Scalable Medium Access Control

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Overview

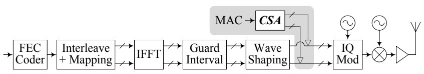
In the future, we expect wireless communications to be in widespread use. We imagine a future where many people own wireless devices running information sharing or other network hungry applications in large highways, conference halls or office buildings, yielding networks with very large number of active nodes. Vehicular networks in particular impose harsh conditions for wireless communications due to high mobility levels and rapid topology changes. Such factors make efficient Medium Access Control (MAC) a high priority.

Contention-based MAC protocols have been proven well suited for such conditions but in order to support such extreme demands, the collision resolution algorithm needs to be highly efficient to minimize the collision probability for all network sizes, impose a low overhead to maintain high throughput and, ideally, be network topology independent.

Multi-Carrier Burst Contention

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

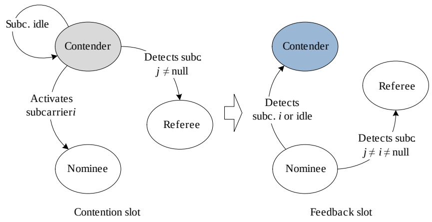
• **Tweaked OFDM PHY.** With minor modifications to the standard IEEE 802.11a PHY, a subset of the 52 OFDM subcarriers set can be used by the MAC to send and sense very short and unmodulated bursts of energy, forming the basis of the active contention algorithm.



Tweaked OFDM PHY for fast active contention

• **Synchronization.** To further reduce contention overhead, contention sessions are synchronized through an external source (e.g. GPS clock) or using MAC control frames (e.g. beacons).

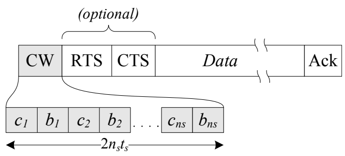
• **Active contention algorithm.** A node elimination algorithm lies at the base of the contention scheme where *contender* nodes are eliminated by *referee* nodes by activating and sensing subcarrier bursts (i.e. non-modulated subcarriers).



Simplified state diagram of the contention alg.

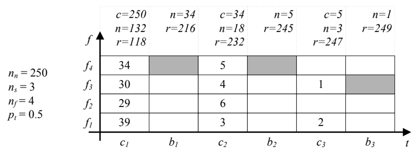
Characteristics and Advantages

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



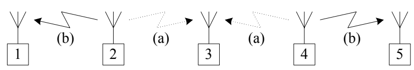
Transmission preceded by the contention window: contention (c) and feedback (b) slots

• **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.



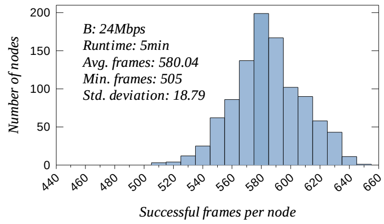
Typical contention session example with 250 nodes

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



Hidden nodes scenarios

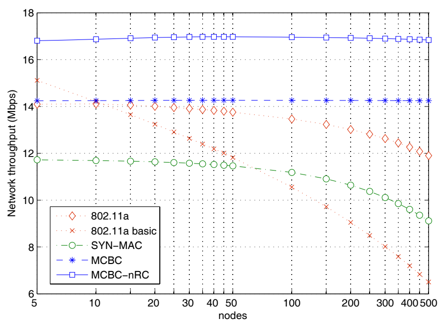
• **Fairness.** All nodes use the same contention parameters so fairness and no-starvation are statistically ensured.



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 of the MCBC protocol allows it to maintain network throughputs close to theoretical limits, even at extreme loads.



Network throughput at 24 Mbps channel bitrate (nRC = No RTS/CTS)

Other Applications

- Since hidden nodes are handled before any MAC frames are transmitted, the throughput can be increased by as much as 30% (depending on the bitrate) by dropping the RTS/CTS scheme.
- Adaptive versions to maintain an even lower collision probability can be implemented with little increase in hardware complexity.
- 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.

† Supported in part by Girton College University of Cambridge UK, Felix Telecom Romania and the Ratiu Foundation UK.

Based on

[1] Bogdan Roman, Frank Stajano, Ian Wassell and David Cottingham. Multi-Carrier Burst Contention (MCBC): Scalable Medium Access Control for Wireless Networks. In *Proceedings of the Ninth IEEE Wireless Communications and Networking Conference 2008 (WCNC'08)*, Las Vegas, March 2008.