Design of MAC Protocols With Less Collision Fast Resolution for WLAN

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Abstract – Development of efficient medium access control (MAC) protocols providing both high throughput performance for data traffic and good quality of service (QoS) support for real-time traffic is the current major focus in distributed contention-based (DCF) MAC protocol research. In this paper, we propose a novel and efficient contention-based MAC protocol for wireless local area networks, namely, the less collision fast resolution (LCFR) algorithm. This algorithm is developed based on the following innovative ideas: to reduce probability of collision and speed up the backoff procedure. We actively redistribute the backoff timers for all active nodes and reduce the backoff timers exponentially fast. The MAC protocol with this new algorithm attempts to provide significantly higher throughput and low latency performance for data services in wireless LANs than the IEEE 802.11 MAC algorithm. We demonstrate that this algorithm indeed resolves collisions faster and reduces the idle slots more effectively.

Keywords - Backoff, IEEE 802.11, medium access control (MAC), wireless local area networks (WLANs).

Less collisions Fast Resolution (LCFR) Algorithm

The major deficiency of the IEEE802.11 MAC protocol comes from the slow collision resolution as the number of active stations increases. An active station can be in two modes at each contention period, namely, the transmitting mode when it wins a contention and the deferring mode when it loses a contention. When a station transmits a packet, the outcome is either one of the two cases: a successful packet transmission or a collision. Therefore, a station will be in one of the following three states at each contention period: a successful packet transmission state, a collision state, and a deferring state. In most distributed contention-based MAC algorithms, there is no change in the contention window size for the deferring stations, and the backoff timer will decrease by one slot whenever an idle slot is detected. In the proposed less collision fast resolution (LCFR) algorithm, we will change the contention window size for the deferring stations and regenerate the backoff timers for all potential transmitting stations to actively avoid “future” potential collisions, in this way, we can resolve possible packet collisions quickly. More importantly, the proposed algorithm preserves the simplicity for implementation like the IEEE 802.11 MAC. The LCFR algorithm has the following characteristics:

1) Use much smaller initial (minimum) contention window size $\text{minCW}$ than the IEEE 802.11 MAC;
2) Use much larger maximum contention window size $\text{maxCW}$ than the IEEE 802.11 MAC;
3) Increase the contention window size of a station when it is in either collision state or deferring state;
4) Reduce the backoff timers exponentially fast.

Items 1) and 4) attempt to reduce the average number of idle backoff slots for each contention period ($E[B_t]$) in (2). Items 2) and 3) are used to quickly increase the backoff timers, hence quickly decrease the probability of collisions. In item 3), the LCFR algorithm has the major difference from other contention based MAC protocols such as the IEEE 802.11 MAC. In the IEEE 802.11 MAC, the contention window size of a station is increased only when it experiences a transmission failure (i.e., a collision). In the LCFR algorithm, the contention window size of a station will increase not only when it experiences a collision but also when it is in the deferring mode and senses the start of a new busy period. Therefore, all stations which have packets to transmit (including those which are deferring due to backoff) will change their contention window sizes at each contention period in the LCFR algorithm.

The detailed FCR algorithm is described as follows according to the state a station is in:

1) **Backoff Procedure**: All active stations will monitor the medium. If a station senses the medium idle for a slot, then it will decrement its backoff time ($BT$) exponentially, i.e., $BT_{\text{new}} = BT_{\text{old}}/2$ (if $BT_{\text{new}} < a\text{SlotTime}$, then $BT_{\text{new}} = 0$). When its backoff timer reaches to zero, the station will transmit a packet. For example, if a station has the backoff timer 2047, its backoff time is $BT = \left\lfloor \log_2 2047 \right\rfloor \times a\text{SlotTime}$.

The backoff timer will be decreased by one half, i.e., $BT_{\text{new}} = BT_{\text{old}}/2$ at each additional idle slot until either it reaches to zero or it senses a non-idle slot, whichever comes first. Therefore, the wasted idle backoff time is guaranteed to be less than or equal to $11 \times a\text{SlotTime}$ for above scenario. The net effect is that the unnecessary wasted idle backoff time will be reduced when a station runs out of packets for transmission.

2) **Transmission Failure (Packet Collision)**: If a station notices that its packet transmission has failed possibly due to packet collision (i.e., it fails to receive an acknowledgment from the intended receiving station), the contention window size of the station will be increased and a random backoff
time (BT) will be chosen, i.e., $CW = \min(maxCW, CW \times 2 + 1)$, $BT = \text{uniform}(0, CW) \times a\text{SlotTime}$, where $\text{uniform}(a, b)$ indicates a number randomly drawn from the uniform distribution between $a$ and $b$ and $CW$ is the current contention window size.

3) **Successful Packet Transmission**: If a station has finished a successful packet transmission, then its contention window size will be reduced to the initial (minimum) contention window size $minCW$ and a random backoff time (BT) value will be chosen accordingly, i.e., $CW = minCW$, $BT = \text{uniform}(0, CW) \times a\text{SlotTime}$.

4) **Deferring State**: For a station which is in deferring state, whenever it detects the start of a new busy period, which indicates either a collision or a packet transmission in the medium, the station will increase its contention window size and pick a new random backoff time (BT) as follows: $CW = \min(maxCW, CW \times 2 + 1)$, $BT = \text{uniform}(0, CW) \times a\text{SlotTime}$.

**PERFORMANCE EVALUATION**

In this section, we present the simulation studies for the proposed less collision fast resolution (LCFR) algorithms and the IEEE 802.11 MAC protocol using DSSS specification. The parameters used in the simulations are shown in Table I, which are based on the IEEE 802.11 network configurations.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>SIFS</th>
<th>DIFS</th>
<th>A slot time</th>
<th>Bit rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>10 μs</td>
<td>50 μs</td>
<td>20 μs</td>
<td>2 Mbps</td>
</tr>
</tbody>
</table>

We assume that the best-effort data packets are always available at all stations. In the simulations, the packet sizes for the best-effort data packets are geometrically distributed with parameter $q$ ([5]).

**Simulation Results for FCR vs.IEEE802.11**
are to use much smaller minimum contention window size comparing to IEEE 802.11 MAC and fast decreasing backoff timers. These changes reduce the average number of idle slots in each contention period, which contributes to both throughput and delay improvement. Extensive simulation studies for throughput and delay have demonstrated that the LCFR algorithm gives significant throughput improvement compared to that for the IEEE802.11 MAC algorithm achieving both high throughput and low delay simultaneously.

REFERENCES


Fig.6. Delay for 50 stations wireless LAN

CONCLUSIONS

In this paper, we propose a novel contention-based medium access control algorithm. The LCFR algorithm can achieve high throughput performance while preserving the implementation simplicity in wireless local area networks. In the LCFR algorithm, each station changes the contention window size upon both successful packet transmissions and collisions for all active stations in order to redistribute the backoff timers to actively avoid potential future collisions. Due to this operation, each station can more quickly resolve collisions when there are a larger number of active stations in the wireless LANs. Other ideas we incorporate in the LCFR