Chapter 10
Femtocell Network Synchronization

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ABSTRACT

Presently, femtocell technology is emerging for cellular wireless networks, which have rapidly engrossed the cellular industry. The main advantage of femtocell to the mobile operators is a reduction of cost and an improvement of the 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 networks (i.e. ADSL). Femtocell Access Points (FAP) or Home Base Stations (HBS) are intended to serve small number of users (i.e. 4 users) and cover about 30-square meters, similar to existing WiFi access points. However, femtocell introduces new challenges to the telecom industries in terms of handoff between femto and microcells, interference management, localization, and synchronization. Among all of these challenges, synchronization is considered as the cornerstone for the femtocells to function properly. The problematic issue in femtocell synchronization is that all the data and control traffic travels through an IP broadband network. The IP broadband network is usually owned and managed by a third party and not by the mobile operator which can complicate the synchronization. Unsynchronized FAPs may cause harmful interference and wrong handover dictions. In this chapter, the authors investigate and overview the current femtocell synchronization techniques and make comparisons between them. Possible improvements and recommendations for each method have been identified. Future research areas and open issues are also discussed.

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INTRODUCTION

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. Femtocell extends the network coverage and delivers high-quality mobile services inside residential and business buildings with a better cellular network coverage, and has since 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. The communication link of the femtocell may be one of Wide Area Network (WAN) technologies, such as, Asymmetric Digital Subscriber Line (ADSL) (WiMAX Forum, 2006), (Andersson et al, 2002). Since a public network is used to establish the connectivity between femtocell and core network elements, however, these present a set of problems for operators. Due to a huge number of possible target femtocell candidates for macrocell to femtocell handover, this situation needs a large neighbor list and communication with many femtocells for the pre-handover procedure. Femtocell architecture is much more different than the existing cellular networks.

Femtocells, similar to any other cellular technology, require synchronization. Usually, three types of synchronization may be required, namely, frequency, time and phase. For instance, for the UMTS 3G/HSPA FDD type of deployments, a frequency type of synchronization is required.

To define the Network architecture and application requirements, the synchronization will consider the following:

1. The IPSec links are used in public networks which can degrade the transport of synchronization message and its performance. With the intention of reducing the impact of security issue in public networks, it is possible to leave some of the synchronization messages unprotected. Prudence should be used on the use of the IPSec and synchronization performance.
2. Synchronization messages traversing the Network Address Translation (NAT) functions need to be considered in order to guarantee a proper connectivity between the Clock Server and femtocell.
3. Scalability features for a large number of femtocells, bandwidth consumption and the placement of clock servers are important as the network architecture is developed.
4. Employment of multicast technologies currently being developed may present opportunities to reduce the bandwidth consumption of synchronization messages and to considerably increase the number of femtocells a server can support.
5. Features of using multicast and IPSec.
6. Aspects involving the QoS treatment and traffic management of synchronization messages.

The absence of time synchronization among femtocells motivates the generation of the interference due to the uplink or downlink transmissions. Considering the adoption of distributed techniques for the time synchronization at frame level, there is need to evaluate how the synchronization is related with the generated interfering power. When a Base Station (BS) operates with Time Division Duplex mode (TDD), a synchronization of the transmission time at the BS is important to so as avoid inter-slot interference with adjacent BSs. Since femto BSs are generally located indoor, they may not receive the Global Positioning System (GPS) signal which is used to synchronize the wireless cellular network. Today, it is strongly considered as a practical solution which is required to secure both the seamless indoor coverage and the high network capacity. The emerging IMT-advanced