Effect of no-LBT NB on 802.11 devices – Part 2

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Overview

This work expands the work previously presented in 11-23/1259r1.

- In that work, we looked at the effect of a fixed duty cycle from a single NB pair of devices, affecting only the primary 20 MHz channel, on a 802.11 XR link with the following 802.11 traffic: 100 Mbps DL @ 72 Hz and 3 Mbps UL @ 500 Hz

We now look at realistic frequency hopping NB traffic profile, with variable duty cycle, with different users streaming music @ 96 kbps to 2 earbuds and explore the effect of multiple NB sets of devices for different 802.11 channel utilizations.

- The AP is 5m away from the XR headset and the interfering users are 2m away from the XR headset.
Simulation Scenario

UL/DL 802.11 link
DL NB link
Example of 100% freq overlap

Frequency

802.11 Data

802.11 Data

802.11 Data

Time

150us
Assumptions

- **802.11**
  - 14 dBm at both AP and STA
  - XR Traffic : 100 Mbps DL @ 72 Hz and 3 Mbps UL @ 500 Hz
  - BW=80 MHz, Nss=2
  - Traffic type : UDP, AC_BE
  - 0.8s GI, 2x HE-LTF, RTS/CTS on
  - BAwin = 256

- **NB**
  - BLE Audio Traffic (96 kbps DL, Number of SubEvents=3, Flush Timeout=2)
    - 1 main TX + 5 retry opportunities
    - ~5.92 * (1+retry) % Duty Cycle (DC) for each peripheral
  - 14 dBm at both Central and Peripheral
  - Each central, denoted by C transmits to 2 peripherals, denoted by P1 and P2
  - 2 MHz BW (40 channels) with 100% overlap with 802.11
  - 2 Mbps PHY
  - -75 dBm/MHz Max ED Threshold value
  - 802.11 AWGN Channel model with dbp=5, fc = 6.425 GHz

<table>
<thead>
<tr>
<th>Retry</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<tr>
<td>DC per P</td>
<td>5.9</td>
<td>11.8</td>
<td>17.8</td>
<td>23.7</td>
<td>29.6</td>
<td>35.5</td>
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</table>
Bluetooth Timing Details

Each Subevent hops on a different NB channel

NOTE: IFS gap = 150 us

Figure not drawn to scale
MCS 2 P95 Latency

With a single central, there is an increase of ~220% for DL and around ~250% for UL

No interferers
MCS 2 Latency CDF

**Solid**: no NB devices
**Dash**: 2 NB centrals with LBT
**Solid**: 2 NB centrals with no LBT
MCS 2 Throughput

Average Throughput DL

Average Throughput UL
MCS 7 P95 Latency

In DL, with 3 centrals, there is an increase of > 10x of latency (from 5ms to >50ms)
**MCS 7 Latency CDF**

- **Solid**: no NB devices
- **Dash**: 3 NB centrals with LBT
- **Solid**: 3 NB centrals with no LBT

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Submission

Slide 11

Carlos Aldana, et al.
MCS 7 Throughput

Average Throughput DL

Average Throughput UL
MCS 11 P95 Latency

In DL, with 3 centrals, there is an increase of ~4.2x of latency (from 5 to ~21)
MCS 11 Latency CDF

Solid: no NB devices
Dash: 5 NB centrals with LBT
Solid: 5 NB centrals with no LBT
MCS 11 Throughput

Average Throughput DL

Average Throughput UL

coexMechanism=LBT, mcs=11
coexMechanism=None, mcs=11
Summary of Results

- XR use case targets p95 burst latency up to 10ms
- The table below summarizes the number of BLE music streaming centrals that meet target 802.11 XR requirements.

<table>
<thead>
<tr>
<th>Interfering NB music streaming devices allowed</th>
<th>Low 802.11 Channel Utilization</th>
<th>Medium 802.11 Channel Utilization</th>
<th>High 802.11 Channel Utilization</th>
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</thead>
<tbody>
<tr>
<td>No LBT</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>LBT</td>
<td>&gt;=5</td>
<td>&gt;=3</td>
<td>maybe 1</td>
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Observations

• For this scenario, 802.11 latency is again more sensitive than 802.11 throughput.
• Lower 802.11 duty cycle allows for increasing in-band LBT NB centrals, but up to 2 no-LBT NB centrals.
• NB LBT helps 802.11 latency in 802.11 low, medium, and high duty cycle scenarios.
Appendix
Impact of Higher MCS at same 802.11 Utilization
MCS 7 w/ 350 Mbps DL 802.11 Latency
MCS 7 w/ 350 Mbps DL 802.11 Latency CDF
MCS 7 w/ 350 Mbps DL 802.11 Throughput

Average Throughput DL

Average Throughput UL