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LTE-Advanced: Femtocell Perspective

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Abstract: Femtocells are small cellular telecommunications base stations that can be installed in residential or business environments for better cellular coverage. Information and communications technology ecosystem now represents around 10 per cent of the world's electricity generation and increasing continuously day to day due to increasing the base stations of 4G and LTE-Advanced wireless communications network and it may create a power management problem in near future. According to the Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, for 2012-2017, "the overall mobile data traffic is expected to grow to 11.2 Exabyte's per month by 2017.To minimize the challenge A femtocell is possible solution, It results in a significantly improved signal quality and substantial cost savings also. The aim of this paper is to examine in a top-down approach the femtocells as an important component of the developing LTE-Advanced Technology, with essential projection into the future of the femto-cellular technology and what the future holds for its deployment for operators and also the benefits of Femtocells.

Keyword: LTE-Advanced, LTE, CA, Femtocell, eNodeB, HNB, HeNB.

I. Introduction:

Femtocells are small cellular telecommunications base stations that can be installed in residential or business environments to provide improved cellular coverage within a building. The technology also means operators can deliver better service to enterprises and high-value customers. While a macrocell delivers coverage to a wide area, a femtocell delivers a lot of capacity in a locale – just delivering power to where the users are. Because they are closer to the users so it takes less RF power to provide a high-bandwidth connection - a typical femtocell may have a 20mW RF section and consume a total of 2W. Using lower RF power also localises signals, so that scarce spectrum can be reused more often than is possible in a macrocell network. The lower power means more efficient RF technology too, so less energy is wasted there. The objective of this paper is to examine in a top-down approach the femtocells as an important component of the developing LTE-Advanced Technology, with essential projection into the future of the femto-cellular technology and what the future holds for its deployment for operators,the benefits of femtocell and advantage over macrocell and challenges to implement it.

II. Need of LTE-Advanced Femtocell:

According to the Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, for 2012-2017, "the overall mobile data traffic is expected to grow to 11.2 Exabyte per month by 2017(Follow figure no:1), .Now a days majority of the traffic would be online video which requires more bandwidth possibly transmission bandwidth of about 100 MHz in DL and 40 MHz in UL. To fulfill the massive bandwidth the possible solution is in the form of LTE-Advanced Femtocell which will gain more capacity in urban area hotspots like shopping centers and office building. Actually coverage has become the major problem in rural areas due to long distance between base stations and in indoor and underground locations due to wall abstractions . Hence factors like coverage, capacity, bandwidth, data rates and security etc. Demonstrates the need of device like femtocell which can provide a solution to such type of problems. From LTE-Advanced Femtocell, the peak data rate is 1 Gbps for DL and for UL, 500 Mbps can be achieved which is 40 times faster than 3G.

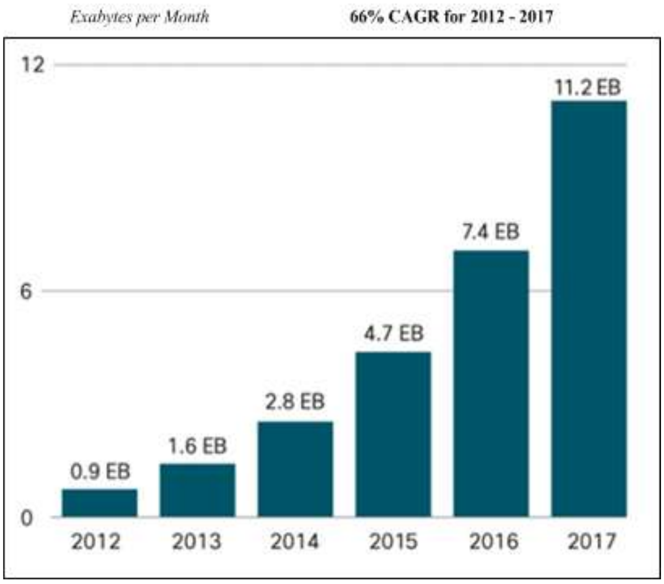

Figure 1: Cisco Forecasts 11.2 Exabyte per Month of Mobile Data Traffic by 2017

III. Concept And Technology Behind LTE-Advanced Femtocell:

Femto cells or femtocells are small cellular telecommunications base stations that can be installed in residential or business environments is a very small, low cost base station with low transmit power . These devices are integrated to small plastic desktop and wall mounts cases that are powered from the customer's electricity sockets. In order to link the femtocells with the main core network, the mobile backhaul scheme uses the user's DSL or other Internet link. This provides a cost effective and widely available data link for the femtocells that can be used as a standard for all applications. Figure No-2 shows the broad level 3G and 4G network architecture using femtocell as a base station.

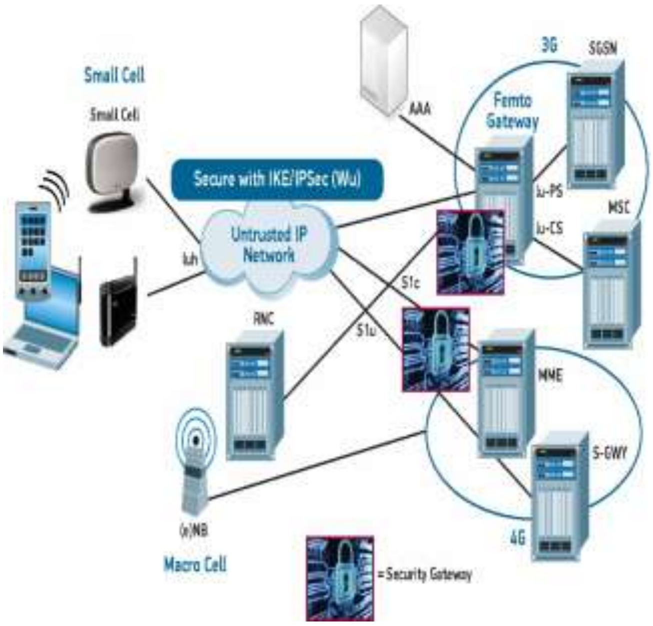

Figure 2: Broad level network architecture of 3G and 4G using Femtocell

In the 3G, the femtocell is refers to as the Home NodeB and in the LTE and LTE-Advanced, it has been named as the Home enhanced NodeB (HeNB).The development of the femtocell is a significant steps made to help network density in microcells. The femtocells help to reduce the cell size for increased quality of service. Of much emphasis is the reduction in the maximum transmits power in 40 femtocells as compared to the broader macrocells. As part of the small cell group. Figure 3 shows a significant comparison with respect to radius of coverage.

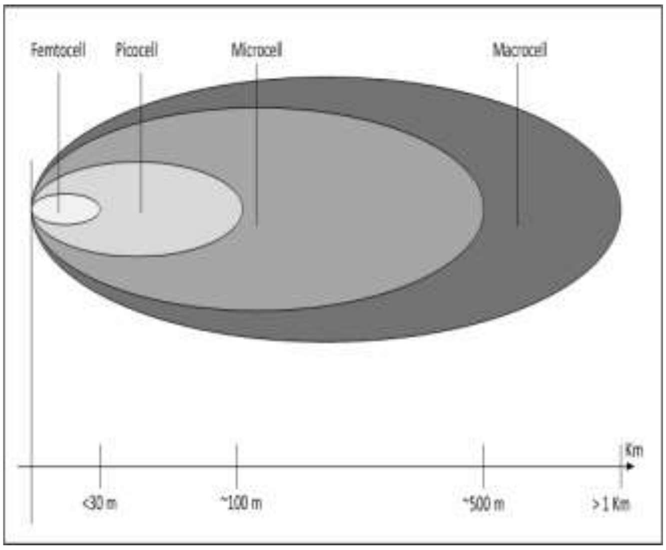

Figure 3: Small cell comparison in terms of range.

LTE-Advanced E-UTRAN Overview:

The core architecture of the LTE-Advanced is enhanced from the LTE E-UTRAN. The Figure 4 shows a typical LTE-Advanced E-UTRAN architecture. E-UTRAN architecture basically has the eNodeB and this creates the air interface for the U-Plane and C-Plane protocols termination to the UEs. The eNodeBs serve as the logical point used for serving the E-UTRAN cells. Also, there is the Home eNodeB (HeNB). The HeNBs are a type of eNodeBs with low cost and good indoor coverage. They are mainly connected to the EPC either directly or through a Gateway that can provide supports for a set of HeNBs. E-UTRAN network element and their interfaces can be seen from Figure 4.

eNB : eNB interfaces with the UE and hosts the Physical (PHY), Medium Access Control (MAC), Radio Link Control (RLC), and Packet Data Control Protocol (PDCP) layers. It also hosts Radio Resource Control (RRC) functionality corresponding to the control plane. It performs many functions including radio resource management, admission control, scheduling, enforcement of negotiated UL QoS, cell information broadcast, ciphering/deciphering of user and control plane data, and compression/decompression of DL/UL user plane packet headers.

Mobility Management Entity: manages and stores UE context (for idle state: UE/user identities, UE mobility state, user security parameters). It generates temporary identities and allocates them to UEs. It checks the authorization whether the UE may camp on the TA or on the PLMN. It also authenticates the user.

Serving Gateway: The SGW routes and forwards user data packets, while also acting as the mobility anchor for the user plane during inter-eNB handovers and as the anchor for mobility between LTE and other 3GPP technologies (terminating S4 interface and relaying the traffic between 2G/3G systems and PDN GW).

Packet Data Network Gateway: The 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.

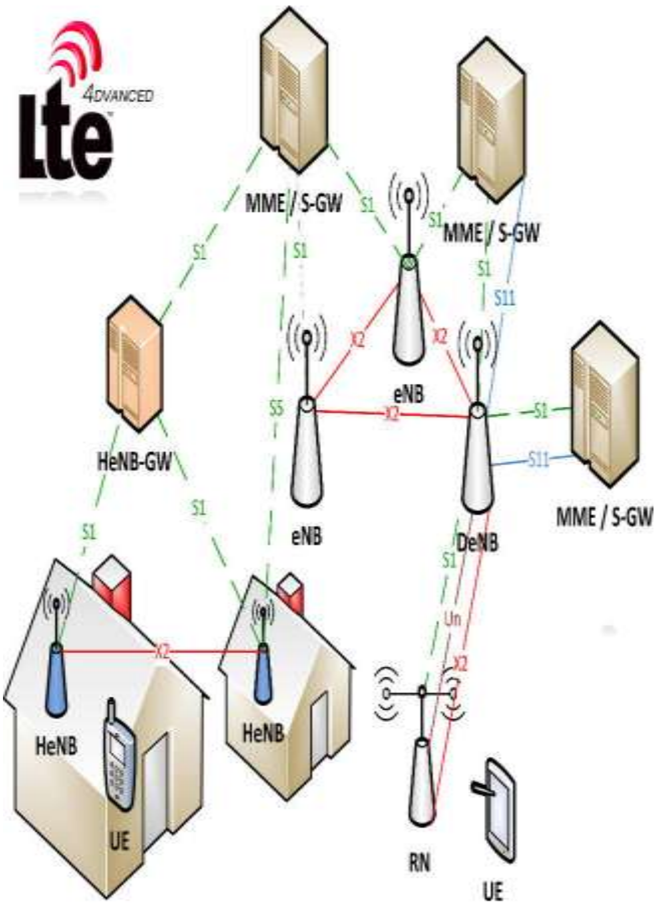

Figure 4: LTE-Advanced E-UTRAN Architecture

From the above figure below are the important interface description in between element of E-UTRAN

- S1-MME : Reference point for the control plane protocol between E-UTRAN and MME.
- S1-U: Reference point between E-UTRAN and Serving GW for the per bearer user plane tunnelling and inter eNodeB path switching during handover.
- X2 : X2 interface is used to communication of eNBs. Technical Specifiaction ETSI TS 136 420 describe X2 Interface. X2 has two plane: Control Plane and User Plane. User plane is based in GPT-U (GPRS Protocol Tunnel), UDP and IP. Control Plane use SCTP and IP.
- S5:- It provides user plane tunnelling and tunnel management between Serving GW and PDN GW. It is used for Serving GW relocation due to UE mobility and if the Serving GW needs to connect to a non-collocated PDN GW for the required PDN connectivity.
- S9:- It provides transfer of (QoS) policy and charging control information between the Home PCRF and the Visited PCRF in order to support local breakout function.
- S10:- Reference point between MMEs for MME relocation and MME to MME information transfer.
- S11:- Reference point between MME and Serving GW.

Below are the some key technology ingredients in the LTE-Advanced**.**

Carrier Aggregation : Although there has been considerable flexibility in terms of bandwidth for previous releases, the LTE-Advanced (Release 10) gives more and desired flexibility in terms of transmission bandwidth of up to 100 MHz, while essentially allowing for backward compatibility with its predecessor. To actualize this, the idea of CA scheme is introduced. The CA is based on aggregating multi-component carriers and jointly makes use of them for transmission to and from mobile terminals (single). Up to 5 transmission components can be aggregated either when they are in the same frequency range or not. The fragmentation of the spectrum allows for the higher data rates by the combination of the all the small fragments to a big component.

Enhanced Multi-Antenna Support: To meeting the LTE-Advanced goals, the multi-antenna solution is vital in driving the increased data rates and much system level performance. The enhanced Multi-Input and Multi-Output (MIMO) system is very important as this is a major enhancement technique that uses multiple antennas at both ends of the transmission system, that is transmit and receiving sides. The main components of the MIMO technologies used in the LTE are fundamentally important in the LTE-Advanced. the multi-antenna configuration in enhanced MIMO is extended for up to 8 x 8 in the DL and up to 4 x 4 in the UL. The transmission diversity and spatial multiplexing are most preferred to be used in actualizing the enhancements for an enhanced improve coverage and absolute peak data rate in the LTE-Advanced targets.

Cooperative Multi-Point Transmission and Reception: The CoMP, as an advanced type of MIMO, provides the higher data rates, with cell edge throughput, coupled with excellent system throughput in high and load scenarios.

Support for Heterogeneous Network Deployment: The issue of achieving a broader coverage with enhanced performance is of significant importance when it comes to the LTE-Advanced. Aside from the previously mentioned technological components of LTE-Advanced (CA, e-MIMO and CoMP), there is futuristic demand to have improved spectral efficiency per unit area. That is, every user within a particular cell must have a smooth and efficiently uniform service. This whole idea of spectral efficiency canters around the development of new deployment strategy called Heterogeneous Networks.

IV. Comparison of LTE and LTE-Advanced

Table 1: Comparison between LTE and LTE-Advanced

LTE	LTE-Advanced
The LTE is not backward compatible with the previous 3G; it is part of the 3GPP Release 8.	The LTE-Advanced (4G) is backward compatible with LTE; and it is part of 3GPP Release 10.
The LTE is meant to give a data rate of 326 Mbps using the 4 x 4 MIMO but 172 Mbps with the 2 x 2 MIMO in 20 MHz spectrum.	The LTE-Advanced offers greater speed of almost more than 40 times faster than 3G. The use of the antenna 8 x 8 in DL and 4x 4 in the UL also helps
The LTE covers a range of up to 5 km for full performance	The LTE-A has quite the same as LTE requirements but there a need for optimization in the deployment for local areas and in micro cells.
A major advantage seen in the LTE is its high throughput with low latency.	The LTE-A offers an all-IP, high speed and low latency for mobile network. The throughput is about 3 times higher average user throughput than in the LTE.
In terms of mobility, the LTE support mobility across the cellular network for various mobility speeds up to 350km/h and could be up 500km/h which significantly depends on the frequency band.	For the LTE-A, there is the same mobility as in LTE; the system performance needs more enhancement for 0 - 10 km/h. The LTE-A will use spectrum allocations in different sizes to achieve higher performance.
Deployed in scalable bandwidths of 1.25MHz to 20 MHz.	Allows for transmission bandwidth of about 100 MHz in DL and 40 MHz in UL.
For the peak data rate, the LTE has 100 Mbps for DL and 50 Mbps for UL.	In LTE-A, the peak data rate is 1 Gbps for DL and for UL, 500 Mbps.
For the plane capacity, the LTE has at least 200 users per cell which should be supported in the active state for spectrum allocations up to 5 MHz.	For the plane capacity, the LTE has at least 200 users per cell which should be supported in the active state for spectrum allocations up to 5 MHz.
For a scalable bandwidth, there are 1.3, 3, 5, 10 and 20 MHz and with connection setup delay of less than 100 ms.	And the LTE-A has a scalable bandwidths of up to 20 to 100 MHz with connection setup delay of less than 50 ms.
The LTE has a capacity of 200 active users for every cell at 5 MHz.	In the case of LTE-A, there are 3 times the capacity of that in the LTE.

V. Benefits offered by Femtocell

The femtocell offers some significant advantages as discussed below:

Coverage and Capacity: The femtocells operate within a small distance, which helps to have a comparative low transmit power, and help to have higher SINR. As a result, there is always excellent signal reception for coverage and higher capacity.

Macrocell Reliability: The use of the femtocell helps to reduce the load on the macrocells. The macrocell uses some of its resources for better reception to serve mobile users; this is because the femtocells will absorb some of the indoor traffic.

Cost: In terms of cost reduction, the deployment of femtocells has been studied to reduce the CAPEX and OPEX for the service providers. Cost of electricity and backhaul is reduced and the cost of deploying extra macrocells is avoided as a result of the femtocells deployment which has significant compensation on the broader macrocell network.

Subscriber Turnover: It is quite popular that customers are not okay with indoors reception; and this has made customers to change their operators more often. So the use of the femtocell will help in creating a better customer's perspective in this regards.

VI. Challenges of Femtocell

Although, there has been a significant paradigm shift in the use of femtocells, there have been so much so few challenges that the femtocells deployment has to combat. To reduce the expence femtocell requires very little for installation and setup The devices should also be auto configuring so that it is very easy for the customer to use it. The user only needs to plug in the cable for internet connections and electricity and every thing else should be automatically configured. Femtocell can even face a problem in adjusting with its surrounding environment as the environment changes continuously. Even opening and closing doors again and again can change the environment. If femtocells will be deployed in large scale, then network should also be strong enough to manage this. Even building walls and windows attenuate the signals. As 70-80% mobile traffic is generated indoors mostly in homes and offices, so it is quite challenging for a femtocell for to deliver excellent data experience indoors. Femtocells face challenges like: Femto cell interference issues, Femtocell spectrum issues and Femtocell regulatory issues Hence we can say that management is big issue as operators today manage tens of thousands of cell sites. Femtocells will number in millions. It will lead to interference problem. That interference can also be femtocell to femtocell interference in adjacent buildings. Even the configurations of femtocell should be so simple that an average user can install it.

VII. Conclusion

In a broader perspectives, this thesis has given a top-down overview into the past, the present and what the future holds for the femtocells. From the advent of the LTE to LTE-Advanced and the incorporation of some of the key ingredients of the LTE-Advanced; it is important to know that the development of femtocells as a part of the big small-cell pictures has a place in the present and future of wireless networks. Of much significance, the femtocells benefits were considered with discussion on what they offer and will continue to offer in terms of improved coverage and better capacity; more system reliability; cost reduction and a boost to subscribers' confidence. In additional, presented accordingly also, are some of the major issues that might set in if the future of the femtocells is not given necessary attention in terms Femtocells will be successful to make the landlines away. More importantly, there are no health effects from radio waves below the limits applicable to wireless communication system.

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