# Discriminative Collision Resolution Algorithm for Wireless MAC Protocol

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**Abstract.** This paper proposes a discriminative collision resolution algorithm for the wireless medium access control protocols to support the quality of service requirements of real-time applications. Our algorithm deals with access requests in different ways depending on their delay requirements. In our algorithm, a collision resolution period is used to quickly resolve collisions for the delay sensitive traffic in order to support their delay requirements. Performance analysis shows that our algorithm may successfully meet the delay requirement of real time applications by reducing access delays and collisions.

## 1 Introduction

Most wireless MAC protocols are based on a demand-assignment scheme, which employs a frame structure consisting with a contention and a reservation period. PRMA/DA and MASCARA are examples of the wireless MAC protocols [1,2]. These protocols employ the Slotted ALOHA (S-ALOHA) to resolve the contention of multiple access requests. With S-ALOHA, initial and retry access requests use the same contention window without considering their priorities. Therefore, all access requests have the same opportunity regardless of whether the requests are delay sensitive or not. As a result, the access delay requirement cannot be guaranteed, a result undesirable for delay sensitive multimedia traffic [3,4,5]. As traffic load increases, this problem becomes more serious and the system throughput drastically drops.

The aim of this paper is to propose an algorithm for wireless MAC protocols to support the QoS requirements of real-time applications. Proposed algorithm deals with access requests in different ways depending on their delay requirements. Thereby, it could successfully support the delay requirement of real time applications by reducing access delays and collisions

## 2 Discriminative Collision Resolution Algorithm (DCRA)

Proposed algorithm, DCRA, is based on traffic discrimination depending on its delay QoS requirement when it accesses the contention period and resolves the collisions. To do this, traffic types are classified into delay-sensitive and delay-insensitive traffic

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on its delay requirement. Fig. 1 shows the frame structure used for our new algorithm, which is divided by two sub-periods; the Contention Period (CP) and the Reservation Period (RP). Furthermore, CP is consisted with three sub-periods; the Collision Resolution Period (CRP), the Urgent Period (UP), and the Normal Period (NP).

First, each Mobile Terminal (MT) sends its request to the access point (AP) through UP when it has delay-sensitive traffic in its queue; otherwise, the MT sends a request through NP. These request messages will be contended with other request messages from other MTs in UP or NP. The AP collects the information on the requests made in CP and determines which terminals are successful as well as how many time slots are collided on the *i*-th frame.

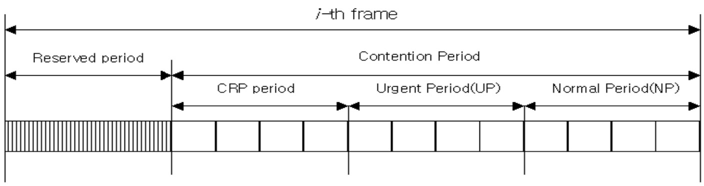



**Fig. 1.** Frame structure for DCRA

This collected information is then broadcast to MTs through the downlink. If the request was successful at a MT, its traffic can be sent through the reservation period, which is allocated by the AP. On the other hand, if MT knows that its request was collided, it has to do retry. The backoff time that the collided MT has to wait for the next retransmission is computed in different ways with ordinary algorithms depending on where the collision has occurred in UP or NP. If collision was happened in NP, it executes the standard S-ALOHA algorithm. On the other hand, if collision was in UP on the *i*-th frame, AP allocates CRP for the (*i*+1)-th frame. Similarly, if the collision is occurred in the allocated CRP on the *i*-th frame, AP allocates another CRP for the (*i*+1)-th frame. It should be noted that the CRP is used only for resolving collisions that occur in UP or CRP. Note that AP does not allocate a CRP when there was no collision in NP. The length for CRP allocated for the (*i*+1)-th frame, denoted by $T_{CRP}$, is determined by (1a) when the number of collided time slots in UP and CRP on the *i*-th frame is given by $N_{COL}$. The collided MT determines the slot position within CRP to access for retransmission by picking up a random value using (1b).

$$T_{CRP} = MIN[2^{N_{COL}}, MAX_{CRP}] \tag{1a}$$

$$T_{bo} = (T_{CRP} * rand()) * T_s \tag{1b}$$

where $MAX_{CRP}$ is the maximum allowing size of CRP or predefined backoff window ($T_{window}$) to access the contention period.

Therefore, DCRA supports a faster collision resolution for delay-sensitive traffic to win the next contention for retransmission than ordinary algorithm. Fig. 2 summarizes the DCRA algorithm described to this point.

```
DCRA (N_COL, T_s )
{
    T_CRP = 2^N_COL ;
    while(Resolve the collision != TRUE) {
        if ((IsTrafficDelaySensitive == TRUE) && ( T_CRP ≤ T_window ))
            T_bo = (T_CRP * rand())*T_s ;
        else
            T_bo = (T_window * rand())*T_s ;
    }
}
```

**Fig. 2.** The DCRA

# 3 Performance Evaluation

It is assumed that both new arrivals and retransmissions due to collisions form an on-off process with mean arrival rates of $\lambda_{ds} = G_{ds} / T(packets/\mathrm{sec})$ and $\lambda_{di} = G_{di} / T(packets/\mathrm{sec})$ for delay-sensitive and delay-insensitive traffic, respectively. Denote $T$ be the packet transmission time and $G_{ds}$ and $G_{di}$ be the offered loads of delay-sensitive traffic and delay-insensitive traffic, respectively, in $T$ interval.

The probability that packet transmission is successful, denoted by $P_0$, is given by $P_0 = e^{-G}$, since success means that there was no collision in the interval. And, the collision probability is given by (1-$P_0$). Throughputs of delay-sensitive traffic and delay-insensitive traffic, denoted by $S_{ds}$ and $S_{di}$, respectively, can be expressed by

$$S_{ds} = G_{ds} P_0 \tag{2a}$$

$$S_{di} = G_{di} P_0 \tag{2b}$$

since these represent the number of successful transmissions in interval $T$. Now, we should consider the total transfer delay experienced by a packet in the network including the slot synchronization time. It means the waiting time after arrival until the beginning of the time slot, the delay due to retransmissions, and the packet transmission time. Since the arrival process for new packets is assumed to be Poisson, all arrival times during a slot are equally likely. Thus, the slot synchronization time is given by $T/2$. When the average number of retransmissions is given by $H$, the average transfer delay for each retransmission cycle is determined to be

$$T_{di} = \left( 1 + r + \frac{(2^H + 1)}{2} \right) T \tag{3a}$$

for delay-insensitive traffic and

$$T_{ds} = \left( 1 + r + \frac{2^{(1-P_0)N_{ds}}}{2} \right) T \tag{3b}$$

for delay-sensitive traffic, where $N_{ds}$ represents the number of delay-sensitive requests on UP and $r$ represents the waiting time for the allocation information broadcast through the downlink from BS.

After simple calculus, the value of $H$ is determined by

$$H = \sum_{i=1}^{\infty} i(1-P_0)(1-P_0)^{i-1} P_0 = \frac{(1-P_0)}{P_0} \tag{4}$$

Now, the average transfer delay can be obtained by

$$T_{di} = T + (T/2) + \left(\frac{1-P_0}{P_0}\right)\left(1 + r + \frac{(2^H + 1)}{2}\right)T \tag{5a}$$

for delay-insensitive traffic and

$$T_{ds} = T + (T/2) + \left(\frac{1-P_0}{P_0}\right)\left(1 + r + \frac{2^{(1-P_0)N_{ds}}}{2}\right)T \tag{5b}$$

for delay-sensitive traffic.

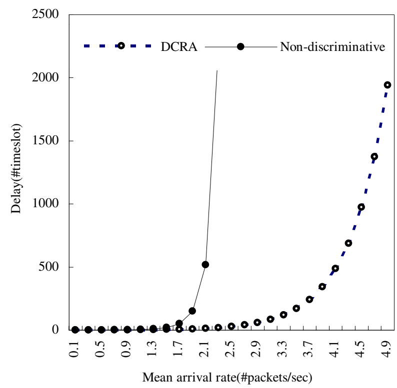
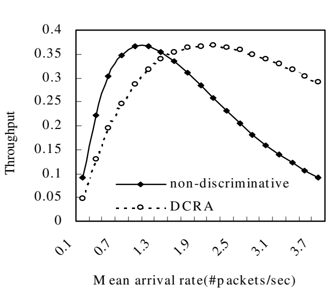



**Fig. 3.** Mean transfer delay of delay sensitive traffic

Fig. 3 depicts the mean transfer delay obtained by DCRA and a non-discriminative algorithm using (5a) and (5b). It can be seen that DCRA offers a lower mean delay than the non-discriminative algorithm for both delay-sensitive and delay-insensitive traffics. This is mainly due to that DCRA offers shorter collision resolution periods than the non-discriminative algorithm.



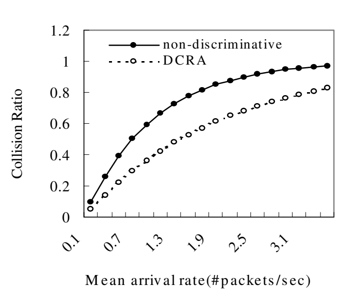




**Fig. 4.** Throughput and collision probability

Fig. 4 shows that DCRA provides a lower collision probability and a higher throughput than the non-discriminative algorithm. It is the reason why that DCRA deals with packets discriminatively depending on their delay sensitivity requirements. As a result, there will be no collision by different types of data in our DCRA.

## 4 Conclusions

This paper proposed a discriminative collision resolution algorithm, named DCRA, which considers traffic delay sensitivity for wireless MAC protocols to support the QoS requirements of real-time applications. Proposed algorithm deals with access requests in different ways depending on their delay requirements. Performance analysis and simulation results showed that DCRA offers better performance in terms of transfer delay, collision probability, and throughput than a non-discriminative algorithm. DCRA could be applicable to wireless networks, including cellular based networks and wireless LAN operating with a centralized MAC such as the IEEE802.16 HyperLAN.

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