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具有公平性保證與高輸出量的分散式排程於移動式隨意網路之研究

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行政院國家科學委員會補助專題研究計畫 ■ 成果報告 □期中進度報告

具有公平性保證與高輸出量的分散式排程於移動式隨意網路之研究

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Abstract— **In this paper, we propose a neighbor-aware dynamic backoff scheme and evaluate the performance of the proposed scheme for ad hoc networks. The backoff scheme that we devised grants node access to the channel, according to the competing number of nodes for a transmitted frame. We use both an analytical model and simulation experiments to evaluate the dynamic performance of our backoff mechanism in an ad hoc network.**

Keywords: backoff; ad hoc networks; neighbor-aware.

I. INTRODUCTION

There has been a growing interest in mobile wireless networks in recent years. Such networks are formed by mobile hosts (or nodes, users) that do not have direct links to all other hosts. They can be rapidly deployed without any established infrastructure or centralized administration; in this situation, they are called ad hoc networks [1]. Because of the greater affordability of commercial radios, ad hoc networks are likely to play an important role in computer communications. The applications of ad hoc network are in building, campus, battlefield or rescue environments.

Unlike wired networks, problems such as: mobility of nodes, shared broadcast channel, hidden and exposed terminal problem, and constraints on resources, such as bandwidth and battery power, limit the applications of ad hoc networks. Due to the above mentioned factors, providing energy aware, packet delivery ratio, and end-to-end goodput guarantees in ad hoc networks are some tough propositions.

Packet scheduling in the Medium Access Control (MAC) layer is for choosing the next packet to transmit, such that a real attempt is made to satisfy the end-to-end delay and packet delivery ratio guarantees. Wireless scheduling algorithms significantly differ from their corresponding wired network. In a wired network, when a node has data packets for transmission, it cares only for the packets in its own transmission queue. But in ad hoc networks, the channel is broadcast; multiple nodes may contend for the channel simultaneously, resulting in collisions. To avoid the collision problem, a node must be aware of traffic at nodes in its two-hop contention area [2]. Therefore, an efficient contention window control algorithm is an important issue for packet scheduling in ad hoc networks.

Recently, the renewed interests in ad hoc networks have centered on using the IEEE 802.11 MAC mechanism. In [3], the authors raised the question: Can the IEEE 802.11 work well in wireless ad hoc networks? They concluded that the protocol was not designed for multihop networks. Although IEEE 802.11 MAC can support some ad hoc network architecture, it is not intended to support the wireless multihop mobile ad hoc networks, in which connectivity is one of the most prominent features.

The performance of IEEE 802.11 MAC mechanism is determined by contention window control scheme, RTS/CTS mechanism, transmission range, etc. In addition, whether or not the IEEE 802.11 MAC protocol is efficient will affect the performance of ad hoc networks. The metrics for the performance of 802.11 ad hoc networks may have throughput, delay, jitter, energy dissipation, etc.

A simulation analysis of the contention window control mechanism in the IEEE 802.11 standard has been presented in [4]. Since the backoff and contention window are closely related, the selection of the contention window will affect the network throughput. The authors in [4] showed the effective throughput and the mean packet delay versus offered load for different values of the contention window parameter and the number of contending stations.

The throughput and the mean frame delay, as functions of offered load for different RTS threshold values and numbers of stations transmitting frames of random sizes, are presented in [5]. When the number of stations increases, the RTS threshold should be decrease. While transmitting frames of random sizes, it is recommended to always set the RTS/CTS mechanism independent of the number of contending stations. The absence of a RTS/CTS mechanism entails considerable network performance degradation, especially for large values of offered load and numbers of contending stations.

The influence of packet size on the network throughput has been discussed in [6]. When the load is fixed and the packet size is increased, the contending numbers will be decreased and the network performance will be degraded. If the hidden terminal problem occurs, the performance worsens. When the network load is not heavy, the network performance varies slightly as the packet size changes. When the network load is heavy, the hidden terminal problem worsens and the network performance is lowered for the longer packet size.

Under a wide set of network and load conditions, multi-hop networks have lower performance than do single hop networks [7]. Data throughput is maximized when all nodes are in range of each other. The performance degradation in networks may be explained by the fact that channel contention in mobile ad hoc networks based on the 802.11 standard is not ideal.

In [8], the author proposed a Markov Chain to model the IEEE 802.11 DCF. This Markov chain model analysis applies to both packet transmission schemes employed by DCF; for the model, the author proposed an extensive throughput performance evaluation of basic and RTS/CTS access mechanisms.

In [9], the author proposed an enhanced distributed channel access (EDCA) mechanism under saturation condition and analyzed the throughput and delay performance of EDCA.

An effective backoff algorithm is proposed in [10] and the authors model it with a Markov chain; propose a hybrid collision resolution method to increase both the throughput and fairness performances of the DCF for the wireless access medium. But the simulation environment is completed in a single-hop BSS, this is not suitable for wireless multihop ad hoc networks.

In this paper, we present the results of a simulation study that characterizes the energy dissipation, packet delivery ratio, and throughput of ad hoc networks. In particular, we use the CBR connection numbers as the main varying parameters for the above mentioned performance metrics. If the contention window control scheme does not consider the competing number of nodes for a transmitted frame of a node, this may cause higher collision probability for a transmitted frame, and may cause some nodes to have shorter life times than other nodes will. This situation will affect the establishment of a route and degrade the performance of the entire network. In order to increase throughput and save power, if a node has large competing number of nodes, the node should have higher backoff time to transmit its packets. On the other hand, if a node has less competing number of nodes, the node should have lower backoff time. Therefore, we redefined the contention window control mechanism in IEEE 802.11 DCF as an neighbor-aware dynamic contention window control scheme.

II. IEEE 802.11

IEEE 802.11 is a standard for wireless ad hoc networks and infrastructure LANs [11] and is widely used in many testbeds and simulations in wireless ad hoc networks researches. IEEE 802.11 MAC layer has two medium access control methods: the distributed coordination function (DCF) for asynchronous contention-based access, and the point coordination function (PCF) for centralized contention-free access. In this paper, we consider the IEEE 802.11 DCF MAC protocol as the medium access control protocol in wireless ad hoc networks.

The DCF access scheme is based on the carrier sense multiple access with collision avoidance (CSMA/CA) protocol [12]. Before initiating a transmission, a station senses the channel to determine whether another station is transmitting. If the medium is found to be idle for an interval that exceeds the distributed inter-frame space (DIFS), the station starts its transmission. Otherwise, if the medium is busy, the station continues monitoring the channel until it is found idle for a DIFS. A random backoff interval is then selected and used to initialize the backoff timer. This timer is decreased as long as the channel is sensed as being idle, stopped when a transmission is detected and reactivated when the channel is idle again for more than a DIFS. When a receiver receives a successful data frame then, it then sends an acknowledgement frame (ACK) after a time interval called a short inter-frame space (SIFS) to the sender.

An optional four way hand-shaking technique, known as the request-to-send/clear-to-send (RTS/CTS) mechanism is also defined for the DCF scheme [13]. Before transmitting a packet, a station operating in the RTS/CTS mode "reserves" the channel by sending a special RTS short frame. The destination station acknowledges the receipt of an RTS frame by sending back a CTS frame, after which normal packet transmission and ACK response occur. Since collision may occur only on the RTS frame, and it is detected by the lack of CTS response, the RTS/CTS mechanism allows increased the system performance by reducing the duration of a collision when long messages are transmitted. The RTS/CTS is designed to combat the hidden terminal problem.

Backoff is a well known method for resolving contentions between different stations willing to access the medium. The method requires each station to choose a random number between 0 and a given number, and wait for this number of slots before accessing the medium, while always checking whether a different station accessed the medium before. The integer number of backoff time slots is uniformly drawn in a defined interval called the contention window.

The algorithm used by 802.11 to make this contention window evolve is called Binary Exponential Backoff (BEB). After each successful transmission, the contention window is set to [0,$CWmin - 1$] (its initial value). When node successive collisions occur, the contention window is set to $[0, min(1024, 2^i * CWmin - 1)]$; i is the number of retransmission; if i $>$ 7, the contention window is reset to its initial value. It is the retry limit of the BEB algorithm [14].

The following equation is the backoff mechanism for IEEE 802.11.

$$Backoff = INT(CW * Random()) * SlotTime$$

where
CW = an integer between $CWmin$ and $CWmax$,
$Random()$ = real number between 0 and 1,
$SlotTime$ = transmitter turn-on delay + medium propagation delay + medium busy detect response time.

III. DYNAMIC 802.11(D802.11)

In [10], the author proposed a Chen 802.11 (C802.11) algorithm for the contention window control mechanism. The author consider N mobile stations in a BSS, the initial contention window size of each mobile station is set to $X * N$, where X is the coefficient for the contention window. If a mobile station experiences a collision and needs to retransmit the data frame, its backoff timer is randomly generated from uniform distribution ranging between 0 and a new contention window. The size of this new window is linearly increased if consecutive collisions occur.

The author suggested choosing CW (Contention Window) from the intervals:

$$[0, X * N * (i + 1) - 1], i = 0, 1, ..., m$$

A. Neighbor-aware dynamic backoff mechanism

The objective of the neighbor-aware dynamic backoff procedure is to save power and increase the throughput for a node with respect to those nodes in the contention area of the node. Let i denote the number of retransmission attempts made for a packet, and i_{max} represent the maximum number of retransmission attempts permitted.

Our proposed neighbor-aware dynamic contention window size mechanism is defined as follows.

$$[X * N * (i) - 1, X * N * (i + 1) - 1], i = 1, 2, ..., m$$

$$[1, X * N - 1], i = 0$$

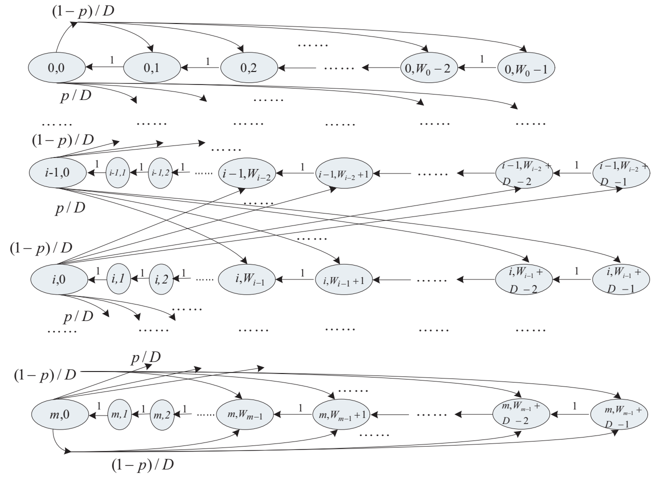

Fig. 1. Markov chain model for the neighbor-aware dynamic backoff window size scheme

B. Analytical model

In this paper, Markov Chain is used to model the backoff operation of each station. Our scheme is similar to that of [8]. Let $b(t)$ be the stochastic process representing the backoff time counter for a given station. Let m be the maximum backoff stage. Let $s(t)$ be the stochastic process representing the backoff stage $(0, \dots, m)$ of the station at time t. Let us adopt the notation $CW_{min} = X * N$ and $W_i = CW_{min} * (i+1)$, where $i \in (0, m)$ is called "backoff stage.". Thus, the process $\{s(t), b(t)\}$ of our neighbor-aware dynamic backoff scheme is a Markov chain. Fig. 1 shows the Markov chain model with the state transition graph for tracking the status of every station at every slot time. Let m,"maximum backoff stage," be the value such that

$$D = (X * N * (i+1) - 1) - (X * N * (i) - 1) = X * N, i \in (0, m)$$

where $i \in (0, m)$ is called "backoff stage."

1) Packet transmission probability: As in [8], the key approximation in this model is that at each transmission attempt and regardless of the number of retransmissions suffered, each packet collides with an independent probability p. In Fig. 1, we adopt the short notation used in [8]. $P\{i_1, k_1\} = P\{s(t+1) = i_1, b(t+1) = k_1 | s(t) = i_0, b(t) = k_0\}$. In this Markov chain, the only non null one-step transition probabilities are:

$$\begin{cases} P\{i,k|i,k+1\} = 1 & k \in (W_{i-1}, W_i - 2), i \in (0,m) \\ P\{i,k|i-1,0\} = p/D & k \in (W_{i-1}, W_i - 1), i \in (1,m) \\ P\{i-1,k|i,0\} = (1-p)/D & k \in (W_{i-1}, W_i - 1), i \in (1,m) \\ P\{i,k|i,0\} = (1-p)/D & i = 0, m \end{cases}$$

Let $b_{i,k}$, $i \in (0,m)$, $k \in (W_{i-1}, W_i - 1)$ be the stationary distribution of the Markov chain. Let τ be the probability that a station transmits in a randomly chosen slot time. Let μ be $\frac{p}{1-p}$. First, note that

$$p \cdot b_{i-1,0} = (1-p) \cdot b_{i,0}; i \in (0,m)$$

$$b_{i,0} = \tfrac{p}{1-p} \cdot b_{i-1,0}$$

$$b_{i,0} = (\tfrac{p}{1-p})^i b_{0,0} = \mu^i b_{0,0}$$

$$b_{m,0} = (\tfrac{p}{1-p})^m b_{0,0} = \mu^m b_{0,0}$$

Because of the Markov chain regularities, for each $k \in (W_{i-1}, W_i - 1)$, it is

$$b_{i,k} = \frac{D-k}{D} \cdot \begin{cases} (1-p)b_{0,0} + (1-p)b_{i+1,0} & i = 0 \\ pb_{i-1,0} + (1-p)b_{i+1,0} & i \in (0,m) \\ pb_{i-1,0} + pb_{m,0} & i = m \end{cases}$$

By means of above relating equations, $b_{i,k}$ can be simplified as

$$b_{i,k} = \tfrac{D-k}{D} b_{i,0}; i \in (0,m), k \in (W_{i-1}, W_i - 1)$$

From above equations, all the values $b_{i,k}$ are expressed as functions of the value $b_{0,0}$ and the conditional collision probability p. Then, $b_{0,0}$ can finally be determined by imposing the normalization condition, simplified as follows:

$$1 = \textstyle\sum_{i=0}^{m} \sum_{k=1}^{D-1} b_{i,k} = \frac{b_{0,0}}{2} \sum_{i=0}^{m} (\frac{p}{1-p})^i (D+1)$$

from which

$$b_{0,0} = \frac{2}{\sum_{i=0}^{m} (\frac{p}{1-p})^i (D+1)}$$

Then

$$b_{0,0} = \frac{2}{\sum_{i=0}^{m} (\frac{p}{1-p})^i (X * N + 1)}$$

Now the probability τ can be expressed as:

$$\tau = \textstyle\sum_{i=0}^{m} b_{i,0} = \frac{1-\mu^{m+1}}{1-\mu} b_{0,0} = \frac{(1-p)(1-(\frac{p}{1-p})^{m+1})}{1-2p} \cdot b_{0,0}$$

In the stationary state, each station transmits a packet with probability τ. So, we get:

$$p = 1 - (1-\tau)^{n-1}$$

2) Throughput: Let P_{tr} be the probability that there is at least one transmission in the considered slot time. And let P_s be the probability that a transmission is successful, given the probability P_{tr}. Therefore, we get:

$$p_{tr} = 1 - (1-\tau)^n$$

$$p_s = \frac{n\tau(1-\tau)^{n-1}}{p_{tr}} = \frac{n\tau(1-\tau)^{n-1}}{1-(1-\tau)^n}$$

Now we are able to express the normalized system throughput S as the ratio

$$S = \frac{E[payload\ information\ transmitted\ in\ a\ slot\ time]}{E[length\ of\ a\ slot\ time]}$$

$$= \frac{P_s P_{tr} E[P]}{(1-P_{tr})\sigma + P_{tr} P_s T_s^{rts} + P_{tr}(1-P_s) T_c^{rts}}$$

Let T_s^{rts} and T_c^{rts} be the average time the channel is sensed busy because of a successful transmission or a

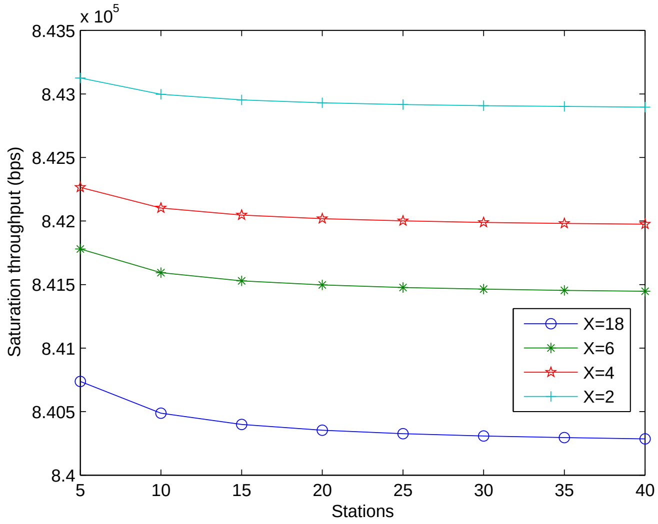

Fig. 2. Saturation throughput for D802.11 analytical model

collision for the RTS/CTS access scheme. Let $E[P]$ be the average packet length and σ is the duration of an empty slot time. Let the packet header be $H = PHY_{hdr} + MAC_{hdr}$ and propagation be δ. For the RTS/CTS access scheme, we get

$$T_s^{rts} = RTS + SIFS + \delta + CTS + SIFS + \delta + H + E[P] + SIFS + \delta + ACK + DIFS + \delta$$

$$T_c^{rts} = RTS + DIFS + \delta$$

Throughput for the D802.11 is shown in Fig. 2 for the case when the RTS/CTS method is adopted.

IV. SIMULATION ENVIRONMENT

We used simulations to study the performance of the ad hoc network using the IEEE 802.11 DCF MAC. Results reported in this paper are performed under *ns2* network simulator [15]. The radio model has characteristics similar to a commercial radio interface, Lucent's WaveLAN [16]. WaveLAN is a shared-media radio with a nominal bit-rate of 2 Mb/sec and a nominal radius of 250 m.

We placed geat effort on studying the impact of a node's probability of frame collision on the network performance. The node's probability of collision for a transmitted frame is added to the neighbor-aware dynamic backoff mechanism in D802.11. In most simulation runs, we considered 200 nodes randomly distributed over a square area of 1200x1200m^2, and simulated 150 sec of real time. To focus on the power awareness study, we did not consider mobility in this paper and all nodes were assumed to be stationary , in order to eliminate packet loss due to broken routes caused by mobility.

Communications between nodes are modeled using a uniform node-to-node communication pattern with constant bit rate (CBR) UDP traffic sources sending data in 512-byte packets at a rate of 10 packets/sec [17]. A total of 5, 10, 15, 20, 25, 30 CBR connections were generated to represent different levels of loading, with a node being the source of only one connection. All CBR connections were started at times uniformly distributed during the first sec of simulation and then remained active throughout the entire simulation run.

Each of our simulation results is the average from 5 randomly generated network topologies. Furthermore, in order to generate a more uniform topology so that the network will not become disconnected when N (the average number of neighbors) is small, we divided the topology into 25 regions and 8 nodes were randomly placed in each region. The distances were also uniformly distributed between the source node and the destination node. That is, we made sure that there were roughly equal numbers of short, medium and long connections.

TABLE I

THE AVERAGE NUMBER OF HOPS FOR A PACKET THAT SUCCESSFULLY REACHED THE DESTINATION NODE FOR VARIOUS NUMBER OF CONNECTIONS

Conn.	5	10	15	20	25	30
802.11	3.882	3.762	4.421	4.636	4.352	4.379
C802.11	3.839	3.674	4.134	4.179	4.133	4.082
mC802.11	3.478	3.375	3.835	4.032	4.060	3.811
D802.11	3.796	3.320	3.847	3.845	3.936	3.837

Table I shows the average number of hops for a packet that successfully reached the destination node, at various numbers of connections. We can see that there are roughly equal numbers of hops for 802.11, C802.11, mC802.11 and D802.11 in all cases.

In order to better understand the characteristics of D802.11 wireless networks in scenarios considered for this paper, we evaluated the performance of 802.11, C802.11, mC802.11 and D802.11 in ad hoc networks based on the following metrics:

- End-to-end goodput: the actual bandwidth that is obtained by CBR connections
- End-to-end delay per packet: the total delay experienced by a packet that successfully reached the destination node
- End-to-end delay per hop: the average delay per hop that experienced by a packet that successfully reached the destination node
- Energy dissipation per packet: the average energy dissipation experienced by a packet that successfully reached the destination node
- Energy dissipation per hop: the average energy dissipation per hop that experienced by a packet that successfully reached the destination node
- Received packet per energy dissipation: the number of received packets per energy dissipation

V. PERFORMANCE EVALUATIONS

In this section, we evaluate how our proposed neighbor-aware dynamic backoff mechanism impacts the performance of the wireless ad hoc networks.

In [10], the author shown dynamic coefficient of contention window versus number of neighbors for a BSS. We use X versus N dynamic coefficient in [10] for ad hoc network and name C802.11. Fig. 3 shows the new dynamic coefficient of contention window versus number of neighbors for ad hoc networks for modified C802.11 (mC802.11) and D802.11. As in [10], the calculations for the dynamic coefficient X needs lots of computation power. To facilitate the implementation of the proposed method, the results for the dynamic coefficient can be built in each node for wireless multihop ad hoc network. We can see from Fig. 3, the dynamic coefficient equals 25 when the number of users is in the range of 1 $\sim$ 3, and converges to 18 when the number of users is greater than 17. Although the coefficient has different values, maintaining such information in each node for wireless multihop ad hoc network is possible. With the information, each node in ad hoc network can determine suitable contention window size. This is really similar to maintain different contention window sizes for all collision stages.

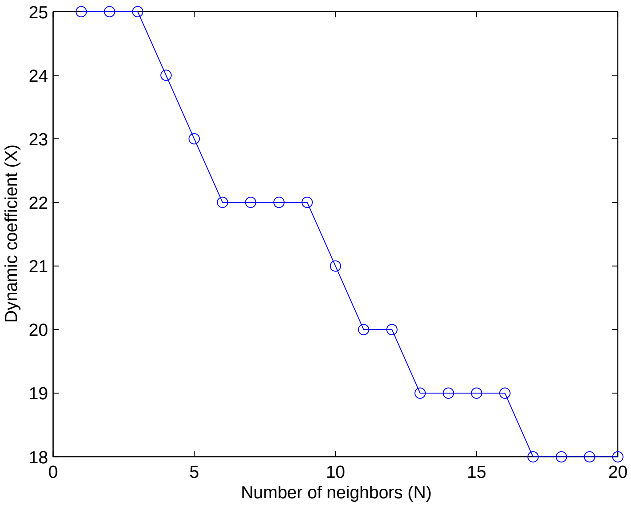

Fig. 3. Dynamic coefficient of contention window versus number of neighbors for mC802.11 and D802.11.

A. Packet delivery ratio

Fig. 4 shows the packet delivery ratio versus the number of connections 5, 10, 15, 20, 25 and 30 CBR connections for 802.11, C802.11, mC802.11 and D802.11 From Fig. 4, we see that the packet delivery ratio is about 1 when the traffic load is light (5 CBR connections). When the traffic load is moderate to high (10 to 30 CBR connections), the packet delivery ratio becomes lower. In the case that the packet delivery ratio is lower than 1, some packets are queued or discarded somewhere in the network. We further looked into the detailed operations and found that packets are lost at the intermediate (or relay) nodes but not at the sources.

Higher loading at the radio/MAC layer increases the probability of frame collision and decreases the network performance. From Fig. 4,we know that the packet delivery ratio for D802.11 is much higher than that for 802.11, C802.11 and mC802.11.

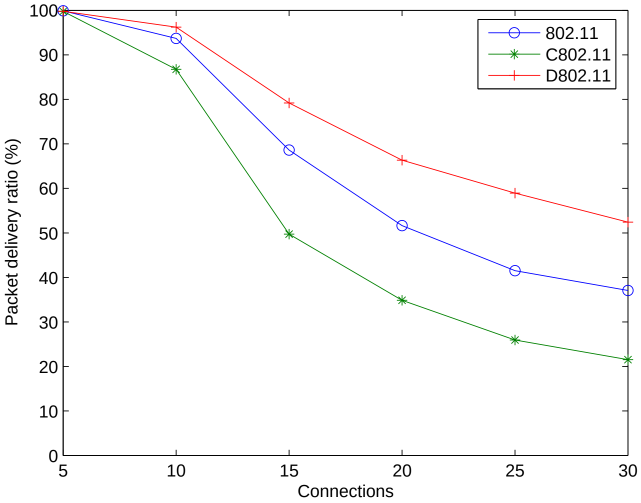

Fig. 4. Packet delivery ratio vs. the number of connections.

B. End-to-end goodput

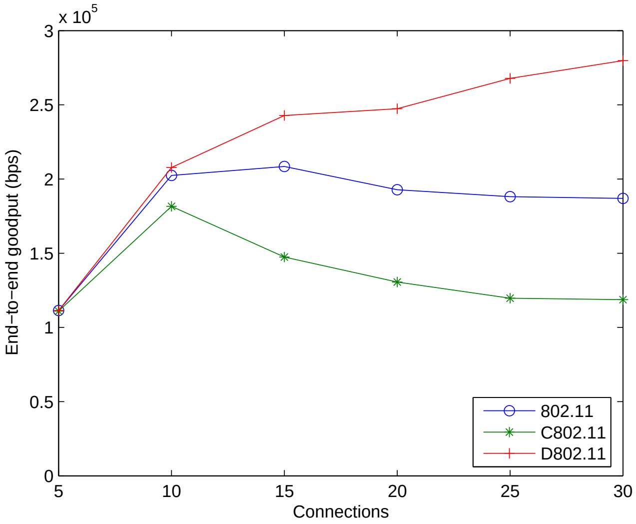

Fig. 5. End-to-end goodput vs. the number of connections.

Fig. 5 shows the end-to-end goodput vs. the connections for 802.11, C802.11, mC802.11 and D802.11 And we know that the end-to-end goodput for D802.11 is much higher than that of 802.11, C802.11 and mC802.11. In Fig. 5, as the number of CBR connections increases, the end-to-end goodput also increases. When the number of connections is large, the end-to-end goodput increases. In addition, given a particular CBR connection number, the goodput for D802.11 is still higher than 802.11, C802.11 and mC802.11.

Take an example from Table I: we know that the average number of hops for a packet that successfully reaches the destination node is about 3.845 at 20 connections for D802.11. From Fig. 5, we know that the end-to-end goodput is about 0.247 $Mbps$ at 20 connections for D802.11. So, we know that the required per-hop throughput should be roughly $3.845 \times 0.247\ Mbps = 0.951\ Mbps$ at 20 connections for D802.11. From Fig. 2, we observe that the saturation throughput for D802.11 from the analytical model is about 0.843 $Mbps$. Therefore, we show a close match between the analytical modeling and the simulation result.

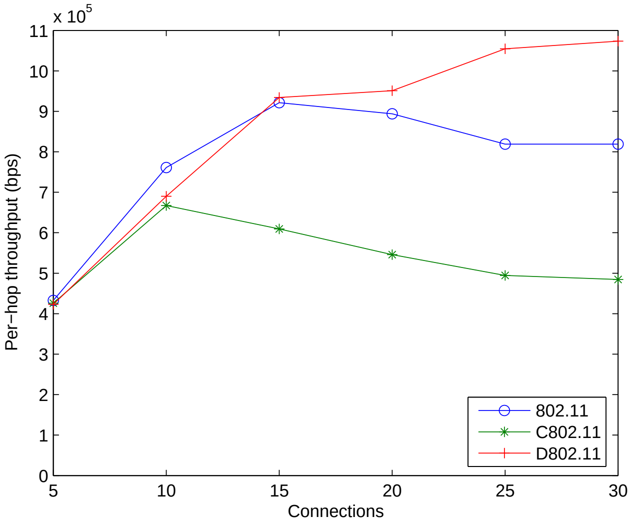

Fig. 6. Per-hop throughput vs. the number of connections.

Fig. 6 shows the per-hop throughput vs. the number of connections for 802.11, C802.11, mC802.11 and D802.11 It demonstrates that the per-hop throughput for D802.11 is higher than that for 802.11, C802.11 and mC802.11, in particular at the higher connection numbers; when the connection number is between 10 and 30, the per-hop throughput ranges from 0.690 to 1.073 $Mbps$ for D802.11, from 0.706 to 1.068 $Mbps$ for mC802.11, from 0.426 to 0.667 $Mbps$ for C802.11 and from 0.761 to 0.921 $Mbps$ for 802.11. In Fig. 2, we show that the analytical model predicts the per-hop throughput to be around 0.88 $Mbps$ for D802.11. Again, there is a good match between analytical modeling and simulation experiments. Note that the analytical model considers the saturation throughput. When the traffic load is low, e.g., at 5 connections, the traffic does not fully utilize the network capacity; therefore, the goodput is lower than that when there are 10 to 30 connections for 802.11, C802.11, mC802.11 and D802.11

C. *End-to-end delay*

In this paper, each node has a nominal radius of 250 meters. Therefore, the end-to-end delay per packet or per hop will not be affected by the range of a transmission. From Tables II and III, we see that A802.11 is slightly larger than 802.11 for end-to-end delay per packet or per hop. In order to save energy, A802.11 takes the energy into consideration at backoff mechanism. In A802.11, the increase in the power saving is achieved by using the adaptive backoff mechanism, but adding certain quantity of delay.

TABLE II

END-TO-END DELAY PER PACKET (SEC) VS. THE NUMBER OF CONNECTIONS

Connection	5	10	15	20	25	30
802.11	0.019	0.510	2.082	3.462	3.532	3.785
C802.11	0.023	0.635	2.654	2.781	3.096	4.026
mC802.11	0.032	0.350	1.681	3.144	3.852	4.067
D802.11	0.035	0.459	1.713	2.932	3.781	4.305

TABLE III

END-TO-END DELAY PER HOP (SEC) VS. THE NUMBER OF CONNECTIONS

Connection	5	10	15	20	25	30
802.11	0.005	0.112	0.464	0.721	0.782	0.830
C802.11	0.006	0.159	0.623	0.627	0.755	0.947
mC802.11	0.009	0.093	0.434	0.749	0.908	1.036
D802.11	0.009	0.128	0.433	0.739	0.936	1.105

D. *Energy dissipation*

Fig. 7 shows the energy dissipation per packet vs. the number of connections for 802.11, C802.11, mC802.11 and D802.11 And we know that the energy dissipation per packet for D802.11 is much lower than that for 802.11, C802.11 and mC802.11. Fig. 8 shows the energy dissipation per hop vs. the connections for 802.11, C802.11, mC802.11 and D802.11 We see that the energy dissipation per hop for D802.11 is much lower than that for 802.11, C802.11 and mC802.11. In Figs. 7 and 8, as the number of CBR connections increases, the energy dissipation increases. When the number of connections is large, the energy dissipation increases. Nonetheless, given a particular number of CBR connections, the energy dissipation per packet or per hop for D802.11 is still lower than 802.11, C802.11 and mC802.11.

From Table IV, we see that D802.11 has more packets received than 802.11, C802.11 and mC802.11 at the same energy dissipation.

From Figs. 7 and 8, we can see that the energy dissipation per packet or per hop for D802.11 is much lower than that for 802.11, C802.11 and mC802.11. From Table IV, we see that D802.11 has more packets received than 802.11, C802.11 and mC802.11 at the same energy dissipation. The reason is that we consider the node's competing number of nodes in the contention window control scheme; this will decrease the probability of collision in a two-hop contention area and save more energy consumption.

VI. CONCLUSIONS

We find that D802.11 produces higher end-to-end goodput than 802.11, C802.11 and mC802.11. D802.11 also achieves

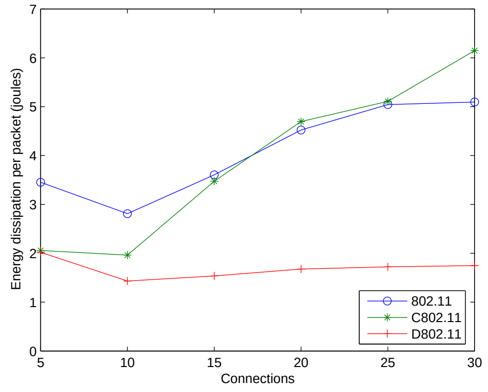

Fig. 7. Energy dissipation per packet vs. the number of connections.

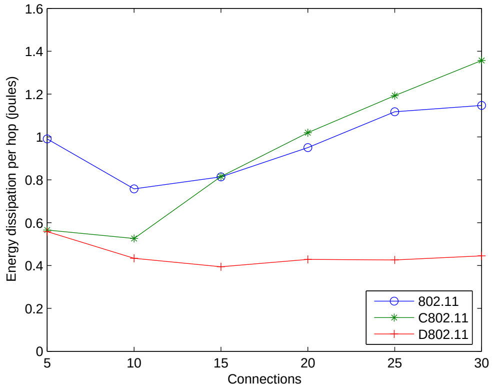

Fig. 8. Energy dissipation per hop vs. the number of connections.

better power saving by taking a node's competing number of nodes into consideration in the designing of the backoff mechanism. In addition, given a particular CBR connection number, the energy dissipation per packet or per hop for D802.11 is still lower than that for 802.11, C802.11 and mC802.11.

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TABLE IV

RECEIVED PACKET PER ENERGY DISSIPATION VS. THE NUMBER OF CONNECTIONS

Conn.	5	10	15	20	25	30
802.11	0.290	0.356	0.277	0.221	0.198	0.196
C802.11	0.486	0.509	0.288	0.213	0.196	0.163
mC802.11	0.504	0.676	0.633	0.552	0.549	0.537
D802.11	0.495	0.698	0.651	0.596	0.580	0.572

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出席國際學術會議心得報告

計畫編號	NSC 98-2221-E-343 -004 -
計畫名稱	具有公平性保證與高輸出量的分散式排程於移動式隨意網路之研究
出國人員姓名 服務機關及職稱	吳建民 南華大學資訊工程系 副教授
會議時間地點	2010/8/16 ~ 2010/8/18 韓國首爾
會議名稱	NCM 2010
發表論文題目	Neighbor-aware dynamic backoff algorithm for wireless multihop ad hoc networks

一、參加會議經過

8/16 邀請一些有關無線光纖通訊與網路的專家學者與會進行專題演講及各個主題所接受論文的研討會

8/17~8/18 進行各個主題所接受論文的研討會

二、與會心得

由於 NCM 2010 是屬於 EI 的研討會,對於個人論文能被接受,表示自己的研究受到高度肯定,內心深感欣慰,與會過程當中,也認識了一些國內外在無線光纖通訊與網路的專家學者,經過交換心得,更加增強個人的研究實力,對於將來的研究方向有莫大的助益,因此能參於這次研討會,深覺獲益良多。

無研發成果推廣資料

98 年度專題研究計畫研究成果彙整表

計畫主持人：吳建民	**計畫編號：**98-2221-E-343-004-
計畫名稱：具有公平性保證與高輸出量的分散式排程於移動式隨意網路之研究	

成果項目			量化			單位	備註（質化說明：如數個計畫共同成果、成果列為該期刊之封面故事...等）
			實際已達成數（被接受或已發表）	預期總達成數(含實際已達成數)	本計畫實際貢獻百分比		
國內	論文著作	期刊論文	0	0	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	7	8	12%		
		專書	0	0	100%		
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（本國籍）	碩士生	0	0	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		
國外	論文著作	期刊論文	11	12	8%	篇	
		研究報告/技術報告	5	5	20%		
		研討會論文	13	13	8%		
		專書	0	0	100%	章/本	
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（外國籍）	碩士生	0	0	100%	人次	
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		博士後研究員	0	0	100%		
		專任助理	0	0	100%		

其他成果 (無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。)	可將此研究成果應用電信服務之無線網路

🟥	**成果項目**	**量化**	**名稱或內容性質簡述**
科教處計畫加填項目	測驗工具(含質性與量性)	0	
	課程/模組	0	
	電腦及網路系統或工具	0	
	教材	0	
	舉辦之活動/競賽	0	
	研討會/工作坊	0	
	電子報、網站	0	
	計畫成果推廣之參與（閱聽）人數	0	

國科會補助專題研究計畫成果報告自評表

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現或其他有關價值等，作一綜合評估。

1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估

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NCM 2010 國際研討會論文一篇

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學術成就: 本計劃已在國際研討會 NCM 2010 發表，並且得到很高的評價。

技術創新: IEEE 802.11 考慮競爭視窗大小是依據倒退時間隨機產生，本計劃所考慮資料傳輸範圍內競爭節點個數來當作競爭視窗大小的參考，經過研究所得到的系統效能比先前的研究成果都有顯著的進步。

社會影響: 對於資訊科技產業而言，如將此技術應用於無線通訊網路技術，必能提升無線通訊網路的系統效能，進而提升無線通訊網路的經濟產值。