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NEXT GENERATION CELLULAR NETWORK TECHNOLOGY – FEMTOCELLS

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ABSTRACT--- It is known that 66% of the mobile handset initiated calls and 90% of the data service requests are generated from home premises. Hence the enormous resource utilization by indoor users encourages operators to provide satisfactory indoor coverage and a higher peak data rate for data services to home subscribers. Vast advances in the field of Information Communication and Technologies (ICT) has significantly increased the energy requirement and CO2 emissions which has adversely affected the atmosphere causing untimely and unanticipated changes. Thus, in order to overcome these various issues Femtocells came into existence.

In this paper, a detailed description on Femtocells is presented. Femtocells offer a different approach to the cellular technology. Femtocells are cellular access points that connect to a mobile service provider's network utilizing residential DSL or cable broadband connections. Femtocells facilitate better in-door mobile call coverage. The architectural and technical aspects of Femtocells and the management system are discussed.

Keywords---- Energy Efficiency, Femtocell, Femto Access Point, Technical Aspects, Wireless Management System

I. INTRODUCTION

Capacity demands of modern mobile telecommunication networks are expanding year by year. Individuals everywhere throughout the world are utilizing not only more number of voice call services but in addition a growing volume in data services with their cell phones. Most of these services, including web browsing, downloading messages, video calls and video streams need high data rate connections and produce lot of information exchange in the network system. The customer expectations are growing and sooner the mobile terminals will need to accomplish the same bitrates as the present fixed internet associations.

Rapid Growth of energy consumption has made global environment issues more severe. As per a survey, 57% of energy consumption of ICT industry attributes to uses and network devices in mobile and wireless networks the scale of which is still growing exponentially. According to a survey, the global mobile traffic is expected to reach a value by 2015 which is more than 26 times as much as traffic load per month in 2010. So, energy efficiency has become a discriminating issue for the government and industries. Current mobile network advancements didn't focus on these issues due to one or the other reason leading to following downsides:

- Majority of mobile communication advancements gave no consideration to energy efficiency while concentrating on attaining better performance metrics.
- Networking loads vary at different times on a day however the power utilization is same as there was not any technique discussed or considered so as to dynamically modify power utilization with respect to the current load (network) so as to consume power efficiently.

Coverage has dependably been a vital issue in mobile telecom networks. It has generally been a issue in rural regions due to the long separations between base stations in indoor and underground areas due to the wall attenuation. The sellers have to continuously emerge with different solutions to make the best utilization of the restricted radio resources: space and spectrum. Smaller cell sizes, for example, microcells and nanocells have been utilized to achieve more capacity in urban hotspots like shopping malls and office premises. Microcells and nanocells and additionally distributed antenna systems (DAS) have also been utilized to enhance coverage inside big houses, undergrounds and tunnels. These arrangements are effective but also costly.

Femtocells offer a alternate methodology to these issues. Femto is a component meaning one thousandth of nano. Femtocells are smaller, lower cost base stations and their greatest permitted transmit power level is low. Femtocells are considerably smaller than nano-cells yet the greatest distinction is not the size of the cell. The gadgets are configured to small plastic desktop or wall mount cases and are installed to the clients' premises by the clients themselves. The clients' current internet connections are utilized as backhaul connections and the gadgets are powered from the customers' electricity sockets.

Femtocells are cellular access points that connect to a mobile service provider's network utilizing residential DSL or cable broadband connections. They have been developed to work with a range of different cellular standards including CDMA, GSM and UMTS. Femtocells is a recent research area .For the mobile operators, femtocell major features are to improve both coverage and capacity in the in-doors while optimizing the energy consumption and make BS deployment cost effective. Mobile subscribers are provided with better signal strength and longer battery life using femtocells. Figure 1 shows a home cell that supports 4 users. The other types are enterprise and metro femtocell which is shown in Figure 2.

Figure 1. Typical Residential Femtocell

Figure 2: Enterprise and Metro Femtocells

II. FEMTO CELL ARCHITECURE

In the day- to-day life, the number of mobile users is significantly increasing and hence the bandwidth allocated to a particular operator can't effectively cover all parts due to the network range and other such issues related to spatial location of the Mobile subscriber. Femtocells are needed basically to provide better in-door coverage for the subscribers of a mobile operator and hence less energy of the operator is consumed for locating the subscriber when a call is made. A femtocell is as small private cell which works on a 3GPP air interface. A femtocell gives a coverage range up to 30-50 meters with a low output power level commonly lesser than 50mW.

In the present UMTS era, the Home Node B is usually called as a Femtocell as well as Femto Access Point (FAP). Commonly HNBs work over the permitted spectrum and associate with the operator's core network by using a home Internet connection. A home Internet connection can be depend on a DSL, cable broadband connection, and optical fiber or wireless last-mile advancements. Like a Wireless Local Area Network (WLAN) Access Point (AP), the HNB is a small device and it is fixed by the user.

The typical femtocell architecture is a flat IP architecture and it is shown in the Figure 3 below. The femtocell is deployed in clusters of up to 64000 femtocells each. A "cluster" is defined as the set of Small Cells which appears as a single RNS (radio network subsystem) to the UMTS Core Network. To support the cluster there are a number of other network elements which include the cluster gateway elements (BSG, BVG, BPG), the Security Gateway, the optional IPC (together called the Small Cell Gateway), plus the OAM solution made up of Device Manager, Cell, Femto Management System and File Server (BSG, BVG, BPG), the Security Gateway, the optional IPC (together called the Small Cell

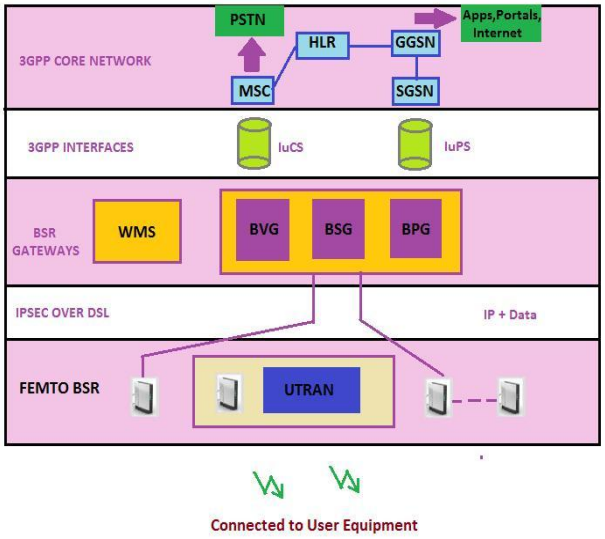

Figure 3: Femtocell Network Architecture.

Gateway), plus the OAM solution made up of Device Manager, Cell, Femto Management System and File Server. The major elements of the small cell (Femtocell) network are explained in brief as follows:

- **BSR**: The Base Station Router provides the air interface for the UEs to connect to the Small Cell Core Network, and from there to the MNO s Core Network.
- **BSG**: The BSR Signaling Gateway provides a single point node for all the Small Cells in the cluster, and interworks the different signaling messages from the Core Network to the individual Small Cells.
- **BPG**: The BSR Packet Gateway acts as a concentrator for packet-switched user plane paths, so that the packet core is not flooded by the number of nodes in the cluster.
- **BVG**: The BSR Voice Gateway acts as a concentrator for circuit-switched user plane paths, so that the circuit core is not flooded by the number of nodes in the cluster.
- **SeGW**: The Security Gateway terminates the IP Sec tunnels from the Small Cells in the cluster and provides firewall protection to the Small Cell Core Network.
- **FMS**: The Femto Management system is responsible for SNMP-based management of all network elements in the Small Cell network, with the exception of the Small Cells themselves; these are managed in conjunction with the device manager. This is liable for management of dynamic aspects of the Small Cells (operator intervention, notifications, etc.) whereas the FMS manages static and semi-static aspects (configuration) and periodic upload of Small Cell information (FM logs, PM files).
- **File Server**: This logical element is a central repository for the software and configuration files for the Small Cells.
- **SGSN** - terminates the IuPS interface on the UMTS core network side. It provides support for IP transport option and support

for Direct Tunnel Feature. 2 GGSN.

- **GGSN** - If the Direct Tunnel feature is operative, the IuPS user plane tunnel can be formed directly between the Small Cell and the GGSN via the BPG.
- **MSC** - terminates the IuCS interface on the UMTS core network side. It supports for IP transport option.

III. FEMTOCELL DEPLOYMENT AND ITS ASPECTS

A single femtocell supports typically at most four to eight concurrent voice connections (simultaneous maximum voice connection support in femtocell is implementation specific i.e. different products support distinctive amount of simultaneous voice connections) in any indoor environment, allowing numerous approved users to have the capacity to the femtocell to use services other than voice, for example, text or real time multimedia video and audio streaming etc. The user's service subscription model for femtocell service access might change conforming to user requirements and depends upon operators. There are many variables that influence the change in hoghest data rates likewise the air interface technology used, the user subscription and broadband link capacity.

For supporting femtocells operations it requires a network element called Femto Gateway which act as an RNC towards the core network .Figure 4 illustrates a basic femtocell deployment model in a real world environment. In order to make utilization of femtocell

There are many challenges which are the present research topics. The key technical challenges facing the femtocell networks depend on their application domains such as:

- Broadband Femtocells: Resource Allocation Timing, Synchronization and backhaul.
- Voice Femtocells: Interference Management
- Network Infrastructure Femtocells: Security

services, customer will purchase a femtocell and will associate to it through its own fixed broadband service. Figure 5 shows the uniformity in coverage on deploying the femtocells and thus the advantage that it provides in offloading macro traffic.

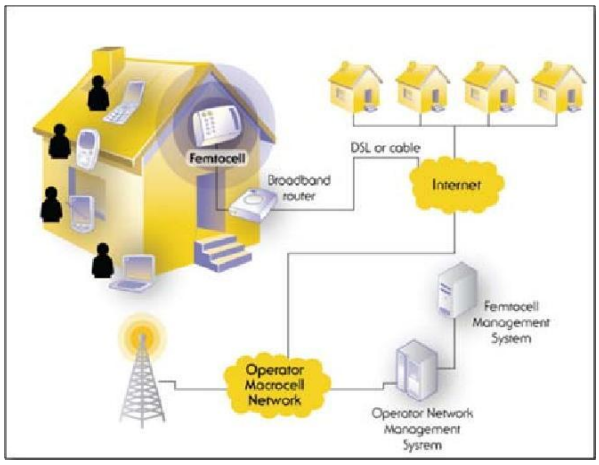

Figure 4. Typical Femtocell deployment

Upon being connected to the broadband access, the HNB will further make the connection to the operator's gateway; thereafter the HNB will be authenticated and configured according to the user's membership policy. Femtocell access is usually available to a restricted number of authorized users. This ensures that the coverage area which is provided by femtocell is only accessible by femtocell owner or by a trusted class of people.

Figure 5. Coverage under femtocell networks

On the other hand Femtocells also provide many advantages based on some of its awesome features. The benefits of using the Femtocells are as follows:

- **Better Efficiency**: As femtocells localize the mobile networks, it minimizes the transmission power and prolongs the handset battery life to accomplish a higher Signal Interference and Noise (SNIR) ratio. These translate into the so-called 5 bar coverage.
- **Improved Reliability and Subscriber Turn-**

Over: Femtocells give a virtual approach to make cellular telephones available on the roof of a house where there is a superior signal strength which enhances reliability and increases consumer satisfaction which thus prompts diminished subscriber turn-over as customer satisfaction is increased and subsequently he doesn't think of changing over to another mobile network.

- **Cost Benefits:** The femtocell gives expense advantages as the femtocell infrastructure is negligible as compared to installing a new tower causes extra expenses such as site lease and additional back haul and power overheads.
- **Other benefits include:** improved spectral efficiency, macro reliability and increased subscriber trace.

IV. FEMTO MANAGEMENT SYSTEM (FMS)

Femto devices bring the home network and subscriber into the end- to-end service delivery chain. This requires a method to deal efficiently with subscriber requests for assistance (customer care). The number of managed devices is much greater (typically 500k compared to 5k). To avoid overloading the management application, the interaction frequency needs to be controllable from the management application and the communication pattern needs to be robust against communication failures.

The FMS is the central management system responsible for providing integrated management of the Femto Gateway, the IP Security channel and the Device Manager. It also provides management of the Small Cell

The home device manager is a network element located within the mobile operator's central office IP network and performs several functions vital to the Small Cell Network. The functions are configuration updates and policy based operations.

in conjunction with the device manager and File Server. The system has been devised to diminish downtime during upgrade, data back-up, data rebuild or when unanticipated outages occur. This offers 3GPP standardized interfaces to interconnect with upstream Operation Support Systems (OSS). Additionally, interoperability testing is done with independent OSS software vendors. Correspondingly, this system fundamentally quickens time-to-market and extensively minimizes the effort of integration with administrator's incumbent systems. The functions of FMS (Figure 6) are:

- Provision of an interface for pre-provisioning and configuration updates for the Small Cells.
- Configuration Management which enables the modification of Femto attributes and features
- Fault and Alarm Management which monitors and corrects alarms that arise
- Cell Planning to help in better network topology in Het Net scenario
- Performance Management to supervise the performance of all other network elements

The file server is a central repository for Small Cell software loads and bulk configuration data, and for uploaded log files and performance files. This is a passive network element. The FMS provides personalized configuration files to it from where the small cell takes it. Also from time to time Small Cells will upload log files and performance data files and they are extracted from file server by FMS.

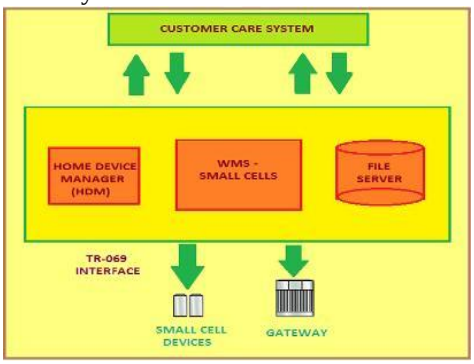

Figure 6. Femto Management System for Femtocells

The FMS is also known as Wireless Management System and is the central backbone of the Femtocell Network that manages and controls the entire operation of the network. The benefits of the FMS are as follows:

- Scalability and capacity

- Powerful solution
- Rapid Deployment
- Investment friendly
- Reliability
- Low cost of ownership

V. CONCLUSION

The advent of the femtocell in UMTS architecture evolution has changed the expectation for broadband customer experience dramatically. Nobody could even have thought of receiving excellent broadband performance with excellent wireless coverage especially in homes during the past few years. The femtocell has turned itself into the only viable solution, so far which is used to provide high quality packet switched services at low cost. Femtocells simultaneously reduce the burden from the operator's core as well as offload traffic from the macrocell access network. Operators are seeing the femtocell as a cost effective solution that can be used to generate more revenue.

For a mobile service provider, the magic for attractions of a femtocell are enhancements to both coverage and capacity, particularly indoors. This can diminish both capital expenditure and working cost. Providing a superior service to end-users in turn diminishes churn. There may also be opportunity for new services. Consumers advantage from enhanced coverage and possibly better voice quality and comparatively better battery life. Depending on the carrier they may also be offered more appealing tariffs e.g. reduced calls from home.

VI. REFERENCES

[1]. Prodromos Makris et al., “A context-aware ramework for the efficient integration of femtocells in IP and cellular infrastructures”, EURASIP Journal on Wireless Communications and Networking , January 2013

[2]. Yong Bai and Lang Chen, “Hybrid spectrum arrangement and interference mitigation for coexistence between LTE macrocellular and femtocell networks”, EURASIP Journal on Wireless Communications and Networking , January 2013

[3]. Jeffrey G. Andrews, et. Al, “Femtocells: Past, Present and Future”, IEEE journal on selected areas in communications, VOL. 30, No. 3, April 2012

[4]. Han Shin Jo et al. – “Open, Closed and Shared access Femtocells in the downlink”, EURASIP Journal on Wireless Communications and Networking , January 2012

[5]. Alan Barbeiri., et Al, “LTE Femto cells: system design and performance analysis”, IEEE journal on selected areas of communication, vol 30, no. 3, April 2012

[6] Simon R. Saunders et al.; "FEMTOCELLS Opportunities And Challenges for
Business And Technology", John Wiley & Sons Ltd 2009

[7] Femto Forum [Online] http://www.femtoforum.org/femto/

[8] Next Generation Mobile Network [Online] http://www.ngmn.org/

[9] Fettweis G, Zimmermann E (2008) ICT energy consumption-trends and challenges. In: Proceedings of the 11th international symposium on Wireless Personal Multimedia Communications (WPMC)

[10] Hansen J, Sato M, Kharecha P, Russell G, Lea DW, Siddal M (2007) Climate change and trace gases. Philos Trans R Soc 365(1856):1925–1954

[11] Karl H (2003) An overview of energy efficient techniques for mobile communication systems. Technische University Berlin, Tech. Rep