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Title	**Supplement to “Contention Schemes For OFDM Mode A_L”**
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Re:	IEEE 802.16 Working Group, Letter Ballot #4, IEEE P802.16a/D1-2001
Abstract	This document shows additional simulation results, following our recent contribution, IEEE C802.16a-02/12.
Purpose	The information should be considered with the comments to IEEE P802.16a/D1-2001.
Notice	
Release	
Patent Policy and Procedures	

Supplement to "Contention Schemes For OFDM Mode A_L"

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1. Summary

This document gives additional simulation results, following our recent contribution, IEEE C802.16a-02/12 [1].

2. Additional Simulation Results

As a result of discussions since writing , we have run additional simulations in order to study the effects of very short frame lengths, and the effects of random backoffs, on slotted ALOHA and in focused contention.

The dashed curves in Figure 1 below show the Average Access Delay in Frames, using the same data as in Figure 6 of [1]. This figure also contains new simulation results run with 1-millisecond frame durations, and with a random exponential backoff.

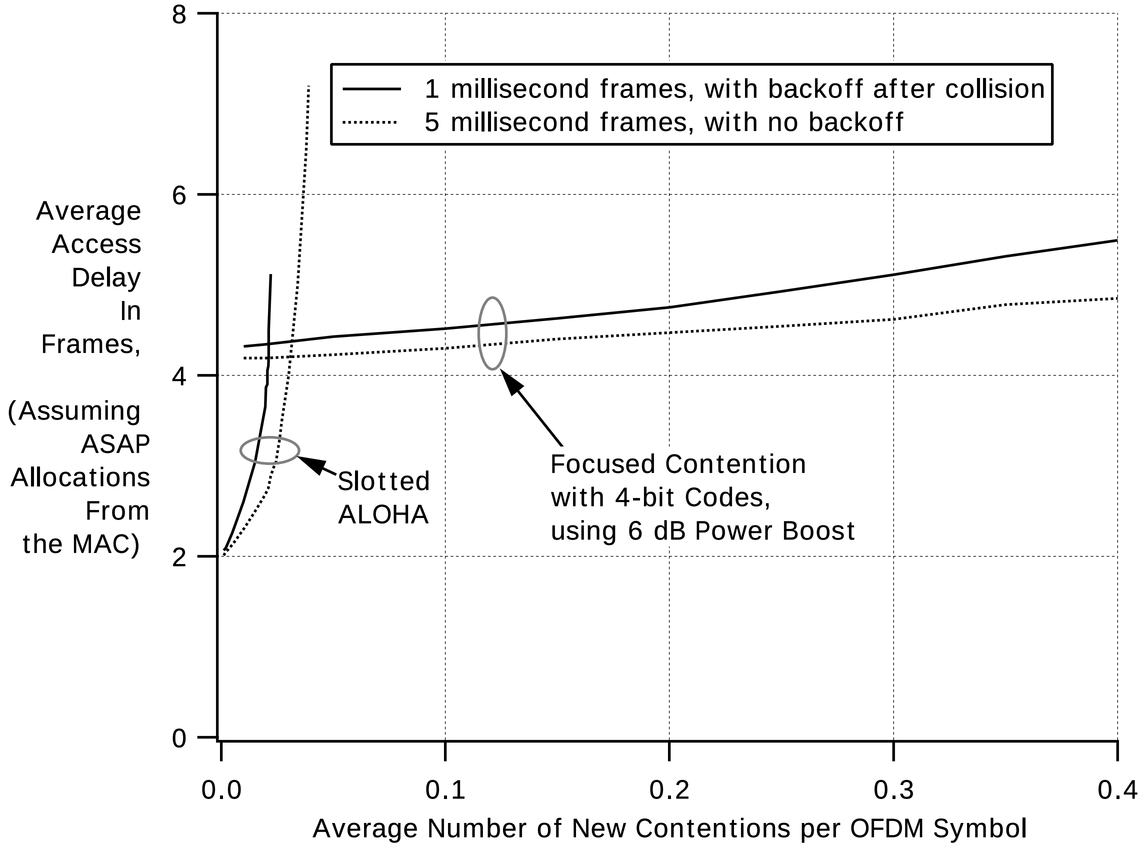

Figure 1 Average Access Delays in Frames, with 15 dB AWGN, 8~10% of UL OFDM Symbols Allocated to Contention.

Without the backoff, the slotted ALOHA simulation showed infinite delay with only 0.02 new contentions per OFDM symbol. The reason for this was that, with 1-millisecond frames, 6 MHz channels, and a guard fraction of (1/8)=0.125, the OFDM symbol duration is only

(1+.125)*(7/8)*(256/6e6) = 42 microseconds

Thus, there are only (1 millisecond/42 microsecond) = 24 OFDM symbols per frame. Allocating 10% of the UL to contention would mean 2.4 OFDM symbols per frame. Requiring that each frame is identical (otherwise we shouldn't call them "frames"), this must be rounded to 2 OFDM symbols, and because each contention slot requires two OFDM symbols, this allocates only one contention slot per frame.

The problem is that, with only one contention slot per frame, colliding stations will *definitely* come back in the next frame and collide again, since they will both use the only available contention slot. Thus, collisions will perpetuate unless we use some kind of backoff mechanism.

(By contrast, with 5 millisecond frames as we originally assumed, there are 119 OFDM symbols per frame, and we can approximate a contention allocation of 10% by allocating 12 OFDM symbols, that is 6 contention slots, per frame.)

The extra delay or “backoff” was made proportional to exp(-k/2), where k is the number of frames of extra delay before retransmission, from the range k=0 (retransmit in next available frame) to k=5 inclusive.

Table 1:

Extra Delay, “Backoff”, in frames	Probability
0	4.14085e-01
1	2.51156e-01
2	1.52334e-01
3	9.23950e-02
4	5.60404e-02
5	3.39902e-02

We should mention that, although it clearly shows the differences between slotted ALOHA and focused contention, Figure 1 is a little misleading in that the ordinate is in units of frames, which of course are five times longer with 5-millisecond vs. 1-millisecond frames. For what it’s worth, another plot of the same data with milliseconds as the ordinate is shown in Figure 2. This shows the expected shorter access delays with shorter frame time, as expected.

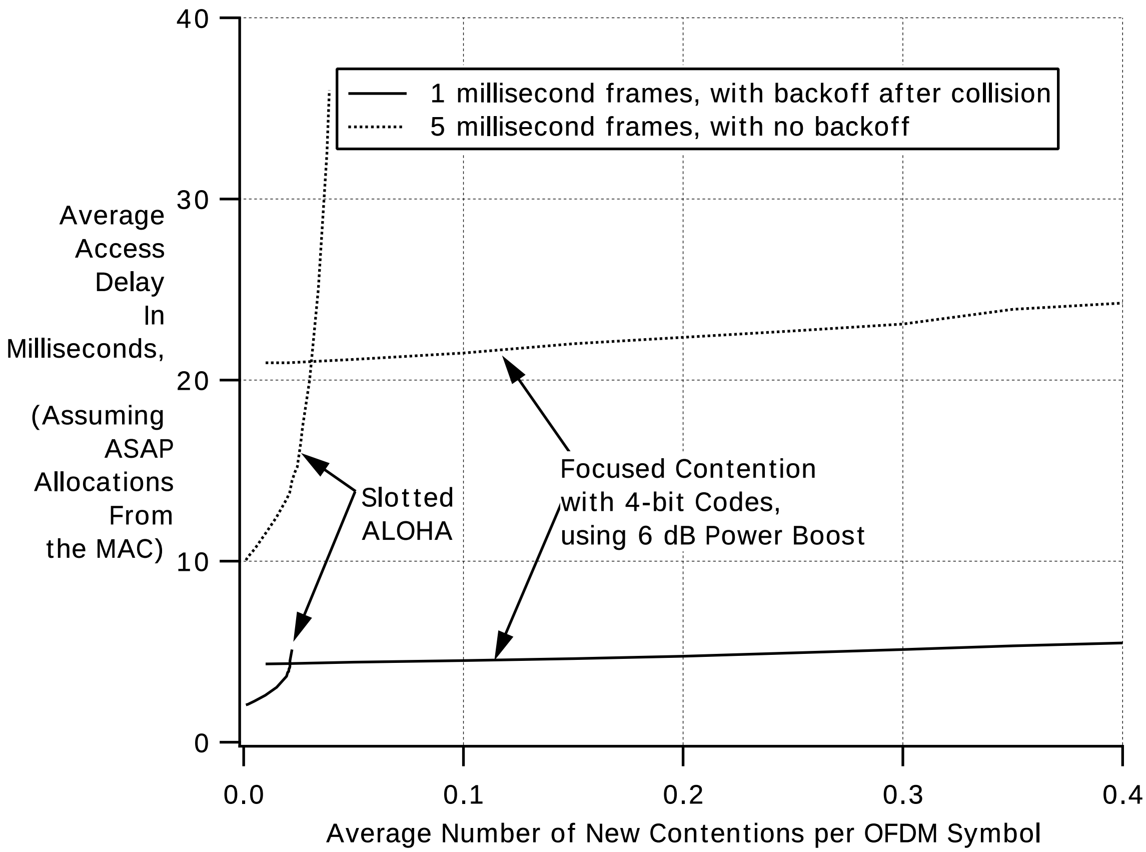

Figure 2 Average Access Delays in Frames, with 15 dB AWGN, 8~10% of UL OFDM Symbols Allocated to Contention.

3. Additonal Conclusions

The preceding data shows that focused contention performs better than slotted ALOHA with very short frame lengths, too.

We learned an additional advantage of focused contention. Even with the minimum number of one contention slot allocated per frame, there are still fifty (50) contention channels available, and it is highly unlikely that two colliding users will choose the same contention channel again in the next frame. Therefore, **focused contention can be operated with zero backoff**. By contrast, when there are few contention slots per frame, slotted ALOHA requires a backoff, which increases the average delay still further, and increases the maximum delay considerably.

To show the regimes in which there are few contention slots per frame, the number of OFDM symbols per frame may be calculated from the formula

$$numOFDMSymsPerFrame = W \cdot T_F / [(1 + f_G) \cdot (7/8) \cdot N_{FFT}] \quad (1)$$

where

W = UL channel bandwidth

T_F = frame duration

f_g = fractional guard time; i.e. 1/16, 1/8 or 1/4

Regimes in which backoff will be required for slotted ALOHA are quite typical. A borderline case would be an UL channel of 3 MHz, with a 10 millisecond frame and 256-point FFT. There will be only 120 OFDM symbols per frame. If, as might be desired, only 5% of the UL symbols are reserved for contention, this is 6 OFDM symbols per frame for contention, which is only 3 contention slots. Due to the significant probability (1/3) of two colliding contenders choosing the same slot again, a backoff would be used in this case.

4. Reference

[B1] "Contention Schemes For OFDM Mode A_L": IEEE C802.16a-02/12.