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Traffic Engineering Based Load Balancing in LTE-A Heterogeneous Network

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***Abstract*— LTE-A is the latest cellular network technology. LTE-A is the use of heterogeneous networks (HetNets) which contains combinations of different cells such as of a macro cells and low power nodes (LPNs). Heterogeneous Network is used to increase capacity of the system and as well as to increase the demand for data capacity, especially in hotspot areas where there is a high density of users. Load balancing is main issue in urban area, heterogeneous network is used for cell splitting gains and ensure for user experiences. Cell range extension (CRE) is a technique that can be used to achieve load balancing in heterogeneous network. By CRE offset is added to LPNs in cell selection, which expand the range of LPNs and offload many users from macro-cells to LPNs. CRE is used for uniform offsets. The result of uniform offset is not optimal in the load balancing of heterogeneous network. In this paper, we use the Heuristic load balancing algorithm which is designed for assigning cell specific offset LPNs. Heuristic methods are used to speed up the process of finding a suitable solution. A heuristic algorithm is used for good quality of load balancing which is close to optimal solution. By apply the concept of cell load coupling, Range Optimization framework algorithm is used for cell specific offset. In this research work, we will implement our algorithm show results by using MATLAB based Vienna LTE simulator to check and compare results in different scenario using different offsets values.**

***Index Terms*– LTE, LTE-A, Heterogeneous Network (HetNets), LPN and CRE**

I. INTRODUCTION

LTE (Long Term Evolution) and LTE-A (LTE-Advanced) are most the latest cellular network technologies. LTE and LTE-A have a flat, all-IP architecture and all services in the system are IP-based. We use the 4^{th} generation system to reach the limit of the high peak data rates which is 100 Mbps for the high mobility and 1Gbps for the low mobility [1]? Heterogeneous Network is the combination of mixed cells such as macro cells and low power nodes (LPNs) cells. In a heterogeneous network, low power nodes such as pico cells, femto cells, and relay nodes are deployed within a macro cell coverage area. Macro cells have a large node density in a heterogeneous. By offloading network traffic from the macro cells to the low power node cell then the data rate capacity will be increased.

Due to higher transmit power of macro cells; it is difficult to offload many users in areas with high number of users to LPNs because a UE will usually select a cell with the highest received signal power. Many UEs linked with macro-cell seven if they are placed in the vicinity of the LPNs and the coverage area of LPNs will be small. LPNs will have low cell load while macro-cells will have high cell loads.

Due to higher transmit power of macro cells; it is difficult to offload many users in areas with high number of users to LPNs because a UE will usually select a cell with the Cell range expansion (CRE) or cell biasing (CB) is a technique that can be used to offload more users from macro cells to LPNs without adding the transmit power of the LPNs. In [2] high cell biasing (HCB) leads to poor performance of HetNets by overloading some LPNs. On the other hand Low Cell Biasing (LCB) not achieves the preferred offloading effect and macro cells will be overloaded. But for load balancing it is necessary to select best offsets so as to achieve load balancing in the HetNet by offloading UEs from macro cells, in such a manner that it will not lead to overloading LPN cells. One uniform optimum offset value for all LPNs has usually been used to achieve a load balancing in the HetNet. So it is necessary to have cell-specific offsets to achieve an even higher degree of load balancing.

Evolved Node B (eNodeB) is the hardware that is connected to the mobile phone network and communicates directly with mobile handsets (UEs), like a base transceiver station (BTS) in GSM networks. The design of eNodeB for LTE depends upon various factors such as number of transmit and receive antenna elements, linear power amplifier (LPA) power, radio head configuration tower bottom, tower top or roof-top, antenna configuration.

A. Goals

Goals of this research paper are:

- By adjusting the range of LPN the use of call specific address has been examined so as to achieve load balancing in heterogeneous networks. A HetNet in which macro-cells and LPNs are in a co-channel scenario will be considered.
- For Range Optimization we design algorithm and this algorithm can be used for call specific offset. By this algorithm we can minimize the call load.

B. Method

- First we made the algorithm then Range optimization framework uses the theory of cell load coupling which will be made the use of this algorithm
- Vienna LTE System Level Simulator is used for simulation. This simulator involves the creation of a system model for simulation and simulation scenarios
- Jain's fairness index will be used evaluate the degree of load balancing.

II. LTE-A AND HETEROGENEOUS NETWORKS

Long Term Evolution (LTE) allows the system to use new and wider spectrum with higher data rates which complements the 3G networks. It provides the path towards fourth generation (4G) cellular networks. LTE Advanced is capable of peak downloading data rates of about 1 Gbps, with a wide transmission bandwidth. Current wireless cellular networks are typically deployed as homogeneous networks using a macro centric planning process [3]**.** A homogeneous cellular system is a network of base stations in a planned layout and a collection of user terminals.

A. Background of LTE-A Network

Table 1: Background of LTE-A Network

Generation	Grouping	Standards
1G	AMPS	AMPS
2G	GSM/3GPP	GSM
	3GPP2	CDMA One (IS-95)
	D-AMPS	IS-54 and IS-136
3G	3GPP	UMTS WCDMA HSDPA, HSUPA LTE Rel. 8
	3GPP2	CDMA 2000
4G	3GPP	***LTE-A (Rel. 10)***
	WiMAX Path	IEEE 802.16m

B. LTE-A Key Features

- System capacity and efficiency of both the LTE and LTE-A should be high
- LTE bandwidth transmission is flexible which is from 1.4, 3, 5, 7, 10 MHz to up to 20 MHz LTE-A have a very high data rates and have an even larger bandwidth required.
- LTE-A support heterogeneous network deployment, advanced uplink and downlink spatial multiplexing and downlink coordinated multipoint (COMP) [4].

Table 2: Comparison of LTE and LTE-A

Features	LTE		LTE-A	
	Uplink	Downlink	Uplink	Downlink
Peak spectrum Efficiency (b/s/Hz)	2.6	5	15	30
Peak data rate (Mbps)	75	300	500	1000
Access Scheme	SC-OFDM	OFDMA	DFT-S OFDM	OFDMA
Bandwidth [MHz]	1.4, 3, 5, 10, 20		100	
Connection setup delay (ms)	<100		<50	
Modulation	QPSK, 16QAM		QPSK, 16QAM,64QAM	

C. LTE System Architecture

LTE system architecture is called Evolved Packet System (EPS) and this is the advance network architecture of the Universal Mobile Telecommunication System (UMTS). Evolved Packet System (EPS) is completely operated in IP domain and base on packet based switching not circuit based switching. EPS access file provides access for terminals which are connecting via the LTE radio access network. LTE has its own core network which is called Evolved Packet Core (EPC) Network. EPC core network is completely different from the core network of GSM and WCDMA. There are many components of EPC such as 1. Mobility Management Entity (MME) supports the control planning of signals from the EUTRAN and also performs security and authentication tools for the subscribers [5]. MME communicates with the Home Subscriber Server (HSS) via the S6a interface. EPS architecture of LTE or LTE-A is shown in Fig. 1.

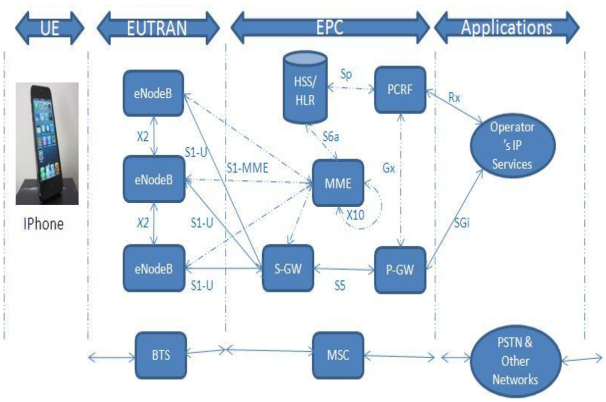

Fig. 1: EPS Architecture

E-UTRAN architecture is of a simpler architecture as compared to EPS systems because eNodeB (evolved NodeB) is the only radio access network node or element in the EUTRAN architecture. Unlike the previous systems which have a hierarchical structure, whereas LTE EUTRAN has a flat architecture. UE gets IP connectivity to the core network through E-UTRAN. In LTE and LTE-A there is no central node such as Radio Network Controller (RNC) in WCDMA/HSPA or Base Station Controller (BSC) in GSM that control movements over the other nodes [6]. E-UTRAN architecture of LTE or LTE-A is shown in Fig. 2.

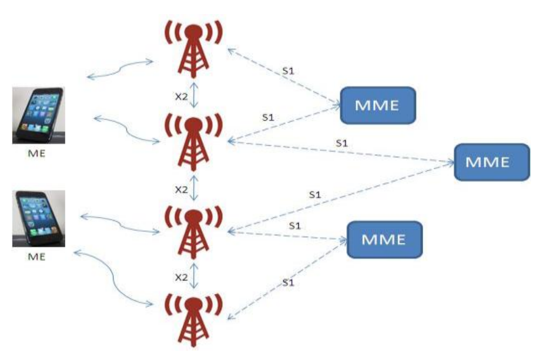

Fig. 2: E-UTRAN Architecture

D. LTE time-frequency spectrum

LTE communication is accessible at different frequency bands, which have a different size. LTE time and frequency grid consists of resource elements (RE) [7]**.** One resource element corresponds to one subcarrier in one OFDM symbol. A RB has duration of 0.5 ms in one slot. One resource block pair consists of 12 subcarriers with each subcarriers has size 15 kHz. Then one resource block pair is 180 kHz wide. LTE time-frequency spectrum resource block is shown in Fig. 3.

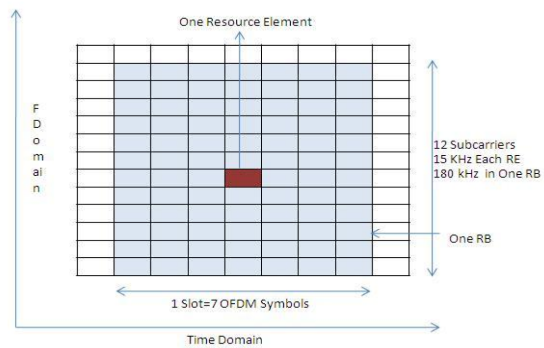

Fig. 3: Resources based on OFDM

In LTE downlink transmissions one frame has of length 10ms. One radio frame is creates 10 subframes which have a 1 ms duration, Each slot counts 6 or 7 OFDM symbols for normal or extended cyclic prefix used [8]. LTE time-frequency frames spectrum is shown in Fig. 4.

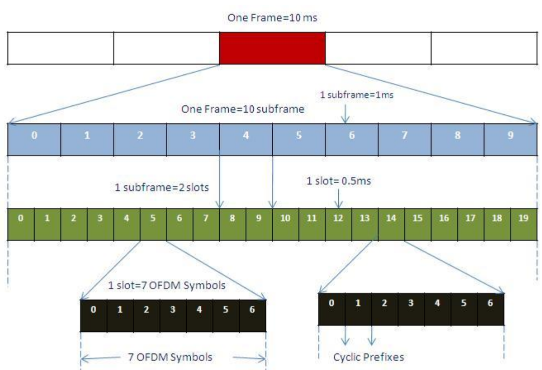

Fig. 4: Frame Architecture

III. HETEROGENEOUS NETWORKS

Heterogeneous Network consists of deployments which have a more than one type of network nodes. Heterogeneous networks are based on homogeneous networks which consist of macro cell base stations. . In heterogeneous network main two types of network nodes are used which are macro cells and low power cells nodes (LPN). In heterogeneous network low power nodes are micro, femto, relay, and pico cell of base station.

A. Architecture of HetNets Network

Architecture of HetNets network is based on micro cells eNodeB and LPN such as micro, femto, pico, and relays, micro cells. In HetNets network, low power nodes such as pico cells, femto cells, and relay nodes are deployed within macro cell coverage areas. HetNet in a cellular system consists of a regular placement of macro cell eNodeBs that normally transmit high power levels (~5W to ~100W). Over macro eNodeB several relay cells, pico cells, femto cells placed which transmit lower power levels (~100mW to ~2W) [9]. Architecture of HetNet is shown in Fig. 4.

Fig. 5: Architecture of HetNets Network

B. Benefits of Heterogeneous Networks

Heterogeneous networks are the combination of macro cell eNodeBs and LPNs eNodeB. LPNs eNodeB have a lower transmission power, small size, lower cost and have been easy to understand. Due to their lower transmission power, smaller size and lower cost LPNs eNodeB are much easier and more flexible for the deployment in a heterogeneous Network. By using LPN user network access becomes easy.

When we deploy additional low power network nodes traffic capacity of the system will be increase. As we increase LPN in the network then Load on the macro eNodeB cell has been minimized. Heterogeneous networks are especially useful in improving capacity in areas with uneven user distribution and in hotspots. Due to higher transmit power of macro cells; it is difficult to offload many users in areas with high number of users to LPNs because a UE will usually select a cell with the highest received signal power.

Deployment of LPNs results in a higher number of the nodes to be managed and increase in effort for system configuration. Secondly user terminals served by LPNs will experience higher interference especially when LPNs are in a co-channel scenario with macro eNodeBs. In a heterogeneous network LPN eNodeB minimized the load on macro eNodeB so coverage capacity and data rate increased.

C. Frequency Allocations in HetNet

The frequency allocation among the macro cell eNodeBs and LPN cell eNodeBs are important for the HetNet. Main problem in HetNet is the frequency allocation between macro cells and LPNs cells. Three types of approaches are used for the frequency allocation and for the aspects of the capacity, coverage and quality.

- Co-channel allocation
- Orthogonal frequency allocation
- Overlapped frequency allocation

The corresponding examples of the three frequency allocation approaches with 20MHz [10] whole bandwidth are shown in Fig. 5.

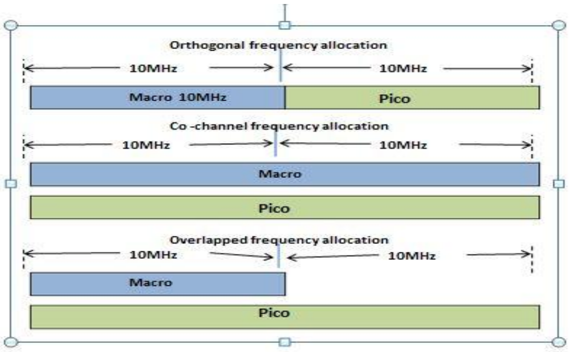

Fig. 6: Frequency Allocations in HetNet

IV. Radio Resource Management in LTE-A Network

Radio Resource Management (RRM) is a technique which is responsible for the use of fair utilization of the radio resources into the air interface for a given cellular network. Radio Resource Management (RRM) is used in wireless cellular networks. RRM is used for to effectively share of radio resources among users.

RRM concerns with multi users and multi-cell network in the form of capacity issues. If our resources are limited then our network will not be efficient and our networks have a low Quality of service. By using cooperative transmission (CoMP) inter cell interference can be reduced. Radio link quality depends upon the resources of radio link.

A. Centralized Architecture

In centralized RRM, a centralized entity is used which gathers all the channel information from the UEs which are directly connected to the eNodeB. Centralized entity is also used for performing user scheduling and signal processing operations. All the UE are connected to the eNodeB and the eNodeB are connected to the central unit. In figure 7 we see that the entire central unit used for the coordination among the different eNodeB [11]. Central unit can be used as a bench mark for performance evaluation. Main overhead which we have facing is the sending and to receiving of information to the users.

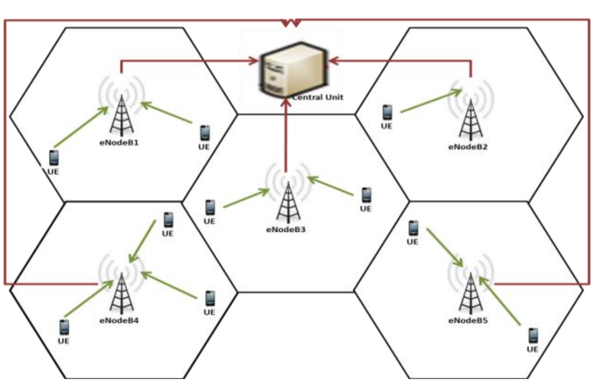

Fig. 7: Centralized Architecture

B. Distributed Architecture

Distributed RRM have another option to minimize the signaling overhead of centralized RRM. Distributed RRM schedulers in all eNodeBs are identical and channel information regarding the whole sets can be available to all the cooperating nodes. In distributed entity there is no central unit between then eNodeBs. After scheduling UE are connecting to the cooperating eNodeB [8]**.** In distributed architecture RRM scheme is not standardized and work as independently whereas in centralized RRM the interface need to standardized and work in a dependent way. Distributed RRM architecture is shown in Fig. 8.

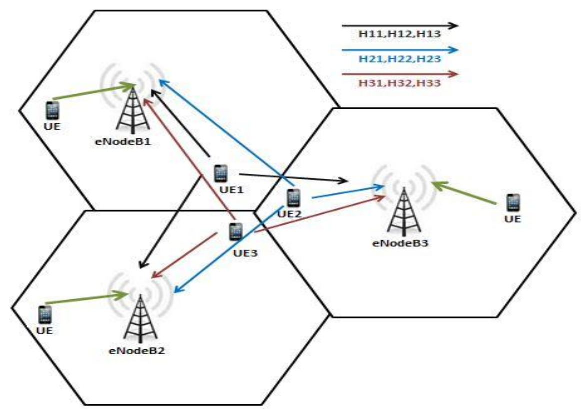

Fig. 8: Distributed Architecture

C. Scheduling in LTE-A

Scheduling is the process through which resources are shared among different users and different UEs. Scheduler assigns the resources in the form of resource blocks. Scheduler assigns the resources in uplink and downlink communication. . Every resource have a resource block (RB) which consists of 12 subcarriers in frequency domain and a one slot of .5ms which consists of 7 OFDM symbols in time domain. Every UE have a different channel quality and different type of scheduling techniques such as round robin (RR), shortest job first (SJF), and first come first serve which are used for the better selection of RBs. There are four different scheduling schemes:

- Channel Quality Information
- Link adaptation
- Power allocation
- Buffer Information

D. RRM techniques in LTE-A

HetNet consist of two layers of cells which are the macro cell and the low power nodes cells. The presence of high inter-layer interference in heterogeneous networks calls for the use of more robust interference management techniques. There are different sets of carrier frequencies are used in the different cell and also used for avoiding strong interference between the different cell layers. Interference management is used to improve performance in the HetNet and have a very important role in the data rate. Inter cell interference management achieved by using the static resource partitioning or dynamic resource partitioning techniques.

V. METHODOLOGY

A. Load Balancing Introduction

In cellular network main problem we have facing is the load imbalance. This is due to the unequal allocation of resources among the users. Different users are connected to different cells and every cell has a different power, range and capacity. First of all we see that this load imbalance is due to the imbalance of power in macro cells and LPN. Due to power unbalancing small amount of user are connected to LPN. When few users are associated with LPN eNodeB then LPN eNodeB have very low cell as compared to the macro cell. So Load balancing between macro cells and LPN cells can be achieved by expanding the coverage area of LPNs. When coverage area is increased then more UEs are served by LPN cells. This is called cell range expansion [9].

B. Cell Range Expansion

By increasing the transmitting power in the LPN then the coverage area of the LPN is increased then more UEs are occupies by the LPN cell eNodeB. Process through which we can increase coverage area is cell range expansion. CRE is used for the uplink transmission. CRE is used to solve all load balancing uplink problems which is useful for all the LPNs. To compensate high path loss UEs which are connected with macro cells have required a high transmitting power for uplink power control [9]. CRE is shown in below given Fig. 11. There are two types of CRE.

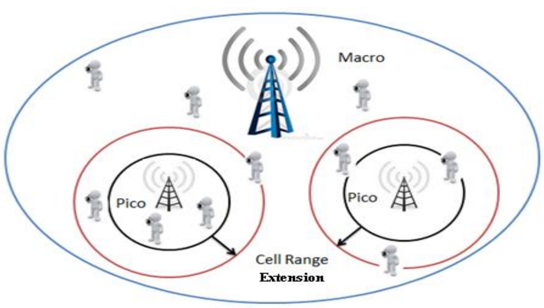

Fig. 10: Cell range expansion

CRE using a uniform offset

Uniform offset value is the process which is used to solve the problem of load imbalance in a heterogeneous network. In this process uniform offset value is assigned to all the LPN. Through this offset value is based on UEs. This offset value checks that how many UEs which are associated with the LPNs. Here offset value is directly propositional to the number of user equipment's (UEs).

CRE using cell specific offsets

By using cell specific offsets value we can achieved better results in load balancing. Some results achieved through uniform offset now we further improve the result by using the cell specific offset value. Main aim of cell specific offset is the better performance in the load balancing. Cell specific offset value means use of different offset values for different LPNs eNodeBs. Because different LPNs have a different coverage, transmitting power and number of user associated with LPNs.

C. Range Optimization

Range optimization is used to find a fine LPN by using cell specific offset through this we can achieve the good performance and high output of load balancing.

Data rate in LTE-A

Data rate control in LTE-A is very important for the link control for channel adaptation and as well as for the load balancing. LTE-A is used for the extremely high data rate and high data rate packet data traffic. Data rate in LTE-A is based on the channel link which is necessary to provide a high data rate for the radio link traffic. . In these conditions advantages of radio link is Eb/No (SINR) which is high at the receiver side [6]**.** In rate control, the data rate is dynamically adjusted and also compensate for the unreliable channel conditions.

Cell load

Cell load is a technique which is used to measure the load on the cell. In LTE-A network cell load is based on the amount of resources which cells have. Cell load can be measured as the total amount of resources in a cell divided by the total number of user in a cell. There are different number of resources are available with different coverage, capacity and bandwidth which are allocated to the users.

Cell Load is the ratio of the quantity of resource blocks in a cell to the number of user equipment's UEs in a cell.

Cell Load = Total Number of Resource Blocks in a cell / Total number of UE in a cell

Cell load Coupling Model

Suppose we have a different cell which is denoted by C such as $C = \{1, 2........,n\}$. These cells are the combination of both the LPNs and macro cells in the whole network. Each cell has an individual eNodeB and coverage area. Cell coverage area consists of number of pixels. Cell pixels are denoted by the latter p and antenna is denoted by a. So that the total power gain between the antenna a and cell pixels p is denoted by the latter G which will become Gap. For the reasonable network arrangement, the traffic demand is not distributed in a proper way. Requirement of UEs at different pixels is p which is denoted by the latter Dp. UEs which are located in different cell pixels their data demand is the same. The required parameter and the system structure extended to multiple types of services. We see that a well-organized and duly planned network have no overloading cell [13].

Load vector $L_c = (L_1, L_2, L_3, \dots\dots\dots L_n)$.

We can see the SINR of the UE p which has been served by the cell c with the following equation.

$$\gamma_p(L) = \frac{P_c G_{cp}}{\sum_{m\in C\setminus\{c\}} P_m G_{mp} L_m + \sigma^2} \qquad (1)$$

By using Shannon capacity formula high data rate is achieved for the individual resource block. So that the Shannon capacity formula by the following formula [13].

$$C = B\log(1 + S/N) \quad (2)$$

Whereas $\frac{S}{N}$ is the SNR, in equitation 5.1 SNR of the UE in a cell is $\gamma_p(L)$=SNR

$$C = B\log(1 + SNR) \quad (3)$$

$$C = B\log(1 + \gamma_p(L)) \quad (4)$$

In equation (4) B is the bandwidth which is used for the single resource block. Where resource block have a length 180 kHz?

Now we see the number of resource units which are required to serve demand Dp for pixel p which is shown in the bellow education.

$$RL_{cp} = \frac{Dp}{B\log(1+\gamma_p(L))} \quad (5)$$

$$L_{cp} = \frac{Dp}{RB\log(1+\gamma_p(L))} \quad (6)$$

In this equation (5) we see that R is the resource blocks in a cell and L_{cp} is the load on the cell C having a pixel p [14]. If we increase bandwidth at 20MHz then the resources will be increased to 60. Now we have to find the total load in a cell which is denoted by Lc overall pixels in a cell from equation (6).

$$L_c = \sum_{p \in p_c} L_{cp} \quad (7)$$

$$L_c = \sum_{p \in p_c} \frac{Dp}{RB\log(1+\gamma_p(L))} \quad (8)$$

$$L_c = \sum_{p \in p_c} \frac{Dp}{RB\log\left(1+\frac{P_c G_{cp}}{\sum_{m \in C\setminus\{c\}} P_m G_{mp} L_m + \sigma^2}\right)} \quad (9)$$

We can see the vector form of the above equation (9) is shown below. This is general form of cell load coupling.

$$L = f(L, G, D, M, B) \quad (10)$$

If we have N cells then there are N nonlinear equations will be produced as same as like equation (10). Shortly we write this above equation as like,

$$L = f(L) \, (11)$$

Now we see the equation cell load coupling for the single cell.

$$L_c = f_c(L_1, L_2, L_3, \dots \dots \dots L_n) \quad (12)$$

For example we have a five cell from the help of above equation (11) we can write the equation of these five cells as like this,

$$L_1 = f(L_2, L_3, L_4, L_5) \quad (13)$$
$$L_2 = f(L_1, L_3, L_4, L_5) \quad (14)$$
$$L_3 = f(L_1, L_2, L_4, L_5) \quad (15)$$
$$L_4 = f(L_1, L_2, L_3, L_5) \quad (16)$$
$$L_5 = f(L_1, L_2, L_3, L_4) \quad (17)$$

From equation (9) cell load will be positive if the σ^2 is not a zero value.

D. Optimization

In LTE-A optimization have a main role in making an optimal decision when a network is dealing with a decision problem. In LTE-A for load balancing optimization completely based on the formulation, modeling and designs. Optimization is based on the optimal decision. Optimization is a tool which is used to calculate the capacity of the network and also calculate the network performance. There are four elements which are used in optimization system model. These are the following four elements are, Assumptions, Decision variables, Objectives and Constraints. So the model of optimization is illustrated in Fig. 11.

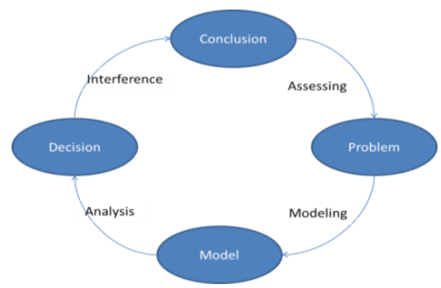

Fig. 11: Optimization Model

E. Jain's fairness index

Jain fairness index is the fair distributions of resources among the all the cell UEs. Jain fairness index has a vital role in load balancing. When we have a lot of users and the amounts of resources are a limited which are shared among the different users then congestion will be created. In [28] wireless communication network technology, fairness is the network that might be used to spend the equivalent attempt to serve different type of users. Jain fairness is same as like as the index that measure the real numbers. These real numbers measures how the fair resources shared among the different hosts [15]. We use expression for the Jain's fairness index as given below:

$$FI = \frac{(\sum_{k=0}^{n} L_k)^2}{N \sum_{k=0}^{n} (L_k)^2} \quad (18)$$

F. Load balancing Algorithm

In this research we see that load balancing algorithm will start by getting a single network value of the cell offset for all the LPNs that minimize or maximizes the Jain's fairness index. This will be done in different stepwise with respect to offset within the specified range from 0dB, 2dB to 10dB. Threshold value is set to be lower of 0.9 and higher more than 1.

In this research we will use flags that indicate whether offsets can be used for specific cells or whether cell offset can be changed. A flag of 1 indicates that an offset can be assigned to a cell or offset adjustment can be done. A flag of 0 indicates that an offset cannot be assigned to a cell or offset cannot be changed. The following variables will be used in this algorithm:

X→Potential network uniform offsets vector

F→Flags vector

NumIterOc→Number of iterations required for overloaded cells' offsets

NumIterUc→Number of iterations required for under loaded cells' offsets.

MaxOffset→Maximum offset that can be applied to cell.

MaxThreshold→Threshold value used to determine cell is overloaded.

X^*→Optimal Network offset.

Y^*, I^*→Optimal cell-specific offsets vector and fairness index respectively.

Number of iterations NumIterOc and NumIterUc will vary from network to network. Each cell will collect and send the necessary load balancing data to the central processing node for a group of cells through the X2 interface.

Load balancing algorithm

Input→ X, NumIterNwo, NumIterOc, NumIterUc, MaxOffset
Output→Y^*, I^*, ρ^{Y^*}
$I^*=0$, $F_c=0$ □ C_1, $F_c=1$ □ C_2
for k=1: length(X) do
Get optimal network-wide offset
$I_{X(K)}=I\left(\rho^{X(k)}\right)$
If $I_{X(K)} > I^*$
$I^* = I_{X(K)}$
$x^* = X(k)$
End if
End for
$F_c=0$, □C_1, $F_c=x^*$ □ C_2
for k=1: NumIterOc do
Deal with overloaded cells
Find overloaded cell
Highest Cell Load = 0
for k=1:length(cells) do
If $\rho_k >$ MaxThreshold and $F_k>0$ and $\rho_k>0$ Highest Cell Load
Highest Cell Load = ρ_k
Highest Cell LoadId = C
end if
end for
y(c)=y(c) - Stepsize
$I_{y(c)}=I(\rho^y)$
$I_{y(c)}>I^*$
$I^* = I_{y(c)}$
else
y(c)=y(c) + Stepsize
$F_c=0$
end if
end for
for k=1: NumIterOc do
Deal with under loaded cells
Find under loaded cell
Lowest Cell Load = 1
for k=1:length(cells) do
If $\rho_k<$Lowest Threshold and $F_k>0$
Lowest Cell Load = ρ_k
Lowest Cell LoadId = C
end if
end for
y(c)=y(c) + Stepsize
$I_{y(c)}=I(\rho^y)$
$I_{y(c)}>I^*$
$I^* = I_{y(c)}$
else
y(c)=y(c) - Stepsize
$F_c=0$
end if
end for

VI. Analysis and Design

A. Simulators Introduction

There are various simulators which are used in LTE-A System for the analysis and design of the system and their network simulation. We chose that simulator which is better for us and for LTE simulation and design. We have three options of simulators such as OPNET Network simulators (NS), Vienna LTE System Level Simulator.

Vienna LTE Simulator

Vienna LTE system simulates based on two types of simulation such as Vienna system level simulation and Vienna link level simulation. Vienna system level simulation support front end simulation and configure at the physical layer. Vienna link level simulation used to support a link between the networks which configure at data link layer of the network [16]. Vienna LTE System allows for simulation of not only LTE physical layer but it is possible to relate with link level issues. In Vienna LTE system physical layer is abstracted from link level results. By using this simulator we got high network performance which is beneficial for our research.

Simulators classes

As we have discussed before, that our simulator has a modular structure which is programmed as in the form of object oriented design. Table 3 shows the major packages.

Table 3: Simulator classes

Package	Classes
Antennas	Katherein Antenna, Omni-Directional Antenna, Berger Antenna
Network Elements	eNodeB, eNodeB Sector, Resource Block Grid, UE
Traffic Model	Full Buffer, Gaming, VoIP, Video, FTP
Channel Model	Downlink Channel Model, Uplink Channel Model,
Channel Gain Wrappers	Fast fading, Shadow fading, Macroscopic Pathloss
Schedulers	Prop Fair Scheduler, Round Robin Scheduler, Best CQI Scheduler

Network layout

These colored are used for their representation in the network. We see that there are two types of eNodeBs are used in this network, 1- Macro eNodeBs are represented big sky blue circles with sectors. 2-LPN eNodeBs are represented big sky blue circles without sectors. Black circles represent those users which are not served by any eNodeB. UE color red served by a Macro cells eNodeBs and UE which have a color blue served by a LPN cells. Network layout of heterogeneous network is shown in Fig. 12.

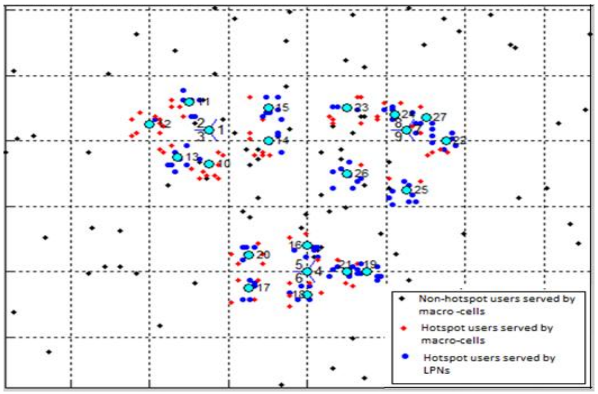

Fig. 12: Heterogeneous Network Layouts

B. Implementation

There are many functions that are used in the simulator which are used to implement the load balancing algorithm. We use following functions in the simulator for load balancing algorithm [17].

- Interfering power can be added from the connecting cell.
- Another function we use here is the cell load estimation. This cell load estimation function also makes use of the array.
- We have another function which is used to get those UEs that are attached to each and every cell. Load balancing algorithm function.
- Function to compute Jain's fairness index
- Function for adding offsets to LPN cells.

These set of equations can be introduced by the combination of equations that will become summation in equation (9).

In the equation $r_u = \frac{d_u}{kRB}$ where r_u is the demand by UEu, R is the number of resource blocks in the selected bandwidth and B is the bandwidth of that resource block. From our configuration we used here d_u= 2 Mbps, R= 70 and B= 150 kHz (when we use transmission bandwidth of 15 MHz is used).

Therefore, $$r_u = \frac{d_u}{RB} \quad (6.1)$$

$$r_u = \frac{2\ \text{Mbps}}{70 \times 150\ \text{kHz}}$$

$$r_u = 0.1905$$

Constant data rate demand is configured using gaming traffic model. Other factors will vary from UE to UE.

In order to get the optimum value of uniform offset range the network is simulated from 0 to 12 dB offset in steps of 2dB. The number of iterations for dealing with cells will low and high cell loads is limited to 15.

C. Simulation Parameters

Simulation Parameters	
Parameter	**Value**
System Parameters	
Carrier frequency	2 GHz
Thermal noise PSD	-174dBm
Penetration loss	20dB eNodeB UE
Pixels resolution	10m/pixel
Bandwidth	20MHz
Inter-eNodeB distance	500m
UE parameters	
Antenna configuration	0dBi
UE noise figure	9dB
Maximum transmit power	23dBm
eNodeB Parameters	
eNodeB antenna config	TX-2,RX-2
eNodeB noise figure	9dB
eNodeB cell transmit power	46dBm
eNodeB antenna gain	Directional,14dBi
LPN Parameters	
LPN antenna gain	Omni-0dBi
LPN noise figure	9dB
LPN transmit power	30dBm
LPN antenna configuration	TX-2, RX-2
Traffic model and scheduler	
Traffic model	Full buffer/Gaming
Scheduler	Round robin

VII. SIMULATION RESULTS AND ANALYSIS

We can find performance on the bases of Jain's fairness index and UE distribution between the Nodes.

A. Load balancing Result and Estimation

We can see cell load with no offsets in Fig. 13.

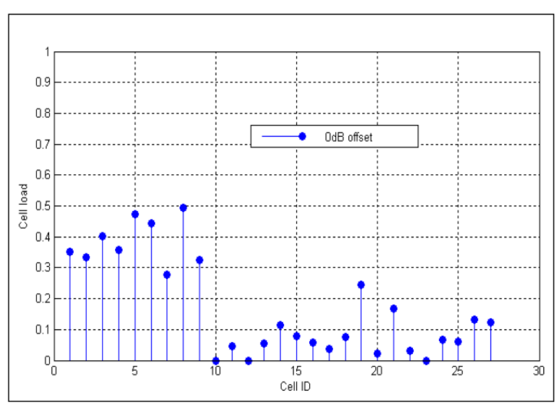

Fig. 13: Network Layout with 0dB offset

In Fig. 13 first nine cells are the Macro cells and the other 18 cells containing the LPN cells? When offset is 0dB then most of the LPNs have a very much low load as compared to Macro cells load. Some LPN has a much low load which is zero loads. So there is need to increase the range of the LPN for load balancing among the Macro cell and LPN. LPN cell which a zero load are the 10, 12, 23 at 0dB.

As the offset is increased from 0 dB, then fairness index increases steadily and become maximum at 8 dB where fairness index to drop again as the offset increases from 8 dB to 12 dB. The load balancing index at 0dB offset is 0.56. It can be seen from figure 14 that the optimum uniform offset is 8dB. When 8 dB offset is used the resulting load balancing index is 0.83.

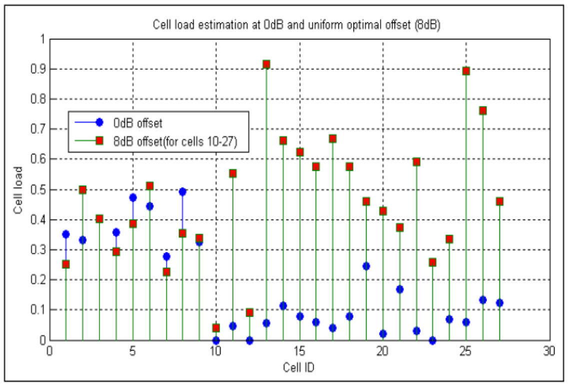

Fig. 14: Comparison of cell load at 0 dB and 8 dB

The fairness index reduce when offset values higher that 8 dB are used because LPNs start to get overloaded. This is illustrated in figure 15 when a uniform offset of 10 dB is used.

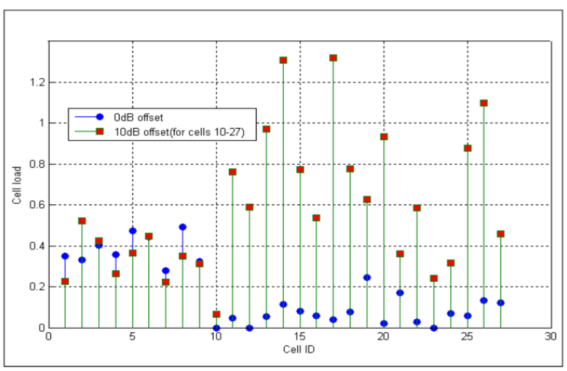

Fig. 15: Combination of cell load at 0 dB and 10 dB

When we apply cell specific offset at 8 dB uniform offset then result will be better than 8 dB. Before the use of cell specific offsets these cells has a very low cell load. We have get good result at 8 dB for LPN cells which is 0.83 and by the use of cell specific offset we have get better result which is o.92. We have defined offset at each LPN cell as you can see in Fig. 16.

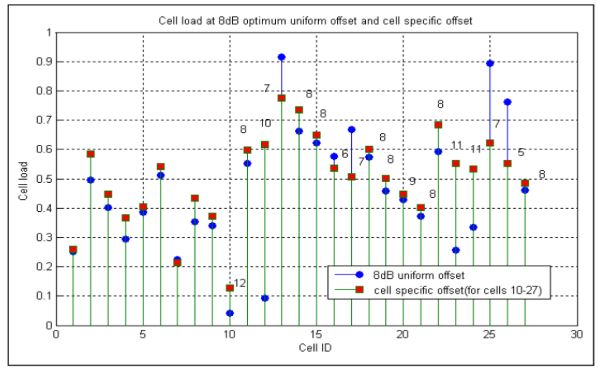

Fig. 16: Apply Cell specific offset and Load value for 8 dB

B. Distribution of UEs between LPNs and Macro cells

We see result at 0 dB offset very large number of UEs connected with the Macro cells even in hotspot areas ~86% of UEs connected to the Macro cells and very few UEs ~14% are connected to the LPNs. At the 0 dB offset some of the LPN cells such as 10, 12, and 23 have attached 0 UE as shown in Fig. 17.

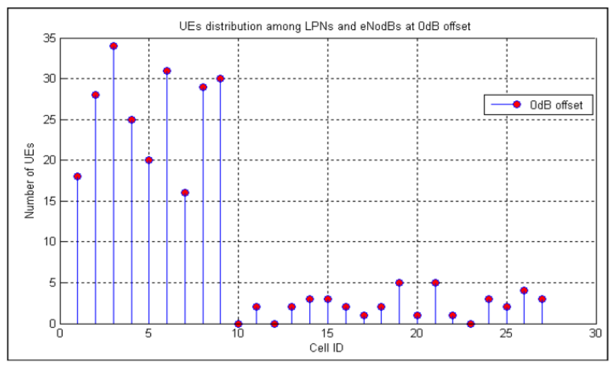

Figure 17: UE distributions at 0 dB offset b/w macro and LPN cell

When we increase the offset from 0dB to the 8 dB offset then we see the tremendous increase in the UEs served by the LPNs. This tremendous increase in LPNs is the 174%. This over all increasing result from 0 dB to 8 dB in percentage is from 14% to 40%. In this way Macro cells offload so many UEs. We can see this result from the figure 18. At 8 dB there is no LPN which is not serving any UE whereas at 0 dB offset result is different.

C. Performance and evaluation

UE distribution

As a result we expected that many UEs are offloaded from macro cells eNodeBs to LPN cells eNodeBs when a uniform offset of 8dB. The percentage of UEs offloaded drops slightly when cell-specific offsets are used. The use of cell specific offsets does not guarantee additional UE offloading. This is because the load balancing algorithm may result in more UEs being handed over from LPN cells to macro cells than those that are offloaded to LPN cells. This is illustrated in Table 3.

Table 3: UE distribution among different cells Networks

Offset	0 DBI		8 DBI		Cell Specific	
No. UEs	Macro	LPN	Macro	LPN	Macro	LPN
	257	43	182	118	189	111
(%)	86.7	14.3	60.7	39.3	63%	37

Jain's fairness index

In Table 4 we see the Jain's fairness index at different offset values. When there is no offset Jain's fairness index is 0.55. When offset is 8dB Jain's fairness index is 0.83. After the use of Cell specific offset Jain fairness index is further improved which is 0.92?

Table 4: Load balancing at different offsets

Offset Value	0 DBI	8 DBI	Cell Specific
Jain's fairness Index	0.55	0.83	0.92

From this result we conclude that load at cell specific offset is higher. This result is most effective for the load balancing.

VIII. Conclusion and Future Work

In Order to see the full control at load balancing in a HetNets we have to improve the implementation of interference avoidance. By this technique we can improve the load balancing result. By using static resource partitioning we can reflect at every cell which is better for the Load balancing. If this partitioning process will done then load balancing in a HetNet using the proposed algorithm will also reflect in UE distribution among macro cells ,LPN cells and not only on computed cell loads. For further research for a big network when there are large numbers of user, we can solve many non-linear equations and we get better result of cell load. From this result in future we can get a highly computational overhead. From this concept we can use upper bound and lower bound scheme for cell load estimation with lower computational overhead [18]. We can say that more work will need to be done if a large network is to be used for simulation or in a real network scenario where there are many cells so as to have a fast algorithm.

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