4G 이동 망에서 적응적 핸드오버 시간을 활용한 효과적인 핫스팟 셀 관리 기법

김동욱[O] 이한진, 전승우, 므리나, 윤현수
한국과학기술원 전산학과
{kimdw[O], hjlee, swjeon, msawhney, hyoon}@camars.ac.kr

An Effective Hotspot Cell Management Scheme Using Adaptive Handover Time in 4G Mobile Networks

Dongwook Kim[0], Hanjin Lee, Seungwoo Jeon, Mrinalini Sawhney, and Hyunsoo Yoon
Dept. of EECS, Korea Advanced Institute of Science and Technology

요 약

4G mobile networks are expected to support various multimedia services over IP networks and also satisfy high spectral efficiency requirement. In cellular systems including 4G networks, hotspot cells can occur when available wireless resources at some location are not enough to sustain the needs of users. The hotspot cell can potentially lead to blocked and dropped calls, which can deteriorate the service quality for users. In a 4G mobile network, a band of users enjoying multimedia services can move around, which may generate heavy flows of traffic load. This situation can generate the hotspot cell which has a short life span of only a few minutes. In this paper, we propose a handover-based scheme which can effectively manage hotspot cells in 4G mobile networks. With the scheme, the current serving cell can recognize the load status of the target cell in advance before handover execution. Adaptive handover time control according to the amount of traffic load of cells can effectively and flexibly manage the hotspot cell in the network. And, through our hotspot cell management scheme, acceptable service quality can be supported as users continuously maintain connections with the network. In the simulation results, we find that our scheme generates smaller number of hotspot cells and supports higher service quality than the compared schemes.

1. Introduction

Fourth generation(4G) mobile networks aim at supporting various multimedia services with high data rate. To effectively provide multimedia services, the air interface technique should satisfy packet data transmission requirement. And, to support high data rate, spectral efficiency should be more enhanced than that of 3G cellular systems with overcoming time and frequency selective fading. Recently, a mobile system based on IP and OFDM(Orthogonal Frequency Division Multi-plexing) is intensively considered as the next generation standard by B3G(Beyond 3G) or 4G committees such as IEEE 802.16e and IEEE 802.20[1][2][3].

As in case of a traffic accident on highway, a lot of traffic load can be generated in the cell where an accident has occurred[4]. A cell which has heavier load than adjacent cells is referred to as hotspot cell. Hotspot cell can be determined by resource affordability, the ratio between the amount of available resources and the total amount of resources in a cell. The hotspot cell· problem degrades the service quality because it causes dropping of handover calls or blocking of new calls. And, the problem can cause degradation of resource utilization from the view point of overall system because available resources which remain in adjacent cells are not used. The hotspot cell problem still remains as not being solved in 4G mobile networks.

In a 4G mobile network, a band of users enjoying multimedia services can move around in the overall network, which can generate heavy flows of traffic load. The cells which these flows pass through become the status of hotspot varying from a few seconds to a few minutes according to the speed of the band. That is, the hotspot cell which has a short life span can be frequently generated in the network.

Many algorithms have been proposed to solve the hotspot cell problem[5][6][7][8]. Previous works focus on distribution of traffic load of the hotspot cell without considering the load status of neighboring cells. And, the works only consider the situation that the status of hotspot is maintained for a quite long time. They may not effectively deal with the cell whose status becomes hotspot for only a few minutes. In summary, if existing algorithms are applied to manage hotspot cells in 4G mobile networks, they may cause more hotspot cells in all the service area and may cause more deterioration of the service quality. Therefore, an effective hotspot cell management scheme suitable for 4G mobile networks is needed.

In this paper, we propose a handover-based scheme which can effectively manage hotspot cells in 4G mobile networks. 4G cellular systems will use OFDM as the physical layer technology and support hard handover. Therefore, the proposed scheme which adopts hard handover scheme dynamically controls the time point of handover according to the load status of cells. The scheme can prevent the outbreak of hotspot cells within the network and

This work was supported by the Ministry of Science and Technology(MOST)/Korea Science and Engineering Foundation(KOSEF) through the Advanced Information Technology Research Center(AITrc)

enhance the service quality. In the simulation, we can find that the proposed scheme generates smaller number of hotspot cells and supports higher satisfaction level of users in comparison to the other two schemes.

The remainder of this paper is organized as follows. In Section 2, we represent our scheme in details. And performance evaluation through comparison with other schemes is given in Section 3. Finally, we conclude this paper in Section 4.

2. Adaptive Handover Time Scheme

We propose an adaptive handover time scheme to effectively manage the hotspot cell in 4G mobile networks. The adaptive handover time scheme is to dynamically control the time point of handover according to the amount of traffic load of cells. Figure 1 shows the procedure of adaptive handover time scheme. As shown in Fig. 1, when the current serving cell, *BS1* receives the report from a mobile which includes signal strength lower than the specific threshold, it requests the load information of the target cell, *BS2*. If the cell, *BS1* determines that the target cell, *BS2* will become the status of hotspot due to increased load caused by handover calls, it sends the hotspot alarm message, *HOTSPOT_ALARM* and it delays all handovers to the *BS2*. Through the message, *BS2* recognizes that its status will be hotspot due to additional load caused by handover calls. It executes all possible handovers earlier than scheduled in conventional handover scheme in order to reduce its load. *BS2* can obtain available resources and prepare to handover calls which occur in the near future with these fast handover executions. If *BS2* gets out of the status of hotspot and obtains the sufficient amount of available resources, it sends the hotspot release message, *HOTSPOT_RELEASE* to *BS1*. If the amount of available resources are sufficient, it should satisfy Equation (1).

$$N_A(S) > N_{TOTAL}(S) \cdot H_d + \alpha \quad (1)$$

Where, H_d is the hotspot threshold and, α gives flexibility to the amount of available resources as a margin factor. If the cell, *BS1* receives the message, *HOTSPOT_RELEASE*, it stops delay of all handovers to the target cell *BS2* and uses conventional handover scheme. In the meanwhile, it is possible that both the current serving cell and the target cell are all in hotspot status. Our scheme can recognize the load status of the target cell with load information exchange before handover execution. If the

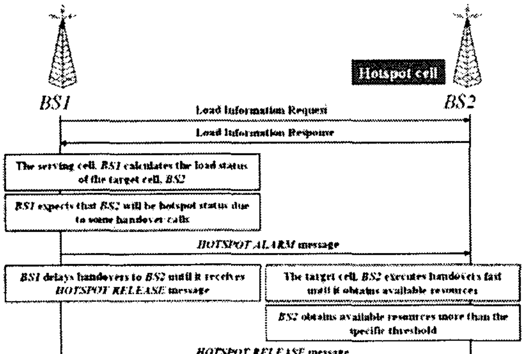

Figure 1. Procedure of adaptive handover time scheme

current serving cell is in hotspot status and the target cell is also expected to the status of hotspot caused by some handover calls, the current serving cell, in our scheme, does not execute the handovers earlier, but uses conventional handover scheme.

In our scheme, slow handover time algorithm is used in order to delay handovers to the hotspot cell whereas fast handover time algorithm is used in order to execute handovers fast. In slow handover time algorithm, to delay all handovers occurred from lightly loaded cell S to hotspot cell T, the following Equation (2) is used.

$$\begin{aligned} &RSS(S) < THRES\_SERVING \\ &RSS(T) > RSS(S) + HYS\_ACCEPTABLE \\ &RSS(T) > THRES\_TARGET \\ &RSS(S) < THRES\_MIN \end{aligned} \quad (2)$$

And fast handover time algorithm uses Equation (3).

$$RSS(T) > RSS(S) + HYS\_MIN \quad (3)$$

Finally, when handovers occur from hotspot cell S to hotspot cell T, our scheme uses conventional handover scheme. The condition of the scheme is equal to the following Equation (4).

$$\begin{aligned} &RSS(S) < THRES\_NORMAL \\ &RSS(T) > RSS(S) + HYS\_MIN \end{aligned} \quad (4)$$

Two handover time algorithms systematically cooperate to enhance service quality for users. Delay of handovers to hotspot cell leads to virtual expansion effect of coverage area of lightly loaded cell. And, fast execution of handovers leads to virtual shrinking effect of the coverage area of the hotspot cell. Through the cooperation between lightly loaded cell and hotspot cell, the shrinking effect of hotspot cell is gracefully compensated by the expansion effect of lightly loaded cell. Therefore, calls can continuously maintain connections with the network, which can support acceptable service quality. If the current serving cell and the target cell are all in hotspot status, our scheme uses conventional handover scheme, which does not cause any change of hotspot cells' coverage area.

3. Performance Evaluation

We present the performance results of our scheme by simulation. We compared our scheme(*AHT* scheme) with soft handover area resizing in [9](*T_DROP* adjust scheme) and conventional handover scheme(*CH* scheme). The soft handover area resizing scheme adjusts the size of soft handover area of hotspot cell by changing the threshold, *T_DROP*. We used following metrics to evaluate the performance of our scheme: handover call drop rate, new call block rate, satisfaction rate, and the normalized number of hotspot cells. Especially, satisfaction rate is estimated as the ratio between the number of users satisfied and the total number of calls. The normalized number of hotspot cells is estimated as the number of hotspot cells normalized by the simulation time. We used OPNET simulator and simulations were performed in two different environments: 1tier and 2tier environment. We used the free space model which assumes the ideal propagation condition[10] and ON-OFF traffic model where ON period is 120s and OFF period is 30s. In our 1tier environment, seven cells are deployed and when the capacity of the center cell is changed from 1 to 10, all neighboring cells have the capacity of 10. The number of users is set to 70. And, for our 2tier environment, nineteen cells are deployed and the capacity of each cell is 10. We performed the simulation by changing the number of users which is set to 70 initially and increasing to 90, 100, 110, 130 and 150.

First, we present the results performed in our 1tier environment. Figure 2 shows the results of the handover call drop rate and the new call block rate, respectively. As shown in Fig. 2, our scheme shows the lowest drop rate(39% decrease over *T_DROP* adjustment scheme and 15% decrease over *CH* scheme in the left figure). And, our scheme shows the lowest block rate(64% decrease over *T_DROP* adjustment scheme and 16% decrease over *CH* scheme in the right figure). Figure 3 shows the results of the satisfaction rate. A user is said to be satisfied if his/her call is neither blocked nor dropped during the total call holding time[11]. In Fig. 3, our scheme shows higher satisfaction rate by 67% than *T_DROP* adjustment scheme and by 6% than *CH* mechanism as the capacity of the center cell increases. Now we present the results performed in our 2tier environment. Figure 4 shows the normalized number of hotspot cells and satisfaction rate. As shown in the left figure of Fig. 4, our scheme generates the smallest number of hotspot cells among three schemes. Also, our scheme shows the highest satisfaction(44% increase over *T_DROP* adjustment scheme and 4% increase over *CH* mechanism in the right figure) rate among three schemes.

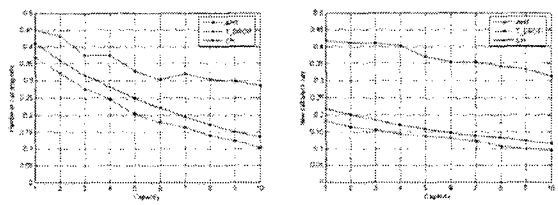

Figure 2. handover call drop rate(left) and new call block rate(right) in the 1tier environment

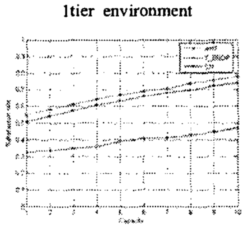

Figure 3. satisfaction rate in the 1tier environment

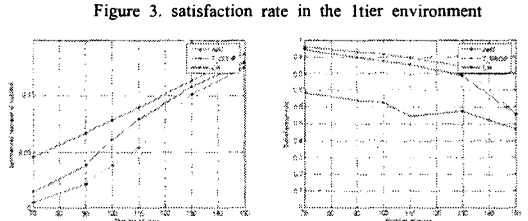

Figure 4. normalized number of hotspot cells(left) and satisfaction rate(right) in the 2tier environment

4. Conclusion

In this paper, we presented a hotspot cell management scheme based on adaptive handover time suitable for 4G mobile networks. Handover time is adaptively controlled according to the amount of traffic load of cells. Handovers to hotspot cell are delayed with slow handover time algorithm until the target cell obtains available resources. And hotspot cells execute possible handovers with fast handover time algorithm to get out of the current status and to obtain more resources. If the current serving cell and the target cell are all in hotspot status, our scheme uses conventional handover scheme. The simulation results show that our scheme generates smaller number of hotspot cells and supports higher service quality than in the compared schemes. It means that handover time control based on the amount of traffic load of cells can effectively and flexibly manage hotspot cells. And, through the hotspot cell management, the service quality can be improved.

REFERENCES

[1] N. Kim, H. Choi, and H. Yoon, "Seamless Handoff Scheme for 4G Mobile Systems based on IP and OFDM", *IEEE Vehicular Technology Conference 2004-Fall*, pp. 3315-3318, September 2004

[2] http://www.ieee802.org/16/tge

[3] http://www.ieee802.org/20

[4] J. Jobin, M. Faloutsos, S.K. Tripathi and S. V. Krishnamurthy, "Understanding the Effects of Hotspots in Wireless Cellular Networks", *The 23rd Conference of the IEEE Communications Society (INFOCOM 2004)*, pp. 660-671, March 2004

[5] D. Kim, N. Kim, and H. Yoon, "Adaptive Handoff Algorithms for Dynamic Traffic Load Distribution in 4G Mobile Networks", *IEEE The 7th International Conference On Advanced Communication Technology*, pp. 1269-1274, February 2005

[6] S. Das, S. Sen and R. Jayaram, "A dynamic Load Balancing Strategy for Channel Assignment Using Selective Borrowing in Cellular Mobile Environment", *Proceedings of IEEE/ACM Conference on Mobile Computing and Networking (Mobicom96)*, pp. 73-84, November 1996

[7] S. Das, S. Sen P. Agrawal and R. Jayaram, "A Distributed Load Balancing Algorithm for the Hot Cell Problem in Cellular Mobile Networks", *Proceedings of 6th IEEE International Symposium on High Performance Distributed Computing*, pp. 254-263, August 1997

[8] X.H. Chen, "Adaptive Traffic Load Shedding and Its Capacity Gain in CDMA Cellular Systems", *IEE Proceedings - Communications*, Vol. 142, Issue 3, pp. 186-192, June 1995

[9] H. Jeon, S. Hwang and S. Kwon, "A channel Assignment Scheme for Reducing Call Blocking Rate in a DS-CDMA Cellular System", *Proceedings of 6th IEEE International Conference on Personal Communication*, Vol. 2, pp. 637-641, October 1997

[10] P. Marichamy, S. Chakrabarti and S.L. Maskara, "Performance Evaluation of Handoff Detection Schemes", *IEEE Region 10 Conference on Convergent Technologies For The Asia-Pacific*, pp. 643-646, October 2003

[11] R. Verdone and A. Zanella, "Performance of Received Power and Traffic-Driven Handover Algorithms in Urban Cellular Networks", *IEEE Wireless Communications*, pp. 60-71, February 2002