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Research Article

Enhancement of QoS in LTE Macro network through Femto Cells with Interference Reduction

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Abstract

Macro network single handedly cannot support the ever growing demand of the data usage among the users. These users are mostly the indoor customers. Macro network in a high density region reduces upto 50% of its actual capacity (QoS). These problems could be reduced with the introduction of femto cells. A femtocell is a small, low-power cellular base station, typically designed for use in a home or small business. It is also known as femto Access Point (AP).These femto cells when introduced into the network benefit both the operator and the consumer.It is beneficial to the operator in terms of coverage (especially indoors) and capacity. Coverage is improved by the reduction in the loss of signal. Capacity is improved by reducing the number of phones using the main network and by the off -load of traffic through the users network via the internet. In this work, we deploy femto cells in an indoor network and analyze the network performance. Split Spectrum technique is then used to manage the interference between the macro and the femto network and to decrease the Block Error Rate (BLER). This work also highlights the offloading of the existing macro network by femto cells.

Keywords: *Femto cell, Macro Network, QoS, LTE.*

1. Introduction

The development of mobile data traffic in the upcoming years is very much predictable. The International Data Corporation (IDC) estimates that 3.2 billion people, or 44% of the world's population, will have access to the Internet in 2016. Of this number, more than 2 billion will be using mobile devices of which 182 million will be LTE subscribers .The dominating part of the mobile broadband traffic is coming from laptops with inherent or USB modem and it is originating frequently from indoor. More and more use of video applications on mobile devices is the primary reason towards increase in the data traffic.

The LTE Radio Access Network, LTE RAN. It describes the architecture and gives an overview of the functionality. Evolved Packet System (EPS) in 3GPP Release 8 is based on a simplified network architecture compared to Release 6. The number of user-plane nodes is reduced from four in Release 6 (NodeB, RNC, SGSN and GGSN) to only two (e-NodeB and S-GW) in EPS.Only a Packet Switched (PS) domain is defined in LTE. This means that the traditionally Circuit Switched (CS) services will be carried by PS bearers.

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2. Material and Methods

The basic data component is an array of MATLAB that does not require location in space.Highlights from Release 8 include: Up to 300 Mbps downlink and 75 Mbps uplink Latency as low as 10 ms Bandwidth sized in 1.4, 3, 5, 10, 15, or 20 MHz blocks to allow for a variety of deployment scenarios Orthogonal frequency domain multiple access (OFDMA) downlink Single-carrier frequency domain multiple access (SC-FDMA) uplink Multiple-input multiple-output (MIMO) antennas Flat radio network architecture, with no equivalent to the GSM base station controller (BSC) or UMTS radio network controller (RNC), and functionality distributed among the base stations (enhanced NodeBs) All IP core network, the System Architecture Evolution (SAE).

Highlights from Release 9 include: Evolved multimedia broadcast and multicast service (eMBMS) for the efficient delivery of the same multimedia content to multiple destinations Location services (LCS) to pinpoint the location of a mobile device by using assisted GPS (A-GPS), observed time difference of arrival (OTDOA), and enhanced cell-ID (E-CID).Dual layer beam forming.

Highlights from Release 10 include: Higher order MIMO antenna configurations supporting up to 8×8 downlinks and 4×4 uplinks Data throughput of up to 3

Gbps downlink and 1.5 Gbps uplink Carrier aggregation (CA), allowing the combination of up to five separate carriers to enable bandwidths of up to 100 MHz Relay nodes to support Heterogeneous Networks (HetNets) containing a wide variety of cell sizes Enhanced intercell interference coordination (eICIC) to improve performance toward the edge of cells

LTE Release 11 included refinements to existing Release 10 capabilities, including: Enhancements to Carrier Aggregation, MIMO, relay nodes, and eICIC.

Packet Data Convergence Protocol (PDCP) Radio Link Control (RLC) Medium Access Control (MAC) The Physical Layer (PHY) The first three protocol entities handle tasks such as header compression, ciphering, segmentation and concatenation, and multiplexing and demultiplexing. The primary features of the LTE physical layer are OFDM.

Physical channels, transport channels, control information, and OFDM modulation Use LTE System .™ mid-level downlink channel processing functions to: Create physical signals and physical channels for transmission and reception.Create, encode, and decode transport channels. Create, manipulate, encode, and decode control information messages. For function mapping within the downlink grid, see Downlink Physical Channels Grid and Downlink Physical Signals Grid.

Parameter Setting Description 'Port7-14' Release 10 up to 8-layer transmission, ports 7–14 (NLayers=1…8) PDSCH transmissions, associated with antenna ports 7 through 14 (or any transmission scheme), can be made using the ltePDSCH and ltePDSCHIndices functions.

Parameter Setting Description 'Port7-8' Release 9 single-antenna port, port 7 (if NLayers=1) Release 9 dual layer transmission, ports 7 and 8 (if NLayers=2) 'Port8' Single-antenna port, port 8 PDSCH transmissions, associated with antenna ports 7 and 8 (or any transmission scheme), can be made using the LTE PDSCH and LTE PDSCH Indices functions.

Doppler Freq Required Scalar value Maximum Doppler frequency, in Hz. Sampling Rate Required Numeric scalar Input signal sampling rate, the rate of each sample in the rows of the input matrix, in.InitTime Required Numeric scalar Fading process time offset, in seconds. NTerms Optional 16 (default) scalar power of 2 Number of oscillators used in fading path modeling.ModelType Optional 'GMEDS' (default), 'Dent' Rayleigh fading model type.

3. Result & Discussion

Without Femto cell deployment (Scenario 1)

Figure shows the Signal to Noise and Interference Ratio (SINR) after applying the signal macroscopic path Loss in the Region of Interest (ROI). It shows 7 eNodeBs, each with 3 sectors covering 120 degrees. The region nearer to the eNodeB (Red Region) is the high SINR region and as we move away from the intermediate towards the edges, the intervention from the neighboring cell increases and thus the SINR value decreases.

The outdoor users are randomly scattered over the whole region whereas the indoor users, depending upon the sub scenario (10%, 20%...and so on) are placed just about the boundaries of the cell. Only the worst case scenario is considered for the simulation, as we are placing the Indoor UEs only at the bad coverage area (edges of the cell).

Figure represents the sub-scenario of 20% indoor UEs located around the boundary of the cells. This snapshot of the ROI represents the path loss added with the outline fading of the region. Figure shows the scenario with 90% of the Indoor users.

Each sub scenario was run for 200 TTI and the equivalent downlinks Throughput were measured. Figure shows the mathematical value of the Throughput while the Figure shows the percentage decrease in the Throughput.

The total aggregated macro network throughput is plotted versus percentage increase of indoor users in Figure. The results are only computed for downlink traffic. Throughput is calculated using the equation given below.

$$Throughput = \frac{Acknowledge\ Date}{Time}\ (Bits/Sec)$$

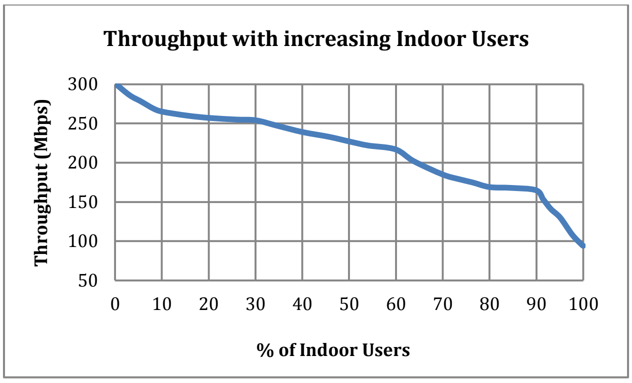

Fig.1

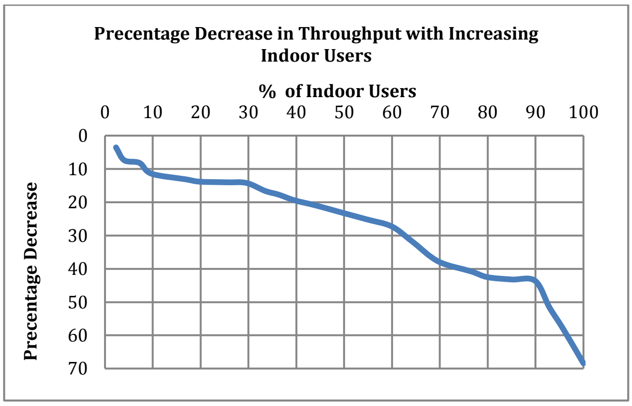

Fig. 2

This decreasing trend of the throughput is in accord with Eq. 1. Since within the indoor environment, which is produced at the edge of the macro cell, SINR value is quite low due to 1) UE being at the farthest distance from the eNodeB and 2) the extra added incursion loss of 20dB, this leads to an overall low Capacity and hence the degraded throughput.

As the quantity of indoor UEs increase, the throughput begins to decrease and for the value of 80-90% indoor users, the throughput decreases by 45% of its original value. This figure is a point of center for all the wireless and mobile operators (referred as OpCos) since the study shows the number of Indoor users in next few years are going to increase to that value and loosing 45% of the network throughput is a point of concern for the OpCos to meet their Quality of Service (QoS) requirements and compete in the market against each other.

With deployment of Femto Cells (Scenario 2)

Like Scenario 1, the number of Indoor users was increased with the step of 10% but instead, they are served by a femto cell, which is defined by the parameters listed in Table.

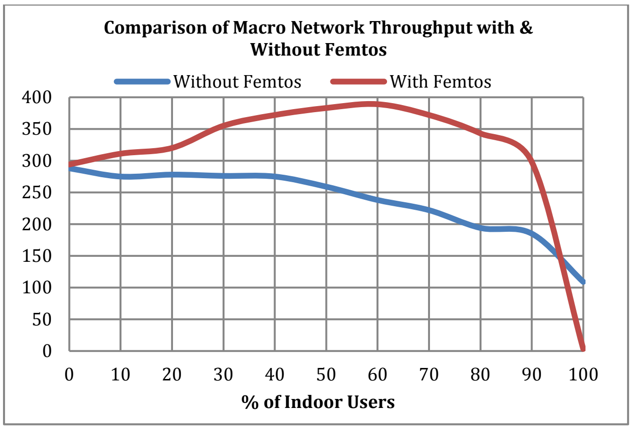

Fig.3

The point of focus here is not the effective throughput of the femto cell but its effect on the macro network throughput. Hence the comparison of Scenario 1 and Scenario 2 was made on the basis of the network throughput in Figure: 3

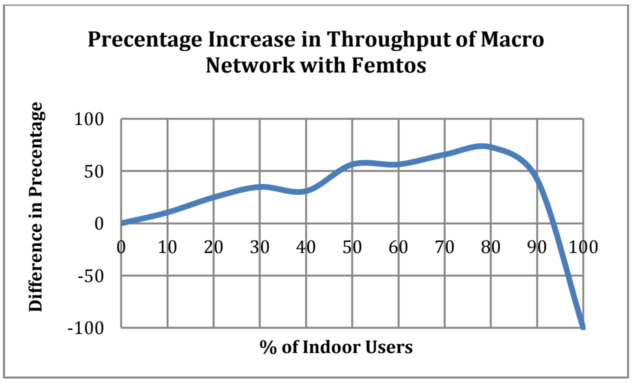

Fig.4

Macro network throughput always stays higher for every percentage of Indoor Users. This is due to the fact that since the indoor users with low SINR are offloaded to Femto cell, the outdoor users could be served better by the eNodeBs. With the 'full buffer' traffic model, where UEs always have something to download from the eNodeB, as more and more UEs with Low SINR were offloaded to the femto cell, macro network throughput kept on increasing until the macro network was under loaded. This effect can be understood better from the Figure: 4, which represents the percentage increase in the throughput of macro network.

Unlike the Scenario 1, where macro network lost about 40% of its throughput (TP) for 80% of indoor users, an increase of about 75% is observed in the throughput. The percentage increase or decrease shows the difference in general for evaluation purposes. The throughput is dropped to zero when the percentage of indoor users reaches a value of 100, showing that all users are moved indoors and now being served by femto cells.

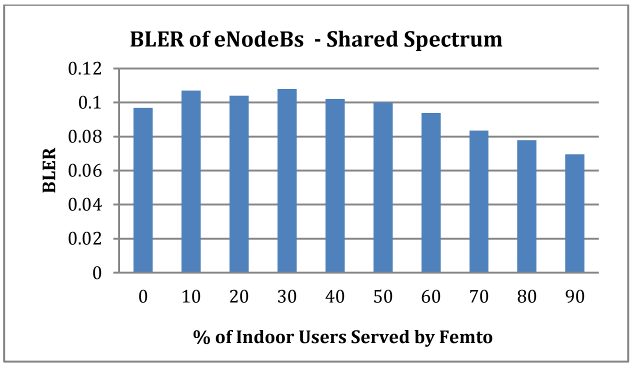

Fig.5

Another interesting aspect to focus on at this point is the interference between the macro and femto cells [Figure: 5]. Femto-femto interference is ignored mainly because of very low Transmitting power of Femto cell and the added high Path loss of 40dB between two femto cell environments would have insignificant effect on each other.

Block Error Rate is a fair measure to evaluate the interference level. BLER is computed at eNodeB using the Equation given below

$$BLER = \frac{No.of\ Blocks\ Sent - No\ of\ blocks\ Correctly\ Received}{Total\ no\ of\ blocks\ sent}$$

In Figure: 5, BLER increases for couple of steps, before following a decreasing curve till the end. One explanation for such pattern could be that at 10% not enough UEs are offloaded and femto cells, which uses the same frequency band, were introduced causing an increase in the Interference level at eNodeB and hence the BLER, but as more UEs with low SINR value are taken indoors and served with femto cells, the Interference level began to decrease and hence the block error ratio (BLER) diminishes.

Effective Offloading

In Scenario 2 all of the indoor users were served by Femto cell (e.g. 20% indoor – all of those 20% were served by femto cells) but now we want to analyze the impact if only a part of indoor users are offloaded. This is also a point of focus for OpCos, since it might not be practical to offload 'ALL' of the indoor users but only a part of them. Each line in the figure represents the percentage of users within the indoor environment, x-axis represents the percentage of indoor users severed by femto cell and y axis represents the macro network throughput.

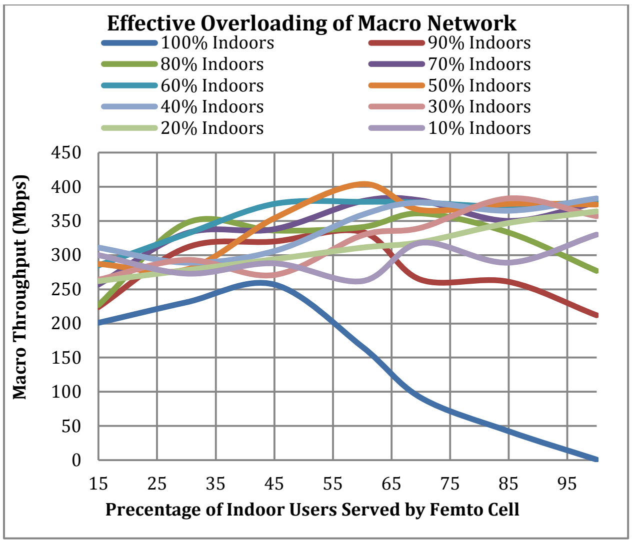

Fig.6

In Figure: 6 it can be seen that indoor users in the range from 15% to 40% do not show any significant drop in the peak value of throughput as the number of indoor users increase. This is because that macro network is not fully loaded by indoor users and the increase in traffic does not reach the threshold yet, which basically does not show their offloading nature.

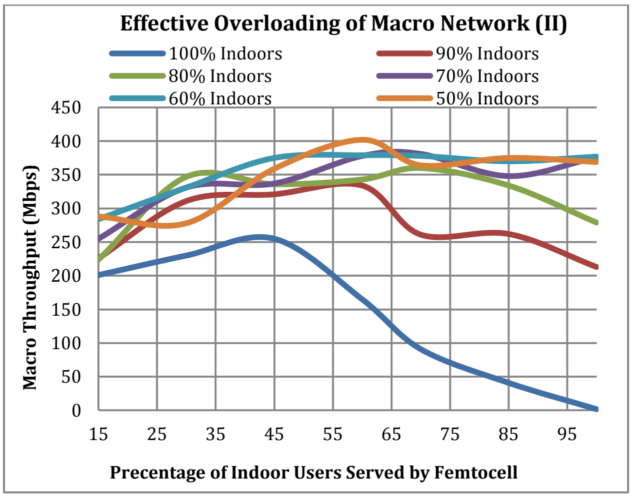

Fig.7

In Scenario 1, when there were no femtocells deployed, it was shown that major degradation occurred when indoor users were in the range of 70% to 90%. Figure 5-8 rather gives a clearer picture of indoor users in the range from 50% to 100%.

If we analyze the graph closely, it can be seen that, depending upon the percentage of indoor users, serving a certain amount of indoor users with femto cells can bring optimal results in terms of the maximum value of the Throughput of the macro network which is shown by the peaks for every percentage of indoor user. For 100% indoor users, it is optimum to offload about 45% of those indoor users to femto cells, whereas, for 90% indoor users, the optimum value is 60%.

Effect of Interference Management (Scenario 3)

If we look at Figure: 8, the Throughput value at 0% indoor users is less for Scenario 3 as compared to Scenario 1. This is because only 15MB bandwidth is available for the macro network as compared to 20MB for Scenario 1.

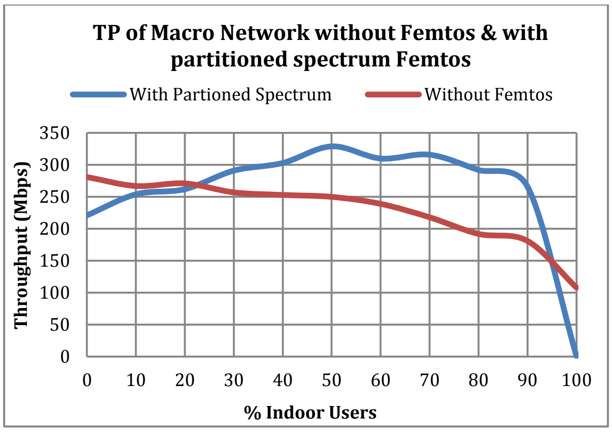

Fig.8

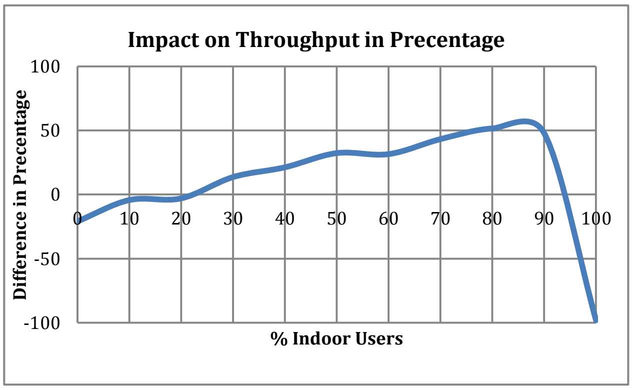

Fig.9

The overall increasing trend is identical to Scenario 2, as we offload the macro network by taking the users indoor but the percentage increase in the Throughput is relatively low in this scenario. In scenario 1, about 75% increase in the Throughput was observed for 80%

of indoor users whereas only about 50% increase was observed in this scenario.

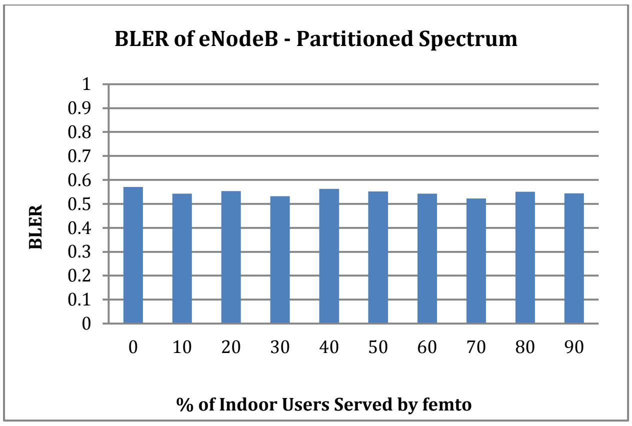

Fig.10

Interesting to note in Figure 5-10 is that the BLER remains almost the same as the number of indoor users increases and, also, the value of BLER at 0% indoor user is low as compared with Figure 5-6, which is expected since femto and macro network are using non-over lapping partitioned bandwidth and have a very low interference level.

Though we observe lower BLER in this scenario as compared to Scenario 2 and yet the gain in macro network Throughput is lower. One possible explanation is since capacity is also dependent on the amount of bandwidth available, in scenario 2 we have more bandwidth available than in scenario 3.

Since in this simulation Scenario, we placed femto cells only at the edge of the circle, the area where the received-signal strength from eNodeB is very low (Low SINR) and hence the interference level between femto and macro network is low. For such scenario, Shared Spectrum technique is more suitable as macro network restores more capacity as compared to Slip Spectrum technique.

Split Spectrum Technique would be more suited for the scenario where Indoor users are placed randomly or closer to the eNodeBs, where the interference level between femto and macro network would be relatively higher and splitting the spectrum would make more sense.

Conclusion

Macro network single handedly cannot support the ever growing demand of the bandwidth hungry applications for the indoor users. Without any assistance, Macro network loses up to 50% of its actual capacity (QoS) and poses serious issues for maintaining QoS for the Telecom Operators. Femto cells provide a smart solution for meeting capacity requirements of the network. Simulation results show offloading the traffic via femtocells restores the Macro Network capacity. Also, for current position of indoor users, shared spectrum gives better results than partitioned spectrum.

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