Relay Node Power Tuning Based Load Balancing in LTE-A Networks

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Abstract

Load Balancing improves the distribution of workloads across multiple nodes. Here we are exploiting the coexistence of Evolved Node Bs with low power relay nodes to increase capacity of the system. We analyse and compared the performance of different guided neighbourhood searching methods like Average User, Min-Max and Random with no-load balancing for different number of users.

Keywords - *Relay Nodes, Load Balancing, Guided neighbourhood searching methods.*

I. INTRODUCTION

Low power Relay Nodes (RNs) have been adopted in 3GPP Long Term Evolution Advanced (LTE-A), as a cost-efficient solution to extend coverage and enhance capacity. The introduction of RNs allows their co-existence with higher power Evolved Node Bs (eNB).The users connected to the overloaded nodes will suffer from a degraded Quality of Service (QoS) as these nodes are unable to satisfy all of its users. Whereas resources may be fully unexploited in other lightly loaded nodes, decreasing their resource utilization and the overall network capacity. Load Balancing fixes the nodes' resources and changes only their serving regions to shift users from highly condensed nodes to their lightly loaded neighbours. This can be achieved by Transmitted Power Tuning (PTu). The concept of power tuning lies in adjusting the cell's coverage area by changing the transmission power of the access nodes; decreasing the power for heavily loaded nodes and increasing it for lightly loaded nodes.

II. SYSTEM MODEL

Consider a cell consists of 1 eNB and 6 RNs located 2/3 of the cell radius away from the eNB. The term access node refers to an eNB or RN. If the UE i is within the coverage area of jth RN in the system. Then we can say ith UE is associated with jth RN.

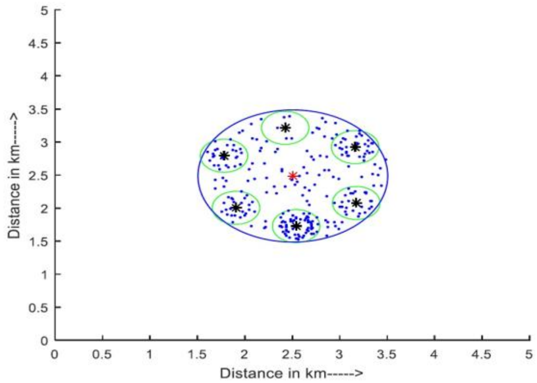

Fig 1: A cell consist of one eNB and 6 Relay nodes

Sj represents the serving relay node of UE j. Pi(t) is the transmitted power of the access node i, Lij the path loss between node i and UE j separated at distance (dij). Xσ,ij is the channel lognormal shadow fading between UE j and access node i. NR, NB and Nu represent the set of RNs, eNBs and UEs in the system respectively. The overloaded RNs are required to decrease their transmitted power in order toshrink their corresponding serving area. On the other side, the lightly loaded RNs are requested to increase their transmitted power. Our main objective U aims at achieving fairness in loads of the RNs in the system to prevent resource overutilization or underutilization. In order to assess the possible power combinations resulting from RN PTu, Jain's fairness index parameter B is used to evaluate load balancing among RNs.

$$\beta = \frac{\left(\sum_{\forall i \in N_R} \rho_i\right)^2}{|N_R| \times \left(\sum_{\forall i \in N_R} \rho_i^2\right)}, 0 < \beta \leq 1$$

$$\rho_i = \frac{\sum_{\forall j \in N_U^i} M_{ij}}{M_i^t} \qquad \forall i \in N_R \cup N_B$$

Where Mij and Mit represent the number of users assigned to node i and the total number users supported by relay nodes. Here we are considering Jain's fairness index as Utility function.

III. GUIDED NEIGHBORHOOD SEARCHING METHODS

A. *Guided Method 1: Average User*

One of the means of enhancing fairness between RN's loads is selecting a load threshold value, and applying PTu to enforce all the RN loads to reach this value. First, the average number of users per RNs is chosen to be this threshold as it represents the central value of all RNs' loads. The average value can be easily reached by all RNs as it is not too high or too low. Average User method calculates the average of the number of users per RN and considers this value as the intermediate threshold. This method then maximizes the power of the network's RNs whose load is less than the average by 1 dB and minimizes the power of the RNs whose load is higher than the average by 1 dB, with the aim of all RNs' loads eventually reaching this average threshold. The power step is chosen to be as smallest possible.

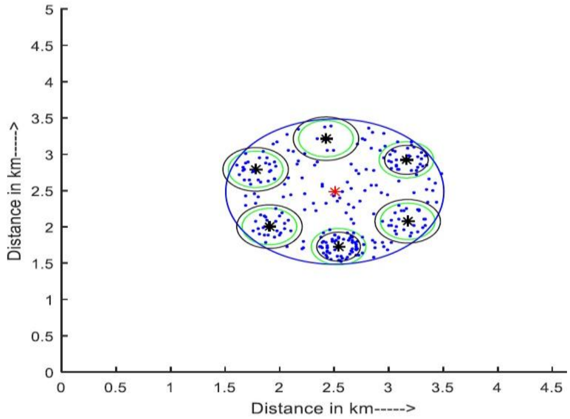

Fig 2: Change in the coverage area of Relay nodes by using Average User Method

B. *Guided Method 11: Min-Max*

This method minimizes the power of the RNs with the highest load by 1 dB and maximizes the power of the RNs with the lowest load by 1 dB, allowing all RN's loads to eventually be in the same range. The significance of Min-Max is that it allows minimizing the undesired characteristics (overloaded RNs) and maximizing the desired ones (balanced RNs).

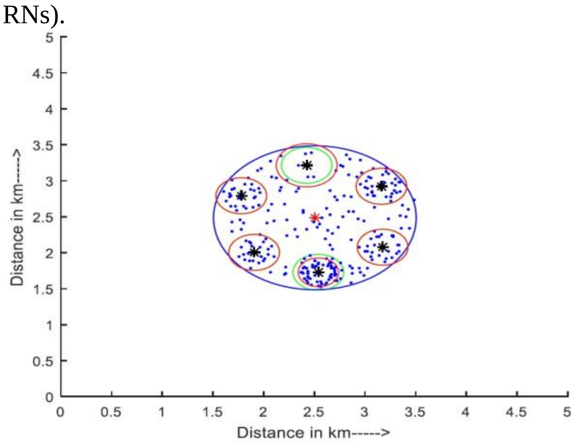

Fig 3: Change in the coverage area of Relay nodes by using Min-Max Method

C. *Guided Method 111: Random*

The Random method introduced does not consider any smart decision making approaches, but rather minimizes the power of a randomly chosen RN by 1 dB.

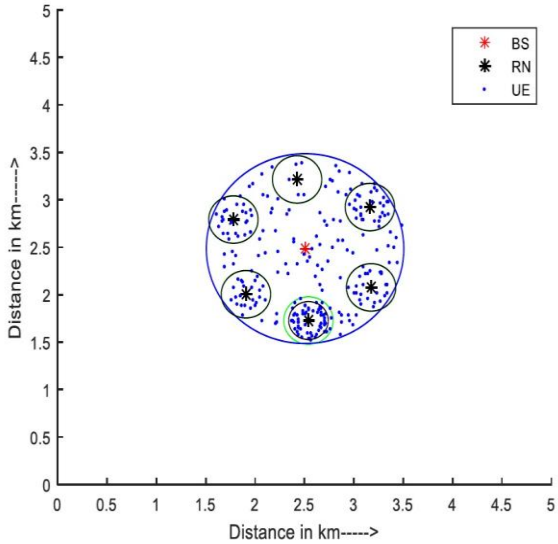

Fig 4: Change in the coverage area of Relay nodes by using Random Method

IV. SIMULATION

Here we are comparing the utility function for various Guided Neighbourhood Searching Methods such as Average user, Min-Max, Random with no load balancing.

We study the performance of different Guided Neighbourhood Searching Methods for low variance as shown in Fig 5(means that there is almost same number of users in all relay nodes) and for high variance as shown in Fig6 (means that there is almost large variation in the number of users in all relay nodes).

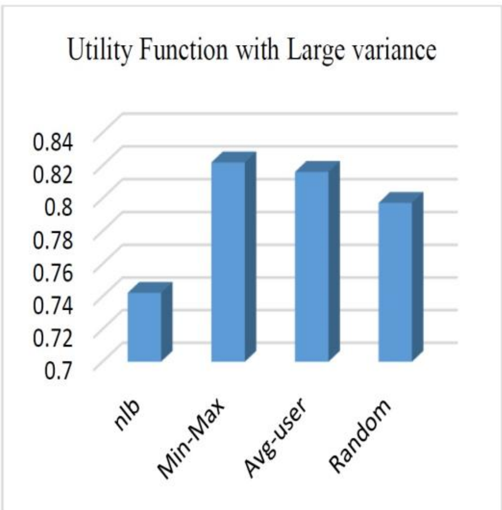

Fig 5: Utility Function for Relay nodes having small variation in the number of UEs

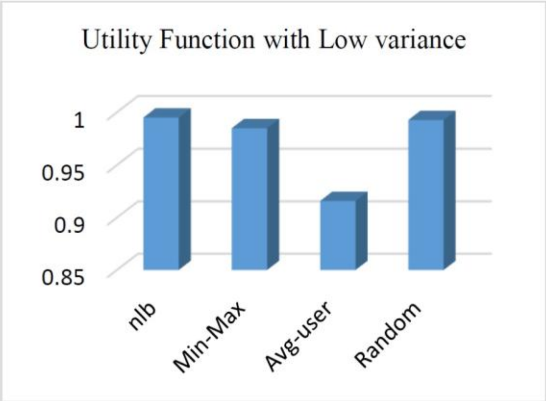

Fig 6: Utility Function for Relay nodes having large variation in the number of UEs

V. INFERENCES

If all Relay Nodes have same number of users (Less variance in the number of users) is having high utility function in no load balancing that means we don't have any advantages for Guided Neighbourhood Searching Methods.

If Relay Node with large variation in the number of users then **Min-Max** method have more advantages other schemes.

VI. CONCLUSION

Load balancing is necessary when number of users is the eNB is larger than the number of users that they can supported. In order to increase the number of satisfied users we are deploying relay nodes. We used different Guided Neighbourhood Searching Methods we analysed their performance. Min- Max is better in terms of number of satisfied users compared to all other methods.

REFERENCES

[1] Power Tuning Based Load Balancing in LTE-A Relays Using Guided Local Search Heuristic by Reem Atteya, Mohamed Ashour, Ramy Atawia IEEE conference vol. 2014.