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LTE Femtocell Simulation of Different Modulation Technique under Different Multipath Fading

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ABSTRACT: The vision of Self-Organizing Networks (SON) has been drawing considerable attention as a major axis for the development of future networks. As an essential functionality in SON, cell outage detection is developed to autonomously detect macrocells or femtocells that are inoperative and unable to provide service. However, due to the two-tier macro femto network architecture and the small coverage nature of femtocells, it is challenging to enable outage detection functionality in femtocell networks. Self-healing functionality in femtocell aims to resolve the loss of coverage or capacity induced by cell outage to the extent possible in the femtocell networks. Existing systems uses local cooperation architecture which seeks solutions with the need for local collaboration among femtocells. Specifically, an outage is detected based on the measurements of surrounding femtocells. Based on these local measurements, a proper set of neighbor femto APs tune their parameters to compensate for the outage. The outage occurs due improper arrangements of femtocell network. Proper placing of the femtocell access points reduces the outage problems. The signal strength, threshold and various parameters are calculated for different configurations and for different modulation technique using a simulation mechanism. The analysis of the same is done .from this analysis proper configuration of the femtocell network is obtained.

KEYWORDS: LTE, Femtocell, Simulation, Modulation Technique, Multipath Fading.

1 INTRODUCTION

Since macrocell coverage becomes expensive to serve indoor customers with large service demands, new methods for the indoor coverage/capacity problem are required. One solution to enhance indoor coverage is the so-called FAPs (Femtocell Access Point) or home base stations [2].These are low-power base stations designed for indoor usage that allow cellular network providers to extend indoor coverage where it is limited or unavailable.

Femtocells are small cellular telecommunications base stations that can be installed in residential or business environments either as single stand-alone items or in clusters to provide improved cellular coverage within a building. It is widely known that cellular coverage, especially for data transmission where good signal strengths are needed is not as good within buildings. By using a small internal base station –Femtocell (femto cell), the cellular performance can be improved along with the possible provision of additional services. 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. One of the key elements of the femtocell it's that its installation, organization and configuration should be completely trouble free and without any intervention from the home owner.

It is a prime requirement that femtocells must be able to be installed by people with no technical knowledge of their operation and once installed, they should continue to operate without any intervention, even if the surrounding environment changes. Therefore the installation of the femtocell should be totally plugged and play, and it should not require any intervention from the users apart from connecting it to an internet router and plugging it in to a mains supply. This requires a considerable amount of intelligence within the femto cell itself. With the deployment of femto cells within the macro cells, the role of interference management becomes extremely important. The idea is to optimize the macro network behavior with respect to interference and capacity relationship. Macro-Macro, Macro-Femto, Femto-Macro Interferences are considered.

For the sake of simplicity, interfering impact of a femto cell on the neighboring femtocell (Femto-Femto) is not considered ,mainly, because femto cells are low powered devices and added penetration loss due to indoor environment would make the impact insignificant. It is estimated that by 2012, there could be around 70million FAPs installed in homes or offices around the world, serving more than 150 million customers [3]. Consequently, the co-channel deployment of such a large femtocell layer will impact existing macrocell networks, affecting their capacity and performance [4]. Therefore, to mitigate this impact, several aspects of this new technology such as the access methods, frequency band allocation, timing and synchronization and self-organization need further investigation before FAPs become widely deployed. Since the number and position of the FAPs will be unknown, interference management cannot be further handled by the operator using traditional network planning and optimization techniques. Therefore, special attention must be paid to the mitigation of interference between the macro- and femtocell layers, as well as between femtocells.

2 PROPOSED SYSTEM

In a standard cellular system using OFDMA-based network access, frequency allocation must take into consideration both inter- and intra-cell interference. Each subcarrier should be allocated to only a single user within the cell (or sector) so that intra-cell interference is avoided. Moreover, users from adjacent cells (or sectors) might cause interference to the users in the cell of interest so frequency allocation has to be optimized to minimize the inter-cell interference. With femtocells overlaying on top of a traditional cellular deployment, the complexity of the interference problem increases significantly and new mitigation strategies have to be designed.

Assume that a femtocell network has a single macrocell base stations (MBS), and then one can expect to encounter three different types of uplink interference. They are listed below:

- MU to FAP interference
- FU to MBS interference
- FU to FAP interference

MU TO FAP INTERFERENCE

In OFDMA-based systems such as mobile WiMax, power control is employed for the uplink. It ensures that, at any time, a given MU is transmitting enough power to achieve a minimum signal to interference plus noise ratio (SINR) at the MBS receiver given the current channel condition, which is measured by the system periodically. If an MU is located far away from the MBS, the power control algorithm will set its transmitted power to a high level to meet the target SINR value, if an MU happens to be in the vicinity of a femtocell and also far away from the MBS, then its signal could be high enough to propagate through the walls of the building where the FAP is deployed and generate interference. This will happen only if the FU in the femtocell uses the same frequency as the MU. It is important to note that it is indeed on the macrocell edge where femtocells are most necessary and useful, so this kind of interference is expected to be very frequent.

FU TO MBS INTERFERENCE

Due to the frequency reuse among femtocells, it is possible that many FUs in different femtocells use the same subcarrier as an MU, thus they will interfere with the macrocellorder to overcome the interference from FUS to the MBS, the MBS measures the interfered subcarrier and applies the uplink power control on the MU, which will determine that it needs to transmit higher power in order to reach its target SINR at the receiver. This increase of the transmission power will worsen even more the MU to FAP interference.

FU TO FAP INTERFERENCE

A femtocell is, by definition, located indoors, so interference occurs when adjacent femtocells use the same subcarriers. The interference level between non-adjacent femtocells is negligible, because any signal coming from one FU travels through at least two walls to reach the FAP of a non-adjacent femtocell. Therefore, the frequency allocation strategy should not allocate the same subcarriers in adjacent femtocells in order to avoid the intra-tier interference among femtocells.

A. INTER-TIER INTERFERENCE MITIGATION WITH PARTIAL COCHANNEL ASSIGNMENT

We focus on inter-tier interference mitigation under a single macrocell scenario. Based on the fact that there are much less number of FUs in each femtocell than the number of MUs in each macrocell, a portion of the whole spectrum would be sufficient for femtocells in most cases. Furthermore, in order to avoid performance degradation due to interference, it may be better to limit the spectrum that a femtocell can use, which is verified in section V.

Given a total number of available subcarriers N, we assume that Ns subcarriers are shared by the FU and MUs, whereas the remaining (N − Ns) subcarriers are used by MUs only. The transmitting power of MU is denoted as P MU and P MU min ≤ P MU ≤ P MU max by using power control according to the measurement of each subcarrier channel state. Owing to the small radius of the femtocell and FU and MU being the same type of terminal, we assume that the transmission power of FU, P F U, is constant and P F U = P MU min. It is shown that such constant power assignment on subcarriers will not bring noticeable rate decline compared to the Mercury Water-Filling (MWF) power control algorithm.

B. INTER-TIER INTERFERENCE MITIGATION STRATEGY

In this subsection we propose a co-channel interference mitigation strategy between MUs and FUs over the shared subcarriers. The uplink interference problem by considering the QoS requirements for both MU and FU in term of SINR. As for mitigating the interference from FUs to the MBS, the MU first uses power control to improve the SINR in order to satisfy its QoS requirement. If the MU cannot reach its minimum SINR requirement due to the long distance from the MBS and the interference from FUs, it should switch to the dedicated subcarriers.

If the MU can meet its target SINR, then it will be checked whether or not its transmission power is strong enough to interfere with its nearest co-channel FU. If the position of the MU is close enough to an FAP to interfere with the co-channel FU, it should use the dedicated subcarriers. The proposed strategy for eliminating the inter-tier interference (i.e., MU to FAP and FU to MBS) is summarized as follows

- For any given MU m, estimate the total path loss to the MBS and estimate the path loss to its closest active FAP by measuring the Reference Signal Received Power (RSRP) of the active FAPs in the downlink.
- Check whether the MU can meet its target SINR by using power control. If yes, consider the worst interference case from this MU to its nearest FAP, where the FU is on the edge of this FAP. Then the MU estimates whether or not its transmission power causes the FU's SINR below the minimum requirement. Here, the reason for considering the worst case scenario is to maintain the uplink coverage of the femtocell.
- If both the MU and the FUs in its closest femtocells can satisfy their SINR requirements, the MU is a regular user and can use either the shared subcarriers or the dedicated subcarriers.

Otherwise, the MU is a femto-interfering user and can only use the dedicated subcarriers. After the above strategy is applied, all MUs within the macrocell are classified as either "regular users" or "femto-interfering user." Such classification of MUs depends on many system parameters, such as the macrocell radius, femtocell radius, penetration loss through the building wall, transmission power of an FU, etc. Let's describe the classification procedure in detail.

C. CLASSIFICATION OF MU'S

In order to make sure that the MUs do not interfere any FU in the closest femtocell, consider the worst case scenario that an FU is at the edge of the femtocell. Assume that the estimated distance from the MU to the closest FAP d MF is obtained by the RSRP measurement from the FAP in the downlink. Based on the value of RSRP and the FAP transmission power which is set to be constant in partial co-channel deployment, the MU can calculate the path loss from the FAP to it, and then the distance from the MU to its closest FAP can be estimated according to the path loss model. Then the interference from the MU to the FAP is given by

$$I^{MF} = \frac{P^{MU} G^{F} G^{U}}{X^{MF}} \quad (3.1)$$

Where P^{MU} is the transmit power of the MU

G^{F} is the antenna gain of the FAP

G^{U} is the antenna gain of MU

MF is the path loss from the MU to the FAP and related to MF. Whereas the antenna gains of FU since both MU and FU is the same type of terminals. As for the interference from FUs in other femtocells to this FU, after applying the auction algorithm for the shared subcarrier allocation to be described in the next section, the interference between adjacent femtocells can be avoided. Then the worst case scenario is shown on the right-hand side, where the femtocells with the same colour use the same subcarrier and interfere with each other. We analyse the interference from FUs in FAPs 3, 11, 15 and 23 to the FU in FAP 13 with the interfering FUs located at the closest positions to FAP 13.The interference from FUs in the outer rings is ignored due to the long distance and extra penetration losses through walls. Then, the sum interference from FUs in FAPs 3, 11, 15 and 23 to the FU in FAP 13 is given by

$$I^{FF} = \frac{4P^{FU}\, G^{F} G^{U}}{X^{FF}} \qquad (3.2)$$

Where X^{FF}accounts for the path loss from one of the interfering FUs to FAP 13 and can be calculated using the distance of 3RF C. GF is the antenna gain of FAP. The interference from FUs to the MU is given by

$$I^{FM} = \sum_{i \in m_{int}} \chi \frac{4P^{FU}\, G^{F} G^{U}}{x_i fm^2} \qquad (3.3)$$

As for I FM, due to the frequency reuse among femtocells, its value is mainly related to the minimum distance from FUs to the MBS and the active probability of femtocells, which varies much slower than χ MF. Therefore, different MUs have different χ MU max due to their different locations. The MU with a larger distance from its closest FAP will have a larger χ MU max. Any MU whose path loss to the MBS is less than its corresponding χ MU max will be classified as a regular user and it can use either the dedicated subcarriers or the shared subcarriers. The others will be classified as femto interfering users and they can only use the dedicated subcarriers. An intuitive way to understand the above MU classification scheme is by defining dmax as the distance where a given MU will suffer a total path loss of χ MU max. Any MU lying within dmax can use any subcarriers, whereas any MU located outside of dmax can only use the dedicated subcarriers. In this way, both the MU and FU can meet their target SINR requirements and therefore the inter-tier interference is avoided. Note that the actual value dmax is not a constant value and depends on the current values of path loss and the distance from this MU to its nearest co-channel femtocell, d MF.

D. Building Structure

A regular building structure and each apartment/house admits same room layout and layout to simplify the model as shown in the fig.1

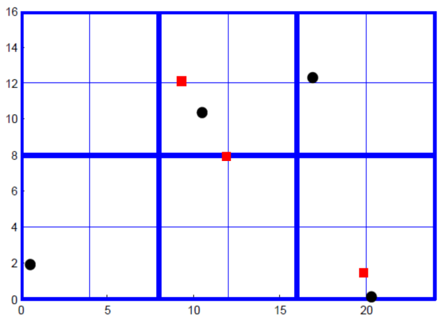

Fig.1 Grid Layout

A number of formalisms have been developed in architectural theories that aim to capture the architectural design process, or particular architectural styles as shown in the fig.2. These models have primarily been used to derive schematic geometric arrangements, rather than detailed floor plans. Formalisms such as shape grammars have so far not yielded models able to produce complete building layouts; akin to ones created by architects in practice. The underlying difficulty is that real-world building layout design does not deal exclusively with geometric shapes and their arrangements.

A central role in building layout is played by the function of individual spaces within the building, and the functional relationships between spaces. In practice, building layout design relies on a deep understanding of human comfort, needs, habits, and social relationships. Numerous guidelines have been proposed for the building layout process, and a few are near-universal in practice. One is the privacy gradient, which suggests placing common areas, such as the living room, closer to the entrance, while private spaces, such as bedrooms, should be farther away. Another concerns room shapes, which should be largely convex and avoid deep recesses, due to the instinctive discomfort sometimes triggered by limited visibility in concave spaces. On the whole, however, the proposed rules of thumb have proved too numerous and ill-specified to be successfully modeled by a hand-designed rule-based system

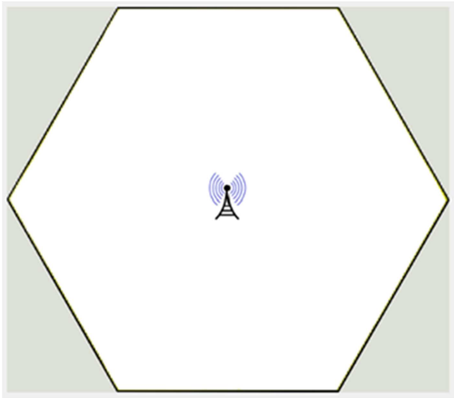

Fig.2 Main Layout of Macro network

The approach is to apply modern machine learning techniques to infer aspects of building layout design from data as shown in the fig.3 In order to derive the methods presented in this report and representation of the building layout process as it is carried out by residential architects in practice. The balance of this section summarizes this process, which serves as the model for our approach. The presented summary is distilled from interviews and on-site observations at three residential architecture practices in a large suburban area, as well as from published references. Schematic geometric arrangements, rather than detailed floor plans. Formalisms such as shape grammars have so far not yielded models able to produce complete building layouts; akin to ones created by architects in practice.

The underlying difficulty is that real-world building layout design does not deal exclusively with geometric shapes and their arrangements. While there is great variability in the design methods of different architects, this summary presents some significant commonalities. The first challenge in the process is to expand the incomplete and high-level requirements given by the client into a detailed specification for the residence. "I want a three bedroom house for under $300,000' is a typical initial problem statement". From these initial requirements, the architect produces a list of rooms and their adjacencies. An adjacency indicates direct access, such as a door or an open wall.

At this stage, the architect often sketches a number of bubble diagrams, in which rooms are represented by ellipses or rounded rectangles, and adjacencies are represented by edges connecting the room. Through prototyping with bubble diagrams, the list of rooms and their relationships is progressively refined. The architect toggles between floors, and specifications for one floor are not finalized until the other floors are pinned down.

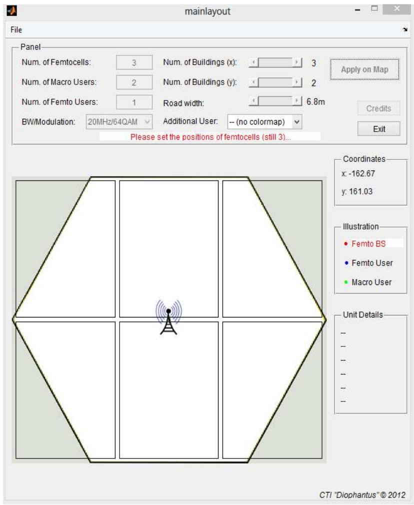

Fig.3 Building Design of Femtocell Network

Multi-story spaces, such as stairwells and atria, are indicated as such. After the architectural program is vetted by the client, the architect creates a schematic plan, or concept sketch. This is a rough planar layout as shown in the fig.4 of the spaces on each floor, such that adjacent spaces are next to each other, and the spaces have roughly the desired sizes. Exterior trim, as well as distinctive windows and entrances, are applied to customize the house in styles such as “American Craftsman” or “Colonial Revival.” of internal spaces on each floor, their adjacencies, and their rough sizes.

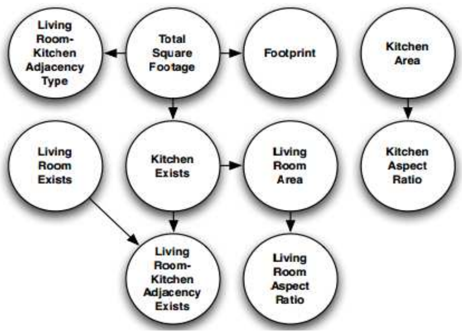

Fig.4 Schematic Process

Cell outage often results in decreased capacity and coverage gap. Such degraded performance leads to high user churn rate and large operational expenditures. Unfortunately, compared to macrocell networks, femtocell networks suffer from more severe outage issues. Unlike well planned macrocells, femtocells are usually user-deployed and much denser.

E. FLOOR PLAN OPTIMIZATION

Once an architectural program is generated, it is turned into a building layout: a detailed floor plan for each floor. These floor plans must realize the program and feature well-formed internal and external shapes. We compute these floor plans by optimizing over the space of possible building layouts. Different floors are optimized together to ensure mutual coherence. A space of floor plans is typically parameterized by the horizontal and vertical coordinates of the rectilinear segments that form the shape of the plan.

Since the number of segments is not constant across floor plans that conform to a given architectural program, the space we want to optimize over has varying dimensionality. Thus global optimization algorithms like Covariance Matrix Adaptation – which have recently been applied to a number of highly multimodal optimization problems in computer graphics – cannot be used. We have successfully experimented with Reversible jump Markov chain Monte Carlo for optimizing over the space of layouts.

However, the detailed balance condition and the associated dimension matching functions complicate both the implementation and the exposition. In practice, we have found the simple Metropolis algorithm, which has been widely used for the related problem of VLSI layout, to be sufficiently effective. Unlike greedy techniques, the Metropolis algorithm can accept moves that increase the cost function, in order to escape from local modes. Specifically, define a Boltzmann-like objective function.

$$f(x) = \exp\big(-\beta c(x)\big) \quad (3.4)$$

F. MACROCELL/FEMTOCELL IN MATLAB

The designated RF spectrum of modern cellular-based wireless communication networks is every time more congested, whilst required to serve an increasing number of users. The RF spectrum reuse has been proposed as one of the key technology drivers for the deployment of next generation BWA systems. The efficient deployment of the previous scheme constitutes one of the main goals of CR. However, the opportunistic reuse of the RF spectrum requires the agile mitigation of the effects caused by in-band interfering RF signals. Interference management is therefore becoming an indispensable feature that has to be accounted throughout the joint design of the PHY and MAC layers of network infrastructure equipment, CPE and UE. Two major interference management categories can be found in the literature. The first one includes interference avoidance techniques such as spectrum sensing, aiming at the instantaneous allocation of unused-unlicensed spectrum.

3 EXPERIMENTAL RESULTS

Despite the advantages of femtocells, effects of femtocell deployments should be carefully analyzed before their release, in order to minimize the risks and failures of femtocells in real markets. Thus, the introduction of a system level simulator that can facilitate various simulations for LTE systems with femtocells. For development of the simulator, described five functional modules, including models of wireless channels, four kinds of IP traffics, and users' mobility, to emulate realistic LTE systems and network environments. In addition, detailed operational events and graphical user interfaces for efficient simulator operations were introduced.

The intensively analyzed signal interference between macro- and femtocells under four Femtocell deployment scenarios utilizing the developed simulator. From the results, it can be found that the imprudent deployment of femtocells may seriously affect performance of overall networks, and various aspects should be considered in the femtocell deployments. Especially, since femtocells are expected to be arbitrarily deployed by customers, transmission power control of femtocells based on self-optimization manner is important for efficient femtocell deployments. For further studies, by utilizing the developed simulator, the research on the transmission power control mechanisms which can effectively mitigate cross-tier interference between macro- and femtocells by actively adjusting transmission power of femtocells based on the close cooperation between eNBs and HeNBs.

In addition, various resource partitioning schemes, which statically or dynamically divide radio resources for femto- and macrocells in order to avoid interference and improve overall performance, will be addressed. The simulation is done for different modulation technique. In each modulation technique different configurations were made by varying the number and also by varying the places of the femtocell, macro users and femto users. The buildings in both axis and also the road width are also varied. The stimulated output for 20MHz/16QAM modulation technique for a certain configuration of femtocell-macrocell network.

Using this parameter a data sheet is made, which contains all the information. From this data sheet an analysis is made and a graph is obtained. The power loss of the femtocell users for different configuration of the femtocell-macrocell network is obtained from the stimulated output is tabulated in table 1 and is plotted as a graph in fig.5

POWER LOSS (DB) – FEMTOUSER

Table 1 Femtouser Power Loss Readings

FEMTO USER	
ID	PL(dB)
1	135.7
2	137.5
3	136.4
1	135
2	134.1
3	137.1
1	135.7
2	135.4
3	140.5

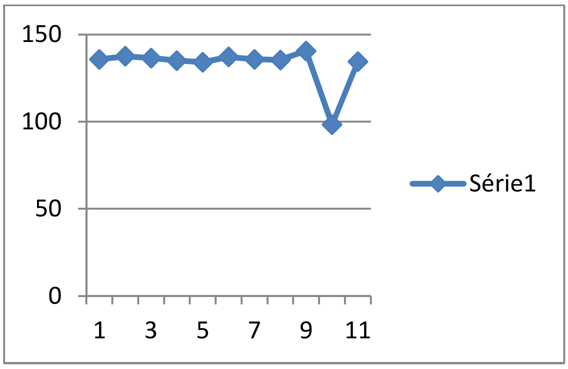

Fig.5 Femtouser Power Loss Graph

THRESHOLD (MBPS) – MACROUSER

The threshold values of the macrocell users for different configuration of the femtocell-macrocell network is obtained from the stimulated output is tabulated in table 2 and using the information from the table a graph is plotted as shown in fig.6.

Table 2 Macrouser Threshold Readings

MACRO USER 1		MACRO USER 2	
ID	THR(Mbps)	ID	THR(Mbps)
1	36	2	36
1	36	2	36
1	36	2	36
1	54	2	54
1	54	2	54
1	54	2	54
1	18	2	18
1	18	2	18
1	18	2	18
1	27	2	27
1	27	2	27

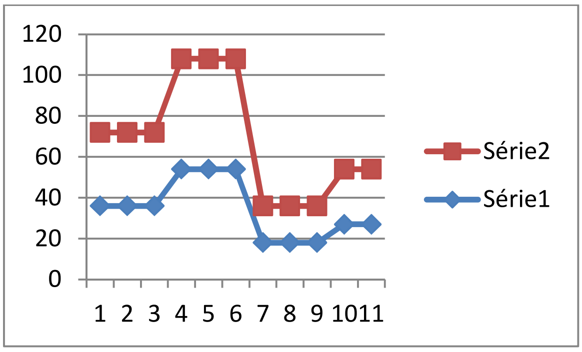

Fig.6 Macrouser Threshold Graph

4 CONCLUSION

The LTE FPC scheme compensates the PL between UE and BS as the OL approach of the PC which is the intended for different received SINR for UE of different locations. Other word to allow users near to the BS to have a better receive SINR compare to users far from the BS. The first period of analysis is focused on the LTE FPC scheme for selection of appropriate slope parameter for further simulation and knowing the correlation of the different slope parameter α and the transmit PSD(Power Spectral Density). The different α parameters 0.6, 0.8 and 1 values are chosen for comparison with different PC schemes in case of simulation. The second period of the analysis is focused on the simulation of the different PC schemes of in case of full power, LTE FPC and proposed APC schemes with chosen α slope parameters. And SINR and throughput comparison of the different PC schemes are illustrated. According to the analysis, could be concluded as below:

- For the SINR (Signal to Interference plus Noise Ratio) at the FBS1, it is seen that performances of the different power control methods are almost the same. But for the proposed scheme gradient angle is lower compare to other PC schemes.
- That means proposed APC scheme is stable in case of SINR. For the cell throughput, the proposed APC scheme is not better than the LTE FPC method.
- For the correction of the obtained results, some additional approach is stated in the next section as future works.

5 FUTURE ENHANCEMENTS

For the future work, the CL (Closed Loop) approach for the LTE Femtocell PC (Power Control) is will be studied. Also for improvement for capacity as minimizing the interference on the Femtocell environment HPC (Hybrid Power Control) technique which is combination of the AOLPC (Adaptive Open Loop Power Control) and ACLPC (Adaptive Closed Loop Power Control) technique will be studied. Besides, for the improvement on the analysis the system based simulation approach could be better solution as a future work.

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