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Resource Reservation for Channel Access in Wireless LANs

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Abstract:
This paper proposes a semi-random backoff (SRB) is fundamentally different from traditional random backoff methods because it provides an easy migration path from random backoffs to deterministic slot assignments. The central idea of the SRB is for the wireless station to set its backoff counter to a deterministic value upon a successful packet transmission. When multiple stations with successful packet transmissions reuse their respective time-slots, the collision probability is reduced, and the channel achieves the equivalence of resource reservation. In case of a failed packet transmission, a station will revert to the standard random backoff method and probe for a new available time-slot. The proposed SRB method can be readily applied to both 802.11 DCF and 802.11e EDCA networks with minimum modification to the existing DCF/EDCA implementations. Theoretical analysis and simulation results validate the superior performance of the SRB for small-scale and heavily loaded wireless LANs. When combined with an adaptive mechanism and a persistent backoff process, SRB can also be effective for large-scale and lightly loaded wireless networks.

Keywords*: 802.11 wireless LAN, backoff algorithm, medium access control (MAC), resource reservation*

1. Introduction

Access Methods: We can access the channel by any one of the following SDMA, CDMA, TDMA and FDMA. In TDMA Assign the Fixed sending frequency to a transmission channel between a sender and receiver for a certain amount of time. In FDMA assign certain frequency to a transmission channel between a sender and receiver. In SDMA we use segment space into sectors use direct antennas and cell structure, in Aloha we use random, distributed and time –multiplex mechanisms and slotted aloha additionally uses timeslots sending must start at slot boundaries. The reservation Algorithms channel efficiency18% for aloha ,36% for slotted aloha, reservation can increase efficiency 80% and a sender reserves a future timeslot and sending with in this reserved timeslot is possible without collision and reservation also causes higher delays, typical scheme for satellite links.

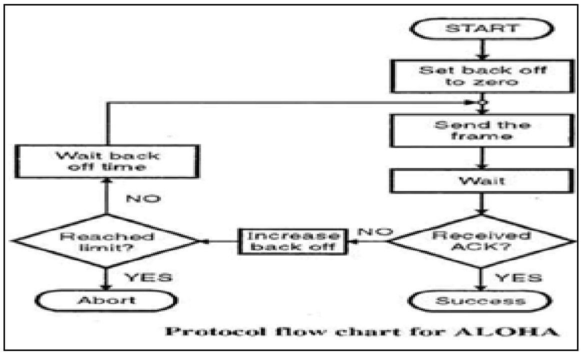

Figure 1: shows the protocol flow chart for ALOHA

The example of used Reservation Algorithms are Explicit Reservation according to Roberts(Reservation Aloha), Implicit Reservation(PRMA), Reservation(TDMA).In reservation TDMA every frame consists of N mini –slots and X data slots every station has its own mini-slot and can reserve up to k data slots using this mini-slot. Other stations can send data in unused data slots according to a round-robin sending scheme. In case of Explicit Reservation we use two modes one is aloha mode reservation competition for small reservation slots collisions possible, reserved mode data transmission with successful reserved slots. It is important for all stations to keep the reservation list consistent at any point in time and therefore all stations have to synchronize from time to time.

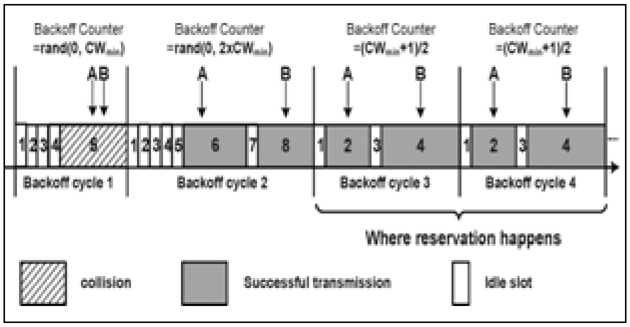

Figure 2

This paper borrows the ideas of reservation from TDMA and R-ALOHA and applies them in wireless CSMA networks. The built-in carrier-sensing mechanism in a CSMA network is lever- aged to achieve synchronization among the wireless stations, but the fully random backoff processes of the wireless stations are changed to an opportunistically random process. This new method, named semi-random backoff (SRB), allows a station to reuse a time-slot in consecutive backoff cycles. Herein, a backoff cycle is defined as a period of time when the backoff counter decrements from the maximal number to zero. Different from a TDMA network, the duration of a time-slot in a CSMA network varies over time. It can be as short as merely several microseconds if the slot is idle (for carrier sensing), or as long as hundreds of microseconds if the slot is busy (for packet transmission). The varied length of the time-slot reduces the wasted time in idle slots while achieving reservation in CSMA networks. Fig. 1 illustrates the operation of SRB by an example. Stations A and B both want to transmit data. In backoff cycle 1, the stations set their backoff counters randomly within window.

The idea to use carrier sensing for resource reservation is applicable in a variety of CSMA-based networks, such as the HCCA networks and multiradio multichannel networks . This general approach has been explored in- dependently by different research groups in recent years. A first exploration to this approach is the enhanced backoff algorithm (EBA) proposed in , where each station announces its backoff counter value in the frame header that allows other stations to select different values for their backoff counters, thus collisions are avoided. Zero Collision (ZC) eliminates the explicit backoff information announcement in EBA and obtains such information implicitly by learning. The extra cost is the online tracking of each time-slot's status. The most similar work to SRB is the learning BEB (L-BEB) proposed by Barcelo *et al.* in the summer school of EUNICE 2008, followed by analytical studies enhancements in 2009 and 2010. For comparison, the basic idea of SRB was first published as a poster in ACM SIGCOMM 2009 as a full paper in IEEE ICNP 2009 . Both L-BEB and SRB employ deterministic backoff to resolve net- work collision. However, they are independent works, and their analytical models, verification approaches, as well as some other details are very different contributions are threefold.

- First, we propose a general framework to use carrier sensing for achieving resource reservation in CSMA-based networks. The approach is simple and elegant, incurs no extra cost, and requires minimal modification to existing implementations. Results show that it significantly reduces network collisions and increases system throughput.

- Second, we provide an analytical model that can be used to evaluate and predict the performance of SRB in no ideal situations, such as carrier-sense errors, clock skew, etc. It obtains the collision rate, system throughput, as well as convergence speed of collision in closed form.
- Third, we investigate the limitations with the basic SRB solution and propose several enhancements to improve its performance. In particular, we provide a simple yet flexible mechanism that dynamically controls the service ring size to boost the system throughput when the number of active stations in the network changes over time. Additionally, we enhance SRB with a persistent backoff scheme that enables resource reservation across multiple backoff cycles.

1.1. Concept of SRB

For the sake of illustration, we discretize the timeline of a CSMA network based on the duration of a time-slot. Here CW represents the backoff window size as defined in traditional random backoff methods, and M is a newly introduced parameter in SRB with deterministic values. Usually, stations share the same M during channel access. However, if it is de- sired, stations can also have different M values. Here, a successful transmission means a transmission that is acknowl- edged by the receiver via ACK, nACK, block ACK, or other appropriate signals.[2]

Once the backoff counter is updated, a station proceeds its usual backoff process. When its counter reaches zero, the station transmits data, and then updates its counter. If the station finds no data to send (post-backoff), the backoff ceases; whenever new traffic comes, the station restarts its backoff process with a new random initial value for the counter. This behavior is exactly the same as the legacy 802.11 DCF/EDCA. In Section VI, we show that this behavior can be changed to further improve SRB's performance.

Equation (1) shows two components with SRB, a random component and a reservation component. The random compo- nent is used to randomly probe the contention window for a time-slot to avoid collision.

1.2. SRB in 802.11 Networks

We discuss how the SRB can be applied to 802.11 DCF and 802.11e EDCA networks. Since both DCF and EDCA are based on binary exponential backoff (BEB), we focus on how to adapt the concept of SRB to the BEB algorithm. For illustration, we use a prefix R (reservation) to refer the method with SRB capa- bility, like R-BEB, R-DCF and R-EDCA.

1.3. Discussions

SRB builds on the underlying assumption that contending stations decrease their backoff counters concurrently upon idle slots. However, in practice, this assumption does not always hold true. The use of arbitrary interframe space (AIFS), the pres- ence of hidden/exposed terminals, as well as some other factors can break this assumption. A number of typical cases are ana- lyzed in the following.

1.4. SRB in Multihop and Error-Prone Networks

Synchronized decrements of backoff counters may also be broken due to factors that are not dependent on the protocol itself, such as hidden terminals (in multihop networks), exposed terminals

All these "unpleasant" factors reduce network efficiency since they eventually lead to failed transmissions. However, the beauty of SRB lies in the fact that it reverts back to the standard random backoff upon such "bad" conditions, and when the situation improves, it takes advantage of the reservation capability to obtain performance gain.

M	N	Convergence time $E(\tau_0)$		M	N	Convergence time $E(\tau_0)$	
		analytical	simulation			analytical	simulation
4	1	1.0	1.0	16	2	1.07	1.07
4	2	1.33	1.33	16	4	1.47	1.48
4	3	2.67	2.67	16	6	2.35	2.36
4	4	8.89	8.90	16	8	4.09	4.07
8	2	1.14	1.14	16	10	8.32	8.33
8	4	2.28	2.27	16	12	25.63	25.65
8	6	7.31	7.28	16	14	234.0	233.7
8	7	19.31	19.32	16	15	1550	1526
8	8	107.1	107.4	16	16	25185	25028

Table 1: Average Convergence Time

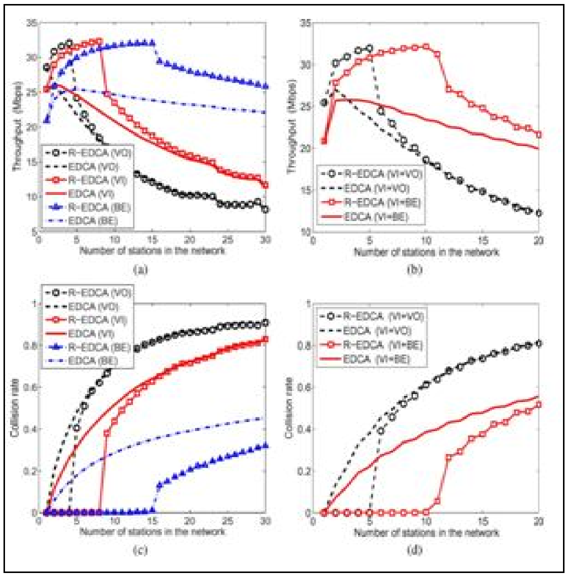

Figure 4: Throughput and collision rate of R-EDCA and EDCA in both single- and mixed-traffic cases. (a) Throughput in single-traffic case. (b) Throughput in mixed-traffic case. (c) Collision rate in single-traffic case. (d) Collision rate in mixed-traffic case.

2. Simulation Results

This section presents detailed simulation results from the net- work simulator *ns2* [32]. The WLAN patch [33] is used due to its clear implementation of backoff and physical clear channel assess (CCA) mechanism. Integrating SRB into this patch only requires an insertion of merely three lines of codes. In our study, two types of EDCA are compared: the legacy EDCA and the SRB-based EDCA (R-EDCA). Our simulation considers a typical 802.11 wireless LAN environment where an AP is located at the center and mobile stations uniformly spread in a 30-m circle around the AP. The receiving range and carrier-sense range are set to 40 and 65 m, respectively. Each station in the network carries a UDP stream to the AP.

3. Conclusion

SRB is a simple, elegant, and effective approach that achieves resource reservation in a CSMA network at no extra cost. In SRB, a station simply needs to track the results of its data trans- mission to properly reset the backoff counter, and sense the wireless channel to synchronize the decrement of its backoff counter with other stations, both of which are already common components for a CSMA network. In the case of imperfect car- rier sense, clock skew, or the presence of hidden terminals, SRB reverts back to a random backoff scheme. SRB can be readily used to enhance current 802.11 DCF/EDCA, with minimum modification to existing implementations. It is also backward compatible with legacy DCF/EDCA. Analytical study and simulation results show that SRB performs better than or equal to the legacy 802.11 DCF/EDCA in all possible scenarios. With enhancements including the adaptive mechanism and the persistent backoff process, SRB can achieve even higher performance gain over legacy 802.11 DCF/EDCA.

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