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A Review on Femtocell Technology with Cellular Network

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ABSTRACT-- *Femtocells, despite their name, pose a potentially large disruption to the carefully planned cellular networks that now connect a majority of the planet's citizens to the Internet and with each other. Femtocells – which by the end of 2010 already outnumbered traditional base stations and at the time of publication are being deployed at a rate of about five million a year – both enhance and interfere with this network in ways that are not yet well understood. In this paper will femtocells be crucial for offloading data and video from the creaking traditional network? Or will femtocells prove more trouble than they are worth, undermining decades of careful base station deployment with unpredictable interference while delivering only limited gains? Or possibly neither: are femtocells just a "flash in the pan"; an exciting but short-lived stage of network evolution that will be rendered obsolete by improved Wifi offloading, new backhaul regulations and/or pricing, or other unforeseen technological developments? This paper overviews the history of femtocells, demystifies their key aspects, and provides a preview of the next few years, which the authors believe will see a rapid acceleration towards small cell technology. This paper reports, we also position and introduce the articles that headline this special issue.*

Keywords— Femtocell, Cellular network, Mobile sensing, Interference with Femtocell, Microcell.

1. INTRODUCTION

The "femto" in femtocell means 10-15. Femtocell acquired the name because they are much smaller than the standard Macrocell cellular to wrens each of Femtocells works with the major wireless telecommunications standard and connects users with cellular provider via broadband Internet links. Mobile cellular and 3G networks normally suffer from poor penetration and reception in certain areas, like indoors. This decreases the quality of voice and video communication and slows down high-speed services.

A femtocell is a small device that is used to improve wireless coverage over a small area, mostly indoor. It is a small cellular base station, also called a wireless access point that connects to a broadband Internet connection and broadcasts it into radio waves in its area of coverage. As a result, mobile handsets can handle phone calls through the femtocell, via the broadband Internet connection. The name femtocell has the prefix 'femto', meaning a very small cell (area of

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network coverage). Small is rather a big word here, because femto denotes a division that is mathematically represented by 10 raised to the power of -15

1.1 Introduction to Femtocell cellular networks

A femtocell (FC) is a simple low-power low-cost base station installed at the user's premises that provides local access to the network by means of some cellular technology (2G, 3G, 4G) .A FC has an IP backhaul connection with the main core of the network through the local broadband access the user already has, being DSL, cable or fiber the most common situations. It is envisioned that in a short term basis, users will start installing their own femtocells in their apartments, offices, etc , and ABI Research predicts 102 million FC users worldwide with over 32million FC base stations deployed by 2012 . It is interesting to note that this represents an estimate of 3 to 4 users per femtocell. Not much bigger or different than the widely used wifi access points, these femtocells are designed with a target cost of about 200$, so they can be afforded by the majority and, therefore, a wide deployment is possible.

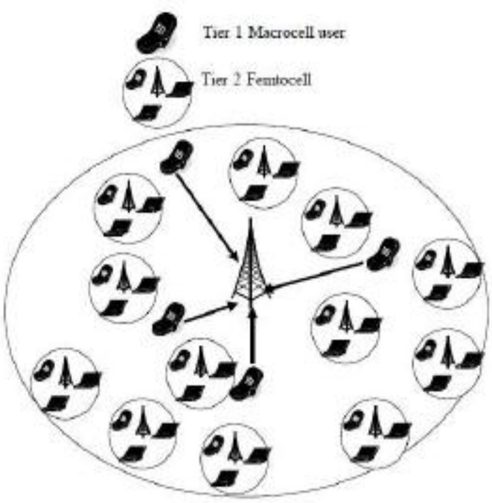

Figure: Network architecture of a cellular deployment with femtocells

2. LITERATURE SURVEY

Following are the terminologies needed to be discussed referring to Femtocell Technology

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2.1 Early Origins

Initially, “small cells” was a term used to describe the cell size in a metropolitan area, where a macro cell (on the order of kilo meters in diameter) would be cell split into a number of smaller cells with reduced transmit power, known today as metropolitan microcells or microcells, and having a radius of perhaps several hundred meters. Simultaneously, cellular repeaters or “boosters” were being in vest gated as an alternative to small base stations. These re-radiating devices were intended to help improve the signal quality in poor coverage regions, while reducing costs by not requiring a wire line backhaul. However, their reuse of the licensed spectrum for backhaul limited the achievable throughput, and hence these repeaters were neither helpful to the system capacity nor simple to deploy. In the 1990s, a precursor to cellular picocells began to appear with cell sizes ranging from tens to about one hundred meters.

2.2 The Birth of Modern Femtocells

New thinking on the deployment and configuration of cellular systems began to address the operational and cost aspects of small cell deployment. These ideas have been applied successfully to residential Femtocells where cost issues are amplified. A femtocell is fundamentally different from the traditional small cells in their need to be more autonomous and self-adaptive. Additionally, the backhaul interface back to the cellular network – which is IP-based and likely supports a lower rate and higher latency than the standard X2 interface connecting macro and picocells – mandates the use of femtocell gateways and other new network infrastructure to appropriately route and serve the traffic to and from what will soon be millions of new base stations. Perhaps more important than the need to provide cellular coverage infill for residential use, the mobile data explosion discussed in the Section I has mandated the need for a new cellular architecture with at least an order of magnitude more capacity.

2.3 Modern Femtocell Research

There is a growing body of research on femtocells, of which we briefly summarize some notable early results here. ANDREWSet al.: FEMTOCELLS: PAST, PRESENT, AND FUTURE 499 Early simulation results for femtocells were presented by H.Claussen and co-authors at Bell Labs (UK) which were extended to self-optimization strategies and multiple antennas shortly afterward. On the academic side, early work included new mathematical models and analysis by Chandrasekhar and Andrews, specifically looking at the uplink interference problem in CDMA-based networks with closed access.

This model and approach was adapted to the downlink and with multiple antennas. Other early work from UCLA suggested adaptive access control to mitigate the cross-tier interference problem, which was given further attention in Das and Ramaswamy in investigated the reverse link (RL) capacity of femtocells, modeling inter-cell interference as a Gaussian random variable.

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This work was extended in which developed new analytical techniques to improve the optimization for WCDMA femtocell systems. Several papers have also considered interference coordination in OFDMA based networks, including co-channel interference management.

3. MOTIVATION

3.1 Interference in Femtocell deployments

This approach is followed throughout this project for the actual subcarrier allocation at each MC and FC. The complexity of the interference problem increases drastically and new strategies have to be designed. One encounters three extra degrees of complexity in the interference problem. Focusing on the Uplink, there is interference generated by the MC users in the nearby of a femtocell (macro cell to femtocell interference, Figure a), by FC users within a femtocell located in the vicinity of the MC base station (femtocell to macro cell interference, Figure b) and by FC users transmitting in the nearby of other femtocells (femtocell to femtocell interference)

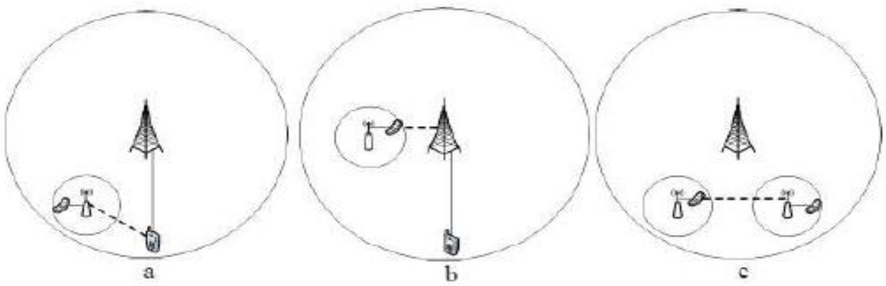

Figure (a) MC user to FC interference, (b) FC user to MC interference, (c) FC to FC Interference

States that, in order to guarantee close to 100 percent coverage, elaborated further Interference strategies have to be applied. Fractional frequency reuse (FFR) is mentioned as a possible solution, but good synchronization is essential for its implementation, and as already mentioned, that is not always possible when dealing with femtocells

4. IMPLEMENTATION STEPS

4.1 Mobile sensing applied to Femtocell networks

In this section I proceed to propose some algorithms and strategies in which a network provider could take advantage of the large amount of “voluntary” sensors that can be used to to synchronize Femtocell networks and to mitigate the interference in this kind of two-tier deployments.

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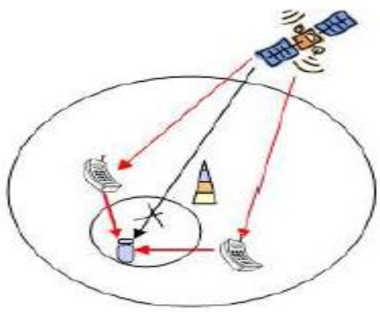

Figure: Femtocell 2-D location via mobile sensing

4.2 Femtocell coverage control

A FC, as already described, is a low-power low-range base station that the user installs in the premises to provide wireless coverage to shadow areas or simply to increase the Qos or reduce its cost. It is important to highlight that FCs emit in licensed spectrum, therefore a very strict protocol has to be implemented to make sure that a given FC radiates only in a geographical area where the network provider owns the spectrum. Some of the currently available access points, such as AT&T's 3G Microcell, are equipped with a GPS receiver. This way, the system ensures that it's radiating in an authorized area. Despite being this the simplest way to enforce the spectrum, it has clear drawbacks.

As it is well known, locking a GPS signal is rather challenging when located indoors, so this forces the user to place the femtocell next to a window, for example. And there it might still be challenging to acquire the signal. I propose a simple algorithm that would mitigate this problem and very likely completely solve it.

4.3 Femtocell synchronization

Expanding the last approach, one can envision further applications to gathering the location and GPS signal from a diverse group of mobile sensors or smart phones in the vicinity of the FC.As opposed to European GSM-based protocols, the TDMA wireless networks in the US territory perform the synchronization of the base stations by means of GPS signals. This allows a very accurate timing acquisition of the system's clock under which the whole network functions. Femtocells, despite being low-power access points in the user's premises, are still a small scale of a regular MC base station, so they require very accurate synchronization.

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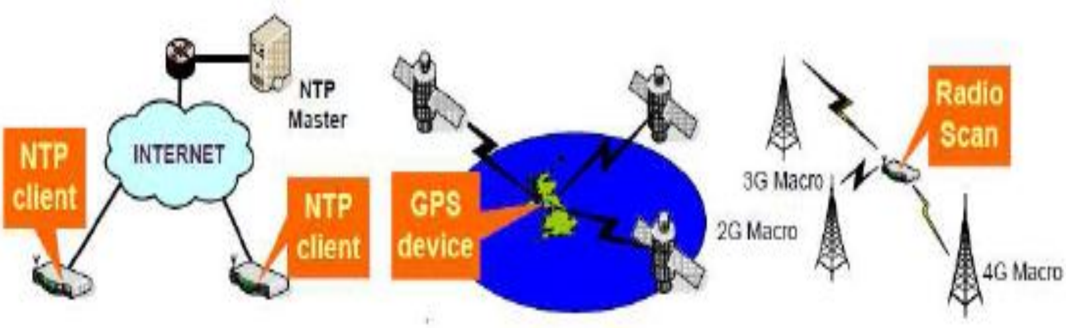

Figure 5.1.3: Femtocell current synchronization solutions

4.4 Frequency allocation in OFDMA-based access networks

Despite not being much work done in subcarrier allocation for OFDMA-based femtocells networks, it is very important to note that most of the literature assumes that the spectrum is divided in two segments so macro cells and FCs do not share any frequencies. This is, given the set of possible subcarriers to be used, a portion of them is allocated for MC users and the rest is allocated to FC users. In the spectrum division is optimized to maximize the Area Spectral Efficiency subject to a certain QoS with respect of the parameter ρ. This parameter represents the ratio between the number of subcarriers allocated for FC users and the total number of available subcarriers.

Spectrum splitting allocation strategies achieve good results and mitigate interference levels but their main drawback is that they present very low spectral efficiency. In this work we present a simple interference mitigation strategy that performs a reuse of the spectrum access points.

5. BENIFITES

This technology provides the better coverage of network which mostly used in networking and makes them perfect of their scale. Femtocell has the higher capacity to organize the cellular network and handle the network. In the form of mobile communication the femtocells technology mostly work for such an environment for producing the lower transmission power and has to be good quality. For the actual handset type the network must be provide the prolong handset battery life. For the mobile user the Femtocell network provide the range anywhere for the mobile calling.

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6. CONCLUSION

In this paper the introduction on femtocell cellular networks and Location-Based Mobile Sensing, an analysis of the Uplink interference and synchronization problems for OFDMA-based femtocells networks is performed in this project. Interference and lack of synchronization are shown to be two of the main issues to address in two-tier wireless networks due to three extra degrees of complexity in the problem. The concept of the femtocells clears the good coverage of network and provide facility appropriate task of particular cells. Also with limited range of femtocells provide good communication without any loss of information.

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