Handbook of Research on Progressive Trends in Wireless Communications and Networking

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A volume in the Advances in Wireless Technologies and Telecommunication (AWTT) Book Series
Chapter 2
Sustainable Growth for Cellular Wireless Networks

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ABSTRACT

It has been widely recognised that the exchange of information is one of the underpinning factors for economic growth in developing and developed nations. One of the fastest growing areas of information transfer is the mobile data sector. In 2012, global mobile data traffic grew by 70%. There is an urgent need to improve the wireless capacity of cellular networks in order to match this growth. One of the key issues faced by mobile operators is the fall in Average Revenue Per User (ARPU) and the growing Operational Expenditure (OPEX) due to capacity growth and rising energy prices. The challenge is therefore how to grow the wireless capacity in a way that minimizes the OPEX and thus improves the ARPU. Furthermore, there is growing focus on the environmental impact of Information and Communication Technology (ICT) sectors. There are tangible, financial, and environmental motivations for reducing the energy expenditure of wireless networks whilst growing its capacity. This chapter examines recent research in the area of future wireless network architectures and deployments. This is done in the context of improving capacity in a sustainable way. That is to say, what is the lowest-cost and -energy method of achieving certain capacity targets? The authors of this chapter were researchers in the world’s first green wireless communications project—Mobile VCE Green Radio (2007-2012).

1. INTRODUCTION

It has been widely recognised that the exchange of information is one of the underpinning factors for economic growth in developing and developed nations. One of the fastest growing areas of information transfer is the mobile data sector. In 2012, the global traffic for mobile data alone grew by 70%, most of the content being video based. One of the fastest emerging growing data transmissions is machine-2-machine (M2M) communications. There is therefore an urgent need to improve the

DOI: 10.4018/978-1-4666-5170-8.ch002
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wireless capacity of cellular networks in order to match this growth in data demand.

One of the key issues faced by mobile operators is the fall in average revenue per user (ARPU) and the growing operational expenditure (OPEX) due to capacity growth and rising energy prices. The challenge is therefore how to grow the wireless capacity in a way that minimises the OPEX, and thus improves the ARPU. Furthermore, there is growing focus on the environmental impact of information and communication technologies (ICT) sectors. There are tangible financial and environmental motivations for reducing the energy expenditure of wireless networks, whilst growing its capacity (Fehske, Fettweis, Malmodin, & Biczok, 2011).

This chapter will examine recent research in the area of future wireless network architectures and deployments. This is done in the context of improving capacity in a sustainable way. That is to say, what is the lowest cost and energy method of achieving certain capacity targets? The authors of this book chapter were researchers in the world’s first green wireless communications project Mobile VCE Green Radio (2007-2012) (“Mobile Virtual Centre of Excellence (VCE) - Green Radio Programme,” n.d.).

Currently, the energy story as shown in Figure 1 is as follows:

- 0.5% of the world’s total energy is consumed by wireless communications, equivalent to 650 TWh of energy per year (35 2000 MW power plants).
- Over 90% of this energy is consumed in the outdoor cellular network, of which 75% is consumed by base-stations.

In terms of digital connectivity, approximately 70% of the developed world and less than 20% of the developing world is digitally connected (Rinaldi & Veca, 2007). Yet, the volume of data communication has increased by more than a factor of 10 over the past 5 years. To foster economic growth and reduce the wealth and knowledge gap: a low energy solution that can increase connectivity and meet the growing data demand must be found.

The chapter will be organised to follow a logical research methodology of proposing metrics for measurement, models for characterization, and technologies as hypothesis to be tested. They are as follows:

1. **Background**: Of cellular network challenges and deployment evolution directions
2. **Metrics**: For measuring average capacity quality-of-service (QoS), energy expenditure, operational cost Expenditure of a multi-cell radio-access-network (RAN).

Theoretical bounds for maximum energy

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Figure 1. Energy consumption of a) ICT and b) Wireless communications as of 2008-2010. A single UK cellular network typically consumes 40MW. c) operational expenditure (OPEX) of typical 3G cellular network.
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REFERENCES


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**KEY TERMS AND DEFINITION**

**4G**: In telecommunication systems, 4G is the fourth generation of mobile phone and mobile communication technology standards.

**Cellular Network**: A radio network distributed over land areas called cells, each served by at least one fixed-location transceiver, known as a cell site or base station.

**Femtocell**: In telecommunications, a femtocell is a small, low-power cellular base station, typically designed for use in a home or small business.

**Heterogeneous Network**: A network connecting computers and other devices with different operating systems and/or protocols.

**LTE**: Long Term Evolution, marketed as 4G LTE, is a standard for wireless communication of high-speed data for mobile phones and data terminals.

**Monte-Carlo**: Monte-Carlo methods are computational algorithms that rely on repeated random sampling to obtain numerical results; i.e., by running simulations many times over in order to calculate those same probabilities heuristically just like actually playing and recording your results in a real casino situation.

**Network Capacity**: The tightest upper bound on the rate of information bits that can be reliably transmitted within the network.
Power Consumption: Energy consumption that uses electric energy.

QoS: The quality of service ("QoS") refers to the networks that allow the transport of traffic with special requirements.

Relay: A station that relays messages between various points, so as to facilitate communications between units.

Sleep Mode: A low power mode.

Spectral Efficiency: The information rate that can be transmitted over a given bandwidth in a specific communication system.

Stochastic Geometry: The study of random spatial patterns with an emphasis on spatial point processes in this chapter.