Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: Channel Access using Clear Channel Assessment (CCA), useful tool for efficient UWB communication
Date Submitted: July 20th, 2021
Source: Frederic Nabki (Spark Microsystems)
Address: 1201 rue Barré Suite 201, Montréal QC, Canada
E-Mail: frederic.nabki@sparkmicro.ca

Re: IEEE 802.15 IG NG-UWB Plenary Meeting

Abstract: Implementing clear channel assessment (CCA) for efficient coexistence of UWB devices

Purpose: Discuss and show the effect of an efficient CCA algorithm on UWB communications

PAR Objective (1/2)	Proposed Solution (how addressed)
Safeguards so that the high throughput data use cases will not cause significant disruption to low duty-cycle ranging use cases.	Channel access using Clear Channel Assessment to improve coexistence of UWB devices, reducing the probability of interference to existing (legacy) devices operating in the same channel.
Interference mitigation techniques to support higher density and higher traffic use cases	Improved channel access will reduce harmful collisions as the number of devices within mutual sphere of influence increases.
Other coexistence improvement	Channel access using Clear Channel Assessment can be used with other coexistence mechanisms.
Backward compatibility with enhanced ranging capable devices (ERDEVs).	Compatibility with legacy ERDEVs is preserved. Channel access using CCA is compatible with all 802.15.4 MAC frame formats and frame processing behavior. Preserving interoperation with legacy ERDEVs.
Improved link budget and/or reduced air-time	Simultaneous transmission may be reduced which reduces interference and perceived noise at receivers in the SOI. Failed transmissions can be reduced which results in fewer retransmissions of lost packets.

PAR Objective (2/2)	Proposed Solution (how addressed)
Additional channels and operating frequencies	Compatible with any UWB channel.
Improvements to accuracy / precision / reliability and interoperability for high-integrity ranging;	Packet transmission reliability can be improved.
Reduce complexity and power consumption;	Fewer failed transmissions save energy.
Hybrid operation with narrowband signaling to assist UWB;	No negative impact on hybrid operation.
Enhanced native discovery and connection setup mechanisms;	No negative impact.

Proposed CCA methods in 802.15.4 standard for non-HRP UWB PHY:

CCA Mode 1: Energy above threshold. CCA shall report a busy medium upon detecting any energy above the ED threshold.

CCA Mode 4: ALOHA. CCA shall always report an idle medium

Channel Sensing introduction Mode 1 (1/2)

- Transmitter listens before transmit and defers (initially) when busy
  - Using Energy Detection or one of the preamble detect modes
  - Simple, and low overhead of implementation
- Used for assessing the background energy inside of a single UWB channel
- Aims to get a pass-fail result to maximize TDMA capability on uncoordinated links beyond statistical luck
- Set a maximum allowable power threshold level in a channel
- Autonomously samples the channel until the power level is adequate or else sends nonetheless

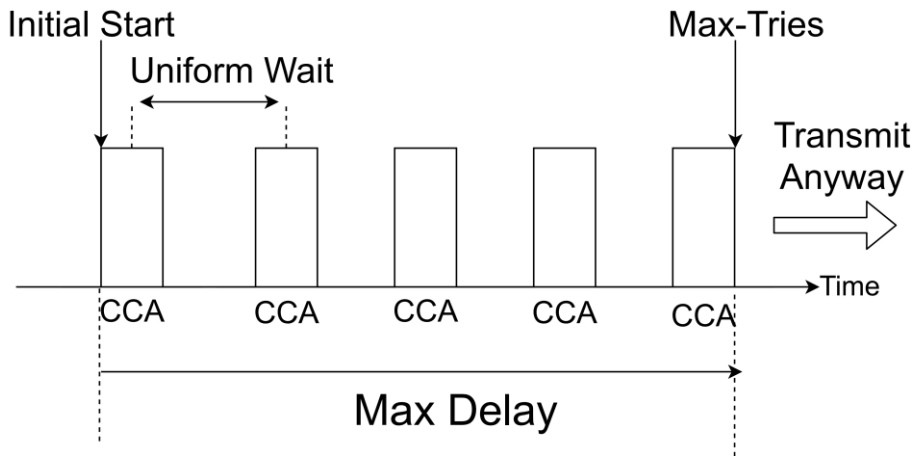
Channel Sensing introduction Mode 1 (2/2)

- Allows for harmonious operation with other uncoordinated UWB systems, including legacy devices
- Can also detect other interferers such as WI-FI (without complex preamble detection)
- Provides avoidance via time-shifted frame
- Channel Sensing is a part of channel access mechanism
- Allows intelligent link optimization (specially for smaller places where the sensitivity is good)

- Threshold can be fixed (CSMA),
- or dynamic based on average tries:

$$Avg = \frac{\sum N_t}{Max(N_t) \times N_{frames}}$$

  - N_t= number of tries
  - N_f= number of frames
  - Max(N_t)= Maximum number of tries



- Keep the average controlled by adjusting the threshold
- Trigger CCA often but not too much

What it means for channel access

- Channel sensing is useful for deploying channel access mechanisms
- Introducing a new channel access mechanism
- Listen before talk
- Uniformly spaced listen periods
- High level channel access protocol

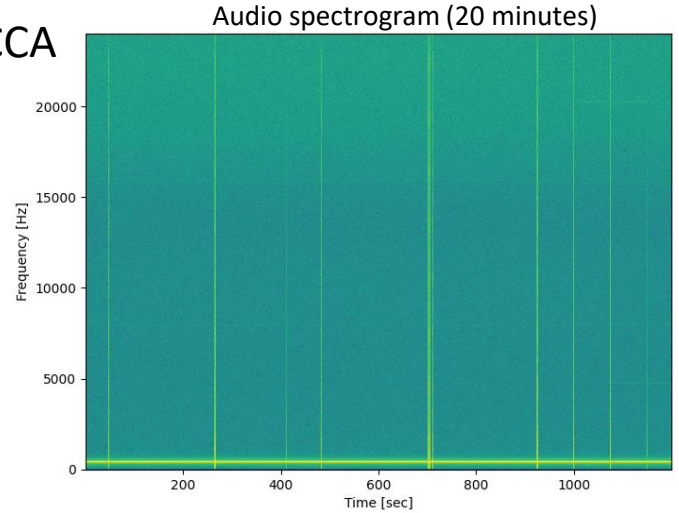
CCA Benefits

- CCA improves the TX efficiency for various UWB transmitters by providing efficient access to the channel (A win for all devices!)
- CCA provides an early assessment of the frequency channel to find a free one!
- What if we cannot detect the preamble from other legacy UWB devices?
  - Link disruption can occur when neighboring devices are too close. In this case CCA can detect the preamble and avoid transmitting in this channel. When the devices are far away and the preamble cannot be detected, it's not very crucial if CCA does not trigger.
- If there is a Wi-Fi burst, the CCA detects its presence and switches the frequency channel to avoid it
- CCA is helpful with higher rate communication which needs more airtime
  - Reduced failed packets reduces retransmission and overall airtime
  - Legacy devices also benefit

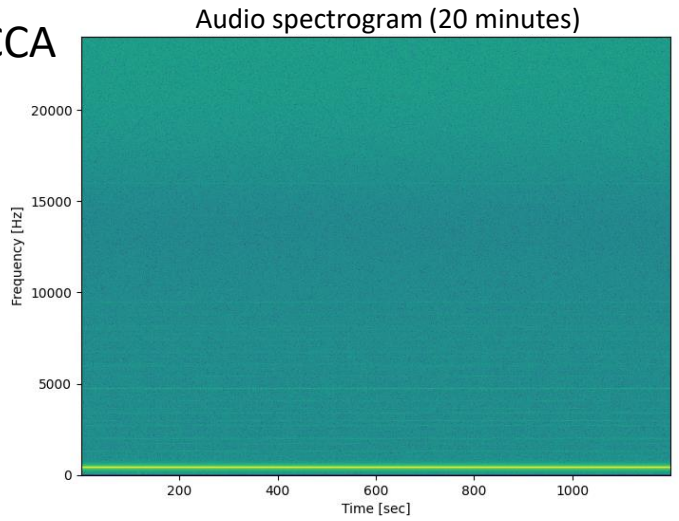
Test 1 : CCA effect on coexistence between three stereo audio links

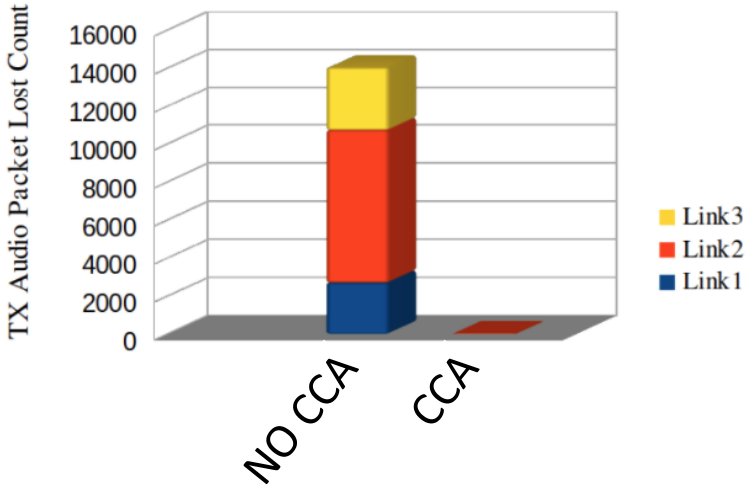
- 3 simultaneous UWB audio links (48kHz, 16 bits, stereo, uncompressed, 1.536 Mbps payload)
  - Not synchronized with each other.

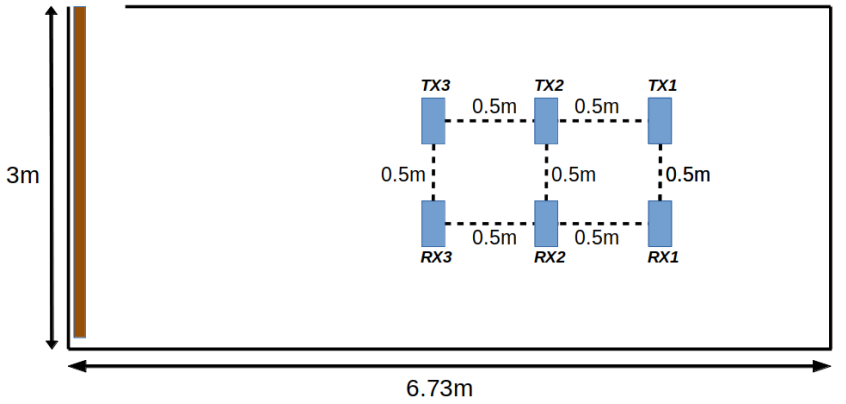
No CCA



CCA



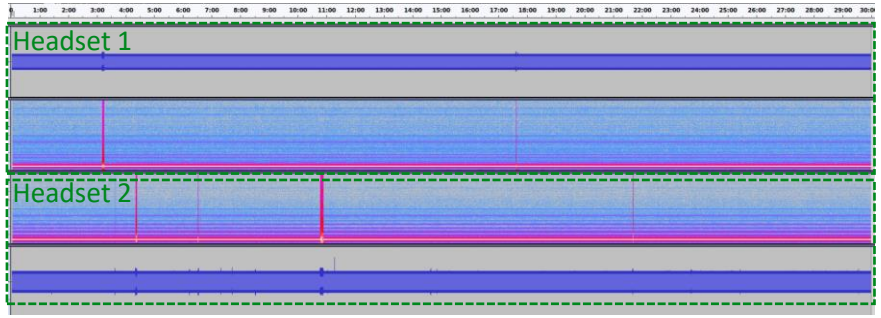




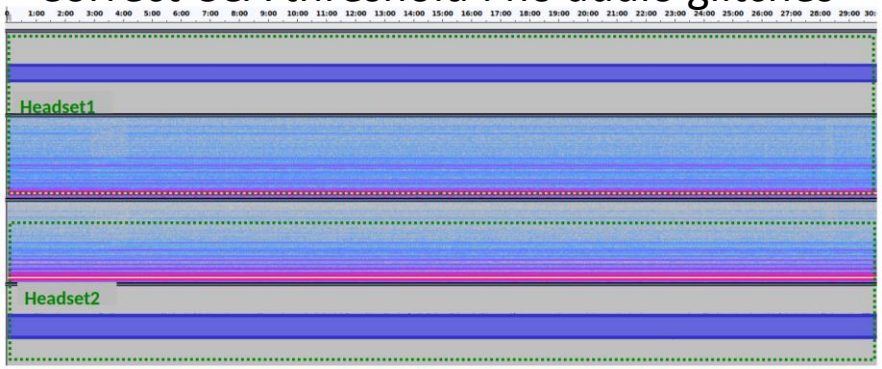
Test 2 : CCA effect on coexistence between two UWB data hub systems

- 2 audio headsets (main 1.536 Mbps + mic 256kbps) + 4 bi.dir. data nodes (256 kbps + 256 kbps) + 2 hubs
- Two star networks that are not synchronized with each other
  - Headset 1, Hub1, Data node 1A, Data node 1B
  - Headset 2, Hub2, Data node 2A, Data node 2B
  - Simultaneous operation of both star networks for 30 minutes

Incorrect CCA threshold : audio glitches on the 2 headsets



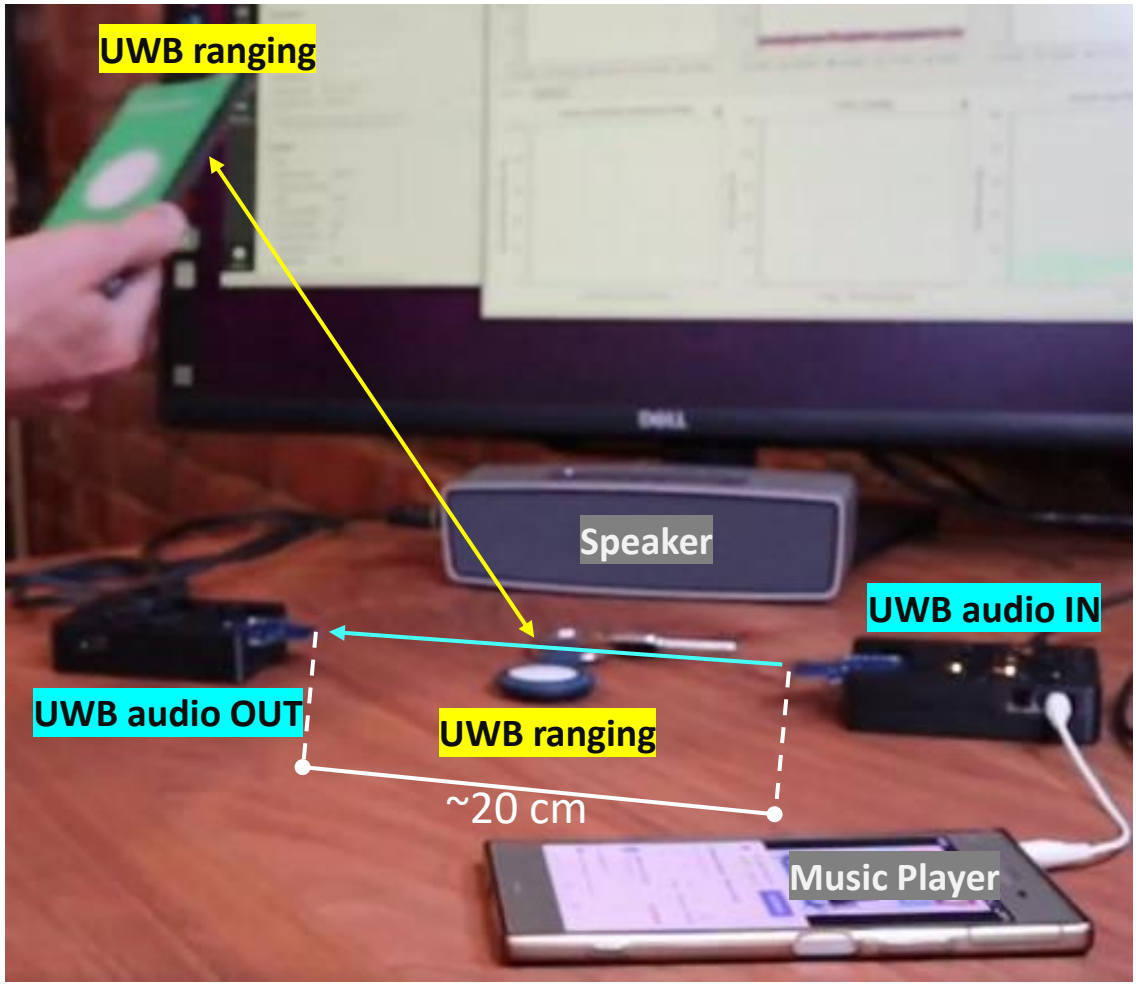
Correct CCA threshold : no audio glitches



Example of coexistence between streaming and ranging UWB systems (1/2)

- UWB Audio and Ranging links
  - Working simultaneously
  - Not synchronized with each other
- UWB Ranging : system 1
  - Spec unknown
  - No access to statistics
- UWB Audio : system 2
  - Channel hopping + CCA
  - Data rate = 1.536 Mbps (48kHz, 16 bits, stereo, uncompressed audio)

- Conclusion :
  - With System 2's data rate = 1.536 Mbps:
    - Ranging Tag (system 1) working **OK**
    - Audio UWB (system 2) working **OK** (PDR>99.99%)



Example of coexistence between streaming and ranging UWB systems (2/2)

Video