Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**	
Title	**Idea for spectrum sharing in LE bands**	
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Re:	IEEE 802.16 – Ad-Hoc Committee for LE coexistence – Call for Contributions	
Abstract	Proposes a protocol for spectrum sharing	
Purpose		
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Idea for spectrum sharing in LE bands

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Introduction

This paper presents some idea for active spectrum sharing in LE bands.
The basic idea is that a system should announce its transmit and receive times.
As 802.16 works with constant MAC frames, it is possible to assume that between 2 announcements the Rx/Tx intervals will have always the same position relative to MAC frame start.

PHY communication

We already have a cognitive radio approach implementation: radar detection in 5GHz, followed by DFS.
The radars are recognized based on repetition patterns: pulse periodicity, pulse duration, pulse template.
This approach is technology independent, and all the 5.3 and 5.4-5.7GHz systems have to implement it.
Lets suppose that a similar mechanism (avoiding radar specific signals), may be developed for inter-system communication, using pulse-position modulation (in time domain). Here down is shown how a FWA system may announce its Tx/Rx reservation periods or the full set of parameters.

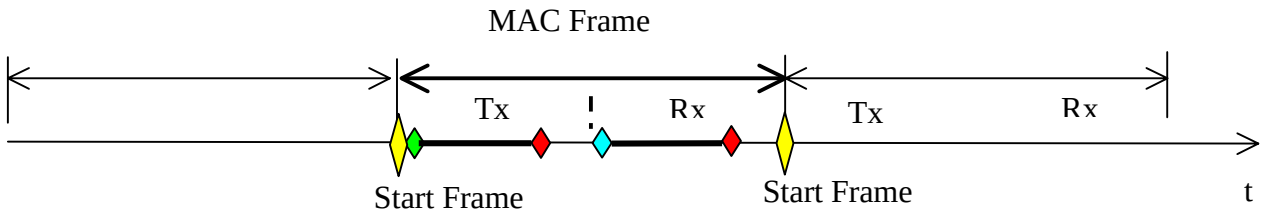

Figure 1 Basic Tx /Rx Reservation signaling

The signaling from the figure above allows to:

- Identify the system
- Determine the periodicity of the MAC frames
- Determine the MAC frame duration
- Determine the Tx duration for different reservations
- Determine the Rx duration for different reservations
- Send full messages, will all the needed parameters.

Operational example, with 802.16 and 802.11 devices

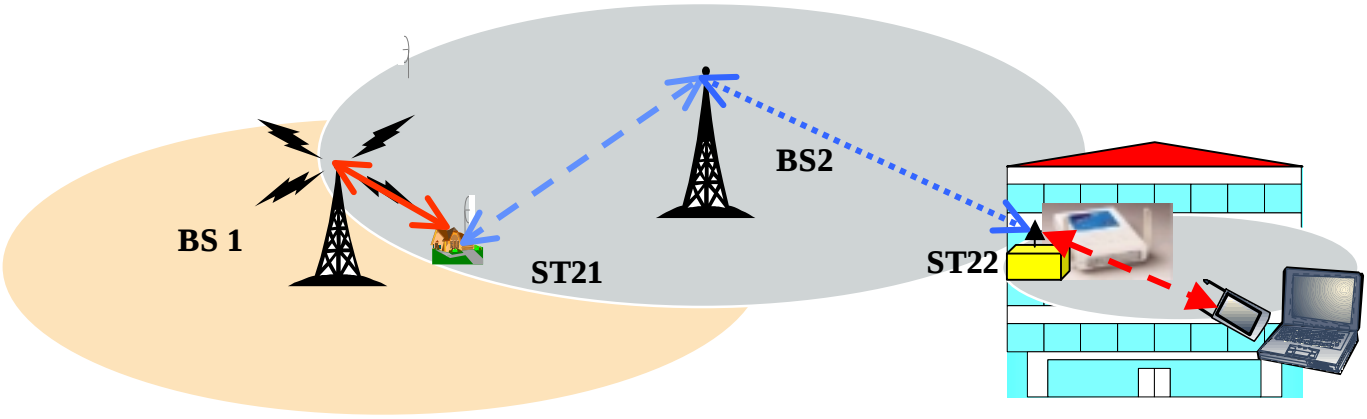

Figure 2 Deployment example

Lets suppose that BS1 (Base Station 1) is occupying frequency F1-F4 and Base Station 2 is occupying frequency F6.
BS1 has 4 APs (sectors, with synchronized MAC frames). BS2 has 1 omni AP.
System 2 is deployed after System 1.
System 1 is transmitting at regular intervals, for 2 consecutive MAC frames, information regarding:

a. AP ID and Tx reservation
b. AP ID and Rx Reservation

The information is transmitted on all the used sectors, using different slots in the multi-frame structure.
BS2 – AP - will recognize that spectrum sharing info is transmitted. BS 2 will identify the sector interfering with itself.
The spectrum sharing will take place as follows:

Sharing Etiquette approach 1:

To avoid/reduce the interference, BS2 chose to synchronize its Tx and Rx periods with BS1.
BS2 starts to work. Its station, ST21 suffers from interference from BS1, and BS2 is aware of that. BS1 suffers from interference from ST21.
ST22 is interfered from a device, for which BS2 is probably hidden (say 802.11 AP).

Sharing Etiquette approach 2:

BS1 reduces both its Tx and Rx durations.

Sharing Etiquette approach 3:

BS2 schedules the communication with ST21 in the period of time, when BS1 is not working.
Interference is avoided.

Sharing Etiquette approach 4:

When told by AP2, ST22 will announce its intended Tx and Rx transmissions (reservation approach).

Sharing Etiquette approach 5:

The 802.11 AP will enter the PCF function. In this mode, will block communication inside its cell, during ST22 reservation intervals.

Sharing Etiquette approach 6:

802.11 AP might search for another operating frequency, with a higher frequency gap

Sharing Etiquette approach 7:

A 802.11 STA is the one hearing the ST22 messages. The 802.11 STA will relay the reservation information to its 802.11 AP (if in P-MP mode) or to the other connected stations (if in Ad-hoc mode)

Sharing Etiquette approach 8:

The stations not hearing the ST22 reservation signals, will refrain to communicate with the stations hearing the signals, during the reserved Tx and Rx intervals.

The general resulting time-frequency behavior is illustrated below.

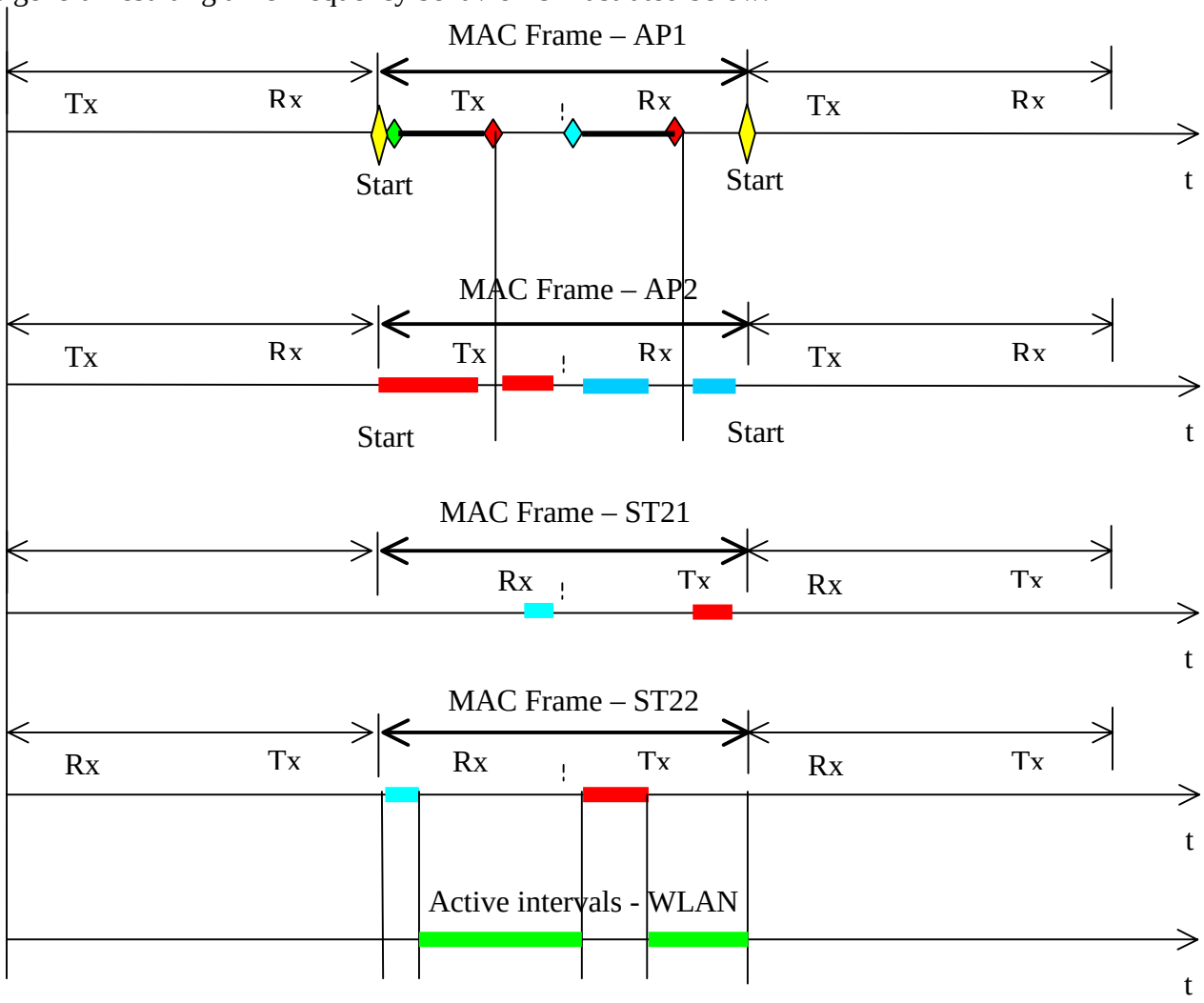

Figure 3 Communications intervals when applying sharing protocol

Conclusion

802.16 air protocol has excellent sharing properties, due to its predictable behavior. The predictable behavior should be enhanced with suitable signaling and messages, in order to optimal use a cognitive spectrum sharing approach. This approach may probably resolve not only co-existence between 802.16 like systems, but also co-existence of 802.16 like systems with bursty systems, like 802.11.