A STUDY OF FEMTOCELL ARCHITECTURE FOR LONG TERM EVOLUTION (LTE) - ADVANCED NETWORK

Mr. Vishal L. Shinde
(ME Student), Department of Electronics and Telecommunication Engineering,
Vishwabhrati Academy College of Engineering, Savitribai Phule Pune University,
Ahmednagar- 414201[MS], India.

Mr. V. G. Puranik
(Assistant Professor), Department of Electronics and Telecommunication Engineering,
Vishwabhrati Academy College of Engineering, Savitribai Phule Pune University,
Ahmednagar- 414201[MS], India.

ABSTRACT

Currently almost of the public having an own vehicle, theft is happening on parking and sometimes driving insecurity places. The safe of vehicles is extremely essential for public vehicles. Vehicle tracking and locking system installed in the vehicle, to track the place and locking engine motor. The place of the vehicle identified using Global Positioning system (GPS) and Global system mobile communication (GSM). These systems constantly watch a moving Vehicle and report the status on demand. When the theft identified, the responsible person send SMS to the microcontroller, then microcontroller issue the control signals to stop the engine motor. Authorized person need to send the password to controller to restart the vehicle and open the door. This project also indicates speed of vehicle which can be calculated by using distance and time. This is more secured, reliable and low cost.

KEYWORDS: 4G Architecture, Femtocell, HeNodeB, LTE Advanced

INTRODUCTION

In order to maintain higher data rates, 4G systems require a good receiver signal level to increase system performance. However, various research results [1] suggest that the majority of mobile users suffer from inadequate indoor signal penetration which leads to poor coverage provided to consumers and they do not enjoy the full data capacity marketed by the operators. 4G systems will facilitate high speed data services, but poor indoor coverage and interference will definitely diminish the quality of real-time applications and will significantly slow down high speed data services. In the traditional macro cell network, it is very difficult for operators to provide high quality services and cell coverage to indoor users, because in order to improve indoor coverage operators need to install a huge number of outdoor base station sites and this is nearly impossible in those areas that are densely populated. Even if operators manage to install more base stations then network planning and optimization become a challenging task for them, because frequency planning and handover management need more care in dense network deployment. The 3rd Generation Partnership Project (3GPP) is continuously working on different aspects to enhance over-the-air capacity and improves broadband user experience in a ubiquitous and cost effective manner. The radio link performance is now approaching its theoretical limits with LTE-Advanced and HSPA evolution [2] [3], the next performance leap in wireless networks must logically come from varying network Topologies. This introduces a heterogeneous networking environment in mobile communication networks. Heterogeneous networks enable flexible and low cost network deployment by using a mix of macro, pico, femto and relays, and facilitate mobile users by providing a consistent broadband experience. The concept of the femtocell is not new [4]. However, in the light of above facts, femtocells are now seen as a good solution for providing higher capacity and coverage by the operators in home and office environments.

Femtocells are low power access points that connect to the mobile operator's network via the consumer's broadband Internet connection, mainly through DSL using standard IP protocol. In a femtocell network topology the transmission of data to and from femtocells is carried over the Internet. Femtocells are operated in the licensed spectrum and allow operators to maintain the assured over-the-air quality of service by avoiding interference and making efficient use of the spectrum.

The Home eNodeB (HeNB) is proposed by 3GPP in release 8 specifications [5]. The HeNB is used especially in home and office environments and its introduction in the existing communication paradigm has already opened new opportunities for operators and service providers. In the present era, the HeNB is usually called a Femtocell or a Femto Access Point (FAP). Typically HNBs operate over the licensed spectrum and connect to the operator's core network by using a residential Internet connection. A residential Internet connection can be based on a DSL, cable broadband connection, and optical fiber technologies. Like a Wireless Local Area Network (WLAN) Access Point (AP), the HeNB is a small device and it is installed by the user [6].

The rest of the paper is organized as follows: Section 2 explains the background and occurrence of femtocells in LTE Advanced. This section also discusses logical architecture of the 4G femtocell. In Section 3, functionality of different components of the 4G femtocell network is explained. Section 4 discusses proposed femtocell architectural arrangements. Finally Section 5 contains the conclusion of this paper.

OCCURRENCE OF FEMTOCELL IN LTE-ADVANCED

LTE-Advanced is a candidate technology for the IMT Advanced standard, and for addressing the IMT-Advanced terrestrial radio interface recommendations, ITU-R issued a circular letter (CL) in 2008 to gather submissions for the candidate radio interface technologies for IMT-Advanced [2]. The circular letter identifies key features of the IMT Advanced standard and defines a framework for further advancements of the evolved universal terrestrial radio access (E-UTRA) and evolved UMTS terrestrial radio access network (E-UTRAN). But specifically for the LTE Advanced network architecture and deployment scenario, IMT-Advanced has adapted the requirements which are based on the Release 8 E-UTRAN architecture and assumptions. It also specifies that new architectural aspects for LTE Advanced will be considered only when significant benefits are expected from the new proposed architecture for Advanced E-UTRAN. In this paper, the architectures that have been proposed for LTE-Advanced are based on Release 8 E-UTRA, E-UTRAN RAN and CT architectures [5]. The femtocell enables users to access voice and broadband services over their own standard broadband Internet connection. A single femtocell supports usually at most four to eight simultaneous voice connections (concurrent maximum voice connection support in femtocells is implementation specific i.e. different products support different amounts of simultaneous voice connections) in any indoor environment, permitting many authorized users to be able to connect to the femtocell to utilize services other than voice, such as text or real time multimedia streaming etc. The user's subscription model (service and charging) for femtocell services may vary according to user needs and depends upon operators. There are various factors that affect peak data rates such as the air interface technology used, the user subscription
and broadband link capacity.

For supporting femtocell operations, the Home eNodeB Gateway (HeNB GW) and Home eNodeB Management System (HeMS) are new network elements that are introduced in release 8. The HeNB GW is used as a concentrator for all traffic received from the HeNB. In the femtocell logical architecture designed by 3GPP in release 8, the HeNB GW is placed in the operator's premises. The HeMS, on the other hand, is used to ensure that the services the user is experiencing are of high quality and sufficiently secured. Hence by analyzing the HeMS and HeNB GW functions, the HeNB is considered as an integral part of the operator network.

Fig. 1 illustrates a logical 4G femtocell deployment model in a real world environment. In order to utilize femtocell services, a user will buy a femtocell and will connect to it through its own fixed broadband access. Upon being connected to the broadband access, the HeNB will further connect to the operator's gateway; thereafter the HeNB will be authenticated and configured according to the user's subscription policy. Femtocell access is usually available to a restricted number of authorized users. This ensures that the coverage area which is provided by the femtocell is only accessible by the femtocell owner or by a trusted group of people.

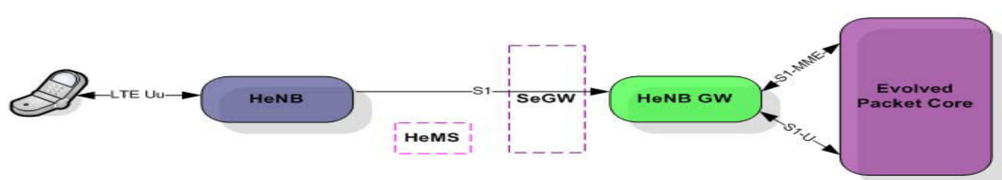

Fig. 1. 4G Femtocell logical architecture

LTE-ADVANCED FEMTO NETWORK

A 4G femto network consists of a femtocell, its various other supporting network elements, and a combination of these elements provides communication security, network provisioning, network management and integration. Typical elements of a femto network are listed and discussed below.

1.1. FEMTOCELL ACCESS POINT/HOME ENODEB

The HeNB is considered as a plug-and-play consumer device. It is zero touch portable equipment, which is easily installed by the users in home and office environments. The HeNB uses the subscriber's broadband backhaul to connect to the operator's core network. Technology specific HeNBs can provide 3G, 4G or Worldwide Interoperability for Microwave Access (WiMAX) coverage for indoor use. Typically the HeNB provides dedicated coverage to authorized users over the licensed spectrum, which leads to good QoS and enriches end-user service experience. Furthermore, HeNB uses the standard 3GPP S1 over-the-air interface to communicate with the mobile devices.

1.2. HOME ENODEB GATEWAY (HeNodeB)

As per 3GPP release 9 [5], RAN functionality is distributed between the HeNB and the HeNB GW. The HeNB GW in a femto network is used to provide various functions related to link security, control, and aggregation. In femto network architecture, the HeNB supports radio management functions whereas the HeNB GW maintains the core network connectivity functions. The HeNB and HeNB GW work together to perform certain operations which cannot be fulfilled without each other's contribution. Paging is one kind of operation which needs HeNB and HeNB GW cooperation. The HeNB GW may optionally have Authentication, Authorization and Accounting (AAA) functions in it [4]. AAA functions in the HeNB GW improve the level of secure access that is provided by the HeNB. Typically the AAA server resides in the operator's core network along with the mobility management entity (MME). In the HeNB GW, AAA functions enable authentication services such as EAP-SIM and EAP-AKA between the HeNB and the MME [7]. These authentication services are known as the Extensible Authentication Protocol-Subscriber Identity Module and the Extensible Authentication Protocol- Authentication and Key Agreement and both are specified in 3GPP release 9. The HeNB GW may also have media gateway (MGW) functionality in it [4]. The MGW functions typically terminate at the MME in the operator's core network. The HeNB GW facilitates authentication and authorization functions for the HeNB during the registration process. The operational functionality of the HeNB GW that is described above can be divided into separate network elements in accordance with operator requirements. A Security Gateway (SeGW), AAA functions or a MGW can be manufactured as standalone devices or in one possible combination: the HeNB GWmay acquire SeGW and AAA functionalities whereas the MGW can be used as a separate network entity.

3.3. SECURITY GATEWAY (SeGW)

In a femto network, a SeGW is used to provide a secure communication link between the HNB and the core network. The SeGW enables HeNBs to create end-to-end secure Internet Protocol Security (IPSec) tunnels [7]. The SeGW also provides secure data access with the help of the GPRS Tunneling Protocol (GTP) over the S1 interface and it runs inside the IPSec connection. The GTP tunnel usually forms between the HeNodeB and the MME and resides in the core network. With the help of these tunnels, the SeGW provides protection of data integrity.

3.4. HeNodeB MANAGEMENT SYSTEM (HeMS)

The functionality of the Home eNodeB Management System (HeMS) is based on the TR-069 family of standards [4]. The HeMS is used to provide Operation Administration Maintenance and Provisioning (OAMP) functions to the HeNBs. It empowers operators to control and manage the configuration of HeNBs. Furthermore, it produces fault reports and collects different performance variance from the HeNBs. With the HeMS, an operator grants access to HeNBs with additional services and applies service usage policies.

3.5. S1 INTERFACE

The S1 is a multifunctional interface which is used to transport all the messages and procedure between the HeNB and HeNB GW. The S1 uses the Stream Control Transmission Protocol (SCTP) to transfer control and signaling messages to and from the HeNB and HeNB GW. The messages and procedures are transported over IPv4 and IPv6 through the S1 interface. This is the only interface which is used by the SeGW and AAA function to provide an IPSec end-to-end tunnel and ensure data integrity [3].

PROPOSE 4G FEMTOCELL ARCHITECTURES

During recent years the concept of LTE is gaining momentum in the field of mobile communication systems. The first commercial LTE deployment has been recently witnessed in Norway and Sweden, where the operator TeliaSonera [8] has deployed the world's first 4G mobile communication network. For a 4G femtocell, this would be quite early, since at this point in time we have only started to think about femtocell deployments and their business proposition in the LTE system. This is because development of 4G femtocells is at an early stage, and even 3G femtocell deployments are still not mature enough. However, the femto industry is taking keen interest in the development of 4G femtocell standards. Recent news about 4G femtocell devices is heard from PicoChip [9], which claims that they have built a microchip (fully hardware and software based) for manufacturing 4G femtocell units. So far, no trace of 4G femto devices based on a PicoChip solution has been found.
All functional elements of the 4G femto network, inherit operational functionality as defined by 3GPP for the LTE communication system. It is important to note that 4G femtocell architecture is a combination of the 3G femtocell architecture model and LTE operational functionality [10].

4.1. FIRST 4G FEMTOCELL ARCHITECTURE VARIATION

Fig. 2 illustrates the first femtocell architecture variation (with a dedicated HeNB GW) which typically depicts straightforward evolved packet system (EPS) based architecture. This is a very balanced femtocell architecture and it works by discovering the availability of the serving HeNB GW. In all femtocells architectural variations presented in this paper have one to one mapping between the HeNB and HeNB GW. The HeNB GW is an operator device and it will be placed in the operator's network. The HeNB GW will not create simultaneous connections to the MME while facilitating one HeNB. This is because after authentication of a HeNB, for the transportation of user data in a secure manner there would be a GTP tunnel, IPSec tunnel and SCTP end-to-end session enabled from the HeNB to the MME [7]. In this 4G femtocell architectural variation, all user equipments (UEs) will be capable of handling close subscriber group (CSG) functionality, such that they can maintain a list of CSG identities. These identities will help in granting the authorized access to those who are members of an associated CSG group [4]. In the case when UEs are not successful in gaining access to the CSG cell, they will be notified with the cause of failure. There are two advantages of this femtocell architecture arrangement, firstly there are no deployment concerns and drawbacks, and secondly this femtocell architecture requires no additional changes when integrating with other network elements.

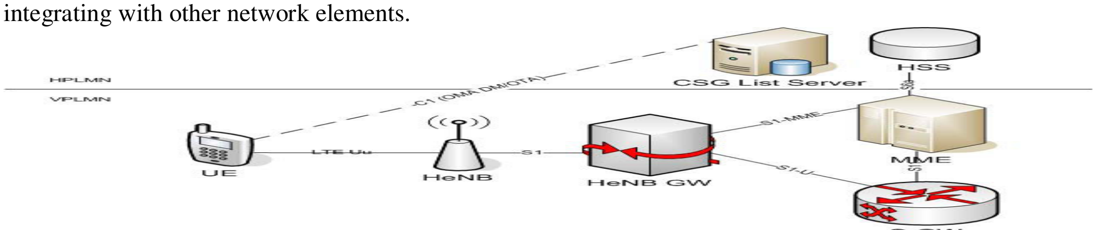

Fig. 2. First 4G Femtocell architecture variation

4.2. Second 4G Femtocell Architecture Variation

Fig. 3 illustrates another variation of the femtocell architecture without physical existence of the HeNB GW. It is important to note that all three different architectural variations in this paper are based on the distribution of HeNB GW functions among other femto network entities and its physical arrangements. It is studies that in order to increase system performance and efficiency, functional operation of different network devices are integrated in one device in such a manner that the newly developed network entity can perform better work under certain conditions with other network entities.

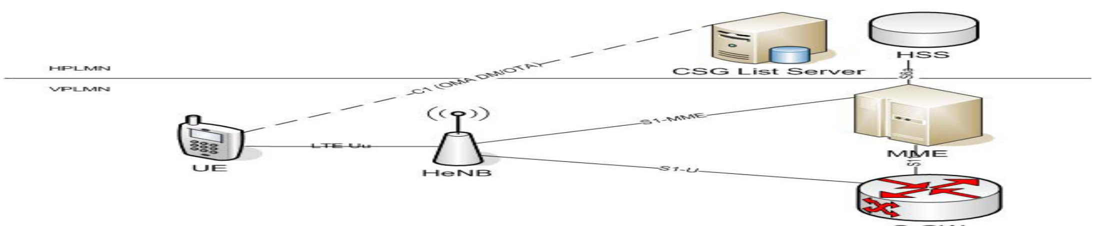

Fig. 3. Second 4G Femtocell architecture variation

In the architecture with no physical HeNB GW, the functionality of the HeNB GW is actually integrated between the HeNB and the MME by reducing the network cost and latency. This architecture also enables the HeNB to be self configurable [11] like other femtocell variations, and opening doors for the concept of a self organizing HeNB such that the HeNB would be used as a plug-and-play device and deployed without any network planning [12]. A user can move with his HeNB to any new position or can change one geographical location to another and, therefore, the HeNB will just need to connect to the Internet according to its new location. From the operator's point of view, deployment scenario for this architectural variation is quite simple, because there aren't any post HeNB configurations required. In this femtocell architecture the occurrence of the HeNB is more critical because with the failure of HeNB, access to the LAN and operators network through HeNB will no longer available.

4.3. THIRD 4G FEMTOCELL ARCHITECTURE VARIATION

We know that the HeNB GW acts as a concentrating device for both the control and user plane signaling [4] [13]. On the other hand, the S1-U interface which transports user plane signaling can also be terminated in the S-GW. Hence on the basis of above facts we can arrange another 4G femtocell architecture variation by separating the user plan and control plan functionalities. Fig. 4 shows deployment variation of 4G femtocell architecture in which the HeNB GW will only be used for aggregating the control plane signaling while the user plane will be directly terminated on the serving gateway (S-GW) [14].

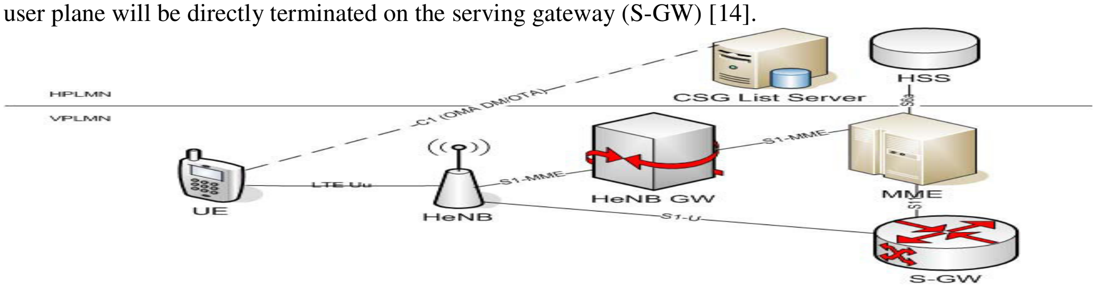

Fig. 4. Third 4G Femtocell architecture variation

In this way, by simply not using the HeNB GW for transporting user plane signaling the efficiency of data packet delivery to the S-GW will increase. Hence there will less processing delays at HeNB while transporting user and control plan signaling. This will naturally increase the overall data packet transport efficiency in the whole network. As per the 3GPP specification, there should be many-to-one mapping between the HeNB and the CGS, such that each cell of the HeNB will have a distinguished CSG IDs. It is important to note that in all the mentioned femtocell architectures, the MME is responsible for providing access control for the UEs accessed through CSG cells during the process of attach, combine attach, detach, and service request as well as during the Tracking Area Update (TAU) procedure [4].

CONCLUSIONS

The concept of femtocells is gaining momentum for home users as they can enjoy real-time high speed transmission on their handhelds at low cost which was not possible in the past. This paper explained, discussed and proposed different variations for indoor femtocell deployment. As technology matures day by day, it also offers various research topics concerning the deployment of femtocells in real network environments. Deployment architecture for 4G femtocells is far from being standardized yet. 3GPP in release 9 specifications has proposed three different architecture scenarios for future 4G femtocells, but it seems that 4G femtocell deployments will be based on operator specific needs and requirements. The reason is that, with 4G femtocell deployment, operators will
have to maintain LTE's all-IP based architecture.

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