Pune, India

MIMO scheme is not always more energy efficient than single input single output (SISO).

The trade-off between transmission power and circuit power consumption to obtain higher energy efficiency(EE) in MIMO systems is considered. The Co-operative MIMO and data aggregation srategies 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 mobie 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.

B. 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 archieved 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 perticular 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.

C. 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. 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 reducizing the overall transmitting power of users have a individual rate constraints in realistic OFDMA systems is NP-hard. The cross-layer optimization reduces energy consumption by considering signaling overhead.

III. 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.

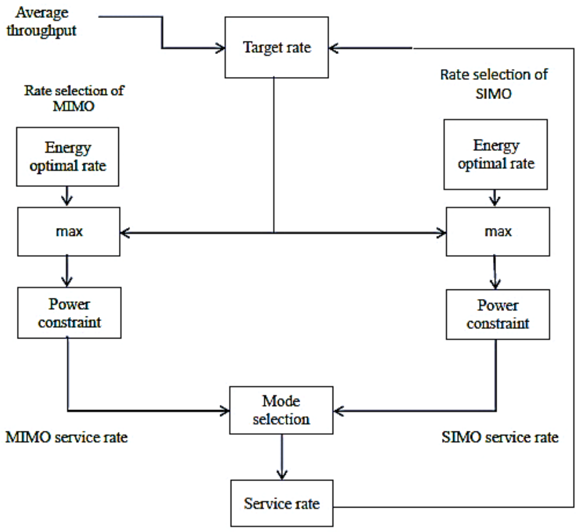

Figure 1. Flow chart of the CUTE algorithm.

A. *Working of the System*

- **Rate selection**

Suppose n(t) is number of users that uses the uplink time varying channel for an equal fraction of time. Suppose ri,z(t) be file transmission rate of user i belonging to transmission mode z ϵ {m, s} and ci,z(t) is maximum transmission rate hence transmission rate is calculated by the MIMO channel matrix H and the output power P0. 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 ci,z(t)/n(t) should be given as the maximum achievable transmission rate of user i. let qi(t) defines as the target rate of a perticular 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 (qi(t)) should be independent of z so the transmission rate is given by

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

- **Mode switching**

Suppose that ri,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 ri,z(t)*n(t) to achieve transmission rate and the corresponding transmission power is given by fi,z(n(t)*ri,z(t)) So the average energy per bit is calculated by using fi,z(n(t)ri,z(t))/n(t)ri,z(t) and according to minimum energy per bit, the transmission mode selected [2] is given by

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

- **Target rate**

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

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

- **Energy-optimal rate ei;z(t):**

We calculate the energy-optimal transmission rate is defined by *ei;z(t)* and by using *fz(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

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

so user i consumes fi;z (n(t)) power for 1/n(t) fraction of time and pidle for n(t)-1/n(t) fraction of time.

IV. 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 Nr*2 spatially correlated Rayleigh fading channels.

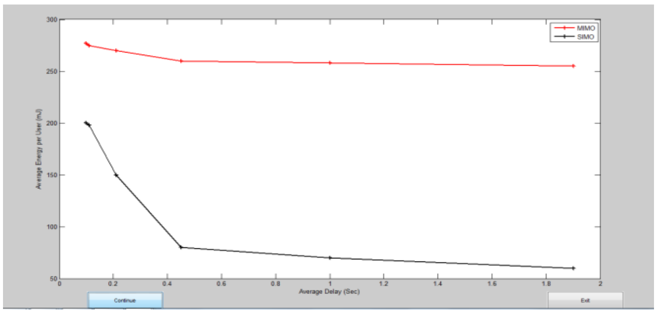

Figure 2 Energy-delay tradeoff curves without circuit and idling power. Zero forcing receiver for MIMO, Nr = 2, Nt = 2, traffic load = 2.51Mbps,rmax = 8.35Mbps.

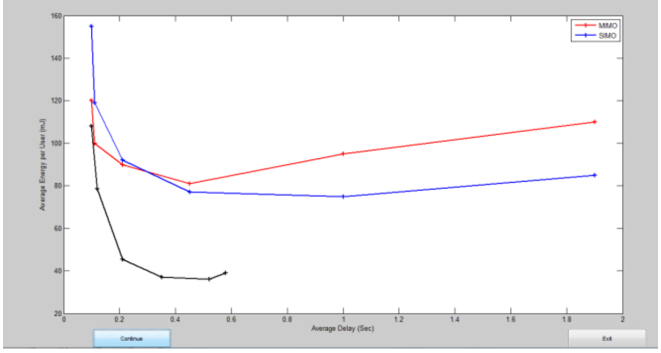

Figure 5.2 Energy-delay trade-off curves with circuit and idling power, zero forcing receiver for MIMO, Nr = 4, Nt = 2, traffic load = 3.70Mbps, rmax = 12.34Mbps.

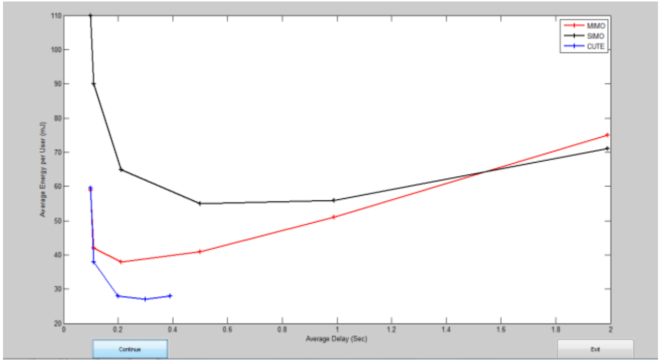

Figure 5.3 Energy-delay tradeoff curves with circuit and idling power: zero forcing receiver for MIMO, *Nr* = 8, Nt = 2, traffic load ρ = 4.51Mbps, *r*max = 15.04Mbps.

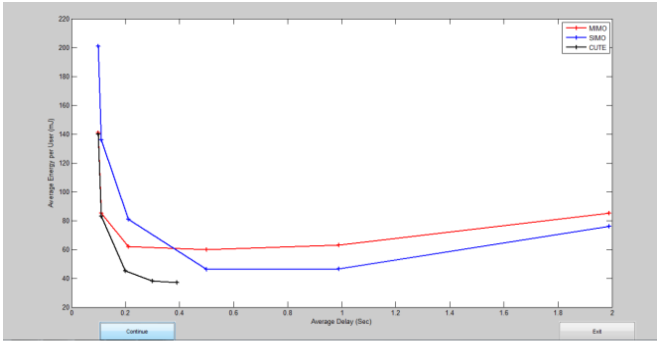

Figure 5.4 Energy-delay tradeoff curves based on energy-opportunistic scheduling (circuit and idling power included) ideal receiver for MIMO, *Nr* = 2, *Nt* = 2, traffic load ρ = 2.51Mbps, *r*max = 8.36Mbps, ν = 0.

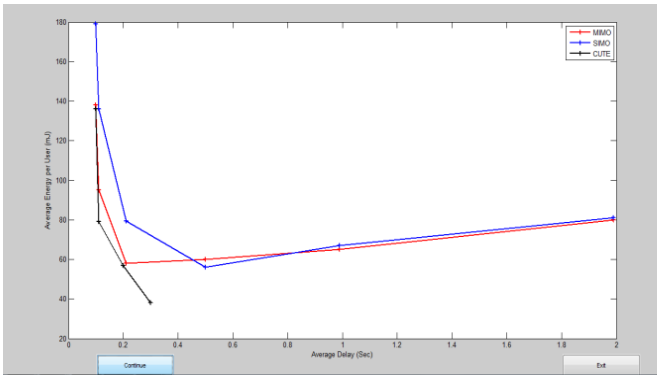

Figure 5.5 Energy-delay tradeoff curves with circuit and idling power: ideal receiver for MIMO, *Nr* = 2, Nt = 2, traffic load ρ = 2.51Mbps, *r*max = 8.36Mbps.

V. APPLICATION

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

VI. CONCLUSION

Switching transmission mode between MIMO and SIMO Significant energy-saving is being saved. 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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