Neighbor Cell List Optimization based on Game Theory and Location Information for the Handover Process in Dense Fcns.

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Abstract*: The integration of cellular networks allows mobile users to eliminate poor indoor coverage and call dropping probability. Femto stations (FS's) appeared to be one of the innovative solutions that enhanced network coverage and the Quality of Service (QoS) when servicing indoor users. The cellular network Operator can potentially benefit by employing FS inside buildings and shares the allocated spectrum among different network entities. The seamless handover (HO) process between network entities is a major challenge of the Femto cellular networks (FCNs). Furthermore, the minimum and appropriate neighbor Femto list (NFL) is the main aim to guarantee the complete execution of the HO process. In this paper, an algorithm is proposed for power control in dense Femto Stations environment as long as possible through the Nash non-cooperative game theory. additionally, it provides location information mechanism to ensure a seamless transition between different network entities based on detected frequency from neighbor FS's, signal to interference noise ratio (SINR), as well as the location information of FS in the coverage area. Simulation results show that the proposed algorithm reduces the HO failure probability through improving the NFL by deducting 40% of the amount of FSs in the NFL. As compared to the traditional scheme based on RSSI and frequency allocation, with increasing the number of FSs, there is around 40- 50% reduction in the probability that the target FS is not included in the NFL which improves the network performance and lowers HO failure probability.

Keywords: Femto station, Handover, Neighbor Femto list (NFL), Signal to interference noise ratio (SINR), Dense Femto station.

I. INTRODUCTION

In recent years, the cellular network developed network architecture to be a large-scale convergence of many wireless technologies which affords the ability to increase wireless network capacity, and quality of communication. FCN is a conventional network integrated with FSs, an economically applicable solution to improve the indoor coverage and achieve the best user experience in a wide range of locations [1]–[3]. FS technology is currently one of the most promising innovative technology integrated into cellular networks to cope with the high traffic load and minimize the costs related to equipment installation and operation [2]. FS technology emerged for cellular wireless networks to offload huge traffic demand and places the installation of an expensive cellular base station with a cheaper tiny cell to facilitate extending network cover to a wide range of locations [1], [3]. FS is a low power Base station that operates in a licensed spectrum, provide strengthened cellular signals for indoor users [3]. In order to provide high data rate communication, the FS network must be scalable to grow into such large networks, while at the same time maintaining reliability. With an equitable distribution of FSs transmit power, benefits from FS deployment back into each of operator and end-user. In FCN, the operator achieves greater network capacity and spectral efficiency while the users experience better signal quality [2].

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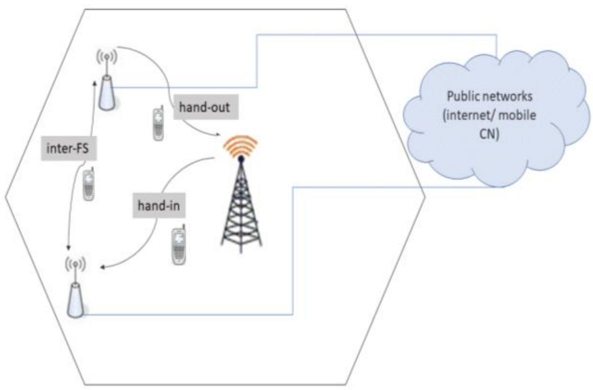

Fig 1. HO scenarios in FCN.

Due to the small range of coverage and a high density of deployed FSs, frequent and unnecessary HOs attempts would rapidly increase [4], [5]. In a conventional HO method, MSs can suffer from increases in the number of HOs as the number of deployed FSs grows rapidly since these users can stay within an FS coverage area for a short period of time [3]. Therefore, the state of a high density of FSs should be considered to avoid a large number of unnecessary HO. Thus, HO Management is the most important challenge to the deployment of FSs within the network which reduces the beauty of these networks [5].

As depicted in Figure. 1, three different conditions for the HO process are considered in the FCNs environment, namely Hand-in, Hand-out, and Hand-off (Inter-FSs) [6].

Hand in / Handout are two contradictory scenarios among different entities in two-tiers FCNs, whereas inter-FS is the HO scenario among separated entities that belong to the same tier in FSs environment. In FCNs, the Seamless HO process among network entities represents a major challenge to construct a system model suited to operate for the deployment of FSs on a large scale [5]. Thus, an effective HO execution algorithm is significantly required to reduce HO failure probability in a large scale FSs environment in FCNs.

A. Femto station network environment

In a conventional cellular network integrated with FSs, operators expect big changes to be a regular occurrence in which new technology leads to a significant increase in the usage of the cellular network. On the other hand, Users are expected to experience an excellent capacity and the same level of service within the FS zone, when compared to a perfectly located position provides within the conventional network. The technology faced a significant threat, which is the issue of having an efficient and seamless transition among different FSs themselves [3]. To this end, there must be a seamless HO between different entities themselves within large densely deployed FSs for the efficient HO process. AS shown in figure 2, the possibility of frequent and unnecessary HOs requests presented a further challenge that needs to be considered in a dense FSs environment. Recently, a various number of researches have been dedicated to find practical and efficient solutions to reduce unnecessary HO [4], [5], [7], [8]. A reactive approach to increase the HO delay as long as possible was proposed [6]. The HO operation is executed between adjustment stations only when MS almost loses its connection with serving FS. reference [8] propose a HO decision mechanism in a conventional network integrated with FSs based on the RSSI and MS's moving speed for reducing the number of unnecessary HO. In this algorithm, the High-speed MS's are allocated only for available MBS and will be prevented from HO to FS. Furthermore, authors in [9] proposed a HO mechanism composed of four criteria: received signal strength (RSS), velocity of MS, SINR, and Bandwidth (BW) as a HO decision procedure. On the other hand, the Access mode of a FS plays a significant role in determining a HO decision [10]. When FSs work in closed access mode, only a limited number of registered MS allowing access to FSs. Thus, HO in a closed access mode is a rare case. the open access mode has more challenges as MS grant access to FS without any authentication. Recent studies have focused on the hybrid mode, which gave registered MS more priority over un-registered MS to access FS [7], [9]. Many ranking schemes based on a combination of multiple criteria were proposed to manage HO in FSs environment where many FSs are deployed within a small coverage area [5], [8], [10]. Normally, in such network, when the MS leaves the FS coverage area, and the received signal strength (RSSI) from the serving FS is going down, the MS receives many signals from several neighbor FSs for the HO process [4]. As a result of scanning multiple FSs, MS consumes much power, and the overhead can significantly affect the entire network performance. So as to get rid of this problem, a new mechanism for the HO process was proposed by ranking all detected network accesses and generate a list of a minimum number of neighbors FSs in order to select the most appropriate target one with the highest rank for the appropriate network selection [5]. The list is ranked according to two parameters:

- Neighbors FS RSSI values.
- serving and adjusting FS frequencies.

For the purposes of these parameters, FSs are divided into two groups. The FSs in the first group consists of RSSI which is greater or equal to the preset threshold. FSs in the second group are those whose RSSI is below the threshold. The simulation results presented a reduction in HOs numbers due to an appropriate number of neighbors Femto list (NFL).

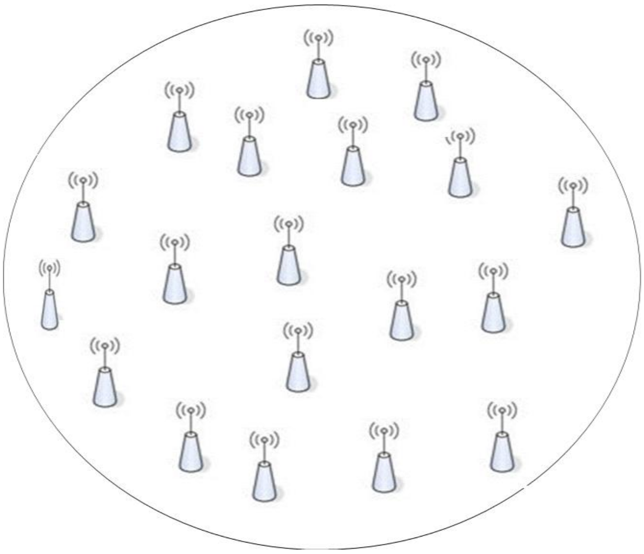

Fig 2. Dense Femto stations in a Femto-zone environment.

II. RELATED WORK

The major goal of our work is to optimize the NFL to overcome a massive number of scanning and signal flow which is the most important key of the HO decision process in FCN. In fact, there is a necessity to map the priorities of each station with its impact on the network selection and performance. The impact of the large NFL on the HO process performance appeared on scanning high list volume during the HO. So, depending on the different metrics in the HO decision, many pieces of research were carried out to ensure a seamless HO movement of MS [4], [7]. Most of the deployed HO mechanisms are not efficient any more to make decisions. Thus, there is a necessity to develop a novel method that aims to reduce HO execution failure and improve the quality of service perceived by the end-users. Our proposed HO algorithm aims at enhancing the NFL in a dense FCN based on power control in FSs environment by using game theory, as well as location information. The aim of power control is to guarantee that transmitter power is capable of reaching a sufficiently high level to be detected by MS, yet optimally low to prevent execution failure. Power control also improves the system capacity and communication quality, enabling power control to be used as one of the main resource management strategies in the mobile communication system.

The goal of this work is minimizing the number of candidates FSs in NFL for the HO process as much as possible, which will minimize time, ensuring better performance and represent the required key to select an optimal target. Generally, the proposed algorithm can be described as follows:

i. enhance the transmit power of FSs in FCNs by using non cooperative game theory.
ii. seeking optimal NFL by using location information for the HO process in the FCN environment.

III. SYSTEM MODEL

In this section, a network model is elaborately described. We considered dense FSs environment in FCNs. The Network consisting of *N* FSs are randomly deployed. There are L_n MSs associated with FS n, $1 \leq n \leq N$. It is assumed that the FSs and MBS operate on the same area, and there are *N* of *FSs* available in the FCNs environment, denote the FS set as *F*, where, F = {I, ….., N}, and the available FSs in the NFL for each FS candidate list is set as V.

Deployed a hug amount of FSs within the FCNs environment leads to construct a large number of nearest neighbors FSs within NFL. Power control using game theory allows every FS considered as a player with a utility function that is formed by the transmit power of FSs in FCNs. Utility function is a formula used to achieve the desired condition- player (payoff)- through the selection of identified strategies. Here, we use a simple distance-determined model for presentation. Note that the RSSI determined model is actually equivalent to those in previous work [11]. The model is constructed as follows: if the $RSSI_{ij}$ between FS_i and *j* is lower than a predefined threshold $RSSI_{th}$, then FS excludes from the neighbor list. On the other hand, the NFL provides all available FSs with an RSSI value above or equal to a predefined threshold. All the nearest neighbor stations are created and frequently updated based on RSSI, Frequency allocation, and Location information. Therefore, in a large-scale FSs deployment, classifying candidate FSs in two classes captured by G = {V, E}, where E is the lowest set of the candidate list, the FSs set excludes from NFL, with a greater likelihood to obtain poor HO process. the lower candidate list can be expressed as:

$$E = \{FS_{ij}\ (RSSI_{ij}, f_{ij}, L_{ij}\ ,((RSSI_{ij} < RSSI_{th}) \vee (f_i \cup f_j) \wedge (f_i \in G)\} \quad (1)$$

On the other side, V is the vertex set of the highest possible in the entire candidate list, FSs set includes in NFL. The most appropriate target one with the highest rank for the appropriate network selection can be represented as:

$$V = \{FS_{ij}\ (RSSI_{ij}, f_{ij}, L_{ij}\ ,((RSSI_{ij} < RSSI_{th}) \vee (f_i \cup f_j) \wedge (f_i \in G)\} \quad (2)$$

The above equations show the influence of the three parameters: RSSI value, Frequency allocation, and location information on ranking the candidate list for fast and efficient HO process.

IV. POWER CONTROL GAME AND NASH EQUILIBRIUM

The optimization goal for the scheme is to make the power transmitted by the FSs to be stable and minimize NFL to decrease the time required for neighborhood scanning and avoid failure HO execution. However, it is challenging to rank all detected networks due to additional processing delay caused by the unnecessary triggered HO. Therefore, we need to solve this problem by developing an approach that can minimize number of scanning and allow overhead FSs to be removed by Providing an effective mechanism, fewer scanning per location area compared to the other techniques leading to a reduction in power consumption, fewer switches which subsequently leads to faster HO execution.

A. Power control mechanisms

Generally, Nash non-cooperative game theory is used to handle and control power transmitted in FSs environment [12]. It is designed usefulness function by taking FSs transmitting variable power and relates to the need of users. The received SINR of FS u_f can be signified as.

$$S_{u_f,f} = \frac{p_f\ G_{u_f,f}}{N_o \Delta f + \sum_{f' \in F'} p_{f'}\ G_{u_f,f'} + p_x G_{u_f,x}},\quad F \in \{1,2,\dots\dots N\} \quad (3)$$

Where p_f and $p_{f'}$ is the transmit power of serving FS *f* and neighboring FS f' respectively. $G_{u_f,f}$ is the channel gain between Femto mobile station (FMS) and its serving F *f*. $G_{u_f,f'}$ is the channel gain between FMS and neighboring FS f' .where $f'$is the set of all neighboring FSs. $N_o \Delta f$ is the noise power spectral density and sub-carrier space. $G_{u_f,x}$ is the channel gain between FMS u_f and microcell x. Eq (1) can be rewritten in terms of a function of transmit power of serving FS and the transmit power of neighboring FS as:

$$S_{u_f,f}(p_f, p_{-f}) = \frac{p_f\ G_{u_f,f}}{I_f(p_{-f})} \quad (4)$$

The SINR of macro user (MU) m can be expressed as:

$$\text{SINR} = \frac{p_x\ G_{m,x}}{N_o \Delta f ++ \sum_{f \in F} p_f G_{m,f}} \quad (5)$$

Where p_x is the transmit power of MS x, $G_{m,x}$ is the channel gain between MU m and its serving MS x.

HO failures occurs if the QoS requirement can't be guaranteed, so we assume that $S_{u_f} \geq \theta_{u_f}$, where θ_{u_f} SINR of FMS u_f, and $\theta_{u_f} > 0$. Also, we assume the SINR of MS (S_m) is equal or greater than a threshold level θ_m ($S_m \geq \theta_m$), where $\theta_m > 0$.

B. Utility function

Due to the problem faced in improving the overall system performance in FCN, author in [13] find a function used by FS to improve its own performance but at the same time achieving a good overall system performance. The utility function here is based on interference model of FS system, that is

$$\Pi_{u_f} = \ln\left(S_{u_f} - \theta_{u_f}\right) + \ln(S_m - \theta_m) - w\left(G_{m,f} + \sum_{f\epsilon F} G_{u_f,f}\right) p_f \quad (6)$$

Where, W represent weighting factor which is a design parameter for keeping the two-items order of magnitude unvarying. The first and the second part of the function, ensures that SINR of FS and MS meet requirement. Finally, the penalty factor is the third part used for controlling transmit power of FSs. Due to the fact that neighbor FMS and MSs are influenced by the transmit power of the FSs. the penalty factor of the utility function takes into consideration the location of FSs. Allocating the transmit power depends on the impact of a fem user to another. Thus, when FMS average SINR improves, it in turn enhances the overall system performance.

C. Non-cooperative and Pareto optimality

Game theory selection methods are driven by self-organized power control and non-cooperative entities, wherefore, FSs suffer from a non-cooperative problem since all the stations maximize greedily their own utility function to get the maximum profit possible. Power control of FS can therefore, be handled by the problem of non-cooperative game model. A non-cooperative power control game model (NPG) presumes that every station tries to maximize its own profit even when it leads to improving profit the others as well. NPG can be expressed as [13]:

$$NPG = \left\{F, \{P\}, \left\{\Pi_{u_f}(.)\right\}\right\} \quad (7)$$

Where, $F = \{1,2,3, \dots \dots . N\}$ are the combinations of FSs, $\Pi_{u_f}(.)$ Represents the utility function of FS F, and $P = (P_1, P_2, P_3, \dots \dots P_f \dots P_N)^T$ is the plans profile selected by FSs in a game and P_f is the plan of one FS.

During interactive games, the utilities of FSs are maximized at Pareto optimal point, mathematically, the concept of pareto optimality can be expressed as follows [13].

$$\Pi_{u_f}\left[p_f^*, S_{u_f}(p_f^*, p_{-f})\right] \geq \Pi_{u_f}\left[p_f, S_{u_f}(p_f, p_{-f})\right]$$

Where $\forall_{p_f}, \in \{1,2, , \dots \dots , N\}$, $\forall_f \in \{1,2, , \dots \dots , N\}$, where, $(-f)$ reflected interference that depends on the power of all FSs except the i-th station (serving). Where p_f is FSs transmit power apart from i-th one, p_f^* is i-th power of Nash equilibrium. To calculate the Pareto optimal point, we need to work out the partial derivatives of first order of $\left[p_f, S_{u_f}(p_f, p_{-f})\right]$ from [13] When $S_m - \theta_m \geq 0,\ S_{u_f} \geq \theta_{u_f}$ we get p_f:

$$\frac{1}{S_m - \theta_m} \frac{p_x G_{m,x} G_{m,f}}{I_m^2(p_{-m})} = \frac{1}{S_{u_f} - \theta_{u_f}} \frac{S_{u_f}}{p_f} - w\left(G_{m,f} + \sum_{f\epsilon F} G_{u_f,f}\right) \quad (8)$$

In the RHS of Eq (8) , S_{u_f} and $S_{u_f} - \theta_{u_f}$ are in the same order of magnitude, $G_{m,f} + \sum_{f\epsilon F} G_{u_f,f}$ and p_f are very small, The RHS value must be higher than 0, so that left side, , $S_{u_f} \geq \theta_{u_f}$ can also be assured. the power update equation on the Proposed power control game will be as follows:

$$p_f^{(n+1)} = \theta_{u_f} \frac{p_f^{(n)}}{S_{u_f}^{(n)}} + \frac{1}{w\left(G_{m,f} + \sum_{f\epsilon F} G_{u_f,f}\right) + \frac{G_{m,f}\left|S_m^{(n)}\right|^2}{p_x G_{m,x}\left(S_m^{(n)} - \theta_m\right)}} \quad (9)$$

The advantage of this function is its ability to guide FSs to an efficient Nash Equilibrium point, and consider the constraint of FMSs $p_f^{(n+1)}$ transmit power, may take p_{max} when it exceeds the limitation. The algorithm enhances the SINR of FSs, thereby improving the entire throughput. Power control game has been able to attain the target SINR so that service quality can be correctly achieved. In terms of achieving the SINR target, power control is superior.

V. NFL OPTIMIZATION USING LOCATION INFORMATION

As shown in figure.3, in FCN, the coverage of MBS is divided into two parts: one is center zone and the other one is edge zone each zone containing massive numbers of FSs. According to their location, FSs can be divided into two main categories: inner group sets for center zone, and outer group sets for edge zone. FSs are allowed to use separate sub-bands per cell. Center FSs will not operate on the same sub-bands that are allocated to cell-edge zone and vice versa. For example, if sub-band A is allocated to the inner zone, edge FSs users will select from sub-band *E, F, G, and H* and inner sub-bands B, C are excluded from NFL regards to location information. location information Provides an effective mechanism to minimize number of scanning.

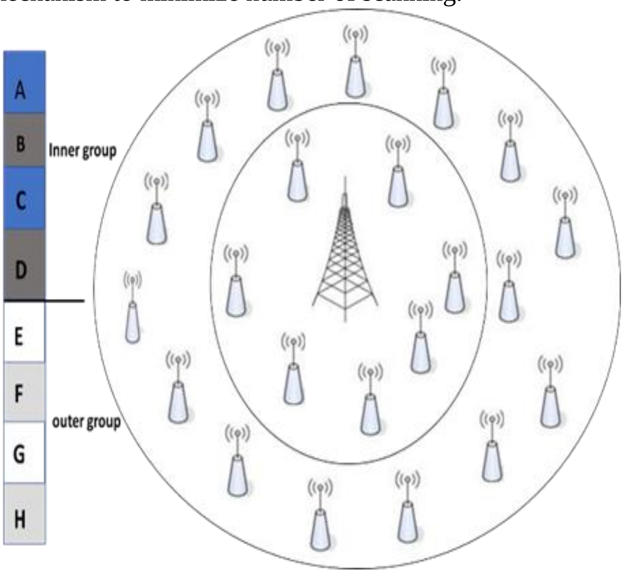

Fig 3. proposed location information scheme.

In the dense FSs environment, MFS HO is accomplished by FS close proximity to a serving FS. The NFL of the serving FS includes any FSs with RSSI value above the threshold, as well as accessible sub-bands and location data. The basis of cell selection is the ranking of candidate list. In a scenario where the list is empty, the best option is to remain on the current FS. Ideally, the first FS in the candidate list is the FS to which the MS should be connected. If there are no available FS in that location, efforts to examine and allocate next rank in the candidate list, should be done. A successful HO implies that an accessible sub-band was discovered in one of the FS candidates and connection to the new sub-band successfully transferred.

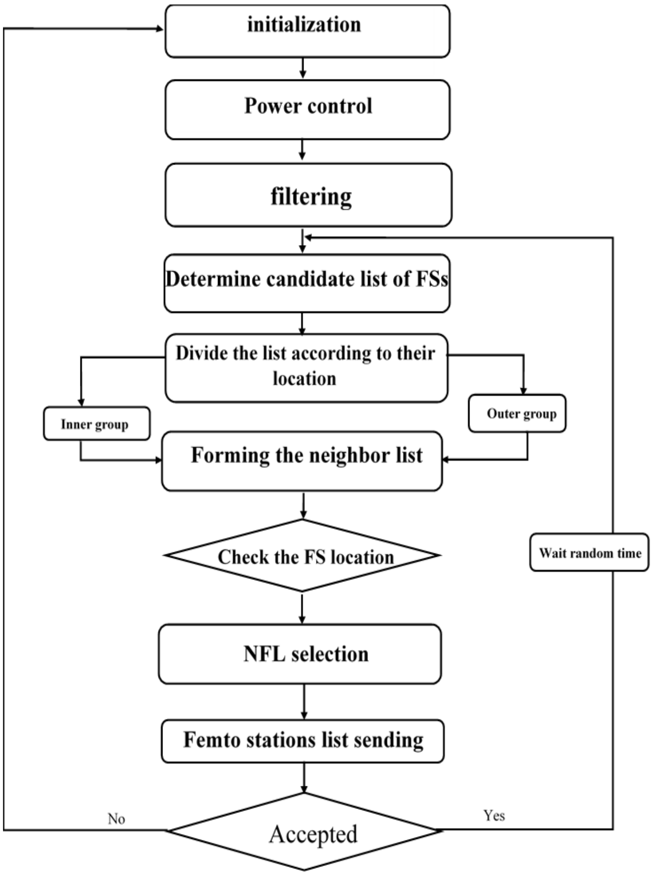

Fig 4. Flowchart of forming a NFL for HO execution.

Power control using game theory allows every FS to improve coverage rate in terms of SINR target achievement. The NFL is performed by the FS currently serving a particular UE. A helpful flowchart model to explain the formation of NFL is shown below in figure 4. Normally, in such network, when RSSI value from the serving FS is going down the serving FS start sensing and/or receiving a trigger that initiates the formation and subsequent transmission of a neighbor cell list to one or more MSs. Signal quality and RSSI values in the DL are measured and filtered by excluding sub bands with RSSI value lower than a predetermined threshold as well as the sub-bands which are not allocated by the FS in the same region. FS ranks all the candidates in a list of all neighbor FSs for HO execution. The FS classifies the candidates list into two separate groups according to their location information, inner group sets for center zone and outer group sets for edge zone. FS checks their own location and re-ranks all the candidates of a local detection and excludes sets that are not representing serving the location. Serving FS transmitting candidate list to one or more FUEs determines whether the NFL transmitted to a MS was acceptable or not for HO execution. If the FS receives a report that the MS has not accepted the transmitted neighbor list, then MS has not accepted the transmitted NFL. If NFL has been accepted to an MS, FS waits for a random amount of time, and then starts iteratively determining a candidate list. On the other hand, if an MS has not accepted the neighbor list, serving FS will then repeat the algorithm steps iteratively for neighborhood list formation with the concerned node. The algorithm steps will be repeated until the MS accepts the transmitted neighbor list.

VI. SIMULATION RESULTS AND DISCUSSION

In this section, we evaluate the HO performance of the proposed scheme using power control and location information in dense FCN. We consider only one of the MBS and many FSs within a 100 m range. The performance measurement parameters of the proposed NFL management scheme are compared to the traditional scheme based on RSSI value and Frequency allocation. FMSs are connected to FS with "n" number of sub-bands. In the hybrid access mode with an available 5 MHz band width MBS was replaced with FBS to study the HO performance. The results show an improvement provided by the proposed scheme, which ensures a lower number of NFL and better QoS for HO execution. The study conducted using the Monte Carlo simulation and the results are taken based on 45 run times and simulation follows LTE specifications.

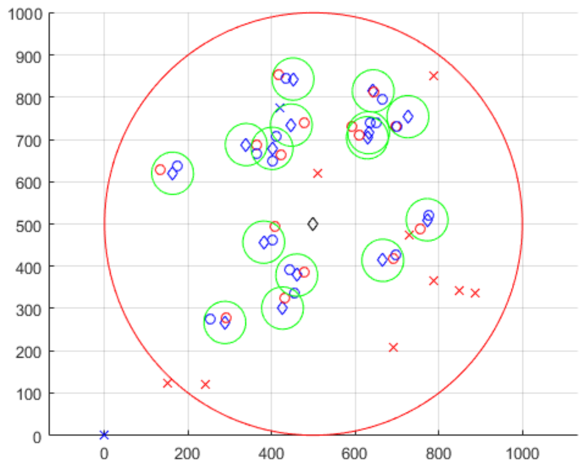

Fig 5. FCN model.

Femto cellular Network (FCN) model is shown in figure 5, with *n* number of MS considered. 45 run times recorded with MBS and FSs. The model study conducted by MS and FMS placed near to the FS and MBS. In dense FSs, The MSs preferred to connect with FSs than the MBS and the power consumption decreased.

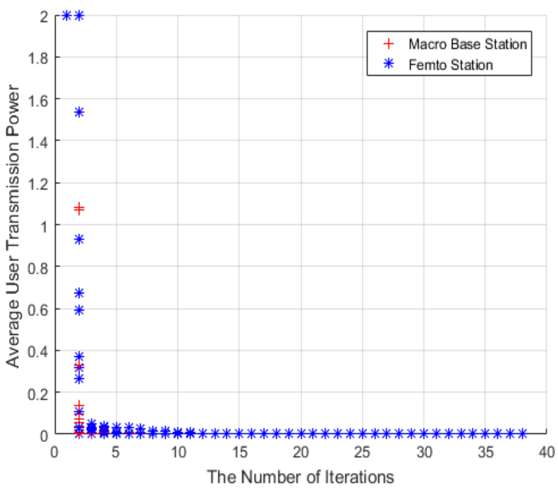

Fig 6. Comparison of power consumption for Femto stations users.

Figure 6 shows a comparison of user power usage in FSs coverage area for FSs and MBS. As shown in Figure 6, FSs coverage area with a maximum 45 iterations and 2watt maximum power, the power consumed in FS is very low., MBS and FSs power consumption observed with 45 iterations. FSs consumes minimum power compared to the MBS with a maximum power consumption of 2 watts. The power usage of FSs in FS converged is relatively low, and is able to attain the specified target SINR.

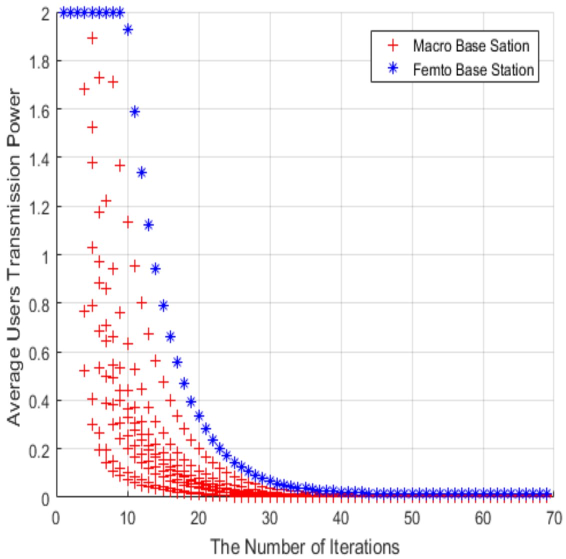

Fig 7. . Comparison of power consumption for macro users.

As shown in Figure 7, 45 iterations conducted with average 2-watt power consumed, MBS transmitted more power than FS. For each 5 iterations 0.2 watts power consumed and the total observation is done with maximum of 2 watts. FMS power consumption is less compared to the MS. The proposed power control used high power to meet the specified target SINR. The power usage of MBS is a higher, and it was used to meet the specified target SINR.

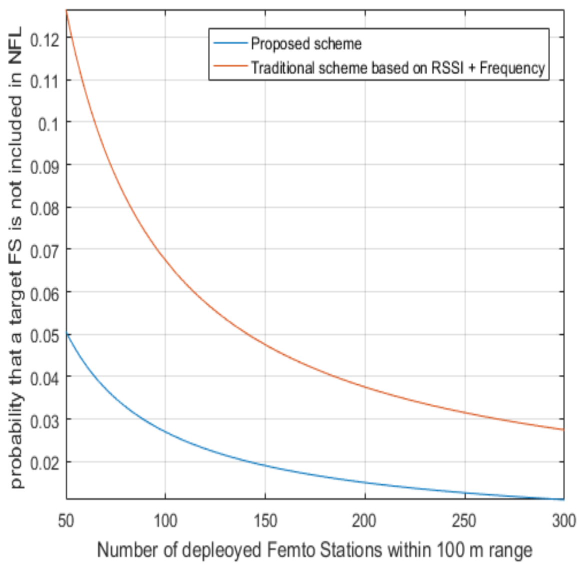

Fig 8. A comparison between two schemes in terms of missing a Target FS in NFL.

Figure 8. depicts the probability that the target FS is not included in the NFL for the FSs environment. Using location information provided by the proposed scheme helps FS construct NFL with minimum list including all available FSs within the area. In a traditional scheme based on RSSI and Frequency allocation, the possibility of the HO failure to the MFS become increasingly critical with missing the appropriate neighbor FS from the NFL. As shown in the figure, with increasing the number of deployed FSs within the FSs environment area, the probability of missing target FS in NFL is decreased. Thus, Result clearly show that the proposed scheme offered better results than in a traditional scheme based in RSSI and frequency. For traditional scheme, the probability of the target FS is not included in the NFL is around 40-50%. While for proposed scheme, the possibility that the target FS is not included in the NFL decreased by 40% and reduced by increasing the number of FSs.

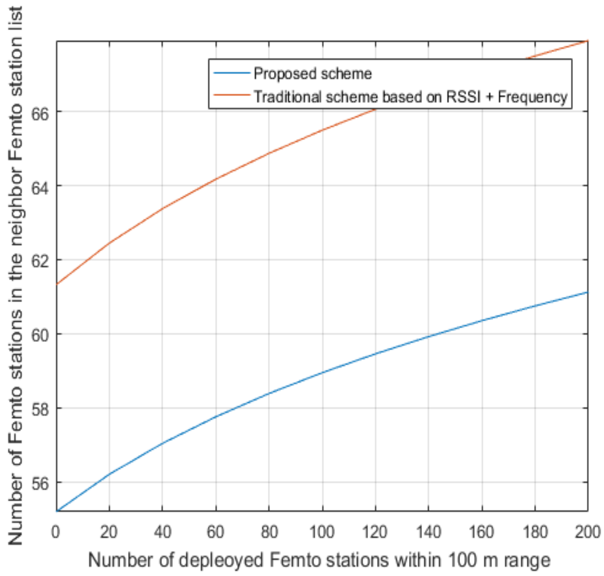

Fig 9. A comparison of the numbers of FSs in the neighbor FSs list.

Figure 9 shows neighbor FSs list for the proposed and the traditional scheme based on the RSSI value and frequency allocation with roughly 68 FSs in NFL and with maximum of 200 FSs deployed in 100 meters range. The number of FSs in NFL was observed less than 40% in a proposed scheme compared to a traditional scheme based on RSSI and frequency. As depicted on figure. 9, the number of FSs in NFL accelerated as the number of FSs increased, the number of NFL for HO execution increased by increasing the FSs numbers. The new proposed scheme shows 40% reduction in the amount of FSs in NFL which provides better HO process than traditional scheme. Location information mechanism reduces the amount of time spend on unnecessary list scanning as long as possible, even though large scale FSs deployments in the FSs environment.

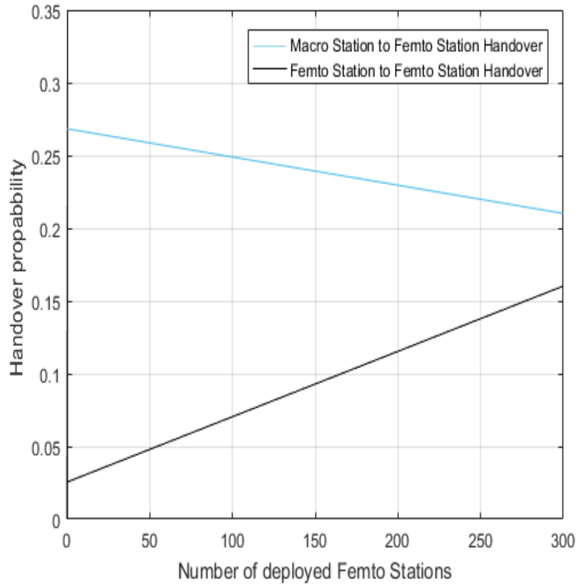

Fig 10. Handover probability in FCNs.

Figure 10 depicts the impact of increasing the number of FSs on the HO process probabilities within a large number of FSs deployment in FCNs. As shown in the figure, with increasing the number of deployed FSs in the FSs environment, the probability of HO scenarios is significantly increased. Due to the very high probabilities of HO between two different tiers, handout probability occurrence increases with increasing the number of deployed FSs. Thus, in a large scale FSs environment, the Efficient handling of these HO decision process is the most important key in FCNs environment. However, inter-FS probability occurrence is slightly lower compared to Handout, and rises with increasing the number of FSs deployment in FCNs.

VII. CONCLUSION

Emerging technologies using FSs showed great improvement with different types of wireless networks, but the HO has become one of the significant challenges in its growth. In dense FCN deployment, one of the major elements for HO which can influence the network performance is to reduce the number of FSs in the NFL and to maintain a seamless HO occurrence. In this article a research has been introduced on the algorithm using game theory and location information to enhance FSs ' SINR, thereby enhancing the overall system performance. The proposed method is based on an approach for constructing an optimal solution to reduce the number of FSs in the NFL and avoid the HO failure process, it considers serving and neighbor frequency, SINR, as well as location information for optimum NFL and appropriate FS selection. The simulation results have proven that our algorithm minimizes HO execution time and reduces the overhead of the entire network, ensuring better performance and represent the required key to select an optimal target. Furthermore, it increases network performance and reduces the HO failure probability by deducting 40% of the FSs total number in the NFL.

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