# Poster: DSCR – A Wireless MAC Protocol Using Implicit Pipelining*

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## Categories and Subject Descriptors

C.2.2 [**Computer-Communication Networks**]: Network Protocols

## General Terms

Algorithms

## Keywords

Ad hoc network, medium access control, pipelining

## 1. INTRODUCTION

In wireless networks, the collision cost is much higher than wired networks since a station cannot detect collision until a transmission is over and the expected acknowledgment does not come back. Therefore, more efficient contention resolution algorithms are desired for wireless networks to reduce the collision probability among contending stations.

IEEE 802.11 defines a distributed random access MAC protocol named DCF (Distributed Coordination Function), which uses *binary exponential backoff* (BEB) algorithm to resolve channel contention. In DCF, a station wanting to access the channel generates a random backoff counter uniformly distributed over the interval [0, CW] (CW represents contention window). This backoff counter corresponds to the number of *idle slots* this station has to wait before its transmission. The contention window, CW, is exponentially increased by a factor of 2 each time when a collision happens, and reset to the minimum value upon successful transmission. An appropriate choice of CW can optimize the performance of 802.11. However, the optimum value of CW changes with the network size and 802.11 operates far from this optimum point. In particular, in a heavily contended network, the collision probability increases significantly, degrading the performance of 802.11.

To improve the performance of IEEE 802.11, [1] proposes that each station continuously observes channel activities and estimates the number of contending stations, hence, dynamically tune the value of CW to the optimum point. [2] also proposes a fast collision resolution algorithm, in which the winning station occupies the channel for a certain period of time to reduce the collision probability. However, both of these two schemes are designed for wireless LANs, where all stations are within each other's transmission range.

This paper proposes a MAC protocol, named DSCR (Dual Stage Contention Resolution), uses "pipelined" two stage contention resolution algorithm to reduce collision probability and achieve better channel utilization than 802.11 in both wireless LANs and ad hoc networks. In our prior work, we developed two explicit pipelining schemes, which use a separate control channel (either to transmit RTS/CTS or to send busy tone) to pipeline contention resolution with data transmission [4]. In contrast, DSCR performs implicit pipelining in that no separate control channel is required.

## 2. PROTOCOL DESCRIPTION

DSCR includes two *implicitly pipelined* contention resolution stages as illustrated conceptually in Figure 1. Intuitively, stage 1 functions as a filter to select some stations to contend for the channel in stage 2. Since the number of stations in stage 2 is typically small, the channel contention can be resolved efficiently. As shown in Figure 1, stage 1 is implicitly performed in parallel with both stage 2 and packet transmission duration without actual consumption of channel bandwidth. At any given time, some stations will be in stage 2 while others stay in stage 1. Only the stations in stage 2 will contend for the channel access.

More specifically, DSCR maintains a backoff counters $bc_1$, a contention window CW1 for contention resolution stage 1, a backoff counter $bc_2$, a contention window CW2 for stage 2. At the end of a successful packet transmission, the station reduces its $bc_1$ by a quantity F. While there are various choices possible for F, in DSCR, we choose F so that the longer a station has stayed in stage 1, the more aggressively it will reduce its $bc_1$, hence, a larger probability of entering stage 2. Whenever a station's $bc_1$ becomes *less than or equal to 0*, this station enters stage 2 and contends for the channel following a procedure defined for stage 2. A station in stage 2 that wins the channel transmits its packet, then *resets* CW1 to $CW1_{min}$ and returns to stage 1. A station that loses channel contention in stage 2 will *double* its CW1 and return to stage 1.

Intuitively, the distribution of CW1 in a given network adapts to the number of contending stations in stage 2.


*MobiHoc'03*, June 1-3, 2003, Annapolis, Maryland, USA.

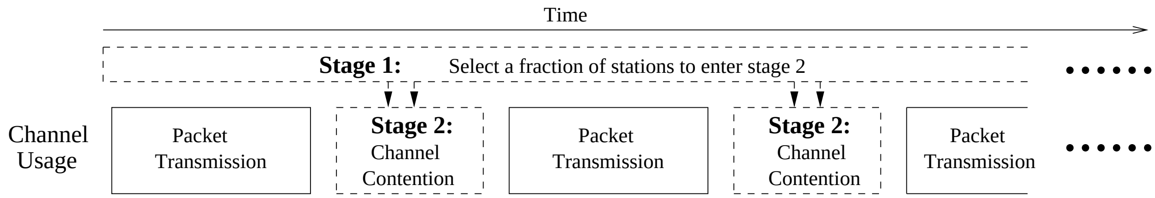


**Figure 1: Dual Stage Contention Resolution**

If very few stations are in stage 2, then very few stations will double CW1 upon losing channel contention in stage 2. CW1 of the contending stations tends to be small. On the other hand, if the channel contention is severe in stage 2, many stations (except for the winning one) will lose the channel and double their CW1. As a result, CW1 of the contending stations tends to be large. As a feedback, the distribution of CW1 then adjusts the contention level in stage 2 accordingly. Larger values of CW1 imply smaller probability of entering stage 2. More details about the DSCR protocol can be found in [3].

HIPERLAN/1 is also a MAC protocol that uses two contention resolution stages (the "elimination" stage and the "yield" stage) to resolve channel contention. HIPERLAN/1 is only efficient in wireless LANs due to the use of burst-sensing. Unlike HIPERLAN/1, DSCR does not rely on bursting mechanisms. Instead, DSCR uses backoff mechanism analogous to 802.11 and statistically control the number of contending stations in stage 2, it can perform well in both wireless LANs and ad hoc networks. Our simulation results show that with a total of 256 contending stations, the number of stations contending for the channel in stage 2 of DSCR is less than 28 on average [3].

The uniqueness of DSCR lies in that it implicitly *pipelines* the contention resolution stage 1 and stage 2. As stage 1 proceeds in parallel with stage 2 and packet transmission durations, it does not consume channel bandwidth in fulfilling its duty of reducing channel contention.

## 3. PERFORMANCE EVALUATION

We simulated the performance of DSCR and IEEE 802.11 DCF in wireless LANs and ad hoc networks with various contention levels. The results indicate that DSCR significantly reduces the collision probability and improves the channel utilization over 802.11, while preserving comparable fairness to 802.11. In addition, by reducing the number of retransmissions, DSCR achieves lower average access delay compared with 802.11. In Figure 2 and 3, we show the simulation results for random multi-hop networks with 80 stations in a 1000m $\times$ 1000m area. 30 different topologies have been generated and each station picks one of its one hop neighbors (if any) to send packets to. The total number of flows (always backlogged) varies from 70 to 75 depending on the topology.

Figure 2 and 3 shows that DSCR achieves 10% to 50% more aggregate throughput, and 15% to 56% less average access delay compared with 802.11 in these simulated multi-hop networks. We expect the performance gap between DSCR and 802.11 to be even larger when the number of contending stations increases. More simulation results can be found in [3].

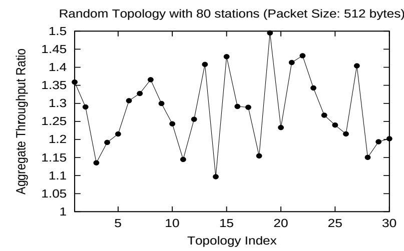


**Figure 2: Throughput Ratio (DSCR over 802.11)**

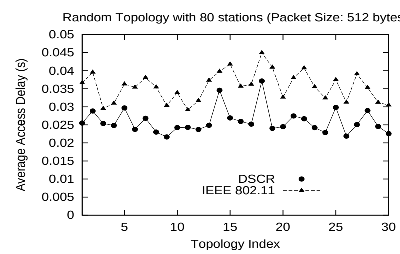


**Figure 3: Average Access Delay (s)**

## 4. CONCLUSION

We conclude that, by using two implicitly pipelined contention resolution stages, DSCR achieves better channel utilization and lower average access delay in heavily loaded networks. DSCR is robust in multi-hop ad hoc networks with the presence of hidden terminals. The performance improvement achieved by DSCR does not rely on any burst-sensing mechanism as used in HIPERLAN/1.

## 5. REFERENCES

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