Energy Conservation Technique for Multiple Radio Incorporated Smart Phones

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Abstract Nowadays the advanced radio system in mobile devices is utilized as part of wireless communication towards an upgrade of channel capacity. Top end applications have allowed high-speed networking interfaces to connect the mobile network with many wireless routers, which helps in data transmission in mobile systems. These network interfaces require huge power for high-speed data transmission. In this, diversity and spatial gains are the two principle points of interest of mobile devices with higher delivery of throughput that are utilized to concentrate on improving bit-rate by increasing the quantity of transceiver antenna systems. This paper introduces an energy conservation mechanism for mobile devices. The key idea in antenna management is to remove adaptively percentage of the antennas and additionally their RF chains to reduce energy dissipation due to circuit power. This mechanism will reduce the power consumption and improve power efficiency by disabling the subset antennas and its RF chains. The proposed system will decide the active antennas for power minimization while achieving its data rate requirements. Matlab simulation is used in the proposed study, and the results are validated using the performance parameters such as data rate, transmit power and data rate constraints.

Keywords Antenna management · Energy per bit · MIMO interface · Mobile system · Power saving management

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R. Silhavy et al. (eds.), *Artificial Intelligence Perspectives in Intelligent Systems*,
Advances in Intelligent Systems and Computing 464,
DOI 10.1007/978-3-319-33625-1_6

1 Introduction

During the past few years the number of users and the demand for cellular traffic has risen astronomically. There has been enormous development in mobile network systems. With the development of Android and i-Phones, utilization of eBook readers, like, i-Pad and Kindle and the success of social organizing giants like Facebook, the demand for cellular traffic has grown significantly in recent years [1]. Such unprecedented development in cellular industry has pushed the limits of energy utilization in wireless network systems. The concurrent utilization of numerous antennas by advanced multiple radio system interfaces causes huge circuit power utilization, because of different dynamic RF chains. The circuit power increment is especially problematic for short-range communication. Existing work on such issues mostly concentrate on enhancing the channel quality like data rate under the transmit power plan; little work has considered the double issue of reducing power utilization particularly the circuit power under a data rate requirement. The numerous antenna systems in mobile devices can be used in two unique ways. One is to make effective antenna systems for diverse systems/applications and the other is the utilization of the numerous antennas for the data transmission of a few parallel streams to enhance channel capacity of the existing mobile systems [2]. The rest of this paper is organized as follows. Section 2 provides literature survey; Sect. 3 discusses the problem area; Sect. 4 presents the proposed framework and implementation method is presented in Sect. 5. Section 6 provides simulation results with discussions and Sect. 7 concludes the paper along with directions for further research.

2 Related Work

A few studies have proposed models for assessing the energy utilization of mobile services. To the best of our knowledge, proposed model is the first outline stage energy utilization estimation model considering the different energy utilization schemes.

Gross et al. [3] presented a state-based energy utilization model by considering the appraisal of the energy utilizations of extensive overlay system recreations; a simple assessment demonstrates that utilizing the model for the energy utilization can be done with a mean error of ±4.7 %. The energy utilization qualities of cellular systems was the focus in the past several years. For instance, Haverinen et al. [4] have analysed how to keep alive emails, required by e.g. Versatile IP and NAT traversal, influencing the battery life of a cell phone in WCDMA systems. The outcomes show that the energy utilization is essentially affected by the RRC parameters and the recurrence of keep alive communications.

Vergara et al. [5] have focused on energy dissipation considering wireless interfaces like 3G, Wi-Fi and analyse the parameters impacting the energy consumption. The authors showed a precision scope of 94–99 % for 3G and 93–99 % for Wi-Fi in contrast with the genuine measured energy consumption by means of a 3G modem and smart phone with Wi-Fi. Balasubramanian et al. [6] present an estimation investigation of the energy utilization properties of 3G, GSM, and WLAN. They observe that 3G and GSM bring about high tail energy overhead because of high power states in the wake of finishing an exchange, being particularly risky in systems including regular signalling, for example, P2P systems. Kelenyi et al. [7] have concentrated on the distinctions in energy utilization of cell phones working either as associates or customers in an organized P2P system, utilizing both 802.11 and WCDMA systems. The studies presume that the energy utilization is altogether higher in the associate mode when compared with the customer mode because of incessant support signalling. Subsequently, it is crucial that the energy utilization model considers motion in evaluating the energy utilization.

Lane et al. [8] have presented a framework for mobile sensor with crowd sourcing information that is intended for developing opportunity to sense, outline and transfer at a small energy consumption introduced by ordinary telephone application utilization. The results of this work authenticate the devise of PCS and demonstrate that it has the capacity to beat existing methodologies for gathering information of the mobile sensors in an energy efficient manner. Damasevicius et al. [9] have presented an energy estimation technique and depicted the executions by an internal and software restrictive and custom and also external software base like Sensor API, Java API, GSM at vitality estimation systems. The case study also presents benchmarking software for energy consumption on a mobile computer. Perala et al. [10] have concentrated on the WCDMA RRC state transition in practice. The outcomes recommend that, in spite of the fact that the 3GPP determinations are taken after, solid forecast of the accurate conduct of portable systems beforehand, taking into account hypotheses, is troublesome. Consequently, genuine estimations are key in tuning the energy utilization model to mirror the genuine qualities of a versatile system. Han et al. [11] have investigated the effect of scrolling operations to the power utilization of the advanced smart phones. The authors found the condition for state-of-art plan of cell phones in reacting to a scrolling operation is to dependably utilize the most noteworthy casing rate which stimulates extremely large estimated load and can help about half to the aggregate force utilization of cell phones. Sun et al. [12] have conducted the case study of Wi-Fi dynamic energy in advanced smart phones.

Though various studies have been taken up in the past, majority of the studies have considered a specific case study that operates only on specific wireless environment. A potential trade off is seen in estimating energy dissipation from 4G network as well as Wi-Fi network on various mobile devices.

3 Problem Area

Cell phones devices draw the energy required for their operation from small batteries. On account of numerous constraints on the consumer devices particularly cellular telephones, battery capacity is extremely constrained because of requirements on size and weight of the device. This implies the energy effectiveness of these devices is essential for their ease of use. Thus, optimal management of energy utilization of these mobile devices is expanding quickly. Modern high end cellular telephones include the usefulness of a pocket-sized communication device with PC. These integrated devices use a voice communication, video and audio playback and short message and emails, web searching, media downloads, gaming etc. The heavy usage of functions, decreases the battery life time and mandates need for a better and successful energy optimization scheme. A prerequisite of effective management of energy is a decent comprehension of where and how the energy is utilized.

4 Proposed System

Our prior study has investigated about various causes and factors of energy dissipation from the mobile devices [13]. We have also developed a simple model which can compute the amount of energy being dissipated from mobile devices due to usage of networking media e.g. WLAN and 3G [14]. In this paper, we present a model that can considerably save better amount of power from the mobile devices. The proposed system uses a novel design of an IEEE 802.11n compliant antenna management to provide better throughout with less energy consumption. The novel method offers an algorithm to manage antenna efficiently to resolve the energy per bit minimization issue in mobile devices.

The principle motivation behind this algorithm is to allot high power level to those receiving antenna, which are having low noise level and not to allocate any power to those receiving antenna, which are having total noise. In this paper, we evaluated the framework outline of antenna management system using Matlab based simulation and also it gives an effectiveness of antenna system management to improve the energy efficiency for mobile system. On an average, antenna management can save one-end and two-end power consumption to the front end of the multiple radio network compared to existing antenna systems. The schematic design considered for the proposed system is shown in Fig. 1. In this, M_t is the transmitter and M_r receiving antennas. The transmitting and receiving side have both L_t and L_r RF chains, separately. Subsequently, it is conceivable to transmitter L_t parallel information streams, so a space-time code can be utilized to give differing diversity. Mean the general $M_r \times M_t$ channel lattice by H and the $L_r \times L_t$ Channel framework finds in the selected antenna systems. These codes have an extremely straightforward decoder and lead to a proportional SISO channel with the equal channel gain.

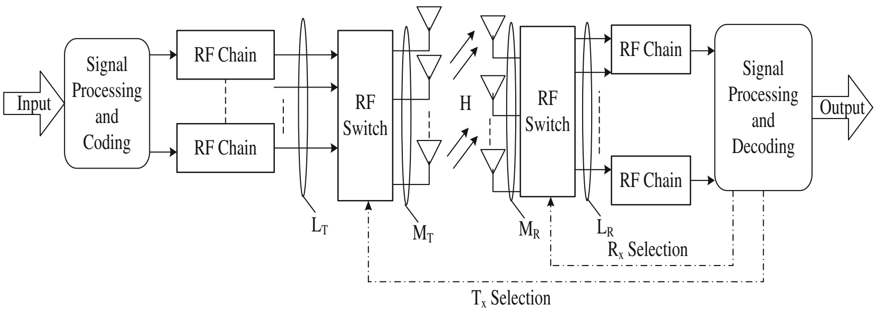

Fig. 1 Schematic design of proposed system

$$h_{eq} = \sqrt{\frac{1}{L_t} \sum_{i=1}^{L_t} \sum_{j=1}^{L_t} |h_{ij}|^2} \tag{1}$$

where h_{ij} are the elements of H. Figure 1 demonstrates architecture of a proposed system that includes both the transmitter and receiver. A sensible multiple radio framework more often works in a half-duplex way along these lines can be either the transmitter or the receiver. The proposed system can permit more inactive antennas than RF chains and utilize different antenna selection procedures to decide the ideal subset of the antenna system. Every pair of transmitter and receiver of an antenna system forms a sub-channel between the transmitter and receiver, and these sub-channels, on the whole, constitute the link. The proposed system channel link can be characterized by a $N_R \times N_T$ complex matrix where the quantity of dynamic RF chains in the collector and transmitter, individually. The time-fluctuating channel model explained by IEEE 802.11n [5] is defined by

$$H(t) = \sqrt{\frac{k(t)}{k(t)+1}} H_{LOS}(t) + \sqrt{\frac{1}{k(t)+1}} H_{NLOS}(t) \tag{2}$$

In the Eq. (2), $H_{\mathrm{LOS}(t)}$ and $H_{\mathrm{NLOS}(t)}$ signify the Line of Sight (LOS) part and Non-Line of Sight (NLOS) segment of the channel. $K(t)$ is the Ricean K variable that shows the dissipating property, or blurring appropriation of the channel. By differing $K(t)$, the system can be studied with suitable channels for different blurring distributions. For a narrow band, frequency level Additive White Gaussian Noise (AWGN) multiple radio link channel, with signal transformed from each antenna systems, equally controlled and free with one another, the capacity of channel C link can be defined by,

$$C = \log \ \det\left(I_{NR} + \frac{P_{TX}}{N_T N_0} HH^H\right) \tag{3}$$

where $\boldsymbol{H}$ denotes the channel matrix. $\boldsymbol{HH}$ is conjugate transposition of $\boldsymbol{H}$, P_{TX} the aggregate transmission power over all transmit antennas, N_0 the channel noise and I_{NR} a $N_R \times N_R$ unique matrix. The energy utilized by an MIMO system for transmitting, P_{Transmit}, can be divided into different power amplifiers P_{PA}, then all other PC circuit blocks P_{Circuit} is [6] given by,

$$P_{Transmit} = P_{PA} + P_{Circuit} \tag{4}$$

The P_{PA} relies on the aggregate transmission power, P_{TX}, while P_{Circuit} is free of it. For effortlessness, we expect that P_{PA} is directly dependent on P_{TX}. Also, P_{Circuit} can be partitioned into that contributed by every dynamic RF chain, P_{R_Chain}, and that by circuit shared by all dynamic RF chains, P_{Shared}.

We can define the power utilization by a multiple radio incorporated in a mobile system for transmitting, P_{Transmit}, as

$$P_{Transmit} = (1 + \alpha)P_{TX} + N_T P_{RF\_Chain} + P_{Shared} \tag{5}$$

where α is a characteristic parameter of power amplifiers and N_T is a total number of dynamic RF chains. To reduce the power consumptions and improve power efficiency by disabling the subset antennas and its RF chains, an efficient technique like power saving mechanism is used to improve the energy efficiency of the mobile device.

5 Implementation

The simulation of the proposed system is carried out in normal 32-bit machine using Matlab. Here, the transmitting and receiving scheme is developed for mobile devices to analyze the energy consumption in network. We have selected 5 transceiver devices for the simulation of the proposed scheme. For this simulation an image signal is taken to analyze the system. The parameters are initialized as follows: different data rates and energy of each bit of data. Then total energy per bit per data rate is calculated as output.

Algorithm for Energy Conservation
Input: *I, Scale, Ebit, Ptx;*
Output: *Energy per bits/Data rate;*

1. ***Start***
2. *Read the input image;*
3. *Initialize different data transmit rates;*
4. *Initialize energy of each bit;*
5. *Calculate total energy;*
6. *Create SNR values;*
7. *Initialize no. transreceiver antennas;*

8. *For each antenna create multiplier;*
9. *Apply BPSK modulation;*
10. *Apply Rayleigh channel;*
11. *Add white Gaussian noise;*
12. *Calculate Eb;*
13. *Transmit antenna configuration;*
14. *Receive antenna configuration;*
15. *Form equalization matrix;*
16. *Receive transmitted image;*
17. *Count the errors generated;*
18. *Plot all the outputs;*
19. ***End;***

In the proposed method we have simulated the power optimization for the given input signals. For this scheme, we have initialized a number of transmitter and receiver devices and the data rate along with the total transmitted power and also the bit rate. After initialization step we need to calculate the power using Eq. (4). Then transmit the given signal thorough a noisy channel and then at the receiving end we can get the received signal. Then we calculated the number of bits requited to transmit the data from transmitter to receiver side through a wireless noisy channel.

6 Results and Discussion

This section shows the evaluation of the proposed method. Here, we set the number of transmitter and receiver to 5. Figure 2 shows that the number bits received is directly proportional to the amount of power consumption. We can observe that, as the transmit power increases, the number of bits received also increases. As the number of transmitter and receiver increases, the data transmit rate will also increase. We utilize the standard static arrangement technique with all receiving dynamic antenna to evaluate the antenna management systems. We measure the power per bit of Node 1 which executes antenna system management and transmits 1000 data segments to Node 2. For both estimations, we utilize four diverse data rate imperatives: 0, 100, 200, and 300 Mbps.

Figure 2 demonstrates the multiple radio system energy per bit diminishment by two-finished and one-finished reception antenna system management. To start with, the energy per bit accomplished by receiving antenna management is entirely no bigger than that of the static design. Second, when the information rate requirement expands, the energy per bit decrease by reception apparatus management drops. Third, under a moderately low information rate requirement, antenna system management turns out to be more successful with bigger receiving antenna systems.

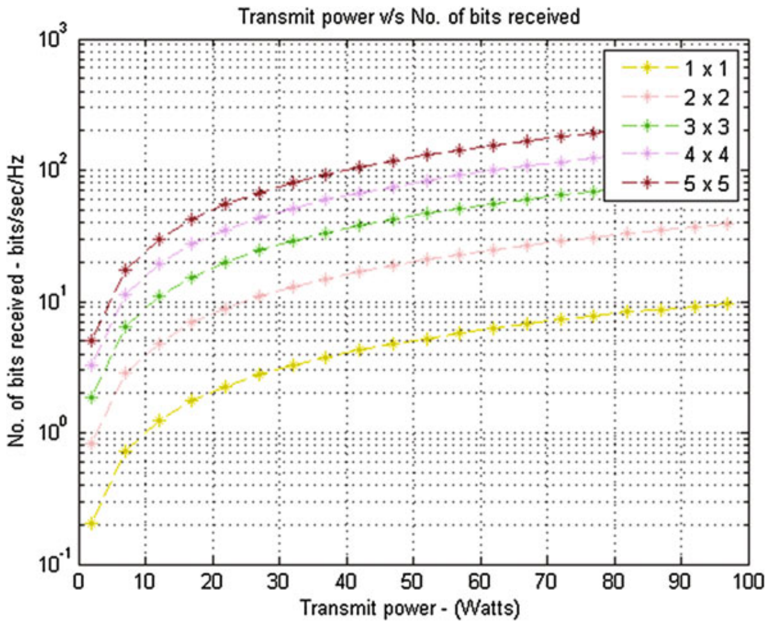

Fig. 2 Effective data rate versus the optimal transmit power

7 Conclusion and Directions Further Research

This paper discussed about a novel energy saving mechanism, namely, reception antenna system management, to boost the energy effectiveness of the multiple radio system interface on cellular frameworks. Reception antenna system management adaptively improves the transmission power and antenna design with the specific end goal to accomplish the base energy per bit under a given information rate limitation. We demonstrated that reception antenna system management can be acknowledged with little change to the 802.11n convention to expand the energy productivity of a single end or both closures of a radio link. Our assessment utilizing Matlab based simulation work demonstrated that reception antenna system management on average can achieve better energy per bit reduction.

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