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Resource Allocation and Handoff for Mobile Multimedia Service

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모바일 멀티미디어 서비스를 위한 자원 할당 및 핸드오프

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Abstract This paper proposes a scheme to maximize traffic capacity for supporting mobile multimedia services. For a handoff session, we suggest a novel resource reservation scheme to adjust the number of reserved resources in macrocell, depending on the number of saturated microcells. The proposed schemes are able to accommodate much more mobile sessions in the microcell and significantly reduce the blocking probability in the macrocell at the expense of the small increment of a forced termination in the microcell. Therefore, our system is more flexible to the increase of traffic in macrocell.

요 약 본 논문은 모바일 멀티미디어 서비스를 지원하기 위하여 트랙픽 수용 용량을 극대화하기 위한 방법을 제시한다. 핸드오프 세션을 위하여, 연관된 마이크로 셀들의 수에 따라서 매크로셀의 예약 자원의 수를 동적으로 조정하는 새로운 자원 예약 방법을 제안한다. 제안된 기법은 마이크로셀에서 서비스 가능한 세션의 수를 증가시킬 수 있으며 블록킹율을 현저히 줄일 수 있었다. 따라서 제안된 시스템은 매크로셀에서 세션의 수가 증가할수록 성능이 최적화 된다.

Key Words : Reserved Resource, Handoff, Resource Reservation, Mobile Multimedia Service

1. Introduction

The demand for mobile radio services has just exploded and the most obvious way of improving the spectrum efficiency of high traffic density area is to limit the radio coverage from base stations (BS) so that resources would be reused several times within a particular area. This fact leads the system to be laid out with microcells [1,2]. However the disadvantage is excessive if the entire service area may be covered with microcells only. On the other hand macrocells are suitable for lightly loaded areas such as rural areas. A macrocell structure offers the lowest cost because even a large coverage area may be covered with a few cells. To utilize advantages of both cell structures, the service area should contain both microcells and macrocells [3,4].

In a hierarchically overlaid system, resources in a higher-layer, called macrocell serve as a sharing resource pool for a lower layer, called microcell. Thanks to this resource pool in macrocell, overflow sessions from a saturated microcell can be served. Hence the overlaid architecture can efficiently accommodate traffic fluctuations and it is easy to implement. However, Dynamic Channel Allocation (DCA) and Hybrid Channel Allocation (HCA) require Carrier-to-Interference Ratio (CIR) estimation. Under high-teletraffic load, it is difficult to maintain the minimum co-channel reuse distance.

Handoff is a significantly important aspect for a seamless service in the B3G environment that should accommodate frequent moves throughout the

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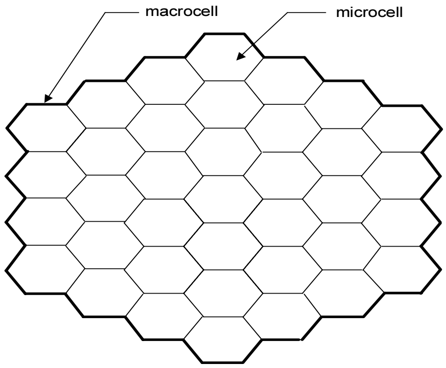
microcell/macrocell system. In systems where the cell size is relatively small, handoff can be made more often. Since handoff usually requires a couple of procedures such as a release of a resource, a new resource acquisition and re-routing, the duplication and loss of packets could happen. The handoff procedure has an important effect on the performance of the system. Hence, an important issue is to limit the probability of forced termination because forced termination of an ongoing session is less desirable than blocking a new session attempt from the point of view of a mobile user. To reduce forced termination of a session in progress, handoff sessions are normally given priority access to resources in both microcell and macrocell. In our system, resources are reserved in macrocell explicitly for unsuccessful handoff sessions at the subordinate microcell[5-7].

In this paper, we propose a new scheme that manages a whole life of a session from the beginning to the end by modeling the procedure of an initial session, a handoff procedure to another cell, and an overflow session from microcell to macrocell when the handoff fails.

2. System Model

The overlay system in general, has two types of BS with different transmit power levels. One is a macrocell base station (MaBS), the other is a microcell BS (MiBS). A mobile would choose either MaBSs or MiBSs and its appropriate transmit power level according to its speed. A slow moving user (e.g. pedestrians) would access a MiBS with the low transmit power level while a fast moving user (e.g. people in car) would access a BS with the high transmit power level. [Fig. 1] shows such an arrangement, where a macrocell is the union of a number of microcells. Thus, mobiles at low speed undergo handoff when crossing microcells boundaries, while mobiles at high speed undergo handoff only when crossing macrocell boundaries. This approach keeps the rate of handoff at acceptable levels for both kinds of users. A homogeneous microcell/macrocell overlay pattern may be assumed where, for some n, every macrocell overlays N = 3n2-3n+1 microcells (in Fig.1, n=4).



[Fig. 1] Microcell/macrocell system

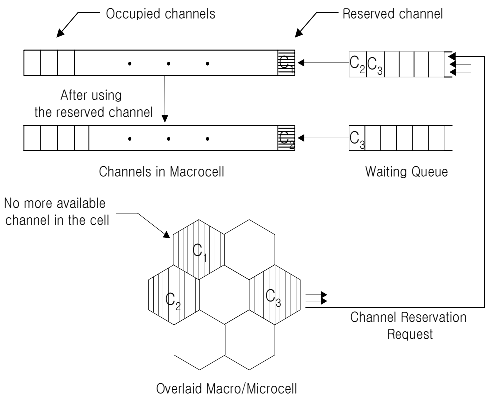
It may be considered as a one way to integrate macrocell/microcell so that several microcells' BSs in the coverage of a macrocell are connected to the BS in a macrocell by wired lines like the optical fiber. The topology of a macrocell/ microcell may be either a star that each microcell is directly connected to a common central macrocell or a ring that each microcell is connected each other by point-to-point links in a closed loop.

3. ACR SCHEME

If several resources are in advance reserved for handoff sessions in the macrocell to reduce the forced termination probability of sessions in progress, a new session attempt on a macrocell may be blocked even if there are unused reserved resources. This scheme effectively reduces the forced termination probability of handoff sessions in microcells, but may significantly increase the blocking probability of new session attempts in a macrocell.

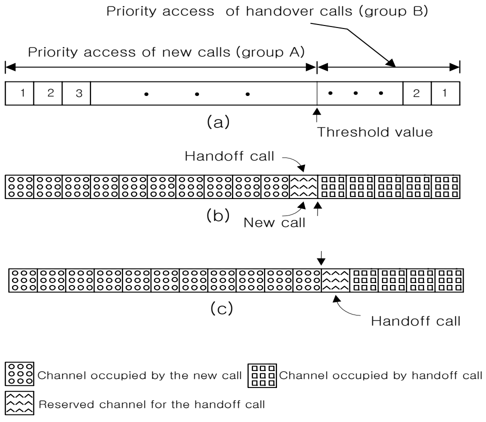
To overcome above problem, a new scheme is proposed which dynamically reserves the resources of macrocell according to the number of microcells in which there is no free resource. This is based on the fact that the number of sessions requiring handoff is proportional to the number of microcells in which there is no free resource. This scheme is called Adaptive Channel Reservation (ACR). In this scheme, the MiBS in which there is no free resource sends a signal to its overlaid macrocell, indicating that the microcell has no free resource left. If there have already been previous requests, this request will be queued. When a handoff fails, the session is overflowed to macrocell and occupies a reserved resource and then a new resource is again reserved by a queued request.

Fig. 2 describes the procedure of resource reservation in ACR scheme. Among the overlaid microcells, C1 first generates a resource reservation request which makes macrocell reserve one resource for C1 (Reserved resource number 1). After that, the overlaid cell C2 and C3 also issue requests. These requests however, will be queued in the macrocell waiting queue. Once the reserved resource by C1 is used for C1, a new resource will be reserved again for the request by C2 in the waiting queue. That is, if resource is reserved by the firstly arrived request, a following request will be kept in queue. The main purpose in this scheme is that we delay the time to reserve resources as could as possible so that more chances can be given to new sessions which is generated in the macrocell.



[Fig. 2] Resource reservation mechanism

Fig. 3(a) shows the resource management structure of the macrocell. The resources of the macrocell are divided into two groups: group A is the set of resources which have priority to new sessions and group B is the set of resources which have priority to handoff sessions. [Fig. 3(b)] shows that reserved resources belonging to group A can serve both handoff sessions and new sessions. resources belonging to group B which are not reserved can serve new sessions. However, if the resource is reserved exclusively for handoffs it can not serve new sessions (see [Fig. 3(c)]).



[Fig. 3] Resource management

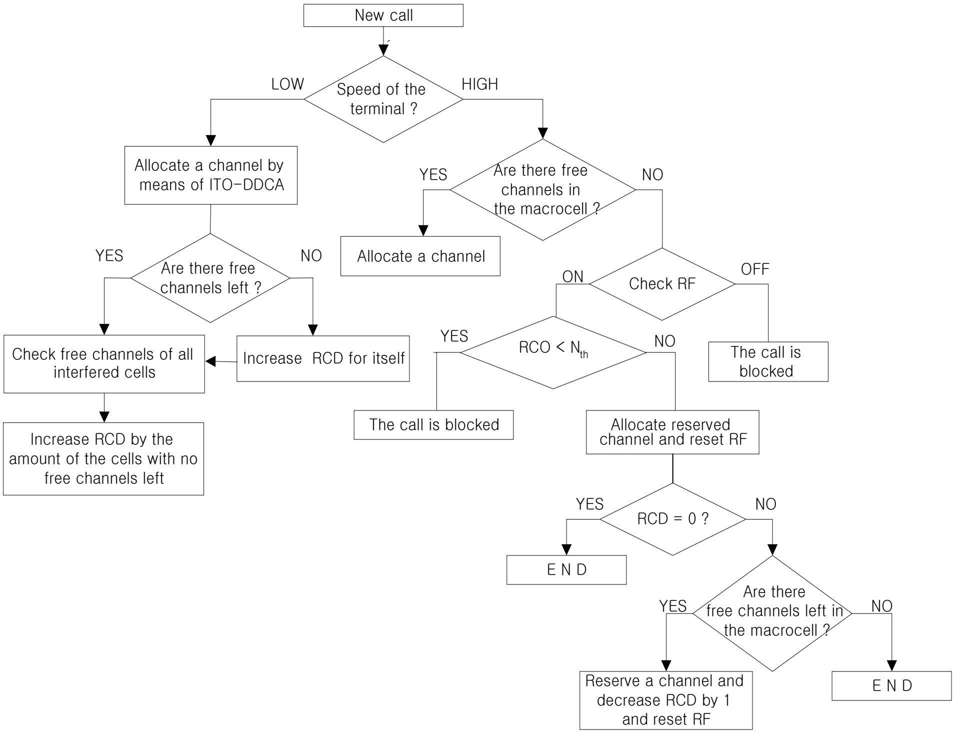
3.1 ACR algorithm for the new session

The proposed algorithm distinguishes sessions by its mobile speed. A session originated from a slow moving user gets access to the microcell. If there are no available resources left after allocating a resource to the session, resource Reservation Request message is sent to the macrocell. In the meantime, A fast moving user's session gets access to the macrocell, but if free resources run out, the system compares RCO with the threshold value(N_{th}). If RCO is greater than N_{th}(there served resource is belonging to group A), then there served resource may be used for the new session.

The system must find out adjacent cells in which have no more available resources left due to resource interference by means of checking the available resource set of the adjacent cells, in order to reserve a resource in macrocell in advance for a possible overflow from the microcell. The parameters used in algorithm are described as follows.

- RF (Reservation Flag): indicates whether there are reserved resources at the macrocell.
- RCO (Reserved channel Occupancy): indicates the number of resources occupied by handoff sessions at the macrocell.
- RCD (Reservation Channel Demand): indicates the number of microcells which want to reserve a resource of the macrocell. That is, the number of waiting requests in the queue in the macrocell

The proposed algorithm for the new session is



[Fig. 4] Flowchart for ACR scheme for a new session

described as the following. The brief flowchart of the scheme is shown in [Fig. 4]

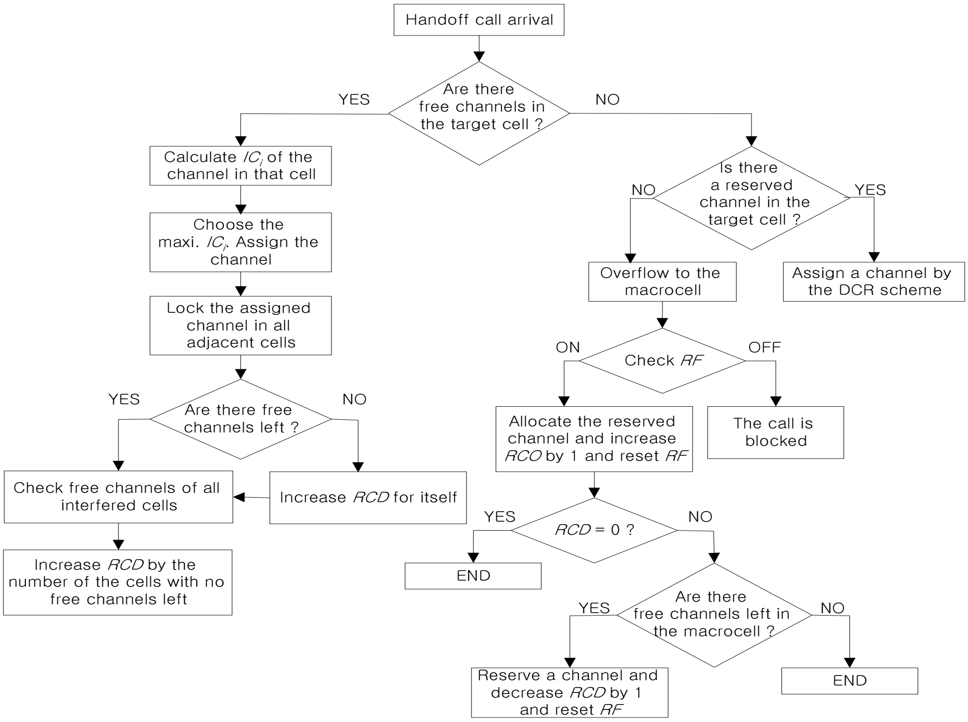
1. When a new session arrives, check the speed of mobile. If the speed is low, go to step 2. If the speed is high, then go to step 5.
2. Allocate a resource selected by the ITO-DDCA scheme.
3. Check the *set of free resources* (FCS_i). If FCSi is empty, increase RCD.
4. Check the *set of free resources of all interfered cells* ($IFCS_i$). Increase RCD by the amount of cell(s) which have no free resources left, and stop.
5. Check the *set of free resources of macrocell* (K_0FCS_i). If K_0FCS_i is available, the first free resource is allocated and stop. Otherwise check RF. If RF is on, go to step 6, otherwise the session is blocked.
6. If RCO is greater than N_{th} then allocate the reserved resource, reset RF and go to step 7. Otherwise the session is blocked.

"RCO > N_{th}" says that the number of reserved resources occupied by the handoffs is greater than N_{th}. It means that the currently reserved resource must be belonging to group A. So the resource can be allocated to a new session. On the other hands, if the RCO is not greater than the variable N_{th}, then the reserved resource must be belonging to group B, so the resource can not be assigned to a new session.

3.2 ACR algorithm for the handoff session

The proposed algorithm for the handoff session is described as the following. The brief flowchart of the scheme is shown in Fig. 5.

1. A handoff takes place in a microcell K_i. Check the *set of free resources of target microcell* ($TFCS_i$). If $TFCS_i$ is available, go to step 2, otherwise go to step 5.
2. Allocate a resource by means of ITO-DDCA scheme except borrowing a resource from neighboring cells.
3. Check the *set of free channels* (*FCSi*) of the microcell. If FCS_i is empty, increase RCD.



[Fig. 5] Flowchart for ACR scheme for the handoff session

4. Check the *set of free resources of all interfered cells* (*$IFCS_i$*). Increase RCD by the number of cells which have no free resources left, and stop.
5. Check the set of reserved resources in the target cell. If there are reserved resources, assign a resource by means of DCR scheme and stop. Otherwise, the session overflows to an overlaid macrocell.
6. Check RF. If it is ON then allocate the reserved resource and increase RCO and reset RF. Otherwise, the session is blocked.
7. Check RCD, if it is equal to zero, then the procedure is over. Otherwise, check if there are free resources left in the macrocell. If none of free resource is available, then the procedure is over. Otherwise, reserve a resource and decrease RCD and reset RF.

4. Performance Analysis

The performance of the proposed scheme is examined by computer simulation using C language. By means of computer simulation, system performance creteria such as the blocking probability (P_b, the probability that a new session is blocked), and the forced termination probability (P_f, the probability that a handoff session is blocked) have been used to analyze and evaluate the performance of various resource allocation and handoff schemes.

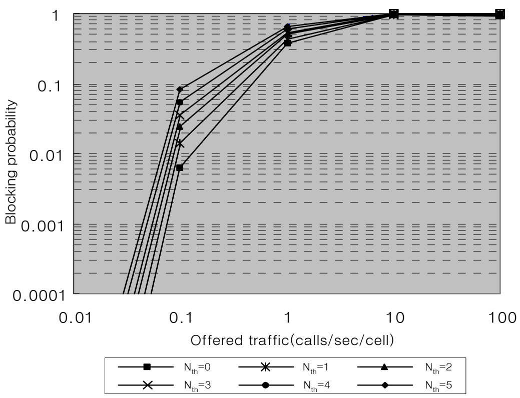
The simulation is continued until the number of sessions goes up to 100,000. The sessions in a cell consist of new sessions and handoff sessions, which are trying to access a control resource to request some wireless bandwidth. If it succeeds, the reservation information is sent and the corresponding bandwidth is allocated. In our simulation, a procedure to access the control resource is not considered, but a procedure to access to the corresponding bandwidth is examined. In the following, the performance parameters for the simulation are listed.

- The radius of a hexagonal microcell is 150 m.
- A single macrocell is overlaid with 37 microcells.
- A session arrival rate and a handoff arrival rate follow Poisson distribution.
- A session duration time and resource holding time

follow exponential distribution.

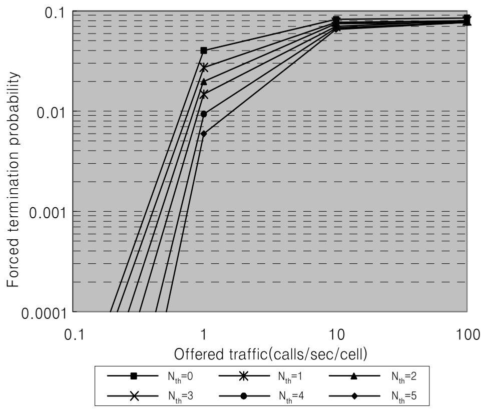
- It is assumed that mobile users can move about randomly at first, but once a direction of vehicle is determined, the direction and the speed of the mobile will not change within a single cell.
- When crossing a boarder of a cell, its direction and speed may be changed.
- The maximum ratio of reserved resources over the total resources is denote as Φ.
- A number of resources are reserved exclusively for handoffs. The remaining resources (c-Φ) can be shared between handoffs and new sessions, but the handoff sessions have higher priority than new sessions.
- The new session arrival ratio from slow moving users is Rf, and the new session arrival ratio from fast moving users is 1- R_f

It is very important to reduce the blocking of a handoff session in a personal communication system. However, as the blocking probability of a handoff session becomes lower, that of a new session becomes inherently higher. Therefore, this paper is focused on the overall system utilization. The simulation is done to verify the proposed algorithms. Two cases are considered to evaluate our proposed algorithms: one case with no reserved resource (NPS), and the other case with specific amount of reserved resources (N_{th} = 1 to 5). In addition, we evaluate P_b and Pf either when the amount of reserved resource is fixed (RCS, the amount of 3 in the simulation) or when the amount dynamically changes.



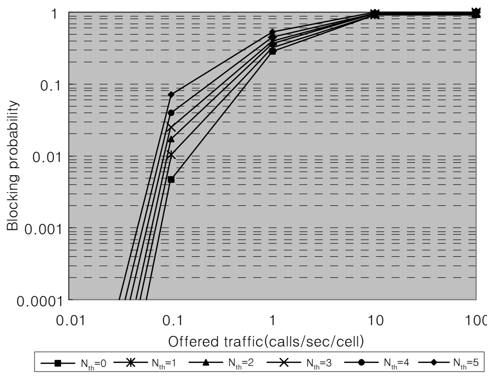
[Fig. 6] P_b of a fast moving user

Fig. 6 shows P_b of a fast moving user according to the threshold variation of ACR scheme. It is seen that Pb is considerably decreased as N_{th} is increased from 1 to 5.



[Fig. 7] P_f of an overflow session

Fig. 7 shows P_f of an overflow session according to the threshold variation of ACR. In Fig. 7, ACR (N_{th} =3) is compared with RCS (n =3), and the results of both schemes are almost consistent.



[Fig. 8] Overall P_b of system

Fig. 8 shows the overall P_b of system (the sum of two P_b of a slow moving and a fast moving user) according to the variation of the amount of the reserved resources.

5. Conclusion

Mobile subscribers in the overlaid microcell/macrocell system are classified, depending on its mobile speed. A session admission scheme for the new session and the handoff session originating in the microcell and a management scheme for the overflow session in the macrocell are proposed in this paper. we improve the probability of the forced termination by dynamically adjusting the number of the reserved resources for handoffs. To reduce blocking probability of new sessions in the macrocell, our system is adjusting dynamically the number of reserved resources, according to the number of cells which have no available resources left. Compared with a scheme with a fixed number of reserved resources, our new resource reservation scheme makes a remarkable decrease in the blocking probability of new sessions, at the expense of the slight increase of forced termination probability.

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<Research Interests>
Mobile communication, Network Security, Database management, multimedia