Study for Load Distribution Method in 3GPP Ultra Dense Network

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Abstract In an Ultra-Dense Network (UDN), the number of users increases dramatically, but unbalanced load balancing in a 3GPP UDN environment is inevitable due to inappropriate cell plan. This paper introduces a method for load balancing in an Ultra Dense Network. We propose a method to measure interference and to share interference information at each Mobile Station and Base Station. The first is a method that use Mobile Station and based interference information, and the second is a method that use Base Station based interference information. And through a simulation, we confirmed the proposed method could achieve higher load balancing effect than SINR based method besides the average data throughput can be enhanced by the proposed new method.

Keywords— Ultra-Dense Network , Load Distribution, SCell Selection.

I. Introduction

Due to smart phones and smart pads etc. of mobile devices increases network traffic and subscriber growth has increased at least twice a year. There in 2010 compared to 2020, a sharp increase each year, including almost x1000 increase in the amount of traffic that is expected. In the past, it has been used mainly for a policy that allows many users as possible to the single Base Station, thus, the plurality of macro cells and a plurality of small cells is appeared as a multi-cell scenario, various networks consisting of multi-carrier type are concentrated in a hot spot to accommodate the amount of traffic increases rapidly [1].

However, the network performance is still deteriorated by load imbalance among cells, which includes a handover decision process and a call admission control process and can be referred to the Mobility Load Balancing (MLB). Load imbalance often causes inefficient utilization of system resource, which may result in a high new call blocking rate. Most previous researches on load balancing in LTE liked packet-switched networks modeled it as an optimization problem on matching between users and cells according to different metrics [2][3].

In this paper, the main idea of improved procedure is to average the data of payload among all the cells with maximum capacity. We suggest the contribution for this idea into two aspects. First of all, average throughput of data UEs is increase. Second, the proposed method is aimed at balancing load between base stations. Proposed methods are discussed in 3GPP Ultra-Dense Network topology and we focus on capacity based targets to optimize traffic payload. The proposed idea takes into account of the available resource in adjacent light overhead cells and the best satisfaction of the needs of overload base stations for the purpose of improving the network performance.

By using load balancing, the new call blocking rates of busy cells may be decreased since proper boundary users are switched to neighboring light overhead cells so as to leave more resources to new coming UEs. The design of the procedure takes LTE system features into consideration. The rest of this paper is organized as follows. Section II investigates related works and motivation, and section III presents information transmission procedure. Section IV introduces the proposed method simulation. The conclusion is given in section V.

II. Related work

Many ideas and algorithms have been proposed for this problem. Network Load minimization with Load Balancing (NLMLB) consider load balancing and network overhead minimization in heterogeneous networks, it formulates the problem to be a various objective optimization problem, and analyze the complexity and overhead of the optimal solution of the problem. Therefore, we propose an efficient algorithm with less overhead, NLMLB, which includes a handover decision process and a call admission control process. It n results showed that NLMLB algorithm can efficiently decrease the new signal blocking rate and increase network bandwidth efficiency and reduce limited resource usage. [5]. MLB is one of the key solutions for Long Term Evolution (LTE) self-optimizing networks (SONs). Therefore, we propose a Concurrent MLB (CLB) scheme to solve the problem of asymmetric traffic distribution among heterogeneous cells and potential small cells. However, CLBs are always too heavy for single triggers on CLBs that contain multiple cells. As a result, it becomes more difficult to deploy a large number of cells in a specific area. Therefore, we propose an irregular CLB (also known as ICLB) scheme to overcome the shortage of cell capacity required by the CLB. A new Irregular CLB (ICLB) to overcome the shortage of CLB of all associated cells who taking part. The irregular formation and detailed implementation of ICLB were introduced and extensive simulation results were provided to show the effectiveness of ICLB, compared to CLB and conventional MLB [6].

A novel two step network flow based mobility LB (NFT-MLB) algorithm in SON. Network flow theory is applied in the first step to optimize the procedure of overload traffic transfer, and then the User Equipment (UE) capabilities are considered to select the specific handover UEs. The cell physical resource is also assumed in the presented algorithm to support the main feature in Advanced Long Term Evolution (LTE-A) systems. The proposed algorithm shows the performance enhancement in terms of Load Distribution Index (LDI), average load ratio of overload cells and maximum load ratio of light overhead cells. It is shown from the simulation results that the NFT-MLB algorithm outperforms the other two schemes significantly, Even if the traffic data of a cell with insufficient resources is extremely high [7].

III. DISTRIBUTION INFORMATION TRANSMISSION

The definition of ultra dense network is proposed in this paper as shown in Figure 1. Different types of cells are deployed in the UDN. A plurality of adjacent cells are set as cell group. If there are too many UEs in one cell group, the UEs should be moved to another group to distribute the load.

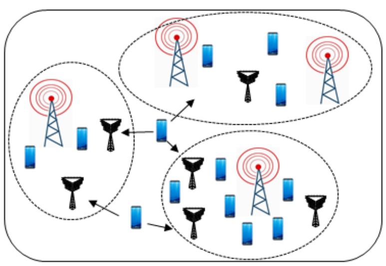

Figure 1. UDN system model

This section provides a method of selecting a radio resource assignment by utilizing interference information that a Mobile Station measured based on static Frequency Assignment (FA) selection information. Main ideas provides a method of transmitting interference information measured by a Mobile Station to a Base Station and assigning a radio resource having an interference minimized by the Base Station based on Mobile Station interference information to the Mobile Station and provides a method of cancelling interference in a wireless communication system by sharing data based on Mobile Station information, or based on the Base Station on the basis of interference information of neighboring Base Station measured by a Signal-to-Interference plus Noise Ratio (SINR) value of the Mobile Station [8][9].

A. *Mobile Station-based interference information providing method*

The method for assigning a radio resource may include a Mobile Station information based method which is another method for measuring interference information on a surrounding radio wave and transmitting the interference information on a surrounding radio wave. For example, the Mobile Station may measure the interference information of a surrounding Base Station through a SINR and collect information on whether the Mobile Station is currently affected by the interference, or which Base Station affects if the Mobile Station is affected by the interference. The Mobile Station information based method may be divided into two types which are described later according to the method for sending the collected interference information to the Base Station.

It proposes two methods:

The first method transfers the information through the RACH (Random Access Channel) Preamble when Random Access procedure between the Mobile Station and Base Station. A Mobile Station may receive the SIB at operating, and may transmit a RACH Preamble message to a Base Station at operation. In this case, the Mobile Station may generate the interference information of the neighboring Base Station as the SINR value currently measured by the Mobile Station, and may additionally define Group C in RACH Preamble message and send to the Base Station if the interference exists. The method is a method of transmitting the interference state information on whether the Mobile Station is currently affected by the interference to the Base Station. The interference state information may be transmitted through the RACH Preamble message in a procedure of registering the Base Station by the Mobile Station. In this regard, if Mobile Station is currently affected by the interference according to a result of collecting the interference information as the SINR by the Mobile Station, the RACH Preamble Group C may be transmitted to the Base Station. Therefore, the Base Station may estimate that a corresponding Mobile Station is the Mobile Station which is currently affected by the interference, when receiving the RACH Preamble Group C message. In addition, the Base Station may select the FA information that can minimize the interference from among a FA list, and may assign the radio resource to the Mobile Station based on the FA information. The above procedure is shown in Figure 2.

The second method transfers the information when RRC Connection procedure between the Mobile Station and the Base Station. The Base Station may generate FA information which can be adaptively selected according to the presence or absence of interference of a Mobile Station which is serviced from the Base Station. The FA information may include a FA list when the interference exists and a FA list when the interference does not exist. Since the current Base Station is difficult to intuitively recognize the interference information of the Mobile Station located in coverage, the current Base Station may send the FA information to the Mobile Station so that the Mobile Station may select corresponding information. The Mobile Station may map the interference information measured by the interference for a current signal or a noise level (e.g., SINR) and the SIB information. Thus, the Mobile Station may select the FA information corresponding to the interference information among the FA list when the interference exists and the FA list when the interference does not exist. The Mobile Station may transmit the selected FA information to the Base Station via a RACH. The Base Station may assign the radio resource to the Mobile Station by performing a scheduling based on the selected FA information. The above procedure is shown in Figure 2. Figure. 2 and 3, 4 are based on the 3rd Generation Partnership Project (3GPP) standard specification [12][13].

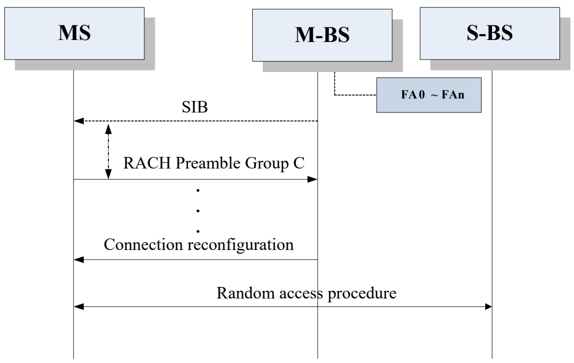

Figure 2. Mobile Station-based interference information providing method through the RACH procedure

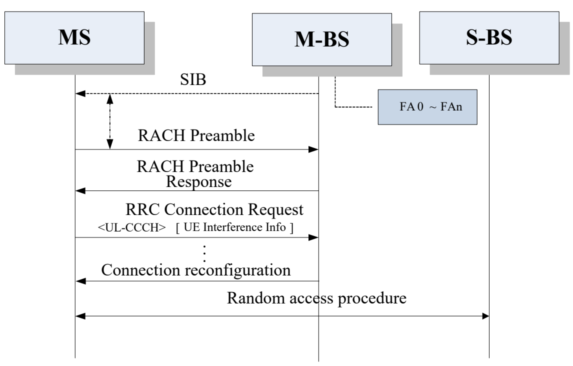

Figure 3. Mobile Station-based interference information providing method through the RRC Connection procedure

B. BaseStation-based interference information providing method.

The Mobile Station may measure a SINR value of a neighboring Base Station and may generate Base Station interference information based on the SINR value. The Base Station interference information may be list information of interference Base Station from which the Mobile Station is currently affected by the interference. The Mobile Station may include the Base Station interference information in the RRC Connection Request message of Uplink (UL) Common Control Channel (CCCH) and transmit to the Base Station, after the RACH procedure. In this case, the Base Station may analyze Base Station interference information in the RRC Connection Request message of UL CCCH, and may select the FA information which can minimize interference based on the analyzed information. And the Mobile Station may be assigned an optimal radio resource which removed interference from the Base Station based on the FA information. Figure 4 is a diagram illustrating a method for assigning a radio resource based on interference factor Base Station information of a Mobile Station according to an embodiment of the present disclosure. Referring to Figure 4, as described above in Figure 3, a Mobile Station may receive the SIB at operating, and may transmit a RACH Preamble message to a Base Station. However, as shown, instead of sending the RACH Preamble Group C so as to correspond to the interference information of a surrounding Base Station at operation, the Mobile Station may receive a response to the RACH Preamble message, and then, generate information on a Base Station from which the Mobile Station is currently affected by the interference in radio resource control (RRC) connection request information and transmit the generated information to the Base Station [13].

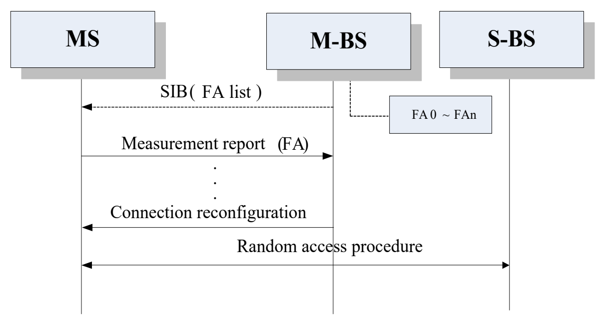

Figure 4. Base Station-based interference information providing method procedure

IV. SIMPLE SIMULATION

The proposed load balance method is compared with the one that is presented in [11]. The performance is evaluated by load balance index and throughput respectively. Simulation setup is as follows. In the simulation, the MS replaces the UE and the BS replaces the evolved NodeB (eNB).

User Equipment (UE)'s speed is 0 to 5m/s. The number of eNB is 7. The number of UEs is 0 to 100. Maximum bandwidth requirement for data users is 3Mbps and Minimum bandwidth requirement for data UEs is 0.3Mbps [10].

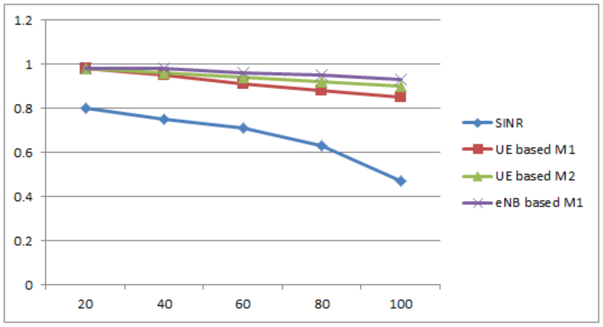

Figure 5. Load Balancing Index

$$Bi = \frac{(\sum_{i\in N} K_i)^2}{|N| \sum_{i\in N}(K_i)^2} \quad (1)$$

The comparison of balance indexes is depicted in Figure 5 and the definition of balance index is the definition of balance index is slightly different from the one that is used in section 4, and it is defined in Eq. 14 where N is the set of all the M-BS and Ki is the average number of used PRBs in M-BS.

Figure 5 shows the load balancing index close to 1 when the UE is to increase from 0 to 100. We can find that the load balancing index of SINR decreases monotonously with the increase of the arrival rate of cell 1. The load-balancing index of the UE-based method is the best, while the load-balancing index of the SINR is not good at all the arrival rate of cell 1. Our proposed all method is close to 1 all the time, which means that proposed methods can achieve a relatively better load balancing. The proposed method shows that the balance index is higher than the other methods. This is because the other method considers only the loading method. [10].

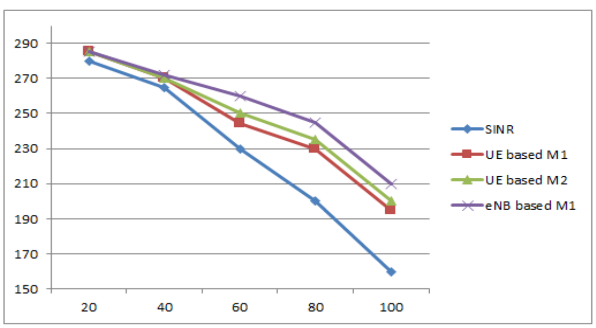

Figure 6. UE Average Data Throughput

Figure 6 shows the average data throughput of UEs with the increase of the number of UEs. As the number of UEs increases, the average throughput decreases because the UEs share resources. As shown in Figure 5, the closer the Load Balancing Index value is to 1, the average data throughput value is high. Figure 6 shows that average data throughput is better in order of balancing index value. Finally, user satisfaction is one of the indicators of efficient load distribution. In this paper, use the success value of handover procedure in load distribution to calculate user satisfaction as the following formula [11].

$$Success\ Value(s) = \frac{The\ number\ of\ successful\ handover\ procedures}{Total\ number\ of\ handover\ procedures} \quad (2)$$

$$U(s) = \left|1 - \frac{1}{1+\varepsilon^{-A(S-B)}}\right| \quad (3)$$

The handover procedure success value S for load distribution is defined in Equation (2). In equation (3), the value of A indicates user's sensitivity to the QoS degradation while B indicates the allowable region of operation.

In Figure 7, when the number of UEs is less than 10, User's Satisfaction is almost 1. When the number of UEs is greater than 10, the User's Satisfaction decreases. We can see that the User's Satisfaction of the SINR method is significantly reduced during simulation compared to the method proposed in this paper. Because the success probability of the handover method based on the interference information is higher than the method of handover through the SINR information. And eNB based method through information exchange between eNB is more effective than UE based method.

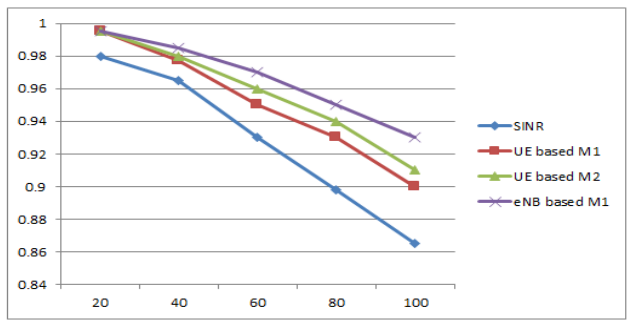

Figure7. User's Satisfaction Probability

V. CONCLUSION

In this paper, in Ultra-Dense Network environment, the Idle or Connected Mobile Station connected to interference minimized Base Station proposed a method and procedures for sharing DISTRIBUTION INFORMATION between the Mobile Station and the Base Station to allocate the best resources in 3GPP UDN. The proposed method is to determine an interference state of the Mobile Station by the Base Station quickly and accurately. If the Base Station can be connected to the Mobile Station through the interference information to the Base Station, it has the following advantages. At the Base Station reduces the amount of calculation to select a Base Station through interference information. Additionally, the process may be based on the accurate interference information. Therefore, it is able to distribute network congestion. The proposed method has the advantage that review the effectiveness of the procedures in compliance with the idea of the 3GPP standard specification applicable to the LTE standard [12][13]. It is also expected to contribute the results of this paper are the current 3GPP Work Item "Multicarrier Load Distribution in LTE" [14][15].

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