Adaptive Handoff Initiation Scheme in Heterogeneous Network

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Abstract—In wireless heterogeneous network, nodes are mobile equipment and can move freely from one area to another. A group of users with a large range of mobility can access around the overall network cause high traffic. In these heterogeneous networks, resources are shared among all users and the amount of available resources is determined by traffic load. The traffic load can seriously affect on quality of services for users thus it requires efficient management in order to improve service quality. If traffic load is concentrated in a cell, this cell becomes the hotspot cell. There is a need to have a proper traffic driven handoff management scheme, so that users will automatically move from congested cell to allow the network to dynamically self-balance. This research proposed an approach which adopts a hard handoff scheme to dynamically control the handoff time according to the load status of cells. The result shows that the effect of hotspot threshold is the most important in initiation the handoff process. Therefore, by incorporating value of traffic load as adaptive factors, it shows how the handoff initiation criteria might be set in accordance with the quality of services requested by users.

Index Terms—heterogeneous, mobility, traffic load, hard handoff

I. INTRODUCTION

Long Term Evolution (LTE) is one of the latest communication technology that is currently being tested and deployed. Third Generation Partnership Project (3GPP) Release 8 defines the standards for LTE and Release 10 pertains to defining the standards for LTE-Advanced. SAE is the core network architecture for establishing a LTE Network. The important factor of this network architecture is that it is heterogeneous. A heterogeneous network is composed of several wireless technologies that constitute together a network that connects users to the Internet [1]. Core network, sometimes called backbone network, combines all access networks together. The technologies utilized in core and access networks may be different, resulting in different characteristics. In these heterogeneous networks, mobile users can move between different networks. In this kind of environment, handoff management is the essential issue that supports the handoff of users between various wireless technologies. Handoff decision, one of the handoff management issues consists of finding the appropriate time to perform the handoff and which cell to hand over in cellular networks. Traditionally, the need for initiating the handoff arises when the RSS of the serving base station deteriorates below a certain threshold value. However, in a heterogeneous network environment, more criteria are needed to initiate the appropriate time to perform the handoff.

This paper presents a traffic driven handoff management scheme which adopts a hard handoff scheme to adaptively control the handoff time according to the load status of cells. Before accepting a new user, it requests the load information of the target cell in advance before handoff execution. Then, the value of adaptive RSS is applied in the scheme to initiate the right handoff time. A dynamic simulator which is based entirely on MATLAB software is developed, using the designed scheme.

II. PREVIOUS WORKS

There also have been many proposals to solve the hotspot cell problem. Two methods for resource controlling and allocating in a roaming based scenario were proposed in [2,3,4]. A number of channel borrowing algorithms which utilize available resources of lightly loaded cells and alternatives have been proposed [5]. In the research area of the load distribution scheme, power control and handoff based algorithms have been investigated [6,7]. In Adaptive Cell Sizing (ACS) scheme [6], this algorithm controls the transmitting power of the base station based on CDMA cellular system. Similarly, in soft handoff resizing algorithm [7], it reduces the size of soft handoff area in the hotspot cell by increasing the value of the threshold value but these algorithms can be only used in the particular system and it requires the negotiation between cells in order to support seamless services for mobiles.

A cell which has heavier traffic load than adjacent cells is referred to as hotspot cell which can be determined by resource affordability, the ratio between the amount of available resources and the total amount of resources in a cell. Hotspot cell can be generated by sudden concentration of traffic load and this hotspot cell problem can cause poor service quality [8]. [9] proposed an effective traffic management scheme using adaptive handover time. Handoff time is adaptively controlled according to the amount of traffic load of cells.

III. ADAPTIVE HANDOFF TIME ALGORITHM APPROACH

In this research, an adaptive handoff algorithm for dynamic traffic load distribution in the hotspot cell is proposed. Traffic load is estimated as the channel occupancy rate in the algorithm. It is essential to distribute traffic load of the hotspot cell in order to effectively use remained resources and maintain
the acceptable service quality.

Active communications between user and base station occur in HOLD and ON state [9]. The HOLD state has full downlink and thin uplink channel while ON state has both full downlink and uplink traffic channel. In this measurement, the load which will be added by the handoff calls also has been considered and it is defined as HANDOFF. The handoff call is assume in the ON state right after the handoff process completed. So, the traffic load can be estimated by measuring the number of users in the states, HOLD, ON and HANDOFF which is described in Equation 1[9].

\[ N_t = \text{Non} + \beta \times N_{\text{hold}} + N_{\text{handoff}} \]  

where \( N_t \) is the number of traffic loads, \( \text{Non} \) is the number of users in the ON state, \( N_{\text{hold}} \) is the number of users in the HOLD state and \( N_{\text{handoff}} \) is the number of handoff calls. In Equation (1), \( \beta \) is an adaptive factor and the number of traffic load varies from 0 to 1. The value of traffic load is approximated to 0 when the current cell is regarded as the lightly loaded cell and as the number of mobile nodes is increase, the traffic load is approximated to 1. The current cell becomes to be the status of hotspot. Figure 1 shows the handoff time algorithm. The handoff time algorithm is based on the handoff scheme proposed by [10]. As shown in Figure 1, when the receive signal strength of the serving cell is less than threshold value, it sends the load request status to the target cell and receive load response status from the cell. The target cell calculates the number of traffic load using Equation (1). If the number of available resources of the target cell is less than the hotspot threshold, \( H_d \), the current serving sends to hotspot alarm status to the target cell. After receiving the status, the proper threshold value should be carefully selected in order to initiate the handoff process. However, the previous work used fixed RSS to initiate the handoff process. An adaptive RSS threshold is recommended to be used so that the mobile has enough time to initiate the handoff process. Therefore, the threshold value for initiating handoff should be carefully selected in order not to degrade the service quality of other users. The algorithm has been modified by applying a mathematical formulation that had been derived in the [11] for controlling the handoff time and called as an adaptive receive signal strength threshold. Receive signal strength value avoids too early or too late initiation of the handoff process. They are completed before the user moves out of the coverage area of the serving network.

III. RESULT AND DISCUSSION

The simulations were performed in MATLAB. Various initial typical parameters assumed in the simulation are described in Table 1 [9].

<table>
<thead>
<tr>
<th>Simulation Parameters [9]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Radio propagation model</strong></td>
</tr>
<tr>
<td><strong>Capacity</strong></td>
</tr>
<tr>
<td>Neighboring cells = 10</td>
</tr>
<tr>
<td><strong>Number of users</strong></td>
</tr>
<tr>
<td><strong>Cell radius</strong></td>
</tr>
<tr>
<td><strong>Velocity</strong></td>
</tr>
<tr>
<td><strong>Handoff signaling delay</strong></td>
</tr>
<tr>
<td><strong>Simulation time</strong></td>
</tr>
</tbody>
</table>

| Parameters | |
|-----------|
| \( H = 0.2 \) |
| \( \text{THREE}_\text{SERVING} = -74 \text{dBm} \) |
| \( \text{THREE}_\text{TARG} = -70 \text{dBm} \) |
| \( \text{THREE}_\text{MIN} = -36 \text{dBm} \) |
| \( \text{THREE}_\text{NORMAL} = -79 \text{dBm} \) |
| \( \text{HIS}_\text{ACCEPTABLE} = 3 \text{dBm} \) |
| \( \text{HIS}_\text{MIN} = 0 \text{dBm} \) |
| \( \text{HIS}_\text{NORMAL} = 2 \text{dBm} \) |
A. Comparison Between Conventional Handoff Scheme, An Adaptive Handoff Time Scheme and Proposed Traffic Driven Handoff Management Scheme

This section analyzes the effect of the $\text{Thres}_{\text{min}}$ for the proposed traffic driven handoff management scheme. $\text{Thres}_{\text{min}}$ is the most important parameter in initiating the handoff process. It is responsible for the quality of connection. If it is set very low, the neighbor's eNodeB cannot involve into the connection until the mobile goes far from serving eNodeB where it is considered to be at the boundary of the cell and the quality of service reaches a bad condition. So, there is a need for an optimum value for this threshold to get the optimum quality of service and optimum system capacity. In the following graphs, the curves labeled as “$\text{Thres}_{\text{min}}=-86 \text{ dBm}$” indicate the proposed scheme and the curve labeled as “$\text{Thres}_{\text{min}}=-83 \text{ dBm}$” indicate an adaptive handoff time scheme proposed by Kim et al. 2007. The labeled “$\text{Thres}_{\text{min}}=-90 \text{ dBm}$” indicate the conventional handoff scheme.

![Figure 2. Effect of the $\text{Thres}_{\text{min}}$ on the handoff probability](image)

As shown in Figure 2, the simulation result indicates the handoff probability increases as the $\text{Thres}_{\text{min}}$ increases. The higher the $\text{Thres}_{\text{min}}$, the earlier the mobile device initiates handoff. Therefore, the mobile device can finish handoff before the RSS falls below the acceptable level. However, if the handoff is initiated too early, the ping-pong effect may occur causes the degradation of service performance. If the handoff is initiated too late, a UE may not have enough time for making handoff, which increases the dropping probability if neighboring cells are in the hotspot status.

The following Figure 3 shows the effect of the $\text{Thres}_{\text{min}}$ on the performance of handoff drop call rate. As shown in Figure 3, the conventional handoff scheme shows a highest handoff drop call rate among the three schemes. The proposed scheme shows similar results to an adaptive handoff time scheme proposed by Kim et al. 2007 and a decrease of 17% at lower capacity in the handoff drop call rate compared to the conventional handoff scheme.

![Figure 3. Effect of the $\text{Thres}_{\text{min}}$ on the performance of handoff drop call rate](image)

B. Effects of the $H_d$ on the Performance of Handoff Drop Call Rate

Figure 4 shows the effects of the $H_d$ on the performance of the traffic driven handoff based management scheme. The handoff drop call rate increases as the $H_d$ increases. If the $H_d$ is higher than the threshold which causing significant delay, the proposed scheme will not initiate handoff and thus cause high handoff drop call rate. The impact is that by increasing the $H_d$, the network delay time will increase and this make the duration of handoff more longer. This implies that data communications will be delayed or even dropped when the mobile device moves across cell boundaries during heavy traffic. Hence, the higher the handoff drop call rate.
C. Effects of the \( H_d \) on the Performance of Satisfaction Rate

Figure 5 shows the effect of the \( H_d \) on the performance of satisfaction rate. A user is said to be satisfied if his/her call is neither blocked nor dropped during the total call holding time. As shown in Figure 5, the satisfaction rate increases as the \( H_d \) decreases. In cellular systems, QoS guarantee for users is the important factor to determine the system performance. A side effect from this is that the \( H_d \) can be used to balance traffic load between neighboring cells and thus enhance network performance. Thus, it is important to consider traffic load as an important factor for initiating handoff since heavy traffic load causes significant degradation of network performance.

D. Effects of the Random and Hotspot Traffic Scenario on the Performance of Handoff Drop Call Rate

Figure 6 shows the relation between capacity and handoff call drop rate for random and hotspot traffic scenario. From the figure, it shows that handoff call drop rate for hotspot scenario is higher than random distribution scenario. This is true because the number of mobiles in the hotspot scenario cross the boundary area much greater than random distribution scenario. In reality, hotspot scenario causes a big consumption in the system resources, especially the system capacity, as most of the mobiles connected to the same eNodeB which has limited number of channels and this problem will appear as an increase in the handoff drop call rate.

D. Effects of the Different Movement on the Performance of Handoff Drop Call Rate

Figure 7 shows the effect of the different movement on the increment of capacity. From the Figure 5.14, it shows that straight lines scenario causes more handoff drop call rate than random movement. This is because in straight lines all mobiles will leave the hotspot cell to the nearest cells. Thus, the minimum number of handoff drop call rate equals the number of mobile.

CONCLUSIONS

An adaptive value for RSS using speed and handoff signaling delay information was proposed to initiate the handoff process. This handoff initiation procedure is applied in a traffic driven handoff management scheme to manage overloaded traffic in the SAE heterogeneous network. The
handoff performance with respect to traffic load has been evaluated. The results show that in heavy traffic load, the $H_d$ should be taken into account to control the handoff time. The effect of $\text{Thres}_{\text{min}}$ also has been evaluated and it is observed that the value of $\text{Thres}_{\text{min}}$ is the most important in initiation the handoff process. Therefore, by incorporating value of traffic load, user’s speed and type of handoff as adaptive factors, it shows how the handoff initiation criteria might be set in accordance with the quality of services requested by users. In this research, a dynamic simulator is presented, which incorporates the effects of the adaptive and conventional handoff management schemes. The handoff drop call rate has been evaluated in order to measure the service quality. It was found that the proposed scheme could efficiently manage overloaded traffic in the system at lower capacity, thereby support better service quality.

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