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Common Preamble Design in the 6 GHz Band – Merits and Challenges

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Outline

Background and Problem Statement

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Correlator-based Physical Carrier Sensing

Summary

Background and Problem Statement (1/2)

During the standardization of License-Assisted Access (LAA) to unlicensed spectrum in LTE Rel. 13, fair coexistence with incumbent technologies was extensively discussed including the simultaneous operation of LTE LAA and IEEE 802.11ac in the 5 GHz band

The definition applied by 3GPP to assess 3GPP LAA coexistence with IEEE 802.11 technologies was that the “LAA design should target fair coexistence with existing Wi-Fi networks to not impact Wi-Fi services more than an additional Wi-Fi network on the same carrier, with respect to throughput and latency”

A performance based coexistence metric is generally problematic due to the fundamentally different air interfaces and resulting spectral efficiencies of 3GPP and IEEE 802.11 technologies or any other radio technology coexisting in overlapping unlicensed spectrum

Background and Problem Statement (2/2)

While the aforementioned performance based definition was motivated by the presence of an incumbent technology in the aforementioned 5 GHz band, different coexistence metrics have been proposed for the 6 GHz band based on equal air time or equal access opportunity

In the 5 GHz band, channel access procedures differ between 3GPP and IEEE 802.11 technologies in that the former uses a single energy detection (ED) based threshold of -72 dBm whereas WiFi uses a dual threshold detection mechanism based on energy detection at -62 dBm followed by preamble detection (PD) at -82 dBm

We propose a common channel access procedure, and in particular, a common preamble design for 3GPP and IEEE 802.11 technologies or any other radio technology in the 6 GHz band

Challenges

3GPP and IEEE radio technologies are developed and maintained under the umbrella of different standards developing organizations (SDOs)

3GPP and IEEE radio technologies use different physical layer channels and procedures

3GPP and IEEE radio technologies use different protocol architectures

3GPP and IEEE radio technologies use different multiple access parameters incl. the sampling rate

3GPP and IEEE radio technologies use different channel coding schemes

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Virtual Carrier Sensing—Background (1/2)

A transmission burst begins with the legacy IEEE 802.11a preamble comprising the

- legacy short training field (L-STF)
- legacy long training field (L-LTF)
- legacy signal (L-SIG) field

The legacy preamble is followed by the IEEE 802.11ax preamble which itself is followed by the IEEE 802.11ax data

Virtual carrier sensing requires decoding of the legacy signal (L-SIG) field which carries, amongst others, information about the length of the on-going transmission

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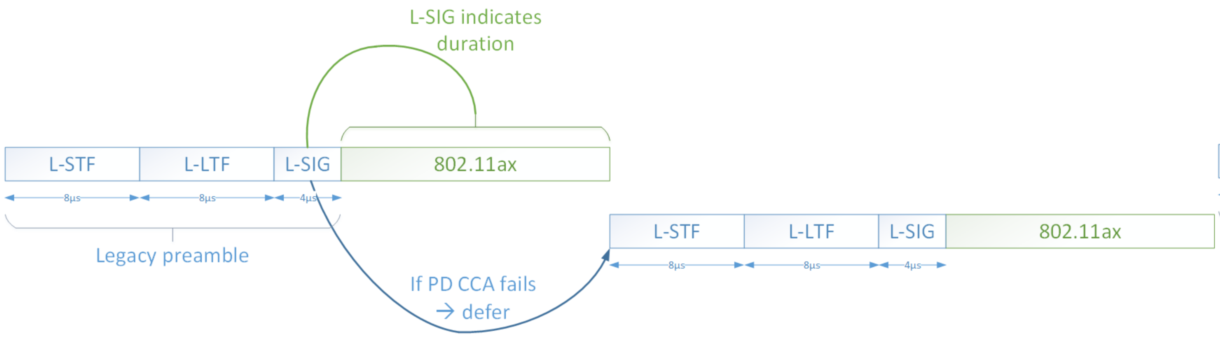
Virtual Carrier Sensing—Background (2/2)

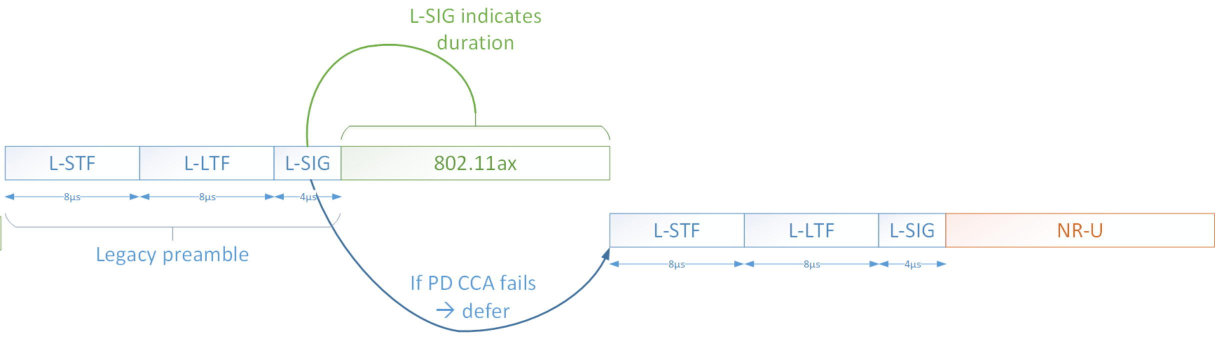
From a power savings perspective, the L-SIG conveys to a device the duration for which it can defer from accessing the medium

From a channel access perspective, the L-SIG lets a device set its NAV to determine for how long the sending station will occupy the channel

- If the NAV is non-zero, the medium is considered busy
- When then NAV expires, the medium is considered idle.

The same mechanism can be used if different radio technologies share the medium





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Virtual Carrier Sensing—Challenges

However …

Because for virtual carrier sensing, the L-SIG field (or any other common preamble) needs to convey the duration of the transmission, channel coding and a protocol stack are required that are generally not common among radio technologies

On the other hand …

The L-STF and L-LTF fields are used for time synchronization, automatic gain control (AGC), frequency offset correction, and channel estimation amongst others and do not carry information

Correlator-based Physical Carrier Sensing (1/2)

Proposal 1: the common preamble only comprises a signal part whereas the channel part of any preamble is not used across radio technologies

- A channel part may still be present but would not be common among radio technologies and would only apply to a specific radio technology

Proposal 2: The overall clear channel assessment procedure comprises a dual threshold detection mechanism, however, instead of ED followed by PD with virtual carrier sense, the second step only involves a signal part and the entire procedure comprising ED followed by PD uses physical carrier sensing

- PD mechanism is correlator based and does not incorporate channel decoding or demodulation
- PD stage uses the received waveform rather than a payload carried by the received waveform
- Unlike virtual carrier sense, the duration of the on-going transmission is unknown to other devices even after detecting the on-going transmission

Proposal 3: Study the feasibility of correlator-based physical carrier sensing when a device uses a sampling rate different from the one used to transmit the common preamble

- Received waveform can be correlated with a stored preamble that accounts for the deterministic distortions

PD is computationally more demanding and more power consuming than ED

- After PD successfully detects an on-going transmission, device continues to perform ED only
- Instead of using the ED threshold of the clear channel assessment procedure it uses a different ED threshold which is a function of the energy/power received when the on-going transmission was successfully detected
- The purpose of this ED procedure with the ED threshold different from the one used for CCA is to detect the duration of the on-going transmission absent any payload in the preamble informing the transmission duration explicitly

Example:

- Let the CCA threshold for ED and PD detection be T_{ED} and T_{PD}
- The device performs ED and PD and the levels it gets are R_{ED} and R_{PD}, respectively (all numbers are in linear scale)
- If $R_{PD} < T_{PD}$ then the channel is clear and the device can transmit
- If $R_{PD} > T_{PD}$ then the channel is busy and the device does the following (since it does not know the defer period)
    - The device adjusts the temporary ED threshold to $T_{ED\_temp} = R_{ED}$
    - The device continues to monitor the channel by using energy detection with T_{ED_temp} to detect the end of the transmission

Summary

A common preamble design for 3GPP and IEEE 802.11 technologies in the 6 GHz band allows for better coexistence and better power savings

Ideally, 3GPP devices perform virtual carrier sensing by decoding the preamble's payload to determine an ongoing transmission's duration

Alternatively, detection of the common preamble can be based on detecting known sequences without decoding the preamble's payload

If an ongoing transmission is detected, subsequent energy detection monitoring is performed to determine when transmission ends

The technology facilitates the usage of different sampling rates by different radio technologies that work concurrently in the same unlicensed band

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