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Interference Mitigation Technique for Two-Tier Macro-Femto Network using Grey Wolf Optimization

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Abstract: With the increase in growth of user and multimedia applications, the traffic load on network capacity increases. In order to meet this demand, one of the most effective ways of improving capacity and data rate is deployment of femtocell networks. Interference management will be one of the major challenges for the dense deployment scenarios of femtocells in coverage of the macro base stations. Power Control mechanism is used to reduce the cross tier interference between macrocell and femtocell. Grey Wolf Optimization is used to improve the average capacity of cell and SINR. The average capacity of macrocell user equipment is increased by 31% using optimization. The average capcaity of femtocell user equipment is decreased by 2.5%.

Keywords: Long Term Evolution (LTE), heterogeneous network, femtocell, macrocell, Signal to Interference plus Noise ratio (SINR), Grey Wolf Optimization (GWO).

I INTRODUCTION

In usual cellular network, macro-centric cell planning is used with only macrocell base station which covers the whole network. This type of homogeneous network uses base station with the same transmitting power, same antenna height, receiver noise, antenna pattern and same connection to the core network [1]. The performance of cellular network using the macrocell base station depends on the geographical position of the users like if the user come close to base station then it will get proper signal strength but if the user goes away from the base station then user may not get strong signal i.e. the strength of the signal degrades. To solve this problem, the transmitter should be close to the receiver but this is not possible and economically reasonable in macro-centric network. A more trustworthy and economic solution is required for improvement of the network for mobile operators. To overcome these issues the heterogeneous Network is proficient solution. Heterogeneous Network is multi-tiered cellular network where the homogeneous network is implanted with supplementary network which is smaller than existing and is short ranged and low powered base station i.e. small cells[2]. The macro-centric cells are unable to give the coverage to the indoor users as the distance between the indoor users and the serving base station is large. As according to the studies, 50% of the voice traffic and 70% of the data traffic is driving from indoor users. The specific way to increase the capacity and coverage of the network is proximity of transmitter and receiver that is distance between the transmitter and receiver should be small [3].

II RELATED STUDY

Literature possesses huge information about two-tier Macro-Femto network. Using proper frequency allocation methods and power control mechanism the problem of interference can be overcome.

Debashis De et al. in [4] have proposed the effective load distribution method for femtocell network. The femtocell increases the indoor capacity, coverage area and signal strength. But femtocell also faces lots of challenges like interference and power consumption. Some times a signal User Equipment receive the signal from two cells which are neighbors to each others, these neighboring cells interferes badly. In this case, User equipment is given to the cell with comparatively higher load and leaving the other cell. Now this cell changes its state to standby mode and reduces the interference with neighboring cell. An algorithm is proposed to reduce the interference and power consumption.

Dionysis Xenakis et al. in [5] have proposed a energy-centric handover decision policy for handover management in the macro-femto network. Now a Femtocell technology become more and more attractive because of better coverage area and enhanced capacity. It also save the battery life because it uses low transmits and receives power. But femtocell also faces lots of challenges like interference, power consumption and mobility management. The proposed handover decision algorithm is used to mitigate the interference. Matlab is used to simulate the result in terms of interference and power consumption. The results determine the decease in the power consumption and interference.

Tomohiko Mimura et al. in [6] have presented a system for mobile relay node (RN) deployed by a multi-operator for wireless networks on a train and bus. By using the Relay Nodes, the spectral efficiency improved because it uses the antenna with higher gain than the antenna used in user equipment. Though, deploying different Relay Nodes by different network operators is costly and also huge space is needed for installation of Relay Nodes in buses. By using the same Relay Nodes by multiple operators, we can solve the above mentioned problem. In addition to this a system is proposed for spectrum allocation dynamically among the operators for Relay Nodes. Nash bargaining solution (NBS) is used to allocate the spectrum dynamically among operators. The result of NBS- based solution for allocating the spectrum dynamically was determined by computer simulation and 20% improvement in total throughput is obtained as compare to when multiple operators deploy different RNs separately.

Peng Lin et al. in [7] have proposed the channel allocation scheme for macro-femto network to help the service provider to allocate the resources efficiently so as to increase the revenue. Femtocell is cost-efficient option to cover the indoor area. This co-tier macro-femto network has lots of advantages but at the same time faces the problems like interferences. By using the proposed resource allocating scheme, interference can also be decreased. Matlab software is used to simulate the result of proposed scheme. The lagrangian decomposition algorithm is used in this paper to improve the results. It has been proved from the result that these scheduling schemes improve the spectral efficiency and also increase the revenue.

Fadoua Mhiri et al. in [8] have proposed the technique to manage the interference in femtocell network. The aim of femtocell technology is to provide the indoor coverage, to enhance the capacity and also to offload the traffic of macrocell. But the two tier macro-femto heterogeneous network faces a lot of problems. Interference between femtocell and macrocell is big concern in femtocell technology. The type of the interference occurred in the two-tier network is Co-tier interference and Cross-tier interference. This paper proposed a mechanism to mitigate the interference and to enhance the capacity. The techniques used are OFDMA (Orthogonal Frequency Division Multiple Access), self-optimization, self-configuration, frequency reuse, optimized cell planning and power control. These techniques can be used individually or can be applied as hybrid.

Anwesha Mukherjee et al. in [9] have proposed a model to determine the power consumption in various size networks. These networks include macrocell, micocell, picocell and femtocell based network. The author discussed five cases where these cells are deployed to provide the coverage to number of users. Then these five cases is compared with network which is based on macrocell. Matlab is used to simulate the results in terms of power consumption. Simulated results shows that minimized power consumption in above mentioned five cases as compare to macrocell. The author discussed about five classes based on this five cases using different network to reduce the power consumption.

Yutao Sui et al. in [10] author have analysed that now a days number of users using wireless internet services while travelling in public and private transportation vehicles is increasing rapidly. But these users suffers because of poor signal strength. The cost efficient solution of this problem is deploying the Mobile Relay Nodes (MRN) on the vehicles like trains and buses. These MRN forms its own cell and serve the vehicular User Equipments (UEs). These Relay nodes unlike analog repeaters firstly detect the error then correct it before transmit the data to the vehicular User Equipment. Using the MRN provide many advantages. Firstly it improves the signal quality and Secondly group handover can be carried out by one MRN which is serving number of vehicular user equipments. Thirdly, Better signal processing schemes and antenna techniques are used by MRNs. And at last, MRNs reduces the Vehicular Penetration Lose (VPL).

Chih-Cheng Tseng et al. in [11] have discussed about the scheme to reduce the cross-interference the between the femto-macro network. Femtocell technology is used to increase the capacity and coverage area of the network. But femto-macro network faces some challenges like interference and worsening in capacity of the macrocell user equipments. To reduce the interference, power control method is used. This scheme is used to regulate transmission power of Femtocell User Equipment. Uplink transmission of FUE interference with MBS. This causes the decrease in the average capacity of macrocell. By controlling the power of the interfering FUE, we can increase the average capacity of the MUE. MALAB is used to simulate the results. The Simulation results show that using the proposed scheme, the capacity of Macro User Equipment can be enhanced by 53.4%.But the capacity of Femtocell Use Equipment is decreased by 7.3%.

III Proposed Methodology

Grey Wolf Optimization algorithm is motivated by grey wolves. The GWO algorithm copies the leadership chain of command and tracking and hunting method of grey wolves in environment. There are the four types of grey wolves such as alpha; beta, delta, and omega are employed for simulating the leadership hierarchy.

1. The wolves on the foremost level are called alpha wolves (α) and they are best in the hierarchy and are leaders of hierarchy. They guides other wolves during the hunting process in which other wolves seek, follow and hunt and work as a team. Alpha wolfs is responsible for the very important task that is decision making and all other wolfs obeys the alpha wolfs.
2. Beta (β) wolf are at the second level of hierarchy. They are the secondary to the alpha wolves and give advice to alpha wolves and subordinate them. They help the alpha wolves in decision making. Beta wolves transmit alpha control to the entire packet and transmit the return to alpha.
3. At third level, Delta wolves are there and they are also called scouts. These wolves are answerable for observing the borders and land. The sentinel wolves are responsible for shielding the group of wolves and the guards are responsible for the care of the wounded and injured.
4. Omega (ω) wolves are at the fourth level of chain of command. They are the followers and follow other type of wolves. They are also called scapegoats and they must submit to all the other dominant wolves.

IV RESULTS AND DISCUSSION

In this section results and their discussion is presented with the help of the graphs and their comparison with the existing approach.

Average capacity of MUE : By using the Grey Wolf Optimization, the average capacity of MUE is increased. The average capacity of MUE varies with the number of femtocells. With increase in the femtocells the average capacity of MUE decreased as with increase in the femtocell, the cross-tier interference increases and capacity

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decreases. By using the power control mechanism the average capacity of MUE is increased as we control the power of the interfering FUE, then it less interfere with the MBS. Further when we use GWO, the average capacity of MUE is increased.

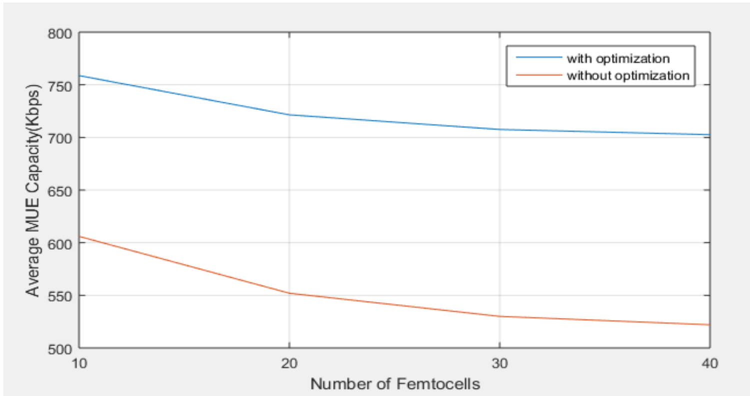

Fig. 1 Average capacity of MUE

Fig. 1 shows the average capacity of MUE with and without optimization with respect to different numbers of femtocell.

Average capacity of FUE: By analysing the simulation, the average capacity of FUE is decreased by using the power control as we control the power of the FUE for mitigating the interference of the two-tier network. The average capacity of MUE is increased by controlling the power of the FUE this decreases the average capacity of the FUE. The average capacity of FUE varies with the number of femtocells. After optimization, this decrease in the average capacity of FUE is less as compare to increase in average capacity of MUE. Therefore, the cost incurred for the improvement of the average capacity of MUEs is minor.

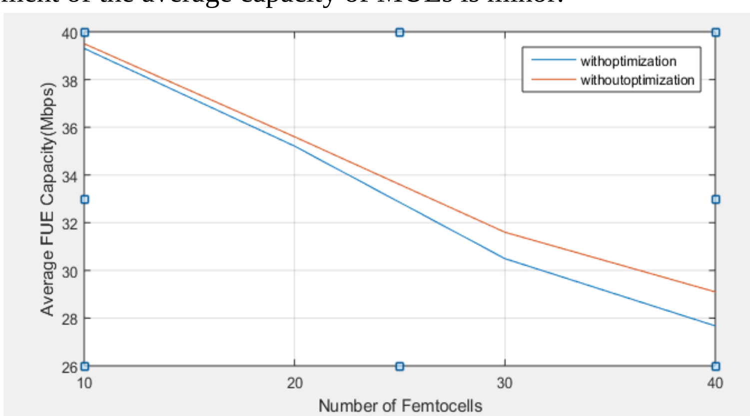

Fig. 2 Average capacity of FUE

Fig. 2 shows the average capacity of FUE with and without optimization with respect to different numbers of femtocell. The figure depicts the number of Femtocells and average capacity of FUE (Femtocells User Equipments). The x-axis on graph represents the value of Number of femtocells and y-axis represents the value of average capacity of FUE. The blue curve on the graph presents with optimization results and red curve represents without optimization results.

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Comparison of SINR of MUE Perceived at the MBS

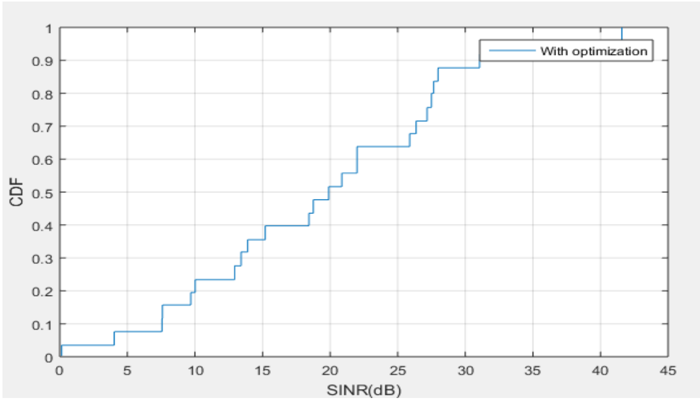

Fig.3 SINR of MUE

Fig. 3 depicts the ratio between the SINR and CDF (Cumulative Distribution Function). The x-axis on graph represents the value of SINR and y-axis represents the value of CDF. By using Grey Wolf Optimization, SINR of MUE perceived at MBS is increased as compare to previous results.

4.3.4 Comparison of SINR of FUE Perceived at the FAP

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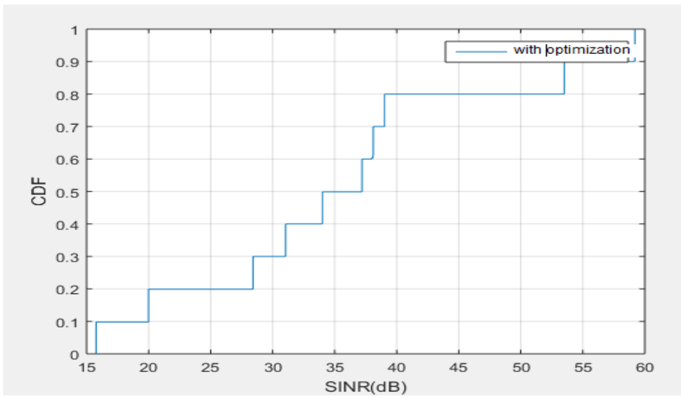

Fig. 4 SINR of FUE

In Fig. 4 we can see the SINR perceived at the FAP with optimization is increased than that of without optimization

The MUE capacity varies with the number of femtocells. It decreases as the number of the femtocells increases For 10 femtocell, the average capacity of the MUE is increased by 25.2%. For 20 number of the femtocell, the average capacity of MUE is increased by 30.7%. For 30 number of the femtocell, the average capacity of MUE is increased by 33.5%. For 40 number of the femtocell, the average capacity of MUE is increased by 34.6%. The FUE capacity also varies with the number of femtocells. For 10 femtocells, the decrease in the average capacity of the FUE is 0.5%. For 20 femtocells, the decrease in the average capacity of the FUE is 1.1%. For 30 femtocells, the decrease in the average capacity of the FUE is 3.5%. For 40 femtocells, the decrease in the average capacity of the FUE is 4.9%.

V. Conclusion

In order to meet the demand of high capacity and the coverage area, one of the most effective ways of improving capacity and data rate is deployment of femtocell networks. Interference management will be one of the major challenges for the dense deployment scenarios of femtocells in coverage of the macro base stations. Power Control mechanism is used to reduce the cross tier interference between macrocell and femtocell. Grey Wolf Optimization is used to improve the average capacity of cell and SINR. The average capacity of macrocell user equipment is increased by 31% using optimization. The average capacity of femtocell user equipment is decreased by 2.5%.

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