In Proc. of IEEE International Conference on Communications (ICC 2005),Seoul, Korea,

An Adaptive Bandwidth Reservation Scheme for Multimedia Mobile Cellular Networks

Hong Bong Kim
Telecommunication Networks Group, Technical University of Berlin
Sekr FT5 Einsteinufer 25 10587 Berlin Germany
Email: hongbongkim@ieee.org

***Abstract*— In mobile cellular networks, limiting handover dropping probability within a prespecified target value is a very important quality of service issue because mobile hosts should be able to maintain ongoing sessions even during their handover from one cell to another. In this paper we propose and evaluate a simple distributed adaptive bandwidth reservation scheme and a connection admission test for multimedia mobile cellular networks that limit handover dropping probability to a prespecified target value. The proposed bandwidth reservation scheme depends on the number of handover successes and failures to adaptively control reserved bandwidth for handover, and the admission test is designed to reduce traffic overhead between cells. We evaluate the performance of the proposed scheme to show that it meets our design goal and outperforms the static reservation scheme under various scenarios.**

I. Introduction

In mobile cellular networks handover management has been one of the most important and challenging issues. It will become more significant in the near future since the current trends in cellular networks are 1) to reduce cell size to accommodate more mobile hosts (MHs) that will cause more frequent handovers, and 2) to support not only voice traffic but also data and multimedia traffic such as video. One of the issues is how to control (or reduce) handover drops due to lack of available bandwidth in the new cell, since MHs should be able to continue their ongoing sessions. Here, two connection-level quality of service (QoS) parameters are relevant: the probability (P_{CB}) of blocking new connection requests and the probability (P_{HD}) of dropping handovers. In ideal case, we would like to avoid handover drops so that ongoing connections may be preserved as in a QoS-guaranteed wired network. However, this is impossible in practice due to unpredictable fluctuations in handover traffic load.

Each cell can, instead, reserve fractional bandwidths of its capacity, and this reserved bandwidth can be used solely for handovers, not for new connection requests. The problem is then how much of bandwidth in each cell should be reserved for handovers. This concept of reserving bandwidth for handover was introduced in the mid-1980s [1]. In this scheme, a portion of bandwidth is permanently reserved in advance for handovers. Since then a lot of research efforts has been carried out for better schemes. Most existing bandwidth reservation schemes for handover assume that the handover connection arrivals are Poisson, and each connection requires an identical amount of bandwidth (e.g., voice call) with an exponentially distributed channel holding time in each cell [2]– [5]. But, it is known that the channel holding time of handed-over connections is not really exponentially distributed [6].

Recently, some schemes attempting to limit P_{HD} to a prespecified target value for multimedia mobile cellular networks have been proposed [7] [8]. A probabilistic prediction of user mobility has been proposed in [7] based on the idea that mobility prediction is synonymous with data compression. From the observation that a connection originated from a cell follows a specific sequence of cells, rather than a random sequence of cells, the scheme utilizes character compression technique to predict future mobility of MHs. In [8], a handover probability at some future time has been derived using the aggregate history of handovers observed in each cell. These algorithms depend on the mobility history of users for statistical prediction to guarantee that P_{HD} is maintained below a prespecified target probability (P_t). Thus, they need a large amount of history data for proper operation. For more information refer to [9] that reported a comparative study of some schemes. In this paper a simple distributed bandwidth reservation scheme that attempts to limit P_{HD} to P_t is proposed. In this scheme each base station (BS) counts the number of handover successes and failures to adaptively change the reserved bandwidth for handover, and it does not depend on a large amount of handover history data unlike the above two schemes. In addition, we propose an admission test for new connection requests that considers not only current cell status, but also status of its adjacent cells, so that it achieves fairness in terms of P_{CB} and P_{HD} as will be cleared later. It is also designed to reduce traffic for control messages exchanged between cells. As compared to the previous ones the proposed scheme is much simpler and easier to implement.

The paper is organized as follows. Section II describes system model, our proposed adaptive bandwidth reservation scheme and connection admission test. Performance evaluation is given in section III which is followed by a conclusion in section IV.

II. Proposed Scheme Description

A. System Model

A wireless network with cellular architecture that supports multimedia traffic such as voice and video is considered. Each cell is equipped with a BS that is connected to mobile switching center (MSC). It is assumed that BSs can exchange control information with one another through MSC or direct links connecting them. Each BS is assigned a fixed number of channels; that is, fixed channel assignment (FCA) is assumed. An MH, while staying in a cell, communicate with other party via the BS that controls the cell. When the MH moves from one cell to another access point must be changed, requiring handover. When a handover request arrives at a BS it is accepted if there is enough bandwidth to accommodate it; otherwise, it is dropped. Whereas a newly generated connection having bandwidth B_{new} is admitted only when an admission test is satisfied considering reserved bandwidth for handover. A simple admission test for a cell i is

$$B_U^i + B_{new} \leq C - B_H^i \qquad \textbf{(AT1)}$$

where B_U^i is the bandwidth being used in cell i by ongoing connections, C is the cell capacity and B_H^i is the reserved bandwidth for handover of cell i. Only when the above test is satisfied the new connection request is accepted. This is called **AT1** in this paper.

B. Adaptive Bandwidth Reservation Scheme

Our proposed scheme, called **AP**, that attempts to limit P_{HD} to a prespecified target handover dropping probability (P_t) is summarized in Fig. 1. When a handover request arrives the BS examines if there is available bandwidth or not. If it is dropped due to insufficient bandwidth, the BS must promptly respond to it by increasing the reserved bandwidth (B_H) for handover by one bandwidth unit (BU) (as an example, in TDMA (FDMA) system BU corresponds to a time slot (a frequency channel)). When the handover request is successful the number of successful requests (R_q) is increased by one. If R_q is greater than the inverse of (P_t), B_H is decreased by one BU and R_q is set to zero. So the algorithm simply says that given a P_t it counts the number of handover failures and successes such that P_{HD} is maintained below P_t. But this scheme may become unfair in terms of P_{CB}, P_{HD} and B_H when combined with admission test **AT1** with heavy traffic loads. The reason can be explained as follows. Suppose two adjacent cells A and B, and at some time instant handover traffic from cell B to cell A is dropped due to insufficient bandwidth in cell A. Then, cell A increases B_H to reduce its P_{HD}, which will suppress newly generated traffic in cell A. That, in turn, reduces handover traffic from cell A to cell B so that cell B could allow more new traffic. This will cause more handover traffic from cell B to cell A. The circulation continues until it reaches an equilibrium point. In an extreme case with heavy traffic, cell A will serve only handed-over traffic from cell B, while cell B will see few handed-over traffic from cell A. This explanation can be extended to a more general case with many cells. That is, with heavy traffic load some cells reject almost all new connection requests while serving only handed-over connections. On the other hand, the opposite occurs in others. This is an undesirable situation into which an adaptive bandwidth reservation schemes may fall unless they are carefully designed considering the above condition. This phenomenon was found in our scheme as well as in other scheme [8]. To solve the problem, another admission test has been proposed in [8] as follows.

```
Rq := 0; B_H := 0;
WHILE (time increases)
    IF (handover into the current cell happens) THEN
        examine available bandwidth in the cell;
        IF (handover request drops) THEN
            B_H := B_H + BU;
        ELSE
            Rq := Rq + 1;
            IF Rq > ⌈1/P_t⌉ THEN
                B_H := B_H − BU;
                Rq := 0;
            END IF
        END IF
        IF (B_H < 0) THEN B_H := 0; END IF
        IF (B_H > C) THEN B_H := C; END IF
    END IF
END WHILE
```

Fig. 1. Pseudo code of the proposed bandwidth reservation scheme for handover. R_q and B_H are initialized to zero from the beginning of the scheme. $\lceil x \rceil$ indicates the smallest integer greater than or equal to x.

C. Admission test

In this admission test for a cell i two conditions are checked out for a new connection request having bandwidth B_{new}. That is,

$$\begin{aligned} &(i) \quad B_U^i + B_{new} \leq C - B_H^i \\ &(ii) \quad B_U^j + B_H^j \leq C \\ &\qquad \text{for each adjacent cell } j \in A_i \end{aligned}$$

where A_i is the set of indices of adjacent cells of cell i. The first line that is the same as **AT1** examines if there is enough bandwidth for the request in the current cell, while the second line investigates whether the corresponding adjacent cell j is likely to be overloaded or not. Not satisfying the second condition suggests the possibility that the cell might be overloaded, so if the new connection request is accepted it will be likely to be dropped when it is handed over to the cell. Only when the two conditions are satisfied the new connection is accepted. Note that the second condition (ii) requires control messages to be exchanged between BSs whenever a new connection request that has passed the first condition (i) is made. This is costly as it will increase with traffic load. An equivalent way to implement the second condition (ii) is for each BS to broadcast its status to its adjacent BSs whenever the condition changes. That is, after start-up each BS monitors the amount of $B_U + B_H$ relative to C. It broadcasts status change to its adjacent cells only when the magnitude changes between the two terms. Then, a BS utilizes information broadcast by its adjacent cells for admission test.

```
broadcast UNDERLOAD to adjacent cells;
WHILE (time increases)
    WHILE (true)
        IF B_U + B_H > C + Th THEN
            broadcast OVERLOAD to adjacent cells;
            break; /* out of WHILE */
        END IF
    END WHILE
    WHILE (true)
        IF B_U + B_H <= C - Th THEN
            broadcast UNDERLOAD to adjacent cells;
            break; /* out of WHILE */
        END IF
    END WHILE
END WHILE
```

Fig. 2. Pseudo code for the condition (ii) of **AT2**, where Th is a threshold to reduce broadcast rate.

Although this procedure can reduce traffic between cells for the condition (ii), it is still expected that the BS frequently sends status information at high load. So, a parameter Th, called *threshold*, is introduced to further reduce status broadcast rate. Using Th the second condition is modified as summarized in Fig. 2. At first a BS monitors $B_U + B_H$ to see if it grows greater than $C + Th$ (called *"overload condition"*). If so, the BS broadcasts *OVERLOAD* message to its adjacent cells. Once it has broadcast *OVERLOAD* message, it continuously checks whether $B_U + B_H$ becomes less than or equal to $C - Th$ (called *"underload condition"*). Only when $B_U + B_H$ becomes below $C - Th$ the BS broadcasts *UNDERLOAD* message to its adjacent cells, and again the BS examines overload condition and so on. Note here that Th can be either fixed or variable. If it is too large, status change information will not be distributed in time which might cause performance degradation, whereas if it is too small the effect on reducing status broadcast rate will become small. In our simulation study we will see the effect of Th on system performance. Now, we propose an admission test for a cell i, called **AT2**, as follows:

(i) $B_U^i + B_{new} \le C - B_H^i$ **(AT2)**

(ii) All adjacent cells of cell i are in underload condition.

III. Performance Evaluation

In this section a simulation study for the proposed adaptive bandwidth reservation scheme and admission test is described. Fixed bandwidth assignment scheme for handover, referred to as **FA**, is compared with our proposed adaptive scheme **AP**. This **FA** scheme utilizes **AT1** as admission test and 10 % the cell capacity is allocated for B_H.

A. Simulation Assumptions and Parameters

We consider two different simulation environments: one-dimensional and two-dimensional cases. The former represents a typical highway environment, while the latter denotes a metropolitan downtown area. Moreover, only mobile users are considered. For the one-dimensional environment, MHs travel along a straight road. The following assumptions are made for this model:

A1) The system is composed of ten square-shaped cells, numbered from 1 to 10, with wraparound to avoid edge effect. One side of each cell is 1 km.
A2) Connection requests are generated according to a Poisson process with rate λ (connections/second/cell) in each cell. A newly generated connection can appear anywhere in the cell with an equal probability.
A3) A connection is either for voice (requiring 1 BU) or for video (requiring 4 BU) with probabilities R_v and $1-R_v$, respectively, where the voice ratio $R_v \le 1$.
A4) An MH can travel in either of two directions with an equal probability with a speed chosen at random between 80 and 120 (km/h). Each MH will run straight through the road with the chosen speed and never turn around.
A5) Each connection's life time is exponentially distributed with mean 120 seconds.
A6) Each cell has a fixed channel capacity (C) of 100 BUs.

For the two-dimensional environment, the roads are arranged in a 5×5 mesh shape, and a BS is located at each intersection of two crossing roads (Fig. 3). We make the following assumptions for this two-dimensional environment.

B1) The cellular system is composed of 25 cells with wraparound to avoid edge effect, and each cell's diameter is 300 m.
B2) MHs can travel in either of two directions along a road with an equal probability at a speed chosen at random between 40 and 60 (km/h).
B3) At the intersection of two roads, an MH might continue to go straight, or turn left, right, or around with probabilities 0.55, 0.2, 0.2, and 0.05, respectively.
B4) If an MH chooses to go straight or turn right at the center of a cell, it might need to stop there with probability 0.5 for a random time between 0 and 30 seconds due to a red traffic sign.
B5) If an MH chooses to turn left or around, it needs to stop there for a random time between 0 and 60 seconds due to the traffic signal.
B6) The cell capacity C is 50 BUs.
B7) The assumptions A2, A3, A5 above are also made.

For a measure of traffic we use the *offered load* (L) per cell which is defined as connection generation rate $\times$ connections' bandwidth $\times$ average connection life time. That is, L is represented by

$$L = \lambda \cdot (1 \cdot R_v + 4 \cdot (1 - R_v)) \cdot 120 \qquad (1)$$

with the assumptions described above. The physical meaning of the offered load per cell is the total bandwidth required on the average to support all the existing connections in a cell.

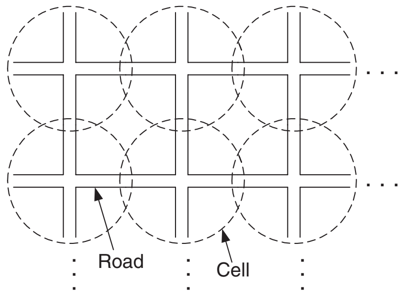

Fig. 3. Two-dimensional Model.

TABLE I

STATUS IN EACH CELL AFTER A SIMULATION RUN FOR ONE-DIMENSIONAL MODEL WHEN OFFERED LOAD IS 200, R_v IS 0.5 AND P_t IS 0.01. (A),(B) AND (C) ARE THE RESULTS WHEN OUR SCHEME **AP** IS COMBINED WITH **AT1**, **AT2**($Th = 0$), AND **AT2**($Th = 0.5 \cdot B_H$), RESPECTIVELY.

Cell	P_{CB}	P_{HD}	B_U	B_H
1	1.00e+0	1.89e-2	79.7	98.4
2	1.58e-1	9.90e-3	80.2	8.5
3	1.00e+0	1.87e-2	79.0	98.1
4	1.52e-1	9.89e-3	82.8	8.1
5	1.00e+0	1.87e-2	67.6	97.8
6	3.11e-1	9.85e-3	84.5	12.8
7	3.40e-1	1.00e-2	78.2	13.9
8	1.00e+0	1.76e-2	57.7	97.7
9	3.29e-1	9.89e-3	76.8	13.3
10	3.31e-1	9.91e-3	71.4	13.5
average	5.62e-1	1.33e-2	75.8	46.2

(a)

Cell	P_{CB}	P_{HD}	B_U	B_H
1	5.50e-1	9.89e-3	76.5	12.3
2	5.62e-1	9.91e-3	85.9	12.4
3	5.77e-1	9.89e-3	78.1	13.4
4	5.82e-1	9.91e-3	73.5	13.0
5	5.63e-1	9.89e-3	80.6	12.7
6	5.53e-1	9.90e-3	77.9	12.1
7	5.63e-1	9.90e-3	78.9	12.6
8	5.81e-1	9.89e-3	83.7	13.1
9	5.85e-1	9.89e-3	80.7	13.4
10	5.63e-1	9.89e-3	83.3	12.6
average	5.68e-1	9.90e-3	79.9	12.8

(b)

Cell	P_{CB}	P_{HD}	B_U	B_H
1	5.68e-1	9.88e-3	70.9	13.1
2	5.62e-1	9.92e-3	78.7	13.9
3	5.72e-1	9.91e-3	64.3	13.8
4	5.71e-1	9.89e-3	85.5	14.0
5	5.74e-1	9.91e-3	72.5	13.6
6	5.59e-1	9.92e-3	87.4	14.0
7	5.79e-1	9.89e-3	86.4	13.2
8	5.73e-1	9.88e-3	82.5	14.6
9	5.90e-1	9.90e-3	85.2	13.5
10	5.63e-1	9.92e-3	71.7	14.2
average	5.71e-1	9.90e-3	78.5	13.8

(c)

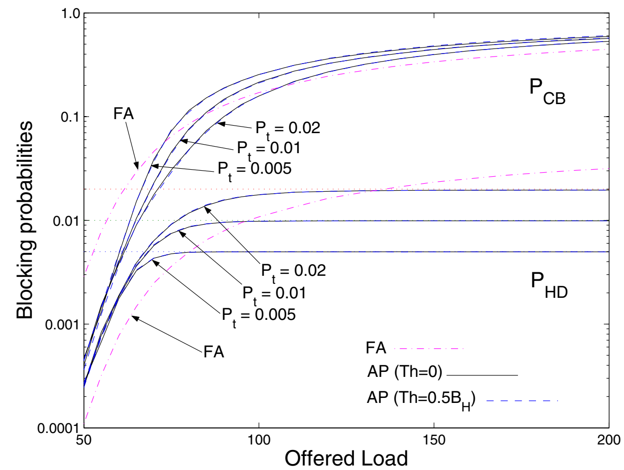

Fig. 4. P_{CB} and P_{HD} vs. offered load for the one-dimensional model when $R_v = 0.5$.

B. Numerical Results

The influence of admission test on the proposed reservation scheme **AP** for the one-dimensional model is shown in Table I, which represents P_{CB}, P_{HD}, B_U and B_H after a simulation run when offered load is 200, R_v is 0.5, and P_t is 0.01. Table I (a), (b) and (c) indicate results when **AP** is combined with **AT1**, **AT2** with $Th = 0$ and **AT2** with $Th = 0.5B_H$, respectively. As described in subsection II-B, unfair results are observed in terms of P_{CB}, P_{HD}, and B_H in (a) (e.g., see cells 1,3,5,8) although average values of them look acceptable (we have also found the similar unfair results in the two-dimensional model, which is omitted for brevity). It suggests that the second condition (ii) of **AT2** plays a significant role for proper operation of the proposed scheme at high traffic load. It should be emphasized that when we consider an adaptive bandwidth reservation scheme for handover careful attention must be paid to fairness in terms of P_{CB}, P_{HD}, and B_H. In combination with admission test **AT2** our proposed scheme shows fair results in terms of P_{CB}, P_{HD} and B_H as indicated in Table (b) and (c). They show that performance is slightly better when $Th = 0$ than when $Th = 0.5B_H$ in terms of P_{CB}, B_U and B_H. In the following results **AP** is assumed to be combined with **AT2**.

We will first see simulation results for the one-dimension model in the following figures. Fig. 4 shows blocking probabilities (P_{CB}, P_{HD}) versus offered load for three different target values (P_t =0.005,0.01,0.02) and $R_v = 0.5$. 10 BU is reserved for B_H in **FA** that corresponds to 10 % the cell capacity. It is observed that in **AP** P_{HD} is always less than or equal to P_t independent of traffic load, while in **FA** P_{CB} and P_{HD} increase with traffic load. In addition, there is no distinguishable performance difference between the cases when $Th = 0$ and when $Th = 0.5B_H$. The figure also indicates that when P_t is smaller it is necessary to reserve more bandwidth for handover, resulting in larger P_{CB}.

The corresponding bandwidth usage of the above figure is shown in Fig. 5. The amount of used bandwidth (B_U)

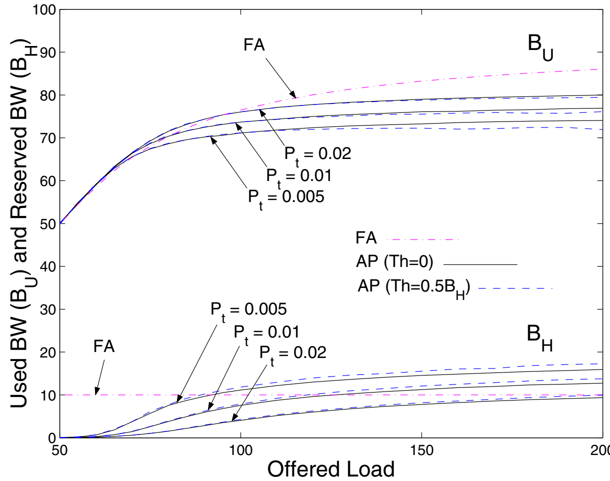

Fig. 5. B_U and B_H vs. offered load for the one-dimensional model when $R_v = 0.5$.

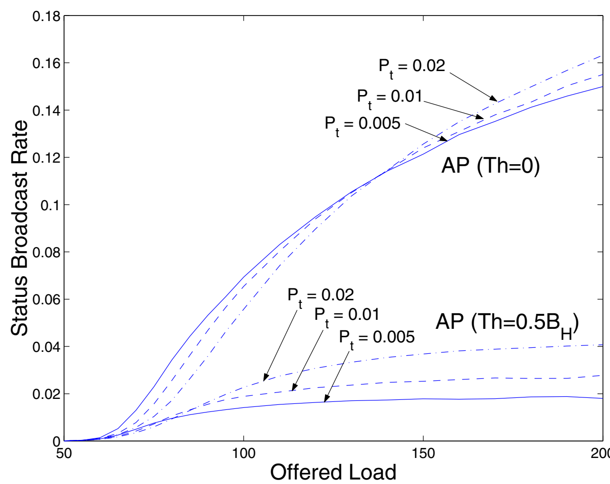

Fig. 6. Status broadcast rate of **AP** for the one-dimensional model when R_v is 0.5.

of **FA** grows with traffic load at a cost of higher P_{HD}. Though bandwidth is used more efficiently when $Th = 0$ than when $Th = 0.5$ we see there is no noticeable difference between them. The more the traffic load and the less the target probability, the more difference between them. The figure also indicates that smaller target probability requires higher bandwidth to be reserved for handover, which, in turn, leads to smaller B_U. As can be expected, it means there is a trade-off between handover quality and bandwidth usage.

The average status broadcast rate (times/seconds) per cell for **AP** is shown in Fig. 6. When $Th = 0$ broadcast rate increases rapidly with traffic load while when $Th = 0.5B_H$ it grows slowly. Great reduction is seen in broadcast rate, indicating that the introduction of Th in **AT2** is effective in reducing traffic overhead between cells. It also represents that when P_t is smaller status broadcast rate becomes smaller as traffic load grows since smaller P_t results in higher B_H, which again leads to higher Th.

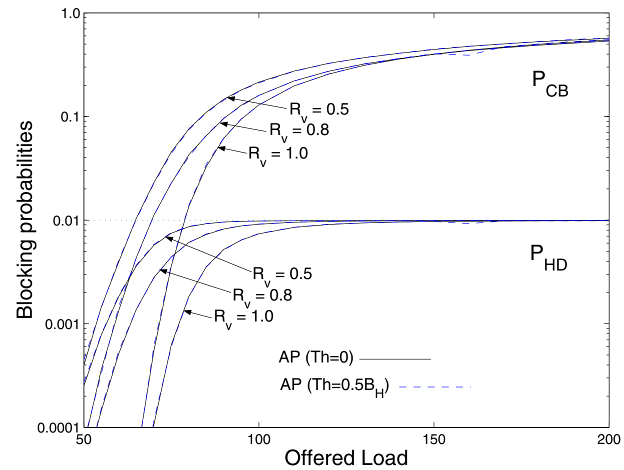

Fig. 7. Influence of the voice ratio (R_v) on P_{CB} and P_{HD} for the one-dimensional model when P_t is 0.01.

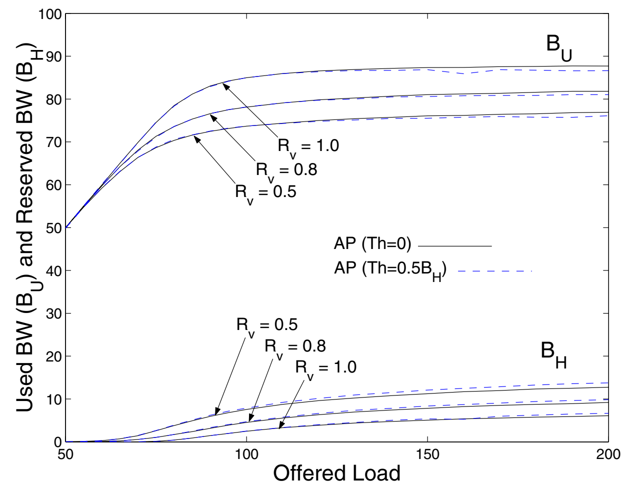

Fig. 8. Influence of the voice ratio (R_v) on B_U and B_H for the one-dimensional model when P_t is 0.01.

The impact of the voice ratio (R_v) on blocking probabilities is shown in Fig. 7 when P_t is 0.01. It depicts also our scheme works well in the sense that P_{HD} is limited below the target value (0.01) irrespective of the voice ratio and traffic load. Moreover, a threshold of $0.5B_H$ does not have a great influence on P_{CB}, P_{HD}. As the traffic tends to be more homogeneous (i.e., R_v comes close to 1.0) P_{CB} and P_{HD} becomes smaller. The voice ratio also has an effect on bandwidth utilization, showing smaller R_v leads to higher B_U and smaller B_H as shown in Fig. 8. Although we consider only two types of connection in this study the figure suggests this heterogeneity in traffic might have a great impact on bandwidth usage in our scheme. A tremendous decrease in status broadcast rate is observed with $Th = 0.5B_H$ as shown in Fig. 9. Since when R_v is 1.0 more connections are active at high load than when R_v is smaller than 1.0, status broadcast rate is increased with R_v.

The influence of threshold on blocking probabilities is de-

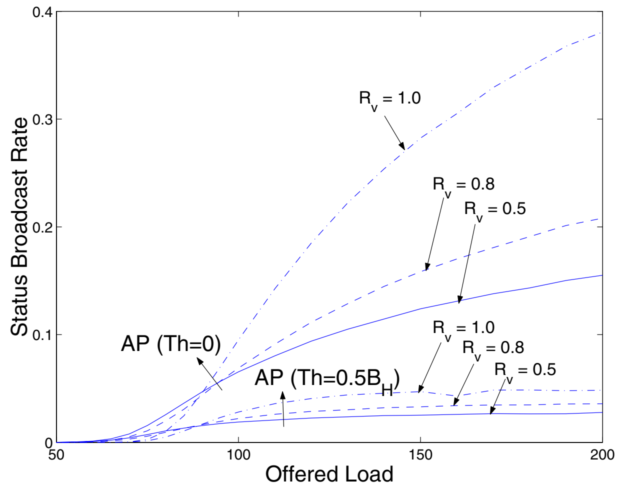

Fig. 9. Status broadcast rate vs. offered load with different R_v for the one-dimensional model when P_t is 0.01.

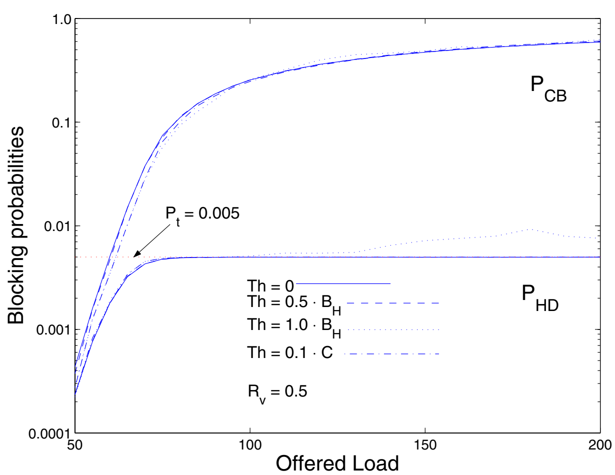

Fig. 10. Influence of Th on P_{CB} and P_{HD} for the one-dimensional model when $R_v = 0.5$ and $P_t = 0.005$.

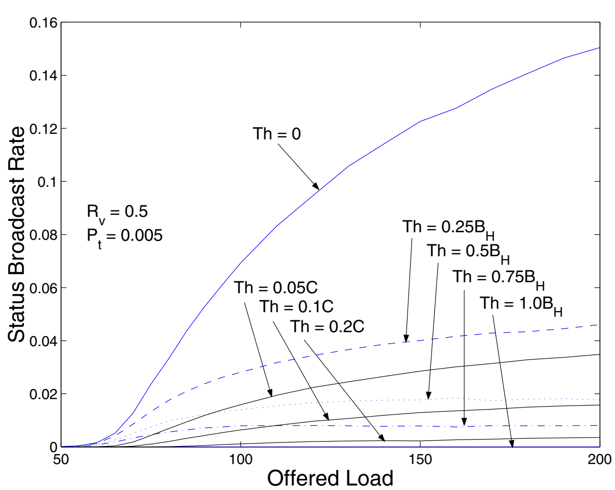

Fig. 11. Status broadcast rate vs. offered load with different threshold for the one-dimensional model when $R_v = 0.5$ and $P_t = 0.005$.

picted in Fig. 10 with $R_v = 0.5$ and $P_t = 0.005$ for which four thresholds are considered $(Th = 0, 0.5B_H, 1.0B_H, 0.1C)$. Note that two of them are variable $(Th = 0.5B_H, 1.0B_H)$, while the other two fixed $(Th = 0, 0.1C)$. As shown in the figure when $Th = 1.0B_H$ the scheme **AP** does not limit P_{HD} to P_t no longer with high traffic load. In this case, since Th is too high no status broadcast, as specified in Fig. 2, between BSs occurs (see Fig. 11). In other words, a high Th can bring about a failure of information distribution for the second condition of **AT2**. In such case, **AT2** becomes **AT1**, leading to improper operation with high traffic load as we have seen in Table I. It means that a careful attention must be paid in choosing Th value so that it may not prevent BSs from exchanging control traffic between them. For example, when $Th = x \cdot B_H$ (where x is a constant) is employed, if B_H is large Th becomes large proportionally, which may keep BSs from exchanging control information, resulting in improper operation. This might occur, for instance, when P_t is small so that a large B_H is required at high traffic load. Fig. 11 represents status broadcast rate versus offer load for various threshold values. It also depicts that even with small Th (e.g., $0.05C$ or $0.25B_H$) a great decrease in the broadcast rate can be accomplished. From our simulation study we have found that the proposed scheme works well in most cases either when Th ranges between $0.1B_H$ and $0.5B_H$ for variable case or when it is set to 5∼10 % the cell capacity for fixed case, and performance difference in terms of blocking probabilities and bandwidth usage is very small.

The figures we have seen so far for the one-dimensional case show that the proposed scheme **AP** along with the admission test **AT2** performs well in limiting P_{HD} to a prespecified target value irrespective of offered load and the voice ratio; moreover, it is efficient in utilizing bandwidth and reducing traffic exchanged between BSs at a cost of small bandwidth.

Now we turn our attention to the two-dimensional model. In this model, the number of adjacent cells is twice as many as the one-dimensional case. Blocking probabilities, bandwidth usage, and status broadcast rate for three target values (P_t =0.005,0.01,0.02) and $R_v = 0.5$ are shown in Fig. 12, 13, and 14, respectively. Almost the same interpretations as the one-dimensional case are true for this model. From Fig. 12 we see again that P_{HD} is maintained less than or equal to P_t regardless of traffic load in **AP**, while P_{CB} and P_{HD} increase with traffic load in **FA**. And there is no noticeable performance difference between the two cases when $Th = 0$ and when $Th = 0.5B_H$. Fig. 13 represents the corresponding bandwidth utilization of the above figure. Compared to the one-dimensional case, it is less efficient in bandwidth utilization since more B_H is required. Fig. 14 shows a great reduction in the status broadcast rate with $Th = 0.5B_H$. The results about the impact of R_v and Th are omitted for short of space, but they follow the same tendency as the one-dimensional case.

In summary, the simulation results presented in this section show that our scheme can provide an efficient way to manage handover quality in multimedia mobile cellular networks, while reducing control traffic for handover between BSs at

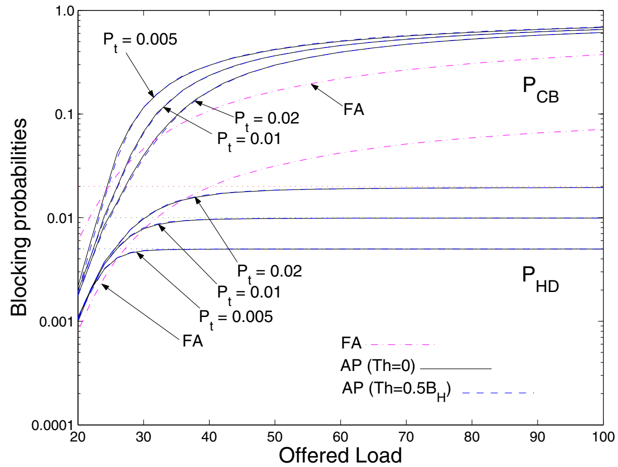

Fig. 12. P_{CB} and P_{HD} vs. offered load for the two-dimensional model when R_v is 0.5.

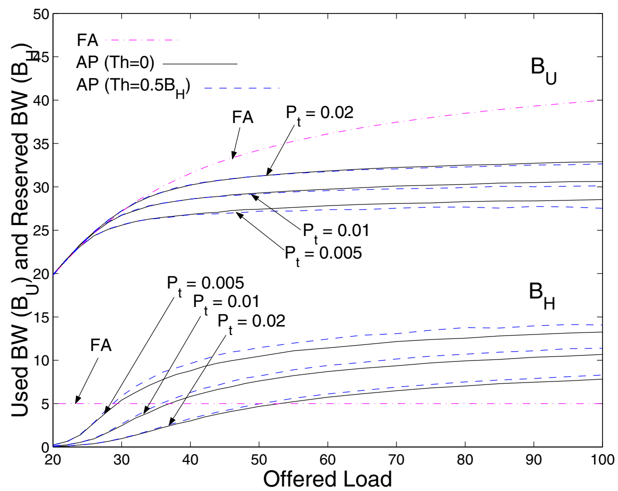

Fig. 13. B_U and B_H vs. offered load for the two-dimensional model when R_v is 0.5.

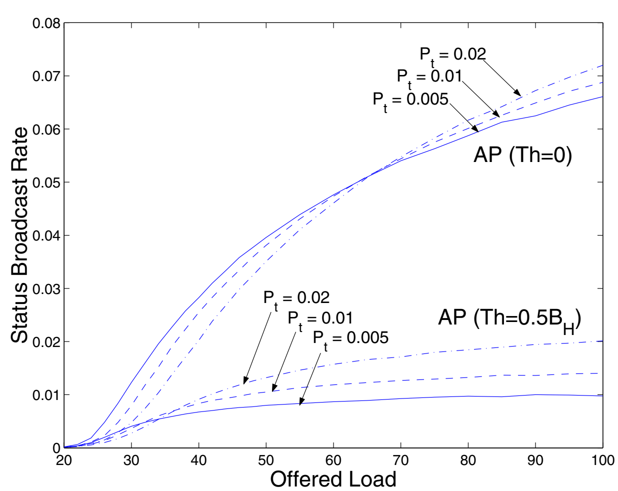

Fig. 14. Status broadcast rate of **AP** for the two-dimensional model when R_v is 0.5.

a cost of small bandwidth.

IV. Conclusion

Handover dropping probability (P_{HD}) is one of the most important quality of service indices in mobile cellular networks. Since it is impossible to guarantee zero P_{HD} due to unpredictable fluctuations in data traffic best alternative is to limit P_{HD} to a prespecified target value regardless of traffic load. In this paper a simple distributed adaptive bandwidth reservation scheme and a connection admission test for multimedia mobile cellular networks have been proposed. As compared to previously proposed schemes it is much simpler and easier to implement since it is not based on a large amount of handover history of mobile hosts; instead, it depends only on the number of handover successes and failures to adaptively control the reserved bandwidth for handover. Furthermore, the proposed connection admission test is designed to reduce control traffic between BSs that is necessary for handover management. It was shown by a simulation study that the proposed scheme performs well in limiting P_{HD} to a prespecified target value regardless of traffic load, while achieving efficient bandwidth usage and reducing traffic overhead between BSs at a cost of small bandwidth. As a result, the proposed scheme can efficiently be utilized for handover management in multimedia mobile cellular networks.

References

[1] D. Hong and S. S. Rappaport, "Traffic Model and Performance Analysis for Cellular Mobile Radio Telephone Systems with Priotized and Nonpriotized Procedures," *IEEE Trans. Veh. Technol.*, vol. 35, no. 3, pp. 77–92, Aug. 1986.

[2] E. Del Re, R. Fantacci, and G. Giambene, "Handover and Dynamic Channel Allocation Techniques in Mobile Cellular Networks," *IEEE Trans. Veh. Technol.*, vol. 44, no. 2, pp. 229–237, May 1995.

[3] R. Ramjee, R. Nagarajan and D. Towsley, "On Optimal Call Admission Control in Cellular Networks," in *Proc. IEEE Infocom 1996*, vol. 1, pp. 43–50, Mar. 1999.

[4] X. Luo, I. Thng, and W. Zhuang, "A Dynamic Channel Pre-reservation Scheme for Handoffs with GoS Guarantee in Mobile Networks," in *Proc. IEEE Intern. Symposium on Computers and Communications*, pp. 404–408, 1999.

[5] L. Ortigoza-Guerrero, and A. H. Aghvami, "A Prioritized Handoff Dynamic Channal Allocation Strategy for PCS," *IEEE Trans. Veh. Technol.*, vol. 48, no. 4, pp. 1203–1215, Jul. 1999.

[6] C. Jedrzycki and V. C.M. Leung, "Probability Distribution of Channel Holding Time in Cellular Telephony Systems," in *Proc. IEEE Veh. Technol. Conf.*, Atlanta, GA, vol.1, pp. 247–251, 1996.

[7] F. Yu and C. M. Leung, "Mobility-Based Predictive Call Admission Control and Bandwidth Reservation in Wireless Cellular Networks," in *Proc. IEEE Infocom 2001*, pp. 518–526, 2001.

[8] S. Choi and K. G. Shin, "Adaptive Bandwidth Reservation and Admission Control in QoS-Sensitive Cellular Networks," *IEEE Trans. Parallel and Distributed Sys.*, vol. 13, no. 9, pp. 882–897, Sep. 2002.

[9] S. Choi and K. G. Shin, "A comparative study of bandwidth reservation and admission control schemes in QoS-sensitive cellular networks," *ACM Wireless Networks*, vol. 6, no. 4. pp. 289–305, 2000.