PERFORMANCE ANALYSIS OF ADAPTIVE ANTENNA SYSTEM IN LTE (4G) USING OFDM TECHNIQUE

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ABSTRACT

The objective of this paper is to deliver 4G LTE and a standard for wireless communication of high-speed data for mobile phones and data terminals, based on the GSM/EDGE and UMTS/HSPA network technologies, the technology architecture, basic function signaling system are presents in this paper . Advantage of using OFDM Technique on LTE. This paper work provides a detailed analysis of the optimization space of antenna parameters and compares different tilt techniques as well as discusses vertical sectorization as a novel capacity optimization approach. The work continues by further focusing on the self-optimization of coverage and capacity using Adaptive Antenna Systems (AAS) on the basis of findings in the previous simulations on antenna parameters.

KEYWORDS: *LTE, OFDM, Network structure, Air Interface, Adaptive antenna system.*

I. INTRODUCTION

The third-generation Universal Mobile Terrestrial System (UMTS), based on Wideband Code-Division Multiple Access (WCDMA), has been deployed all over the world. Third Generation Partnership Project (3GPP) launched the Long Term Evolution (LTE) project in November 2004 in order to ensure the continued competitiveness of the UMTS in the future. The specifications of the LTE project are formally known as the Evolved UMTS Terrestrial Radio Access (E-UTRA) and Evolved UMTS Terrestrial Radio Access Network (EUTRAN). The work of 3GPP on the evolution of the 3G mobile system is aimed at achieving additional substantial leaps in terms of service provisioning and cost reduction. 3GPP has concluded a set of targets and requirements for Long Term Evolution in Release 8, on the basis of the LTE feasibility study [1]LTE was first proposed by NTT DoCoMo of Japan in 2004, and studies on the new standard officially commenced in 2005 [2].

II. SYSTEM ARCHITECTURE OF LTE

System Architecture Evolution, standardized by 3GPP, increases data plane efficiency and minimizes the number of nodes with respect to the second and third generation systems. Intermediate nodes such as the Radio Network Controller (RNC), the Serving GPRS Support Node (SGSN) and the Gateway GPRS Support Node (GGSN) are removed and replaced by the SAE Gateway (GW), for the reduction of inter-node data traffic delays [3].

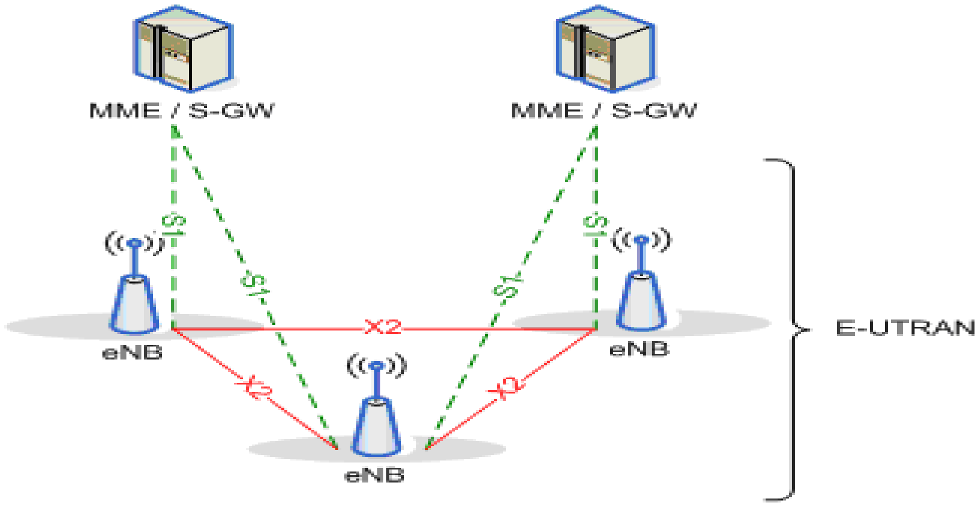

Figure 1: LTE Radio Access Network (RAN) architecture

In SAE, the central control functions of the RNC are distributed between the evolved Node B (eNB) and the Mobility Management Entity (MME) as eNBs are able to communicate with each other using a new logical inter-eNB interface, called X2 as shown in [Figure 1]**.**Thus, the eNB has more control functions than a 3G Node B. The S1 interface is a multiple interface that connects a pool of eNBs to a pool of mobility management entities and gateways. Since an LTE/SAE network is all-IP, previous trans-coding delays are avoided. The eNB incorporates the radio protocol terminations in the user plane shown in Figure 2.a (PDCP / RLC / MAC / PHY) and the Control plane shown in Figure 2.b (PDCP / RRC / RLC / MAC / PHY) towards the User Equipment (UE). The Non Access Stratum (NAS) is the only radio control protocol layer that is terminated in the

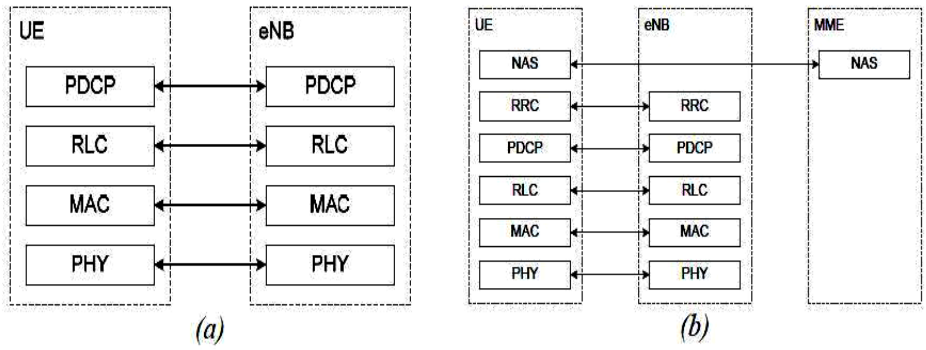

Figure 2: Use- plane (a) and Control-plane (b) Protocol stacks

MME. 3GPP reference model [4] introduces several interfaces from Operations Systems (OS) to Network Elements (NEs) as follows:

1. Itf-S is the vendor specific interface between the Network Elements and the Element Manager (EM)
2. Itf-N is the standardized open interface between the Element Manager and the Network Manager (NM), Itf-N facilitates multivendor management.

Itf-P2P is the interface between the Domain Managers (DM).The 3GPP evolution for the 3G mobile system defined the UTRAN Long Term Evolution (LTE) and System Architecture Evolution (SAE) network. These standards define an all-IP network as a base for the LTE/SAE. The LTE/SAE does not have separate packet switched data traffic and circuit switched voice network. Both data and user plane communicates over the same network, which is called Evolved Packet System (EPS) network [5].

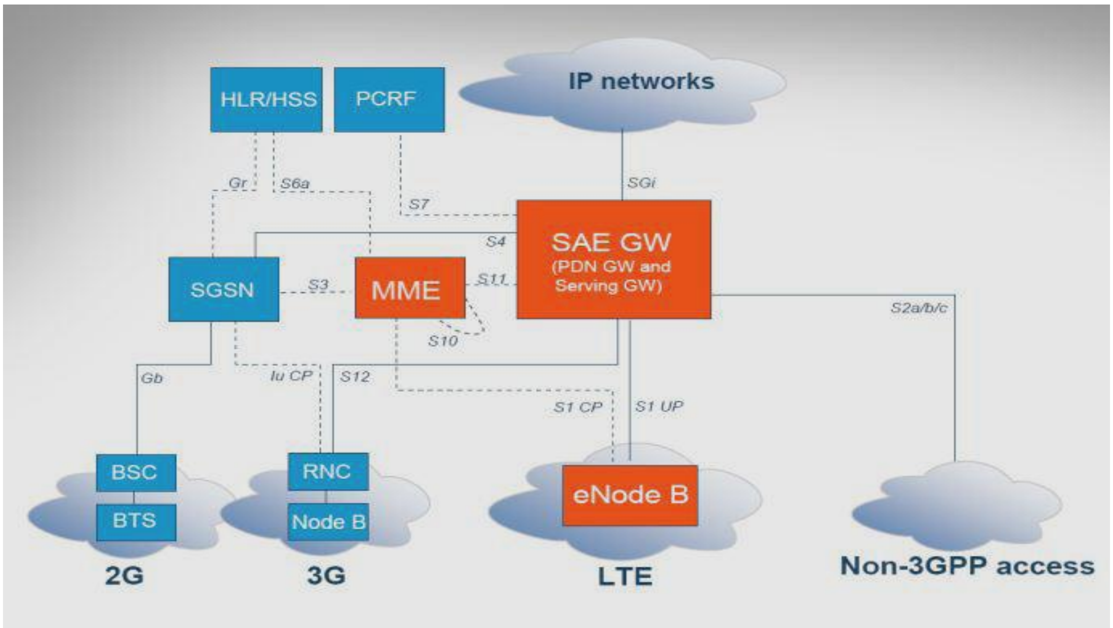

Figure 3: LTE/SAE architecture

Radio resource management IP header compression and encrypting of user data stream ,Selection of an MME at UE attachment ,Routing of user plane data towards SAE gateway Measurement and measurement reporting configuration for mobility and scheduling . *SAE* gateway consist two different gateways; Serving SAE gateway and Public Data Network (PDM) SAE gateway. Serving SAE gateway is the contact point to the actual network when Public Data Network (PDM) SAE is the counterpart for external networks. These gateways are used to process the user-plane data.

Mobility management Entity (MME) main task is to take care signaling of control plane, and especially for mobility management and idle-mode handling. SAE GW is upgraded from SGSN by installing new Software.

Home Subscriber Server (HSS) can be compared to Home Location Register (HLR) in UMTS network. It contains the subscription-related information (subscriber profiles), performs authentication and authorization of the user, and can provide information about the subscriber's location and IP information [6]**.**

Policy and Charging Rules Function (PCRF) is used to manage quality of service and applied charging policies.LTE network combined with GSM and UMTS networks will be complex because the network will have so many symbiotic relationships between the various elements within the system. For example voice handover between LTE and UMTS networks is not possible to do.

III. AIR INTERFACE IN LTE

One of the main changes in LTE compared to 3G is the use of multiple transmission schemes in the air interface. LTE is designed to be based on OFDMA in the downlink, whereas the uplink air interface is based on SC-FDMA.

3.1 E-UTRAN

E-UTRAN or EUTRAN is the air interface of 3GPP's Long Term Evolution (LTE) upgrade path for mobile net works. It is the abbreviation for evolved UMTS Terrestrial Radio Access Network, also referred to as the 3GPPwork item on the Long Term Evolution (LTE) also known as the Evolved Universal Terrestrial Radio Access (E-UTRA) in early drafts of the 3GPP LTE specification [1]. It is a radio access network standard meant to be a replacement of the UMTS, HSDPA and HSUPA technologies specified in 3GPP releases 5 and beyond. Unlike HSPA, LTE's E-UTRA is an entirely new air interface system, unrelated to and incompatible with W-CDMA. It provides higher data rates, lower latency and is optimized for packet data. It uses OFDMA radio-access for the downlink and SC-

FDMA on the uplink. EUTRAN consists only of eNode Bs on the network side. The eNode Bs performs tasks similar to [7] those performed by the Node Bs and RNC (radio network controller) together in UTRAN. The aim of this simplification is to reduce the latency of all radio interface operations. eNode Bs are connected to each other via the X2 interface, and they connects the packet switched (PS) core network via the S1 interface.

3.2 LTE Downlink: OFDMA

Orthogonal Frequency Division Multiple Access is a variant of Orthogonal Frequency Division Multiple-xing (OFDM).It performs well in frequency selective fading channels and provides a feasible and affordable solution with its low-complexity in the implementation as well as allows high spectral efficiency by means of compatibility with advanced receiver and antenna technologies. Weinstein and Ebert [8] first introduce the DFT to parallel data transmission system which become part of modulation and demodulation process.

3.3 LTE Uplink: SC-FDMA

The Third Generation Partnership Project decided to use SC-FDMA as an uplink transmission scheme due to having a low Peak-to-Average Power Ratio (PAPR), efficient frequency–domain equalization at the receiver side and more flexible frequency allocation with respect to OFDM. In SC-FDMA, data symbols in the time domain are moved into the frequency domain by using Discrete Fourier Transform.

IV. OFDM TECHNIQUE

Orthogonal frequency-division multiplexing (OFDM), essentially identical to coded OFDM (COFDM) and discrete multi-tone modulation (DMT), is a frequency-division multiplexing (FDM) scheme used as a digital multi-carrier modulation method. A large number of closely-spaced orthogonal sub-carriers are used to carry data. The data is divided into several parallel data streams or channels, one for each sub-carrier. Each sub-carrier is modulated with a conventional modulation scheme (such as quadrature amplitude modulation or phase-shift keying at a low symbol rate, maintaining total data rates similar to conventional single-carrier modulation schemes in the same bandwidth.

V. BASE STATION ANTENNA SYSTEM

An antenna in a telecommunications system is the port through which radio frequency (RF) energy is coupled from the transmitter to the outside world for transmission purposes, and in reverse, to the receiver from the outside world for reception purposes. Dipole and monopole antennas are the most widely used ones for wireless mobile communication systems [9]. At the base station of a cellular radio network, an array of dipole elements is extensively used because of its broadband characteristics and simple construction

5.1 Smart Antenna Systems

First Definition: A smart antenna is a phased or adaptive array that adjusts to the environment. That is, for the adaptive array, the beam pattern changes as the desired user and the interference move, and for the phased array, the beam is steered or different beams are selected as the desired user moves. Such as: Phased array or multi-beam antenna, Adaptive antenna array

Second Definition: A smart antenna system combines multiple antenna elements with a signal processing capability to optimize its radiation and/or reception pattern automatically in response to the signal environment. Smart antenna systems are customarily categorized as either switched beam or adaptive array systems. Such as: Switched beam antenna system, Adaptive antenna array systems Adaptive.

5.2 Multiple Antenna Techniques

In modern wireless communication systems, multi-element antenna arrays have been adopted for reliable communications and higher data rates compared to Single Input Single Output (SISO) systems. The major drawback in the deployment of the Multiple Input Multiple Output (MIMO) systems is the increased hardware complexity and the cost due to expensive RF chains (e.g., low noise amplifiers, analog to digital converters). On the other hand, the increasing demand for higher data rates and the reducing capital expenditures (CAPEX) make MIMO technology more favorable from the operator's point of view. Hence, the first release of LTE standards covers up to 4 antennas. Furthermore, LTE-A is going to support up to 8 antennas in order to achieve IMT-A targets.

VI. ADAPTIVE ANTENNA SYSTEM (AAS)

An Adaptive Antenna System (AAS) can focus its transmit energy to the direction of a receiver. While receiving, it can focus to the direction of the transmitting device. The technique used in AAS is known as beam forming or beam steering or beam shaping. It works by adjusting the width and the angle of the antenna radiation pattern (a.k.a. the beam). Combined with multiple antennas in the Base Station (BS), AAS can be used to serve multiple Subscriber Stations (SSs) with higher throughput. A technique known as SDMA (Space Division Multiple Access) is employed here where multiple SSs(Subscriber Station) that are separated (in space) can transmit and receive at the same time over the same sub-channel.

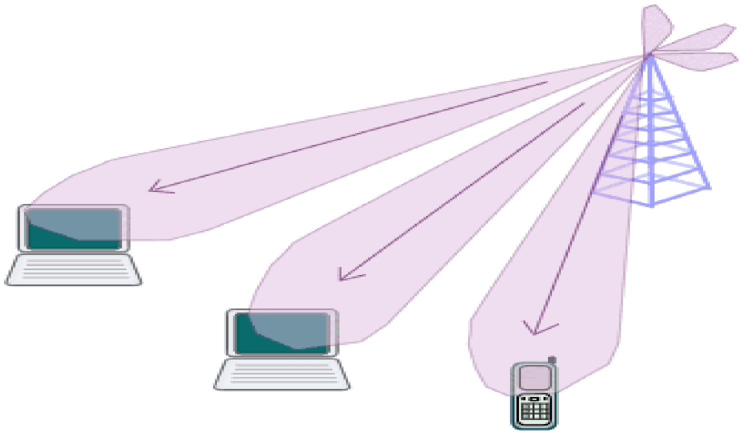

Figure 4: LTE BS with multiple antennas and AAS

AAS and multiple antennas combined in the BS can increase per user data rate.AAS also eliminates interference to and from other SSs and other sources by steering the nulls to the direction of interferers. But due to its effectiveness in improving performance and coverage especially in LTE case, many vendors integrate AAS capability into their products.

6.1 Antenna Radiation Pattern

In LTE simulations, the two equations below are applied to model horizontal and vertical radiation patterns [10] It needs to be considered that antenna characteristics, e.g., the patterns which are shown in Figures 6 and 7**,** are typically measured in an anechoic chamber, whereas in real world deployment there are the significant impacts of scattering in the near field of the antenna (e.g., mast, mountings, other objects in the vicinity, such as roof-top, etc.) and diffraction. These near-field scatterers and diffractions are not accounted for by the propagation models; therefore, they need to be conceptually included in an effective antenna pattern. A basic property of such an effective antenna pattern would be the attenuation of nulls, reduction in the front-to-back attenuation A_m and the side lobe attenuation SLA_v as shown in Figures 8 and 9 respectively. It is also visible that the design of the narrow vertical beam in a practical antenna leads to more severe and strong side lobes than we encountered in case of a wider horizontal pattern.

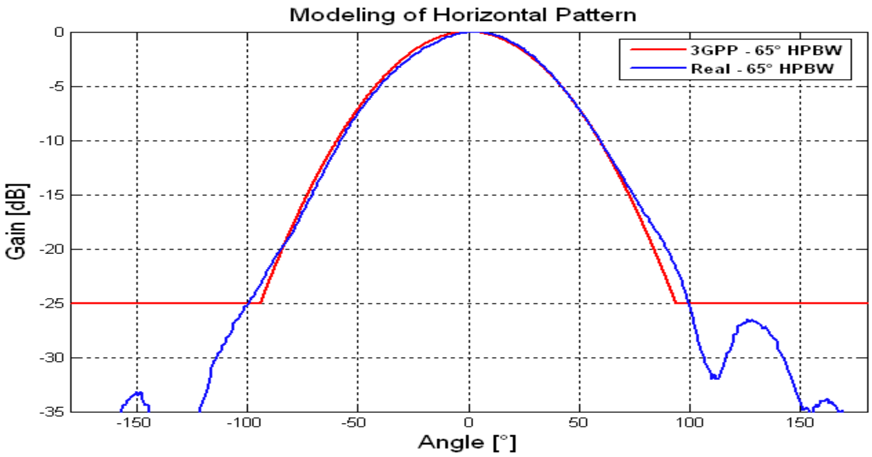

Figure 5. Modeling of horizontal pattern

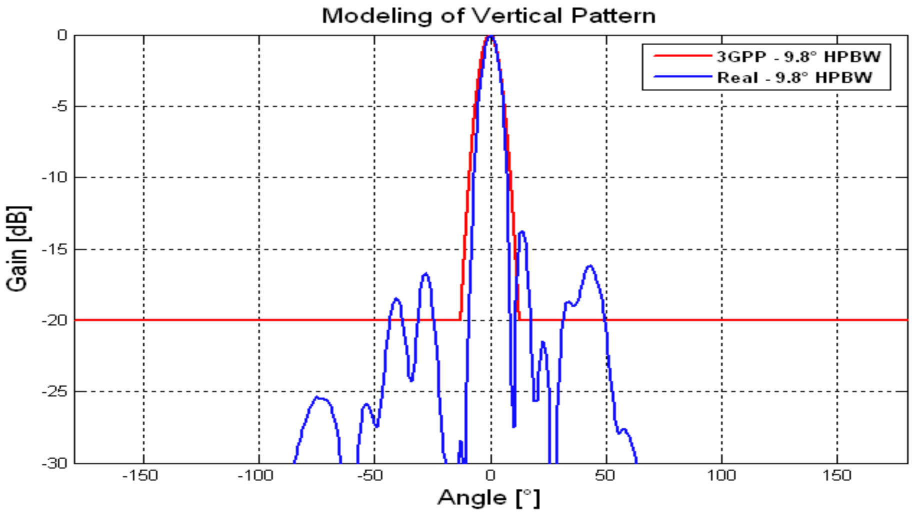

Figure 6: Modeling of vertical pattern

VII. CONCLUSIONS

This paper focused on the coverage and capacity optimization use case by means of the adaptive adjustment of RET, antenna direction and horizontal HPBW. It is shown that the self-optimization of antenna tilts and directions may provide significant performance improvements in instances of suboptimal network planning or reuse of 3G network planning, and/or varying radio network environment conditions.

VIII. FUTURE WORK

The paper work investigated the self-optimization of coverage and capacity in LTE networks using adaptive antenna systems. Future work includes corresponding simulations in the uplink direction of LTE as well as base station transmit power optimization in the scope of the coverage and capacity optimization and interference reduction use cases the necessary insights for the development of self-optimization algorithms. Furthermore, the vertical sectorization as a novel AAS technology was discussed aiming to build a future self-optimization use case. Future work for the shown studies includes corresponding simulations in the uplink direction of LTE as well as base station transmit power optimization in the scope of the coverage and capacity optimization and interference reduction use cases. Moreover, other use cases such as 51 RACH optimization, mobility load balancing and mobility robustness optimization as well as self-coordination of those use cases will be future topics in the research area of SON.

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