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Title: Energy conservation techniques for base station in cellular wireless network

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Submitted to: ECE Department

Submission date: 12/27/21

Adama,Ethiopia

Abstract

Due to global climate change as well as economic concern of network operators, energy consumption of the infrastructure of cellular networks, or "Green Cellular Networking," has become a popular research topic. While energy saving can be achieved by adopting renewable energy resources or improving design of certain hardware (e.g., power amplifier) to make it more energy-efficient, the cost of purchasing, replacing, and installing new equipment (including manpower, transportation, disruption to normal operation, as well as associated energy and direct cost) is often prohibitive.

By comparison, approaches that work on the operating protocols of the system do not require changes to current network architecture, making them far less costly and easier for testing and implementation. In this proposal, we first present facts and figures that highlight the power consumption of information and communication technology infrastructure from this we focus on cellular network especially on base station and then review existing green cellular Networking research with particular focus on techniques that incorporate the concept of the cell zooming, cell sectoring and adapting beam forming in base stations. It takes advantage of changing traffic patterns on daily or weekly basis and selectively switches some lightly loaded base stations to low energy consumption modes. As base stations are responsible for the large amount of energy consumed in cellular networks, these approaches have the potential to save a significant amount of energy. Finally we show the simulation result using MATLAB software.

Acknowledgement

Firstly, we would like to thank our almighty God who helped us for the completion of this partial fulfilment of proposal. Next of all, we would like to express our gratitude and sincere thanks to our respected advisor Dr. Harish Kalla for his professional guidance, advice, motivation, endurance and encouragements. The present work would have never been possible without his vital supports and valuable assistance.

Acronym

BS: - Base Station

CMA: - Constant Modulus

EADM: - Equal Area Division Method

EIRP: - Effective Isotropic Radiated Power

GRAND: - Green Radio Access Network Design

GSM: - Global System for Mobile Communication

HetNets: - Heterogeneous Networks

HSPA: - High Speed Packet Access

ICT: - Information and Communications Technology

IEEE: - International Electronics and Electrical Engineering

LDM: - Linear Division Method

LMS: - Least Mean Square

LTE: - Long Term Evolution

MMSC: - MUSIC Multiple Signal Classifier

OPEX: - Operational Expenditure

PA: - Power Amplifier

QoS: - Quality of Service

RF: - Radio Frequency

RLS: - Recursive Least Square

SMI: - Sample Matrix Inversion

UMTS: - Universal Mobile Telecommunication Service

WADs: - Wireless Algorithms and Data structure symposium

WiFi: - Wireless Fidelity

WiMAX: - Wireless Maximum

UL: - Uplink

2G: - Second Generation

3G: - Third Generation

4G: - Fourth Generation

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Chapter One

1. Introduction

1.1. Background

- Currently, 3% of the world-wide energy is consumed by Information and Communications Technology (ICT) infrastructures [1]. In mobile communications, 90% of energy consumption is done at the Core Network and Base Stations (BS's), so with the increase in the number of sites, due to larger capacity and bandwidth requirements, energy efficient solutions became a major concern for telecommunications operators.
- In addition to minimizing the environmental impact of the industry, cellular network operators are as well interested in reducing the energy consumption of their networks to reduce their Operational Expenditure (OPEX), and therefore increase profits. Furthermore, over 80% of Energy in mobile telecommunications is consumed in the radio access network, more specifically in the BSs, whereas 50-80% is spent for the power amplifier (PA) under these the Energy consumption is fall in to antenna.
- So by optimizing energy consumption or creating adaptive operating mode solutions of the equipment's at the sites, there are considerable savings in energy at the BS and in the expenditure for operators [2]. With the energy aware adaptive solutions comes the importance of traffic load modelling, where daily, weekly or even seasonally, telecom's users' migratory patterns can be studied and then modeled to improve the operators knowledge of its network. The reduction of traffic in some areas of the cellular network is due to the combination of the typical day-night behavior of mobile phone users, like the daily swarming of users carrying their mobile terminals from residential areas to offices and back, resulting in the need for high capacity in both areas at peak usage times; on the opposite, the family weekends where the mobile phones are put aside, leading to a decrease on the volume of voice calls on the networks at those days and therefore the energy waste of the same unused resources deployed for the weekdays traffic load.

- Knowing the duration and the timing of low traffic hours, when virtually all BSs are operating at low load, or even not serving any user at all, is crucial in order to increase the energy efficiency of the network. For the operators is also important to have some insight about the power consumption of each equipment inside a site, and their contribution for the overall site consumption, in order to have energy savings by investing in technological development of the most consuming equipment.
- This evaluation needs to be considered for all 2G, 3G and 4G technologies, as well as for all BS's sizes. Instead of the purchase of better equipment, power consumption variation factors must also be studied, and then used as parameters for intelligent energy aware models. In this proposal the main focus is analysing different energy conserving techniques those are cell zooming, adaptive beam-forming and cell sectoring and finally we compare which technique is more efficient energy conservation technique.

1.2. Statement of problem

- The usage of cellular devices has been advanced in recent years and expected to increase rapidly in the coming years. Thanks to rapid development of technologies which is making us comfortable in the field of communications. The rapid development in technology is causing many serious hazards to the environment and also the mobile operators are facing problems with increasing energy costs and regulatory pressures to reduce carbon footprint to operate Green networks.
- Due to global climate change as well as economic concern of network operators, energy consumption of the infrastructure of cellular networks, or "Green Cellular Networking," has become a popular research topic. As base stations are responsible for the large amount of energy consumed in cellular networks, these approaches have the potential to save a significant amount of energy. Most of the existing system shown in the above literature review are earlier and they are specifically analysing one technique but in this proposal we propose to focus on different techniques of power conservation and to compare which technique is the best on power conservation for other.

1.3. Significance of the project

- The purpose of this project is to make Energy conservation techniques for base station in cellular wireless network which is used to dispose some kind of pests from nearby weeds and crops on agriculture fields.
- The project has the following main advantages;
  - It will increase the quality of communication.
  - It will maximize quantity of user.
  - It will reduce energy wastage.
  - It will reduce cost.

1.4. Objective

1.4.1. General objective

- The general objective of the project is to study the techniques of energy conservation for base station in cellular wireless network.

1.4.2. Specific objective

- To Study existing and emerging technologies that can be used in energy saving, due to the increased environmental pollution that has resulted from the rapid increase of the number of base stations.
- To map the various approaches for energy efficiency in base stations.
- To identify the best technology that suits the base station platform in terms of energy efficiency and power consumption.

1.5. Scope and limitation of the Research

1.5.1. Scope of Research

- The scope of the proposal is to study energy conservation technique on base station for cellular network and to show the result using MATLAB simulator. Based on the result this proposal try to analyse and estimate the efficient power consumption on base station.

1.5.2. Limitation of Research

- While we are dealing with cell sectoring the following drawbacks will happen:
  - The no of hand off increases
  - There will be loss of traffic
  - There will be an increase in number of antennas per base station
  - There also be a decrease in trunk efficiency.

Chapter Two

2. Literature review

- Energy consumption has got more important to study because resultant increase in the rate of data access has raised power consumption in the base station in cellular networks. In [3], the author evaluate the power consumption savings in GSM/UMTS with the use of energy efficient models, based on the switch off of RF equipment, in low traffic hours that vary within the urban regions. For each region, traffic models were developed for both voice and data traffic, to be used as input to the energy efficient models. The Traffic Model uses the collected traffic data to obtain voice and data traffic models. The Energy Efficiency Model uses the power consumption model and energy efficient algorithms to produce energy consumption daily profiles. In the Energy Efficient Algorithm the RF equipment is switched on and off according to the traffic load, producing energy savings. This proposal is to evaluate the energy efficiency of intelligent techniques for carriers switch on/off for both 2G and 3G networks, with the analysis of power consumption profiles with and without energy efficient procedures, using previously developed traffic models as input. In [4], the authors address the base station (BS) deployment problem in heterogeneous networks (HetNets) and propose an energy-efficient solution. Supporting the network with additional BSs increases the total capacity of the network. However, this process may reduce the energy efficiency of the network. The proposed algorithm studies the energy efficiency aspect of the micro BS deployment problem. In [5], the authors identify a power consumption model for both macro-cell and micro-cell base stations is proposed. This model is validated by temporal power measurements on actual base stations and an excellent agreement is obtained. Furthermore, the power consumption's evolution during the day is investigated by means of these measurements.
- The energy efficiency of three different wireless technologies is compared namely mobile WiMAX, LTE, and HSPA. Based on the model proposed,the

deployment tool GRAND (Green Radio Access Network Design) is implemented which allows to design an energy efficient access network for a predefined area. In [6], the authors first present facts and figures that highlight the importance of green mobile networking and then review existing green cellular networking research with particular focus on techniques that incorporate the concept of the "sleep mode" in base stations.

- It takes advantage of changing traffic patterns on daily or weekly basis and selectively switches some lightly loaded base stations to low energy consumption modes. As base stations are responsible for the large amount of energy consumed in cellular networks, these approaches have the potential to save a significant amount of energy. The need to find ways to conserve energy in cellular networks in this proposal is increasing energy bills for telecommunications service providers In [7] the author investigates the power consumption of indoor/outdoor Wireless Access Devices (WADs, specifically WiFi and WiMAX access points) and provides novel techniques for improving the energy efficiency of wireless access networks.
- Our approach focuses on monitoring and analysing the power consumption of WADs using real–tested and experimental measurements in order to understand the fundamental limits and trade-offs involved. This, in turn, will be used to propose efficient techniques to reduce power consumption and to maximize the energy efficiency of wireless access networks. This proposal is the cost of the electricity is increasing every year due to the report that electricity increased in the last three years, from 2010 to 2012, and it will continue increasing in the coming years. It will have a dramatic impact on the communication service prices especially on those countries that are importing their energy such as Italy and Cyprus, which actually have the highest industries electricity prices in the Europe Union. Therefore, considering the environmental and economical motivations explained before, one of the most urgent challenges in the new century for current and future human generations is to investigate and introduce new energy efficiency technologies that can enable a transition towards a more sustainable society with a reduced CO2 footprint.

Chapter Three

3. Research design

3.1. Component in Base Stations

- **Power Amplifier (PA):** An amplifier is any device that magnifies the amplitude of a signal. In radio frequency (RF) PA's, such as the one used in cellular BS's and broadcast transmitters, a very important parameter is the efficiency. The PA could be in four possible states: switching state, transmitting state, turned off state and idle state. During switching state, the PA commutes from active to inactive and vice versa. In transmitting state, the PA is active and boosts the signal to be transmitted over the BS air interface. The PA is in turned off state when its circuitry is inactive and no signal can be amplified. In idle state, the PA is active but not transmitting.
- **Air Conditioning (Cooling System):** In electronic equipment and circuits, power dissipation is generally a stated condition. Electronics also have specific margins of operative temperature and in order to keep the temperature of most components of the BS within specified design limits we need to cool the sites. Air conditioners (A/C) are often the choice for radio sites. Such cooling requires as much power as one third of the heat power generated inside the BS, i.e., one extra Watt is required to dissipate three Watts of heat.
- **Signal Processing:** UMTS signals are much more complex than GSM signals regarding the signal processing on transmitter and receiver side, whereas LTE signals are even more complex. Thus, the signal processing per link is substantially increased. Signal Processing Circuit is considered as having a constant power consumption.
- **Power Supply:** the loss within these two components is typically between 7% and 10% and depends mainly on the employed technology. By using 7%, an optimistic value is assumed. Every power supply must obtain the energy it supplies to its load, as well as any energy it consumes while performing that task,

from an energy source. All power supplies have a power input, which receives energy from the energy source, and a power output that delivers energy to the load.

3.2. Energy Consumption in Base Stations

- A cellular mobile network consists of three elements, a core network that takes care of switching, base stations providing radio frequency interface and mobile terminals in order to make voice and data connections, of these base station alone contributes 50% to 80% of the whole network energy consumption , Of these cellular networks the energy consumed by the base station components. In a conventional BS, the power consumption depends on the traffic load; it is mainly the PA power consumption that scales down due to reduced traffic load. This mainly happens when, e.g., the number of occupied sub carriers is reduced in idle mode operation, and/or there are sub frames not carrying data. The following are the base station components with their power consumption.
  - Power amplifier (65%)
  - Air conditioning (18%)
  - Signal processing (10%)
  - Power supply (7%)

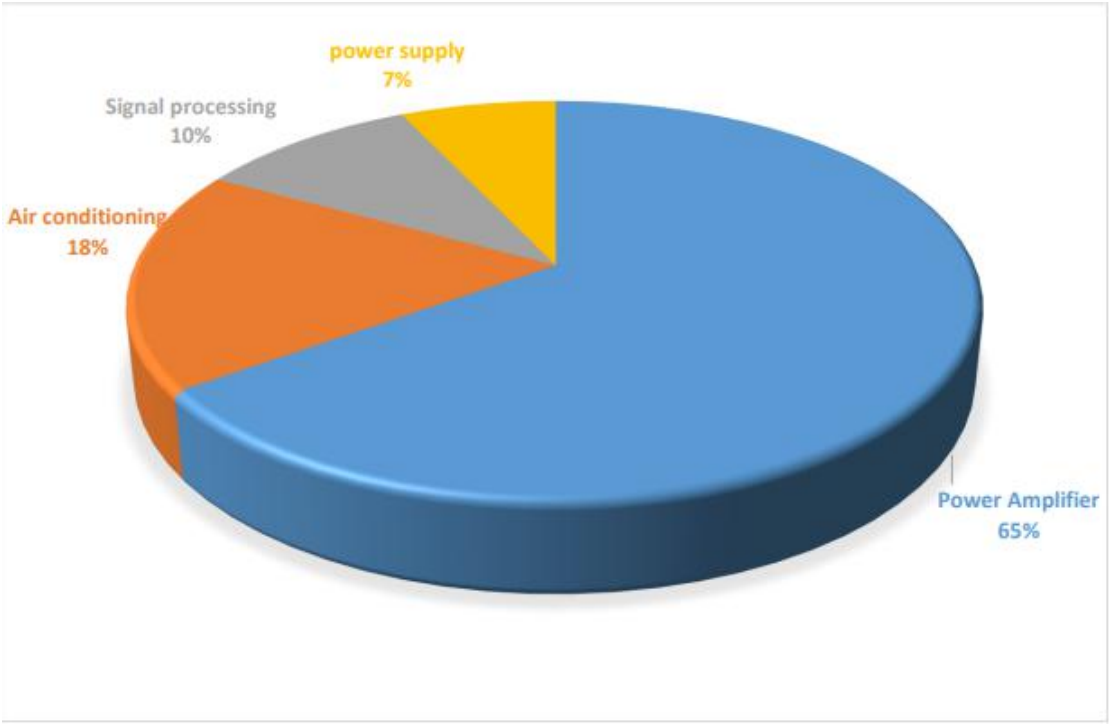

Figure 1:energy consumption pie chart

3.3. Fundamentals of Cell Zooming

- Energy consumption has become one of the most important issues in the world, as large number of base stations contribute to major energy consumption. To overcome this problem, cell zooming concept is introduced in this project. Cell Zooming has the capacity to dynamically adjust the cell size without switching off or putting the base station to sleep completely.
- Therefore by merely controlling the transmit power, the effect of energy saving is marginal and Switching on/off schemes will add more overhead to the network, which leads to increase in energy consumption. Obviously, cell could not to zoom to infinity due to constraint of power. Depending on the traffic load and distant user location, base station transmit power can be calculated and cells will be zoom in or zoom out based on the transmission power [8].

3.4. Beam forming

- Beamforming comprises the functions performed by a device (usually called as beam former or generically adaptive antenna) in order to allow the power radiated

by an antenna to be focused into a specific direction. In the same way, beamforming consists of receiving a signal from a desired direction, while reducing the interference generated by interferers located in directions that are not the desired one. A single-element antenna has no evident lobes in its radiation pattern. An array with a number of basic radiators is used to create lobes and nulls in directions of interest. The direction of the main lobe or nulls can be tuned by changing the spacing of the basic radiators in the array. Besides the basic radiators' spacing, also the configuration of the array can change in order to obtain the radiation pattern with more interest to the application, which can be linear, circular, etc. This physical changes made to set up the antenna's radiation pattern are actually performing relative phase shifts between signals captured by each antenna element. Typically, for a desired application, the antenna with the most advantageous radiation pattern is chosen and it remains the same during the operational life of the system.

- A Beamforming Network, also referred to as an adaptive antenna array, consists of a number of antenna elements coupled together by a complex shift control, to form a very directive beam able to move the radiation pattern. By creating a directive high gain beam into the direction that the signal preferentially comes from or goes to, the interference generated out of the direction of interest is significant lower than the signal coming from the direction of the high gain beam. At the same time, when the antenna is transmitting, the extra gain of the antenna (due to the smaller width of the beam) increases the effective isotropic radiated power (EIRP), which leads to an increase of coverage, or keeps the same coverage with less feed power. Also when the antenna is transmitting, a high directive radiation pattern brings reduction of interference to other users in the neighborhood, and increases at the same time the frequency reuse ratio. The scope of this thesis falls into the energy efficiency improvement by using beamforming in DL. A basic beamforming network layout is shown in Figure 2.

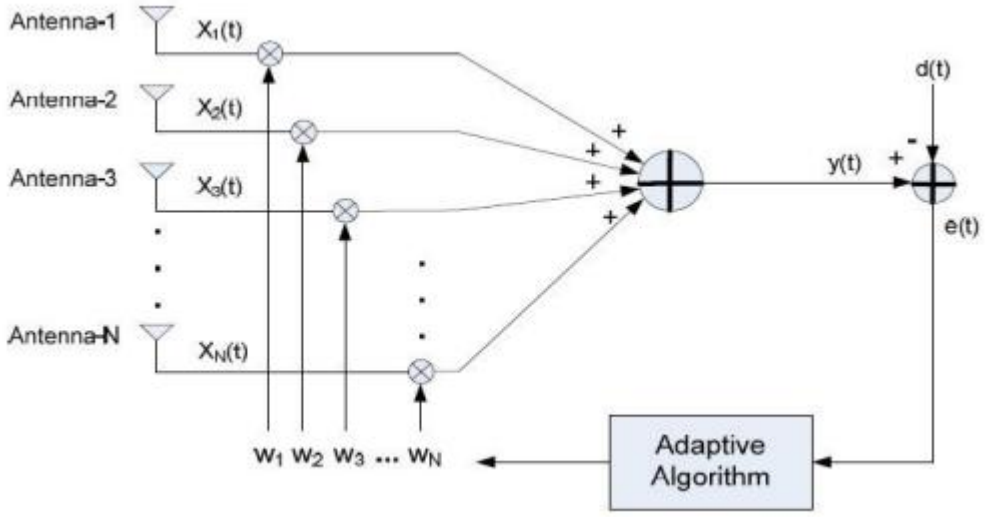

Figure 2:Adaptive Beam forming block diagram

3.5. Cell Sectoring

- Cell sectoring gives a room for increasing capacity by keeping the cell radius unchanged and seeking methods to decrease D/R ratio. Sectoring increases S/I so that the cluster size may be reduced. In this approach S/I is improved by using directional antennas, then capacity improvement is achieved by reducing the number of cells in a clusters, thus, increasing the frequency reuse. However in order to do this successfully, it is necessary to reduce the relative interference without decreasing the transmit power. The co-channel interference in a cellular system may be decreased by replacing a single omnidirectional antenna at the base station by several directional antennas, each radiating with a specified sector. By using directional antennas, as given cell will receive interference and transmits with only a fraction of the available co channel cells.
- The technique for decreasing co-channel interference and thus increasing system performance by using directional antennas is called sectoring. The factor by which co-channel interference is reduced depends on the amount of sectoring used [12]. It is one way to increase to subscriber capacity of a cellular network is replace the Omnidirectional antenna at each base station by three (or six) sector antennas of 120 (or 60) degrees opening. Each sector can be considered as a new cell, with its own (set of) frequency channel(s). The base station can either be located at
  - the center of the original (large) cell, or

✧ the corners of the original (large) cell.

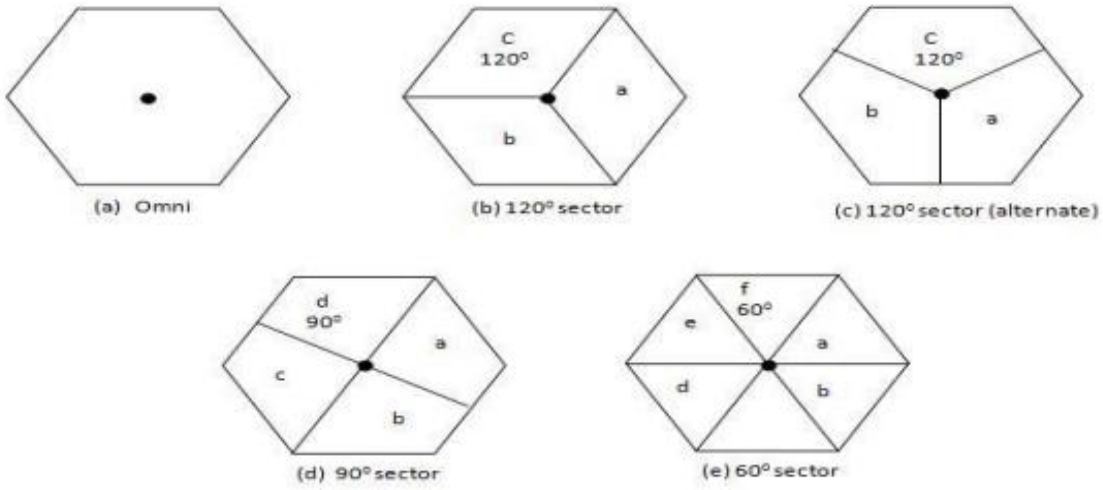

Figure 2:The approximations of the hexagonal and the circular cell

Chapter Four

4. Conclusion and Recommendation

4.1. Conclusion

- More than ever, the global awareness for energy issues is motivating several trends for efficiency. The telecommunications area is not out of this perspective, with vendors, operators and customers committed to reduce the overall energy bill by adopting green behaviours that, isolated, do not introduce a significant impact, but together can create a major revolution on the cost associated to energy consumption.
- In this project, an approach is analyzed for reducing the overall network power consumption for cellular wireless network in base station by using different techniques like cell zooming, adaptive beam forming and cell sectoring technique and we compare those techniques based on the advantage and disadvantages. From this project, we conclude that beam forming and cell Sectorization is more applicable and advanced than cell zooming.

4.2. Recommendation

- Power conservation in this techniques may bring poor QOS since it undermines users below the specified threshold; as a future research direction one take this metrics as a hot research topics.
- In beam steering there side lobes interfering main beam, therefore side lobe adaptive cancelling can also be considered as a hottest research directions.

4.3. Time schedule

Table 1:time table

No	Activities	Duration in month											
		NOV.				DEC.				JAN.			
		Wk .1	Wk .2	Wk .3	Wk .4	wk .1	Wk .2	Wk .3	Wk .4	Wk .1	Wk .2	Wk .3	Wk .4
i.	Data collection												
ii.	Analyzing Data												
iii.	Proposal writing												
iv.	Software design												
v.	Writing conclusion and Recommendation												
vi.	Submitting semester project												
vii.	Project presentation												

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