A Study on Femtocell and Macrocell Network Deployment

Sadman Saffaf Ahmed

Abstract— **Next generation wireless communication needs seamless connectivity with high level of quality of service (QoS), high data rate services, favorable price, and multimedia applications among different access networks. The ubiquitous services of wireless communication networks are growing rapidly by the development of wireless communication technologies. With the development of communication technology, the services of wireless networks are upgrading fast. Different wireless networks, i.e., macrocellular, microcellular, picocellular, femtocellular networks can be deployed. In this paper, we have reviewed the deployment of femtocell and Macrocell which covers a very significant terminology of communication.**

Index Terms— Picocellular network, femtocellular network, macrocellular networks, quality of service.

I. INTRODUCTION

MODERN wireless communication systems aim to provide users with the convenience of seamless connection to access various wireless technologies and try to support ubiquitous services among the users. The wireless networks use multiple technologies that offer unrestricted user access to different services [1]. With the development of communication technology, the services of wireless networks are upgrading fast. There are many wireless networks like macrocellular, microcellular, picocellular, femtocellular networks. We can define a cellular network as a communication network where the last link is wireless. The network is distributed over land areas is called cells which can be macro, micro, or pico cells, each served by the least one fixed location transceiver known as base station. This base station provides the cell with the network coverage which can be used for transmission of voice, data and others. A cell might use a different set of frequencies from neighboring cells, to avoid interference and provide guaranteed QoS with each cell. When joined together, these cells provide radio coverage over a wide geographic area. This enables a large number of portable transceivers such as mobile phones, tablet pc, to communicate with each other and with fixed transceivers and telephones anywhere in the networks via base stations, even if some of the transceivers are moving through more than one call during transmission. A macrocell is a cell in a mobile phone that provides radio coverage served by a high power cellular base station [2]. The antennas for macrocells are mounted on ground-based masts, rooftops, and other existing structures, at a height that provides a clear view over the surrounding buildings and terrain. Fig. 1 shows the basic architecture of macrocellular network (4G).

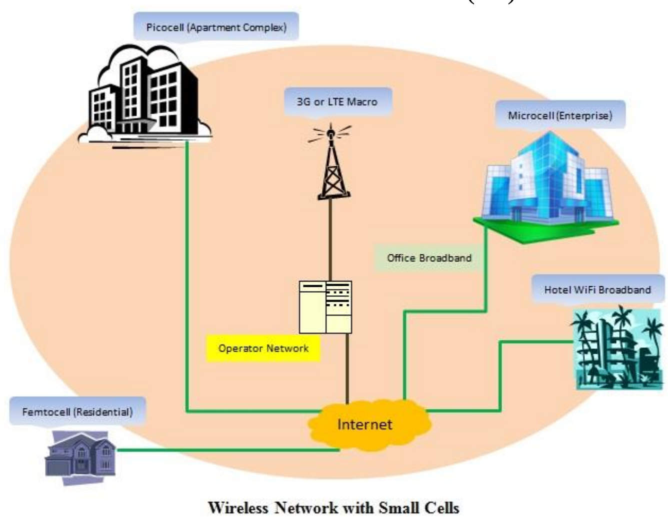

Fig. 1. Macrocellular network deployment (4G).

In communications, a femtocell is a small, low-power cellular base station, typically designed for use in a home or small business. A broader term which is more widespread in the industry is small cell, with femtocell as a subset. It connects to the service provider's network via broadband such as DSL or cable. The femto-access-points (FAPs) enhance the service quality for the indoor mobile users. Some key advantages of femtocellular network technology are the improved coverage, reduced infrastructure and the capital costs, low power consumption, improved SNIR level at the mobile station (MS), and improved throughput [3]. Femtocells operate in the spectrum licensed for cellular service providers thus, it can provide high performance. Also, no need to use the dual mode terminal for this technology, whereas WLAN needs dual mode terminal and hence, the key feature of the femtocell technology is that user does not require any new femtocell user equipment (FUE) [4-5]. One of the key advantages of the femtocellular technology is in the fact that it uses the same frequency bands as the macrocellular networks, thus avoiding the need to introduce new user equipment. However, the use of the same frequency spectrum can also cause substantial interference if no adequate interference management is incorporated into the network design, infrastructure, and the

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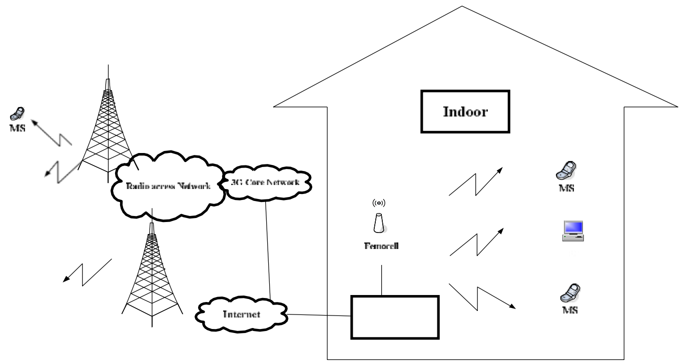

Fig. 2 Femtocell network deployment.

Interference between two or more femtocells could be managed through on-demand scheme along with proper frequency allocation scheme, which would allow largest utilization of the valuable radio spectrum and the highest level of user's quality of experience (QoE). Although the interference in a femtocellular network cannot be fully eliminated, it is possible to reduce the interference to within a reasonable range by proper management. Fig. 2 shows the basic femtocell network deployment. In this figure the femtocell serves the indoor coverage area. If a macrocell users enter this indoor area then this macrocell users served by the femtocell network and include this femtocell network.

II. Main Advantages of Femtocell Network Architecture

Femtocell is a low cost, more reliable, less power utilizing network deployment planning for future cellular system with a small coverage area. The wireless engineering community has been searching for low-cost indoor coverage solutions since the beginning of mobile networks. Femtocellular network technology is one of such solutions. Use of femtocells benefits both the mobile operator and the consumer. The range of a femtocell is about 10m. There are some basic or key advantages of using femtocell network in the perspective of network operator [6-7].

A. Enhanced Coverage

For a mobile operator, the attractions of a femtocell are improvements to both coverages, especially indoors, and capacity. Coverage is improved because femtocells can fill in the gaps and eliminate loss of signal through buildings. Capacity is improved by a reduction in the number of phones attempting to use the main network cells and by the off-load of traffic through the user's network (via the internet) to the operator's infrastructure. Instead of using the operator's private network (microwave links, etc.), the internet is used. Consumers benefit from improved coverage since they have a base-station inside their building.

B. Longer Battery Life

The mobile phone (user equipment) achieves the same or higher data rates using less power, thus battery life is longer. They may also get better voice quality.

C. High Capacity

Higher mobile data capacity, which is important if the end-user makes use of mobile data on his or her mobile phone, may not be relevant to a large number of subscribers who instead use Wi-Fi where femtocell is located.

D. Licensed Spectrum

Femocell operates in licensed spectrum so. It needs not additional spectrum as it can use cellular spectrum. Femtocell transmits licensed frequencies which belong of different network operators in different countries.

E. Reduced Cellular Network Congistion

Femtocell provide better indoor coverage as full speed data transfer at home and ubiquitous mobility between home cell and overlaying macrocell. We can use femtocell where network is too much peak used as more network traffic. As a result, network congestion may reduce.

F. Low Cost

Femtocells are low cost volume product. It is automated installation process. Femtocell use the existing home broadband connectivity for backhauling the femtocells' traffic. Thus, by steering users' traffic into their own FAPs and away from the macrocells, femtocells reduce the cost of macrocellular networks.

G. Security

Femtocells use the same over-the-air security mechanisms that are used in macrocell radio networks. But additional security capabilities need to be supported to protect against threats that originate from the Internet or through tampering with the femtocell itself. Femtocell network architecture provides network access security, and includes subscriber and femtocell authentication and authorization procedures to protect against fraud.

H. Scalability

Femtocell networks can have millions of access points. Therefore, the femtocell network architecture must be scalable to grow into such large networks, while at the same time maintaining reliability and manageability.

I. Simple Orientation

Femtocells are installed by end-users. Therefore, the femtocell network architecture must support an extremely simple installation procedure with automatic configuration of the femtocell and automated operational management with "zero-touch" by the end.

III. Different Loss Models for Cellular Networks

Signal coverage is essential for deployment of both narrowband and wideband wireless communication and calculation is important for design as well. Signal coverage is influenced by a variety of factors most prominently the radio frequency of operation and the terrain. Often the region where a wireless network is providing service spans a variety of terrain. An operation scenario is defined by a set of operations for which a variety of distances and environments exist between the transmitter and receiver. As a result, a unique channel model cannot describe radio propagation between transmitter and receiver [8]. So various model for variety of environments are needed to enable system design.

A. *Path loss models for megacellular networks*

Megacellular areas are those where the communication is over extremely large cells spanning hundreds of kilometers. Megacells are served mostly by mobile satellites usually low earth orbiting LEO. The path loss is usually the same as that of free space, but the fading characteristics are somewhat different.

B. *Path loss models for macrocellular networks*

Macrocellular areas span a few kilometers to ten of kilometers, depending on the location. There are the traditional cells corresponding to the coverage area of a base station associated with traditional cellular telephony base stations. The most popular model was Okumura, which included frequency, height of base station antenna, and height of mobile antenna as important parameters. Then Masaharu Hata created empirical models that good fit for the measurements taken by Okumura for transmitter-receiver separation. The expression for path loss development by Hata is called the Okumura-Hata models [9-10].

C. *Path loss models for microcellular networks*

Microcells are cells that span hundreds of meters to a kilometer or so and are usually supported by below rooftop level base station antennas mounted on lampposts or utility poles. The shapes of microcells are also no longer circular because they are deployed in the streets in urban areas where tall buildings create urban canyons. There is little or no propagation of signals through buildings and the shape of microcell is more like a cross or a rectangle depending on the placement of base station antenna at the intersection of streets or in between intersections. The propagation characteristics are quite complex with the propagation of signal affected by reflection from buildings and the ground and scattering from nearby vehicles [7, 11].

D. *Path loss models for picocellular networks*

Picocells correspond to radio cells covering a building or pars of buildings. The span of picocells are anywhere between 30m and 100m. Usually picocells are employed for WLANs, wireless PBX systems and PCSs operating in indoors areas. Characterize indoor path loss for picocellular areas by a fixed exponent of 2 (as in free space) + additional loss factors relating to number of floors and walls intersected by the straight-line distance between terminals.

E. *Path loss models for femtocellular networks*

Femto-access points (FAPs) are low power, small sized home placed base stations that create islands of increased capacity in addition to the capacity provided by the cellular system. These areas of increased capacity are referred to as femtocells. Femtocells operate in the licensed for cellular service providers. The key feature of the femtocell technology is that users require no new equipment [12].

IV. COMPARISON AMONG THE TECHNOLOGIES

There are various technical methods to improve the indoor coverage; femtocell appears to be the most attractive away. Compared with the fixed mobile convergence (FMC) framework, femtocell allows servicing large number of indoor users. Femtocells are fully featured for very low power single mode mobile phone. As a result, dual mode handset is not required. The connection of femtocell uses standard broadband DSL, Cable, FTTx, PLC, WiMAX, etc. The drawback of Wi-Fi is its use of the increasingly crowded unlicensed ISM band that causes significant interference. Finally, repeaters improve the wireless access coverage, but not the wireless capacity. Repeaters need new backhaul connections and only solve the poor coverage problem in remote areas, where fixed broadband penetration is low. Fig. 3 shows the microcell and femtocell networks deployment.

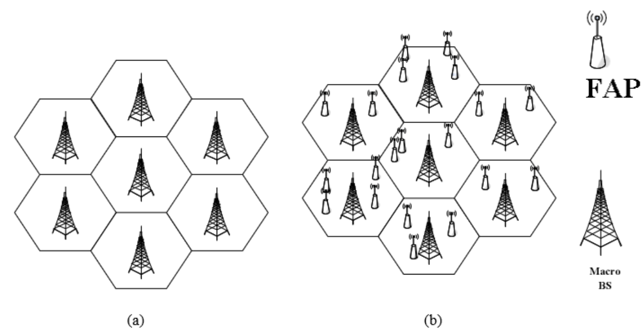

Fig. 3 (a) Macrocell and (b) macrocell overlaid femtocell networks deployment.

Table 1 shows the comparison between macrocell and femtocell technologies. Table 2 provides the comparison among the repeater, FAP, and Wi-Fi technologies [4].

Table 1 Comparison between the macrocell and femtocell

Feature	Macrocell	Femtocell
Network	Few numbers of BS	Large number of FAP should be supported by network.
Way of deployment	Deployed by the operator in a controlled way	Typically deployed by the customer in an uncontrolled way.
Environment	The environment of each node is well known.	The environment of FAP is not known.
Access node	Access node are on safe locations and integral part of the network	FAPs are on customer premises but still an integral part of the network.
Configuration	Autonomous O&M is preferable but manual configuration is possible.	Autonomous O&M is mandatory.

Table 2 Technical solutions for indoor poor coverage

Feature	FAP	Repeater or signal	3G/Wi-Fi UMA

		booster	
Installing infrastructure	Existing xDSL or CATV connection	Needs new connection	Existing Wi-Fi connection
Coverage	In indoor, hot spot or remote area where cellular voice or data services are required	Solves poor coverage issues in remote areas where fixed broadband penetration is low	In indoor, hot spot or remote area where cellular data services are required
Terminal mode	Single mode	Single mode	Dual mode
Data speed	High	Low	High

V. Conclusion

Due to the high demand, our wireless technologies such as WiMAX, WiFi, WLAN, femtocell, macroccell, etc., have been researched upon to improve user types and prerequisite. However, femtocell and macrocell are the two most important terminologies for wireless communication. This is why, this study can introduce the readers about the inner technologies of modern wireless communication technology.

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