Preface

Nowadays, mobile operator's principal thinking is to save the cost by reducing the macro cell traffic load and offloading it over public broadband connections to the core network. Potentially this technology reduces the cost and complexity of having to deploy higher-capacity links to the macrocell. The femtocell extends network coverage and delivers high-quality mobile services inside residential and business buildings with the better cellular network coverage, and has triggered the design and development of new structured cellular standards such as WiMAX (802.16e), the Third Generation Partnership Project's (3GPP's) High Speed Packet Access (HSPA) and LTE standards, and 3GPP2's EVDO and UMB standards.

Currently, Femtocell technology emerged for cellular wireless networks, which has rapidly engrossed cellular industry. The principle of femtocell to the mobile operators is to reduce cost and improve signal quality in indoor coverage which is also considered a possible path to the Fixed–Mobile Convergence (FMC) goal. Femtocell extends network coverage and delivers high-quality mobile services inside residential and business buildings through broadband network i.e. ADSL. Femtocell Access Point (FAP) or Home Base Station (HBS) intends to serve small number of users i.e. 4 users and covers about 30 meter square similar to existing WiFi access points.

Femtocell is receiving special attention in mobile wireless market as a solution to main user and operator pain points, cost and coverage. In that context, femtocell technology is gaining scores of attentions as a cheap yet possible technique of accomplishing high spectral efficiency. Femtocell is currently the most promising technology that would support increasing demand of data traffic in wireless networks. Femtocells present a innovative opportunity to enable innovative mobile applications and services in in-door based environments such as homes and offices.

ABOUT THIS BOOK

Due to huge number of possible target femtocell devices that will be deployed without the operator control; femtocell may introduce many new challenges to the telecom industries in terms of handoff between femto and macrocells, interference management, localization and synchronization. For example synchronization can be a problematic issue in femtocell due to the fact that all the data and control traffics travel through IP broadband network. The IP broadband network is usually owned and managed by third party and not by the mobile operator, which is complicated the synchronization. Unsynchronized FAPs may cause harm interferences and wrong handover dictions.

This book represents an extensive and thoroughly revised version of a collection of review and research based chapters on femtocell technology. The focus is on the mobility and security in femtocell, cognitive femtocell, and standardization and deployment scenarios. Several crucial importances are addressed in the book such as interference mitigation techniques, network integration option, cognitive optimization as well as economic incentives to install femtocells that may have larger impact on the success of femtocells. The book is optimized for use of graduate researchers who are familiar with basic of wireless communication and cellular concepts. The key idea is to compose a synopsis of the major achievements and developments in femtocell technology field and show the most promising challenges that remain in femtocell. In fact, the book is organized to cover several areas of research in femtocell and is sectored as:

SECTION 1

Consists of three chapters: **Chapter 1** gives an introduction to femtocell concepts like cellular theory and system architecture. In this chapter an extensive overview of femtocell and its opportunities for grow and challenges may face operators are discussed. Some of the industry practices for femtocell deployment and issues like femtocell markets, products, and applications are reviewed and described the technology aspect as well as technical challenges the face worldwide deployment of femtocell.

Chapter 2 covers the worldwide standardizations of femtocell, which is provides the reader with an understanding of how the standards bodies responsible for the principal 3G and 4G technologies addressed the distinct challenges of incorporating femtocells into their respective network architectures. The chapter covers standardization activities in 3GPP, 3GPP2 and the WiMAX Forum, as well as related activity in the Broadband Forum (BBF) and Femto Forum. Common challenges introduced by femtocell technology are identified, as well as the reasons for pursuing standardized solutions and why the various standards bodies diverged in their approaches. A brief overview of each group is given (e.g., the Technical Specification Groups and/or Working Groups in which femtocell-related discussions take place). This is followed by detailed review of the femtocell architecture devised for each radio access technology, including the network elements, interfaces and protocols that were created or revised to support femtocells, and a summary of the femtocell-related documents published by each group. Finally, brief descriptions of the supporting role played by both the BBF and Femto Forum are given.

Chapter 3 provides an extensive technical comparison between Femtocells and WiFi in terms of architecture, operation and standards. This chapter gives a future expectation and forecasting about the possibilities of the effect of femtocell as disruptive technology for WiFi. The Fixed Mobile Convergence (FMC) is also discussed, whereas shown that the femtocell is one of the big initiatives that industry took toward FMC. Where femtocell is a wireless communication device that is work as a cellular system (i.e. WiMAX, 3GPP, and 3GPP2) while it connects to the cellular through broadband connection i.e. xDSL, dial-up. In the other hand to connect WiFi to cellular system we need to introduce new gateway system that convert the traffic from WiFi to cellular and vice versa.

SECTION 2

This section covers aspects of LTE Femtocells and the associated propagation and interference issues. This section focuses on optimized power control techniques for interference mitigation. It also discusses cognitive femtocell networks and shows robust solutions of spectrum handover in cognitive femtocell as well as multiple frequency offsets compensation in OFDMA femtocells. It consists of five chapters that cover the interference issues and cognitive optimization of femtocell technology.

Chapter 4 presents LTE femtocells with emphasis on propagation and interference Issues, which the possible cellular network architectures, including macro and femto cells, and the consequent impairments due to their coexistence are discussed. For femtocells based on Long Term Evolution (LTE) technology, the latest evolution of 3GPP standards and the most attractive mobile market for their application are analyzed. Furthermore, in addition to the state of the art of femtocell architectures, an alternative solution, based on an "enhanced femtocell" integrated into a cabled distribution network (for example condominium infrastructure), is taken into account in extremely critical applications, where the indoor or building nearby outdoor areas suffer a poor radio coverage from macrocell base stations. This chapter is mainly focuses on the implementation of LTE, and the corresponding femtocells, in the "Spectrum Digital Dividend" frequency band (790-862 MHz), which is the band that released after the digital TV deployed in U.S.

Chapter 5 discusses the interference mitigation in femtocell scenarios using optimized power control, where an interference enhancement for OFDMA systems is developed and designed for two tiers macro-femtocell networks. First, the chapter focuses on understanding the concept of femtocells system, to distinguish between different types of interferences to Femtocell Base Station (FBS), to investigate the different types of power control schemes and to introduce an optimized power control scheme for interference mitigation in femto-cellular. An adaptive power control is calculated by selecting the minimum interference channel with the optimized channel gain. A simulation environment is also conducted based on Matlab, where a number of the FAPs, the distance between the macrocell and the femtocell and the path loss between the macrocell node and the FAPs are used as a design parameters. By using optimized power control performance enhancement in the interference degradation ratio can be observed.

Chapter 6, this chapter proposes novel spectrum handover solutions to improve the spectrum efficiency by suggesting different transmission strategies that can avoid unwanted spectrum handover. The main goal is to optimize the cognitive femtocell spectrum handover scheme to improve the spectrum utilization, where new Cognitive Femtocell Switching Unit (CFSU) is proposed to support handover management for 10-20 cognitive femtocells as a local geographical cluster. Then, CFSU described to acts as a service coordinator between femtocells and macrocell areas to improve spectrum utilization and coexistence. Then, presents solutions for spectrum handover to achieve guaranteed quality of radio service, spectrum utilization and enable an excellent local handover management to reduce unnecessary handovers between femtocell base stations and increase the overall femtocell network performance. The challenges and solutions that are presented in this chapter have the ability to maintain services by evaluating the requested quality of services.

Chapter 7, this chapter aims to introduce the concept of cognitive femtocell networks and examine how the cognitive capabilities can enhance the femtocell networks. The concept of CR-Capable Femtocell Access Points (CFAP) is discussed where CFAP can analyze, adapt to and learn from the operating RF environment. The propose CFAP discovers the spectral opportunities by applying various sensing policies. To this aim, it provides the basics of cognitive radio with an emphasis on capacity improvement via spectrum sensing. In addition, this chapter introduces cognitive femtocell network architecture and lists the improvements of such architecture over the conventional femtocell networks. Since it is a new research area, there is very little amount of researches on this topic. A survey of these previous works is provided in this chapter and the alternative definitions of cognitive femtocell concept in these works are discussed. In the last part, open research directions that are fundamental for the realization of the cognitive femtocell networks are outlined.

SECTION 3

Consists of three chapters that describe the security and mobility aspects of femtocell networks, handover procedures in femtocells, and femtocell network synchronization.

Chapter 8, in this chapter the security and mobility aspects of the femtocell networks is discussed. By nature femtocells are very much prone to attacks. The backhaul between access point and the core network is vulnerable to threats are discussed. The connectivity between FAP and core network has a high risk of being compromised. In general, the chapter investigates few secure mobility management protocols such as HIP, MOBIKE, PMIPv6, HIP and the advantage over IP/Locator separation is emphasized. Furthermore, overviews of these protocols, message exchanges and the security concerns are discussed in this chapter. How Host Identity Protocol (HIP) can be adapted in femtocell technology to improve security and mobility issues is also presented. Several enhancements to the femtocell security discussed, such as strong authentication, service registration, identity verification and node multihoming. In addition, Encapsulating Security Payload (ESP) is used to provide confidentiality, data origin authentication, connectionless integrity, anti-replay service and limited traffic flow confidentiality. Furthermore, enhanced mobility support by means of locator/identity separation and node multihoming is discussed in the scope of 3GPP femtocells.

Chapter 9, this chapter gives an overview on issues related to the handover procedure in networks with femtocells and focuses on a mobility management and problems closely related to a handover procedure. The main challenge is to guarantee efficient handover between femtocells. It means to ensure minimum signaling overhead due to unnecessary handovers, to minimize handover interruption, and to mitigate interference caused by elimination of redundant handovers. The basic principle of handover is explained together with the main challenges concerning handover in scenario with deployed femtocells. Furthermore, individual issues are described in detail and possible ways how to solve them are contemplated. The chapter does not stick to any specific standard; however it is focused on the general principles and problems of the handover procedure from the femtocell's point of view. Further, efficient creation and maintenance of NCL and proper assignment of Physical Cell Identifier (PCI) to individual FAPs are discussed in this chapter even if both are not directly connected to the handover procedure.

Chapter 10, Femtocell introduces new challenges to the telecom industries in terms synchronization. The problematic issue in femtocell synchronization is that all the data and control traffics travel through IP broadband network. The IP broadband network is usually owned and managed by a third party and not by the mobile operator who can complicate the synchronization. Unsynchronized FAPs may cause harmful interferences and wrong handover dictions. In this chapter, overviews of the current femtocell synchronization techniques are discussed. Possible improvements and recommendation for each method have been identified. Future research areas and open issues were also discussed. A number of solutions are evaluated for femtocell synchronization, such as, timing and location, GPS, cell tower signal and network timing.

SECTION 4

Consists of two chapters covering the deployment and application of femtocell including game theory and femtocell communications for making network deployment feasible. It concludes with a case study of emergency telemedicine public safety communications based on femtocell.

Chapter 11, this chapter looks at the strategic interaction between the macrocell and underlaid femtocells from a game theoretic perspective. Different game theoretic formulations were investigated along with different information assumption. The chapter shows that the deployment of femtocell networks is cast into a dynamic spectrum sharing problem with different interference scenarios such as femtocell-to-femtocell and femtocell-to-macrocell interference. The chapter discussed one of the most important issues in self organized networks, namely learning. Learning is an inherent part of self-organization paradigms and is crucial for developing and adapting multi-agent strategies based on their perceived reward. The problem boils down as to how femtocells gradually learn from their environment (through trials-and-errors) while at the same time not interfering with the overlay macrocell network.

Furthermore, all possible interference scenarios related to femtocell communications coexisting with one overlay macrocell network are outlined.

Chapter 12, this chapter is about femtocells communications for Public Safety applications, which is emphasis on the emergency telemedicine as a case Study. The chapter reviewed the added value of utilizing femtocells for various public safety communications scenarios. To that end, a detailed case study on the exploitation of femtocellular resources for emergency telemedicine applications is presented as an illustrative example. Simulations for an LTE network environment is carried out where it demonstrates significant improvements in terms of achievable throughput for the emergency response personnel when access to subscriber-owned residential LTE Home eNode BS. Furthermore the chapter analyzes how residential femtocells deployed autonomously by subscribers could be leveraged to support rich multimedia communications for PSC use case scenarios, with a particular focus on authority-to-authority communications.