論文
2-2-6

Improvement of Dynamic Slot allocation algorithm for wireless ATM networks
(무선 ATM 망에서 실시간 가변성 서비스를 위한 동적 슬롯 할당 알고리즘의 개선)

Hyun-joo Kim*
(김 현 주)

Abstract

This study is on the design and performance evaluation of a multi medium access control(MAC) protocol for multimedia access in the wireless ATM network.

In general, MAC protocols for multimedia data transmission are classified into the fixed slot allocation algorithm that allocates base-station slots equally over terminals, and the dynamic slot allocation algorithm that with flexible penetration. The conventional slot allocation algorithms assign slots based on the average bandwidths required for various services types. Although the algorithms have a wide bandwidth for real-time -variant services, the slots are being wasted due the service types. To improve the slot waste problem, this thesis proposes a method that minimizes the waste by assigning variable slots based on the most appropriate bandwidth after a base-station analyzes the service type requested from terminals.

요 약

본 연구는 무선 ATM 망에서 실시간 가변성 서비스를 위한 동적 슬롯 할당 알고리즘의 개선에 대한 것이다. 일반적인 슬롯할당 알고리즘은 단말기에서 요구하는 서비스를 몇 개의 형태로 나누고 거기에 따른 평균대역폭을 기준으로 슬롯을 할당하는 방식을 사용하였다. 따라서 실시간 가변성 서비스의 경우 단말기에서 요구하는 서비스의 대역폭의 범위가 광범위함에도 불구하고 이러한 방식을 사용함으로써 슬롯의 낭비가 발생하게 되었다.

본 연구에서는 슬롯할당 알고리즘의 단점을 개선하기 위하여 한계셀 수를 설정하여 슬롯할당을 가변적으로 함으로 서비스 품질을 향상시키고, 단말기에서 요구하는 서비스의 종류를 기지국에서 분석하여 기지국이 설정한 단계별로 가장 근접한 대역폭을 중심으로 슬롯을 할당하여 셀 손실률을 최소화하였다. 설계된 프로토콜은 실시간-가변성 서비스 품질에 대해 채널 이용률, 셀 손실률, 지연시간의 항목으로 구분하여 성능평가를 하였다. 성능 평가의 결과 기존의 정적인 슬롯 할당 알고리즘에 비해 우수한 효과를 얻게 되었다.

* 종신회원 : 명지전문대학 정보통신과 부교수

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1. Introduction

The world of mobile communications is projecting at its exciting pace, driven in by success in voice and data communications. And, henceforth the global phenomenon of mobile communication is inclined toward a rapid evolution from simple voice telephony to multimedia services. In the integrated environment of the mobile communications, the wired network and the wireless network, further destined to adopt harmoniously to wireless multimedia application services. It will provide an integrated service of voice-oriented cellular mobile communication, graphic and video as well as the current services in the Public Switched Telephone Network(PSTN).

It will also offer various multimedia services for such fixed-type wireless services as wireless Internet and wireless CATV.1) As an alternative to that, the wireless ATM(Asynchronous Transmission Mode) network extends the ATM technology, fundamental to B-ISDN(Broadband Integrated Services Digital Network), into the wireless area2).

However, since wireless ATM network shall support various multimedia services through the wireless channels, which has high bit error ratio in mobile environments, and consequently a new technology to provide additional benefits is required. This is especially true in wireless ATM network that requires broadband transmission rates, where the frequency ranges from 5 GHz to 60 GHz, and therefore enhancing channel properties and thus the required technology.3) In short, modulation/demodulation technology, coding technology, error control plans are being proposed. Bands should be allocated according to the user's requirements in consideration with the band's effectiveness and maintaining service quality. As it is, in the process of developing and implementing various technological components, one of the most important and the first area to develop should be MAC (medium access control) protocol.

Most of MAC protocols for support of multimedia access under development do not take into account realtime and non-realtime features. Especially, they allocate slots consistently regardless of bandwidth of the type for service request of handset in slot allocation, or allocate slots based on the average bandwidth by classifying service types into several categories. These methods have two problems. First, they can't support various multimedia services and second, as slots are allocated on a consistent bandwidth, base station has a waste of slots.

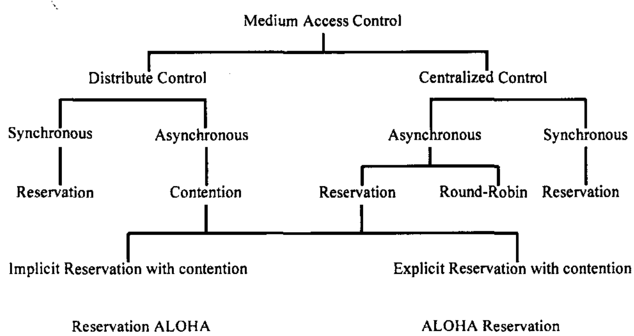
Therefore, this thesis has set up various services supported by base station for support of multimedia access, and proposed an algorithm to allocate slots based on the average bandwidth in phase in slot allocation to avoid a waste of slots.

Especially in real-time variant service, the type of data (bandwidth) to be transmitted is analyzed at the base station after receiving transmission request from the terminal in-order to reduce cell loss that often occurs in slot allocation using average bandwidth. Advanced dynamic slot allocation(ADSA) method has been proposed, for dividing optimal bandwidth into 3 types according to the bandwidth of the requested signal after analysis.

2. Wireless ATM MAC Protocol

For multiple terminals to share channels, a protocol is required as a mediator to clear signal interference between terminals. Protocols with the function are called the medium access control protocol. Basically, in the time division-based Time Division Multiple Access(TDMA) system, it is defined as a method to decide on time to be used by each terminal.[4)]

The control method for the wireless medium access is divided into two types: The page method that allows each terminal to manage its own medium access independently and the centralized



[Fig. 1] Classification of medium access control schemes.

method that allows, to control centrally, the uplink of each terminal. In other words, depending on whether the subject of medium access is the center or terminal, it is divided into the paged or the centralized medium access control method.[5)]

The [Fig. 1] shows a classification of the medium access control method, and the Paged and the centralized methods are classified into the synchronous and the asynchronous mode depending on the control time. The synchronous mode has the medium access time decided for each terminal, which applies to the Time Division Multiplexing (TDM). The asynchronous mode has uncertain me- dium access time for each terminal, which applies to LAN(Local Area Network). The medium access control in the Paged asynchronous mode is usually based on the competition method between terminals, which applies to the most simple, typical ALOHA (Additive Links On-Line Hawii Area) protocol.[4,6)]

Another method is the centralized asynchronous control mode is divided into the round robin and the reservation method. The round robin method applies to the Token-Passing technique standardized by IEEE 802.4 and 802.5. For the reservation method, studies have been conducted to find a method enabling all terminals to allocate available bits for reservation independently before frame transmission.[5,7)] Regardless of wired or wireless *transmission, the medium access control is divided* into the Paged and the centralized methods depending on the controlling subject, the synchronous and the asynchronous modes depending on the control time, and competition, round robin and reservation depending on the control method.

3. Design of ADSA Protocol

3.1 Traffic model

Effective multimedia traffic transmission is possible if B-ISDN services are classified by rt-VBR, rt-CBR nrt and medium connection and control is performed on the wireless interface according to the properties of the classified service. The proposed multimedia slot allocation protocol in this thesis classifies defined multimedia services into rt-CBR service, most widely used voice service, rt-VBR that requests lots of bandwidth, and nrt service, as shown in the <Table 1>.[8)] Multimedia slots allocation algorithm that takes into consideration the properties of each traffic in the medium access control layer, is proposed for each service classified according to traffic to allocate slots exclusively to each service according to parameters such as average call arrival rate, average call time and bandwidth.

<Table 1> Classification of multimedia services.

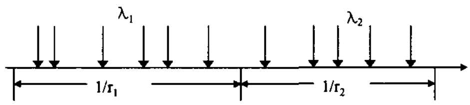
service	application	bandwidth	cell loss rate	cell delay time	burst rate
rt-CBR	voice	8 - 64Kbps	10^{-4} - 10^{-6}	10 -150ms	1
	high quality audio	1.4Mbps	10^{-6}	500ms - 2s	1
	video phone	64K - 2Mbps	10^{-9}	150 - 350ms	2 - 5
voice	voice	64Kbps	10^{-4} - 10^{-6}	10 - 150ms	1
rt-VBR	video phone	64K - 2Mbps	10^{-9}	150 - 350ms	2 - 5
	video conference	128K - 14Mbps	10^{-9}	150 - 350ms	2 - 5
	medical X-ray	1.5 - 10Mbps	10^{-12}	2s	25
nrt	H-H file transfer	64K - 1.5Mbps	10^{-12}	1 - 500s	1
	PC file transfer	9.6 - 64Kbps	10^{-9}	10 - 100s	1
	electronic paper	2.4K - 2Mbps	10^{-6}	200ms - 10s	2 - 5

3.1.1 Real-time variant service

Real-time variant service refers to real-time applications that request very limited delay and delay changes. The transmitted cells must be contained within a pre-defined value using cell transmission delay. Since the source generates cells at different rate at different times, it can be represented by burst. Therefore, better service quality can be achieved if the number of slots referring to bandwidth of the call is transformed dynamically during connection setup to guarantee QoS for real-time variable services with burst properties.

This thesis proposes a dynamic slot allocation algorithm fit for real-time variant services. According to the algorithm, slots are allocated with the burst properties of the cell taken into account, after bandwidth is set by each service connecting to the base station when terminal requests slots. Also, dynamic slot allocation is performed to provide optimal connection for the terminal by analyzing the relationship between the allocated slot and the terminal number.

For source model, MMMP having the properties of statistical Poasong process is used. The two-phase MMPP is a special case of the PH-MRP (Phase-type Markov Renewal Process), and is generally used widely to model burst traffic such as packet traffic in the ATM, because of its scalability. Also, MMPP is analyzed using matrix analysis methods.



[Fig. 2] Two-phase MMPP

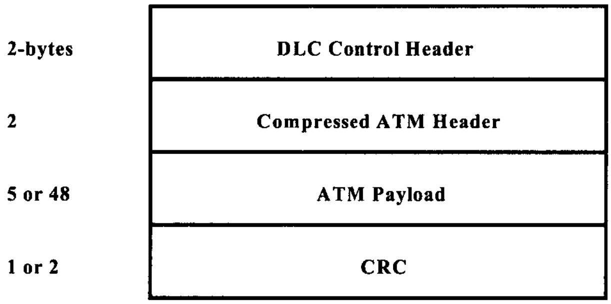
The [Fig. 2] shows the exponent distribution with the average life time γ_j^{-1}, indicating the distributed phases sequentially and showing the two phase MMPP model with the arrival rate $\lambda j(j=1, 2)$ in each phase. It is defined by (R, Λ) as in the equation 3.1

$$R=\begin{bmatrix} -\gamma_1 & \gamma_1 \\ \gamma_2 & -\gamma_2 \end{bmatrix} \quad \Lambda=\begin{bmatrix} \lambda_1 & 0 \\ 0 & \lambda_2 \end{bmatrix} \qquad (3.1)$$

R = Markov Chain Infinitesimal generator

Λ = Arrival Rate Matrix

Also, n-phase MMPP is displayed as (R, Λ) with n × n size matrix. This thesis used two phase MMPP model to model real-time variant service traffic. To generate two phase MMPP cell, the average lifespan is 7, is 6, and Poasong arrival rate is 0.3, and is 0.16, generating real-time variant cell.



[Fig. 3] Frame structure of data link control.

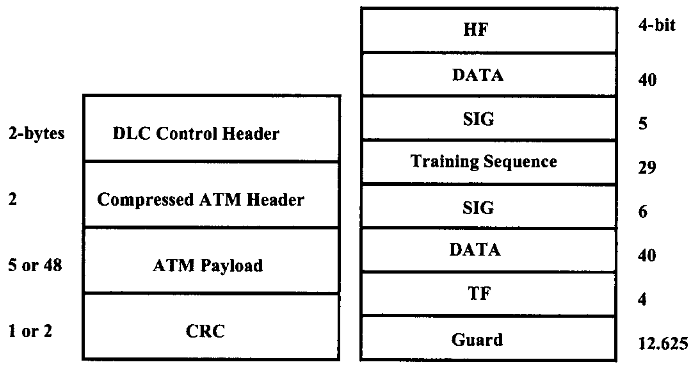
3.1.2 Definition of System Transmission Structure

Defines the frame structure of the wireless layer used in the multimedia slot allocation protocol, and the system transmission structure uses wireless ATM protocol structure.8,9) Compared to a wired network, a wireless ATM system has lower service quality and also requires transparent interface. Therefore, in a wireless ATM protocol structure, Data Link Control, medium access control , wireless physical layer exist. The functions and the structure of the cells used in the proposed multimedia slot allocation protocol are as follows.

A. Data link control layer

A form of error control should be provided for wireless ATMs due to the high error rate of the wireless medium and inferior physical characteristics. Such error control can be done using the PCN packet sequence number field in the header according to the 2 byte standard CRC frame check sequence trailer, and HDLC-style re-transmission method can be used for non-link data. Also, the frame structure of data link control layer using compressed headers to reduce the size of the 53 byte data that is transmitted in the ATM layer is shown in [Fig. 3].10)

As for the frame type of the data link control layer, 2 bytes CRC and DLC control header fields are added to the 53 byte (5 byte header and 48 bit data) frame created in the ATM layer for voice, video and data traffic to protect the bits of all DLC frames. Also, the size of ATM payload is 5 bytes for voice and 48 bytes for video data traffic.



(a) DLC frame format (b) MAC Packet(wcell) format

HF : Header Flag TF : Tailor Flag SIG : Signaling in band

[Fig. 4] DLC and MAC format in wireless ATM networks.

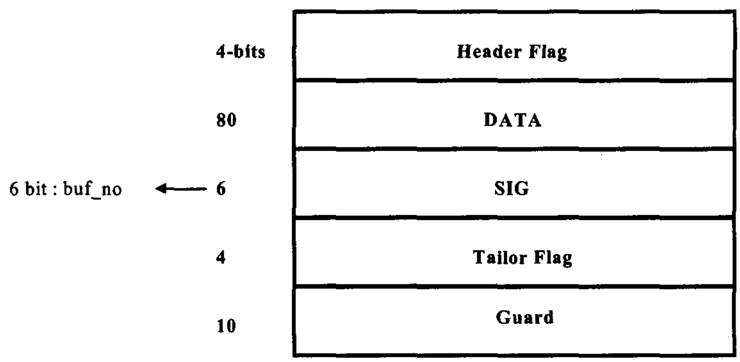
B. Medium Access Control Layer

Medium access control protocol includes definition of service type, error control, and handover support functions. The service type field simplifies the protocol processing for the base station, and is for displaying the current service type among packet monitor and control , constant bit rate, variable bit rate, and available bit rate. The medium access control layer of the proposed multimedia slot allocation protocol transmits the dynamic parameter (threshold flag, the number of cells in buffer, and last cell) of the service together when transmitting data cells, and the base station creates slot and request table of all parameters to dynamic slot allocation. [Fig. 4] shows the relations between DLC and MAC packet format. The MAC packet format is called wcell (wireless ATM cell), and is as in [Fig. 4](b). Signalling in band(SIG) field is used for piggyback signal when the terminal is transmitting using wcell.

Although real-time variant service transmits cells according to bandwidth for the connected call, there are moments where the number of cells are more or less than that of the buffer according to the burst properties of the generated cell. Therefore, slots are dynamically divided and allocated in comparison to the average number of slots, and a limit larger than the number of slots allocated is set to increase the utilization rate of the channel and to guarantee real-timeness. The terminal transmits the threshold flag value, which represents whether the number of cells of the buffer goes over the limit, to the base station in values of 1 or 0. When 5 bit signal message that represents the number of cells of the buffer is transmitted to the SIG field along with the cells, the base station dynamically allocates slots according to related parameters.

4. Design of Dynamic Slot Allocation Protocol

Although many MAC protocols have been proposed and are under development, most were protocols for voice transmission, unfit for multimedia data transmission, which has various properties (delay and burst) according to type of traffic. Therefore, this thesis focuses on dividing frame slots according to the arrival rate of the call requesting real-time service such as real-time constant, voice and real-time variant service, which are concepts divided according to service properties during connection setup, to enable the service to use the appropriate slots allocated to the service. Since the allocated slots may be used by each service independently, dynamic multimedia slot allocation protocol is proposed, which can apply slot allocation algorithm according to the properties of each service may be applied to each service separately.



[Fig. 5] Structure of wireless MAC frame for rt-VBR services.

4.1 Channel Multiplexing and Frame Components

Since the proposed multimedia slot allocation protocol uses the central system structure in which the base station manages the related terminals, a physical channel is used for multiple traffic channels related to each multimedia terminal to communicate with the base station.

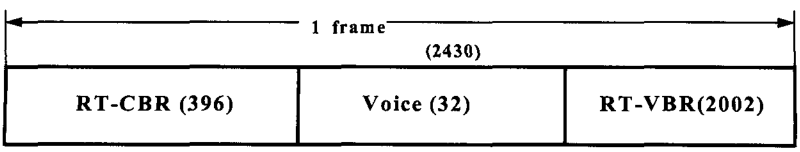
A. Reception of requests from Real-time constant, voice, real-time variant and non-real time service, which are according to service type, from the terminal through request slot
B. Classification of the services which requested, according to bandwidth
C. Correction of slot request and allocation table values according to the availability of available slots and the priority of the service
D. Transmission of reservation, slot re-allocation, or polling signal to the terminal
E. Enabling of cell transmission from the terminal.

4.1.1 Real-time variant service

Real-time variant service classifies the type of service that is requesting slots when the terminal is requesting slots. According to the request of the classified service, slot reservation and allocation is performed if a slot with the necessary bandwidth is available, and dynamically reallocates to all real-time variant terminals according to the number of cells in received buffer and threshold flag values received from the terminal through the SIG field, to increase service quality. The base station requires a threshold flag that represents whether the number of cells in any terminal or number of slots allocated in any terminal has gone over a given value (limit) to perform slot allocation according to the number of cells in the buffer that is received from the real-time variant terminal.

The proposed ADSA protocol supports various types of service traffic, and calls authorized through connection request go through ATM Application Layer(AAL) and ATM layer. The maximum transmission speed for slot allocation for each service, as defined in the Table 3-1, assumes the 155.52 Mbps17) rate as defined in the wireless ATM network. Since a frame is created every $125\mu s$, 8000 frames are created every second, and a frame consists of 2430 bytes to implement the maximum transmission rate of 155.52 Mbps. The number of slots allocated to each service at connection setup change dynamically according to the call arrival rate of the related service, average call time, and bandwidth.

However, if all services have the same terminal number and parameters, and all slots are equally divided according to the average bandwidth of each service as defined in the <Table 1>, the number of allocated slots that can be used independently by each service can be calculated. Therefore, the average transmission rate (bandwidth) for real-time constant service is 800 Kbps, for voice service 64Kbps, for real-time variant service 4048Kbps, and for non real-time service 576 Kbps. Therefore, when configuring the general frame by the ratio according to the average speed (bandwidth) of each service, the number of slots are as in [Fig. 6].



[Fig. 6] Structure of frame(number of slots).

According to traffic properties, non real-time service are transmitted in "best effort service" method, and therefore, a separate fixed slot is not allocated. The base station first uses fixed allocated slots for real-time constant, voice and real-time variant services, and then allocates the remaining slots for non real-time service by transmitting polling signal to the terminal that requested the non real-time service, and then allocates slots so that the terminal can transmit cells.

4.2 Slot Request and Transmission Algorithm of the Terminal

By classifying the available frame slots according to the properties of the service, MAC protocol algorithms fit for services with different properties can be applied. When a packet to be transmitted is generated, the terminal competes with other terminals for fixedly allocated request slots assigned to the frame, and transmits dynamic parameters to the base station to receive slot reservation from the base station.

The transmission algorithm for real-time variant service is shown in [Fig. 7]. When the number of slots allocated to a terminal(alc_no) exceed the threshold cell number(th_no) and is larger than the current number of standing by buffer cells(buf_no), it means that the remaining cells are less than the allocated slots. Therefore in this case, cells only as many as those in the buffer are transmitted. Remaining slots will not be used in the current frame.

However, slot allocation of base station and canceled algorithms are reallocated to the terminal with the lease allocated slots to enable use of the slot in the next frame. Next is the general situation where the number of slots allocated to a terminal does not exceed threshold cell number. In this case, the terminal compares the number of cells in the buffer with the threshold cell number, and if larger, when

```
        START :
        Receive request of slot from terminal
        Set register XX(2) to number of terminal and I=1
LOOP :  IF  I>XX(2) THEN  GO TO TERM :
        ELSE IF register flag set to 1  THEN
                  IF buffer cell > 1  THEN
                    send cell via the reserved slot
                      I=I+1
                  ELSE send cell and last cell signal via the reserved slot
                      I=I+1
                  END IF
              ELSE IF buffer cell > 1 THEN
                  IF request flag = 1 THEN
                     IF content number < 3 THEN
                            increment content number
                                IF buffer cell > 1 THEN
                                      send request cell via the request slot
                                      set request flag to "1"
                                ELSE I=I+1
                                END IF
                            ELSE drop cell
                                IF buffer cell > 1 THEN
                                      send request cell via the request slot
                                      set request flag to "1"
                                ELSE I=I+1
                                END IF
                  ELSE send request cell via the request slot
                        set request flag to 1
                  END IF
            I=I+1
        ELSE I=I+1
TERM : END
```

[Fig. 7] Request and transmission of real-time services.

```
        START :
        Receive request of slot from terminal
        Set register XX(10) to number of terminal and I=1
LOOP :   IF I>XX(10) THEN GOTO TERM
        ELSE IF any request THEN
                IF STM services THEN
                assign the slot at call setup phase
                I=I+1
                ELSE IF RT-Voice THEN
                GOTO slot allocation algorithm for voice
                I=I+1
                ELSE IF RT-VBR THEN
                GOTO slot allocation algorithm for RT-VBR
                I=I+1
                ELSE update slot request
                      reservation table
                I=I+1
                END IF
        I=I+1
        END IF
TERM :  GOTO slot allocation algorithm for NRT services
        END
```

[Fig. 8] Algorithm of multimedia slot allocation.

transmitting the number of cells equal to the number of slots allocated, and if threshold flag(th_flag) value (if number of cells in buffer is larger than threshold flag, 1, if not, 0) and current number of cells in buffer is transmitted together. If smaller, the number of cells equal to the number of cells in the buffer is sent along the number of cells in the buffer.

All terminals transmit the number of cells equal to the number of cells in buffer or the number of slots allocated according to the transmission algorithm. Then, a parameter called competition number is set up to designate cell transmission since all cells in the buffer cannot be transmitted through the slot of the current frame, and are delayed. Therefore, when the competition number reaches a certain value, the related cells are terminated to enable fluent traffic transmission.

4.3 Slot allocation algorithm of Base Station

[Fig. 8] shows the slot allocation algorithm of multimedia traffic service supported by the base station. This is using the features of centralized structure system by requesting slot reservation to base station through request slot when cell to be transmitted is generated.

The base station interrogates dynamic parameters received with the cells during slot request or transmission from the first terminal such as threshold flag and number of cells in buffer, to correct slot request and allocation tables corresponding to according real-time constant, voice, real-time variant and non real-time service, and performs each slot allocation algorithm.

With voice, slot reservation or denial is determined according to the availability of allocated slots for voice service in the frame, and such information is transmitted to the terminal.

With real-time variant service, the slots left after real-time variant service uses the slots in the frame are made to be equally used between terminals that requested slots according to request terminal and the number of cells of buffer that are stored in the slot request and allocation table.

Real-time constant service allocates slots during connection setup. The base station processes slot allocations for all real-time service terminals, and then allocates a certain number slots that are left using round robin method to the terminals that requested non real-time service stored in slot request and allocation tables.

```
START :
analysis of request terminal
IF requested bandwidth < 2Mbps THEN
GOTO sub algorithm A
        ELSE IF  2Mbps <= requested bandwidth < 4048 Kbps THEN
        GOTO sub algorithm B
                ELSE IF requested bandwidth > 4048Kbps THEN
                GOTO sub algorithm C
                END IF
        END IF
END IF
END
```

[Fig. 9] Slot allocation algorithm for real-time VBR services.

For new slot requests from terminal, slot allocation is implemented dynamically according to whether allocated slots are available excluding those reserved or allocated already for each service. For real-time constant service requests, slots are already allocated at connection setup, and for voice service request, reservation and allocation are performed only if slots are available, and for real-time variant service request, if slots that satisfy the minimum bandwidth of the requested service exist, the number of average slots are allocated for the new call.

According to the type of service that requested during connection setup, allocation is done by classifying from least allocation slot(LAS) to the maximum allocation slot(MAS). Even with such measures, problems arise in guaranteeing real-time and with cell loss due to random cells from the burst properties of rt-VBR traffic. Therefore, the base station changes the number of allocated slots dynamically according to the number of buffer cells in each terminal for the number of slots allocated to all terminals.

Slots that are remaining between LAS and MAS are allocated in order as follows according to the request of service.

A. In the order or service request, allocation slots from LAS to MAS are divided to those with bandwidths closest to the requested service.
B. Slots with appropriate size is selected and allocated starting from the left (the starting point of slot).

The base station interrogates the number of buffer cells(buf_no) and threshold flag(th_flag) stored in the slot request and allocation table transmitted from all terminals through piggy-back method.

Slots are released and reallocated as in the below according to the limit number of cells and number of buffer cells.

A. If the threshold flag value of the service of the terminal currently in use is 1, the currently allocated slot is used.
B. If the threshold flag value of a terminal is 1(buf_no > th_no), terminals with 0 threshold flag value is searched for.
C. If a terminal with threshold flag value 0(buf_no<th_no) is detected, the slot of the terminal (MT) with the longest buffer is released and reallocates the slot allocation table from the left (the starting point of a slot).
D. If multiple threshold values of 0 (buf_no<th_no) are detected at one time, they are released starting from MAS to LAS in order and arranged from the left.
E. The number of remaining slots are scanned and 1 slot is increased for the terminal (MT) with the longest buffer among those with threshold value of 1.

Real-time variant traffic service takes the properties of the two phase MMPP traffic into consideration and dynamically allocates optimal slots from LAS to MAS during connection setup. After connection setup, the base station reallocates slots for all terminals according to the length of the buffer that change during transmission. The slot allocation algorithm for real-time variant service is as shown in [Fig. 9].

5. Performance Evaluation of ADSA

It is assumed that the performance evaluation of slot allocation protocol divides slot of one frame into each service according to average bandwidth like <Table 2> classified with characteristics of multimedia service. In case of adapting slot allocation algorithm suggested based on each service, evaluated performance of protocol is presented after reviewing and analyzing cell loss rate, average delay time and channel utilization rate.

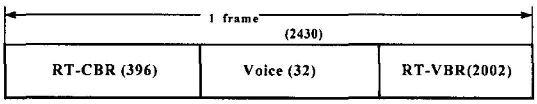
5.1 Simulation Circumstance

In case of using proposed algorithm in all the supporting service traffic, following items of performance evaluation are considered.

A. Service quality according to the maximum number of terminal acceptance of real-time variant service
B. Service quality according to the uppermost limit of real-time variant service
C. Service quality of non real-time service
D. Multi-profits of voice service

For comparing and analyzing results about average delay time , cell loss rate and channel utilization rate as terminal number increases, performance evaluation of proposed protocol used the simulation tool, AweSim 3.0. Though the signal slot used for requesting and approving in multimedia slot allocation protocol should be excluded, in this simulation, it is assumed that all slots are used in cell transmission and one byte is one cell. The whole size of using bandwidth is 155.52Mbps. The whole bandwidth allocates usable slot into each service by dynamic parameter such as average incoming rate of each service call in connection setup. However, assuming that simulation regularly uses classified slot by average bandwidth of each service, service quality is compared and analyzed.

In case of real-time variant, service quality is analyzed when slot is allocated by stage from LAS to MAS within regularly classified slot variably. When 1 frame generates per 125us in the whole bandwidth(155.52Mbps), the size of 1 frame is composed of 2430byte. In this case, if byte of frame is divided in proportion to average bandwidth of each service type defined in <Table 2>, allocated slots into each service are such as [Fig. 10].



[Fig. 10] Structure of frame(number of slot).

On the average, the number of byte generated per one frame is 800,000/8/8000=12.5 in one real-time constant terminal, 64,000/8/8000=1 in voice terminal, 4,048,000/8/8000=63.25 in real-time variant terminal and 576,000/8/8000=9 in non real-time terminal.

In this simulation, dividing the number of generated cell and allocated frame of all the services by the number of cell(12.5) of real-time constant service, the structure of allocated frame is used such as [Fig. 11].

Assuming that if the cell of each service is generated per 125μs, 8000 cells are generated for one second, simulation parameter is set up as follows.

A. real-time constant

On the average, the number of cell(the number of byte) is 12.5/12.5=1 per one frame in one terminal, so the number of cell is 1 x 8000= 8000.

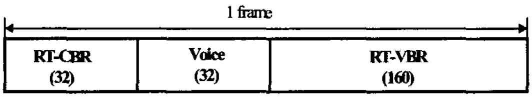
B. Voice

On the average, the number of cell(the number of byte) is 1/12.5=0.08 per one frame in one terminal, so the number of cell is 0.08 x 8000=640.

C. real-time variant

On the average, the number of cell(the number of byte) is 63.5/12.5=5.08 per one frame in one terminal, so the number of cell is 5.08 x 8000=40640.

However, in proposed algorithm if assuming that slot 1, 3, and 5 are allocated based on average 5 slot, the number of cell is generated proportionately. The average gap of exponent distribution possessing ON-OFF property of voice terminal is a^{-1}= 9, and the generated time is T= 0.32 between fixed cells. In real-time variant terminal, the average durability interval of exponent distribution possessing two phase MMPP characteristics, $\gamma 1$ is 7, $\gamma 2$ is 6, and Poasong arrival rate is λ_1 =0.3 and λ_2= 0.16.



[Fig. 11] Frame structure for simulation.

The character of real-time constant is real-time and consistency, so, I set the competition number as 0. the arc is set or paragraph is determined in the terminal(1slot/frame) that request real-time constant, so let us assume that the connected slot is always allocated to arc, and average transmission time is 125ms. And there is no cell loss, then compare the service quality according to the algorithm that is applied to real-time constant, voice and real-time variant service.

If the voice and real-time variant service waiting in buffer for slot allocation doesn't get slot allocation, increase the competition number by 1, and reach a certain number but doesn't get a slot allocation then, destroy the cell. Voice that is real-time service get competition number 2,3 and 4, real-time variant service competition number is 3.

Assuming each byte is a cell, one terminal as a standard, the simulation parameter that include the bandwidth used in average bandwidth and real-timevariant service and the number of slot used in simulation is shown in <Table 3>.

5.2 Real-time variant Service

Dynamic slot allocation algorithm proposed in this article is designed to maximize its performance in real-time variant service. It allocate slot separated into 3step to terminal which request slot in connection setup. Cell can randomly happen according

<Table 3>. Bandwidth and Threshold cell value.

average bandwidth	4,048 Kbps		
3 step bandwidth	LAS		MAS
	500Kbps	2,000Kbps	4,048Kbps
bytes/frame	8	32	64
cell no.	5,120	20,480	40,640
slot no.	1	3	5
threshold no.	2	4	7
slot no. on average bandwidth	160	160	160
maximum terminal no.	160	53	32

to the burst character of data transmitted. So it improve the service quality by dynamic reallocation method according to the number of the buffer cell of terminal in servicing. In this section, we compare the service quality of the dynamic slot allocation algorithm ADSA and fixed slot allocation algorithm. The former is proposed by threshold cell number and the latter transmit cell with only slot allocated in connection setup.

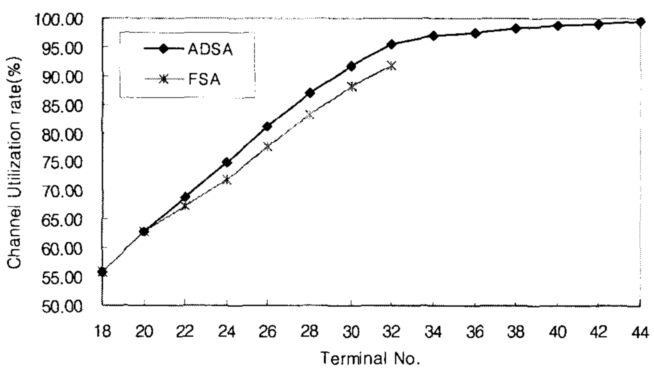
5.2.1 Service quality by threshold cell number of ADSA algorithm

The algorithm proposed to change dynamically the slot number allocated to real-time variant service according to the number of buffer cell sets the certain bigger number(threshold cell number) than the number of allocated slot. if the number of the buffer cell is bigger than the threshold cell number, i reduce the number of slot allocated to terminal which has the smallest buffer cell, increase one slot allocated to terminal which is larger than threshold cell number. Therefore, dynamic slot allocation algorithm gets service quality by variable slot allo- cation according to the threshold cell number set in all kinds of service such as a service requesting smaller bandwidth than average bandwidth or a ser- vice requesting bigger bandwidth than average. the number of total slot allocated for real-time variant service simulation is 160, all terminals are divided into 3 step and terminal number is determined like <Table 3>.

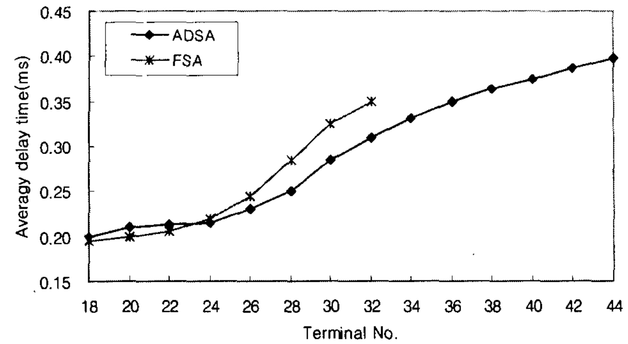
If service that terminal request is larger than average slot, then algorithm devide the total slot number by terminal number, and allocate this divided slot to each terminal regularly. And then it allocates the left slot one by one to terminal additionally. And the number of slot and connection terminal is determined by 3 step in case that the service request a smaller slot than average bandwidth.

5.3 Service Quality of ADSA

Service quality was better when the threshold cell number was 7 in simulation to set average band- width as 5 slot. According to this result, we conclude it is good to set threshold cell number close to average bandwidth. Therefore in ADSA algorithm proposed by 3 step, I set the relation between number of slot allocated and threshold as <Table 3> for simulation. through the simulation the result of service quality is presented in [Fig.12], [Fig.13], [Fig.14]



[Fig.12] Channel utilization of ADAS and FSA algorithm.



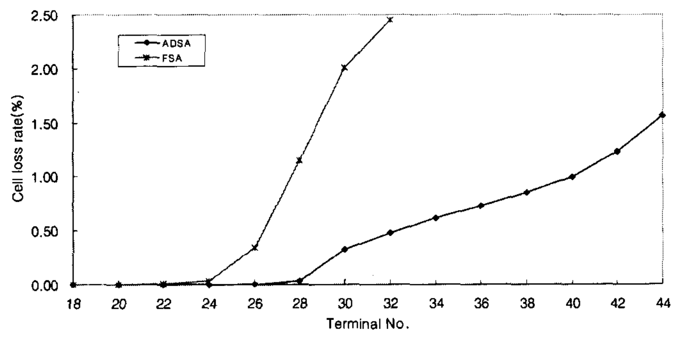
[Fig.13] Average delay time of ADAS and FSA algorithm.

As we can see in the [Fig. 12] dynamic slot allocation algorithm which has marginal cell value has higher channel utilization rate than fixed slot allocation. also, there is 4% difference in average between the fixed slot allocation algorithm to average bandwidth and the same terminal number. In ADSA, it is able to use 44 terminals, we can use 37.5% more terminal in channel utilization rate than fixed slot allocation algorithm.

[Fig. 13] shows the average delay time of dynamic and fixed slot allocation algorithm. as the terminal number increases the difference of average delay time between the dynamic slot allocation algorithm and fixed slot allocation algorithm. This is resulted from the difference of slot number. because the slot used in dynamic slot allocation algorithm is more than in the fixed slot allocation algorithm, the average delay time and the cell loss rate decrease. In the case of the same terminal, it is possible to reduce 14% of delay time with 32 terminal number.

[Fig. 14] shows the sell loss rate of dynamic and fixed slot allocation algorithm. it shows that the cell loss rate of the fixed slot allocation algorithm is higher than the rate of dynamic slot allocation algorithm. After the terminal number is 26, the cell loss rate of fixed slot allocation algorithm increases drastically and the gap with the dynamic slot allocation algorithm. The terminal number which satisfies 1% of limit in fixed slot allocation algorithm is 40, and the difference is 48%.

Dynamic slot allocation algorithm is proposed to satisfy the service quality of real-time variant traffic



[Fig.14] Cell loss rate of ADSA and FSA algorithm.

in which the occurrence of cell is burst. the DSA changes dynamically the average delay time and the limit of cell loss rate of all terminal to fit number of slot allocated to each terminal according to the condition of the buffer.

Especially the algorithm which allocate the optimal slot at each step do efficiently slot allocation.

6. Conclusion

The multimedia slot allocation protocol separates multimedia application service into real-time constant, voice, real-time variant and non real-time service, allocate dynamically frame slot which is available to each service periodically according to average arrival rate requested when service set the arc at connection setup, average call time and average bandwidth. Moreover in real-time variant service, I analysis the arc bandwidth requested by terminal in connection setup, divide 3 steps in frame of real-time variant already set, allocate slot dynamically and certificate it to satisfy the balancing QoS in all kinds of multimedia application service.

Most designed slot allocation protocol allocate statically slot based on the average bandwidth. So even in case to request less service than average slot, cell loss rate gets high in standard of average bandwidth. However, the dynamic slot allocation algorithm of ADSA method proposed in this thesis give slot allocation variant by applying threshold cell number, separate the band under average bandwidth into 3 steps and allocate slot according to the service requested. And I get improved result compared with existing slot allocation algorithm like following.

The simulation of dynamic slot allocation algorithm proposed for real-time variant service compare the result from threshold cell number set by average bandwidth, prove that using threshold in dynamic slot allocation is better than FSA. Comparing dynamic slot allocation algorithm proposed by this result with fixed slot allocation in the same terminal number, dynamic slot allocation can reduce 14% of delay time. And also, the number of terminal in dynamic slot allocation is more excellent by 48% in satisfying 1% of cell loss rate limit than in fixed slot allocation.

ADSA, the dynamic slot allocation protocol for multimedia, proposed in this thesis has proved its superiority to the static slot allocation algorithm for slot allocation of realtime services such as realtime-equilibrium, voice and real-time variant identified in connection setup. In addition, it is verified that they have less cell loss rate than the old dynamic slot allocation protocol as they allocate proper slots in connection setup step based on the bandwidth of the requesting handset. The designed protocol can enhance the channel usage rate and supports all defined multimedia services. It can also be used as the medium access control protocol that supports multimedia access in the next generation wireless network.

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김 현 주

1989년 명지대학교 전자공학 학사
1991년 명지대학교 전자공학과 공학석사
2000년 명지대학교 전자공학과 공학박사
1988년 ~ 1990년 효성컴퓨터 전자연구소
1991년 ~ 1992년 삼성전자 컴퓨터 개발실
1993년 ~ 2000년 명지전문대학 컴퓨터과 부교수
1999년 ~ 현재 한국컴퓨터산업교육학회 기획이사
2001년 ~ 현재 명지전문대학 정보통신과 부교수
관심분야 : 무선통신, 가상교육