Peter Langendoerfer
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Preface

The International Conference on Wired/Wireless Internet Communications (WWIC) was held for the second time, following a successful start in 2002, in Las Vegas. The goal of the conference was to present high-quality results in the field, and to provide a framework for research collaboration through focused discussions that designated future research efforts and directions. The number and the quality of submissions indicate that we are well on the way to establishing WWIC as a major event in the field of wired/wireless internet communications.

We received around 60 competitive submissions from Europe, North America, the Middle East and the Far East. Each submission was reviewed by at least two experts, although the majority received three or more reviews. Based on this rigorous reviewing procedure, the International Program Committee selected 26 submissions for presentation and publication in the proceedings. Therefore, we should all expect the quality of a selective conference in this volume. We hope you will enjoy it.

The papers selected for presentation at WWIC 2004 were stimulating and of utmost interest. They were organized into eight sessions:

1. Protocol engineering and energy efficiency in wireless networks
2. Mobility management and mobile devices
3. Transport layer and congestion control
4. Architecture, implementation and experimentation
5. Network and protocol modeling
6. Wireless network scheduling and analysis
7. Multimedia distribution and group communication
8. Service discovery.

We would like to thank the authors for choosing WWIC 2004 to submit their results. We would also like to thank all the members of the Technical Program Committee, as well as the additional reviewers, for their effort to provide detailed and constructive reviews.

Peter Langendoerfer
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Distributed MAC Protocol to Improve Energy and Channel Efficiency in MANET

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Abstract. Bandwidth and battery power are key constraints for efficient and continuous operation of mobile computers. Power consumption during data transmitting and receiving significantly depends on the MAC protocol of wireless networks. This paper presents a channel efficient and power conserving protocol, named PC-DST, to enhance IEEE 802.11 DCF. PC-DST improves wireless channel throughput and saves huge amount of energy consumption. We illustrate PC-DST advantages via extensive simulation performed over wireless LAN. The results of simulation show that significant enhancements on frame goodput, frame delivery latency, and wireless channel efficiency are obtained. Moreover, PC-DST conserves more than 70% energy consumed in IEEE 802.11 DCF operation.

1 Introduction

The proliferations of portable computers and handheld devices have driven networks to support wireless connectivity [2, 12]. Wireless LAN (WLAN) is one of essential technologies of wireless computer networks. In fact, WLAN has successfully adopted in many campus networks and enterprise networks. Basically wireless networks deliver much less bandwidth than wired networks, for example 1-54 Mbps of WLANs versus 10-1000 Mbps of LANs. Thus, wireless medium is a scarce resource. When multimedia contents are broadly disseminated over WLAN, efficient utilization of wireless medium in WLAN is becoming an important issue [3, 5, 10].

To address the issue, a few past researches had proposed different protocols. Monks et al. [11] propose the power controlled media access (PCMA) protocol to improve channel utilization of wireless media. PCMA enables a greater number of simultaneous senders than the 802.11 by adapting the transmission ranges to be the minimum value required to satisfy successful reception at intended destination. Although, PCMA enhances the throughput of wireless media, a single hop wireless network is possible to become several multi-hop wireless networks due to transmission range reduced to its minimum. Multiple smaller ranges of wireless networks are formed by the space partition. On the other hand, power adjustment is

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not only applied to medium access control of wireless ad hoc networks, but also affects the topology [14, 16, 17], the lifetime [2, 6] of wireless ad hoc networks.

Multi-hop wireless networks need a routing facility to find routes for delivering frames from source to destination. Perkins and Bhagwat [12] propose the destination-sequence distance-vector (DSDV) routing protocol for multi-hop mobile ad hoc networks (MANET). DSDV routing suffers from the propagation delay and the overhead of periodically updating its routing table. Next, Perkins and Royer [13, 15] propose the ad-hoc on-demand distance-vector (AODV) routing protocol which eliminates global periodic routing updates in DSDV. However, route discovery latency and per-hop processing overhead are essentially expenses.

We investigate the issues of efficient channel utilization and energy conservation at the MAC layer. Therefore, we propose a novel method, named PC-DST, for enhancing the channel utilization of 802.11 DCF. PC-DST adopts transmission range controlled medium access for spatial reuse purpose. In PC-DST, all communications follows a desired power constraint learned from previous handshaking, which guarantee that all transmissions would not disturb to each other during communication periods. This could enable multiple senders to simultaneously issue their communications within the same period. We model PC-DST mechanism and simulate communication behavior on randomly generated MANET. According to our simulations, the effect of enhancement is significant. PC-DST uses exact power requirement for transmitting frame from source to destination. Comparing to full power transmission of 802.11 DCF, PC-DST saves a large amount of energy consumed during data communications. To show the effectiveness of our scheme, we developed a simulation model to measure some transmission related data to calculate the channel efficiency and energy efficiency of PC-DST and 802.11 DCF. We compare the performance of energy utilization in the energy efficiency derived from the results of simulation. From simulation results, we assure PC-DST not only provides outstanding channel throughput, but also conserves a huge amount of energy for data communications in MANET.

The remainder sections of the paper are organized as follows. In Section 2, we introduce 802.11 DCF to be applied on MANET. Section 3 describes key ideas of PC-DST and the least-required power constraint for simultaneous transmissions. Section 4 describes our simulation model and compares the results of experimental simulation of PC-DST to that of 802.11 DCF. Finally, we summarize major results of the performance simulation in Section 5.

2 IEEE 802.11 Ad Hoc Networks

The IEEE 802.11 specification includes MAC layer and physical layer. This paper only addresses to the MAC layer portion. Aad et al. [1, 5, 7, 8] introduces 802.11 standard with more widespread descriptions. The detailed description is described in the ANSI/IEEE standard [18]. We briefly introduce the terms defined in IEEE 802.11 standard.

A Wireless Medium (WM) is the medium used to implement the transfer of protocol data unit (PDU) between peer physical layer (PHY) entities of WLAN. A

Station (STA) is any device that contains 802.11 conformant MAC and PHY interface to the WM. STAs working in either distributed coordination function (DCF) or point coordination function (PCF) form a basic service set (BSS). The BSS covered area is called the basic service area (BSA). A BSS can either be an infrastructure network or an independent ad hoc network.

An ad hoc network composed solely of stations within mutual communication range of each other via the WM. An ad hoc network is typically created in a spontaneous manner. The principal distinguishing characteristic of an ad hoc network is its limited temporal and spatial extent. These limitations allow the act of creating and dissolving the ad hoc network to be sufficiently straightforward and convenient so as to be achievable by non-technical users of the network facilities; i.e., no specialized technical skills are required and little or no investment of time or additional resources is required beyond the stations that are to participate in the ad hoc network.

There are two service control methods specified in 802.11 MAC. One is PCF and the other one is DCF. DCF provides contention based service, whereas PCF provides a contention free service. However, DCF is the only service provided in an ad hoc network. Therefore, we only focus on control function in this paper. DCF supports delay insensitive data transmission, and works in contention mode. 802.11 DCF adopts carrier sense multiple access (CSMA) / collision avoidance (CA) scheme. The hidden terminal problem [2] implies a collision is possible to happen while multiple hidden STAs try to transmit their frames after the channel to become idle. To avoid collision, 802.11 uses a binary exponential back-off scheme. The binary exponential back-off scheme is implemented by each station by means of a parameter, named back-off counter, which maintains the number of empty slots the tagging STA must observe on the channel before performing its own transmission attempt. When the tagging STA needs to schedule a new transmission, it selects a particular slot among those of the contention window, whose size is maintained in a MAC preset parameter *CW_min*. The back-off value is defined by the following expression:

$$Backoff\_counter(rt\_att) = \lfloor \{ rand() \times \min(W\_\max, CW\_\min \times 2^{rt\_att}) \} \rfloor \quad (1)$$

Where *CW_max* is a MAC preset parameter, *rand()* is a function which returns pseudo random number uniformly distributed in [0..1], and *rt_att* is the number of retransmission attempt with initial value one. After each unsuccessful transmission, the *rt_att* is incremented by one. The STA doubles the contention window size until it reaches the *CW_max*. The increasing of the contention window size is the reaction that the IEEE 802.11 DCF provides to react to a congestion condition and to make the access adaptive to channel conditions.

The back-off counter is decreased as long as an idle slot is sensed, it is frozen when a transmission is detected, and reactivated after the channel is become idle for at least a DIFS time. While the back-off counter reaches the value zero, the STA can transmit its data frame. If the transmission generates a collision, the size of contention window is doubled for next retransmission attempt to reduce the contention of the medium.

RTS/CTS scheme is added to relieve the hidden terminal problem of the basic CSMA/CA scheme. RTS is sent before PDU transmission. If collision happens, the wasted channel time is only 20 octets instead of a full PDU length. CTS is replied by a destination if it is ready to receive PDU. When source receives CTS, it starts transmitting its PDU. All other STAs update their network allocation vector (NAV) whenever they hear RTS, CTS, or PDU frame. The handshake-timing diagram of RTS/CTS/DATA/ACK, SIFS/DIFS, and NAV is shown in Fig. 1.

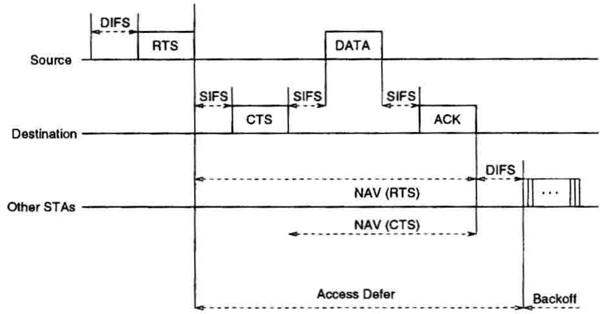

Fig. 1. DCF frame sequence

A source has to wait at least DCF Inter Frame Spacing (DIFS) time and an additional random back-off time after the channel is idle to resolve collision problem. Short ISF (SIFS) is shorter than DIFS. This is a simple prioritized scheme to let ACK, CTS, or PDU frame has higher priority than RTS frame.

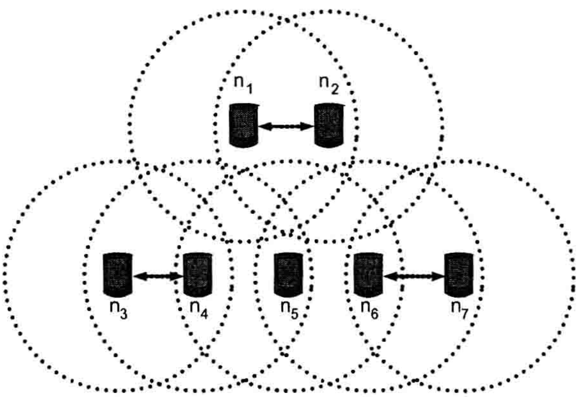

Fig. 2. Spatial reuse scenario

3 PC-DST Scheme

In a highly saturated ad hoc network, assume that all STAs in the network have power control functions in their radio units and all STAs are stably located within the coverage area which any STA can achieve each others with maximal transmitting power. Consider an example at a conference room with lots of mobile audiences,