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# 무선ATM망에 대한 동적 자원할당 매체접속( DRAMA) 프로토콜

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# Dynamic Resource Assignment Multiple Access (DRAMA) Protocol for Wireless ATM Network

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ABSTRACT

In the wireless ATM network which supports an integrated mix of multimedia traffic, the media access control(MAC) protocol should be designed such that the limited wireless bandwidth can be utilized efficiently maximizing quality of service(QoS) guarantee for various service classes. In this paper, we study an efficient dynamic resource assignment multiple access(DRAMA) protocol adopting a dynamic channel allocation scheme for a mix of three service classes:constant bit rate(CBR), variable bit rate(VBR), and available bit rate(ABR). Some preliminary results of computer simulation for the performance of the proposed scheme are also proposed.

## I. Introduction

In recent years there has been a rapid increase of portable computers and communication devices. Future wireless personal communication networks will be required to interconnect broadband wired networks in order to provide a high speed backbone as well as reasonable QoS requirements and seamless integration of network based multimedia applications on both fixed and portable devices. Wireless ATM, therefore, has been proposed as a technology to support this because of its free access capability, mobility, and multimedia handling capability[1,2,3,4,5].

A major technical issue related to the wireless ATM is the selection of an appropriate MAC protocol to efficiently arbitrate between mobile terminals over a common shared wireless medium. A MAC protocol has significant impact on the user performance, system capacity and complexity[6]. Some protocols such as fixed assignment access methods(TDMA, FDMA, CDMA) and random access methods(ALOHA, CSMA/CD) are typically suitable for voice and data traffic. In a wireless ATM network, however, that supports an integrated mix of multimedia traffic such as CBR, VBR and ABR, the MAC protocol needs to be designed such that mobile terminals share the limited wireless bandwidth efficiently, maximizing the utilization of the frequency spectrum and QoS guarantee. As a result, demand assigned protocols that achieve high channel throughput by requesting a user to reserve communications bandwidth is suitable for a wireless ATM[7].

There are several proposals for wireless ATM MAC protocols in the literature, such as

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TDMA/TDD[1,4], DQRUMA[6,7], DSA++[8,9] and DMAC[10,11]. Most all of them use TDMA-like access protocols which enable mobile terminals to transmit ATM cells over shared channels to base station. The TDMA protocol with dynamic reservation provides sufficient degree of transparency for many wireless ATM applications by integrating QoS handling into the medium access protocol, and there is a flexible frame structure allowing a dynamic usage of available bandwidth to provide required QoS.

In this paper we propose an efficient multiple access scheme, called dynamic resource assignment multiple access(DRAMA) protocol, by which the real time traffic can be transported in the up-link on a frame-by-frame basis. The request slot for access(RSA) is used for all the traffic types to contend for access to the up-link initially by using the slotted ALOHA protocol. CBR traffic is assigned and reserved to fixed periodic slots according to the required bit rate for the whole duration of its connection if the request is successful while VBR traffic is handled as a dynamic reservation on a frame-by-frame basis controlled by the request slot for the number of information slots(RSN) during its whole duration. ABR traffic is assigned a RSN to transmit the message and it has to release them at the end of the current frame. If the number of assigned information slots of ABR is insufficient to transmit the entire message, the user needs to contend again for access available slots in the next frame to transmit the remaining portion. We report some simulation performance results of this protocol. The rest of this paper is organized as follows. In section II, we describe a wireless ATM system and our detailed MAC protocol. Section III presents dynamic allocation of available slots. In section IV, we describe some preliminary simulation results. Section V presents the concluding remarks.

## II. System and Protocol Description

There are three typical multiple access schemes, FDMA, TDMA, and CDMA. To support the transmission speed of 20 Mb/s or higher, CDMA will need 200 Mb/s signal processing speed to achieve 10 dB processing gain. Thus, CDMA will not be appropriate for such high speed wireless system. On the other hand, FDMA is not suitable to support variable transmission rate capability since it requires different modems working at different frequency band. A dynamic TDMA approach will be one of the most promising multiple access scheme for high speed wireless ATM[12].

Fig.1 schematically shows the concept of the TDMA based wireless ATM network. The base station(BS), which is connected to the wired ATM networks, controls many wireless terminals(WTs) in its cell. In the up-link(WTs to BS) transmission, WTs share the channels using the multiple access protocol while the down-link(BS to WTs) transmission, channels operate in a contention free broadcast mode.

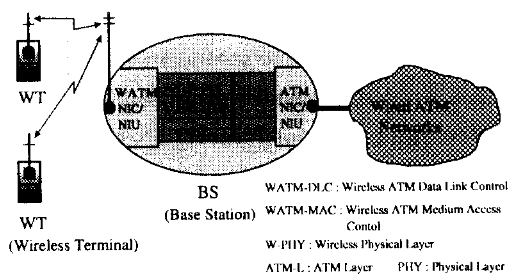


Fig.1 Network configuration of the wireless ATM network.

We assume high speed transmission in the range of 20 Mb/s on the wireless ATM link. WTs share the wireless ATM link by using the time slots on the TDMA frame assigned to it by the BS. In the ATM transport system, the transmitted information is divided into ATM cells. The transmission speed of the connection call can be fluctuated to match the instantaneous cell transmission rate. Therefore, minimal protocol conversion processing is required at the BS which simply strips off the wireless protocol header and trailer for a packet moving from the WT to the wired ATM networks, and inserts the wired ATM header for a reverse packet moving. Also, the BS performs connection admission control(CAC) through the bandwidth allocation function. The CAC procedure is always executed during the call setup procedure to check the existing connections and resources reserved for them.

Wireless information and control data slot formats are shown in Fig.2. The information cell format is harmonized with the standard ATM cell format, consisting of 48-byte payload, 2-byte ATM header(VCI, PT, CLP), 4-byte wireless header(SYN, CSN, ST, WCF), and 2-byte CRC (total of 56 bytes). The control packets consist of a 3-byte wireless header(SYN, MTN, ST), 3-byte control field, and 2-byte CRC (total of 8 bytes).

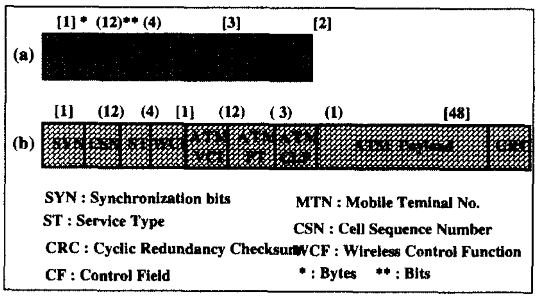


Fig.2 Slot format. (a) Request/Control slot (b) Information slot.

In the information slot, the SYN field provides slot synchronization. The CSN field is used to detect lost packets or support data link control error recovery as shown in Fig.3. The ST field is used to indicate the service type. The WCF field is used for other wireless network functions such as handoff indication and cell segmentation for further development. A compressed 2-byte ATM header with 12 bits VCI and 4 bits for ATM control(PT and CLP) is used for improving radio channel efficiency(GFC field is not necessary for wireless access, and HEC field is replaced by the CRC[13]). The CRC field is used for error detection. In the control slot, the mobile terminal number(MTN) field identifies the WT for a source or destination address. The CF field contains the number of information slots(NIS) and QoS parameters in the RSA region, the NIS or the end of transmission(EoT) of the VBR service in the RSN region, the cell sequence number(CSN)(or the assigned slot number(ASN) of RSN in the case of the initial VBR call setup message) in the scheduling slot(SS) region, and other wireless network functions in the base to WT control slots(BWC) region.

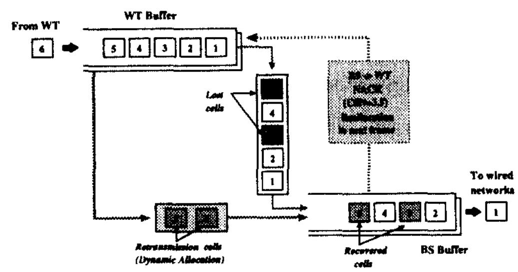


Fig.3 Data link control error recovery in the wireless ATM.

Fig.4 shows the TDMA frame structure supporting CBR, VBR and ABR traffic classes. Each MAC frame contains an up-link and a down-link part, and each part is further partitioned into information slots and request slots(up-link) or control slots(down-link). The information slots are used to carry the information data according to traffic requirements, which are allocated to the WTs by the BS on a frame-by-frame basis.

The request slots of up-link are classified as RSA and RSN. The RSA is employed for all the traffic

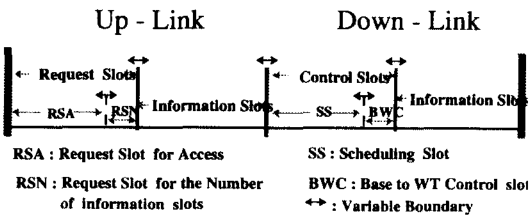


Fig.4 Frame structure.

types to contend for access to the up-link initially using the slotted ALOHA protocol. The RSN is used to reserve VBR traffic on a frame-by-frame basis after accessing through the RSA. CBR traffic is assigned and reserved to fixed periodic slots according to the required bit rate for the whole duration of its connection. However, VBR traffic is handled as a dynamic reservation on a frame-by-frame basis controlled by the RSN during its whole duration. ABR traffic is assigned whenever some information slots are available after CBR and VBR assignments on each frame, and which has to release them at the end of this frame.

The SS of down-link is used by the BS to transmit control messages to the WTs for allocation information, acknowledgment, retransmission request, and other wireless control information. Each WT scans the SS of the next frame after sending a request slot(RSA or RSN), and finds the assigned slots from the SS field.

As an example, Fig.5 shows CBR slot assignment. When the request slot of CBR user 1 asking for three NIS is successfully transmitted through the RSA using the slotted ALOHA, BS assigns three SS slots for the CBR user 1, and these slots are reserved at fixed periods on a frame-by-frame during the whole connection. And, WCF field of the assigned information slot is used to indicate the end of transmission for CBR service as seen in Fig.5, and this is done by setting the WCF field to all 1's in the front

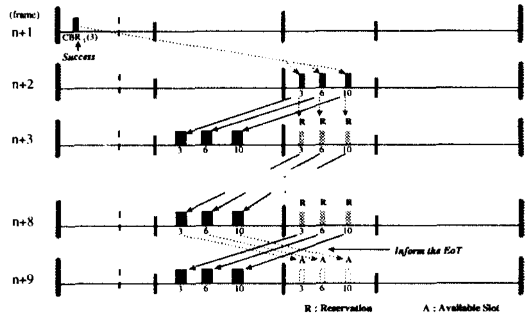


Fig. 5 CBR slot assignment.

of last transmission frame.

Fig.6 shows an example of VBR slot assignment. When the request of VBR user 1 is successful, BS assigns the RSN and the initial slot(IS) to the VBR. The RSN that contains the number of slots required will be sent frame after frame during its connection as shown in Fig.6, and the IS that contains the information of the detailed traffic parameters for VBR is used for bandwidth allocation at the BS. Thus, VBR traffic is handled as a dynamic reservation on a frame-by-frame basis controlled by the RSN during its whole connection. The RSN is used to indicate the end of transmission as shown in Fig.6. This is done by setting the field to all 1's in the RSN that has been assigned to real time VBR service.

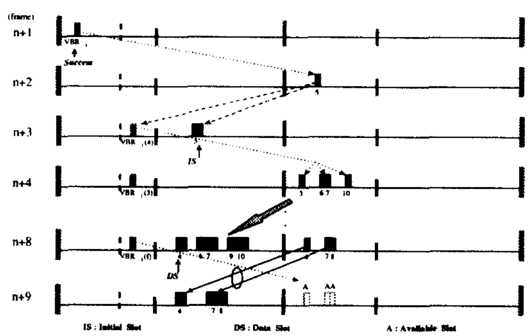


Fig.6 VBR slot assignment.

ABR users have to contend for the RSA at every frame. ABR traffic is assigned a number of available information slots if the requests go through successfully. Those slots have to be released at the end of this frame. If the request for access is not successful, ABR user backs off for a random number of frames before trying again. Fig.7 shows an example of ABR slot assignment. When the access of ABR user 1 with the two NIS is successful, BS assigns two SS slots for ABR user 1, and the user transmit the message and release them. If the number of information slots assigned is insufficient to transmit the requested NI, the remaining portion of the NIS will be assigned first by the BS in the next frame as shown in Fig.7.

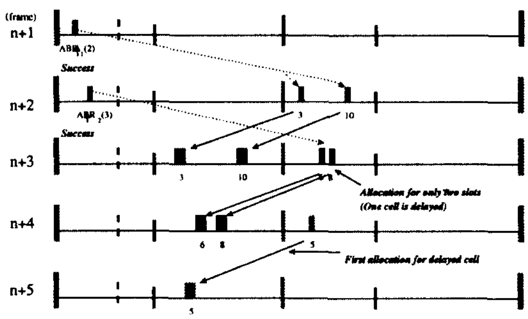


Fig. 7 ABR slot assignment.

## III. Dynamic Bandwidth Allocation

CBR, VBR, and ABR traffic streams has its own unique traffic properties and service requirements respectively to maintain the desired QoS. For example, CBR and real time VBR streams have a strict timing constraint, and the bandwidth demand for VBR traffic fluctuates due to their bursty nature while CBR traffic requires constant quantity of bandwidth. To cope with these requirements, dynamic bandwidth allocation is needed. The objective of a dynamic bandwidth allocation is to achieve maximal throughput and minimal delay performance. Under the severe propagation conditions common in wireless environments, the continuous use of wireless links can be assured by fixed bandwidth allocation at the pick cell rate for all the traffic classes. However, the peak cell rate can be much higher than the average cell rate for the bursty traffic often encounters in multimedia services. The difference between the peak and the average cell rate degrades the throughput performance. In order to maintain the high channel utilization and guarantee QoS, an efficient bandwidth allocation scheme is need at the BS.

Fig.8 shows the up-link MAC scheduling at the BS. Channel access scheduling for all the traffic classes is done by the MAC schedule controller within the BS. Unlike in the wired ATM, the MAC schedule controller of BS must deal with the difficulties imposed by the buffer lengths of WTs and TDMA frame structure in order to achieve the dynamic allocation. Since the allocation for an up-link slots in a frame can only be decided at the beginning of the MAC frame, no unutilized slots can be reallocated based on the instantaneous requirement of the other streams originating from different WTs. Therefore, to overcome these difficulties, we propose the DRAMA protocol, by which the real time traffic can be transported in the up-link on a frame-by-frame basis. Based on the scheduling data from the schedule table, the MAC schedule controller computes the slot requirement of each user for the next MAC frame. If the total computed requirement does not exceed the available bandwidth, the MAC schedule controller assigns available bandwidth to users directly.In an instance it exceeds, CAC is performed to derive the actual allocation from the computed value.

Fig.9 illustrates the bandwidt allocation for the DRAMA protocol. CBR users are assigned slots periodically with a full reservation according to their

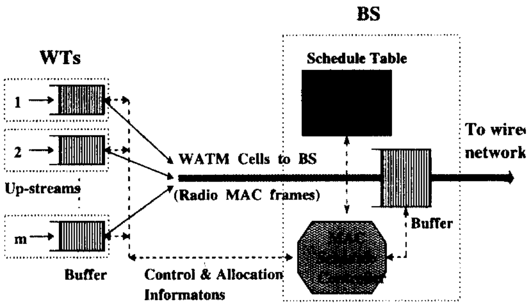


Fig.8 Up-link MAC scheduling at the BS.

cell rate, and reservation for the real time VBR users can be dynamically controlled on a frame-by-frame basis for a certain rate by using the RSN. ABR users are handled as a dynamic allocation according to the number of available and required slots.

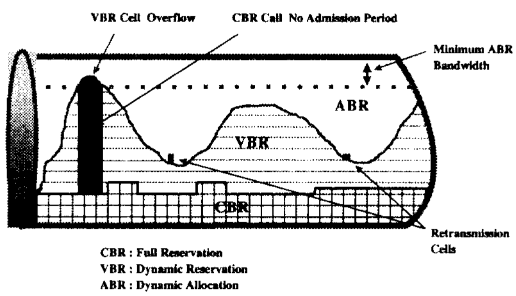


Fig.9 Bandwidth allocation in the wireless ATM.

As seen in the Fig.9, the MAC schedule controller of BS can assign a certain minimum bandwidth to reserve for ABR users(The guaranteed minimum number of cells on an ABR connection is specified in ATM service category attributes defined by the ATM Forum[14]). Therefore, if the total computed requirement for CBR and VBR does exceed the total remaining bandwidth except the minimum ABR bandwidth(MAB), newly arrived CBR calls should be rejected by the CAC function and will be lost. Also, an overflow of VBR traffic in this period will be occurred and be lost. In addition, the retransmissions will be allowed to assign the slots only when there are available slots in a frame. Here, the MAC schedule controller will assign arbitrary slots among the available slots in a frame through the SS. Note that, unlike ABR retransmission, CBR and VBR retransmissions can be released once the time limit on retransmissions expires because the delay time for CBR and VBR is critical.

## IV. Simulation Results

In this section, we provide some simulation results for DRAMA protocol operating in a mixed multi-service environment. The computer simulations are run to evaluate the performance of the DRAMA protocol. The communication channel is partitioned into frames, and each frame contains a fixed number of slots(1,000 or 1,500). The simulation is based on a wireless link speed of approximately 16~25 Mb/s. Each simulation result is averaged over 3 different runs with each containing 2 million TDMA frames, and a warming-up period of 100,000 frames has also been used to minimize the effects of initial simulation transients.

Three types of traffic source are used : CBR, VBR, ABR sources. A new CBR call arrives according to the Poisson process. The CBR call duration is exponentially distributed with an average of 3 minutes. MPEG-1 VBR compressed digital video is used for VBR traffic source which is obtained by MPEG software encoding. We consider two video users with the video frame rate of 30 frames per second. One is "Indiana Johnson"(peak cell rate: 906 cells/s, mean cell rate: 290 cells/s) and another is "Star Trek"(peak cell rate: 449 cells/s, mean cell rate: 228 cells/s) as shown in Fig.10. The duration of the VBR connection lasts the entire simulation. A new ABR call arrives according to the Poisson process, and the average length of the packet(E[L]) is exponentially distributed. It is assumed that WTs and BS have a sufficient buffer capacity, and also an ideal communication channel is assumed, implying that transmission error and retransmission do not occur in the simulation.

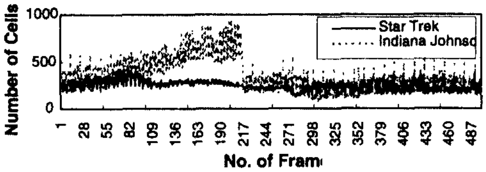


Fig. 10 Example of VBR traffic sources.

Fig.11 shows the curves of CBR call loss probability versus total offered load for varying the MAB. The number of slots for frame is 1000, and E[L] is 14. The offered load of ABR is fixed on 0.0038. The number of multi-slot for a CBR call is 3, and the CBR call duration is an average of 3 minutes. The results show that the difference between the call loss probability for MAB=50 and the other for MAB=0 is high according to increasing the load as expected.

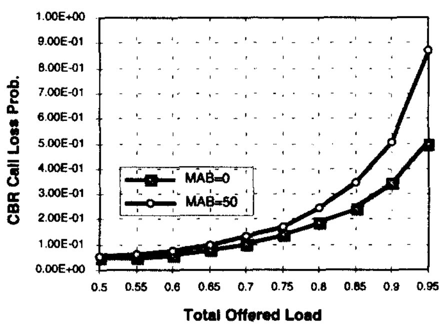


Fig. 11 CBR call loss probability versus total offered load.

Fig.12 shows the VBR cell loss probability versus total offered load for varying the MAB. The number of slots for frame, the number of multi-slot and call duration for CBR, E[L], and the offered load of ABR are the same as given values in the Fig.10. It is clear that the cell loss probability for MAB=50 become a rapidly higher according to the total offered load while that for MAB=0 is not increasing.

Also, Fig.13 shows the mean ABR cell delay versus total offered load for varying the MAB. All values of parameters are the same as those of the Fig.10. As expected, it is clear that the MAB can obviously reduce the delay of ABR even if the total offered load increases high as seen in the Fig.13. However, the MAB can increase the CBR call loss and the VBR cell loss as seen in the Fig.11 and Fig.12.

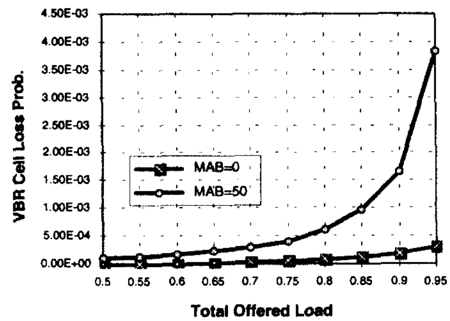


Fig.12 VBR cell loss probability versus total offered load.

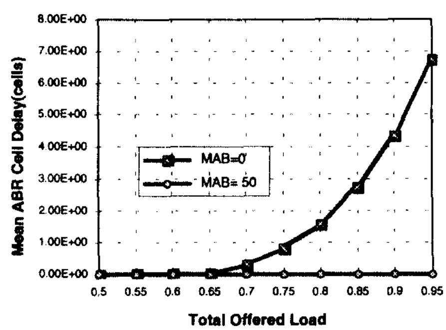


Fig.13 Mean ABR cell delay versus total offered load.

In the Fig.14, the mean ABR delay is plotted as a function of the E[L]. Here, the number of slots for frame is 1500, and MAB is zero. The offered load of ABR is fixed on 0.0018(in case E[L]=10) or 0.018(in case E[L]=100). The number of multi-slot for a CBR call is 5, and the CBR call duration is an average of 3 minutes. It can be seen that the delay of large E[L] is rapidly increased on the high link load. However, the delay of small E[L] is not increased even if the total offered load is high.

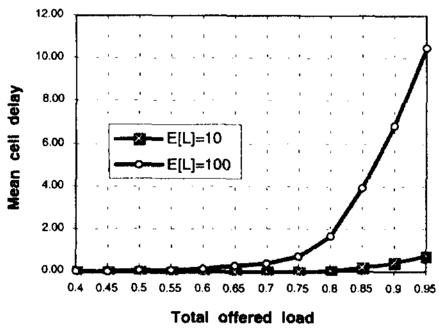


Fig.14 Mean ABR cell delay versus total offered load for different E[L].

## V. Conclusions

In this paper, we presented an efficient DRAMA protocol for wireless ATM networks which allows seamless integration from the wired ATM network in consideration for the various QoS and traffic characteristics of different service classes. The paper focuses on the role of the media access control protocol in supporting multimedia traffic and QoS requirements. This protocol can be used for wide range of applications for a wireless ATM. Some preliminary performance results are obtained by simulation. It was shown that in high load system, in order to reduce the ABR cell delay, the guaranteed minimum ABR bandwidth is needed for reasonable QoS support. While this paper emphasizes on media access control protocol and bandwidth allocation, more work involving CAC and wireless QoS guarantee for different service classes and further detailed performance is in progress.

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