Secure HeNB Network Management Based VPN IPSec

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***Abstract* — Femtocells are small base stations used inside buildings to improve radio coverage (Indoor).**

In this paper we present an overview of femtocells, focusing more particularly our research topic on the congestion, power and security management of HeNB (Home eNodeB). We also propose new architecture for managing in a secure way femtocells network using VPN IPSec.

***Keywords* —LTE, Femtocell, HeNB, Self-organization, Security, Power**

I. Introduction

Femtocells are small base stations designed for use as an ideal solution to ensure good radio coverage in the residential and corporate environments.

They benefit mobile users with extended capacity enabling them to enjoy the latest services such as high data rate voice, data, internet and new applications.

Femtocells also offer several advantages over solutions like Wi-Fi in particular. They use advanced signal processing techniques to save battery and optimize spectrum usage.

The 3GPP provides a standard for Home eNodeB, LTE (Long term Evolution) femtocell, which is one of the best approaches to reduce the Operating Expenditures (OPEX) for operators as well as to balance the load from the LTE macrocell networks. Femtocells are low power access points, providing wireless voice and broadband services to customers primarily in the home. 3GPP has carried out the research on Home eNodeB, while the Home eNodeB applications may also introduce some challenges to the work related to LTE-Advanced. [1]

Today, the progress of standardization and the launch of the marketing of femtocells in the residential market in many countries suggest massive deployments soon. Finally, femtocells fully self-configuration also offers promising prospects for deployment in outdoor environments. [2]

Indeed, different publications in the literature dealing with femtocells deployment are using cognitive radio tools for interference management and energy saving. They open new perspectives for the deployment of large scale large coverage low cost energy efficient networks which is the topic of this work.

In this paper we present new architecture for managing in a secure way femtocells network using VPN IPSec.

This paper is organized as follows. In the first paragraph, we present an introduction and generalities about femtocells. The second paragraph deals with existing femtocells architectures. In the third paragraph we present our new architecture for femtocells management. In the fourth paragraph we conclude.

II. Existing architectures

In this section we review existing standard architectures such as LTE HeNB (Long term Evolution Home eNodeB) network. In the first sub-section, we review three logical architectures for the successful deployment of 4G 3GPP.

- Architecture with dedicated HeNB –GW (HeNB Gateway)
- Architecture without HeNB GW
- Architecture with HeNB GW for C-Plane

In the second sub-section, we review:

- Lte HeNB Standard Architecture

A. Architecture with dedicated HeNB GW(HeNB gateway)

In this architecture, the HeNB will only connect to a single HeNB GW due to the specific requirements mentioned in the 3GPP specification which defines the architectural aspects of the Home NodeB and Home eNodeB [3]. Hence there will only be one to one mapping between the HeNB and HeNB GW. The HeNB GW is an operator device (this device is connected to the subscriber’s home network and as such is part of the home network) and it will be placed in the operator's network. The HeNB GW will not create simultaneous connections to the Mobility Management Entity (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 GPRS Tunneling Protocol (GTP tunnel), Internet Protocol Security (IPSec) tunnel and Stream Control Transmission Protocol (SCTP) end-to-end session enabled from the HeNB to the MME [3, 4, 5]. In this 4G femtocell architectural variation, all 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 [6]. The UEs that are not the members of the CSG are not allowed to access CSG HeNBs. The UEs hold a white list in the Universal Subscriber Identity Module (USIM) containing a user controlled list of the allowed CSG identities. In the case when UEs are not successful in gaining access to the CSG cell, they will be notified with the cause of failure.

B. Architecture without HeNB GW

This architecture also enables the HeNB to be self configurable [7] like other femtocell variations, opening several doors for the concept of a self organizing HeNB such that the HeNB would be used as a plug-and-play device and would be deployed without any network planning. 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. Distributing the HeNB GW functionalities in the HeNB and CN might cause performance degradation in HeNBs. But at the time of writing this report we have no numbers to measure and analyze performance issues in the HeNB, thus we cannot predict exactly how this architecture will affect the service delivery of 4G communication systems.

C. Architecture with HeNB GW for C-Plane

In this architecture, the HeNB GW acts as a concentrating device for both the control and user plane signaling [8, 9, 10]. On the other hand, we also know that the S1-U interface which transports the user plane signaling can also be terminated in the S-GW.

In this variation of 4G femtocell architecture, the HeNB GW will only be used for aggregating the control plane signaling while the user plane will be directly terminated on the S-GW [11]. 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. This will naturally increase the overall data packet transport efficiency in the whole network.

D. Architecture LTE-HeNB 3GPP

a) LTE-HeNB Standard Architecture

The Evolved Packet System (EPS) includes the Evolved Packet Core (EPC) and Evolved Universal Terrestrial Radio Access Networks (E-UTRANs). An E-UTRAN includes two types of base stations, named as eNBs and HeNBs. This is pictured in Fig. 1.

The EPC may contain many MMEs, Serving Gateways (SGWs) and Packet Data Network Gateways (PDN GWs) together with a HSS, which, located in the center of the EPC, is in charge of the storage and management of all of users' subscriber information. [12]

The MME is responsible for all the functions relevant to the users and the control plane session management. When an UE connects to the EPC, the MME first contacts the HSS to obtain the corresponding authentication data and then represents the EPC to perform a mutual authentication with the UE. Different MMEs can communicate with each other. [12]

b) Functional entities

- HeNB**:** The functions supported by the HeNB shall be the same as those supported by an eNB (with the possible exception of NNSF) and the procedures run between a HeNB and the EPC shall be the same as those between an eNB and the EPC. The HeNB secures the communication to/from the SeGW.[12]
- HeNB GW: HeNB GW serves as a concentrator for the C-Plane, specifically the S1-MME interface. The HeNB GW may optionally terminate the user plane towards the HeNB and towards the S-GW, and provide a relay function for relaying User Plane data between the HeNB and the S-GW. The HeNB GW supports Non-Access Stratum (NAS) Node Selection Function (NNSF). [12]
- SeGW**:** The Security Gateway is a mandatory logical function. It may be implemented either as a separate physical entity or co-located with an existing entity. The SeGW secures the communication from to the HeNB. [12]
- PDN GW: The Packet Data Network Gateway (PDN GW) provides connectivity to the UE to external packet data networks by being the point of exit and entry of traffic for the UE. A UE may have simultaneous connectivity with more than one PDN GW for accessing multiple PDNs. The PDN GW performs policy enforcement, packet filtering for each user, charging support, lawful interception and packet screening.[13]
- MME: The Mobility Management Entity (MME) is considered as the main controlling element which is used to process signaling and control functions between the UE and EPC. The main functions of the MME are to provide network resources and mobility management. [14]
- HSS: The Home Subscriber Server (HSS) is typically a database where user profiles are stored. In the EPC concept of HSS which is not new, the HSS works like the Home Location Register (HLR) and Authentication Center (AuC) and inherits their functionalities from release 99. In the HSS, the HLR functions are used to store and update the database with the user subscription information whereas the AuC functions are used to

facilitate the generation of security information from user identity keys. [14]

In this architecture, we note the absence of an energy manager. For this reason we propose in our architecture a manager that handles network resources taking into account energy issues.

We also propose a manager of network congestion, whose main role is to reduce network congestion.

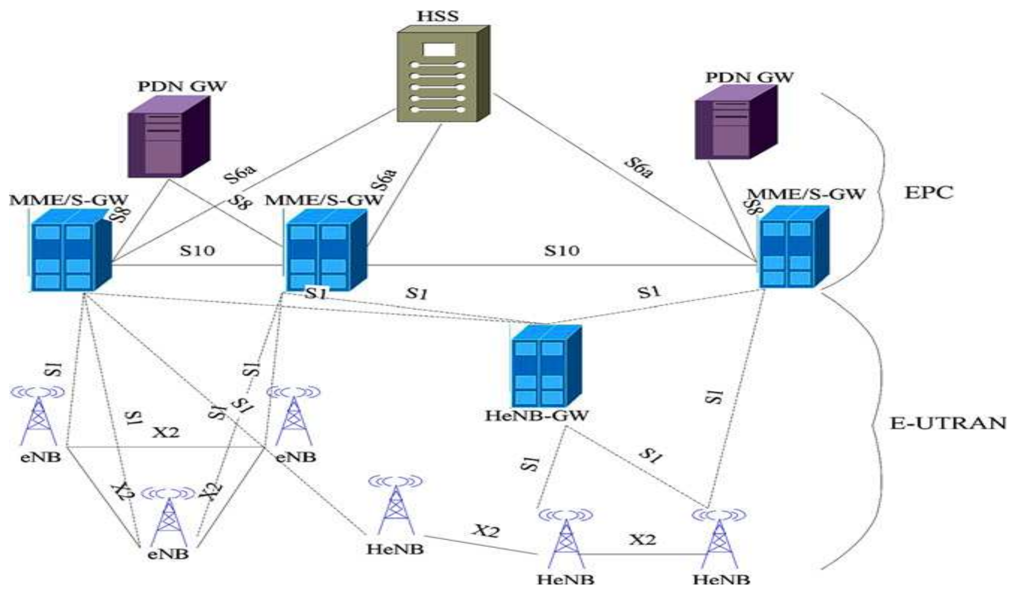

Fig. 1 Architecture Lte HeNB [12]

III. PROPOSED NEW ARCHITECTURE BASED ON VPN IPSEC

a) Motivation

The rapid evolution of the use of femtocells to improve radio coverage in the residential environment and in the small businesses raises a problem of management and administration of network HeNB.

Contrary to the standard architecture already presented, we want to:

- Connect HeNB outside radio coverage in a geographical area already fixed by a secure link
- Manage energy resources HeNB networks
- Reduce network congestion

We propose here a new secure solution to manage femtocells network to reduce congestion and energy consumption in the network.

b) Architecture Based on VPN IPSec

- A VPN (virtual private network) is a technology for using the Internet or another intermediate network to connect computers to isolated remote computer networks that would otherwise be inaccessible. A VPN provides security so that traffic sent through the VPN connection stays isolated from other computers on the intermediate network. VPNs can connect individual users to a remote network or connect multiple networks together. [15]

- IPSec (Internet Protocol Security) is a protocol suite for securing Internet Protocol (IP) communications by authenticating and encrypting each IP packet of a communication session. IPSec also includes protocols for establishing mutual authentication between agents at the beginning of the session and negotiation of cryptographic keys to be used during the session. [15]

Our architecture (Fig. 2) is based on using a secure VPN connection with IPSec Protocol (Internet Protocol Security) with self configuration between the HeNB and the HeNB-ECS (HeNB Energy and Congestion Server).

The role of HeNB-ECS is that of HeNB-GW, Se-GW and it manages energy and network congestion. It chooses the HeNB where the UE can connect according to its availability and energy.

To the difference of the existing architecture, it allows manage energy resources by a collective and collaborative approach; each HeNB contributes to the reduction of network congestion and energy consumption.

To connect HeNB outside radio coverage in a geographical area already fixed by a secure link, we need to determine a geographical area to manage and administer network resources.

We also integrate a database DB in the HeNB-ECS to record all necessary data for the transfer of communications from busy HeNB to another available and it helps to manage the network energy.

The HeNB-ECS manages the connection between UE and HeNB according to several criteria inter alia:

- State energy of each HeNB
- State Network (Number of UE connected to each HeNB)
- Geographic area

E. Connection between HeNB and HeNB-ECS

The data (State energy, State Network, geographic area …) is transferred from HeNB to HeNB-ECS and is saved in the DB of HeNB-ECS.

In this section we talk about three types of connection:

1) HeNB outside radio coverage with VPN support:

We propose a tunnel VPN IPSec connecting HeNB with HeNB-ECS.

2) HeNB outside radio coverage without VPN support:

HeNB connects to HeNB-ECS via another HeNB by a support equipped VPN.

3) HeNB to inside of coverage zone:

HeNB connects to HeNB-ECS via a radio link.

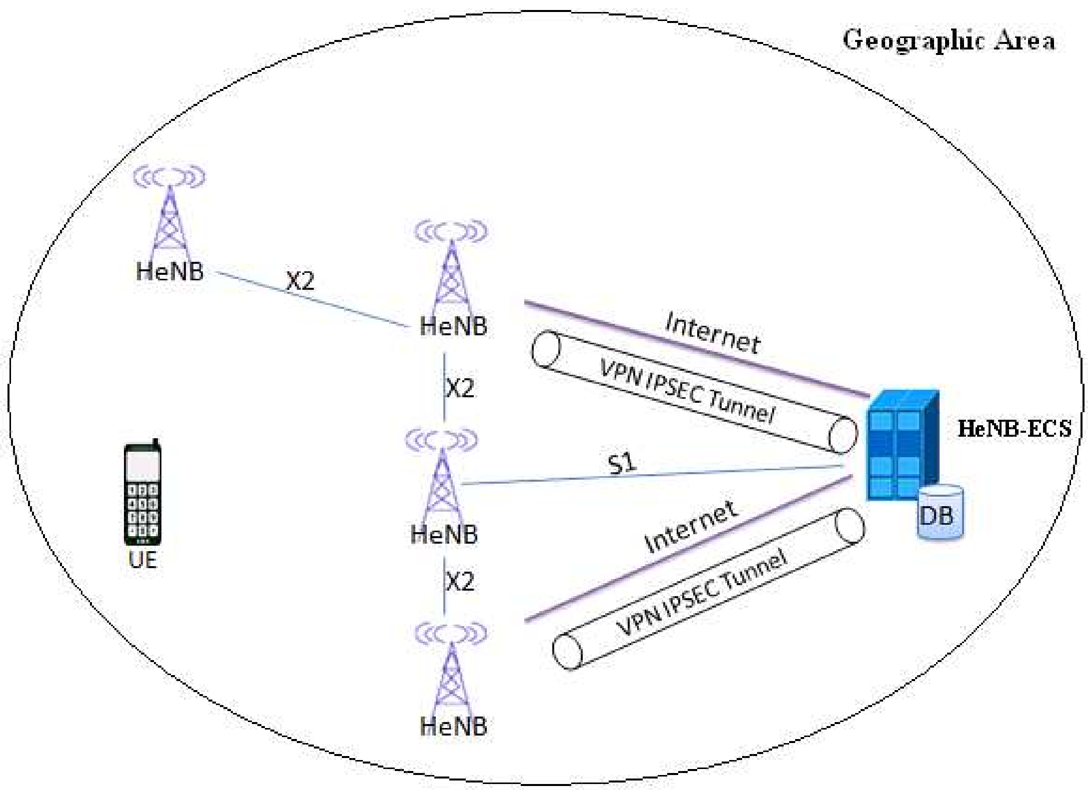

Fig. 2 New Architecture Based on VPN IPSec

IV. CONCLUSION

In this paper we have presented an overview of femtocells, has been given standard architectures and in the last section we have proposed our new architecture for femtocells management using VPN IPSec and HeNB-ECS has several options including optimization of security, congestion and energy consumption in the network.

To the difference of the existing architecture, our solution allows to manage energy resources by a collective and collaborative approach. It also helps improve the efficiency and reliability of the entire network.

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