IEEE P802.11
Wireless LANs

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| Narrowband coexistence issues with enhanced DAA in 6 GHz |
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Abstract

This document analyzes the potential detrimental effect of interference by narrowband frequency hopping devices on Wi-Fi in the 6 GHz band.

**Introduction**

ETSI BRAN is currently discussing possible narrowband (NB) frequency hopping operation in the 6 GHz band in Europe. This document illustrates several potential latency issues with the latest proposal for narrowband (NB) sharing in BRAN, which is referred to as enhanced detect and avoid (eDAA). eDAA requires a CCA every 0.5 s, and 2.5 s unavailability time per 20 MHz segment where interference was detected during the CCA.

This IEEE submission is a transcript of a similar submission to ETSI BRAN, BRAN(21)110d003r1 (Response to BRAN(21)110a003). Related IEEE coex SC submissions are 11-21-0832-00-coex (Narrowband coexistence with WiFi in 6 GHz) and 11-21-1191-00-coex (NB coexistence in 6 GHz - eDAA).

Document BRAN(21)110a003 proposes to adopt eDAA for NB, citing an eDAA throughput plot as showing that eDAA-based sharing is adequate. However, the throughput plot shows that the impact of the NB link on the Wi-Fi throughput is significant in the higher SINR range, certainly taking into account the low bitrate in return on the NB link. In addition, Wi-Fi may experience significant service interruptions and latency in the lower SINR ranges, which is the main focus of this document.

**Wi-Fi latency issue**

A latency plot illustrating the Wi-Fi latency issues caused by eDAA across a wide range of SINR values is reproduced in Figure 1.



Figure 1. Latency issue with eDAA

This plot indicates that eDAA may cause 0.5 s interruptions on a Wi-Fi link. The cause for these interruptions is the 0.5 s time before a CCA is required by eDAA. (This plot is comprised of 80 separate simulation runs of 10 s at different SINR levels, each of which may produce a different maximum latency depending on how the specific hopping pattern interacts with the Wi-Fi transmissions during the simulation run.)

**Wi-Fi ramp-up issue**

A related latency issue caused by eDAA is that Wi-Fi may experience a significant ramp-up time when a Wi-Fi flow starts on a channel where NB is active. This is illustrated in Figure 2.



Figure 2. Ramp-up issue with eDAA

The ramp-up issue is caused by the 0.5 s time before a CCA is required by eDAA. The odds that an NB link can be active on an idle Wi-Fi channel are realistic, because NB is not necessarily aware of nearby Wi-Fi networks or their operating bandwidth. Ramp-up times of this magnitude will be very detrimental for the Wi-Fi user experience.

**Suddenly in-range issue**

eDAA may also cause significant interruptions to Wi-Fi when an NB link suddenly comes into range of a Wi-Fi link, such as when opening a door or walking into a room. This is illustrated in Figure 3.



Figure 3. Suddenly in-range issue with eDAA

The suddenly in-range issue is caused by the 0.5 s before a CCA is required by eDAA, and this issue may occur repeatedly depending on the mobility of the NB links and the Wi-Fi devices. Such repeated service interruptions will be very detrimental for the WiFi user experience.

(The second interruption in Figure 2 and Figure 3 occurs after the 2.5 s unavailability time required by eDAA, in the assumption that the NB link will attempt to reclaim the channel when it is allowed to do so under the eDAA rules. This may or may not happen in practice, depending on whether the NB Adaptive Frequency Hopping (AFH) algorithm determined suitable new spectrum to operate in and stays there. But it is also noted that eDAA essentially appears to allow an NB device to assign 6 blocks of spectrum and use those round robin for 0.5 s at a time, without ever using a CCA.)

**NB-NB sharing issue**

Another, orthogonal reason why eDAA appears inadequate as a spectrum sharing mechanism is because it precludes NB to meaningfully share spectrum with other NB devices. A related throughput plot illustrating this issue is reproduced in Figure 4. This plot shows very unstable throughput for two NB eDAA links that are active within the same spectrum.



with eDAA, no meaningful spectrum sharing between NB links

Figure 4. NB sharing issue when eDAA is used

NB-NB sharing without eDAA is illustrated in Figure 5.



without eDAA, sharing is fine between NB links

Figure 5. NB coex when eDAA is not used

Without eDAA, spectrum sharing between two NB links is essentially fine, because frequency hopping ensures that most transmissions will occur on different NB channels, and there is no significant penalty for occasional hop collisions.

The NB-NB sharing issue is caused by the very high penalty that eDAA puts on hop collisions (e.g. 2.5 s unavailability time per 20 MHz segment). Hop collisions will not occur very often, but the high eDAA penalty on a CCA busy event causes that NB links may effectively be unable to share the same spectrum. Without eDAA and with only frequency hopping, such spectrum sharing between NB links is generally not an issue. So also from an NB perspective, eDAA appears undesirable as a coexistence mechanism.

The implication is that NB links using eDAA would never share the same spectrum in practice. Multiple NB links will therefore occupy a wide range of spectrum, which will increase the expected interference to Wi-Fi channels. For example, a 4 MHz frequency hopping link using the minimum required 15 hops will cause interference in 60 MHz of spectrum. 8 such links would fill up the entire 6 GHz band currently available in Europe.

**VOIP latency in Wi-Fi**

BRAN(21)110a003 asserts in Scenario 3 that the VOIP latency is up to 2 s in a scenario with 2 full buffer data nodes, 2 video nodes and 2 VOIP nodes, and that this delay is caused by LBT. This scenario has been reproduced in Figure 6 and Figure 7.



VOIP starts at time 0

data and video are added after 5 s

Figure 6. Aggregate throughput



the VOIP latency stays low also when data and video are added

VOIP starts at time 0

Figure 7. VOIP latency

In this simulation, the VOIP traffic starts at time 0, the data and video traffic are added after 5 s. As shown in the figures, the VOIP latency stays low, which is due to the EDCA access differentiation and the use of AC\_VO for the VOIP traffic (priority class 4 in EN 303 687).

**Conclusion**

Based on the potential coexistence issues highlighted in this document, eDAA may not be an adequate spectrum sharing mechanism. eDAA may cause long outages on a Wi-Fi link, long ramp-up times for Wi-Fi flows, sudden interruptions of a Wi-Fi flow when NB comes in range, and it may preclude NB from sharing with NB. The cause of these issues is the 0.5 s time between eDAA CCAs, and in case of NB-to-NB coexistence, the high unavailability time penalty on a hop collision.

The potential coex issues with eDAA are summarized below:

* high latency at Wi-Fi
* long Wi-Fi ramp-up times
* suddenly in-range issue
* NB-NB coex issue
* low return on interference

These coexistence issues should make it unlikely that a notified body could certify 'no-LBT' NB equipment, because eDAA would not satisfy the requirement of an 'adequate spectrum sharing mechanism' as required by the ECC.