FEMTO CELL: HISTORY, TECHNICAL ISSUES AND CHALLENGES

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Abstract - *Femtocell is a small range, low power cellular base station. It can be deployed inside the home and small office building. The device communicates with the mobile phone and converts voice calls into voice over IP (VoIP) packets. The packets transmit to service provider through a broadband connection such as DSL, cable and optical fiber. Femtocell and cellular network operate on same licensed frequency band spectrum. So active mobile phone easy interference with Femtocell and macro cell (part of cellular network) and the access method used in Femtocell two-tier networks such as Cross-tier and Co-tier networks. Cross-tier interferes between Femtocell tier and macro cell tier. Co-tier interferes between the same elements of the same tier. In this thesis work, an overview of Femtocell has been undertaken. Femtocell is considered an aim of digital India has to connect with a digital communication network anywhere, anytime, anyone. However, the people live in different types of geographical areas, such as mountain, desert, plain, forest and some people face environmental problems so they cannot connect any communication network. Therefore, the Femtocell is a unique solution of this problem and Femtocell installation cost is very low and easily install according to cellular site. Further, the use new standards Home eNode B (HeNB) is a LTE-A (long term evolution-advanced) and also use the Metro-Femto for increase the number of capacity of active mobile phone, improve the coverage area and quality of service (QOS).*

*Key Words***: Connectivity, LTE-A, Metro-Femto**

1. INTRODUCTION

Femtocells [Femto Base Station, (FBS)] are minor, low-power cellular base stations (access levels) that are user-installed, which sufficiently enhance the conventional Mobile communication in the expanded coverage area and improved capacity in cellular networks. In summation, they can be denoted to as typically designed radio access interfaces that plug in the main macro cellular base station with user equipment for home or office usage in small or large business locations. The evolution of the femtocell is a significant steps made to help network density in Macrocells.

The femtocells help to cut the cell size for increased quality of inspection and repair. Of much emphasis is the

decrease in the maximum transmits power in femtocells as compared to the broader macrocells.
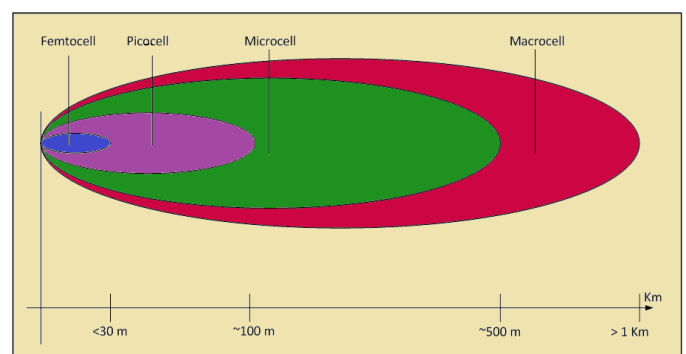

Figure 1: Small cell comparison in terms of range.

As the voice of the small cell group figure 1.1 presents a significant comparison with respect to radius of coverage.

1.1 How Work Femtocells

If your cubicle phone is calling, and you do it. If the phone is in tight proximity to your home femtocell, it will automatically route its voice transmission through the fanatical rather than through the closest cell phone tower. Essentially, the femtocell is low-output cell tower that can route voice data over short distances.
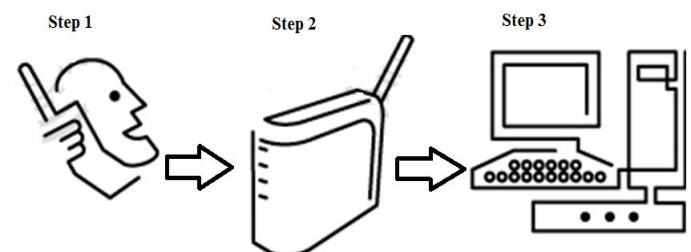

Figure 2: How work femtocell

1.2 Femtocells Technologies

As the voice of the major benefits attached to the role of femtocells is the use over the licensed spectrum and the role of the operators' network coupled with the role of the internet connections at home or office. The femtocell

requires technology designs that could into the carefully planned cellular networks of service suppliers. The power of the femtocells to offload data and video traffics will depend on how efficient and reliable the technology.
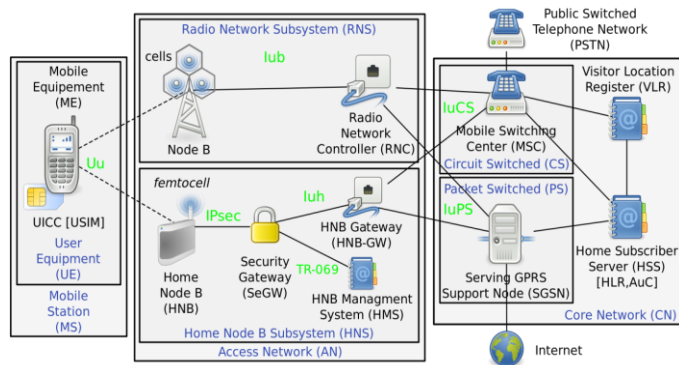

Figure 3: Femtocell Architecture

1.3 Typical Femto-Cellular Network

In the 3GPP standards, more or less of the fanatical operational elements in the femtocell architecture is the Home Node B Gateway (HNB-GW) and Home Node B Management System (HMS).
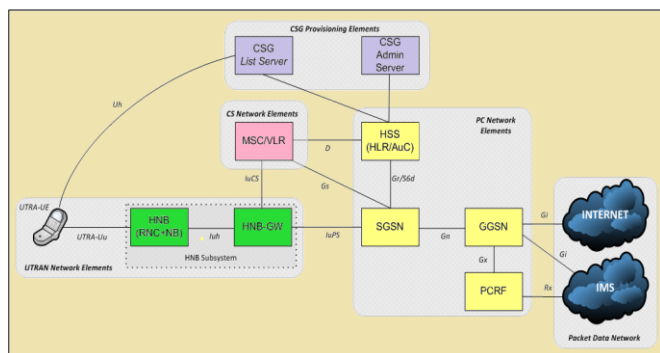

Figure 4: logical architecture.

These two network components have been freed as part of the release 8 that focuses mainly on the 3G UMTS network architecture.
1. Iuh Interface
2. HNB Management System, HMS
3. Security Gateway, SeGW
4. Home Node B Gateway, HNB-GW
5. Home Node B, HNB

1.4 Types of Femtocell

There are four types of femtocells: - Domestic, Enterprise, Metro-femtocell and Rural.

>Domestic

It is typically a four channel Unit; it is capable of handling four voice calls and others many more attached to it to standby. It is use in the home.

>Enterprise

It is typically a larger device capable of handling between 8 and 32 channels in the very heavily populated environment. It is use in the office.

>Metro-femtocell

It is a new concept where the operator himself micro lies large number of femtocells to saturate particularly high traffic areas. This is particularly use of 4G and LTE technology.

>Rural

It is a unique concept for rural areas. It can connect the rural areas with digital communication through a broadband or satellite system.

2. HISTORY OF FEMTOCELL

First time in 1984, 'small cells' can be found in literature. In this article "small-cell mobile phone system" Arthur stoke describes a system that has "direct access to land line telephone and designed to connect any mobile telephone or user equipment" in 1990's these was increasing need for cellular service as a result the macrocell were overloaded so urgently find a fresh answer for increased cellular capacity.

Southwest Bell and Panasonic of a method of reusing the same frequency an outdoor cellular system to provide wireless communication inside the building, it was accomplished by broadband wire backhaul. The Motorola's engineers in 2002 were investigating the possible new technologies and methodologies that could be used with mobile communication. After two years in 2004, this idea was beginning to gather some momentum and varieties of companies were looking into the estimation. In particular, two new companies, Ubiquisys and 3WayNetworks were from in the UK to address the field of networking. The idea is gaining momentum used many more companies investigating femtocell technology the (www.Femtoform.org) was set up in July 2007. Its aim was promoting the large-scale adoption of femtocells also femtocell shipment had reached 2 million units, at the end of 2011. Great number of shipments in many states they were deployed the femtocell within densely populated regions.

According to Cisco Visual Networking index (Cisco white paper: forecast and methodology, 2015-2020) global mobile data traffic reached 3.7 Exabyte per month at the close of 2015 and monthly global mobile data traffic will be 30.6 Exabyte by 2020, with this incredible growth, the demand for new cellular architecture with greater capability.

3. TECHNICAL ISSUES

3.1 Quality of Service Issues

The term quality of service refers to the requirements that are imposed by IEEE 802.11 on all aspects of an internet connection. Some of these requirements are adequate signal to noise ratio, frequency response, loudness levels, reaction time, etc. To achieve the QoS requirement, there often requires being hardware change. Different service prioritized packets according to the character of service they desire router and switches can prioritize these to improve quality. introduced a heterogeneous network in which multiple small cell base station (SBSs) an off load a quantity of macrocell user equipment (MUE) to reduce the energy consumption of the network while routing the QoS requirements of all UEs. They design ascending bid, action magnesium to reach this end [1].

3.2 Bandwidth / Frequency Issues

The electromagnetic spectrum is a scare and crowded resource femtocell operate on the same licensed spectrum is allocated to a cellular service provider, to deal with this overcrowding issue two methods have been used the co-channel frequency development and orthogonal channel development. Under the macrocell allocating frequency band by the FFR, the femtocell chooses sub-sets, which are not utilized in the macro cell sub-area to avoid noise [2].

3.3 Interference Issues

There are fewer femtocell interference problems when the femtocells work on separate carrier frequency to the surrounding macro cell network for the cellular telecommunication system.
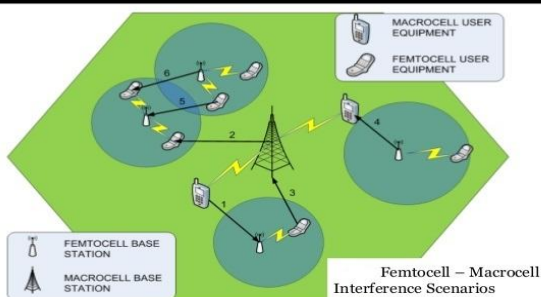

Figure 5: Interference Problem in Femtocell

However, its more complicated scenarios arise when the femtocells work on same carries frequency this scenario also provide the highest level of spectrum efficiency and the greatest challenges to the interference management system. The integration of the femtocell into the 3G architecture, as well as various interferes faced the femtocell [3].

> Types of femtocell interference:
- Femtocell interfering with home station
- Base station interfering with femtocells
- Interference with each other
- Mobile phone received signal by both femtocell and macrocell

3.4 Interference Management

Two-tier femtocell network Implantation in femtocell, two-tier networks such as Cross-tier and Co-tier networks. Cross-tier interferes between Femtocell tier and macro cell tier. Co-tier interferes between the same elements of the same tier. A qualitative comparison among the different approaches is offered. To this end, open challenges in designing interference management schemes for OFDMA femtocell networks are discussed [4].

> Few of methods resolving the interference:
- Adoptive pilot power control
- Femtocell receiver dynamic gain management
- Mobile phone capping uplink power

3.5 Synchronization Issues

An issue with Femtocell deployments that further contributes to equipment tracking and emergency call support difficulties/issues is that of synchronization/timing challenges of RF signals. This is because Femtocells are deploying in indoor locations and the operator has little commend over the location of the femtocell in the customers house or office location. Synchronization and Timing issues are also introduced due to 'deteriorated' indoor signal conditions due to errors and interferences in RF signals received by femtocells, caused by multi-path propagation (reflections off walls, ceilings, floors, etc.).

> Few of the solution resolving the equipment tracking, emergency call and time Synchronization issue:-
- GPS (Global Positing System) chip installed in femtocell device.
- Interference with Neighboring cell/Macrocell.
- TV broadcast use for femtocell synchronization.
- Timing of the internet for femtocell synchronization.

3.6 Access Control Issues

Access control is a characteristic of Femtocells, which controls as the fact to which mobile devices can access the femtocell. It tailors the support of a restricted number of concurrent users. Our demand of 'Access control' based along the idea of users from multiple network operators being able to access a single femtocell for service.

Open Access Mode

If a femtocell has an Open Access mode, all mobile users (registered or unregistered) can access that femtocell.

Therefore, every mobile user always connects to the femtocell that provides the best signal quality.

Closed Access Mode

The femtocell base station is able to provide the best signal quality to the non-associated user even then, the non-associated user not be allowed to connect to the closed access femtocell [5] and [6].

Hybrid Access Mode

In a hybrid access mode, a femtocell operates in open access mode and closed access mode at the same time. Only open access and closed access modes in femtocells are investigating [7].

3.7 Backhaul

The topic of security and quality of service over the third party backhaul is a major worry in the deployment of femtocell. Since the femtocells are backhauled over public infrastructure like the internet there are major concerns relating to the security of the femtocell, reduced level of QoS and bandwidth limitation. Femtocells can be configured to be either open access or closed access. Open access allows an arbitrary nearby cellular user to use the femtocell, whereas closed access restricts the use of the femtocell to users explicitly approved by the owner [8].

4. FEMTOCELL CHALLENGES

4.1 Regulatory Challenges

The femtocells are operating in a licensed spectrum and they require regulatory approval. If the user takes their femtocell from one nation to another, so it can involve the international agreement every country has different radio spectrum and regulation. This means a user could not operate a femtocell in another country. Although, there had been a significant paradigm shift in the used of femtocells, there had been so much so few challenges that the femtocells deployment had to combat. In a short form, some of these challenges had been based on (accordingly to (a) unplanned deployment b) user-installation (c) restricted access and (d) interoperability with existing infrastructure [9].

>Major Regulatory challenges in these fields:

a) Licensed spectrum usage
b) Deploy GPS (global positioning system)
c) Support emergency calls
d) Lawful interception

4.2 Handover or Handoff Challenges

Femtocell is obviously an essential element of the technologies. Femtocell handover is more challenging with macrocell (part of cellular network) handover. Because the backhaul network is different and there is different type of direct communication between the femtocell and macrocell. Recommended a handover algorithm and proposed schemes to reduce the amount of unnecessary handovers of an MUE from MNB to the HNB, handover call

flow for 3GPP Universal Mobile Telecommunication System (UMTS) based MNB and HNB [10].

>Types of handovers:-
A) Inbound femtocell handover
B) Outbound femtocell handover
c) Femtocell to femtocell handover

4.3 Security Challenges

Femtocell security is on the top of many femtocell developer and user minds. Wi-Fi security measures, and in the WEP (wire equipment privacy) scheme are very easily fail. We also propose novel solution directions in order to undertake some of these threats by getting inspiration from solutions to similar challenges in wireless information networks such as WLANs and mobile ad hoc networks (MANETs) [11]. We numerically demonstrate the benefits of our approach via comparison to a centralized scheduler and reuse one scheme using system simulations based on the 3GPP evaluation methodology [12].

>Mainly require for security challenges in :
- User privacy
- Denial of services
- Service theft and fraud

5. FEMTOCELL LTE-A SYSTEM ARCHITECTURE

LTE-A (long Term Evolution) is a cellular networking standard that offer higher throughput its predecessor, the Long Term Evolution (LTE) standard. LTE-A network can render up to 3GB per second of data, compared to an uttermost of 300 MB per second over LTE network. Increasing demand for cellular bandwidth. However means that carrier may use LTE advanced, to increase their capacity. LTE-A network use multiple-input-multiple-output (MIMO) technology to deliver higher data rate. It was officially stated as a cellular system to ITU in late 2009 as meeting the requirement of IMT advanced standard and was standardized by the 3rd generation partnership project (3GPP) in March 2011 as 3GPP release 10.
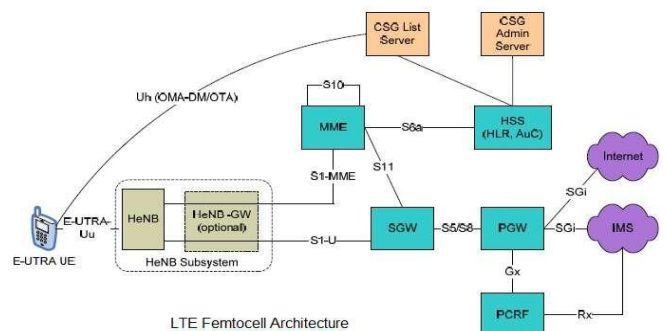

Figure 6: LTE Femtocell Architecture

Suggested Issues generated by deployment of multiple LTE femtocells as self-organizing networks (SON) at a close distance in indoor environments (e.g. Enterprises) are discussed different types of access policy: open access to all, closed access only for a pre-determined list of users or hybrid, with division of the resources open and the rest folded [13].

6. METRO-FEMTO

The Metro-Femto is a singular idea for densely populated areas to offer a better cellular coverage and higher data rate. In Metro-Femto, system deploys a big number of femtocells their interference with each other and create as a cellular arrangement. A comparison of existing schemes that consider the above mentioned challenges is demonstrated and a road map is given to point out the main protocols and access type that should be adopted in case of dense areas planning [14]. That system used for densely areas such as urban area, a small town, buildings, etc.
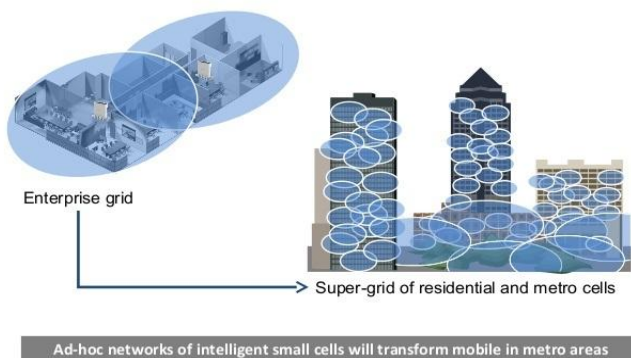

Figure 7: Metro-Femto self-organizing

Femtocell, picocell and Microcell have a range of a few meters to few hundred meters in that they do not always have self-organizing and self-capabilities. Deploying a number of femtocells to jointly provide coverage in an enterprise environment raises critical challenges, especially in future self-organizing networks, which rely on plug-and-play fashions. Depending on a multi-objective function for optimizing the reporting, the algorithm leads to a dynamic update of the pilot powers of the group of femtocells [15].

Therefore, the Metro-Femto is a unique solution to provide a better coverage. Small cells are available for a wide range of air interference, including GSM, CDMA2000, TD-SCDMA, W-CDMA, LTE-A and WiMax.
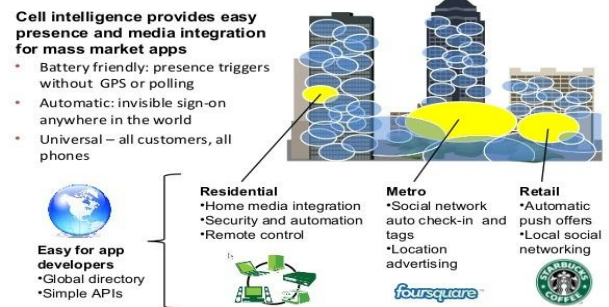

Figure 8: Metro-Femto Super-grid

7. CONNECTIVITY

Femtocell is considered an aim of digital India has to connect with digital communication network anywhere, anytime and anyone. However, the people live in different types of geographical areas, such as mountain, desert, plain, forest and some people face environmental problems so they cannot connect any communication network. Therefore, the Femtocell is a unique solution of this problem and Femtocell installation cost is very low and easily install according to cellular site.

The LTE-A (Long Term Evolution of 3GPP - Advanced) networks have largely tackled the Doppler Effect problem in the physical layer and are able to keep wireless service with 100Mpbs throughput within a cell in speeds up to 350 km/h. Our solution is based on a Cell Array that smartly organizes the cells along a railway, together with a Femto cell service that aggregate traffic demands within individual train cabins [16].
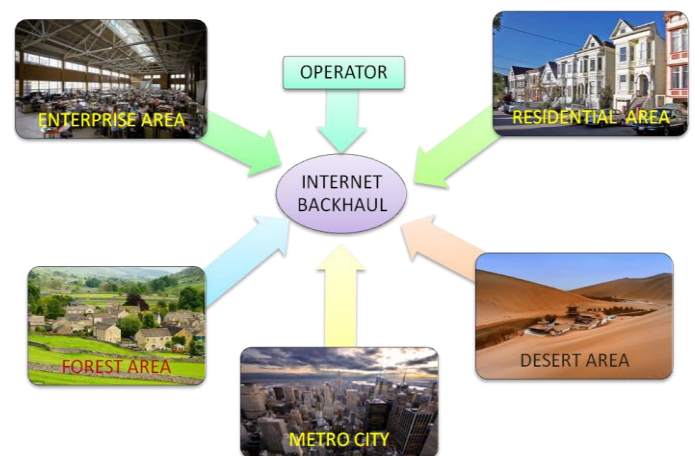

Figure 9: Connectivity with Femtocells

We propose an open-access algorithm for femtocell BSs (FBSs) in D2D LTE-Advanced networks, to optimize network connectivity. To boot, a greedy algorithm is proposed to balance macrocell BSs and FBSs to maximize network connectivity [17].

8. COMPARISONS OF FEMTOCELL WITH MACROCELL, MICROCELL AND PICOCELL

(a) Femtocell

In telecommunications, a femtocell is a modest, low-power cellular base station, typically designed for use in a dwelling house or small business.

(b) Macrocell

A macrocell is a mobile phone in a mobile telephone network that provides radio coverage served by a high power cellular base station (tower). Generally, macrocells provide coverage larger than Microcell.

	FEMTOCELL	MACROCELL
Key Application	Indoor residential areas	Large coverage, carrier class
Range	20 to 30	Up to 5 km (mobile)
Sectors	1	3
Number of users per sector	>10	>200
Mobility	Noun	High
Typical RF power output	100mw	10W
Deployment	Indoors	Outdoor
Cost	Very low	High
Example scenarios	Home, Office	Rural residential
Access mode	CSG or Open	Open

Table 1: Femtocell vs. Macrocell

(c)Microcell

A Microcell is a mobile phone in a mobile phone network served by a low power cellular base station (tower), passing over a limited field such as a mall, a hotel, or a shipping hub.

	FEMTOCELL	MICROCELL
Key Application	Indoor residential areas	Medium coverage areas
Range	20 to 30	Up to 3 km (mobile)
Sectors	1	3
Number of users per sector	>10	Up to 200
Mobility	Noun	High
Typical RF power output	100mw	4W
Deployment	Indoors	Outdoor
Cost	Very low	Medium High
Example scenarios	Home, Office	Rural residential
Access mode	CSG or Open	Open

Table 2: Femtocell vs. Microcell

(d) Picocell

A picocell is a small cellular base station typically covering a modest arena, such as in-building (offices, shopping malls, train stations, stock exchanges, etc.), or more recently in-aircraft.

	FEMTOCELL	PICOCELL
Key Application	Indoor residential areas	Outdoor and Indoor coverage areas
Range	20 to 30	100m to 1km (mobile)
Sectors	1	1
Number of users per sector	>10	10 to 50
Mobility	Noun	Low
Typical RF power output	100mw	500mw
Deployment	Indoors	Outdoor/ indoor
Cost	Very low	Medium/low
Example scenarios	Home, Office	Airport, stadium, aircraft
Access mode	CSG or Open	Open

Table 3: Femtocell vs. Picocell

9. ADVANTAGES AND DISADVANTAGES OF FEMTOCELLS

(a) Advantages for Users

1. Better indoor coverage: Wall penetration loss is a reason for the weakening of the signal, which arrives from Macrocells at indoors. Hence, femtocells are a good low cost option.

2. Lower transmission power at home: Both phone and the base station are now indoors, thus they do not require transmitting with higher transmitting powers.

3. Increased phone battery life: The HeNB receiver is at indoors, the UEs do not require transmitting at higher forces to reach a better reception quality. Hence, this increases phone's battery life.

4. Easy installation: The femtocells are plug and play devices; the users for installation and operation require no technical knowledge.

(b) Advantages for Operators

1. Higher data rates: The users subscribed to the Mobile Network Operators (MNO) receive higher data rates from femtocells depending on their broadband connection through Local IP Access.

2. Increased Network capacity: Traffic offload from macrocells provides better network capacity and it contributes for a slower maturation of the backhaul costs.

3. **Increased Revenue**: MNOs can place special tariffs for calls taken through femtocells. This likewise depends on the pricing policy of the manipulator.

(c) The Disadvantages of Femtocells

1. Interference: This is the main problem of using femtocells is that they interfere with the nearby macro users as easily as other femtocell users if it's under co-channel deployment.

2. Quality of service: If the femtocell shares the home backhaul connection for data traffic with other equipment such as internet shopping and gaming consoles, this might bear upon the caliber of service that it offers to the Femto users. Some QoS differentiations as well as link reservation for Femto traffic can be given at the subscriber backhaul equipment.

3. Spectrum accuracy: Femtocells are low cost devices. It is hard to get a very slowed down its standards for spectrum accuracy for femtocells from its later standards starting from Release 8.

4. Equipment location: Base stations usually find their fix from the Global Positioning System (GPS). GPS most of the time is unable to find locations indoors due to low signal quality that happens because of high wall penetration losses.

10. FUTURE SCOPE

1. Corporate sector:-Future target are provide to preliterate corporate office ensuring employees full access high quality voice and fast mobile data.

2. Integration:-A feature addition to set of box or integrated with a DSL modem.

3. Public access:-Femtocell may begin to preliterate in coffee shops, malls, railway station, hospital and other hotspot.

4. Services:-Home automation, sms alerts, application etc.

5. Highway safety:-In future femtocell use to highways and provide better coverage. Deploy the femtocell in every vehicle and connected with GPS mention the location and distance to other vehicles to alerts then help of this reduce the accident probability.

11. CONCLUSION

In this thesis work, an overview of Femtocell has been undertaken. Femtocell is consider an aim of digital India has to connect with digital communication network anywhere, anytime, anyone. However, the people live in different types of geographical areas, such as mountain, desert, plane, forest and some people face environment problems so they cannot connect any communication network. Therefore, the Femtocell is a unique solution of this problem and Femtocell installation cost is very low and easily install according to Macrocell site. This thesis focuses on digital communication network provide to in every location. So deploying the femtocell through a (DSL, optical fiber etc.) also faced the some problems such as technical issues and challenges, therefore it can resolving the help of literature survey. Femtocell is use in both indoor/outdoor locations and provides a better cellular coverage area for few of users. Then multiple number of femtocell interference with each other creates a Metro-Femto scenario, it can provide a better cellular coverage for large number of active mobile phone and improve quality of services (QOS). Metro-Femto concept is very useful in office buildings, residential area, rural area and Metro city. The femtocell connected with macrocell, microcell and any nearly cellular site, it can connect through broadband, optical fiber and satellite. Further, the use new standards Home eNode B (HeNB) is a LTE-A (long term evolution-advanced) in femtocell, it is today top on higher data rate standards. So LTE-A system used in femtocell scenario for higher data rate provide to femtocell user and operator. In this thesis, work on many concepts and ideas for provide to higher data rate, better coverage and quality of services (QoS) in every location.

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