# Chapter 1
# Technical Challenges in 4G Cognitive Femtocell Systems

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## ABSTRACT

*This chapter studies the application of femtocells as part of the future cognitive 4G networks. It starts with a demonstration for the evolution of cellular and wireless networks. The developing technology that leads towards a converged LTE-Femtocell wireless environment is described in detail. The chapter presents the key challenges of deploying cognitive femtocell in the macrocell networks. As spectrum utilisation management is the main concern in the future network, the main models for spectrum allocation used to provide enough bandwidth to the femtocell in coexistence with the LTE systems are incorporated for further investigation. In addition, the Quality of Service (QoS) provisioning and the main approaches for measuring end user performance are given as function small range transmission domains. The requirement of an effective mobility management solution in such systems is analysed for future development. The chapter is concluded with a summary.*

## INTRODUCTION

The evolving fourth generation (4G) mobile communication systems are expected to solve still-remaining problems of third generation (3G) systems and to provide a wide variety of new services, from high-quality voice to high-definition video to high-data-rate wireless channels. The term 4G is used broadly to include several types of broadband wireless access communication systems, not only cellular telephone systems. 4G is intended to provide high speed, high capacity, low cost per bit, IP based services. 4G is all about an integrated, global network that's based on an open system approach (Govil, 2007). With the successful deployment of 3G cellular networks worldwide, the attention of the cellular industry is now focused on the beyond-3G evolution of the wireless cellular network. The upcoming 4G mobile communications system is foreseeing

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potentially a smooth merger of these technologies with a goal to support cost effective seamless communication at high data rate supported with global roaming and user customized personal services. The evolution of the cellular systems has come through three generations over the past 40 years (Raj & Gagneja, 2012).

There are three different potential approaches in developing the future 4G networks. Firstly is to increase the cell capacity using new techniques such as Long Term Evolution (LTE), which is replacing the Microwave Access (WiMAX) backbone stations. Secondly, is to improve the spectral efficiencies using reconfigurable technologies such as the Cognitive Radio (CR) and advanced antenna systems. The third approach is to develop new architectures for mobile networks that help to achieve an autonomous communications. A combination of these technologies and arrangements, if not all three, will lead to the new generation of efficient 4G networks that can be deployed to deal with huge traffic requirements and various corresponding technologies. Figure 1 illustrates the various given solutions for future standardization of 4G systems.

The future networks employ an IP-based environment for all traffic requests counting voice, video, broadcasting media and Internet that can access landline and wireless networks. This is integrated in the future 4G solutions and its applications. Together with intelligent terminals, 4G can provide easy access to the broadband services and understanding of the personal downloading profiles. This allows uninterrupted coverage for a user that change terminals or switch unnoticeably between the underlying fixed and mobile networks (UMTS, WLAN, etc.). This is very important for ad-hoc networking and for a mobile user that travels among different terminals of a single network or with the terminals of third parties. In short, a 4G network provide its individual users with full control over privacy and costs. This is a natural extension of the current technologies of broadband Internet and 3G mobile networks like UMTS.

This chapter addresses the key technical challenges encountering suitable femtocell system deployment management. There are so many requirements for keeping femtocell costs as low as possible for effectively competing against the ubiquitous Wi-Fi technology. The main challenge for the femtocell deployments is the interference with the macrocell base station. Other femtocell functions are addressed, including resource management, spectrum allocation management, providing QoS over an Internet backhaul and allowing access to femtocells (Chandrasekhar, Andrews, & Gatherer, 2008). Handover and mobility also very important aspect in femtocell networks, as there are different types in femtocell handover from/to macrocell. Furthermore, power consumption is very important consideration to be taken into account in the next generation wireless networks.

*Figure 1. Future 4G cognitive systems with different corresponding technologies*