MCBC: Highly Scalable MAC Protocol

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Approaching theoretical throughput limits in contention-based wireless networks

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Overview

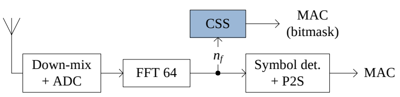
One can imagine a future where most people own wireless devices potentially running network hungry applications in large conference halls, congested highways etc. Such networks may easily reach hundreds and even thousands of active nodes. Vehicular networks in particular have very high mobility levels and rapid topology changes imposing very harsh conditions for wireless communication.

Contention-based MAC protocols are suited for ad hoc networking but, in order to support such extreme demands, the collision resolution algorithm needs to be highly efficient to minimize the collision probability for any network size, impose a low overhead to maintain high throughput and, ideally, network topology independent.

Multi-Carrier Burst Contention

We propose a high performance solution based on active contention through node elimination, with the following main components:

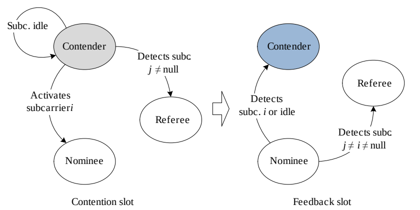
• **Tweaked OFDM PHY.** With minor modifications to the standard 802.11a PHY, a subset of the 52 OFDM subcarriers set can be used by the MAC to send and sense very short bursts, forming the basis of the active contention algorithm.



Tweaked OFDM PHY for fast active contention

• **Microsecond synchronization.** In order to further reduce the contention overhead, an external synchronization source should be used that provides microsecond accuracy. A GPS clock offers up to 15 ns accuracy.

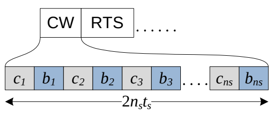
• **Active contention algorithm.** A node elimination algorithm lies at the base of the contention scheme where *contender* nodes are eliminated by *referee* nodes by activating and sensing subcarrier bursts (i.e. non-modulated subcarriers).



Simplified state diagram of the contention alg.

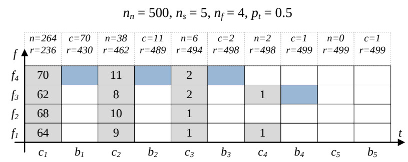
Characteristics and Advantages

• **Reduced contention overhead.** With the modified PHY, no data encapsulation is needed at the MAC and no symbol modulation is needed at the PHY, thus drastically reducing the global turnaround time.



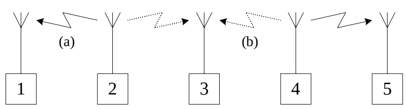
Contention (c) and feedback (b) slots

• **Low collision probability.** The contention scheme using both the time and frequency domains is able to finish with a unique contention winner with a very high probability, as the number of contenders decrease exponentially.



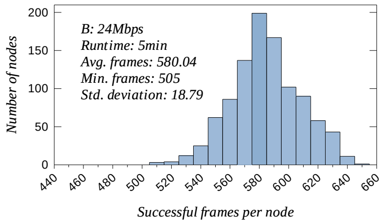
Typical contention session example with 500 nodes

• **Hidden node handling.** The protocol inherently deals with hidden nodes as early as the contention session due to its feedback nature.



Hidden nodes scenarios

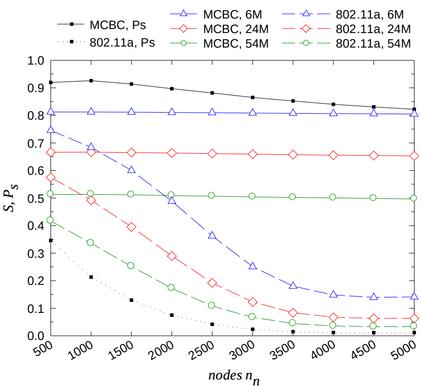
• **Fairness.** All nodes use the same contention parameters so fairness and no-starvation are statistically ensured.



A network of 1000 nodes under asymptotic load

• **Topology independent.** The collision resolution algorithm is non-adaptive and does not rely on outcomes of past transmission attempts.

• **Virtually constant throughput.** The high probability of non-collision and the efficiency of the RTS/CTS scheme allows the protocol to maintain network throughputs close to theoretical limits, even at extreme loads.



Normalized network throughput

Other Applications

- Because of the ability to deal with hidden nodes before any MAC data is transmitted, the throughput of the protocol can be increased by as much as 25% by dropping the RTS/CTS scheme and employing a fast-adaptive algorithm to maintain a low collision probability.
- Strict and relaxed QoS can be achieved by mapping the traffic categories and statistical round-robin schemes onto the subset of OFDM subcarriers used for contention.
- The fast convergence and lack of message exchange allow the proposed contention algorithm to be used in fast leader election protocols.

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Based on

[1] Bogdan Roman and Frank Stajano. An Arbitrarily Scalable MAC Protocol for Wireless Networks. (*in submission*)