A Packet-Based Channel Access Scheme in Wireless ATM Network

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Abstract:

This paper proposes a packet-based channel access scheme in Distributed-Queuing Request Update Multiple Access(DQRUMA) MAC(Media Access Control) protocol. To increase a channel access ratio, we eliminate the wait-to-transmit state that does not transmit Xmt_Req(Transmission Request) although the mobile terminal(MS) has new arrival packets in buffer.

Keywords: Channel access, MAC protocol, DQRUMA

1. INTRODUCTION

Wireless ATM has been considered as a communication networks for quality-of-service (QoS) based multimedia services. In a wireless ATM network that supports an multimedia traffic, because mobiles share the limited communications bandwidth, the medium access control (MAC) protocol needed to be designed in an efficient manner. These requirements have led to novel and complex MAC protocols that can support multimedia traffic and increasing the utilization of the wireless frequency by mobiles.
Here, we consider wireless access network composed one base station (BS) and many mobile station (MSs), as shown in Fig.1. Fixed-sized packets arrive at the MSs for data communications according to the burst random process. If the MSs behave voice communications, the fixed-length packets arrive at them periodically during their talkspurts. The packets are transmitted via uplink to the BS according to the channel access protocol. The BS broadcasts packets via downlink that are destined for each MS. We assume that uplink and downlink communications are separated physically.
Wireless MAC protocols have been studied extensively since the 1970s. The initial protocols were developed for data and satellite communications. The multimedia applications require delay and jitter guarantees from the network. This demand of the network is known as the Quality of Service (QoS) guarantee. Many of multiple access schemes have been researched up to now. DQRUMA(Distributed Queueing Request Update Multiple Access) MAC protocol is the representative of them. DQRUMA is a slot-based channel access scheme using FDD(Frequency Division Duplex). In DQRUMA MAC protocol, the state of each MS determines whether or not transmits the packet to the BS. The state of each MS is determined by incoming to its buffer. The MSs Ready to transmit a packet is transited to Wait-to-transmit state. Although new packets are arrived in the buffer, MSs do not transmit packets because MSs are in the Wait-to-transmit state. Therefore new arrived packets are delayed to the time acquire to the transmit chance. Ultimately to alleviate the access delay and to improve the channel utilization, we eliminate the Wait-to-transmit state of the MS.
Based on this point of view, we propose a packet-based channel access scheme. The composition of the paper is as follow. In the next section, we provide a description of DQRUMA. In section 3, we address a packet based channel access protocol and in sections 4, we present our simulation and simulation results. Section 5 concludes the paper.

2. DQURMA DESCRIPTION

In DQRUMA MAC protocol, the uplink and downlink are frequency duplex. Fig.1. shows the composition of the channel of DQURMA protocol

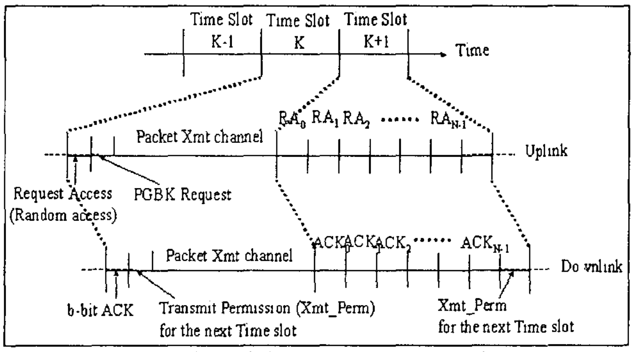

Fig. 1. Channel model in DQRUMA MAC protocol

The uplink consists of a request access(RA) channel and a packet transmission(Xmt) channel. The first slot is used to send a transmit request(Xmt_Req); the latter to send data packet. The transmission channel is also used to piggyback additional requests when the buffers of sending MS are non-empty. The downlink is composed of three messages. The ACK message acknowledges the result in the current uplink slot. The transmit-permission carries a grant for the terminal that is allowed to use the transmission mini slot in the next uplink slot. The third message is data from the BS to one of MSs. It is possible that during some time slots the number of MSs in the Wait-to-Transmit State equals zero. This happens when all entries in the Request Table of the base station have empty XMS Req fields. As a result, the uplink XMS channel will be idle in the next time slot. To avoid wasting the valuable transmission time, the idle uplink XMS channel converted it into multiple RA channels in the next time slot[1~5].

Fig.2. shows the state transition diagram of the terminal in the DQRUMA protocol. MSs in the system are each in one of the three states: Empty, Request, or Wait-to-Transmit. MSs with empty buffers are said to be in the Empty State. When packets arrive to the buffer of a MS in the Empty State, the terminal enters the Request State. A terminal in the Request State sends its request via the RA channel and stays in the Request State until the request is successfully received by the BS. When a MS in the Request State successfully sends a request, it transits to the Wait-to-Transmit State. A MS in the Wait-to-Transmit State listens to the Xmt Perm channel until it hears its b-bit Access ID, at which point it transmits a packet in the Xmt channel of the next time slot, and also transmits a contention-free Xmt_Req using the PGBK Request Bit. If the MS transmits a non-zero PGBK Request Bit, the terminal stays in the Wait-to-Transmit State. If the mobile transmits a zero PGBK Request Bit, the mobile transits to the Empty State. Since a MS in a Wait-to-Transmit State remains there until its buffer is empty[6~11].

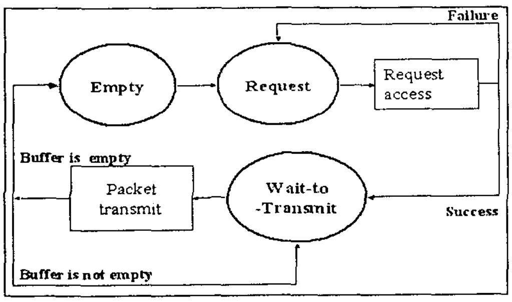

Fig .2. The state transition diagram of the DQRUMA

2.1. The Problem of DQRUMA protocol

The idle uplink Xmt channel converted it into multiple RA(MRA) channels in the next time slot. Fig. 3. shows the frequency of MRA channels. As traffics are increased, the MRA frequency is decreased. It means that terminals waiting the Xmt_Perm message are increased. But, the MRA frequency has a certain value although traffics are increased more and more. It means that there are a few MSs in the Request Table reserved to use the XMS channel in the next time slot. Because MSs sent Xmt_Req receive ACK after a time slot. Mainly, the number of MSs accesses to MRA channels and success ratio is of small number. Ultimately, an optimal scheme for MRA channel can increases the performance of the DQRUMA protocol.

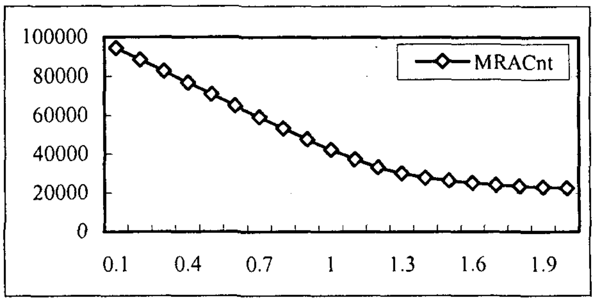

Fig. 3. MRA channels generating ratio

3. PROPOSED SCHEME

We propos a new channel access protocol that MSs access the channel by the packet for the MRA channels to increase the channel access ratio of the DQRUMA MAC protocol. In the proposed scheme, the state of MSs is determined by the packet arrived in the buffer. Fig.4. shows the state transition diagram of the proposed scheme.

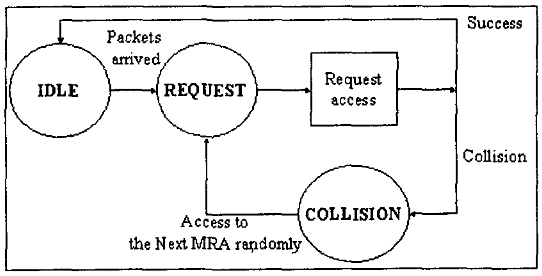

Fig. 4. The State Transition Diagram of MSs

MSs can have each in one of the three states: IDLE, REQUEST or COLLISION. MSs with no packets in buffers are staid in the IDLE State. When packets arrive to the buffer of a MS in the IDLE State, it transits to the REQUEST State. A MS in the REQUEST State sends its Xmt_Req via the RA channel after marking the packet. If the MS receives the successful ACK about the transmitted Xmt_Req, it transit to the IDLE state. After transition to the IDLE state, if additional packets to transmit are in the buffer, the MS iterates the above procedure.

By the way, the Xmt_Req collided with the other Xmt_Req, the MS transits to the COLLISION state. In COLLISION state, it selects a random slot to access in the MRA channels. As soon as terminals receive the message that the next Xmt channel converted to MRA channels, it transits to the REQUEST state. In REQUEST state, it transmits the Xmt_Req to the slot that selected in the COLLISION state. According to result of the ACK about the transmitted Xmt_Req, MSs transit to the IDLE or the COLLISION state. In the proposed scheme, MSs do not have the Wait-to-Transmit and PGBK Request. The collided MSs cannot access to the RA channel of the general time slot.

In traditional DQRUMA, although MSs in the Wait-to-Transmit state have new packets in their buffer, they stay in the Wait-to-Transmit state until it received the Xmt_Perm from the base station. Therefore new packets must wait for a delay time until MSs receive the

Xmt_Perm message. MSs having new packets in the Wait-to-Transmit state, the number of access counts of MSs in that state is decreased because MSs in the Wait-to-Transmit state do not transmit the Xmt_Req to the base station. Ultimately, we eliminate the Wait-to-Transmit state of MSs and let it access to channel by the packet in its own buffer to increase the channel utilization and to decrease the media access time.

Fig. 5. shows the procedures of DQRUMA MAC protocol using the proposed access scheme. Each mobile station differ the access method according to the form of next time slot which is broadcast by base station. In case of common time slots, it is operated by DS-ALOHA and if it senses MRA channel, it is operated by DE-MRA. In MRA channel, if the mobile station transmitting Xmt_Req receives successful ACK, it gets out of MRA channel access loop and can access both RA and MRA channel, if not, it can continuously access only MRA channel loop.

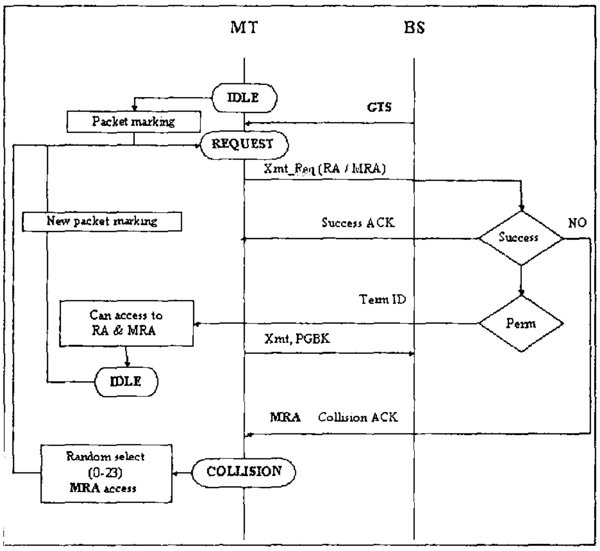

Fig. 5. The procedure of the proposed scheme

4. SIMULATOIN

Fig.6. shows conceptual form of simulation model. The system form is classified into base station, channel, and mobile station, and then each inner component is composed of one module.

4.1. Simulation Model

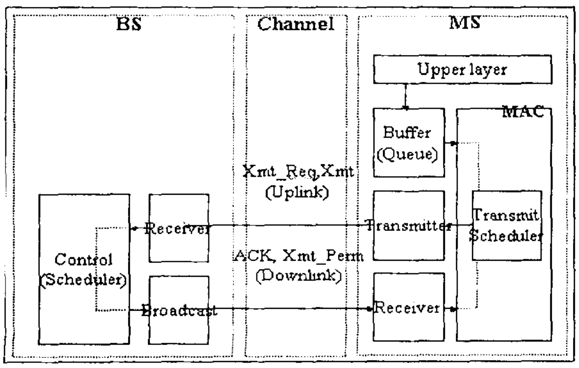

Fig. 6. The conceptual model of system

The buffer of mobile station stores the data received from the upper layer and MAC has the information about whether the new packet arrives at its own buffer or not. The transmission scheduler transmits the control message about the packet that newly arrives at the buffer to transceiver, so that transceiver can transmit Xmt_Req through the upper link. The receiver receives the result of Xmt_Req through the lower link and according to the result, transmission scheduler decides to set up the back off time or to wait for transmission of data packet. The upper link channel collects the Xmt_Req transmitted from each mobile station and stores the result to its own module. The receiver of the base station receives the result in upper link module and then it transmits the access result of each mobile station to controller. The receiver of the base station acknowledges access result ACK, Xmt_Perm, and the information allowing time slot to transceiver on the basis of receiving information and the transceiver delivers this information to lower link module. The mobile stations wait for next access and data Xmt_Perm on the basis of the result of upper link access stored in lower link module.

Table 1. Simulation parameter

Parameter	Mean	Value
N_T	The number of the mobile station	100
λ_i	Average traffic generation rate	Poisson
RA	Slot time	1
MS_{RA}	RA channel unit time	1/25
N_{MRA}	The number of mini slot of MRA channel	25
T	Simulation time	100,000

The average packet delay time is total packet queueing delay time of each mobile station divided by total receiving packet as follows.

$$\hat{\tau}_d = \frac{\sum_{i=1}^{N_T}\left(\sum_{j=1}^{N_{suc}(j)}\left(Q_{De}(i,j) - Q_{En}(i,j)\right)\right)}{\sum_{i=1}^{N_T} N_{suc}(i)} \quad (1)$$

The collision ratio is the ratio of total packet occurring collision to total packets transmitted by each mobile station as follows.

$$p_{col} = \frac{\sum_{i=1}^{N_T} N_{col}(i)}{\sum_{i=1}^{N_T} N_{new}(i)} \quad (2)$$

The throughput of MRA is the average that the XMS_Req successfully accesses the media in one MRA channel.

$$\hat{S}_{MRA} = \frac{\sum_{i=1}^{N_{MRA}} M_{suc}(i)}{M_{tot}} \quad (3)$$

4.2. Simulation Result

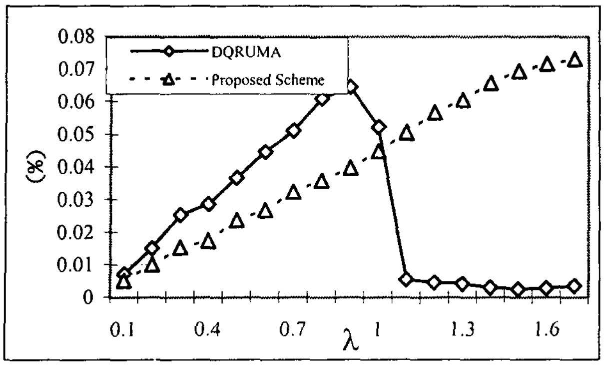

Fig.7. The collision ratio of each scheme

Fig.7. shows comparison of proposed scheme with DQRUMA MAC protocol drops the collision ratio at 1.0. All MS don't transmit Xmt_Req since the value of 1.0 means that all 100 MS is WAIT state so that the collision is dropped. Additionally, the channel access ratio is dropped since they receive one Xmt_Perm at a time. The proposed scheme removes the WAIT state of mobile station so that it transmits Xmt_Req which corresponds to new packet arriving at buffer. As a result of it, The collision of the packet is continuously increased.

Fig.8. shows where the mobile station stay by the percentage. Before and after 1.0, there is much difference IDLE state and WAIT state. Each mobile station doesn't transit WAIT state into Request state since it can't immediately receive Xmt_Perm from base station. The mobile station doesn't rapidly transit WAIT state into Request state, since the base station assigns Xmt_Perm to a mobile station at a timeslot so that there is much delay.

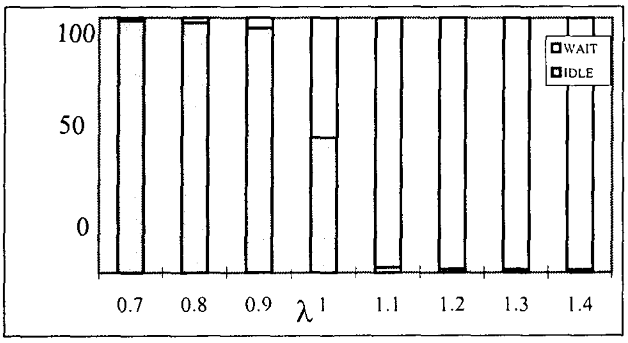

Fig.8.The state of the MS in the DQRUMA.

The collision ratio of the packet that doesn't affect to the total delay of system doesn't have much difference according to each scheme. In case of high traffic, there is the difference of 0.06 percent between DQRUMA and proposed scheme. We can know that it is not necessary for DQRUMA scheme to resolute collision algorithm.

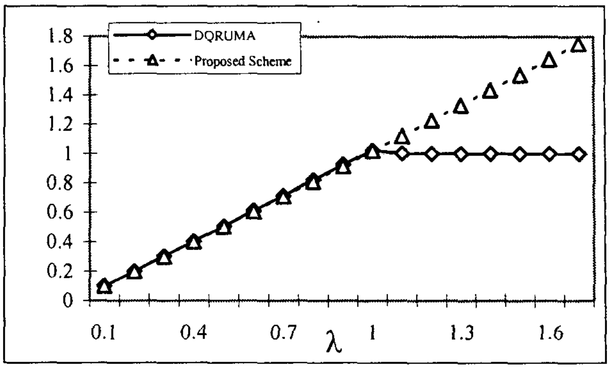

Fig.9. The average access of the MRA channel

Fig.9. compares the average that the mobile station access MRA channel In case of 1.0, DQRUMA scheme doesn't increase more access. This fact validate that the mobile station is almost in WAIT state. If the traffic is increased, the number of access isn't diminished but constant state is stayed, Since the 100 mobile station receive a Xmt_Perm per a timeslot. If a mobile station receives Xmt_Perm in WAIT state, it transits WAIT state to Request state. If a mobile station sends Xmt_Req in Request state, it transits Request state to WAIT state.

The number accessing the channel is successively increased in proportion to average packet generation rate, since the proposed scheme request transmission for incoming packet arriving at buffer regardless of WAIT state of other two schemes

5. CONCLUSION

In this paper, we proposed packet based channel access scheme by means of the effective method to Multiple RA(MRA) channel originating collision of the contention channel in DQRUMA MAC protocol. MRA channel access scheme of the DQRUMA MAC protocol doesn't have the difference in collision ratio and the number of successful access, since mobile station doesn't do Xmt_Req when mobile station is WAIT state. However, the proposed scheme can improve MRA channel access ratio and the number of channel success, since the proposed scheme removes WAIT state so that it requests Xmt_Req to the packet arriving at the buffer of the mobile station.

We can know that the collision resolution algorithm is almost needed if the collision affecting the delay of the packet isn't occurred in MRA channel. We can infer that the fact affecting total delay of protocol is not contention channel, but Xmt_Perm policy of the base station.

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