# INTEGRATING FEMTOCELLS WITH INTERNET PROTOCOL MULTIMEDIA SUBSYSTEM

**BY**

**RAPHAEL WAMBI AGONG**

**ADMIN no: 15/00973**

**MASTERS OF SCIENCE IN DATA COMMUNICATIONS**

**November, 2017.** **A dissertation submitted in partial fulfilment of the requirement for the award of masters of Science in data communications in the graduate school/faculty of computing and information management at KCA University**

**November, 2017**

# TABLE OF CONTENT

## CHAPTER FIVE TESTING AND DESIGN

# DECLARATION

I declare that the dissertation is my original work and has not been previously published / produced or submitted for award of any degree. I further declare that the materials herein written have not been published by other people except where reference is made and the author is duly acknowledged.

Signature ………………………………date…………………………….

I do here confirm that I have examined this master dissertation of

**Raphael Agong**

And certified that all revision cited by the examiners and the recommendations have been adequately addressed

Signature ……………………………. date………………….

Dissertation supervisor

**ACKNOWLEDGEMENT**

The knowledge presented in this dissertation encapsulates the directions given to me by my supervisor and classmates; therefore, I highly appreciate them. I also acknowledge my sponsor for the course and the friendly lecturers, professor Gatheri, professor William Ddembe, Professor Patrick Ogao, Mr. Samwel Matende , Dr Alice Njuguna , Mr Peter Main among others.

Their work and dedication worth mentioning here in the dissertation

God bless you all

**ABSTRACT**

*The functionality of IMS was to work with wireless access technologies and other network coverage like macro cell, microcells and Femtocells. The trend of next generation networks' evolution is towards providing multiple and multimedia services to users through ever present networks. The aim of IMS is to integrate mobile communication networks and computer networks. The internet protocol subsystem (IMS) is a framework that was specified for the 3G mobile network to provide internet protocol telecommunication services. It supports multiple access types like GSM WCDMA, CDMA2000 or Wireless Fidelity (IEEE802.11). A Femtocell allows service providers to extend service coverage indoors or at the cell edge, especially where access would otherwise be limited or not available. The Key functions of IP multimedia subsystem (IMS) are to introduce enhanced features like signal initiation protocol [SIP] (a protocol that has been devised for establishing, managing and terminating session on IP networks) in the fixed and AD HOC network infrastructures.*

*The poor lose of signals in a an enclosed building forces communication to drop. Poor signals may be  caused by poor building materials. There is no study that have been performed to addresse this problem  adequatly. This study is to solve signal drops due to poor building material by integrating femtocell with IMS.Use of Femtocells will greatly increase network capacity, coverage area, support high speed data rate and utilization of power. The focus of the study is to improve wireless signals indoors by using a Femtocell integrated with IMS. This will improve services, network capacity among other things for users and operators. Integrating a femtocell with IMS architecture will maintain the signal levels to a point that communication will not be dropped. Femtocell will improve signals by about 10% both TX and RX in an average distance of 10M between the ME and Femtocell.*

**Key words:** *Femtocell, UMTS*, Communication network, 3G, mobile core network, Broadband Router, HNB**.**

## 1.09 ABBREVIATIONS

ADC --------analogue digital converter

AEC --------authentication equipment centre

AUC --------authentication unit controller

BTS ---------base terminal service

BSS ---------basic service set

BTS ---------base transmitter station

CDE --------core distribution and edge

CDMA----- code division multiplex access

DTE-- -----data terminal equipment

ESS--------extended service set

EDGE ----enhanced data

ETSI-------European Telecommunications Standards Institute (ETSI)

ER--------Electronics Resource

FAP------Femtocell access point

GPRS-----global positioning radio service

GSM-----global subscriber mobile

GMSC ----global mobile subscriber circuit

GSN------Global Positioning Radio Service support node

HLR-----home location register

HSCSD----high speed circuit switched data

IJNGN ------International journal on next generation networks

JPEG-------joint picture engineering group

MSC-------mobile subscriber centre

NGN------next generation network

NASS-----Network Attachment Subsystem

PSTN-------public service telephone network

QoS---------quality of service

RACS ----- Resource and Admission Control Subsystem

SGSN-- ----signals of GSM service network

TISPAN----- Telecommunications and Internet converged Services and Protocols for Advanced Networking

UMTS---- universal mobile for telecommunication services

VLR----- visitor location register

WCDMA— wavelength code division multiplexes access

WiFi------- Wireless fidelity

WiMax----- wireless interoperability microwave access

List of figure and tables

# CHAPTER ONE

## INTRODUCTION

### 1.01 OVERVIEW

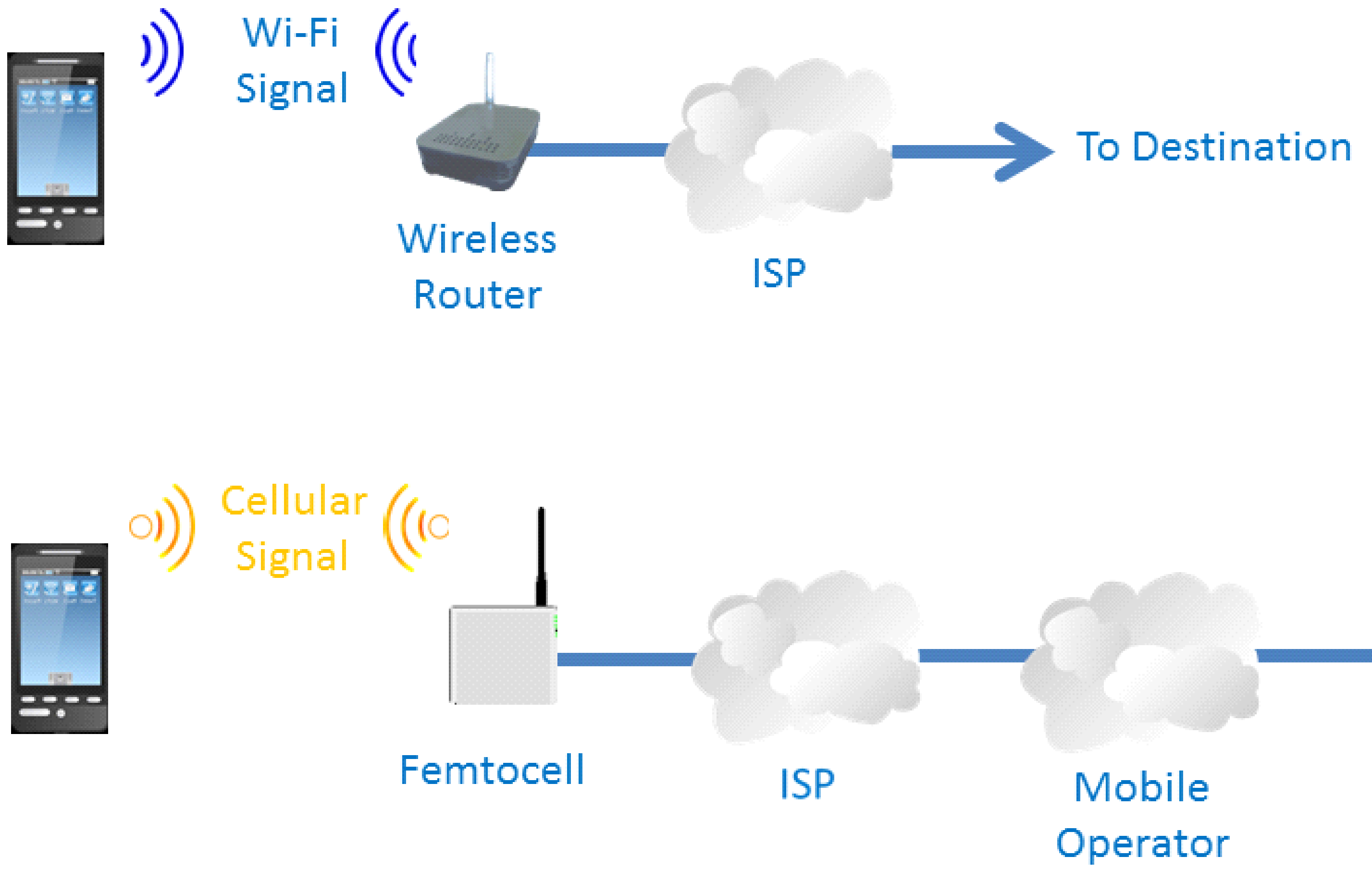
A Femtocell is an electronic equipment that can be used as a small cell site to improve communication services indoors. It allows service providers to extend service coverage indoors or at the cell edge, especially where access would otherwise be limited or unavailable. Femtocell improves the quality of service to customers by ensuring that calls are not dropped during communication. Implementation of Femtocells will benefit both the mobile operator (service provider) and the consumer (user) (lee, 2015), (Rao, 2011).

There are other equipment that can do the same as femtocell. The advantage of the femtocell over other technologies that serve the same as femtocell are:

- Femtocell are more upgradable or scalable to adapt other technologies like DSL
- The cost of femtocell is relatively cheaper than other technologies.
- A FEMROCELL base station, usually referred to as a femtocell, provides integration with other technologies like IMS while other has not been proved to do the same.
- Femtocell can be used as a base station for individual use in a small coverage area.

Imagine a device that can provide high quality cellular phone reception within a home, allowing user unlimited voice and data usage for a low monthly fee (cameron, 2014). A femto base station, usually referred to as a femtocell, provides all these and more. This small wireless device, which improves local wireless coverage when placed in a home or office, is poised to dramatically change the wireless infrastructure landscape (cameron, 2014) . Figure 1 illustrates the femtocell concept. While traditional base stations provide wide area coverage, a femtocell provides wireless coverage in a small area such as a residence. The femtocell routes mobile traffic to the network through the user’s broadband Internet connection, thus offloading traffic from the radio network  (cameron, 2014). The femtocell improves the capacity of the network, while reducing backhaul, power, and maintenance costs for the operator. It also enables operators to compete for services in homes that have limited signal coverage. In exchange for a subsidized femtocell, the operator adds an additional fee to the customer’s monthly cellular plan  (cameron, 2014). When in the femtocell zone, all mobile usage would be covered under the home billing plan, allowing unlimited voice and data usage in the home without incurring large monthly bills. The proximity of the femtocell enables a high quality link, while simultaneously reducing handset battery usage. The femtocell overcomes the limitation of 3G signals from the base station to penetrate walls, enabling high-speed access to mobile data services such as browsing the Internet, downloading music, and streaming video on the handset. Basically, a Femtocell is electronics equipment that can be used as a small cell site to improve communication services indoors. It allows service providers to extend service coverage indoors or at the cell edge, especially where access would otherwise be limited or unavailable.

Figure 1 (cameron, 2014)




Femtocell improves the quality of service to customers by ensuring that calls are not dropped during communication. Implementation of Femtocells will benefit both the mobile operator (service provider) and the consumer (user) (lee, 2015), (Rao, 2011).

### 1.02 Background of the research

The continuous change in technology forces the user of the technology to be conversant with the way the new technology works. This doesn't happen before the component is in the telecommunication market. The user realizes that he/she doesn't know how to use or control the equipment when it is already in the market. This forces the user to do a lot of trial and error method learning how to use the technology leave alone maintaining it.

New telecommunication services and related telematics applications are the strongest drivers of the modern technology (Chang, 2010). They pose new need to network construction and how issues that emerge may be solved.

Technological innovation, stimulated through digitization (a phenomenon realized by most countries in the world) and mobile communication has been a major factor in driving change in the communication sector (Narkhede, 2014).

When a new technology is implemented within a new generation in communication sector, a set of network design architecture, protocol and traffic related mechanism need to be invented. As an example, when 3G services come to the market, the mobile communication facilities couldn't be used with the new network service (3G) and this follows with the 4G (Melvi Ulvan, 2010). Mobile cellular and also 3G networks normally acquire poor penetration and reception in certain areas, like indoors. This decreases the quality of voice and video communication and slows down high-speed services.

Major concerns are the integration of multimedia subsystem which is an architecture integrated with Femtocell which is a technology (Arkas, 2015). Some of these concerns include calls being dropped, no network coverage, especially in enclosed places. Notwithstanding the fact that cellular technology has a weakness in providing services especially indoors, a call may be dropped or no services may be available within a residential area or business place. A Femtocell can improve these services in such areas by connecting the mobile equipment signal to the internet through a DSL or Cable line (lee, 2015). The major requirement for a Femtocell used to be a broadband channel but this study may prove that IMS may replace a broadband channel. Such innovation is necessary to reduce cost especially in home call charges, produce excellent indoor coverage and enhance the capability of the mobile network.

## 1.03 PROBLEM STATEMENT

Wireless signals are strongly attenuated indoors leading to call dropping or poor call quality (Rao et al, 2011). The causes of poor signal are categorized into two.

The localized and the geographical. Localized poor signals are caused by building materials and destructive interference. The geographical are due to distance and obstacles between the cell phone and the cell site (fourezian, 2008).

The geographical ones are solved by installing Repeaters or signal regenerators depending whether the signal is analoge or digital.

Poor signals caused by poor building materials have not been addressed adequatly. This study is to solve signal drops due to poor building material by integrating femtocell with IMS.

Use of Femtocells will greatly increase network capacity, coverage area, support high speed data rate and utilization of power. The focus of the study is to improve wireless signals indoors by using a Femtocell integrated with IMS. This will improve services, network capacity among other things for users and operators.

## 1.04 AIMS

The main objective is to improve wireless signals strength and achieve good network capacity indoor by using a Femtocell integrated with IMS.

## 1.05 SPECIFIC OBJECTIVES

i. Identify a technology that can improve wireless services indoors.
ii. Outline the Integration of a technology and an architecture
iii. Define the interfaces in the integrated network of Femtocells and IMS
iv. Test and validate the integrated network of Femtocell and IMS

## 1.06 CONTRIBUTION

This study has to come up with a design of a network that includes a technology and an architecture for the benefits of improving network capacity, low power consumption, reduction in home call charges, excellent indoor coverage, and improved quality of service. This has to be approached in two ways.

### Scientific approach

The use of IMS is crossing the boundaries of mobile network and fixed line technologies because IMS has no mobile specific, it has no boundaries in implementing any technology (microcells, macro cells and in particular the Femtocells) (Ulvan et al, 2010). Although a broadband internet connection was the only pre-requisite for connecting a Femtocell. Femtocell enables encryption for all voice calls and data sent or received by the mobile phone. This makes it impossible for an external user to break into a user's network (Narkhede, 2014). Since a Femtocell operates at very low radio power, battery life is high. To a standard 3G cellular phone, the Femtocell appears as another cell site or macro cell when the mobile phone is used outdoor. This was because of multiple services which were required by the user (lee, 2015).

Femtocell can be modified to integrate other technologies like IMS to improve service delivery especially in wireless communications. It has a microprocessor unit that can be modified especially its port implementation to match the desired results

### Industrial approach

Due to the impact of IMS on telecommunication industry (wired and wireless) the use of IMS is widespread as fixed line providers are also being forced to find ways of integrating mobile or mobile associated technology into their system. This will improve network services and capacity in mobile communication, giving benefits to operator and the customer (Chang, 2010). Services of the wireless signal which get attenuated indoors are greatly improved. In order to ensure customer loyalty and satisfaction, with a view to improving signal strength in restricted areas, wireless operators need to come up with an efficient solution for them (operators) and the customer.

## 1.07 SCOPE AND LIMITATION

Traditional Fixed Mobile convergence [FMC] requires use of dual mode (MiFi) handsets but with Femtocell, ordinary cell phones can be used for FMC. One of the most considerable advantages of Femtocell for the wireless operator is that by directing home mobile calls on the internet, operators can free of charge up the wireless network this study highlights implementation of Femtocell to achieve these advantages. The study also explains the deployment of Femtocell networks embedded into macro cell to improve the coverage, capacity and quality of service indoor environments. This study also explains how IP Multimedia Subsystem (IMS) which is the overlay architecture for session control in all-IP Next Generation Networks (NGNs) using the Session Initiation Protocol (SIP) for signalling can be integrate with a Femtocell.

# CHAPTER TWO

# LITERATURE REVIEW

This chapter explains the current position of the state of the art concerning cellular technology and the critics of the literature review.

## 2.01 STATE OF THE ART

Cellular Technology enables mobile communication because they use a complex two-way radio system between the mobile unit and the wireless network (Srinivas, 2012).

It uses radio frequencies (radio channels) over and over again throughout a market with minimal interference, to serve a large number of simultaneous conversations (Srinivas, 2012).

This concept is the central tenet for cellular design and is called frequency reuse.

Most frequency reuse plans are produced in groups of seven cells (Srinivas et al, 2012).

There are numerous seven cell frequency reuse groups in each cellular carrier.

Higher traffic cells will receive more radio channels according to customer usage or subscriber density. What happens when I moved out of a cell coverage area or move into another cell area?

Another requirement of the wireless system is frequency agility.

This is the ability of the mobile unit to operate on any given frequency within their assigned spectrum. This allows the mobile unit to switch from one channel to the other seamlessly and allows for another important component of cellular technology –Call Hand-Off. Without Call Handoff, Frequency Reuse would not be possible and vice versa.

The Mobile Switch Center (MSC) monitors the power levels of the mobile units. When the MSC detects the mobile unit power levels degrading it seeks out other BTSs.

Base station coverage overlap with other cells in the area and it is this overlapping that allows call handoff to occur.

Base station coverage overlap with other cells in the area and it is this overlapping that allows call handoff to occur. This action is handled by a microprocessor at the MSC and is seamless to the user. This is a complex act that uses frequency synthesizers, the controller, and memory functions within the wireless handset. This is why cellular phones must have frequency agility or the ability to change from one channel to another.

**Fundamental Components of a Wireless System**

There are five main components to a wireless network the Mobile Unit, the Cell Base Station, The Backhaul or Fixed Network, The Mobile Switching Center, The interconnection to the Public Switched Telephone Network (PSTN)

There are two classifications of mobiles units in use today when we speak of cellular telephones and mobile devices.

## 2.02 THE MOBILE UNIT

The Portable telephone or device –these are your small handsets, portable devices with network connection capabilities such as PDA's and GPS units.

The Mobile telephone or device –devices that are mounted in the locomotion device, such as installed telephones and GPS units.

## 2.03 THE CELL BASE STATION

The Cell Base Station is the physical location of some of the equipment needed to operate the wireless network, such as antennas, GPS timing systems, cell towers etc.The size of the base station is dependent upon its location and system needs. Microcells –An outdoors network base station usually on rooftops, water tanks and the like. The Base Station range of a Microcell is generally 100 meters to 1000 meters. Pico cells –the smallest, usually used indoors and intended to provide coverage for a small area. The Base Station range of a Pico cell is generally less than 100 meters.

## 2.04 THE MOBILE SWITCHING CENTER

Often called the brains of a wireless network, the MSC is responsible for switching data packets from one network path to another. This process is called call routing.

MSC provides subscriber service information such as user registration, authentication, and location updating.

The MSC provides connection to the Public Switched Telephone Network (PSTN) and the Integrated Services Digital Network (ISDN) using SS7 based interconnection (Corella, 2014).

The MSC provides subscriber management functions such as, Mobile registration, Location updating, Authentication

## 2.05 CALL ROUTING TO ROAMING SUBSCRIBERS.

These functions are carried out by various databases, among which are the Home Location Registry (HLR), the Visitor Location Registry(VLR), Equipment Identity Register(EIR) and the Authentication Center(AuC) in GSM. HLR is a database that contains records of all subscribers. HLR is used to identify and verify a subscriber on the network. The record of what service the subscriber has is kept here. HLR connects and interacts with a number of other components on the system and the Gateway MSC for handling incoming calls.

The VLR for handling request from mobile phones attached to the network and the SMSC for handling incoming SMS (fourezian, 2008).

The voice system for delivering a notification to the mobile phone that a message is waiting. In theory, the HLR data is stored for as long as the subscriber is with the mobile phone operator. The HLR is a system that directly receives and processes Mobile Application Part (MAP) transactions and messages. If the HLR fails, the system fails. The HLR manages the Location updates as mobile phones roam. The HLR is now a powerful server more so than telephone switch hardware (Liu, 2016).

## 2.06 VISITOR LOCATION REGISTER

The storage of information about mobile devices currently under the jurisdiction of the MSC is done by VLR. Most important is the current Location Area Identity or LAI. LAI identifies under which BSC the Mobile Station is currently operating on.

Relevant data stored there are;

1. IMSI –the subscriber's identity number
2. Authentication Data
3. MSISDN –the subscriber's phone number

GSM services the subscriber has access to Access Points (GPRS) that are subscribed to and the HLR address of the subscriber.

The VLR also connects to:

The Visited MSC (V-MSC), to pass data needed for certain procedures i.e., authentication and call setup. The HLR to request data for the mobile phones attached to its service area. Other VLR to transfer data as the MS roams from one area to the next accessing new VLRs.

## 2.07 GATEWAY MANAGEMENT SWITCHING CENTER

The GMSC provides the interface with the Public Switched Telephone Network or PSTN

In order for mobile units to connect to landline users there must be a system in place to achieve these goals. This is completed by having a physical connection to the PSTN (the local land-line phone company). This is done by the use of a data system known as the PDSN or Public Data Switched Node. There are other forms of connection such as the Asynchronous Transfer Mode or ATM and TCP/IP connections.

## 2.08 FEMTOCELL IMPLEMENTATION AND OPERATIONS

In order to ensure customer loyalty and satisfaction, with a view to improving signal-strength in restricted areas, mobile operators needed to come up with an efficient solution to them and the customers. The deployment of Femtocells was one such solution. Femtocells are small base stations installed in residential areas (Arkas, 2015). They are similar in size to a router and offer excellent signal coverage indoors, thereby reducing the load on the external macro cell. In order to avail the features of a Femtocell, a user must have an internet broadband connection. This broadband connection is a pre-requisite and it is imperative that a Femtocell remains a simple plug-and-play device, as a complex installation process is likely to prevent users from adopting it. When the user enters their home, the Femtocell will detect the mobile handset and vice versa, and a connection will be established. All calls are then made via the Femtocell. This technology is being tested by mobile operators around the world and is thought to be the technology that will revolutionize cellular communication around the world.

However, unlike Wi-Fi, Femtocells operate in the licensed spectrum. In most countries, mobile operators are allotted three, licensed 5 MHz frequency bands (Rao, 2011).

In order to maintain customer satisfaction and maximize profits, operators need to utilize these bands intelligently and efficiently. Since both Femtocells and macro cells are required to operate in these limited bandwidths, there is interference.

## 2.09 OPERATION OF THE FEMTOCELL

The Femtocell enables encryption for all voice calls and data sent or received by the mobile phone. This makes it impossible for an external user to break into a user's home network. To a standard 3G cellular phone, the Femtocell appears as another cell site or macro cell, hence communicating with it as it would with a macro cell, when the mobile phone is used outdoors. Since Femtocells operate at very low radio power levels, battery life is high.

Also, as the distance between the Femtocell and the mobile handset is short, call quality is excellent.

The mobile operator's telephone switch and data switch communicate with the Femtocell gateway in the same way as for other mobile calls. Therefore, all services including phone numbers, call diversion, voicemail etc. all operate in exactly the same way and appear the same to the end user. The connection between the Femtocell and the Femtocell gateway is encrypted using IPSec, which prevents interception. There is also authentication when the Femtocell is installed for the first time to ensure that the access point is a valid one. Inside the Femtocell are the complete workings of a mobile phone base station. Additional functions are also included, such as some of the RNC (Ulvan, 2010)

(Radio Network Controller) processing, which would normally reside at the mobile switching centre. Some Femtocells also include core network element so that data sessions can be managed locally without needing to flow back through the operator's switching centres.

The extra capabilities of a Femtocell demand it to be self-installing and self-configuring. This requires considerable extra software which scans the environment to determine the available frequencies, power level and/or scrambling codes to be used, thereby increasing complexity to a certain extent. This is a continuous process to adapt to changing radio conditions.

## 2.10 FEMTOCELL RADIO TECHNOLOGIES

The most commonly used implementation of the Femtocell, makes use of the 3G (Ulvan, 2010) UMTS standard. However, other radio technologies are also being tested with Femtocells and could be successfully launched in the near future. The most commonly used radio technologies are: (Ulvan et al, 2010)

**a. GSM**

The most commonly used wireless technology, GSM accounts for 85% of the current mobile market share. GSM cell sites are termed as picocells rather than Femtocells because they are not auto-configuring. They require the operator to get these cell sites up and running for use (Ulvan et al, 2010).

**b. UMTS**

This technology is an evolution of GSM; hence it is also known as 3G. It was derived from GSM by replacing the standard GSM radio sub-system, with one based on the CDMA technique. It offers a much larger capacity as compared to GSM and also requires a lesser number of cell sites.

UMTS networks are usually used in combination with GSM technologies (Ulvan et al, 2010)

**c. High Speed Packet Access (HSPA)**

This is an improved version of UMTS obtained by increasing coding on radio transmissions, thereby improving throughput to a large extent. They provide data rates of up to 21Mbits/sec.

They work satisfactorily with UMTS equipment. However, new handsets would be required to take advantage of the high data rates provided by HSPA (Rao, 2011).

**d. Code Division Multiple Access (CDMA)**

This standard grew in popularity at its launch but did not achieve the global assimilation that was expected of it. The first phase of CDMA was termed '1xRTT', an efficient technology for voice and text services (Rao et al, 2011).

**e. Long Term Evolution (LTE)**

This is a joint undertaking by GSM and CDMA vendors in order to develop a common standard for mobile communications. This is a 4G standard and is capable of achieving data transfer rates of up to 100 Megabits per second. It uses the orthogonal frequency division multiplexing (OFDM) scheme, in order to tackle issues such as multi-path propagation (Rao et al, 2011).

**f. WiMAX**

This is a standard that is used to provide wireless broadband services in regions where it is infeasible to set up fixed telephone systems. It makes use of OFDM technology and is the biggest competitor to the LTE system mentioned above. It supports data rates of up to 75 Megabits per channel, making it an excellent alternative for Femtocell implementation (Rao et al, 2011).

## 2.11 FEMTOCELL INTEGRATION INTO THE UMTS ARCHITECTURE

UMTS is a third generation (3G) mobile communications technology which is also being developed into 4G. Many solutions have been proposed in order to provide a smooth transition from the second generation GSM system to a third generation. Therefore, UMTS is sometimes marketed as 3GSM, emphasizing the close relationship with GSM and differentiating it from competing technologies. The UMTS architecture is composed of three major domains: User Equipment, UTRAN and the Core Network (Ulvan et al, 2010).

**a. User equipment (UE)**

The user equipment domain is assigned to a single user. It consists of functions that are required for the user to access the various UMTS services. This domain includes User Subscriber Identity Module (USIM) and mobile equipment domain. The Subscriber Identity Module (SIM) contained within the USIM, performs functions related to encryption and user authentication. The user equipment also consists of the actual end device itself. All necessary user interfaces and radio transmission modules are located here (Ulvan et al, 2010).

**b. UTRAN**

The UTRAN consists of the various radio interfaces and also handles cell level mobility. It comprises several radio network sub-systems (RNS). A NodeB is used to control several antennae, making a radio cell. The UTRAN is connected to the user equipment via the Iu interface and to the core network via the Iu interface. Each RNS is controlled by a radio network controller (RNC). The functions of the UTRAN include: Congestion control, Encryption and decryption, Code allocation, Handover control, Management

**c. Core Network (CN)**

The core network contains functions for inter-system handover, gateways to other networks (fixed and wireless). It also performs location management if there is no dedicated connection between UE and UTRAN. The core network is a combination of circuit-switching and packet switching elements. The circuit-switched elements include GSM components such as mobile services switching centre (MSC), gateway MSC (GMSC) and Visitor Location Register (VLR).

The packet-switched elements include GPRS components such as gateway GPRS support node (GGSN) and serving GPRS support node (SGSN). Thus, the infrastructure of UMTS enables cellular operators using GSM, to switch over easily to UMTS since there is reuse of components, thereby saving money and resources. However, the standard UMTS architecture cannot sustain the addition of a Femtocell. There are a few modifications made to the standard UMTS architecture in order to accommodate the integration of a Femtocell. The new essential network elements in the revised UMTS architecture are the Femtocell, itself, known here as the 3G Home NodeB (HNB), the 3G Home NodeB Gateway (HNB GW), Security Gateway (SeGW) and the 3G Home NodeB Management System (HMS) (Ulvan et al, 2010).

FEMTOCELL IN UMTS ARCHITECTURE

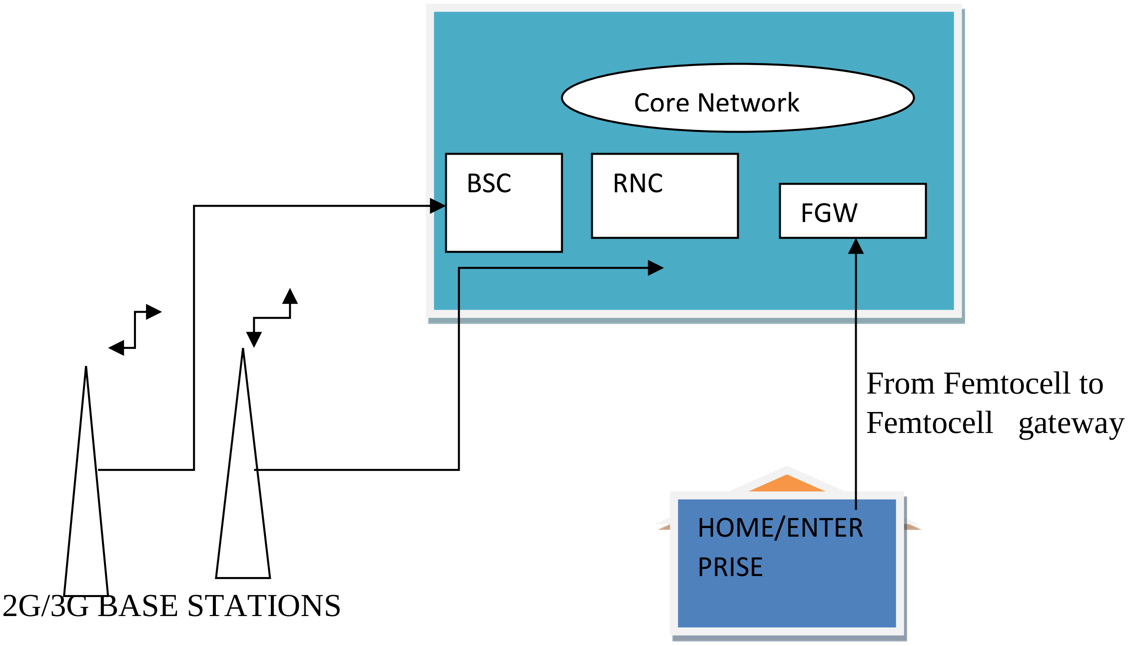



Figure 1 Femtocell deployments (Rao et al, 2011)

### Home NodeB

The 3G Home NodeB (HNB) is the device that is installed in the user's premises, serving as a Femtocell. The HNB is able to operate with 4 to 8 existing UEs and offer them the same services as if they were operating under a regular NodeB. The device is low cost and relatively small in size and can be installed in the user's home, office or a location he/she chooses. The operator has no exact control of the location. The HNB is powered from the user's electric network using most likely, an external power adapter (Ulvan et al, 2010).

### Home NodeB Gateway

The Home NodeB Gateway (HNB-GW) is the device used to connect the HNBs to the UMTS network. The HNB-GW concentrates connections from a lot of Femtocells. The new Iuh interface is used between HNB and HNB-GW. HNB-GW is connected to the CN using the standard Iu interface and the network sees it as a standard RNC. The HNB-GW can be located anywhere on the operator's premises (Ulvan et al, 2010).

### Security Gateway

The Security Gateway (SeGW) is a logical element which can be physically implemented separately or as an integrated solution with the HNB-GW. SeGW acts as a firewall between the operator's core network elements and the public internet (Ulvan et al, 2010).

### Home NodeB Management System

The Home NodeB Management System (HMS) uses an interface based on the TR-069 standards widely used in DSL modem and DVB set-top-box management and updates. The management system sends the configuration data to the HNB and helps the HNB in HNB-GW and SeGW discovery. It can also initiate HNB software updates and perform HNB location verification (Ulvan et al, 2010).

## 2.12 INTERFERENCE ISSUES IN FEMTOCELLS AND INTERFERENCE MITIGATION

Although the growth of the Femtocell could see a sharp rise in the popularity of cellular phones, there are still concerns regarding interference between Femtocells and the external macro cell as well as similar such devices. Since the Femtocell and the macro cell operate in the same range of frequencies, there is bound to be interference. The main problem of interference arises from the fact that Femtocells are installed in an ad-hoc manner, or independent of the structure of the cellular network. One simple solution discussed, was for the Femtocell to operate on a different carrier frequency with respect to the macro cell. However, this solution is not simple to implement since most mobile operators are allotted a fixed spectrum to provide their services, as mentioned earlier. To find an effective and logical solution to any drawback of femtocells, the Femto-forum has been organised which involve in conducting research into mitigating the problem of interference in Femtocells. In the 3G architecture, most operators are allotted 2 frequencies for use. So, interference could also be reduced by allowing Femtocells to transmit on the unused second frequency. However, this still does not resolve interference that may arise between two Femtocells that operate on, say two floors of a building. This scenario may also affect the quality of service and capacity of each individual Femtocell. Another alternative suggested (Narkhede, 2014), was that mobile operators to implement a two-tier Femtocell network, by sharing spectrum rather than splitting spectrum between the two tiers.

As per studies conducted by the Femto-forum, the main forms of interference that arises in Femtocells are mentioned below:

**Femtocells interfering with base-stations on the same frequency:** a large number of Femtocells operating on the same carrier frequency may increase the load on the overlaying macro cell, thereby reducing the capacity of the entire network (Srinivas, 2012)

**Femtocells interfering with each other:** if there are multiple Femtocells operating close to each other, they produce a level of background noise that reduces the quality of service of each Femtocell (Srinivas et al, 2012) (Ulvan et al, 2010).

**Cell phone signals received by both, macro cells and Femtocells:** In some cases, when a mobile phone connects to a Femtocell, the signal strength is strong enough to be received by the surrounding macro cell as well. This leads to a level of noise at the macro cell, which is beyond its tolerable level to be received. All the scenarios mentioned can lead to degradation of the capacity of the overall network, thereby reducing the quality of service offered by the network. On account of the different types of interferences that arise in Femtocells, different techniques must be implemented in order to bring down interference to acceptable levels. One such technique has been suggested in (Chang, 2010). Chandrasekhar and Andrews have developed an architecture that helps in limiting cross-tier interference between Femtocells and macro cells.

This helps in increasing the uplink capacity for a shared spectrum network.

**Adaptive Pilot Power control:** The Femtocell detects transmission signals from other devices around it and accordingly adjusts its own transmission signal power while still maintaining its coverage area.

**Dynamic receiver gain management:** for satisfactory operation, there must be some sort of automatic gain or attenuation adjustment in Femtocells. This will enable the user equipment to operate without increasing their transmitting power beyond a certain extent, thereby keeping the levels of noise and interference to a minimum (Chang et al, 2010).

**Mobile phone uplink power capping:** this technique places a limit on the maximum power output of the mobile phone in the Femtocell environment. This allows the mobile phone to perform a hand-over to the macro network without increasing the transmission power to a level where it adds noise to the macro network (Chang et al, 2010).

**Extended dynamic range for Femtocell receiver:** In order to ensure that the Femtocell operates with maximum efficiency in the presence of high-power mobile phones connected to the macro cell, its receiver must have a very high dynamic range (Chang et al, 2010).

## 2.13 A NETWORK OF THE FUTURE (IMS)

Services with Low rate high latency data will co-exist with services of high rate low latency real-time multimedia applications in the next generation networks.

When the volume of multimedia increased the flow in an environment with heterogeneity in bandwidth, propagation medium and statistical characteristics of traffic can be expected to generate time-varying demands on the quality of service (QoS) and network resources. The support for heterogeneity in services, participating network devices and transportation medium is driving the evolution of the next generation communication networks (IMS) (Ulvan et al, 2010). The traffic in IMS is required to be supported on relatively unconstrained computer as other personal devices that may be constrained by power, processing capability and bandwidth availability.

The traffic or the load is increasing in volume and gives dynamical statistical behaviour (Tripathi, 2015). The real-time traffic such as voice, video or other multimedia services are driven by different quality of service (QoS) requirements that may also differ with equipment implementing it. The QoS constraints can be expected to vary with time.

A research paper on challenges in design on IMS shows that contemporary networks are based upon the concept of a hierarchical three tier architecture comprising of Core, Distribution and Edge (CDE) networks (Tripathi, 2015). The core network is typically supported over wired or fibre-optic connections. Distribution and edge networks are a heterogeneous combination of wired, wireless and/or free-space optical links connecting end-users to the core network. The input traffic from all end-users is collected by the edge network and then forwarded to the distribution network. Several such distribution networks feed the traffic to the network core. In the reverse direction, the distribution network takes the input from the core and distributes the traffic to the intended users connected to the edge network. Such a hierarchical architecture is pervasive in today's networks and can exist at several levels. At global level, an optical core can pervade across several continents and nations. At national level, a core network may connect several cities. At an organizational level, for example, in a university, the core network can feed several functional units such as campuses or colleges. The end users for the core network in each case may vary depending upon the level of the core and distribution network of interest. At the organizational level, end user pool may comprise of individual users. For a national or global level core network, the end-users may be the Internet service providers (ISPs) or organizations with inter-continental/international presence.

The architecture of the network consists of three tiers as shown in figure 1

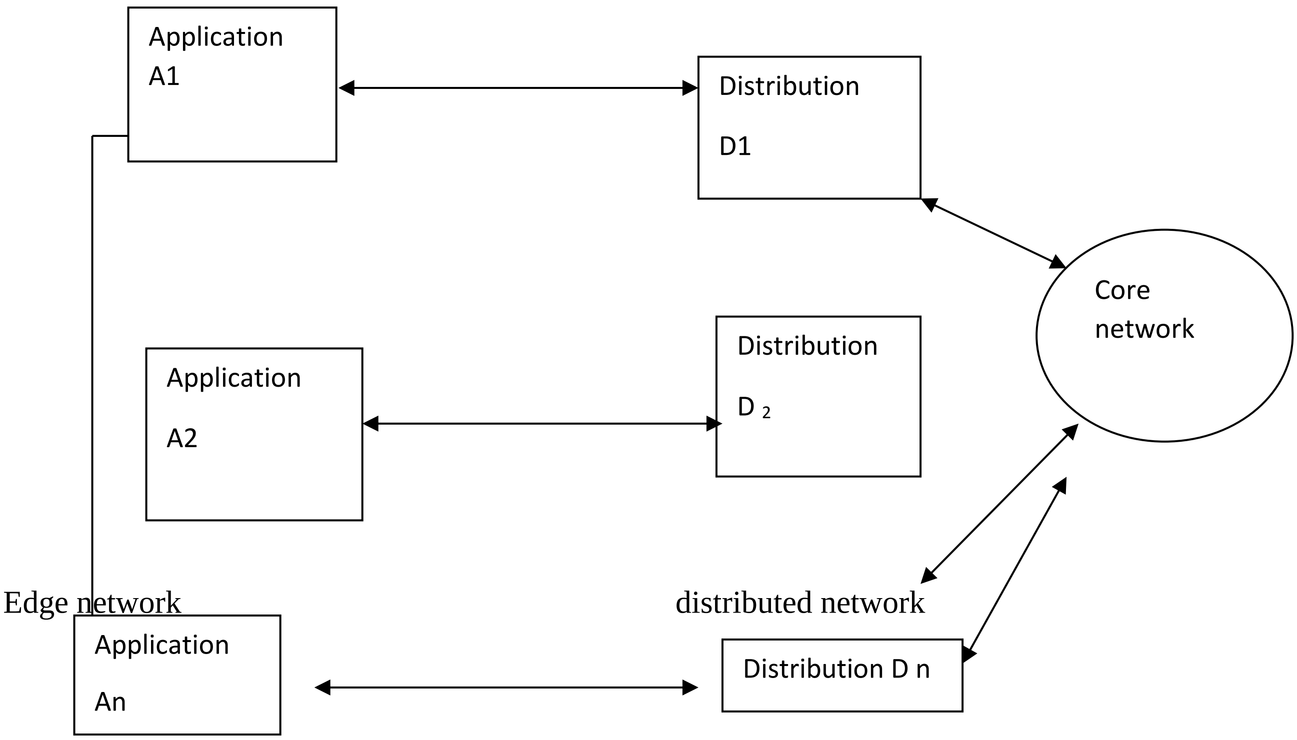



**Figure 2**

IMS as a convergence of communication networks which tries to reduce costs and offers integrated services via a common IP Technology backbone. IMS as a convergence of communication networks which tries to reduce costs and offers integrated services via a common IP Technology backbone. IMS includes three advantages: layered structure, standard interfaces and multi-service. IMS functions are in several layers: access, transport, control and application. Mobile communication networks also contain several generations which are based on circuit switch, packet and their mixed systems. The intention is to include mobile networks and connect it to IMS via mobile media gateways and common backbone (Ulvan et al, 2010) .

## 2.14 TECHNOLOGIES USED TO IMPLEMENT IMS NETWORKS

IMS was established in order to merge all the communication networks toward IP technology and users widespread access to the network and its integrated services.

Increasing growth of Internet users and their improved Quality of Service demands made the service providers to offer IMS deployment. Integrating IMS with femtocell in individual network is to allow all services such as voice, data, mobile and video will be offered in a single path. It is also capable to provide such new high data rate services as moving pictures and also reducing service costs for users. Internet and its capabilities have resulted in new IP based services. New fixed and mobile service integrations have resulted in IMS deployment (Srinivas et al, 2012)

**IMS is defined as:**

A concept for integrating network of telecommunications carriers that would facilitate the use of IP for packet communication in all known forms over wireless or landline. It is the architectural framework for delivering IP multimedia services.

The cost of network services will be reduced if IMS is implemented in a backbone protocol with fibre. This is because fibre being fast and has new service creation and adaptability.

The capability of controlling QoS of the relevant services offered and the applicability of the services offered in both fixed and wireless networks together with centralized management of the whole network are also defined by the IMS. The above capabilities need a vast traffic volume in the forward link and backhaul. Cost of capacity increase in the backbone by E1/T1 has been evaluated up to 25% of capacity of the total network cost ( Srinivas et al, 2012).

IMS is deployed on the three bases, layered Structure, standard interface and multi-service and deployed in the access, transport, control and application layers (Chang, 2010). Soft switch is an intelligent node in the IMS application layer that controls call admission and session for telephony and multimedia services. In the layered structure we can optimize each layer independent of the other layers. IMS architecture provides itself change and scalability features and also provides flexibilities which reduce the service creation time. Each layer relates to the next layer by the standard interfaces which enables the service provider to provide various services and extend IMS coverage for the network. Contrary to customary networks which have been developed for only one service type, IMS multiservice property enables the service providers to offer various services (Srinivas et al, 2012).

## 2.15 MOBILE TELEPHONY AND MOVING TOWARDS IMS

The 3G radio frequencies based on 3GPP and UMTS standards were granted by the European countries since the year 2000 and was done gradually in phases (Srinivas et al, 2012) (Ulvan et al, 2010).The cellular technology was implemented in phases (Zhiang, 2010)

Phase one: is based on second generation GSM and circuit switching technology and is very similar to PSTN and includes the limitations that PSTN has in data transmission (Fig. 2). As we see a customary mobile network include AUC, HLR, BSC, BTS, SC/VLR, GMSC and EIR nodes which are interconnected via hierarchical digital links. GSM was originally designed for speech and not for data transmissions. The basic user data rate in GSM is 9.6 kbps and is suitable for only a limited numbers of data services. The GSM data rate can be enhanced with High Speed Circuit Switched Data (HSCSD) technology in which multiple traffic channels can be allocated to one user. With HSCSD the user data rate can be up to 64 kbps. One of the drawbacks with HSCSD is that used channels remains allocated during the session even if no data is transmitted (Arkas et al, 2015).

Phase two: is constituted of 2.5 generation of GSM and GPRS. It includes both circuit switch and packet switch systems. Data rate is 171kbps in this technology. It is also connected to the data network through GPRS support Node (GSN) which is constituted of two GGSN and SGSN nodes

Figure 3 below show the deployment.

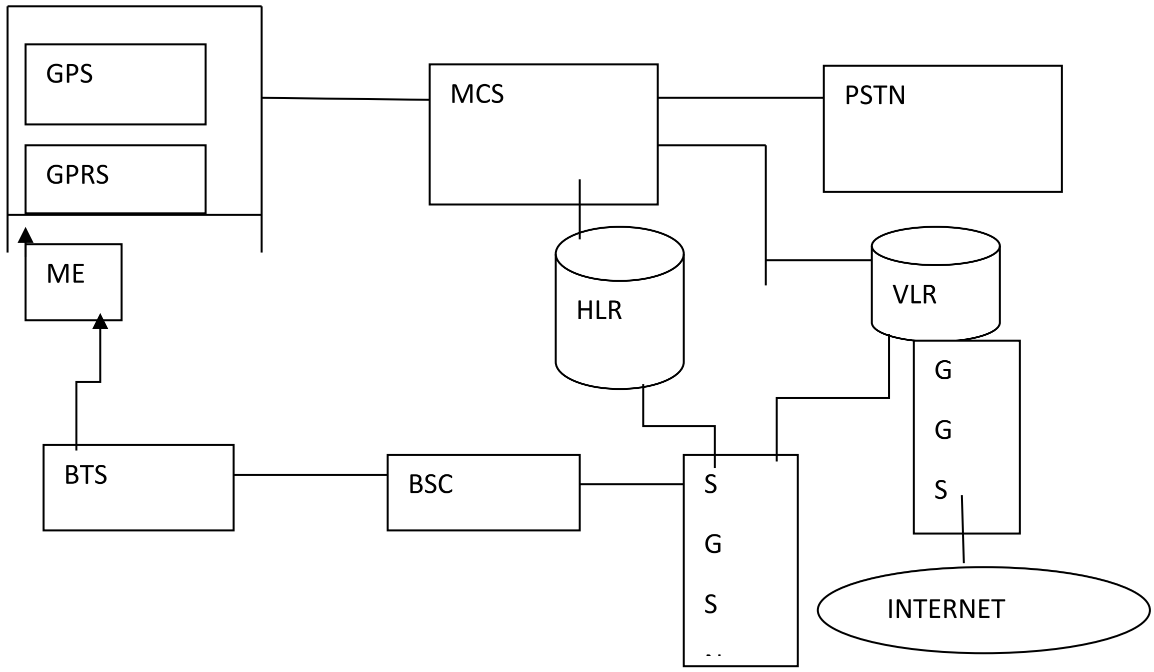



**Figure 3 is a** GSM and its GPRS deployment

Figure two above shows that:

1 With GPRS, the possibility for volume based charging opens up i.e. a user will only pay for the actual amount of transmitted data and so the packet switching is more suitable for busty traffic like interactive Internet services in this technology

2 Enhanced Data rates for Global Evolution (EDGE) systems have the same configurations but as result of some additional variations in the physical layer are capable to carry data rate of 384kbps (Ulvan et al, 2010).

Phase three: Third generation is deployed based on 3GPP and is called UMTS. Release 99 of UMTS has been deployed in separate packet and circuit switch systems. But the only difference with the previous generations is in its radio interface.

Release 5 and later releases of UMTS are all based on a common IP backbone.

It is further explained that, Network operators experience much voice calls but they don't earn much money from them, on the other hand, although operators don't earn revenue from data services but most of them agree with the next wireless technologies (such as 3G, WLAN and WiMax) developments. Data services occupy wider spectrum than the voice services (Ulvan et al, 2010) (Ulvan et al, 2010).

There is stiff competition facilitated by opening up of telecommunication market. Large telecommunication operators have played a role in the process of convergence that promoted new market players that have moved rapidly an in unpredictable way adopting different market models from traditional telecommunication firms. VOIP is a clear example of such services, disrupting traditional markets, pushing towards adoption of next generation networks and facilitating convergence. Internet service providers started offering VoIP as a cheaper way to communicate over the Internet. Services were offered on a "best-effort" basis by third parties, over any Internet connection. Today the market for VoIP services is varied, with network access operators providing VoIP as a replacement for PSTN voice telephony, often guaranteeing access to emergency services, or a certain QoS. Internet service providers continue to offer access to VoIP services from multiple platforms and from anywhere in the world. Mobile VoIP is also emerging, either as a service provided by the network operator or as an application that can be downloaded on any Wi-Fi enabled handset. Initiatives, such as Google's '*Android*', are likely to put pressure on existing mobile operators to charge flat rates for mobile Internet access, thus eventually increasing the degree of substitutability between mobile and fixed Internet access (in terms of price rather than speed) (Corella et al, 2014).

**Table1. Converged environment based on all IP**

| IMPLEMENTATION OF NETWORKS | PURPOSE, CONTROL, BAND AND USER |
|---|---|
| Telecommunication environment Next-generation converged environment | Single purpose networks Multi-purpose networks |
| PSTN, cellular, broadcast IP network (providing voice, video and mobile services) | Narrow-band Broad-band |
| Vertical silos Destroys compartmentalization | Traditional boundaries between industry segments (e.g., telephony, |
| cable TV, broadcasting, wireless) are blurring-need to re-think market | definitions (product definition and geographic boundaries definition) |
| Network-service link New services and content developed independently of the network | Operators control services to end users Increased consumer control |

**(Ulvan et al, 2010), (Kanalikova, 2010)**

## 2.16 TELECOMMUNICATION AND NEXT-GENERATION CONVERGED ENVIRONMENTS

A growing number of operators are also focusing on mobile content, in particular on the possibility to download music, or access applications and online services from a mobile device. The possibility to provide video content over IP is often seen as a new way to propose content to users, and as an opportunity for network operators to enlarge the range of services they offer to their customers.

Content services, especially those over managed IP networks, have still not exploited their full potential. In most cases, access to content is offered in a form very similar to traditional broadcasting, with defined timetables, geographical distribution, rigid copyright schemes, a very low degree of interactivity, and a traditional billing scheme although a number of operators are now beginning to offer more flexible programming with video on demand and distribution of video content from popular Internet sites.

These developments also increase the need to communicate, and the demand for symmetric communications.

Although the extent and effects of such convergence are yet to be seen, the phenomenon is already challenging the existing remit of many sector–specific domestic regulations. For example, the impact of convergence on competition is likely to be mixed. On the positive side, the move towards next generation networks, able to deliver a wide range of communication services, creates a schism in many traditional market definitions. While in the past telecommunication companies only offered fixed-line voice, and policy makers could easily define the specific market and make regulatory decisions, today the convergence of video, voice and data on next generation broadband networks can lead to more competition in individual markets for each of these services. As a result, convergence touches the telecommunication, cable television and broadcasting sectors, and involves a wider range of activities at different levels, going from manufacturers of terminal equipment, software developers, media content providers, ISPs (jia, 2005)

## 2.17 BRIEF OUTLINE OF NEXT GENERATION NETWORKS

There is a significant amount of work underway in standardization forums on IMS, at the policy level although there is a still not complete agreement on a specific definition of

“IMSs”. The term is generally used to depict the shift to higher network speeds using broadband, the migration from the PSTN to an IP-network, and a greater integration of services on a single network, and often is representative of a vision and a market concept. IMS is defined by the International Telecommunication Union (ITU) as a “packet based network able to provide services including telecommunication services and able to make use of multiple broadband, QoS enabled transport technologies and in which service related functions are independent from underlying transport-related technologies.” IMS offers access by users to different service providers, and supports “generalized mobility which will allow consistent and ubiquitous provision of services to users” (jia et al, 2005). IMS, also defined as “broadband managed IP networks” that includes next generation “core” networks, which evolve towards a converged IP infrastructure capable of carrying a multitude of services, such as voice, video and data services, and next generation “access” networks, i.e. the development of high-speed local loop networks that will guarantee the delivery of innovative services.

## 2.18 IMS ACCESS NETWORKS

IMS access networks is usually specific to investment in fibre in the local loop, i.e. fibre replacing copper local loops and are able to deliver next generation access services – i.e. an array of innovative services, including those requiring high bandwidth (voice, high-speed data, TV and video). However, while next generation access networks tend to refer to a specific technological deployment, there are other technologies which can compete in providing some of the services which it is envisaged to be provided by IMSs. There are also other technologies which may not be able to fully compete with IMS access networks in terms of capacity (Ulvan et al, 2010)

The different technologies available include existing copper networks upgraded to

DSL, coaxial cable networks, power line communications, high speed wireless networks, or hybrid deployments that uses light and any of these technologies (lee et al, 2015).

Fibre, in particular for point-to-point development, is often described as the most "future proof" of network technologies to deliver next generation access, there are likely to be a number of alternative and complementary options for deployment of access infrastructures by incumbent telecommunications providers, and new entrants.

Considering Cable television (CATV), operators have begun to upgrade their infrastructure to hybrid fibre copper (HFC) allowing for bidirectional traffic and using DOCSIS technology to increase network capacity (maphis, 2005).

These developments are allowing CATV companies to offer voice and Internet access (data services) in competition with telecommunication companies which through their offer of Internet TV (a type of multimedia system) have begun to compete with CATV companies. Offering data and voice services, in addition to television, helps cable companies to differentiate their product offering from satellite providers. The bandwidth provided by cable networks, using DOCSIS 3.0, will allow for 160 Mbit/s downstream and 120 Mbit/s upstream for end-users (maphis et al, 2005).

## 2.19 BROADBAND WIRELESS ACCESS:

Broadband wireless access **(**BWA) technologies aim at providing high speed wireless access over a wide area. Certain early fixed wireless access technologies, such as local multipoint distribution service (LMDS) and multi-channel multipoint distribution service (MMDS), never gained widespread market adoption. WiMAX technologies, – the IEEE 802.16 set of standards that are the foundation of WiMAX certification, and similar wireless broadband technologies, are expected to address some of these shortcomings, and fill market gaps left by wired networks, or compete with wired access providers. The WiMAX Forum has estimated that new WiMAX equipment will be capable of sending high-speed data over long distances (theoretically 40 Mbit/s over 3 to 10 kilometres, in a line-of-sight fixed environment). When multiple users are connected, capacity sharing will significantly reduce speeds for individual users sharing the same resource (Rao, 2011).

Wi-Fi (or wireless fidelity) refers to wireless local area networks that use one of several standards in the 802.11 family. Wi-Fi allows LANs to be deployed without cabling for client devices, typically reducing the costs of network deployment and expansion. Due to its affordability, scalability and versatility, its popularity has spread to rural and urban areas. Wi-Fi range is usually limited to about 45 -12 m indoors and 90 m outdoors; however, Wi-Fi technologies can also be configured into point-to-point and point-to-multipoint networks in order to improve their range and provide last mile solutions in fixed wireless broadband access. One way to serve remote areas which cannot be reached with WiFi and WiMAx technologies is with wireless “mesh” solutions. They often include a satellite backhaul connection through Very Small Aperture Terminals (VSAT), usually coupled with wireless technologies such as Wi-Fi. This combination allows access to telecommunication and data services even to more remote areas, although with limited bandwidth (Rao et al, 2011).

Terrestrial wireless services offer the opportunity to deploy competing access infrastructure.

However, they may offer different service characteristics to fixed-line services in terms of coverage, symmetry, scalability and speeds. These networks may be less suitable to deliver sustained high bandwidth connections for larger numbers of users, or for high bandwidth applications, such as High Definition TV on demand. In addition, wireless service deployments are constrained by frequency spectrum availability (Rao et al, 2011).

## 2.20 BROADBAND OVER POWER LINES (BPL)

Use of the power grid as a communications network, or "power line communications" appears to provide a series of advantages, offering not only voice, but also broadband services, with the connection speed not dependent on distance from the telephone exchange (as with DSL) or number of customers connected (as with cable). With this system a computer (or any other device) would need only to plug a BPL "modem" into any outlet in an equipped building to have high-speed Internet access, notwithstanding the benefits that the availability of an extensive infrastructure that can be allowed. For the moment, the service provision is far from standardized, and the capacity of bandwidth provided through BPL is still being questioned (lee et al, 2015).

## 2.21 3G MOBILE NETWORKS

The term IMS frequently encompasses some kind of fixed-mobile convergence (FMC), as it allows the transition from separate network infrastructures into a unified network for electronic communications based on IP, which facilitates affordable multiple business models, seamlessly integrating voice, data and video (Narkhede, 2014). The introduction of 3G technology supports the transmission of high-speed data with speeds theoretically reaching 2 Mbits to 4 Mbit/s (Arkas et al, 2015). This will provide higher data speeds to users enabling them to access innovative networks dedicated to provide mobile video or television programming scheduling. However, existing 3G technologies will need to be upgraded in order to support very high bandwidth or extensive concurrent usage that may be demanded by users in the future. The future evolution of mobile networks, for example, using LTE technology (Long Term Evolution), which is a next generation mobile technology, may significantly increase data speeds, enabling high peak data rates of 100Mbit/s downlink and 50Mbit/s uplink (Arkas et al, 2015)

## 2.22 SATELLITE NETWORKS

Satellite services are typically dedicated to direct-to-home television and video services, satellite radio, and specialized mobile telephony uses. More recent technological advances such as spot beam technology and data compression algorithms, have enhanced the technical efficiency in satellite communications thus enabling more efficient use of frequency spectrum, and reduced redundancy. It has resulted in increased effective data density and reduced required transmission bandwidth. Satellite broadband is usually provided to the customer via geosynchronous satellite. Ground-based infrastructure includes remote equipment consisting of a VSAT antenna with an indoor unit. Gateways connect the satellite network to the terrestrial network (Narkhede et al, 2014). The common way of presenting information is by text. Text and a combination of graphics can be used to communicate a concept or an idea. Factors that influence the textual communication are typeface, font and style, kerning (It refers to adjustment of the space between two characters), anti-aliasing (the technique of making the edges of characters smooth), animation, special effects, special characters and hypertext. While dealing with text in multimedia, it is very important to note that, it is not by all means the only mode of communication. In multimedia, text is most often used for titles, headlines, menus, navigation and content (Narkhede et al, 2014).

## 2.23 CRITICS OF THE LITERATURE REVIEW

The introduction of the Femtocell cellular network and the mobile user equipment analyze the specialty of the network and the improvement of signals indoors. Unsatisfactory coverage will be a thing of the past if Femtocells are integrated with IMS. There are several driving forces in this but two major ones are: the increasing number of high data rate coverage. Femtocells have the potential to provide high quality access indoors to UE at low cost, improved coverage and huge capacity. These benefits were not in the literature review and they form the basis of this study.

## 2.24 LITERATURE SUMMARY

The review shows that a lot of research has been done pertaining to wireless signal improvement outdoor. The UMT architectures explained in the literature review are circuit switched and packet switched architectures. This study however, approaches the issue of improving wireless signals indoor using IMS architecture. This architecture is a dynamic technology which gives it ease of integration.

Literature review in this study emphasizes on the wireless communication outdoor and implementation of Femtocell with broadband network not with IMS.

The integration of Femtocell with IMS architecture is not mentioned in the literature. This study however, highlights this implementation with more references from journals and books.

Satisfactory coverage, network capacity will be realised with this technology and the integration with IMS. Several driving forces in this study include increasing number of high data rate coverage. Femtocells have the potential to provide high quality access indoors to User Equipment at low cost, improved coverage and huge network capacity. These benefits form the basis of this study.

# CHAPTER THREE
# RESEARCH METHODOLOGY

## 3.0 INTRODUCTION

According to Creswell 2002 explanation, Research methodology refers to methods and technique employed during research in the area of data collection, analysis and presentation of the finding.

The major role of research methodology as used in this research is to assist in achieving the objectives of the Femtocell integration with IMS. The aim of this integration is to specify certain communication problems indoors, their scope, and solution to call drops and achievements after integration with research limits maintained.

This study used a Simulation as a method of social research. The *target* as Doran and Gilbert 1994; Zeigler 1985 calls it, aims at creating a model which is simpler to study than the target itself. The conclusions drawn about the model will also apply to the target because the two are sufficiently similar. However, since my modelling abilities are limited, the model will always be simpler than the target. The target here is the integration of Femtocell with IMS which is always a dynamic entity, changing over time and reacting to its environment.

## 3.01 EXPERIMENTAL RESEARCH METHODS

The research method used in this study is experimental research method that implement simulation. Simulation is used here as a tool to achieve experimental research.

Simulation means 'running' the model forward through (simulated) time and watching what happens. Whether one uses an analytical technique or simulation, the initial conditions, that is, the state in which the model starts, are always important. Often, the dynamics are very different depending on the precise initial conditions used (Dooley et al, 2012). Simulation research method is growing in popularity as a methodological approach for organizational researchers. Other research methods must make various assumptions about the exact cause and effect nature of the system under study. If other methods answer the questions “What happened, and how, and why?” simulation helps answer the question “What if?” Simulation enables studies of more complex systems because it creates observations by “moving forward” into the future, whereas other research methods attempt to look backwards across history to determine what happened, and how

### 3.02 TYPES OF SIMULATION RESEARCH TOOL

There are three main types of simulation practice: Discrete event simulation this involves modelling the organizational system as a set of entities evolving over time according to the availability of resources and the triggering of events. System dynamics, which involves identifying the key “state” variables that define the behaviour of the system, and then relating those variables to one another through coupled, differential equations. Agent-based simulation, which involves agents that attempt to maximize their fitness (utility) functions by interacting with other agents and resources; agent 3 behaviour is determined by embedded schema which are both interpretive and action-oriented in nature (dooley et al, 2012). Simulation help the study to compare both the existing state of the unit under study and what is in place. It helps to answer what if ?

### 3.03 WHY SIMULATION RESEARCH TOOL

The selection of Simulation research method for this study is derived by its simplicity and therefore, it does not work in all three domains. Axelrod (1997) outlines seven different purposes of simulation in the social sciences as prediction, performance, training, entertainment, education, proof, and theory discovery. In this study, the selection of simulation is due to its purpose on training and performance.

### 3.04 RESEARCH ANALYSIS

The analysis consists of two steps: first, I will consider whether the model generates predictions that have some similarity to the data that have actually been collected (this is typically assessed by means of tests of statistical hypotheses); and second, the measures the magnitude of the parameters (and perhaps compares their relative size, in order to identify the most important among other alternatives.

Feasibility study carried on October 2017 show that:

1. Femtocell were used in DSL only
2. Femtocell have a microprocessor which is 8 bits internal and 16 bits external [that allows it to adapt a connection to other 16 bits external and internal systems]

The research of this study was conducted using information provided by the consumers using the wireless technology indoors. Several research papers from various conference and journals were chosen for this research. Upon analyzing each paper, different implementation of Femtocell was found especially based on broadband utilization. The researcher also spent time observing different media behavioral changes with different bandwidth usage in order to gather firsthand information on implementation of Femtocells.

## 3.05 VALIDITY AND RELIABILITY

The above methods applied were achieved through information sharing i.e. from books and journals involving multi-disciplinary teams with different approach, experience and viewpoints that will validity different parts of the research. Also incorporating different tools and research techniques for data collection and analysis; and gathering different sources of information on the same research topic. Industries have developed a range of implementation strategies to improve signal quality in the industrial manufacturing plants. This has not been done by the industrial network users but by the service providers. The service providers will take their plight first because the service providers are keen on profit making. Some industries have developed a system that can improve signals outside but not inside.

## 3.06 DESIGN AND IMPLEMENTATION

In the development and implementation, the aim is to accomplish the integration of Femtocell with IMS. To successfully implement this integration, both vision and commitment from current implementation of Femtocell with broadband network and the service provider's authority since Femtocell work within the licensed spectrum, understanding of technology and systems operations is necessary.

## 3.07 TESTING AND EVALUATION

The design should prove if the study has met the objectives set. The criteria employed include: Setting up a system hoping it will work within the licensed band. As a system, it aims at assisting efficiency and effectiveness of other systems by permitting communications to work by the set standards. The tests carried out in this study is simulated with the test carried out by Rohde and Schwarz and released in their document published on January 2009 entitled Production Measurement on 3GPP WCDMA femtocells.

During Rohde and Schwarz test, the following are instruments used:

1 computer used as a remote controller for the signal analyzer and the femtocell chip board

2 Analyzer to analyze the test frequency results and the reference frequency.

3 Frequency generator to generate the reference frequency

4 A resistive divider

5 An attenuator

Two requirements are necessary for the integration: The interfacing to provide Port implementation, Buffering, Synchronization and Broadband network for the wide bandwidth data transmission with ability to simultaneously transport multiple signals and traffic types

## CHAPTER FOUR

## CONCEPTUAL DESIGN AND IMPLEMENTATION

### 4.0 OVERVIEW

The design of how a Femtocell operate and its implementation in the integration with IMS starts from the end user to the Femtocell then to the network (IMS) and through the macro cell which is outdoor equipment.

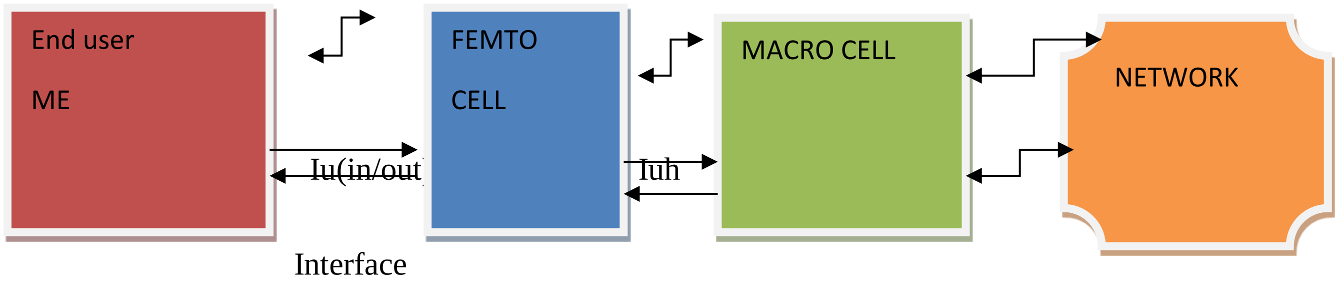



Figure 4 implementation of femtocell with interfaces

The A interface cannot be used here because it offers a port implementation between a Mobile Equipment and the BTS. This only happens if there are enough signals to offer this connectivity indoors. Such a situation never happens perfectly indoors and that is why a Femtocell is necessary.

From the above design, Iu interface is more appropriate (carter, 2015).

The increasing integration and interworking of networks and the changing from the existing discrete networks to networks with a high potential for interconnection and mobility is important specially to have well defined, flexible interfaces. A particular example of this is the interface between ad hoc networks and the core networks.

The interface between mobile access networks and core networks is generally referred to as the Iu (“Interface UMTS1”) or Basic Interface (carter et al, 2015).

The Iu interface is primarily an interface between radio (or satellite) access networks and core networks (carter et al, 2015).

When considering network integration in the long term, like using Femtocells, it is important that any solution allows not just interworking between different networks, but stable integration. It highlights the requirements that various networks put on the Iu interface, both from the access and the core side (carter et al, 2015). The way the Iu interface is defined strongly supports the re-use of existing resources, components, protocols and services as far as this study is concerned.

Requirements for the Iu interface can be described in terms of functions that need to send messages, voice and data through this interface. They are: Call Control, Mobility Management, Handover and Macro diversity, Radio Resources Management (carter et al, 2015)

It illustrates the role of the Iu interface based on UMTS. Although adaptation functions are necessary between existing core networks and the Iu interface, no adaptation function is needed between the UMTS core network and the Iu interface (carter et al, 2015).

According to carter and wes (carter et al, 2015) separating the radio dependent and independent parts in the access network, the difference between several radio access techniques (e.g. CDMA, TDMA) can be solved at the access network level to allow the Iu interface to be generic.

## 4.01 WHY IU INTERFACE?

UMTS network can contain a number of different entities, which need to receive and send control (or signalling) messages. The Iu interface needs to support the routing of these signalling messages to their destinations. There will be no single, unique structure of a UMTS network. UMTS environments will differ in the number of entities they contain, as well as in the way these entities are interconnected (carter et al, 2015). As a consequence, the way that the functions of the access network are distributed between these entities will vary. The Iu interface will have to support this flexibility and mobility. Mobile terminals should only be allowed to identify the type of functions they need to use in the network, rather than explicitly identifying a specific element of the network in which that function is implemented. The Iu interface should support generic function messages, while system specific messages should be terminated in the particular system (carter et al, 2015). Where several systems co-exist and interconnected, there is a need for a common basis for Communication between the systems. A good example of this is the Call Control functionality.

Generic Call Control messages like call set-up which are used in all types of systems must be supported by the Iu interface. This will also apply between Femtocell and the mobile equipment or Femtocell and the IMS network. The information contained within these messages has to be mapped onto a generic set of identifiers and elements (carter et al, 2015). Messages that are specific to a certain system (e.g. the DECTCC-INFO message) have to be terminated within that system, rather than be passed to systems which do not understand them and have no use for them (carter et al, 2015). The Iu interface should be aligned with GSM interface taking into account that GSM is currently a very widespread system and used outdoor and indoor.

## 4.02 CONTROL

The Iu interface should perform UMTS Bearer Control by re-using fixed Call Control functions. This is a typical opportunity for re-use explains CARTER AND WES. Bearer Control, what is needed is point-to-point connection capability. This is already offered, for example, by B-ISDN Call Control. The only modification needed is the introduction of suitable mobility parameters if needed for indoor and outdoor but for this study it is not necessary. The Iu interface should support separation between call and bearer control especially in a mobile call. Connections can change during the same call (handover). In this case, the bearer control may change, but there is no need to change the call control (carter et al, 2015). Another reason for such separation may reside in Radio Resource Management, e.g. for enhanced bearer capability. In this case many bearers could serve a single call, thus reinforcing the need for separate bearer and call control. The Iu interface should not only support user registration and location update but also domain update for changing networks. In UMTS it will be possible to, not only to change location in the same domain but also to change operator or network like from GSM to UMTS also must be supported by Iu interface (carter et al, 2015).

## 4.03 ARCHITECTURAL FRAMEWORK ISSUE

The migration towards IMS changes the architecture and topology of networks which potentially involves several structural changes, such as a reorganization of core network nodes and changes in the number of network hierarchy levels (Kanalikova, 2010).

The shift to IP networks also raises questions whether interconnection frameworks need to be revised or not and likewise to the protocol used.

### 4.04 Quality of Service ISSUES

IMS will be all-IP based and will have to provide guaranteed QoS to mobile terminals. QoS provisioning in a heterogeneous wireless and mobile networks will bring in new problems to mobility management, such as location management for efficient access and timely service delivery, QoS negotiation during inter-system handoff and frequency hopping (fourezian, 2008).

### 4.05 DESIGN OF USER TERMINALS ISSUES

The design of single user terminal that is able to autonomously operate in different assorted access networks will be another important challenge. This terminal will have to exploit various surrounding information (e.g. communication with localization systems and cross-layer with network entities) in order to provide richer user services (e.g., location/situation/context-aware multimedia services). This will also put strong emphasis on the concept of cognitive radio and cognitive algorithms for terminal re-configurability (Zhiang, 2010).

### 4.06 LOCATION AND HAND-OFF MANAGEMENT IN WIRELESS

Future wireless networks will be inherently hierarchical where access networks have different coverage areas. Mobility management in wireless overlay networks will pose a difficult challenge to solve. Design of efficient cross-layer-based approaches will be involved in developing new mobility management schemes. It has already been observed through research that cooperation between the network and link layers is able to improve the performance of mobility management in IP-based heterogeneous communication environment (Srinivas, 2012). Information from the link layer such as signal strength and velocity of mobile terminals may help the decision making of mobility management techniques at the network layer. In cross-layer optimization, how to cooperate, how tight the cooperation is, and how much information is to be exchanged between the two layers are possible IMS issues (Chang et al, 2010). Efficient use of spectrum, Fault-tolerance, availability of network services, enhanced security, intelligent packet and call routing, intelligent gateway discovery and selection protocol design and development of a unified protocol stack and vertical protocol integration mechanisms are some of the other important issues in next-generation networks (Srinivas et al, 2012).

## 4.07 UNDERSTANDING OF IMS

The general understanding of IMSs is now clear with the release of architecture and functional architecture of main components by European Telecommunications Standards Institute (ETSI). The three main aspects characterizing the IMS design are the packet-based networking, end-to-end multi-service QoS support and the separation of service and transport planes (Chang et al, 2010) (kingston, 2005). Replacement of circuit switching with packet switching enables IMSs provide services over multiple broadband transport technologies. This is also closely coupled with the QoS support for a wide range of services with different traffic types such as voice, data and video with different Service Level Agreements (SLAs). Finally, the separation of transport and service layers provides independence to service-related functions from underlying transport related technologies (kingston et al, 2005).

The current IMS design is shaped by the requirements of both the users and the providers. The user and provider shape up the IMS networks adding the requirements imposed by the trends in society, the pattern in the technological developments and the market conditions focused on transforming the traditional network into a customer-driven and service-centric network (Kanalikova et al, 2010). On the one hand, it is desired that the services are customized to allow the user enjoy services.

# CHAPTER FIVE

## TESTING AND FINDINGS

There is a mathematical model of the coexistence of a WiFi, WLAN and a Femtocell operating over a fully-utilized unlicensed band to derive the performance of each network in the unlicensed band (Liu, 2016). A Femtocell can adjust its channel usage and the impact to WiFi users by tuning its channel access parameters using the analytical tools to be developed in this section, therefore achieving a friendly coexistence with WiFi users. WiFi performance is measured by the total throughput of all WiFi nodes. Femtocell performance is measured by the fraction of time that a Femtocell occupies the unlicensed band. In the licensed band and considering the down linked transmission in wireless network, the study outlines a network with single wireless access point and single Femtocell base station in the simulation. In this study only the licensed spectrum will be considered.

There are only two assumptions made in this study section;

1. Femtocell control message during both channel access and data transmission phases are exchanged only in the licensed bands. Unlicensed band only convey data traffic. This assumption is made because licensed bands are more reliable than unlicensed band.
2. The fBS access the channel licensed and only at this point it will inform user equipment to turn on their unlicensed bands and operate on the channel otherwise there will be a problem on the channel utilization.

The study explains the simulation of the licensed band with the implementation of the IMS; the femtocell requires a significant protocol which can be installed as software.

The relevant protocol will be divided between HNB, HNB-GW and MSC thereby forcing the femtocell to incorporate the functionality of UE allowing the determination of the surrounding Macro cell.

## 5.01 EVALUATION

To evaluate the performance of the femtocell transmitted and received power to and from the MSC through the IMS, a practical test is done using simulation that involve:

1 A wifi technology and a mobile equipment.

2 A dummy load with impedance calculated from the parameters found at the time of the test

   a. Capacitance 6600uf electrolytic capacitor

   b. Voltage 33V DC

   c. Frequency of oscillation 3300hz

3 Modified ADF4602 and AD9863 boards – this is a chipset which has the capability of transmitting and receiving wireless signals at a short distance. The modification done here is changing pins that corresponds to the AD9863

The objective of this chapter is indeed the experimental analysis of the femtocells behaviour and performances from the view point of user's applications. The speed and ping test of the signals, when femtocell is included were verified because the facilities for these tests are available with Rhodes and Schwartz's Company that offered me to do the test and come up with results shown. The simulation for the test is done using the WiFi connection.

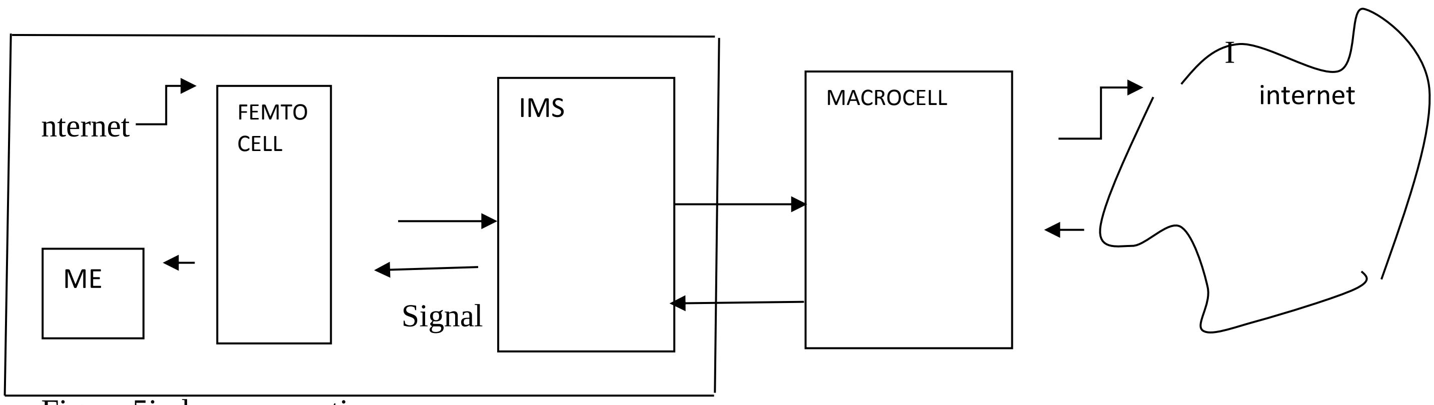



Figure 5indoor connection

INDOOR: Sometimes enclosed places can have poor signal [ perceived to have poor signal] which will bring call drops during conversation. In real situation the results are not exactly as the theory depicts because of loses due to intermodulation, noise, and the equipment calibrations.

Screen short from Rhodes and Schwartz's company taken on 15/10/2017

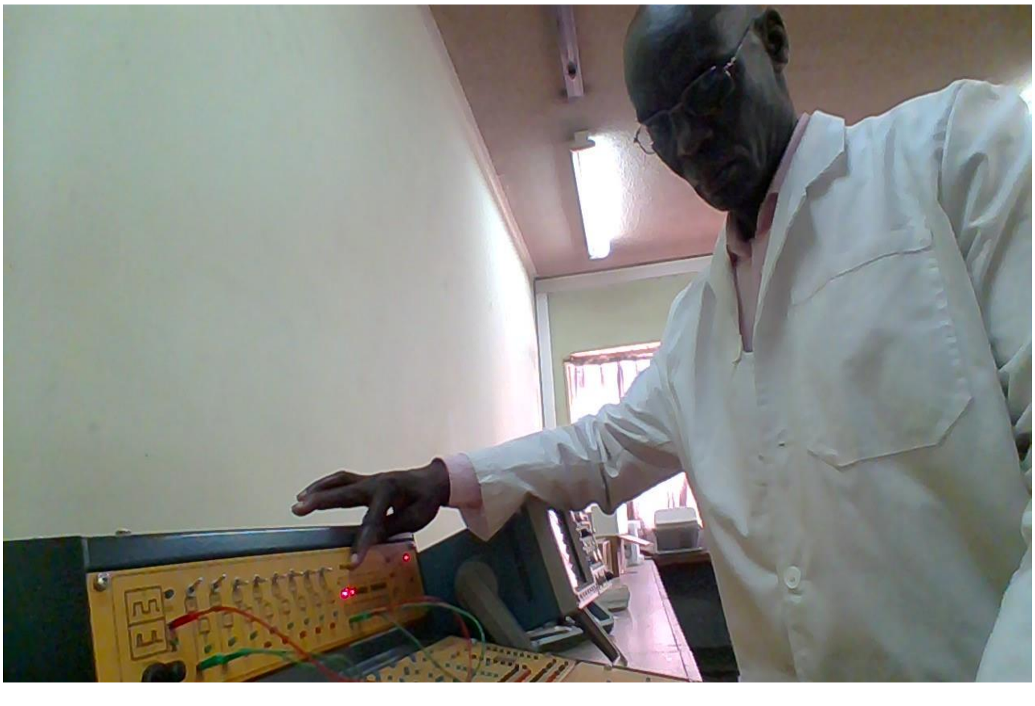
Picture 5.0

This is the lab for the analysis of the study to find how femtocell can be implemented to achieve objective 1 [identification of a technology that improve wireless service in door]

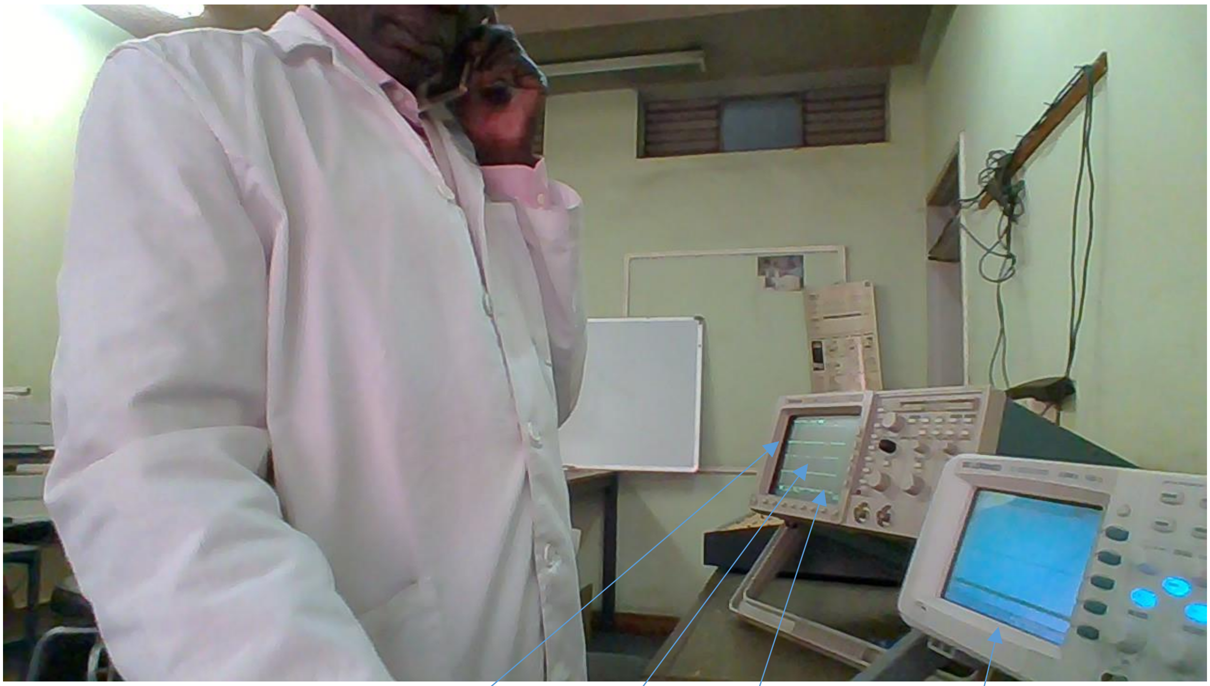
Microprocessor analysing system (MLAB 36458)

Picture 5.1 Femtocell analyser machine and microprocessor system connected to IMS network.

This is the machine used to analyse a microprocessor assembly language (from R/S)



Picture 5.2 Signal strength as displayed by the system. One light is for reception and the other is for transmission.



The oscilloscope displays: first line normal signal strength without femtocell

Second line and third signal drop or call drops during communication

Fourth line femtocell introduces and the signal strength improved

The digital oscilloscope showed results in digital format although the original signal is analogue.

This is to achieve objective two [outlining the integration of a technology and an architecture] picture  5.3 A femtocell module

Picture 5.4

Enlarged module of a femtocell and its amplification unit.

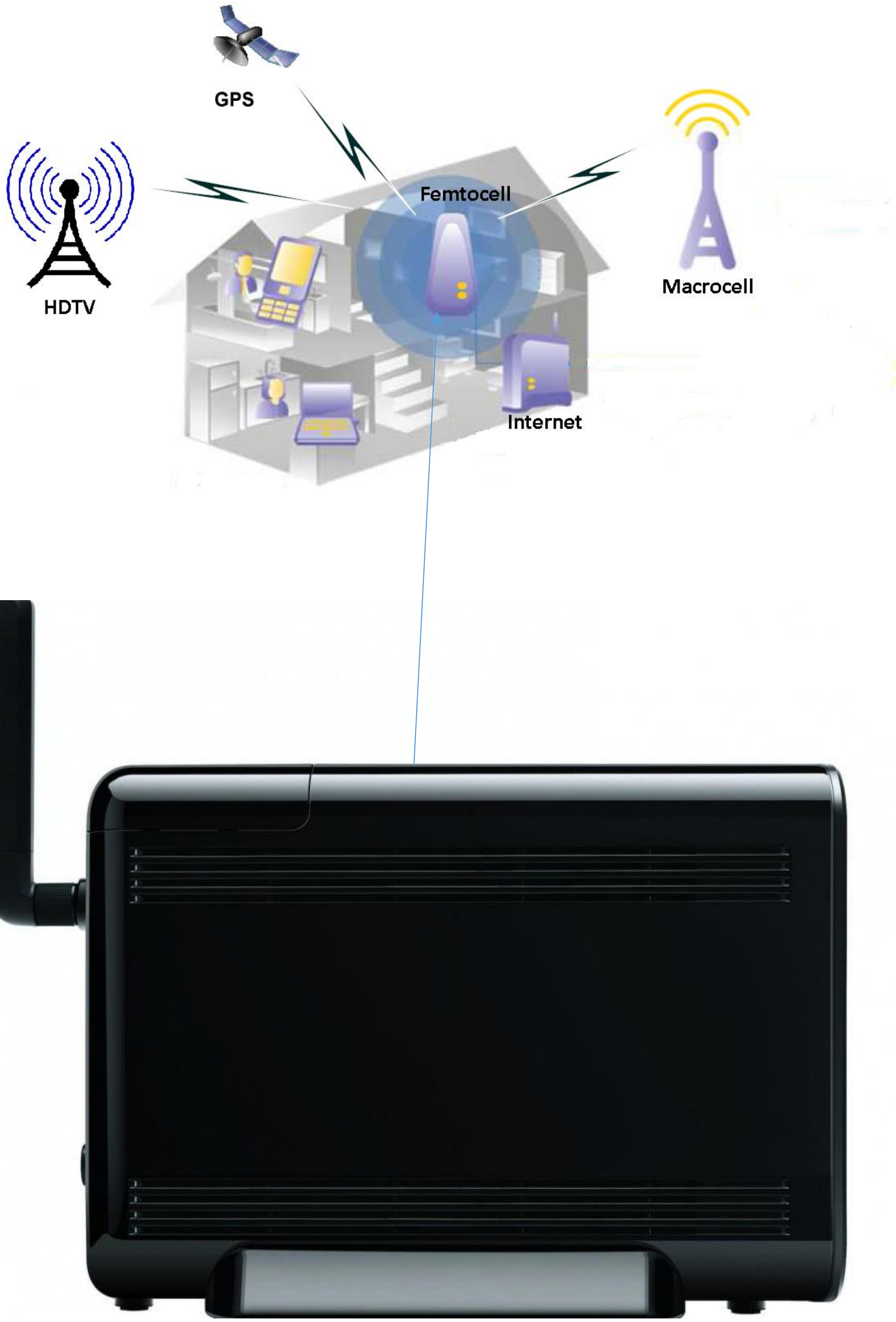
This picture is used to define an interface in the integration of network and a technology. Objective no three [defining the interface for IMS and femtocell]

Picture 5.5

Signal generator used to generate signals during simulation.

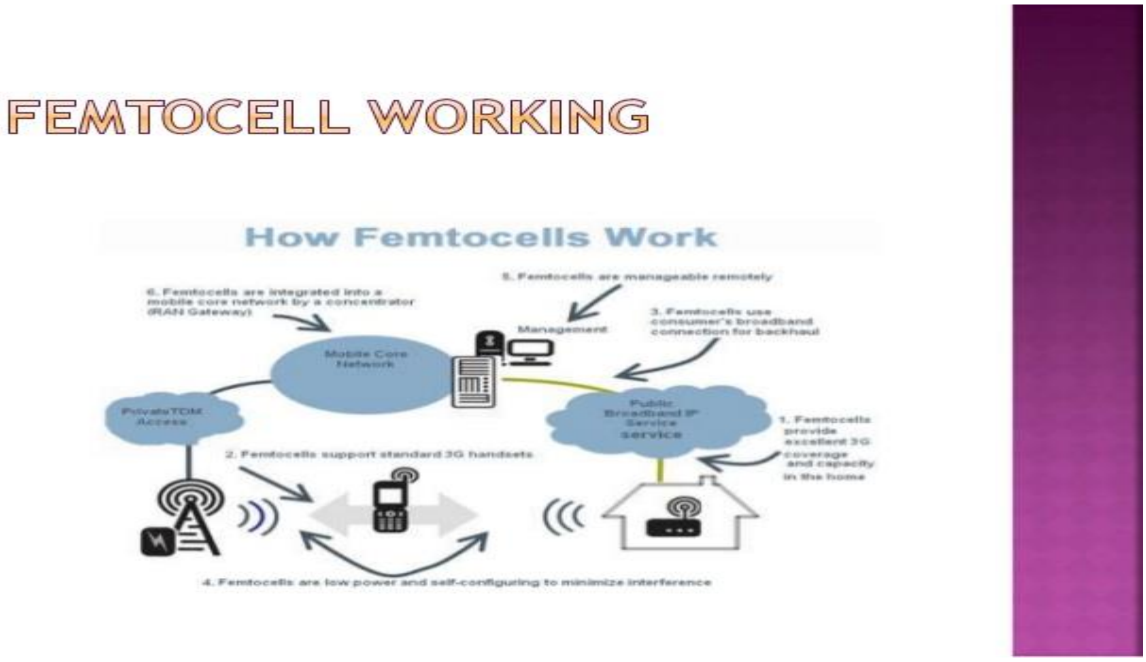
A signal is generated and monitored to show how the femtocell can achieve the results when integrated with IMS.

Testing and validation of the technology and an architecture is carried out using the signal generator of range 1200Mhz to 5600Mhz which was available in the LAB




Picture from internet

Pictures from internet




| Technology | Functions | Coverage |
|---|---|---|
| Vodacom signal booster | • Work as a repeater station<br>• Works only on Vodacom signals<br>• Cannot integrate IMS<br>• Service provider managed | 25 sq m |
| Mini telecom voice + MTN, cell C and Vodacom 4G | • Automobile conversion kit<br>• Compatible with all repeaters<br>• Service provider managed | 250 sq m |
| Mini booster GSM 900/3G | • Automobile conversion kit<br>• Compatible with all repeaters<br>• Service provider managed<br>• 900Mhz freq.<br>• No integration | 250 sq m |
| FEMTOCELL | • Customer managed<br>• Can integrate with other technologies e.g. IMS<br>• Can serve as a cell site<br>• Easy scalability<br>• No restriction to any network and low power consumed during TX. | 30- 50 meters |

Table 1. the above table shows how femtocell will improve signal in places where communication would be poor or dropped. when integrated with IMS it will offer wide communications like voice, data video and multimedia services.

Table2

Test are done in the lab where signal strength for RX and TX are as shown. A dummy load is used of an impedance of 50Ω. Here outlines the real test done at Rhodes and Schwartz Company in Nairobi Kenya. Objective four is achieved.

| **Equipment employed in the test** | **Rx down load [down link]from macrocel]** ***signal received by the ME*** | **Tx Up load[uplink] to macrocell signal transmitted to macrocell** | **Indoor signal strength fluctuation (%)** | **ME distance from equipment on test** | **Power consumption (TX)** |
|---|---|---|---|---|---|
| ***Vodacom signal booster*** | -81dBm<br>-86dBm<br>-104dBm | -90dBm<br>-90dBm<br>-97dBm | 10%<br>7%<br>-10% | 5 meters<br>10 m<br>15 m<br>More than 15m | 2%<br>2.2%<br>4% |
| ***3G mini booster*** | -77dBm<br>-80dBm<br>-100dBm | -90dBm<br>-98dBm<br>-108dBm | 14%<br>7%<br>8% | 5M<br>10M<br>15M | 2%<br>2.4%<br>6% |
| FAP | -68dBm | -67dBm | 10% | 5 m | 1.6% |
| | -68dBm | -67dBm | 10% | 10 m | 1.67% |
| | -77dBm | -78dBm | 2% | 15 meters | 1.69% |

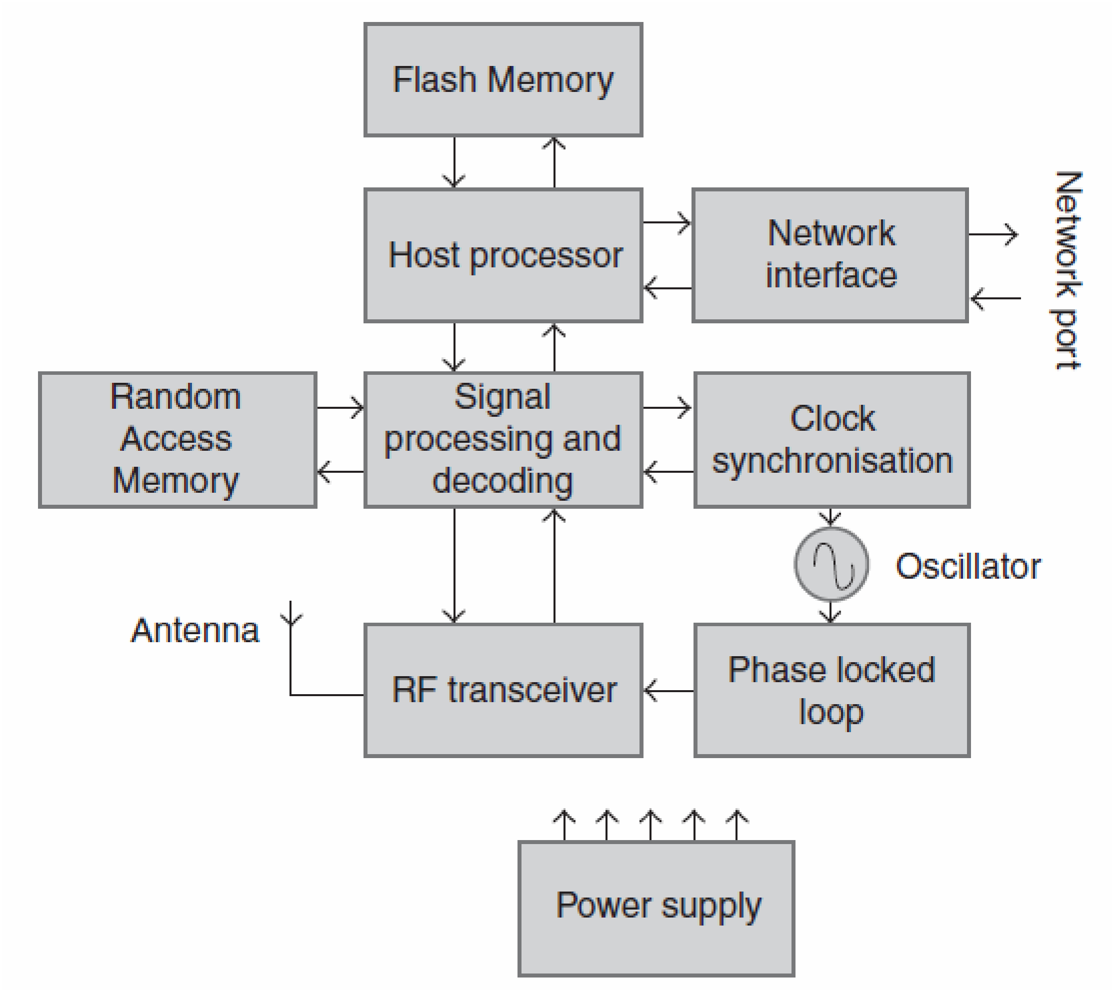



Figure 6 The real internal block diagram of a femtocell

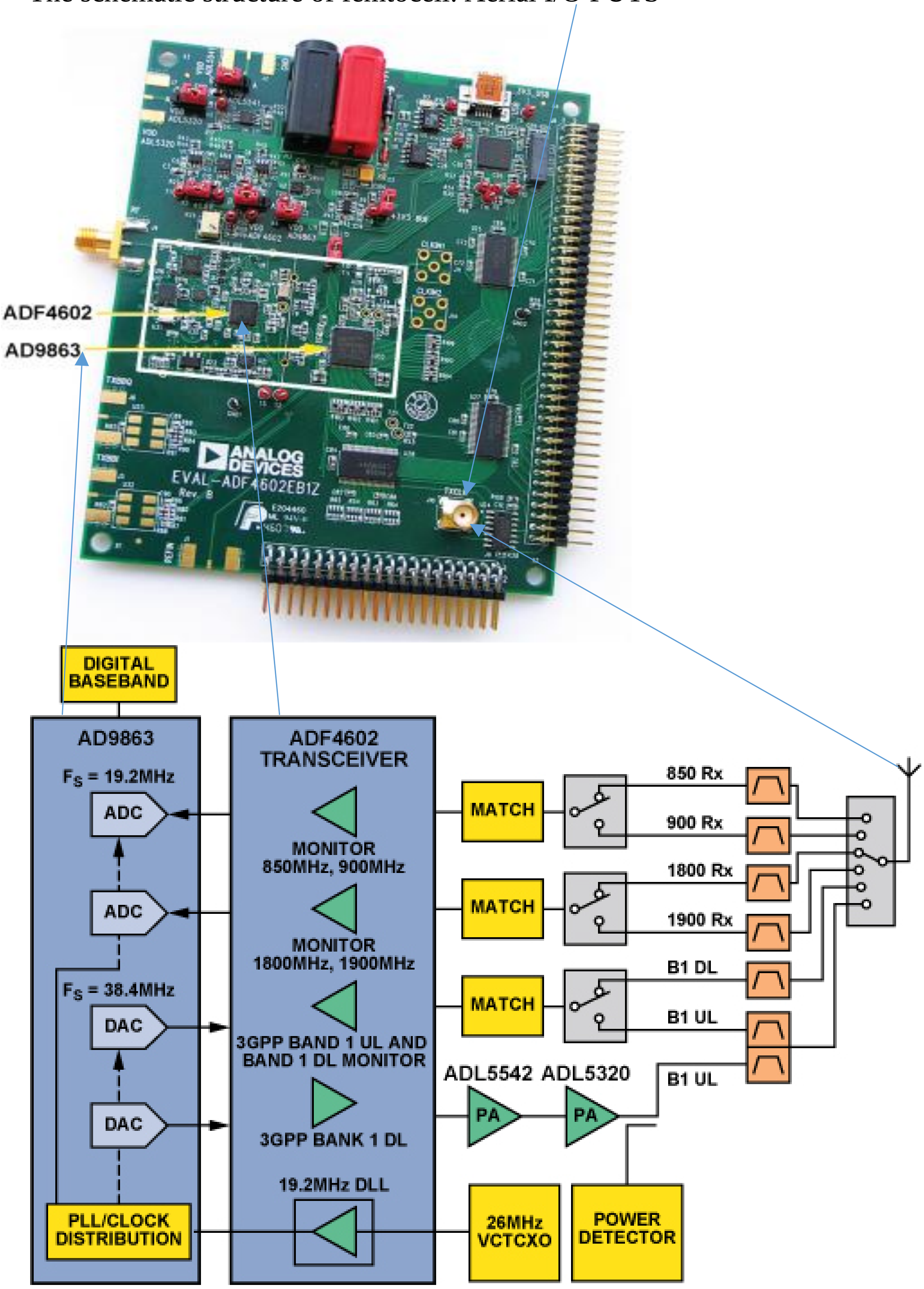
Practical arrangement from internet.

Plug in put/output generator

macrocell

signal generator/frequency

The schematic structure of femtocell. Aerial I/O PUTS




The component layout of a femtocell

## Conclusion

Wireless signals and 3G networks normally suffer from poor penetration and reception in certain areas like indoors. This will prompt a call drop during conversation and decrease in quality of voice and video communication and slows down high-speed services even in Integrated Multimedia 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. The growing number of cellular network users raises issues about coverage extension in some areas such as rural zones, indoor or underground locations.  Mobile network operators have been offering femtocell services and plans for both voice and data to residential or commercial customers in order to improve geographical coverage and capacity of a mobile network by allowing service providers to extend service coverage indoors, especially where access would be difficult. Femtocells are low-power wireless access points that operate to connect standard mobile devices to a mobile operator's network by using residential cable, fibre and even broadband connections. Femtocell connects to the service provider's network via broadband like DSL. This technology may be better known to the user as an Access Point Base Station, which acts as a small device which is installed in the home or office in order to offer better support to wireless communication. It Can be managed by the user not the operator only and it also offer Less Cost of installation and running cost of maintenance. Despite all these achievements, there is still room for improvement on this technology. It has a Radio Range Size - 30-50 meters with a backhaul -Broadband internet which can be improved if the microprocessor unit can accommodate high level language. The number of cell phone that can be accommodated at the same time with a femtocell is five. Beyond this number its power consumption increases with 2 % per extra mobile phone added in the vicinity. The Domestic applications, Office applications, Application in poor coverage area. generally, Femtocells provide good services for users in terms of improved performance within the home, or business office. It Improve their coverage which will be transformed to gaining extra revenue by the provision of additional services.

**References**


[1] IMS signalling in LTE based Femtocell network [UBICOM 2010]

[2] Femtocell technology IJIERT [VOL 3 MARCH 2015]

[3] NGN architecture and layered end to end QoS control

[4] Challenges in next generation services in IP multimedia subsystem

[5] Femtocell current status and future direction [Elleithy and Rao march 2011]

[6] Quality of service improvement in femto based cellular networks [GJCSTNW&S 2012]

[7] IJARCSMS FEMTOCELLS [ Narkhede ]

[8] Viviane Reding, European Commissioner for Information Society and Media,

[9] IMS with LTE based network [UBICOM 2011]

[10] LTE and Femtocell technology IJIERT [VOL 4 MARCH 2016]

[11] NETWORK architecture and layered end to end QoS control

[12] Next generation services in IP multimedia subsystem

[13] Femtocell current status and future direction [ Rao march 2015]

[14] Quality of service improvement in femto based cellular networks [GJCSTNW& 2013]

[15] IJARCSMS FEMTOCELLS [arkas and Narkhede ]