ISSN: 2278 – 909X
International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 5, Issue 6, June 2016

A Review of Energy Efficient Operation of Cellular Network

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***Abstract*—**increasing number of base stations and reducing the energy consumption of the stations in cellular networks has become an important research topic. The operation of cellular network infrastructure incurs significant electrical energy consumption. From the viewpoint of cellular network operators, reducing this consumption is not only a matter of showing environmental responsibility, but also of considerably reducing their operational expenditure. This emerging trend of achieving energy efficiency in cellular networks is encouraging the standardization authorities and network operators to continuously survey future technologies in order to bring improvements in the entire network infrastructure. This paper presenting a brief survey of methods to improve the power effectiveness of cellular networks. Also different approaches have been discussed to increase the energy efficiency. Also summarized the energy savings obtained by some techniques. Different categories and network based on these categories of energy efficient technology of cellular network is discussed.

***Index Terms*— Information and Communication Technology (ICT), Component level, Link level, Network level, Archtecture**

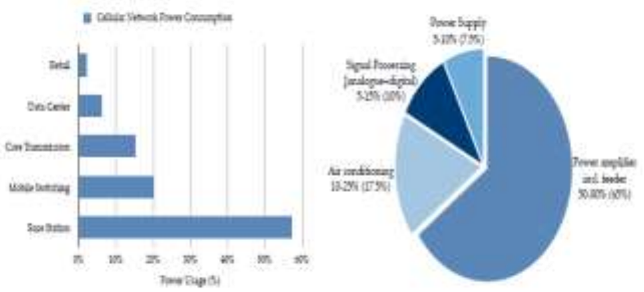
INTRODUCTION

1. INTRODUCTION TO ENERGYEFFICIENTOPERATION OF CELLULAR NETWOKS:

In the last several decades, due to the continuous enhance of communication requirement, the Information and Communication Technology (ICT) developed rapidly focused on the higher capacity and larger coverage And correspondingly, the energy consumption is also growing at an amazing speed: the ICT is accountable for about 3% of energy consumption and 2% - 4% of CO_2 emission all over the world [1]. In January 2013, there were more than six million customary base station (BS) sites worldwide, a number expected to exceed more than 11 million by 2020. Furthermore, the global number of small cells, not counted in this figure, now exceeds the total number of conventional base stations. It is well known that the main source of energy consumption in cellular mobile network is the BSs, which are accountable for roughly two thirds of the total CO2 emissions of radio access networks [2]. With increasing awareness of the potential harmful effects to the environment caused by CO2 emissions and the reduction of non-renewable energy sources, there is a growing consensus on the need to develop more energy-efficient Telecommunication systems [3] In order to reduce the energy consumption, several organizations or projects, such as the (EARTH) Energy Aware Radio and Network Technologies have been founded, and many workshops have been organized at international conference [1].

1.2 ARCHITECTURE: ENERGY SAVINGS IN BASE STATIONS

Due to the rapidly growing demand for mobile communication Technology, the number of worldwide cellular BSs has amplified from a few hundred thousand to many millions within a last couple of years. Such a significant jump in the number of BSs that power a cellular network accounts for the sudden increase in greenhouse gases and pollution, in addition to higher energy costs to operate them. Therefore, BS equipment manufacturers have start to offer a number of eco and cost friendly solutions to reduce power demands of BSs and to support off-grid BSs with renewable energy resources. A typical cellular network consists of three main elements; a core network that takes care of switching, BSs giving radio frequency interface, and the mobile terminals in order to make voice or data connections. As the number of BSs maximizes, it becomes crucial to address their energy consumption for a cellular network.Fig1 gives the breakdown of energy consumption in CN and corresponding base stations.



(a) Power utilization of a typical wireless cellular network
(b) Power consumption distribution in radio base stations

Fig1. Breakdown of power consumption in a classic cellular network and corresponding base stations

The energy efficiency of base stations is predominantly poor in this condition, which can be attributed to:

• Component level: The efficiency of the power amplifier (PA) considerably degrades at lower output power.

• Link level: System information, synchronization, and reference signals (pilots) need to be transmitted constantly, so that base stations are required to be always on.

• Network level: The cellular network deployment prototype with large macro-cells requires additional (micro- or pico-) cells to fulfill peak capacity require, but this rather static topology does not adapt to low load situations [6].

1.3 APPROACHES TO ENERGY EFFICIENCY:

- There has been a significant interest in energy efficiency in sensor networks and multihop mesh network architectures due to the restricted battery life of the communicating nodes.
- In conventional cellular communication systems work on the energy efficiency has rather been narrow to the mobile terminal with their limited battery power, and the energy competence of the infrastructure has been largely ignored.
- OPERA-Net investigates the opportunities to developed the energy efficiency of broadband cellular networks by considering optimized cooling and energy recovery from the base stations and the optimization of the mechanism used in communication systems.
- The projects PANAMA ,ELBA and Class-S focus on a more efficient design of the power amplifiers in the base stations that typically still run at quite low efficiency.
- The Cool Silicon project focuses on the optimization of individual aspects like the system construction, communication algorithms and protocols as well as physical components in three main areas: micro/nano technology, broadband wireless access and wireless antenna networks. Mobile VCE Green Radio aims at extending the efficiency studies to energy metric for cellular and end to end communication [5].
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LITERATURE SURVEY

Xiaochen Su et al.(2013) In this article, author present a short survey on energy-efficient technology of cellular networks. Moreover, we classify them into three categories relied on their application scenarios: energy-efficient architectures, energy-efficient resource management and energy-efficient radio schemes. For the first scenario, the applications of relay, (CoMP) Coordinated Multiple Points and heterogeneous network are explained in facet. For the second scenario, the switching off scheme will be introduced as an importance of this part. And for the third scenario, the Multiple-Input Multiple-Output (MIMO) and OFDM:(Orthogonal Frequency Division Multiplexing) to be introduced as the representatives of the Energy-Efficient Radio Technologies. Finally, relied on the technologies introduced above, a prospect forecast of the energy-efficient wireless cellular network is presented.

Yong-Hoon Choi et al.(2015) this paper, attempt to find an adaptive cell zooming method to reduce the energy consumption of base stations. The cell zooming machinery was formulated as an optimization problem with consideration of varying traffic patterns and intervention, as well as the service availability of the whole area. Simulations were then conducted to verify the performance of the suggested cell zooming method. The simulations considered varying traffic conditions, both timely and spatially, in conventional 19-cell configuration. The proposed scheme demonstrated reduction of energy consumption of up to 4.72 times for town environments and 3.78 times for rural environments against traditional static cell operation.

Eunsung Ohet al.(2011) The operation of cellular network infrastructure incurs significant electrical energy consumption. From the viewpoint of cellular network operators, reducing this consumption is not only a matter of showing environmental responsibility, but also of considerably reducing their operational expenditure. We discuss how dynamic operation of cellular base stations, in which unnecessary base stations are switched off during periods of low traffic such as at night, can provide important energy savings. We quantitatively estimate these potential savings through a first-order analysis relied real cellular traffic traces and information regarding base station locations in a part of Manchester, United Kingdom. Author also discuss a number of open issues relevant to implementing such energy- efficient dynamic base station operation schemes, such as various approaches to guarantee coverage, and interoperate coordination.

Ziaul Hasan et al.(2011) this paper gives brief survey of methods to advance the power efficiency of cellular networks, explore some research issues and challenges and propose some techniques to enable an energy efficient or “green” cellular network. Since base stations consume a maximum section of the total energy used in a cellular system, we will first provide a comprehensive survey on strategies to obtain energy savings in base stations. Next, we discuss how heterogeneous network deployment relied on micro, pico and fem to cells can be used to attained this goal. Since cognitive radio and cooperative relaying are undisputed prospect technologies in this regard author suggest a research vision to make these technologies more energy efficient. Lastly, author explains some broader perspectives in realizing a “green” cellular network technology.

Oliver Blume et al.(2007) Due to increasing data traffic rates and rollout of advanced radio transmission technologies wireless networks devour increasing amount of energy and contribute a growing fraction to the CO2 emissions of ICT industry. Thus, climate and cost matter now shift the research focus of wireless communications to energy consumption and energy efficiency. Two techniques can be followed: Incremental improvements of existing systems or a clean slate re-design with a fundamental change of paradigms. Author describes two such initiatives and discusses their differences. The EC FP7 project EARTH is a 30 month project targeting for a reduction of the overall energy consumption of 4G mobile broadband networks by 50%, about network aspects and individual radio components from a holistic point of view. The Green Touch enterprise is a privately financed consortium addressing fundamental research that will pave the way to much higher minimizes for future systems in the order of several magnitudes, with first proof of concepts available in 5 years.

Luis M. Correia et al.(2010) a holistic approach for power efficient mobile radio networks is presented. The matter of having suitable metrics and evaluation methods that allow assessing the energy efficiency of the complete system is discussed. The joint Supplementary saving concepts comprise component, link and network levels. At the component level the power amplifier accompanied by a transceiver and a digital platform supporting advanced power management are key to competent radio implementations. Discontinuous transmissions by base stations, where hardware components are switched off, facilitate energy competent operation at the link level. At the network level, the potential for reducing power consumption is in the outline of networks and their management, that take into account slowly changing daily load patterns, as well as highly active traffic fluctuations. Moreover, research has to analyze new disruptive architectural approaches, terminal-to-terminal communications consisting multi-hop transmission, ad-hoc meshed networks, and cooperative multipoint architectures.

Mahmoud Hadef et al.(2014) In this paper author evaluate an energy-aware relay selection machinery which exploits channel state information and the accessibility of buffers at relays to perform flexible relaying relied on a backpressure-driven optimization model. This mold ensures the maximization of the cell throughput while maintains the constancy of backlog queues. Performance evaluation is implemented using a System Level Simulator (SLS) which is fully compliant with IEEE 802.16m and supports certain relaying scenarios. The Below Roof Top (BRT) relaying scenario is measured in this work. A holistic and stretchy energy framework is implemented to capture the energy consumption of the cellular network nodes. The mold maps the RF output power radiated at the antenna elements of each node including relays on the network to the entire supply power of the node equipment. Two derivatives of the proposed mechanism, half-duplex and full duplex are suggested and evaluated. Results of the two derivatives on BRT relaying scenario revealed noticeable increases of both cell throughput and system energy competence of the cell-edge users compared to the conservative relaying protocol and the non cooperative scheme.

NEHA ROHILLA et al.(2013) Carrier aggregation (CA) is one of the most important technologies to ensure the success of 4G technologies. Carrier aggregation allows both an proficient use of spectrum already deployed and the required support for the resource distribution in new frequency bands. The Release 8 LTE carrier maximum bandwidth is 20 MHz. This bandwidth can be further extensive in LTE-Advanced by carrier aggregation, with which the base stations can transmit multiple LTE carriers, all having bandwidth upto 20 MHz. When no carrier aggregation is used, the user will receive one carrier. When carrier aggregation is used, it is probable to send not only one carrier but multiple carriers to the users, which guides to a higher bit rate. Adding carrier aggregation influences energy efficiency for some modulation schemes. So, the purpose is to study energy efficient LTE system in order to reduce power consumption of the system and to increase the energy efficiency and throughput.

Suhail Najm Shahab et al.(2015) this paper, gives a framework focuses on the Area Energy Efficiency (AEE) estimate of LTE BSs is presented. The parameters affect on the AEE and the coverage area of LTE BS in different scenarios are observed. AEE analysis has been done using a few key performance indicators consisting transmit power, bandwidth, load factor with the assumption of different scenarios (urban, suburban and rural). The simulation results gives that the LTE BSs have better AEE in an urban environment for cell radius less than 750 m evaluate with the suburban and rural environments. Furthermore, it is obvious that there is a strong influence of traffic load, BW and communication power on AEE of LTE network. On the other hand, AEE increases significantly as the BW size increases. Eventually, it has been show that the AEE of LTE macro BS decreases with increasing the percentage of traffic load for all scenarios.

TABLE1:

CLASSIFICATION OF ENERGY EFFICINT TECHNOLOGY OF CELLULAR NETWORK		
CATEGORIES		
Energy efficient Architecture	Energy efficient Resource Management	Energy efficient Radio Technology
NETWORK BASED ON CATEGORIES		
Applications of relay	switching off scheme	Multiple-Input Multiple-Output (MIMO)
Coordinated Multiple Points (COMP)	cell zooming	Orthogonal Frequency Division Multiplexing (OFDM)
Heterogeneous Networks	using of renew-able energy	-
FINDINGS FROM THESE TECHNOLOGIES		
1. The cell zooming and CoMP can be adopted to cover the communication blind district. 2. The OFDM and MIMO should be introduced into the signal transmission due to their better performance of balancing the EE and other criterions such as SE and capacity.		

TABLE 2: ENERGY SAVINGS OBTAINED BY SOME OF THE DISCUSSED TECHNIQUES

Description	Savings
Improvements in Power Amplifier	- up to 50% with Doherty Architecture and GaN-based amplifiers - up to 70% with switch-mode power amplifiers
Network self-organizing techniques	between 20-40% BS power savings
Renewable Energy Resources in off-grid sites	up to 0.35% of global diesel consumption
Dynamic spectrum management	up to 50%

Conclusion

The energy efficiency is serious issue from the viewpoint of cellular network operators in minimizing their operational costs and dropping their energy footprint for environmental reasons. In the context of power efficiency of cellular networks, this paper outlined the labors with respect to energy efficiency in cellular networks. Although cellular networks account for a rather small allocate of energy use, lowering their energy consumption appears beneficial from an reasonable viewpoint. In this regard, the consumption of small, low power base stations, beside conventional sites is often believed to greatly diminish the energy utilization of cellular radio networks. Cell zooming method achieved reduction of the energy utilization by up to 4.72 times for the urban environment and 3.78 times for the rural environment compared to conventional static cell Operation while maintaining adequate throughput and full service coverage. by using renewable power resources such as solar and wind energy in place of diesel generators significantly reduce the power utilization of BSs, in particular, those at the off-grid sites.
Heterogeneous network deployment based on smaller cells such as micro, pico and femto cells is another significant technique that can possibly reduce the power consumption of a cellular network. Introducing a femtocell layer, complementing a macro cell layer is an admirable leap forward in energy efficiency and system performance. LTE-A carrier aggregation and MIMO improves network's energy efficiency.

References

1. Xiaochen Su, Enchang Sun, Meng Li1, F. Richard Yu1, Yanhua Zhang,"A Survey on Energy Efficiency in Cellular Networks",sept.2013.

2. Yong-Hoon Choi, Jungerl Lee, Juhoon Back, Suwon Park, Young-uk Chung, and Hyukjoon Lee,"Energy Efficient Operation of Cellular Network Using On/Off Base Stations", Volume 2015, Article ID 108210.

3. Eunsung Oh and Bhaskar Krishnamachari, Xin Liu,Zhisheng Niu,"Toward Dynamic Energy-Efficient Operation of Cellular Network Infrastructure", June 2011

4. Ziaul Hasan, Vijay K. Bhargava," Green Cellular Networks: A Survey, Some Research Issues and Challenges",sept.2011.

5.Oliver Blume, Dietrich Zeller, Ulrich Barth, "Approaches to Energy Efficient Wireless Access Networks",2007.

6. Luis M. Correia, Dietrich Zeller, Ylva Jading and István Gódor, Gunther Auer, Liesbet Van der Perre," Challenges and Enabling Technologies for Energy Aware Mobile Radio Networks",Nov2010.

7. NEHA ROHILLA & ANIL KAMBOJ," SURVEY OF LTE AND LTE ADVANCED SYSTEM", Vol. 2, Issue 5, May 2014.

8. Mahmoud Hadefy, Apostolos Apostolarasz; Jim O'Reillyy, Alain Mourady,Belkacem Mouhouchey, Iordanis Koutsopoulosz, Thanasis Korakisz and Leandros Tassiulasz,"Energy Aware Buffer Aided Cooperative Relay Selection",2014

9. Suhail Najm Shahab, Ayad Atiyah Abdulkafi, and Ayib Rosdi Zainun,"Assessment of Area Energy Efficiency of LTE Macro Base Stations in Different Environments", 2015