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Adaptive and Prioritized Random Access and Resource Allocation Schemes for Dynamic TDMA/TDD Protocols

Hyun-Ho Choi*, ***Member, KIICE***

Donald Bren School of Information and Computer Science, University of California, Irvine, CA 92697, USA, and
Department of Electrical, Electronic and Control Engineering, Hankyong National University, Anseong 17579, Korea

Abstract

The medium access control (MAC) protocol based on dynamic time division multiple access/time division duplex (TDMA/TDD) is responsible for random access control and radio resource allocation in dynamic traffic environments. These functions of random access and resource allocation are very important to prevent wastage of resources and improve MAC performance according to various network conditions. In this paper, we propose new random access and resource allocation schemes to guarantee quality of service (QoS) and provide priority services in a dynamic TDMA/TDD system. First, for the QoS guarantee, we propose an adaptive random access and resource allocation scheme by introducing an access probability. Second, for providing priority service, we propose a priority-based random access and resource allocation scheme by extending the first adaptive scheme in both a centralized and a distributed manner. The analysis and simulation results show that the proposed MAC protocol outperforms the legacy MAC protocol using a simple binary exponential backoff algorithm, and provides good differential performance according to priorities with respect to the throughput and delay.

Index Terms: Dynamic TDMA/TDD, Medium access control, Priority service, Quality of service, Random access

I. INTRODUCTION

The dynamic time division multiple access/time division duplex (TDMA/TDD) protocol has a flexible frame structure suitable for centralized control. Thus, it is widely used for supporting the quality of service (QoS) and a priority service in wireless networks. However, there has been little research on an efficient control of its time resources to support QoS and priority in dynamic traffic environments [1-3].

In most studies, a simple binary exponential backoff algorithm was used for access control because it is easy to implement and operates in a distributed manner [4-6]. Thus, this algorithm is mainly used in the carried sense multiple access (CSMA)-based protocol. However, this backoff algorithm is not suitable for the TDMA/TDD frame structure because this frame structure generally assigns a fixed number of resources for random access. Therefore, it is difficult to prevent access collisions in the case of a high traffic load and to support a priority access service [7]. Moreover, some resource allocation schemes have been developed for dynamic TDMA/TDD systems, but these focus mainly on solving optimization problems from the perspective of system optimization and do not provide concrete algorithms for a practical operation of TDMA/TDD systems.

Therefore, in this study, we have attempted to develop a specific algorithm to support QoS and priority services in

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***Corresponding Author** Hyun-Ho Choi (E-mail: hyunhoc1@uci.edu, Tel: +1-949-302-1479)
Donald Bren School of Information and Computer Science, University of California, Irvine, CA 92697, USA.

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TDMA/TDD systems, in order to enhance the medium access control (MAC) performance of a conventional TDMA/TDD framework. In this context, we first propose an adaptive random access and resource allocation scheme for QoS guarantee by introducing an access probability. Then, by extending this adaptive scheme, we propose a priority-based random access and resource allocation scheme for providing differential services. Through Markov modeling, we analyze the performance of a TDMA/TDD system using the proposed schemes with respect to throughput and delay.

The rest of this paper is organized as follows: we describe the standard MAC protocol by using a binary exponential backoff algorithm in Section II. We explain the proposed schemes in detail in Section III. Numerical analysis is discussed in Section IV. Analysis and simulation results are provided in Section V. Finally, concluding remarks are presented in Section VI.

II. DYNAMIC TDMA/TDD PROTOCOLS

The basic frame structure of a typical dynamic TDMA/TDD protocol is illustrated in Fig. 1. Each MAC frame has a fixed length of 2 ms and is continuously transmitted between an access point (AP) and a mobile terminal (MT). The MAC frame structure consists of time slots for the broadcast channel (BCH), frame channel (FCH), access feedback channel (ACH), and the random channel (RCH). These channels are used for exchanging the control message. Further, the MAC frame has data transmission phases of downlink (DL), uplink (UL), and directlink (DiL). These phases are dynamically allocated depending on the need for transmission resources [7, 8].

BCH is used for broadcasting general control information and several status bits to all MTs within a radio cell. FCH informs the MTs of the current frame composition and resource allocation pattern scheduled by an AP. ACH sends acknowledgements about an MT's access attempts in the previous frame. RCH is an uplink channel and is used when the MTs need random access to request uplink resources. The user data are transmitted in the DL phase (from an AP to an MT), UL phase (from an MT to an AP), and DiL phase (optional and directly used between two MTs).

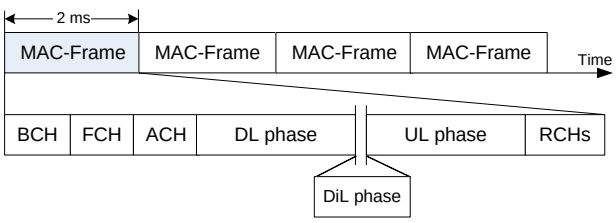

Fig. 1. MAC frame structure of a typical dynamic TDMA/TDD protocol.

The allocation of these resources for the transmission of user data as well as the allocation of the appropriate number of RCHs for the random access can be dynamically controlled by the AP scheduler for every MAC frame.

For the access request, an MT must use RCH, which is controlled by a contention window CW_a maintained by each MT. The contention window is derived from a, which denotes the number of retransmission attempts made by the MT. For the first access attempt, a should be set to 0. The size of CW_a is defined as follows [3]:

1) Initial attempt:

$$a = 0, CW_0 = n. \tag{1}$$

2) Retransmission:

$$a \geq 1, CW_a = \begin{cases} 256, & \text{if } 2^a \geq 256 \\ 2^a, & \text{if } n < 2^a \leq 256 \\ n, & \text{if } n \geq 2^a \end{cases}. \tag{2}$$

where n represents the number of RCHs in the MAC frame. The RCH number used for the access attempt is determined by a uniformly distributed random integer value r_a within [1, CW_a]. An MT starts counting r_a from the first RCH in the MAC frame, in which the ACH indicates the failure of the previous access attempt. In the initial attempt, the MT starts counting with the first RCH in the current frame. This first RCH is specified as $r_a = 1$. The RCH with a number equal to r_a is the RCH that the MT can access. The MT cannot access the RCH until its counter has reached the RCH with the number equal to r_a. After the MT receives the ACH with positive feedback, a is reset to 0 and the MT can transmit data in the uplink phase.

III. PROPOSED SCHEMES

A typical TDMA/TDD system provides the basic frame structure but does not mention any specific control algorithm for the operating parameters. However, the determination of the number of RCHs to be used is very important because too many RCHs may result in a waste of radio resources and too few RCHs may result in many access collisions. Moreover, it is well-known that the standard CW control algorithm has a limit to control the access of MTs robustly, particularly in heavy traffic load situations. Considering these issues, we attempt to enhance both the random access and the resource allocation mechanisms simultaneously. First, we propose an adaptive random access and resource allocation scheme for the QoS guarantee, and then, we present a priority-based random access and resource allocation scheme for priority services.

A. Adaptive Random Access and Resource Allocation Scheme

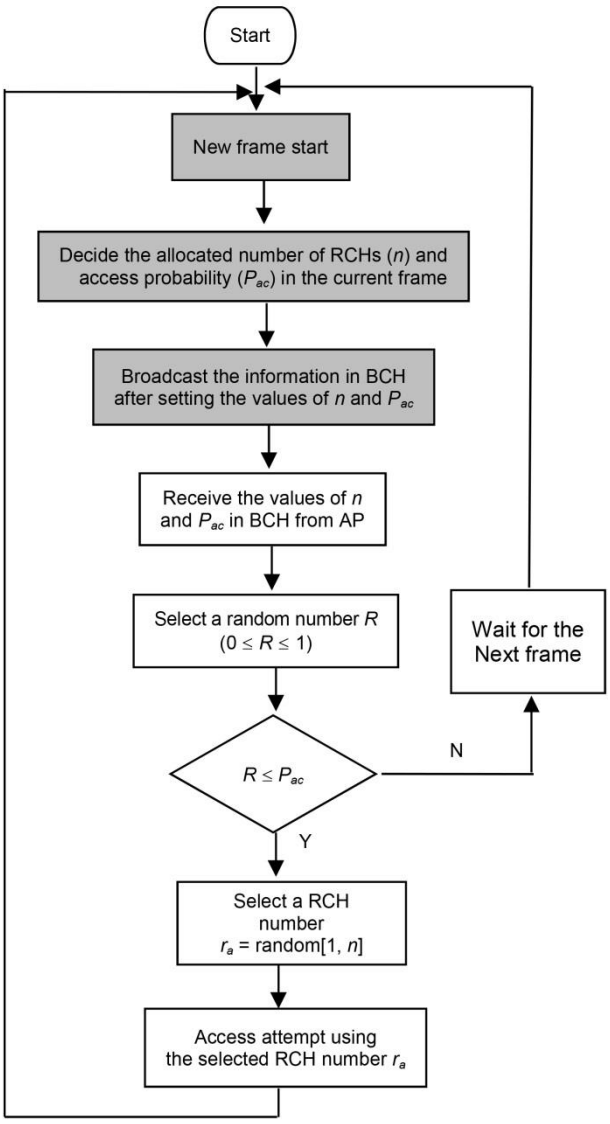

Fig. 2. Procedure for the proposed adaptive random access and resource allocation scheme.

For the adaptiveness, in this scheme, the AP controls the number of RCHs allocated to the current frame by using an access probability introduced newly and the estimated number of MTs accessed in the previous frame. Then, the AP broadcasts this access probability for the access control of MTs, and each MT performs an access attempt on the basis of the access probability. Fig. 2 shows the operation of the AP and the MT for the proposed scheme. Gray blocks correspond to the operation of the AP, and white blocks correspond to the operation of the MT.

This procedure operates frame by frame. After a new frame starts, the AP estimates the number of MTs that were accessed in the previous frame and determines both the number of RCHs and the access probability in the current frame. First, the number of RCHs allocated in the current frame t, $n(t)$, is calculated as follows:

$$\hat{n}(t) = \frac{P_0}{P_{ac}(t-1)} \times k(t-1) + \alpha \tag{3}$$

$$n(t) = \min\{\hat{n}(\mathrm{t}), R_{\max}\}, \tag{4}$$

where P_0 denotes the initial access probability, which we desire to broadcast at the beginning, and $P_{ac}(t\text{-}1)$ represents the access probability used in the previous frame. $k(t\text{-}1)$ refers to the number of MTs that were accessed in the previous frame and is assumed to be the sum of the number of successful RCHs and twice the number of the collided RCHs. The adjustment factor, α, denotes the additional allocated number of RCHs for increasing the probability of successful access. Even if the calculated $n(t)$ is greater than $R_{\max}$, i.e., the maximum assignable number of RCHs, $n(t)$ is limited by $R_{\max}$, as shown in (4). In this case, the AP cannot use the initial access probability P_0 for broadcasting; thus, a new access probability $P_{ac}(t)$ should be calculated as follows:

$$P_{\mathrm{ac}}(t) = \frac{n(t)-\alpha}{k(t-1)} \times P_{\mathrm{ac}}(t-1). \tag{5}$$

Accordingly, the AP uses a new access probability $P_{ac}(t)$ lower than P_0. After the AP sets the values of $n(t)$ and $P_{ac}(t)$ in BCH, it broadcasts this information to the MTs.

When an MT receives this information through BCH, it generates a random number R between 0 and 1. If the selected R is lower than the access probability, the RCH number used for the access attempt is selected by a random integer value r_a within [1, $n(t)$] and the MT starts an access attempt at the corresponding RCH equal to r_a. Otherwise, the MT does not transmit data in the current frame and starts this access procedure again in the next new frame.

Therefore, this proposed scheme controls the MT access adaptively, by broadcasting the access probability instead of employing the standard contention window method and dynamically adjusts the number of RCHs every frame, according to the current traffic load. Even though the required number of RCHs exceeds the maximum value when the traffic load is heavy, it naturally reduces the access probability and eventually induces only MTs that can be serviced by the offered number of RCHs to access.

B. Priority-Based Random Access and Resource Allocation

By naturally extending the previous scheme, we also propose a priority-based random access and resource allocation scheme in order to offer differential services. We devise two types of schemes according to the entity (MT or AP) that has the initiative. One scheme provides the differential service by controlling the distributed MTs; thus, it is called the distributed priority-controlled access (DPA)

scheme. The other scheme provides the differential service by controlling the centralized AP; thus, it is called the centralized priority-controlled access (CPA) scheme.

1) Distributed Priority-Controlled Access

The DPA scheme makes the MT execute the priority control. In other words, the AP broadcasts the number of RCHs, $n(t)$, and the access probability, $P_{ac}(t)$, obtained by (3)-(5) in the current frame. If the MT receives the broadcast information from the AP, it adjusts the access probability according to its priority level as follows:

$$P_{ac}^{i}(t) = P_{\mathrm{ac}}(t) - \delta_{\mathrm{i}}. \tag{6}$$

Here, i represents the priority level and δ_i denotes the adjustment factor given according to priority level i. The value of δ_i increases with a decrease in the priority level. Therefore, the initially received $P_{ac}(t)$ varies dynamically according to the priority level.

The MT can make an access attempt only when the generated random number R is lower than the adjusted access probability P_{ac}^{i}. Thus, its access opportunity is dynamically varied in proportion to priority level i. Eventually, the high-priority MTs can have more access opportunities and thus, higher probability of successful access. In the case of low-priority MTs, the opposite phenomenon occurs. If the MT obtains a chance of an access attempt, it chooses an RCH number, r_a, between 1 to $n(t)$ and starts an access attempt at the corresponding RCH equal to r_a.

The DPA scheme can provide the priority service simply by a few modifications of the MT operation. However, it may be difficult to provide guaranteed services for MTs requiring a particular QoS level, because the DPA operates in a distributed manner; i.e., it is controlled by the MT alone.

2) Centralized Priority-Controlled Access Scheme

In the CPA scheme, the AP performs the priority controls as it decides both the number of RCHs and the access probability corresponding to each priority level. This broadcasting information is based on (3)–(5) but is differently obtained according to each priority level.

When priority level i is given, the estimated number of RCHs allocated to MTs with priority level i can be calculated as follows:

$$\hat{n}_{\mathrm{i}}(t) = \frac{P_0^i}{P_{ac}^i(t-1)} \times k_{\mathrm{i}}(t-1) + \alpha_{\mathrm{i}} \tag{7}$$

$$n_{\mathrm{i}}(\mathrm{t}) = \begin{cases} \hat{n}_{\mathrm{i}}(t), & \text{if } \sum_{\mathrm{i}} \hat{n}_{\mathrm{i}}(t) \le R_{\max} \\ \hat{n}_{\mathrm{i}}(t) - 1, & \text{otherwise.} \end{cases} \tag{8}$$

Here, all parameters are classified by priority level i and the number of additionally allocated RCHs, α_i, is set differentially according to the priority level. In other words, the higher the priority level is, the larger is α_i. Therefore, the allocated number of RCHs is increases with an increase in the priority level; thus, a high-priority MT can access the RCH more successfully. It should be noted that if the total number of allocated RCHs exceeds $R_{\max}$, the number of RCHs allocated to each priority, $\hat{n}_i(t)$, decreases one by one, beginning with a low priority level, until the constraint is satisfied as shown in (8). In this case, the AP does not use the initial probability P_0^i and recalculates the access probability suitable to the newly allocated $n_i(t)$ as follows:

$$P_{ac}^{i}(t) = \frac{n_{\mathrm{i}}(\mathrm{t}) - \alpha_{\mathrm{i}}}{k_{\mathrm{i}}(t-1)} \times P_{ac}^{i}(t-1). \tag{9}$$

By using (7)–(9), the AP controls both the number of RCHs, $n_i(t)$, and the access probability, $P_{ac}^{i}(t)$, according to the priority level. These operations of the AP make a high-priority MT use larger values of n_i and P_{ac}^{i} than a low-priority MT. Hence, the CPA scheme can support priority services effectively by this discriminated control at the AP. If these values are broadcasted to the AP cell, each MT begins an access request by using the received n_i and P_{ac}^{i} that correspond to its priority class.

Note that although the CPA scheme has more complexity than the DPA scheme, it can support effective priority services according to the QoS, irrespective of the distribution of MTs with each priority level.

IV. PERFORMANCE ANALYSIS

In the proposed schemes, the operation of an MT can be modeled by two states. The MT can be either in the waiting state (WAIT) standing by the generation of a new request packet or in the contending state (CONT) trying to transmit the generated request packet. The state transition of an MT is illustrated in Fig. 3. Here, we assume that the request packet is generated independently in each MT and follows the Bernoulli distribution with λ_0 packets/frame. We denote P_{succ} as the transmission success probability. When the total number of MTs is N, the system can be described by the state variable N_c, which is the number of MTs in the contending state. Then, the number of MTs in the waiting state becomes $N_w = N - N_c$. We can model the evolution of the system as a Markov chain. This Markov chain is ergodic since it is obviously irreducible and has a finite number of

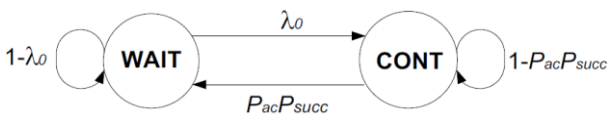

Fig. 3. Two-state Markov chain model for the proposed scheme.

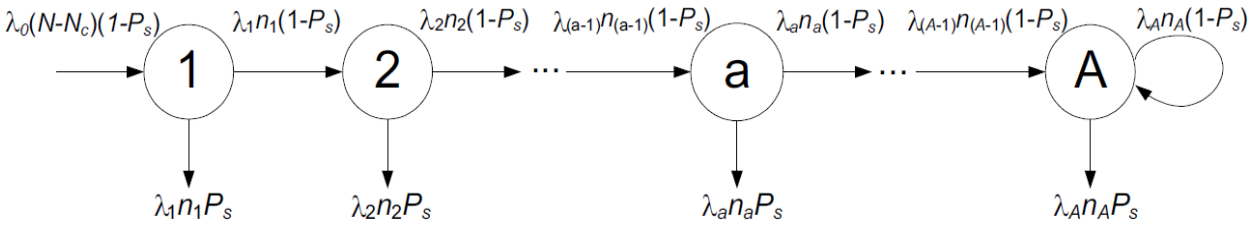

Fig. 4. Markov chain model for a legacy TDMA/TDD system.

states. Thus, a stationary distribution of the system state exists [9]. Therefore, we express the stationary distribution of the contending state as follows:

$$\Pi = \{\pi(n_c)\} = \{P(N_c = n_c)\}. \tag{10}$$

We need to construct a one-step transition probability matrix and solve the balance equation to find Π. We can express the one-step transition probability matrix as follows:

$$\mathbf{P} = \{P(N_c(x+1) = j \mid N_c(x) = i)\}. \tag{11}$$

where $i, j = 0, \ldots, N$ and $N_c(x)$ denotes the number of MTs in the contending state at the beginning of the xth frame. The state transition probability is given by

$$P_{ij} = \{P(N_c(x+1) = j \mid N_c(x) = i)\} = \sum_{k=\max(0,i-j)}^{\min(i,N-j)} \Phi(k,i,R)B(N-i, j-(i-k), \lambda_0) \ . \tag{12}$$

where k denotes the number of MTs leaving the contending state in the current frame, $\Phi(k, i, R)$ represents the probability that among i contending MTs, k MTs transmit request packets successfully in a frame with R RCHs, and $B(\cdot)$ refers to the binomial distribution given by $B(x, y, z) = \binom{x}{y} z^y (1-z)^{x-y}$. Using the numerical result in [10], we can calculate the probability Φ as follows:

$$\Phi(x,y,z) = \frac{(-1)^x y! z!}{x! z^y} \sum_{i=x}^{\min(y,z)} (-1)^i \frac{(z-i)^{y-i}}{(i-x)!(y-i)!(z-i)!}. \tag{13}$$

With the one-step state transition probability, we can solve the following balance equations:

$$\Pi = \Pi \cdot \mathbf{P} \text{ and } \sum_{n_c} \pi(n_c) = 1\,, \tag{14}$$

and find the stationary distribution of the contending state, Π.

We consider the average throughput, delay, and transmission success probability as the performance measures. First, the average number of request packets successfully transmitted in a frame, η, can be calculated as follows:

$$\eta = \sum_{n_c=0}^{N} \sum_{k=0}^{n_c} k P_{ac} \Phi(k, n_c, R) \pi(n_c)\,. \tag{15}$$

Since the average number of MTs accessing the RCHs is $N\lambda_0$, the average transmission success probability, P_{succ}, can be obtained as follows:

$$P_{succ} = \frac{\eta}{N\lambda_0}. \tag{16}$$

The average throughput is defined as the total number of MTs that access an RCH successfully over the total number of offered RCHs. If the average number of offered RCHs is R, the average throughput S can be expressed as follows:

$$S = \frac{\eta}{R}. \tag{17}$$

The average delay is defined as the average waiting time until the beginning of a successful transmission. By using Little's formula [11], we can calculate the average delay, D, as follows:

$$D = \frac{E(N_c)}{S} = \frac{\sum_{n_c=0}^{N_c} n_c \pi(n_c)}{S}. \tag{18}$$

On the other hand, in the legacy binary exponential algorithm, the contention window size CW_a increases exponentially whenever the access request fails, and thus, the arrival rate of the request packets decreases according to the value of CW_a. Thus, its backoff algorithm can be modeled to the slotted ALOHA system with a binary exponential backoff [12]. Since the contending MT has its own window size and arrival rate according to the backoff frequency, the contending state in Fig. 3 is divided into several backoff states, as shown in Fig. 4. Each backoff state generates a new request packet at a rate of λ_a packets/frame. The arrival rate λ_a is decided by the contention window size as follows:

$$\lambda_a = \frac{1}{CW_a}, \ (a = 1,2,\ldots,A)\,. \tag{19}$$

We use a mean value equilibrium analysis [13] based on equating flow rates into and out of each system state, n_i. The state transition diagram shows the average flow rates into and out of each of the A classes of contending MTs. The probability of the successful transmission of a request packet in an RCH slot, given the current state vector n, is denoted as $P_s(n)$. Transitions into the state with $a = 1$ are due to the arrival of a new request. Entries into states with other values of a are due to a retransmission from the state with $a-1$ previous retransmissions. Further, requests that are retransmitted more than A times use the retransmission rate corresponding to $a = A$, creating a loop at $a = A$. At equilibrium, the mean inflow and outflow rates into each state are postulated to be equal. This generates the set of A equations, as follows:

$$\begin{cases} \lambda_1 n_1 = \lambda_0 (N - N_c)\big(1 - P_s(n)\big), \text{for a} = 1 \\ \lambda_a n_a = \lambda_{a-1} n_{a-1}\big(1 - P_s(n)\big), \text{for a} = 2,3,\dots,A-1 \\ \lambda_A n_A = (\lambda_{A-1} n_{A-1} + \lambda_A n_A)\big(1 - P_s(n)\big), \text{for a} = A\ . \end{cases} \tag{20}$$

Here, the total number of contending MTs is denoted as $N_c = \sum_{a=1}^{A} n_a$. The probability of successful access, $P_s(n)$, is calculated as follows:

$$\begin{aligned} P_s(n) &= \exp(-G) \\ &= \exp[-\{(N - N_c)\lambda_0 + \textstyle\sum_{\mathrm{a}=1}^{A} n_a \lambda_a\} T]\ , \end{aligned} \tag{21}$$

where T denotes the RCH slot size in seconds.

The above set of A nonlinear simultaneous equations can be solved numerically to determine the equilibrium state vector n^*. The solution procedure starts with an initial guess of the total contention, N_c. The corresponding values of n_a are obtained from (20) in the order of increasing a. The probability of successful access $P_s(n)$ is then updated using the new value of G from (21), and the calculation is repeated for the same guess N_c. This iterative procedure is continued until the change in n_a, $a = 1, 2, \dots, A$, between successive iterations is sufficiently small. Having obtained a solution for n at a given N_c, we can determine the equilibrium solution n_a^* by testing for

$$d(N_c) = N_c - \textstyle\sum_{\mathrm{a}=1}^{A} n_a = 0. \tag{22}$$

If $d(N_c)$ is nonzero, the value of N_c is incremented and the above procedure is repeated. This operation is continued until an equilibrium solution is found.

For a stable system, the average throughput and delay are approximated from the equilibrium backlog by using Little's formula. They can be respectively expressed as follows:

$$S = (N - N_c^*)\lambda_0 T\ , \tag{23}$$

$$D = \frac{N_c^*}{\lambda_0 (N - N_c^*)}. \tag{24}$$

V. RESULTS AND DISCUSSIONS

For the evaluation, we consider one wireless LAN cell, which has one AP and many MTs. The radio channel environment is assumed to have no transmission error between the AP and the MT, and the transmission fails only when there is an access collision [14]. Moreover, we assume that each MT generates a request message with a Poisson arrival rate λ. Here, λ is assumed to be the superposition of newly arriving and retransmitted request messages [15]. Moreover, we perform a Monte Carlo simulation using MATLAB to verify the numerical analysis. Further, we compare the proposed scheme with a legacy scheme that has a fixed number of RCHs.

Table 1 shows the used parameters. In this analysis, the arrival rate of access requests, λ, is 100 per second (i.e., the inter-arrival time between access requests is 0.01 s, which is equivalent to 5 MAC frames). The length of a request message is equal to one RCH duration, and every MT has homogeneous traffic generation [16]. To evaluate the priority-based scheme, we assume three priority classes: high, medium, and low priority [17]. In the DPA scheme, the parameter δ_i is set to 0 (high priority), 0.1 (medium priority), and 0.2 (low priority), which are adopted as reasonable values to discriminate the received access probability. Moreover, the adjustment factor α is set to 3, which is a suitable value for the number of additionally allocated RCHs. In the CPA scheme, α_i is set to 2 (high priority), 1 (medium priority), and 0 (low priority). Irrespective of the priority classes, the used initial access probability P_0 is 1, which implies that the AP allows an MT to access an RCH as much as possible in the case of a normal traffic load.

Fig. 5 shows the throughput as the number of MTs increases. The result shows that the throughput of the scheme with a fixed number of RCHs exhibits an ALOHA-like throughput versus the number of MTs.

Table 1. Parameter setup

Name	Value	Description
T_{frame}	2	Duration of one MAC frame (ms)
Λ	100	Arrival rate of access request (1/s)
P_0	1	Initial access probability
$R_{\max}$	31	Maximum number of RCHs
α	3	Adjustment factor for the number of RCHs
δ	0.1	Adjustment factor for the access probability

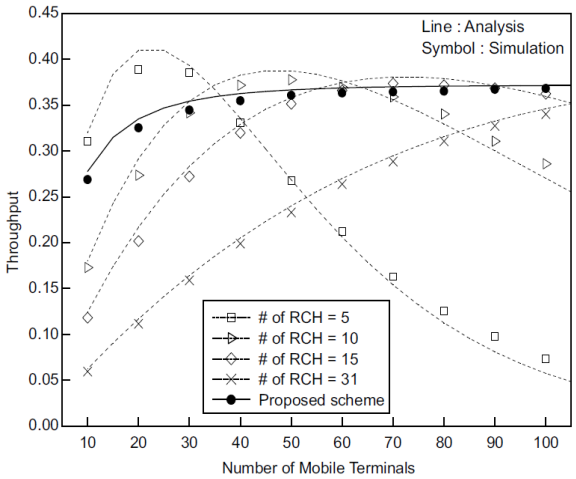

Fig. 5. Throughput vs. the number of mobile terminals (MTs).

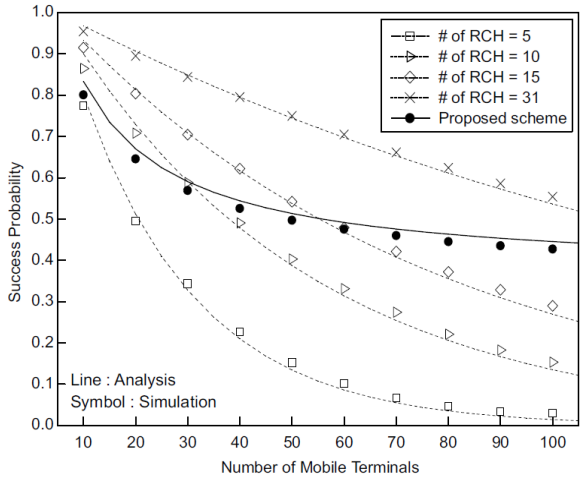

Fig. 7. Probability of successful access vs. the number of MTs.

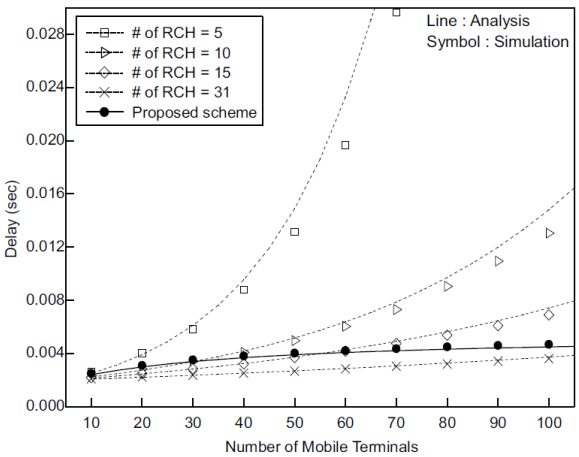

Fig. 6. Delay vs. the number of MTs.

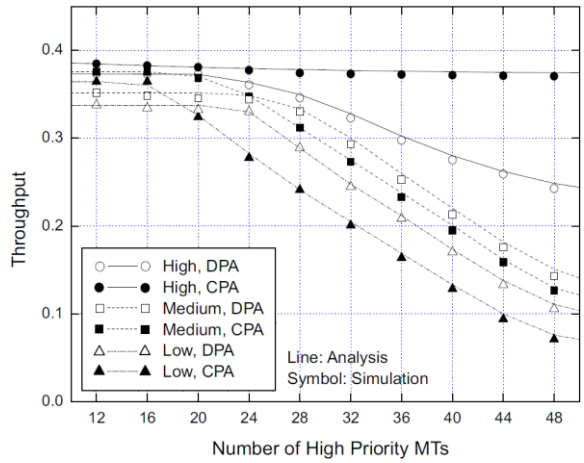

Fig. 8. Throughputs of DPA and CPA vs. the number of high-priority MTs.

In other words, the throughput increases with the traffic load, but eventually decreases as the traffic load becomes larger. This is because the legacy scheme uses a fixed number of RCHs and the access collision increases with an increase in the number of MTs. However, the proposed scheme maintains a throughput almost similar to the peak throughput of the legacy scheme although the number of MTs increases. That is, the throughput of the proposed scheme is not decreased but is maintained constant as the traffic load is increased because it controls MT accesses using the access probability.

Fig. 6 shows the delay performance versus the number of MTs. The delay of the legacy scheme increases exponentially with an increase in the number of MTs, but the delay of the proposed scheme is not more than 0.006 seconds, which is just a three-frame duration. Note that although the proposed scheme does not have a better throughout than the legacy scheme in the case of five fixed RCHs when the number of MTs is less than 40, as shown in Fig. 5, it has a better delay performance under the same condition, as shown in Fig. 6. Moreover, the proposed scheme shows an almost constant delay despite the traffic variation because it efficiently controls both the RCH allocation and the MT access. This implies that the proposed scheme can be adapted to delay critical services such as a real-time service.

Fig. 7 shows the probability of a successful access attempt. The probability of successful access of the legacy scheme using a fixed number of RCHs decreases quickly with an increase in the number of MTs, but that of the proposed scheme is decreases slowly and converges at 0.47 because it controls the MT access using the access probability in accordance with the traffic load. Therefore, the proposed scheme shows a better performance in terms of the probability of successful access with an increase in the number of MTs.

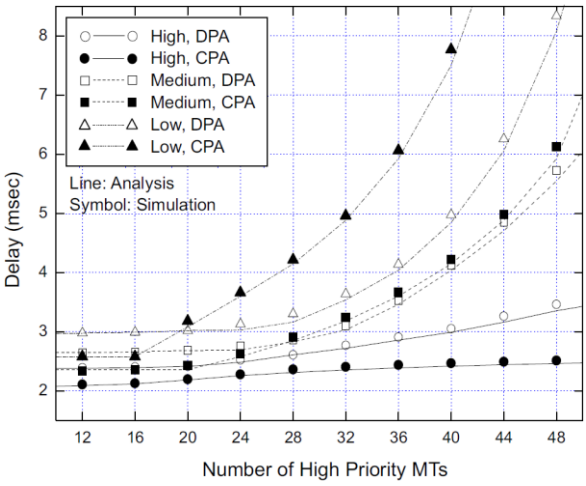

Fig. 9. Delays of DPA and CPA vs. the number of high-priority MTs.

Figs. 8 and 9 show the throughput and delay of the proposed DPA and CPA schemes, respectively, versus the number of high-priority MTs when there are 20 medium-priority MTs and 20 low-priority MTs. The throughput and delay graphs of the two schemes show obvious differential performances, according to the service priority. In the DPA scheme, the performance difference between each priority increases with an increase in the number of high-priority MTs. However, in the CPA scheme, the high-priority service maintains an almost constant delay and throughput, even if the number of high-priority MTs increases. This phenomenon implies that the CPA scheme guarantees a high-priority service preferentially. This is because it adaptively controls both the MT access and the AP resources according to the number of MTs that require high priority. However, this control induces the CPA scheme to have a worse performance than the DPA scheme in the case of medium- and low-priority services. In contrast, the DPA scheme does not show a constant performance for a high-priority service according to the traffic load, because it controls the MT access just by differentiating the access probability.

VI. CONCLUSION

In this paper, we proposed an adaptive random access and resource allocation scheme by exploiting the access probability according to the traffic load in a dynamic TDMA/TDD system. In addition, we extended it to the priority-based random access and resource allocation scheme in order to provide differential services. Numerical analysis and simulation showed that the proposed adaptive scheme outperforms the legacy scheme using fixed RCH allocation in terms of the throughput, delay, and transmission success probability. Further, the proposed adaptive scheme effectively offers a differential performance according to the priority level. Notably, the CPA scheme shows a more reliable performance in the case of a high-priority service because it exercises centralized control. We believe that the proposed random access and resource allocation scheme can be effectively applied to any dynamic radio communication system that requires the QoS guarantee and priority service.

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Hyun-Ho Choi
received his B.S., M.S., and Ph.D. in Electrical Engineering from Korea Advanced Institute of Science and Technology (KAIST), Korea, in 2001, 2003, and 2007, respectively. From Feb. 2007 to Feb. 2011, he was a senior engineer at the Communication Lab., Samsung Advanced Institute of Technology (SAIT), Korea. Since March 2011, he has been an associate professor in the Department of Electrical, Electronic, and Control Engineering, and the Institute for Information Technology Convergence, Hankyong National University, Korea. His current research interests include bio-inspired algorithms, in-network computations, mobile ad hoc networks, and next-generation wireless communication and networks. He is a member of IEEE, IEICE, KICS, and KIICE.