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Insights into Frequent-Handovers and Interference Algorithms in Advanced Heterogeneous Networks

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ABSTRACT

The Next Generation Advanced Heterogeneous Networks are the trending networks for future 5G networks. In earlier cellular networks such as Long-Term Evolution (LTE), there was dense deployment of cells and users moving at high velocities, handovers occurred frequently. While dense deployment of small cells in advanced Hetnets would result in unnecessary handovers which happens due to short sojourn time in target small cell, therefore resulting in degraded experience for the user. For improving the net efficiency of the cellular networks, small cells i.e. Femtocells are being currently deployed in Advanced network and are found to be a better solution for bandwidth limitation and coverage problems. Though, the use of femtocell also comes with a lot of limitations when they are deployed in a dense and highly mobile using environment. User equipment in such environment faces various problems such as frequent and unnecessary handovers, interference between femtocells, interference between femtocell and macrocell, power outage and security issues. There is a need of a more efficient method to remove the existing problems and provide a more efficient method to reduce unnecessary handovers, solve interference management issues along with focussing on power management of the cells. In order to know about latest trends to curb the problems and outrage of new problems arising from the same, will be reviewed further in this paper.

Keywords : Heterogeneous networks, LTE, Networks, Femto cells, Handover, Interference, BAT Algorithm.

I. INTRODUCTION

The mobile user number's and their demands have been increasing exponentially over the last few years. Due to the increasing number of mobile users traffic load has also increased which has lead to higher bandwidth consumption, applications like multimedia data, streaming video etc. To deal with the increased traffic, planned network planning and its optimization must be done. As the technologies develop, it lead to improvement of technologies smart devices, laptops, tablets, etc. which support high end applications. Before, the main concern was of Radio Frequency engineers to satisfy the need of customer for the voice services by doing planned frequency planning. That is why more efforts have been put in for frequency planning and improved radio spectrum utilization.

According to the latest research by 2021 figure of mobile devices will reach up to 1.6 billion and there will be a 53% increase in mobile data volume from 2016 to 2021. Mobile video would use 60% to 78% of total data although mobile web will use 14%, mobile audio will be using up to 5% and mobile file sharing will consume 2% of total data. The prime parameter in mobile network is the utilization of spectrum and to support higher data rates along with improving the

service quality. Heterogeneous Network technology is the technology that helps to provide us high quality services. This technology consists of cells getting partitioned into macro, micro and femto cells who have high and low power transmission base stations. To reduce the interference, base stations with controlled transmission power are used in heterogeneous network [1].

The demanding of the new applications along with the existing applications generates a call for the existing technologies to work collaboratively with the new technologies. The heterogeneous wireless networks take the toll of technologies ranging from 2.75G to 4G and it is believed that it will go beyond than that.

The HWN (heterogeneous wireless network) comprises multi-tier networks that possess different potential abilities in terms of hardware, protocols, operating system, etc. The reliability of the overall communication system is enhanced by using HWN. The handovers in HetNets (heterogeneous networks) are one of the most important concerns these days. The removal of interference among the different cells like femto cells are one of the daunting tasks [6].
Two tier heterogeneous network macrocell in first tier and embedded with small cell in second tier [7]. Among all the small cells, femtocells or HeNBs are of great interest and significance to mobile operator. Studies show that 50% of the voice traffic and 70% of the data traffic is driving from indoor users. The definite way to increase the coverage and capacity of the network is closeness of transmitter and receiver that is space between the receiver and transmitter should be small.

1.1 Different types of cells

The consumption of data over the cellular networks is increasing at an exponential rate as users download more video, thus consumes more data and use of smartphones and tablets as their main access point for mobile communications. HetNets become important as they combine cells from various sizes ranging from macrocells to different kinds of small-cells are widely used to solve the problem of rapidly increasing data traffic in cellular networks [10][11]. These cells are discussed as follow.

A. Macrocells:

- Coverage > 500 m
- Minimal handover frequency
- Channel fading and traffic congestion

B. Small cells:

a) **Picocells** (malls, airports, stadium):
- Coverage > 200m
- Number of connected devices

b) **Femtocells** (home or small business):
- Coverage < 200m
- Only for selected devices

c) **WiFi access** (home or small business):
- Coverage < 100 m
- Only for selected devices

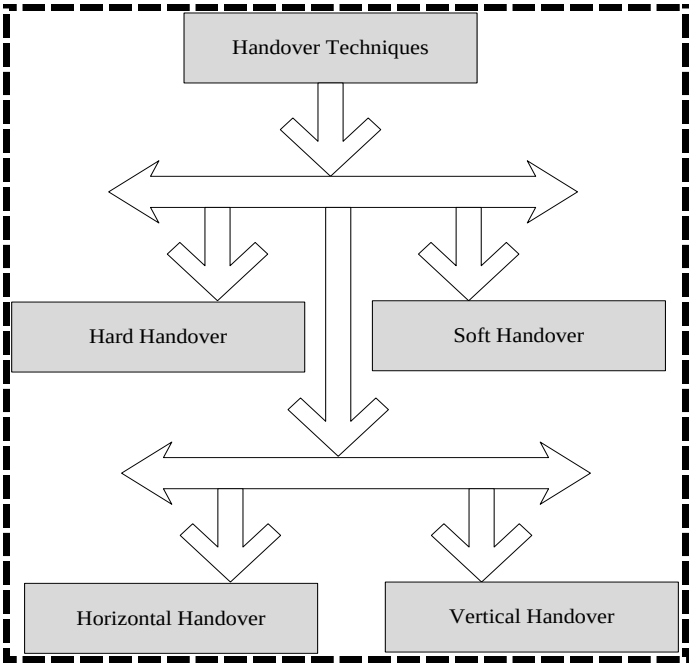
1.2 Handover

A handover refers to the process of transferring an active call from one cell in a cellular network to another cell. Handover is also defined as when a call is transferred from one channel to another channel in a cell [12]. Different types of handover techniques are considered like horizontal and vertical handover. Depending on the requirements user equipment will select the particular handover method. Fig. 1.2 shows the classification of handover methods. The handover methods can be used between two same networks or it can be used between two different networks [13]. To reduce the packet loss during handovers there should not be unnecessary handovers.

In non-CDMA networks when the user behaviour changes e.g. when the user who is travelling very fast is connected to an umbrella-type cell which is quite fast, stops then the call can be transferred to a small macro or even to a micro cell in order to free capacity of the umbrella cell for other users that are travelling very fast and to reduce the interference to other users. Also, when a user is moving faster than a predefined threshold, the call might be transferred to a bigger umbrella type cell thus the frequency of the handovers due to movement of user's can be minimal. The handover in which the source cell and the target cell are different is called inter-cell handover. The objective of inter-cell handover is to avoid the disruption when the user is on call as the user is moving out of the coverage area of the source cell and entering into the coverage area of the target cell. Some handovers are those in which the source cell and the target cell are one and the same channel is used is during change of handovers. Such handovers, in which the cell remains same is called intra-cell handover [14].

1.2.1 Different types of Handovers

Handovers are of various types depends on the networks whether it is single homogeneous networks or it is a combination of networks. Also, it depends on connection between the user equipment and the base station. They are necessary in the communication system to avoid call drops. More the call drops more the system become inefficient. So, to make the system efficient and to improve overall performance of the system handovers are necessary.



1) Fig. 1.2 Classification of Handovers

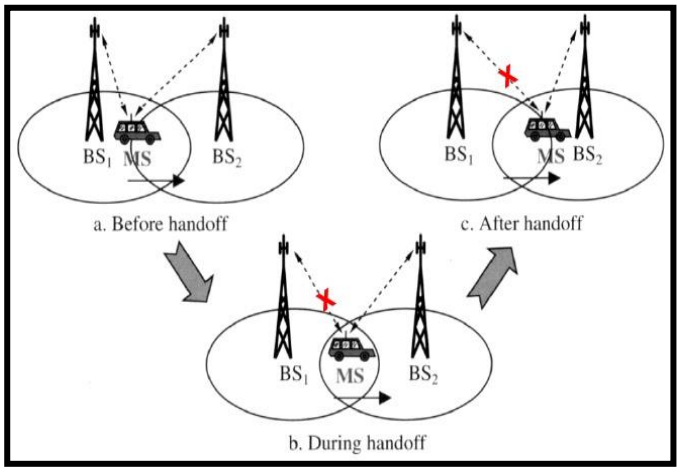


Fig. 1.3 Hard Handover Procedure [15]

1.2.1.1 Hard Handover

In this the radio link to the previous base station is released and then the radio link to the new base station is established. It means by using hard handover, a mobile terminal is allowed to make a connection with only one base station at a particular time. The concept of hard handover is described in fig. 1.3. It is also called break before make connection type of handover.

1.2.1.2 Soft Handover

In this handover a mobile terminal makes a radio link with no less that two base stations in overlapping handover region and it first makes a connection with new target base station then release the connection with the previous base station as shown in fig. 1.4. It is also called make before break connection type of handover.

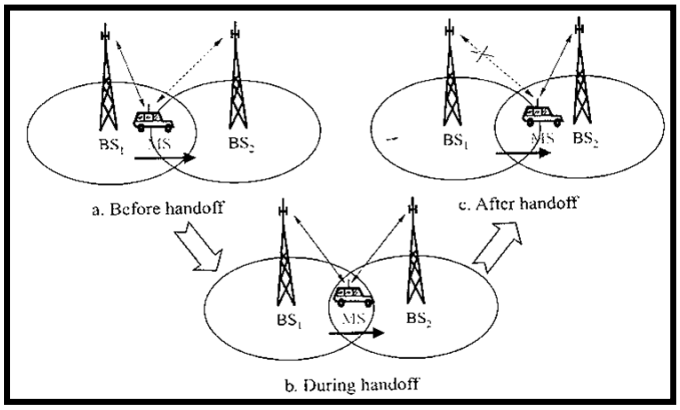


Fig. 1.4 Soft Handover Procedure [15]

1.2.1.3 Vertical Handover in LTE-A Hetnets:

In LTE-A HetNets small cells are deployed in order to increase the capacity of the wireless communication. Handover between two different types of network is called vertical handover. Mobile Terminal changes point of connection across different types of network. Fig. 1.5 shows the concept of handover between eNB and HeNB. Hand in and hand out is explained. Hand in means when the handover takes place from eNB to HeNB and hand out means when the handover takes place from HeNB to eNB. It can also be classified as upward vertical handover and downward vertical handover.

Vertical handover phases

Basically, vertical handover phases cover three elements that are explained below.

a) **Initiation:**
   - i Network discovery
   - ii Network selection
   - iii Handover negotiation

b) **Decision:**
   - i. Handover algorithm

c) **Execution:**
   - i. Mobility management
   - ii. Handover management

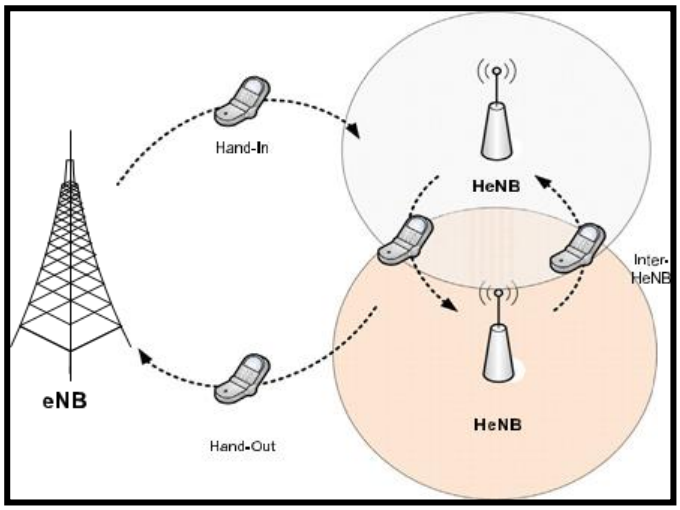


Fig. 1.5 Hand in and Hand out Handover [6]

The first stage is the phase in which measurement or information has to be gathered, where the UE calculate the strength of every neighbour Base Station (BS) and the current BS that is serving. The second stage is the phase about the decision of handover, where the current serving BS decides about the handover initialisation based on the evaluated data from the first phase. The last phase is the exchange of the cell, when the user equipment releases the serving eNB and connects to the new eNB or from eNB to HeNB or from HeNb to eNB.

1.3 Evolution of Femtocell

Two-tier macro-femto is need of today. A macro-femto heterogeneous network comprise of number of femtocells which are embedded in macrocell and network which connects them. Femtocell comprise of low powered and short-range base station which is known as Home eNodeB (HeNB) in LTE-A network which provide the signal strength to user equipment in indoor environment and these user equipments are called Femtocell User Equipments (FUEs). At the

same time macrocell comprise of high powered and long-range base station known as Macrocell Base Station or eNodeB (eNB) in LTE-A network and corresponding user equipments are called Macrocell User Equipments (MUEs) [16]. Femtocell is of two types: First one is fixed femtocell and second is mobile femtocell. In vehicle, mobile user travelling from one position to another position may receive poor signal strength and suffer from poor reception. To solve this problem, Femtocell can be deployed in the vehicle. This femtocell is called mobile femtocell and provide the coverage to user in vehicle. By using the femtocell, mobile users in vehicle connected to MeNB via HeNB. The femtocell technology also saves the battery life by not connecting the user equipment to main Base station. Where mobile femtocell is deployed in the vehicle, fixed femtocell provides the coverage in bus stand, railway station, airport and shopping complex where huge number of users are accessing the services. Fig. 1.5 shows the architecture of two-tier macro-femto network [8].

1.4 Cross-Tier Interference

As the name implies, Cross-tier interference occur between two tiers or the two networks [17]. This interference occurs between the femtocell and macrocell and vice versa. In the uplink (UL) direction, a Mobile User Equipment (MUE) near Home NodeB (HNB) moves away from its Mobile NodeB (MNB) transmitting the signal in uplink direction at high power interferes with uplink signal from Home User Equipment (HUE) to its Home NodeB (HNB). In the same way HUE near MNB can interfere with signal from MUE to MNB. Both the scenario are shown in Fig. 1.4.

In the Downlink (DL) direction, a MNB will transmit the signal at high power to its MUE which are far away from base station and this MNB will interfere with the DL signal from HNB to its HUE. Similarly, a MUE near a HNB and far away from its MNB will interfere in the DL direction by the HNB. Both scenarios for DL interference are shown in Fig. 1.4.

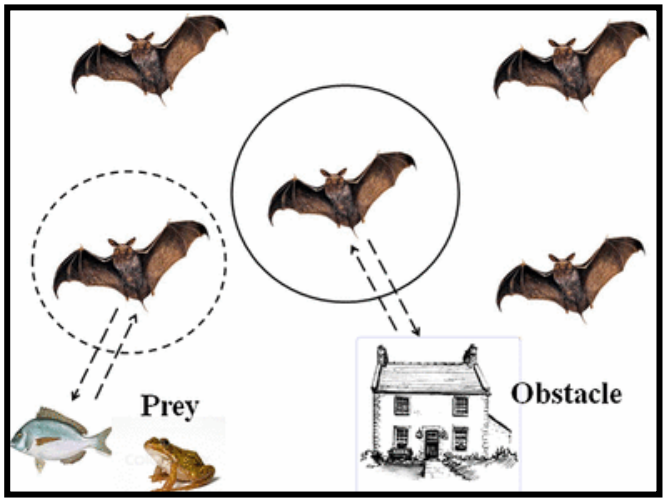
1.5 Co-Tier Interference

As the name implies Co-tier interference is the interference which occurs between same network and same tier. In femtocell network, the co-tier interference takes place between adjacent femtocells. During the uplink direction, a Home User Equipment causes interference to the neighboring Home NodeB. In the downlink direction, a Home NodeB reason for interference to the neighboring Home User Equipment. Both uplink and downlink co-tier interference[11].

The above discussed interference types have many adverse effects on the performance of the femtocell network and also on the macrocell network. Due to this problem capacity of the femtocell and macrocell decreases. There are lots of scheme which is used by researcher to avoid the interference.

1.6 BAT Algorithm

The BAT Optimization Algorithm was developed by Xin-She Yang in 2010 [18]. Bats are fascinating creatures. They are the single mammals having wings and innovative skill of finding location according to sound called echolocation.



Real behaviour of Bats

Bats utilizes echolocation to a definite angle; from all the types, micro-bats utilize more echolocation as compared to mega-bats. Micro-bats utilize echolocation for finding food, evade hurdles, and discover its resting cracks in the night. BAT algorithm was established depending upon the echolocation process of bats. In this process, pulses are created by bats that stay alive for 8-10 ms at some constant frequency. There are some significant characteristics of bat algorithm that are discussed below.

a) Non-requirement of visibility to sense and estimate the distance for the food and the objects.
b) Association with velocity, position, and frequency with changing loudness and wavelengths
c) The value of loudness is dependent upon the kind of strategies employed.

1.6.1 Pseudo Code of BAT Algorithm

The pseudo code of BAT algorithm is explained as below [18].

Objective function f(x), $x = (x_1, \ldots, x_d)^t$
Initialize the bat population x_i (i=1,2,3, . . .,n) and v_i
Define pulse frequency f_i at x_i
Initialize pulse rates r_i and the loudness A_i
While (t <Max number of iterations)
Generate new solutions by adjusting frequency,
and updating velocities and locations/solutions
If (rand >)
Select a solution among the best solutions
Generate a local solution around the selected best solution
end if
Generate a new solution by flying randomly
If (rand < A_i&f(x_i) < f(x_*))
Accept the new solutions
Increase r_i and reduce A_i
end if
Rank the bats and find the current best x_*
end while

BA initiates with some random initial population of bats in which the position of the bat *i* represented by x^t and velocity is denoted by v^tat time *t.* ${x_i}^{t+1}$ and ${v_i}^{t+1}$ denote the new position and new velocity of *i* bat at time t+1. The α_{min} and α_{max} denote the minimum and maximum values of pulse frequency, respectively. β is random number that varies from [0 1].

$$\alpha_i = \alpha_{min} + (\alpha_{max} - \alpha_{min}) \times \beta \quad (1.1)$$
$${v_i}^{t+1} = {v_i}^{t} + ({x_i}^{t} - x^{best}) \times \alpha \quad (1.2)$$
$${x_i}^{t+1} = {x_i}^{t} + {v_i}^{t+1} \quad (1.3)$$

a) Step 1: Set the basic parameters: population size (PS), attenuation coefficient of loudness δ, increasing coefficient of pulse emission γ, the maximum loudness A0 and maximum pulse emission r 0 and the maximum number of iterations T .
b) Step 2: Define objective function f (xi), *i* = 1, 2,..., PS.
c) Step 3: Initialize pulse frequency αi ∈ [αmin, αmax];
d) Step 4: Initialize the bat population x and v.
e) Step 5: Start the main loop. If rand < ri , generate new solutions by updating process for both velocity and current position by using Eqs. (1.1-1.3). Otherwise, generate new position of bat by making a random disturbance, and go to step 5
f) Step 6: If rand < Ai and f (xi) < f (xbest), accept the new solutions and fly to the new position.
g) Step 7: If f (xi) < fmin, replace the best bat and adjust A(i) and r(i) according to Eqs. (7) and (8).
h) Step 8: Evaluate the bat population, and return the best bat and its position.
i) Step 9: If the termination condition is met (i.e., satisfy the search accuracy condition or reach a maximum number of iterations), go to step 10; else, go to step 5, and perform the next search.

Step 10: Get the output (i.e., global solution and the best fitness). where, rand is a uniform distribution in [0, 1].

II. LITERATURE SURVEY

2.1 Introduction

This literature covers broadly two aspects; handover techniques and interference generated due to the two tier Macro-Femto network. Due to the unnecessary handover techniques that results in packet loss and packet drop. The role of femtocell is studied through the literature and some of the techniques employing new strategies to reduce the interference in the HetNets are also discussed.

2.2 Literature Review

2.2.1 Related work regarding avoidance of handovers:

This section covers the techniques discussed for avoiding the unnecessary handovers.

Xu et al. [19] have presented an analytical model for the HetNet to evaluate the cross-tier handover and to acquire expressions for rate of handover, ping-pong and handover failure that are dependent on TTT (Time to Trigger), user mobility and density of BS. It is to be noted that the 3GPP handover (cross tier) take place from macro to small cell tier (M2S). When the UE travels from the coverage of macro to small cell, M2S handover is triggered and TTT timer is started. Consequently, the handover failure rate decreases when thr TTT decreases while the ping-pong rate increases. The accuracy of the analytical model is verified through MATLAB that helps in optimization of handovers in Heterogeneous Network.

Bhoite and Gengaje in [20] have proposed a method to deal with the seamless handover between the macrocell and femtocells. Seamless handover and fast handover are two factors that are achieved. Call admission policy is used for successful handovers. Three handover cases are to be taken, Hand in, Hand off, and Inter-FAP. This proposed work improves the femtocell utilization and number of handovers is also decreased.

Goyal et al. in [21] have proposed a method to ammend the choices of static user based on real time in accordance with present value of respective handover decision features to transfer them to dynamic. The consequence of Dynamic User Preferences is calculated to identify the best available network during handover (vertical) using Multi Attributes Decision Making technique in HetNets. MADM techniques mostly used are MEW, SAW, TOPSIS and GRA.

Mian et al. in [22] have presented that IEEE 802.11 protocol to evaluate the experiments under mobility. To calculate the efficiency of handover experiments are conducted on the basis of real mobile testbed. This testbed consists of three nodes. One is placed on the vehicle to calculate the effect of speed of vehicle on the 802.11 mechanism for handover. It has been analysed that the speed of vehicle is not affecting the performance of handover mechanism. Calculations show that there are frequent handovers under mobility. It is ping pong effect in which hysteresis is not present in 802.11 protocol. To decrease the unwanted handovers the author suggested to perform experiments on the basis of real time on large scale that use link metric and also coupled with the hysteresis.

Baghla and Bansal in [23] have discussed that the consumption of energy is the main problem in HetNets. The coming generation mobile users has a large number of interfaces to connect themselves by using one or more networks simultaneously. In HetNets there are vertical handovers. Vertical handovers help in finding out which network is

providing better services but consuming more energy during operation or handover. The author has proposed vertical handover scheme that is energy efficient based on VIKOR algorithm. It helps in decreasing the consumption of energy by using three interfaces: cellular, WIMAX and WLAN interface working at the same time. It also helps in the reduction of handovers as compared to selected optimum network.

Ahmad et al. in [24] have proposed a handover scheme by applying two policies for two tier LTE networks, the method of moving direction prediction and the distance between location of HeNB and the current position of UE. The path of UE is used to guess its position in future and on the basis of these guesses target cell is selected. The polynomial function is used to predict its future position and the cosine function is used for the candisate cell selection. The proposed algorithm MDD VHD (Movement direction distance vertical handover) increases the performance of the system by reducing the handovers by 48%, the packet delay ratio by 91%, packet loss ratio by 86.2%, the average number of signalling measurements by more than 99% and throughput is improved by (15.3%) of the proposed salgorithm as compared to Deswal algorithm.

Ying-Dar Lin et al. in [25] presented that now a days to solve the increasing demand of data HetNets are used. To avoid blockage and meet users demands, two schemes are there one is using the information of BS and UE separately and another one is combination of BS and UE. UE information takes into account only the quality of channel between only one UE. BS information takes into account the overall traffic load of a single BS. Only using BS and UE is not sufficient and increases blocking ratios. The author has proposed the advantages of combined usage of BS and UE and presented a design CUBI (Combined UE and BS Information) scheme. It has benefits of both the information collected separately. Simulations show that there is reduction of blocking ratios by 8.9 and 26% as compared to UE and BS simulation respectively.

2.2.2 Related work regarding avoidance of interference

Some of the studies that have focused on the interference issues at the end of user equipment, are discussed below.

Akinlabi et al. in [26] have discussed about femtocells advantages in improving the coverage area. Now a day's femtocells are also used for power saving function. Renewable energy sources can be used to power the femtocells. So, with improving the coverage area, femtocell can also reduce the cost of the cellular network by saving the energy. There are lots of advantages of using renewable energy as it is environment friendly, economically beneficial, stable energy prices and sustainable electricity. Matlab is used to simulate the results. The result shows the reduction in the cost, energy consumption and carbon emission by the use of renewable energy powered home appliances and femtocells.

Ichkov et al. in [27] have proposed the two-tier heterogeneous network which composed of multiple base stations. This LTE network consists of macrocell and femtocell. Heterogeneous network faces lots of challenges like reduced network capacity and efficiency. This paper proposed Radio Resources Management techniques to improve the above-mentioned problems. Matlab is used to simulate the result in terms of network capacity and efficiency. By effectively utilizing the resources to macro and femto cell, the performance of congested network is imroved. The proposed femtocell hybrid access increases the data rate upto 20 times for the users who are authorized as compared to the users who are not authorized.

Chen et al. in [28] have discussed that two tier HetNets with large number of small and macro cells are spreaded is favourable solution to 5G networks. Instead of large band used the problem of capacity and coverage arises with the number of users increases. The author has presented a optimization scheme in which coverage as well as capacity is self-organised to increase them. It has been shown that the ratio of coverage for HeNB is very large as compared to static power transmitted in macro eNB case. When HeNets are densely spreaded the ratio of coverage is same as in -20dBm but when it is sparsely spreaded then the power which is optimised will be more than -20dBm. Hence the presented scheme increases coverage and enhances capacity for 5G networks.

Hasan et al. in [29] proposed Frequent Handover Mitigator algorithm for ultra-dense HetNets. On the basis of mobility behaviour, FHE (frequent handover experience) user as either ping-ping or fast-moving users. Handover parameters are adjusted for fast moving users. If in a case, the handover parameters are not adjusted for ping pong user then they are handover over to the macro layer. The algorithm worked for reducing the handover significantly at a very low magnitude however it suffered from some drawbacks. The interference issues were not taken into consideration which questions the reliability of the proposed algorithm.

2.3 Inferences drawn from literature survey

After studying the various techniques working towards mitigation of interference and minimizing handovers, the following inferences can be drawn.

a) With the technology advancements, the number of users are increasing and their requirements of seamless connection is getting prioritized. The Advanced Hetnets technology meets such demand of the user's satisfaction and brings more network efficiency.
b) In order to meet the exponentially increasing demands, the Third-generation partnership program (3GPP) in long term evolution (LTE and LTE-advanced) adopts the concepts of deploying femtocells or home-evolved nodeBs (HeNBs) that not only support indoor coverage of evolved nodeB (eNB) cell coverage.
c) Different HetNets (Heterogeneous networks) combining various cells from macro to femto and to pico, solves the concern for rapid enhancement of data traffic.
d) HeNBs are low-power (short range), low-cost base stations, which are designed for home or business enterprises.
e) To resolve interference, various techniques have been proposed in which effective techniques are those who dealt with transmission power control of user equipment.

Effective work is still to be done for the platform that works for both objectives simultaneously.

III. PROPOSED RESEARCH

3.1 Problem Definition

After studying various techniques working towards the mitigation of handover the following concerns are reported.

a) Mobility management is the main issue in Advanced HetNets. For the efficient management of mobility of users there is a need of handovers.
b) In Advanced HetNets to switch between femto to macro cells and macro to femto cells there are vertical handovers.
c) Sometimes there are unnecessary handovers that are not required resulting in loss of packets. Both

the unnecessary handovers and packet loss ratio can further reduce to get a better throughput efficiency.

d) Detection of frequent handover experience (FHE) users as fast moving and ping pong users can be further improved. The distance of the UE (User Equipment) from the next enodeB can be computed to monitor the signal strength. Thereafter, the decision for handover can be taken.

Interference between different cells macro and femto; can be removed by adjusting the transmission power of UE according to the requirement.

IV. CONCLUSION

The unnecessary handovers and interference have been the root cause of performance degradation of heterogeneous networks cellular networks. In order to address these issues the proposed work using bat algorithm is reported, it is expected that the heterogeneous network performance will improve on the benchmark of performance matrix namely throughput, handover reduction and interference mitigation.

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