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Femtocells: Technology of the Future

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Abstract: As the wireless technology and standards continue to evolve, wireless communication systems and standards promise to support an even higher number of mobile users, new applications, higher data rates, better coverage and more stringent quality of service (QoS) standards. Users need to be provided with high data rates and reliable service irrespective of their mobility or location. Therefore, to meet the greater demand with limited resources is becoming an important problem. In a network with nomadic users, this inevitably involves deploying more infrastructure, typically in the form of microcells,hot spots, distributed antennas, or relays.

Another concept that has gained considerable attention is that of femtocells. It is an emerging wireless access point that can improve indoor coverage as well as reduce bandwidth load in the macrocell network.

In this article, we present the description of the femtocells and the technical challenges faced in their deployment.

Keywords: Omni-directional antenna, Femtocell access point, Macro base station, Co-tier interference, Cross-tier interference, Handover

I. INTRODUCTION

Traditional cellular networks are designed to provide voice and data services of comparatively low bandwidth over wide areas, using 2G and 3G base stations placed outdoor. However, with time, we have observed that large cell dispositions give assistance to thousands of users, all jostling for dissension of the approachable network resources, does not meet our requirements for the current mobile communication framework any longer.

Before the femtocell, Picocell was the ultimate solution for indoor coverage. The coverage area of picocells usually ranges between 75 meter and 150 meter. The picocells consist of Omni-directional low-transmission antennas providing significant indoor coverage to the UEs in the public places such as airports, railway stations, stadiums, and shopping malls [6]. DASs comprise of several separate Antenna Elements (AEs) and /or Remote Radio head connecting to Macro Base Stations (MBSs) via dedicated Radio frequency (RF) links or fiber optics cables to extend the macro coverage. Equivalently to picocells, relay nodes are also put to use to enhance coverage in the indoor domains (e.g., events, exhibitions, tunnels, and high-speed trains, etc.). However, relay nodes backhaul their data traffic via wireless link to a donor cell.

A comparison of the different technologies [7] for indoor coverage is summarized in Table 1 below.

TABLE 1.Comparison of Various Indoor Wireless Access Technologies

Specifications	Femtocell	Picocell	DAS	Relay	Wi-Fi
Spectrum type	Licensed	licensed	licensed	Licensed	Unlicensed
Typical power	10–100 mW	250mW–2W (out) < 100 mW (indoor)		250mW–2W (out), < 100 mW (indoor)	100–200 mW
Power control	Support	Support	Support	Support	Not support
Coverage range	20–50 m	150 m	Macro coverage extension	Macro coverage extension	100–200 m
Services	Voice and data	Voice and data	Voice and data	Voice and data	Data and VOIP
Handset device	All ordinary devices	All ordinary devices	All ordinary devices	All ordinary devices	Dual mode devices
Working environment	Indoor (home/office)	Outdoor/indoor (hot spot/office)	Indoor extension	Hot spot/office /tunnel, high speed train	Indoor/outdoor home/ hot spot
Backhaul	DSL/cable/ Optical fiber	X2 interface	Optical fiber or RF links to macrocell	Wireless in-band or out-of-band	DSL/cable/ optical fiber
Access methods	Closed/open/hybrid	Open access	Open access	Open access	Closed/open
Security	Robust	Robust	Robust	Medium	Fades
Installation	By consumer	Operator	Operator	Operator	Consumer
Data rate peak	LTE-Advanced (3GPP R10): 1G b/s (DL) 300M b/s(UL)				600 Mb/s (802.11n)

The femtocell is a wireless approach, consisting of small base stations which will be deployed in homes or small buildings to boost indoor cellular coverage.

In a femtocell, the FAP working as a Base Station (BS) is of much importance. Both the FAP and Wi-Fi access point have similarities but have difference as well, both uses internet as a backhaul network and thus the QoS mainly depends on the backhaul. However, the FAP implements cellular technology while Wi- Fi is WLAN and mainly used for data services [8]. Table 2 shows the main difference between femtocells and Wi-Fi.

TABLE 2.Difference between Femtocell & Wi-Fi

Specifications	Femtocell	Wi-Fi
Data Rates	7.2-14.4Mbps	11 and 54Mbps
Operational Frequency	1.9-2.6GHz	2.4-5GHz
Power	10-100mW	100-200mW
Range	10-30m	100-200m
Services	Primarily Voice and Data	Primarily Data and Voice

The advantages of femtocell include maintained coverage in that particular area and the usage of a mobile phone as the main phone [9]. However, the increasing number of Femtocell Base Stations leads to more interference and path loss. Interference may occur between two femtocells, between a femtocell and a macrocell network and inter-operability of femtocells with existing handsets.

II. FEMTOCELLS

A femtocell is a small low-powered base station, designed to be deployed within home or small business premises to provide enhanced coverage for in-building cellular services. It has been introduced as the cheapest solution for indoor wireless broadband.

Femto Base Station (FBS) or Femtocell Access Point (FAP) is a low power, short-range small base station typically designed for providing voice and broadband services in an indoor environment.

The term femtocell itself was first coined in 2006. FBS is not a new concept as it was first studied in 1999 by Bell Labs, while GSM based home base station were brought to the market by Alcatel in 2000. The first 3G-based home base station was introduced by Motorola in 2002[1, 2]. In the metric measurement system, “Femto” means one-quadrillionth (10-15). The femtocell is designed to be installed by the subscriber, with no technical knowledge, i.e. it is a “plug and play" device. These are installed in an indoor area by the end user just like a Wi Fi router and provide almost all of the cellular functionalities to the end users [4]. The FAP is then connected to the operators core network through the users broadband internet connection. The femtocell manoeuvres the end users’ broadband network (DSL or Cable Modem) to transmit data to the mobile operators’ basic network. FBS is installed by the users to ensure seamless indoor coverage with better voice and data reception [3, 4]. In fig 1, a stereotypical indoor femtocell is represented [8], where various indoor User Equipments (UEs) can link to the FAP and utilize data and voice services.

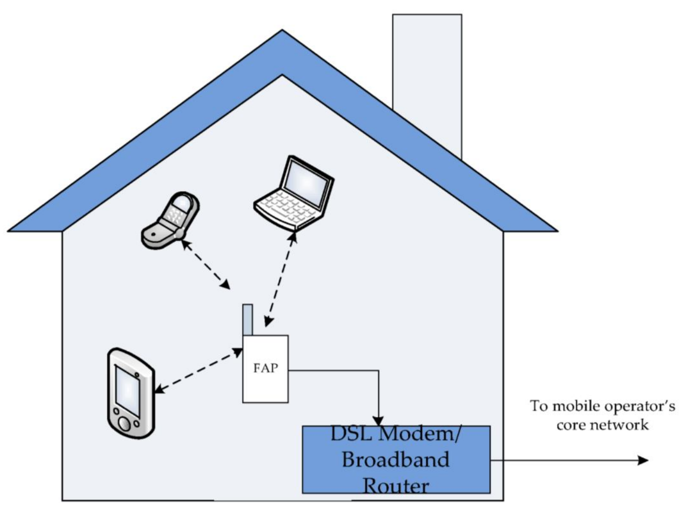

Fig 1 A typical indoor femtocell

The femtocell concept can be applied to wide variety of technologies. Each type of femtocell provides different type of services [8]. The selection of a femtocell based on a particular technology depends on the need of the user. The main types of femtocells are shown in fig. 2.

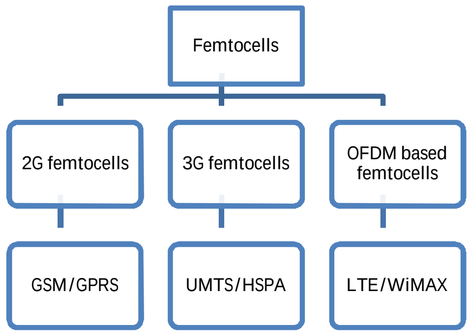

Fig 2 Types of Femtocells Based on Technology Used

III. TECHNICAL CHALLENGES IN FEMTOCELL DEPLOYMENT

The deployment of femtocell brings several technical challenges to the operators [7, 9]. The vital technical problems which come handy with the compact stationing of femtocell, most explicitly in urban and sub-urban areas are described below in short:

A. *Interference management*

The major technical issues associated with the mass deployment of femtocells are the interference management between femtocell and other serving cells in the same spectrum. Considering that femtocells use same frequency spectrum as macrocells, it is necessary to amplify an efficient interference management technique that will increase the capability and throughput of the network alongside improve QoS to the UEs.

B. *Handover and mobility management*

Once a large range of femtocells are deployed beneath the coverage of macrocell in a very typical Heterogeneous Network (HetNet), it is terribly difficult to implement a quality mobility management and handover scheme. The problem gets more complicated especially for the unplanned deployment of femtocells in LTE networks.

C. *Timing and synchronization*

Femtocell synchronization over IP backhaul is quite complex due to a huge number of femtocells serving next to each other and inconsistent delays triggered by varying traffic congestion. In OFDMA-based femtocell network, errors in temporal arrangement and synchronization can cause inter symbol interference (ISI) and therefore structured algorithms ought to be developed to resolve this issue.

D. *Security*

Since femtocells could be vulnerable to malicious attacks, security of femtocell is considered as a key issue. Network access security for authentication and authorization procedures is required to protect subscribers and femtocell network against fraud and unwanted risks.

IV. INTERFERENCE IN FEMTOCELL NETWORK

The major technical issue associated with the mass deployment of femtocells is the interference management between femtocell and macrocell and among neighboring femtocells. Generally, interference can be classified into two major types [7]; co-tier interference and cross-tier interference as shown in fig 3.

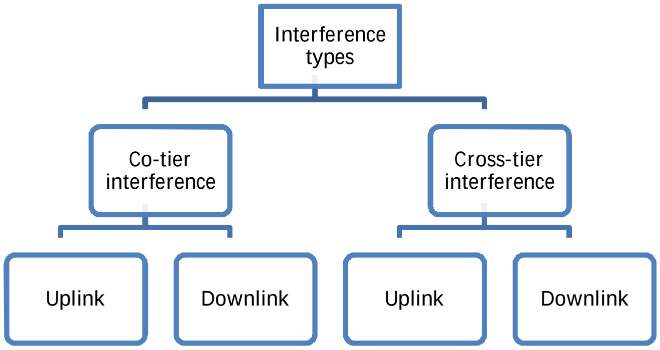

Fig 3 Types of Interference

A. Co-tier interference (Femto to Femto)

This interference is caused by one femtocell to another femtocell, usually the neighboring ones, of same layer. This sort of interference takes place among network parts that belong to an equivalent tier within the network. In case of a femtocell network, co-tier interference occurs between neighboring femtocells. Cotier interference occurs in two different forms; uplink co-tier interference and downlink co-tier interference. The uplink co-tier interference is caused by femtocell UE to the neighboring femtocell base stations. The downlink co-tier interference is caused by femtocell base station to the neighboring femtocell UEs.

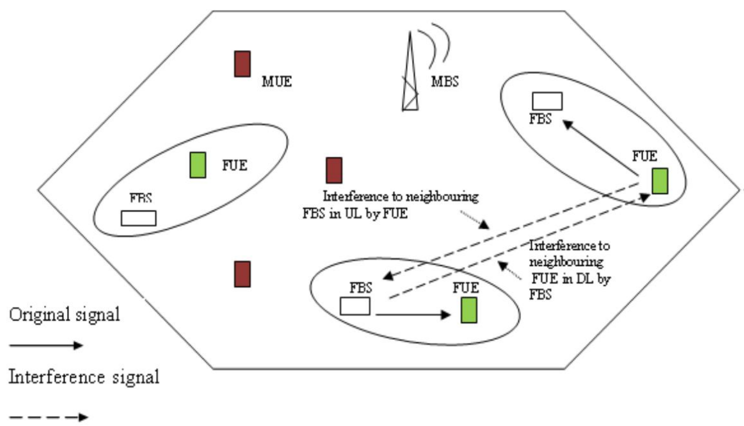

Fig 4 Co-Tier Interference

B. Cross-tier interference (Femto to Macro)

This type of interference occurs among network elements that belong to the different tiers of the network, i.e., interference between femtocells and macrocells. The uplink cross-tier interference is caused by femtocell UEs and macrocell UEs to the serving macrocell base station and the nearby femtocells, respectively. The downlink cross-tier interference is caused by serving macrocell base station and femtocells to the femtocell UEs and nearby macrocell UEs, respectively

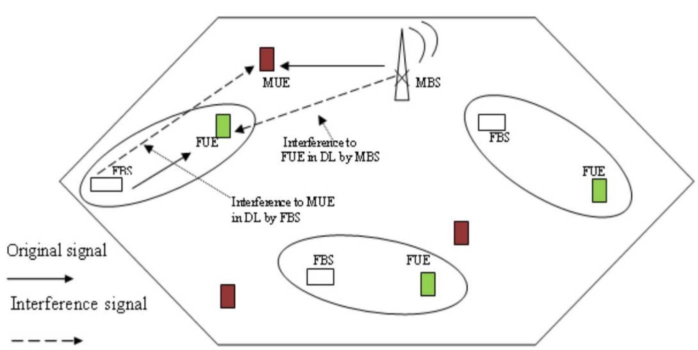

Fig 5 Cross-Tier Interference

V. INTERFERENCE MANAGEMENT & CHALLENGES

A primary obstacle to the unrestricted femtocell networks is the utility-based resource management. In public femtocell networks, multi-units are necessary to jointly provide high rate, high quality services to indoor users, but there is often heavy resource competition as well as mutual interference between multiple femtocells. Therefore, it's terribly vital to optimize the radio resources allocation to satisfy femtocells' demand as attainable and scale back the interference.

Interference management scheme efficiency depends upon the type of femtocell scenario being deployed, for the less dense deployment scenario of femtocells, a simple scheme would do the intended task of interference management for both macrocell and femtocell network layers. The main aim is to enable femtocell to be deployed densely and hence, efficient interference management schemes that can cope with the ad hoc nature of femtocells and provide QoS to each macrocell and femtocell consumers ought to be developed. It should also be kept in mind that the FAP is a small low powered device and it should be able to handle the complexity of these schemes. The limitations of a femtocell should be studied and the schemes should be able to overcome the limitations. Some of the basic challenges of FBS are due to the following factors:

A. User Installation

FBS are installed by subscribers without special training or knowledge regarding antenna placement and system configuration. Because of this, the femtocell should be capable of self-configuration.

B. Unplanned Deployment

Unlike a macro network, FBS are deployed without network planning; no special consideration is given to traffic demand or interference to/from other cells.

C. Restricted Association (or Restricted Access)

To protect the utilization of restricted resources (femtocell capacity, DSL/modem connection), FBS may be designed to limit access to solely lincensed subscribers (e.g. members of the family or edifice guests).

D. Legacy System Support

Currently available handsets are femto-unaware; FBS need to support these handsets as well as femto-aware handsets. Moreover, they need to interface with existing access and core networks.

VI. CONCLUSION

Femtocells is believed to be the technology of the future that could quench the thirst of ever growing demand for high data rates while maintaining the quality of service in the wireless cellular networks. Femtocells offer several advantages to both the user and the mobile network operator. Due to their short transmit-receive distance, femtocells can greatly lower transmit power, prolong handset battery life, and achieve a higher signal-to-interference- plus-noise ratio (SINR). These translate into improved reception—the so called five-bar coverage—and higher capacity. Femtocells are aimed at delivering dedicated 3G coverage to a household and in doing so can provide a very good end-user experience within the home environment. As a result, femtocells have a design "capacity" of up to 6 end-users [9]. However, there are yet a number of challenges to be dealt for it to be widely acceptable.

REFERENCES

[1] Jeffrey G. Andrews et.al, "Femtocells: Past, Present, and Future", *IEEE Journal on Selected Areas in Communications*, Vol. 30, pp 497-508, Mar. 2012, p-ISSN: 0733-8716, DOI: 10.1109/JSAC.2012.120401.
[2] Gurpreet singh, Rahul Malhotra et.al, "Femto Cell: History, Technical Issues And Challenges", *International Research Journal of Engineering and Technology*, Vol. 03, pp 2710-2717, May 2016, e-ISSN: 2395 -0056, p-ISSN: 2395-0072.
[3] V. Chandrasekhar, J. Andrews and A. Gatherer, "Femtocell networks: a survey," Communications Magazine, IEEE, vol. 46, pp. 59-67, 2008.
[4] Claussen Holger, Ho Lester T.W. and Samuel Louis G., "An overview of the femtocell concept," *Bell Lab.Tech.J.*, vol. 13, pp. 221-245, 2008
[5] V. Chandrasekhar and J. Andrews, "Femtocell networks: A survey,"IEEE Commun. Mag. , vol. 46, no. 9, pp. 59–67, Sep. 2008.
[6] S. F. Hasan, N. H. Siddique, and S. Chakraborty, "Femtocell versus Wi Fi- A survey and comparison of architecture and performance," *1st International Conference on Wireless Communication, Vehicular Technology, Information Theory and Aerospace and Electronic Systems Technology*, pp. 916–920, 17-20 May 2009.

[7] Motea Al-Omari, Abd Rahman Ramli et.al, ”Deployment of Femtocell and Its Interference Management Approaches in LTE Heterogeneous Networks”, *Journal of Theoretical and Applied Information Technology*, Vol. 87, pp 54-79, May 2016, ISSN: 1992-8645, E-ISSN: 1817-3195.

[8] Kamran Arshad, Klaus Moessner et.al, “Interference Management in Femtocells”, *IEEE Communications Surveys & Tutorials*, Vol. 15, pp. 293-311, Jan. 2013, DOI: 10.1109/SURV.2012.020212.00101.

[9] Seema M Hanchate1 et.al, “3GPP LTE Femtocell – Pros & Cons”, *International Journal of Engineering Science & Advanced Technology*, Vol. 2, pp 1596-1602, Nov-Dec 2012, ISSN: 2250–3676.