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Survey on Energy Saving Methods for Green Communication Network

J. Premalatha*, U. Anitha, V. Manonmani and P. Ganesan

Faculty of Electrical and Electronics Engineering, Sathyabama University, Chennai - 600 119, Tamilnadu, India; lathaaram@gmail.com, anitaumanth@gmail.com, v_manonmani17@yahoo.com, gganeshnathan@gmail.com

Abstract

In recent years telecommunication is playing a vital role in communication field. The power usage has become a major problem since the usage of wireless communication has increased, which has leaded to environmental impact in a drastic manner. The main goal of designing green base stations is for saving energy and reducing power consumption while guaranteeing service and coverage for users and ensuring the capability of base station for evolution. To reduce the energy consumed by base station sleep mode mechanism is adapted. For uplink and downlink communication a joint bandwidth and power allocation method is deployed which promotes energy saving for both network operators and mobile users. Thus, Green networking is to reduce the unnecessary energy consumption keeping environmental factors into consideration. This paper deals with the survey of the problems upon implementation of base station in cellular networks for heterogeneous communication and also compares the various work related to green networking.

Keywords: Base Station, Energy Efficiency, Green Networking, Heterogeneous Network, Sleep Mode

1. Introduction

1.1 Green Base Station

Power saving in base station can be achieved by minimizing energy consumed by base station which utilizes energy efficient sets of rules for power saving when all unnecessary components are shut down, power management for energy aware cooperative base station which organizes the cells of its own and by zooming of cell, or by using natural sources of energy[1] and also design of hardware must be taken into account. Different types of network can be implemented for energy efficient base station. In next section the base station architecture redesign is been discussed.

1.2 Heterogenous Wireless Medium

In the preceding section, heterogeneous network has to be deployed for the improvement of energy efficiency of base station is been discussed. Both bandwidth and allocated power approach scheme has been proposed in this paper for uplink and downlink communication in a heterogeneous wireless medium which promotes energy saving for both mobile users and also for the person who monitors and maintains the network. Among MTS (Mobile Terminal) and BS/APs (Base Station/Access Point) the path losses of different networks, an operating frequency band with the bandwidth which is available at different networks can further enhance the efficiency of energy along with the condition of channel. Bandwidth and allocated power approach jointly results in a significant advantage in energy efficient communication over the power only allocation scheme[2] which is reviewed in the further sections.

1.3 A Comparative Survey

Xiao Ma et al.[9], investigates the benefits of concurrent transmission from the perspective of green communications. The flow of traffic splitting for multiple networks a concurrent transmission scheme under the metric of bit per-joule method is proposed which is modeled as a constrained optimization problem. To maximize the system energy efficiency the threshold of

* *Author for correspondence*

the traffic splitting starting point and the optimal rate allocation of each flow are derived. From the demonstrated result it is analyzed that this scheme can save significant power and can improve the energy efficiency by a constrained optimization model.

To decrease the CO_2 emissions[3,4] and to increase the profits of both operators and users the financial or the environmental considerations, reducing the amount of energy consumption has become an important factor . In wireless networks, the maximum number of bits that the network can deliver per joule of energy deployed into the networks is referred as Energy Efficiency (EE), which can also save the energy in the network[5]. This EE for energy saving in wireless network is focused nowadays, which is done by translating code into the original form, planning dynamically, and cooperation with in the network. In paper[5], based on the rate-fairness and QoS (Quality of e\service) requirement the EE is measured by different decoding policies, and EE contours are adopted to identify optimal transmission rate of users.

A scheme which can guarantee both the traffic requirements and coverage has been proposed in paper[6] to reduce the energy consumption by obtaining a desired result for the coverage extension functionality of the inter-cell cooperation. Thus, to improve EE, network cooperation with in the network becomes an effective technique. Any deviation in the traffic load which maximizes the energy saving by an optimal resource on-off switching framework has been described in[3]. The method of minimizing energy consumption is proposed in[7] which is by means of shutting down some resources of the system followed by two types of sleep mechanism. From the survey of all these papers it is understood that these existed energy-saving solutions is obtained to achieve EE by switching off some BSs (Base Station) or part of resources of these BSs to reduce energy use. But the main draw back in these above mentioned schemes is that it will block the users who can only access to these switched-off BSs or resources. In heterogeneous networks (HetNets) the Multimode User Equipment (MUE) can obtain multi-access gain, by simultaneously combining transmissions over several Radio Access Technologies (RATs) by network cooperation[8]. To improve EE the multi-access gain from the combining transmission via traffic control is utilized.

To maximize EE in HetNets Xiao Ma et al.[9] firstly explores the intrinsic relationship between the energy consumption and the transmission rate, and a concurrent transmission scheme is then proposed, called as MECT (Maximum EE Concurrent Transmission). The concurrent transmission at which the threshold values begins and the optimal transmission rate of each flow have been derived which is analyzed in this paper. This novel approach proposes a constrained optimization model to find the threshold and optimal splitting probability. Numerical results provide a detailed analysis of the effects of MECT strategy on EE of MUE in HetNets[9].

Taking into consideration the environmental, financial, and quality-of-experience considerations, for both mobile users and person who monitors and maintains the network, developing energy efficient communication network is necessary and is also been a topic of interest. The developed solutions are referred to as green communications, which focuses environmental impact also. The main challenge for energy efficient communication in heterogeneous network is the overlapped coverage from different networks, taking into account the vast diversity in fading channels and propagation losses among mobile terminals and base stations. To overcome all these problems Muhammad Ismail et al.[2,3], has proposed a joint bandwidth and power allocation approach, for both uplink and downlink communication. Also they have discussed several challenging issues, including design and implementation and they have given a case study of uplink communications for demonstration purpose also.

Wireless access networks have been deployed with the increasing demand on wireless communication services. In addition, there are great advances in MT design and manufacturing. MTs allow not only allows voice services but it supports video streaming and data applications also which are equipped with processing and display capabilities. To access different types of wireless networks, such as wireless local area networks (WLANs) and cellular networks, MTs can use their multiple radio interfaces. Thus, there is high energy consumption for both mobile users and network operators due to great evolution in wireless communications[9]. There are around three billion MTs in the world with annual power consumption of 0:2 - 0:4 GW[10] w for mobile users. Since, the Base Stations (BSs), which is responsible for 57% of the total energy consumption in network infrastructures[11,12], with an average annual energy consumption of about 4:5 - 9 MWh per BS[1]. Thus, the high energy consumption, for mobile

users and network operators, has raised environmental, financial, and Quality-of-Experience (QoE) concerns.

Keeping environmental consideration into mind, it is estimated that the telecommunication industry is responsible for 2% of the total CO_2 emissions worldwide, and this percentage is expected to double by 2020[13]. Moreover, the life time of MT rechargeable batteries are about two to three years, which results in high annual disposed batteries, raising high environmental (and financial) impacts. Apart from environmental concerns, when we overview financial perspective, almost half of the operating expenses on energy costs is spent by mobile users. At last, when we think on user side that is on user QoE perspective, more than 60% of mobile users complain about their limited battery capacity. Also it is found that there is a gap between the demand for energy and the MT offered battery capacity which is increasing exponentially with time[13]. Thus analyzing all the above mentioned problems, there is a growing interest in developing energy efficient wireless communication networks. These energy efficient solutions are referred to as green communication networks.

The medium in wireless communication is heterogeneous environment with overlapped coverage from different networks[3]. For both mobile users and network operators there are several ways to enhance EE. In literature, to improve energy efficiency, existing green solutions mainly focus on diversity in fading channels and propagation losses and deal with how to optimally allocate transmission power at BSs and MTs, given an allocated bandwidth. However, incorporating the diversity in available resources (e.g., bandwidth) and operating frequency bands through joint bandwidth and power allocation, further enhancement can be achieved in networking environment. Muhammad Ismail et al.[2,3], discusses energy efficiency in a heterogeneous wireless medium. The contributions of their work are: They have proposed a joint bandwidth and allocation of power approach, for both uplink and downlink communications, which maximizes energy efficiency for mobile users and network operators using multi-homing capabilities of MTs in a heterogeneous wireless access medium. Muhammad Ismail et al.[2,3] has also discussed the challenging design and implementation issues of the proposed joint approach. They have presented a case study to support energy efficient uplink communications for MTs with best effort multi-homing service to illustrate the improved performance of the proposed joint approach, in comparison with power only allocation scheme. As discussed earlier, environmental, financial, and QoE considerations have motivated research in the area of energy efficient (green radio) communications. To improve energy efficiency, and to satisfy the QoS of mobile users, heterogeneous wireless access medium has great potentials. To enable better mobility support, and reduce energy consumption for mobile users and network operators, multi-homing services can aggregate bandwidth from different networks. In addition to exploit different channel conditions and path losses among MTs and BSs/Aps of different networks, the available bandwidth and operating frequency bands at different networks can further enhance energy efficiency. Thus, the power only allocation scheme results in a significant advantage in energy efficient communications for joint bandwidth and power allocation approach.

Beibei Wang et al.[14] in their paper proposes that the Time-Reversal (TR) signal transmission is an ideal technique for green wireless communications because it fully extracts energy from the surrounding environment by making use of the multi-path propagation from which all signal energy are recollected in spite of being lost in existing communication system. The user must experience low energy consumption and low radio pollution in the communication system. TR wireless communications gives considerable transmission power reduction when compared to the conventional direct transmission using a Rake receiver, which, achieves high interference alleviation ratio, and exhibits large multi-path for improving the reliability of a message signal, when analyzed theoretically, simulated numerically and measured experimentally. Thus TR is an ideal technique for the development of green wireless systems. In terms of transmit power reduction and interference alleviation the theoretical analysis and numerical simulations shows an order of magnitude improvement. Experimental measurements in a typical indoor environment also demonstrate that the transmit power with TR based transmission can be as low as 20% of that without TR. In a nearby area the average radio interference can be up to 6 dB lower[14]. In the multipath channel a strong time correlation is to be maintained when the for a varying environment. This indicates that in TR radio communications, high bandwidth efficiency can be achieved. The increasing energy consumption in wireless

network results in high operational cost which leads to demand for battery usage among operators. These in turn causes more electromagnetic (EM) pollution to the global environment. Therefore, this new concept of "Green Communications" has received considerable attention to improve EE, so that radio pollution can be reduced to unintended users.

In green wireless technology, one must consider two basic requirements: first one is the energy consumed by the user must be low (environmental dimension) and second one is the low radio pollution to unintended users (health concerns)[14]. In this paper Beibei Wang et al.[14] illustrates that the time-reversal model gives solution to meet two basic requirements. Also they have shown that along with these requirements, very high gain in multi-path diversity, as well as high bandwidth efficiency has been preserved due to high channel correlation. TR wireless communication was used in extreme multi-path environment. In olden days, in late 1990's[14], in TR communication, when transceiver 1 wants to transmit information to transceiver 2, a delta-like pilot pulse is propagated through a scattering and multi-path environment and the signals are received by transceiver 1; then, the time-reversed signals are transmitted by transceiver 1 back through the same channel to transceiver 2. By utilizing channel reciprocity, TR essentially takes advantage as the multi-path channel to be a matched filter, which focuses the wave at the receiver in both space and time domains.

In this paper, Beibei Wang et al.[14] shows that the TR technique is ideal for green wireless communication which can efficiently use the energy from the environment. In this paper the direct transmission with a Rake receiver is compared with the theoretical power reduction and interference alleviation of the TR-based transmission. Their theoretical analysis and simulations shows that the power reduction and interference alleviation can be achieved over an order of degree. It is also investigated that in a TR system the multi-path diversity gain with the TR-based transmission, high multi-path diversity gain can be achieved. The full use of all the multi-paths is achieved by considering each multipath as a virtual antenna in TR transmission. It is also shown that, in different time period the channel measurements shows that, a multi-path environment in static door is strongly related with time. So, the spectral efficiency can be much higher than typically achieved value of 50% and there is no need for the receiver to keep sending pilot pulses to the transmitter[14]. When the transmitter receives pilot pulses from the receiver, which sends back the reversed waveforms, the transmitter focuses energy with high resolution which is utilized by the receiver in both spatial and of time domain.

Thus it collects energy from the environment and causes less interference to other receivers. The results in this paper investigated by Beibei Wang et al.[14] shows that the TR system has a potential of over an order of magnitude of reduction in power consumption and interference alleviation, and also has a very high multi-path diversity gain. The interuser interference and transmission power consumption is reduced in TR-based transmission when analyzed upon numerical simulations and experimental measurements. Beibei Wang et al.[14] has also proved that in green wireless communication high spectral efficiency is achieved in a time varying environment when TR technique is used.

Another way to improve the efficiency of spectrum without the use of base station is to incorporate mobile to mobile communication (M2M). M2M communication has been proposed in order to satisfy the rapidly increasing demand for local traffic and to provide better Quality of Service (QOS), for LTE Advanced environment where the users in a cellular network can communicate directly with one another without a need for base-station. It can provide service to more users which can also maintain efficiency of spectrum as well as throughput of network15.

2. Conclusion

This paper surveys on the how the energy efficiency can be improved when deploying a BS in heterogeneous network.BS is been topic of interest, because the energy consumed by BS is more, compared to other devices in communication network. Table 1 gives the various method proposed in regard to EE and the respective scope of their work is been discussed. When we increase the EE, the energy consumed by the network is reduced considerably which will reduce the CO_2 emission in the environment. But, still there are many technical issues which are to be experimented to improve EE of base station.

Table 1. Comparative survey on energy saving methods

References	Proposed method	Inference
2	Power only allocation scheme	Saves energy for both mobile users and network operators
3	Use cooperative networking	Saves energy at network level
4	Auctioning strategy is proposed for cellular networks	Enforce energy gains into cellular networks
5	Linear power model which defines total power consumed at the base station	Overall power consumed by Base station is calculated
6	Energy aware network planning scheme	Reduces energy consumed by base station
7	New energy-efficient, radio resource management scheme is proposed	Energy consumed at the network is optimized while preserving the Quality of Service (QoS) perceived by users
9	MECT strategy	Energy Efficiency is improved in heterogeneous networks
12	Discusses models of current energy consumption in base station devices	Proper modeling of energy consumed by base station has to be concentrated to reduce the energy consumed by base station
14	Time reversal transmission in green communication	Reduces transmission power consumption and interuser Interference

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