Traffic Management Algorithm and Adaptive Handover Initiation Time for Dynamic Traffic Load Distribution

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Summary

In next-generation all-IP based wireless systems, Radio Resource Management (RRM) algorithms are required in order to effectively control resources and maintain the acceptable service quality. RRM algorithms are needed to guarantee the required Quality of Service (QoS), to supply the optimum coverage area and to offer high capacity. Therefore, there is a critical need for RRM to provide efficient utilisation of the air interface resources. A users, with a large range of mobility, will access the network and will be able to seamlessly reconnect to different networks, even within the same session. The core network will enable inter- and intra-access handover. In the next-generation wireless systems coverage/capacity will change dynamically to accommodate changing user patterns. Users will automatically move from congested cell to allow the network to dynamically self-balance. The objective of this research is to propose a handover-based traffic management algorithm in order to adaptively controls the handover initiation time according to the load status of cells. Under the proposed algorithm, the signaling burden is evenly distributed and the regional network boundary is dynamically adjusted according to the up-to-date mobility and handover types for each terminal. A simulation model is developed to investigate the handover performance. Simulation results show that the proposed algorithm can reduce call drop rate of handoff calls and the use of adaptive value of received signal strength avoids too early or too late initiation of the handover process.

Key words:
Radio Resource Management, Quality of Service, inter- and intra-access handover, handover-based traffic management, adaptive handover time.

1. Introduction

In next-generation wireless systems it is important for RRM functionality to ensure that the system in not overloaded and guaranteeing the needed requirements. If the system is not properly planned, the capacity is lower than required and the QoS is degraded. The system became overloaded and unstable. Therefore, a proper traffic management scheme is required to effectively manage overloaded traffic in the systems.

There has been many proposals to solve radio resource problems. They can be divided into two areas as resource allocation scheme and load distribution scheme. In the research area of the radio allocation scheme, major papers propose a number of sharing concepts including site sharing, radio access network (RAN) sharing, common network sharing and geographical network sharing [1-8]. A number of channel-borrowing algorithms which utilize remaining resources of lightly loaded cells and alternatives have been proposed [9,10]. In the research area of the load distribution scheme, power control and handover-based algorithms have been investigated [11,12]. In ACS (Adaptive Cell Sizing) scheme [11], this algorithm controls the transmitting power of the base station based on CDMA (Code Division Multiple Access) cellular system but this scheme is based on the particular system. In soft handover resizing algorithm [12], it reduces the size of soft handover area in the hotspot cell by increasing the value of the threshold value but this algorithm can be used only in the particular system.

The traditional scheme has shortcomings of the insufficient of system resources and degradation of service quality due to sudden traffic increase. In addition, the previous works not considering the load status of neighboring cells which may degrade the service quality if the neighboring cells are also heavily loaded. Proposed algorithms also differently set the handoff threshold based on traffic cells and not considering other factors. Therefore, there is a critical need in RRM in order to effectively control resources and maintain the acceptable service quality.

In this paper, we propose a handover-based traffic management algorithm to adaptively controls the handover time according to the load status of cells. We considers traffic load as an important factor for initiating handover. The traffic load can seriously affect on QoS for users thus it requires efficient management in order to improve service quality.

The rest of this paper is organized as follows. First we develop a slow and fast handover time algorithm where in this proposed algorithm we set the threshold value based on traffic load of cells. Then we use the concept of dynamic boundary area size based on mobile's speed and handover types to estimate the right time to initiate the

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handoff process. We discuss the simulation results and finally the conclusion.

2. Traffic Management Algorithm

If the traffic load of cells is increase excessively, the coverage area of the cell is reduced below the planned values and the quality of service of the existing connection cannot be guaranteed. We propose a traffic-driven handover algorithm to manage overloaded traffic in the systems. In these algorithms, the handover execution is executed not only by the measurement of signal strength but also the status of the traffic load where our algorithm considering the load status of neighboring cells. These algorithms is executed when the neighboring cells not in the hotspot status. A slow handover time algorithm is used to delay time for the target cell to come out of the hotspot status and fast handover time algorithm is used when cell happens to be in hotspot status due to sudden occurrence of many new calls. Before accepting a new user, it requests the load information of the target cell in advance before handover execution. The traffic load can be estimated by measuring the number of users in the states, ON and HOLD, which is described in Equation 1.

$$Traffic = ONcurrent + HOLDcurrent \qquad (1)$$

In (1) the amount of traffic varies from 0 to 1 where the value of traffic is approximated to 0 when the current cell is lightly loaded cell and as the number of mobile nodes is increase, the traffic is approximated to 1 and the current cell becomes to be the status of hotspot.

Figure 1 and 2 shows the slow and fast time handover algorithms. As shown in figure 1, when the signal strength of the serving cell is less than threshold value, it sends the load information request message to the target cell and receive load information response message from the cell. If the amount of available resources of the target cell is less than the hotspot threshold, H_d, the current serving cell execute the slow handover time algorithm and otherwise. The slow handover time algorithm delays time for the target cell to come out of the hotspot status and the fast handover time algorithm recovers their normal status. In this proposed algorithm, the proper threshold value should be carefully selected in order not to degrade the service quality of other users.

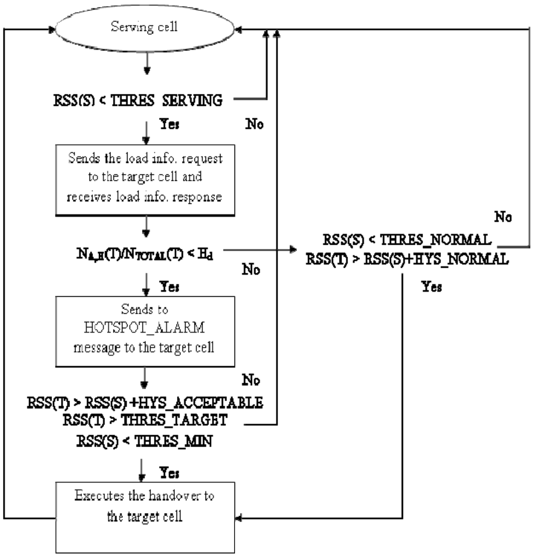


Fig. 1 The fast handover time algorithm.

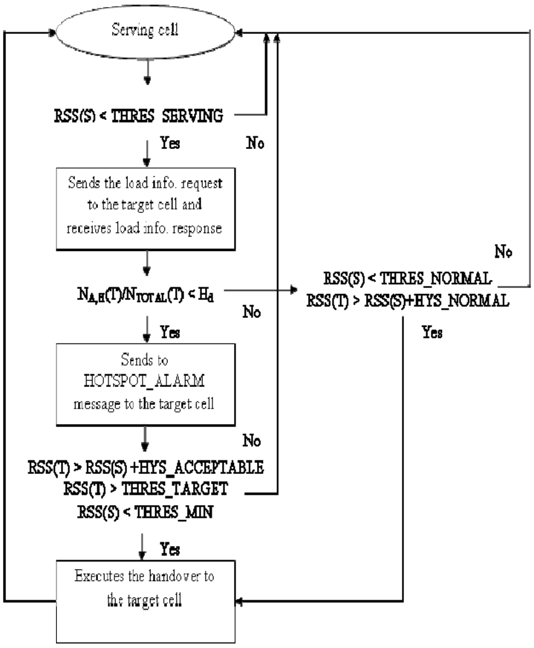


Fig. 2 The slow handover time algorithm.

3. Adaptive Handover Initiation Time

The two handover time algorithms can recognize the load status of the neighboring cells with the load information message in advance, before handover execution. After received the load information message, the proper threshold value should be carefully selected in order to initiate the handover process. In this algorithm, we derive the mathematical equation for control the handover time, *THRES_MIN* according to the load status of cells, mobile's speed and handover types.

For different values of v, first the required value of d for a desired value of the probability of handoff failure, pf is determined.

$$pf = (1/\theta) \times ar\cos(d/vt) \qquad (2)$$

where a handover percentage, θ, is used to consider the viability of inter-cell overlap when commissioning a new cell, d is the distance of mobile from the boundary, v is the speed of mobile and t is the handoff signaling delay. Then, the required value of *THRES_MIN* is calculated.

$$THRES\_MIN = 10\ell og_{10}[\Pr(a-d)] \qquad (3)$$

The *THRES_MIN* value should be carefully selected in order not to degrade the service quality of other users. Adaptive threshold value avoids too early or too late initiation of the handoff process (registration). They are completed before the user moves out of the coverage area of the serving network.

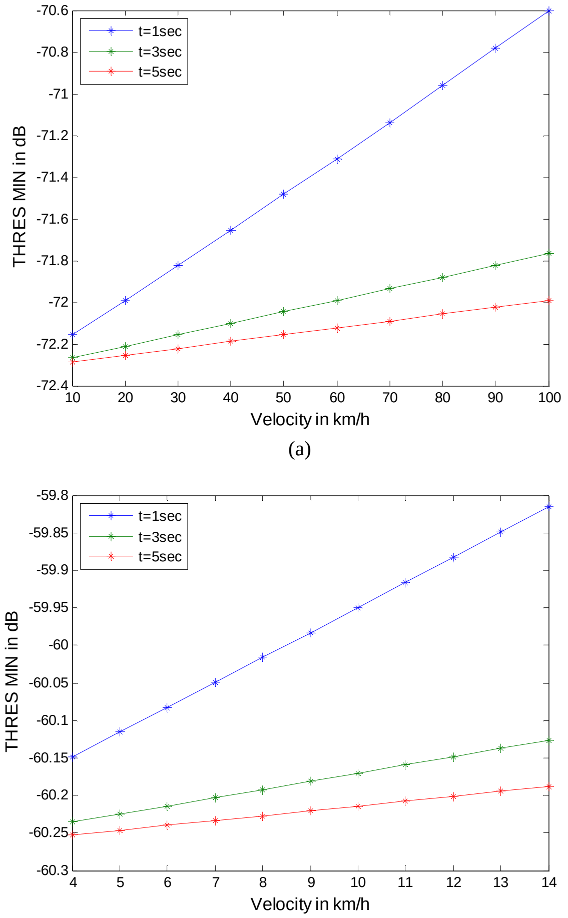
4. Performance Evaluation

We present the performance results of our algorithm by simulation. The parameters assumed in the simulation are described in Table 1.

Table 1: Simulation parameters

Hexagonal cell radius, a	Macro = 0.5 Micro = 0.5macro
Max speed of mobile, v	Macro = 100 km/h Micro = 14 km/h
Standard deviation of shadow fading, ε	8 dB
Path-loss coefficient, α	4
Probability of handoff failure, pf	0.02
Minimum value of RSS, S_{min}	-64 dBm
Hotspot threshold, H_d	0.2
Simulation time	2000
THRES_SERVING	-74 dB
THRES_TARGET	-79 dB
THRES_NORMAL	-79 dB
HYS_ACCEPTABLE	3 dB
HYS_MIN	0 dB
HYS_NORMAL	2 dB

The relationship between *THRES_MIN* and mobile's speed (v) for different values of handoff types (τ) is analyzed. Figure 3(a) shows the relationship between *THRES_MIN* and v for different value of τ when the serving BS (OBS) belongs to a macro-cellular system. Figure 3(b) shows the similar results when the OBS belongs to a micro-cellular system. Figure 3(a) and (b) show that for particular value of τ, the value of *THRES_MIN* increases as mobile's speed increases. This implies that for a mobile with high speed, the handoff initiation should start earlier compared to a slow moving mobile to guarantee the desired handoff failure probability to users independent of their speed and handover types. Figure 3 also shows that *THRES_MIN* increases as τ increases. The lower and higher values of τ correspond to intra- and inter-system handoff, respectively.

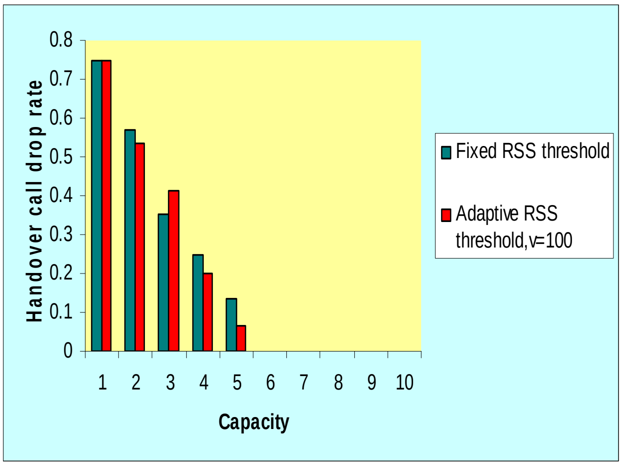


(a)

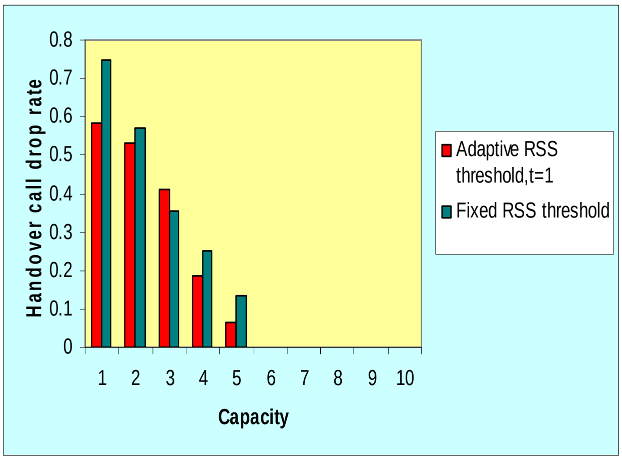
(b)

Figure 3 : RSS threshold (*THRES_MIN)* for different speed values when the serving BS belong to a : (a) macro-cellular system, (b) micro-cellular

Figure 4 shows the effects of handover time control of traffic load. Our algorithm shows a lower drop rate than fixed algorithm. The reason the fixed algorithm has a high handover call drop rate is that it just tries to reduce traffic load of the hotspot cell even though the neighboring cells are in the hotspot status and these handovers may be dropped in the cells. In addition, the algorithm forcibly executes handovers without considering the speed and handover types of mobiles. On the other hand, our algorithm shows lower drop rate compared to fixed algorithm. The current serving cell delays all handover executions if neighboring cells are in hotspot status, which can lead to a small dropping of handover calls. Our scheme also adaptively controls the handover initiation time based on the mobile's speed and handover types.



(a)



(b)

Figure 4 : Effects of adaptive handover time control of traffic load based : (a) mobile's speed, (b) handover types

5. Conclusion

In this paper, we proposed a handover-based traffic management scheme to adaptively controls the handover time according to the load status of cells. We proposed the proper threshold value to control the handover initiation time according to the load status of cells, mobile's speed and handover types. This algorithm is specially developed to effectively manage overloaded traffic in the systems and avoid too early or too late initiation of the handover process. To summarize the comparison between fixed and adaptive handover time algorithm, we measured the adaptive value of received signal strength. In addition, we evaluated the handover call drop rate between fixed and adaptive received signal strength. The results show that the proposed algorithm can supports higher service quality than the algorithm compared. The use of adaptive value of received signal strength avoids too early or too late initiation of the handover process. We have a future plan to measure the system performance to improve handover latency and packet loss. Moreover, we will study a method to improve the service quality with respect to mobility management.

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