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Title	**Comments on Listen-Before-Talk for Wide Area Networks**	
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Re:	IEEE 80216h-07_013	
Abstract	Offers comments on limitations of LBT for important classes of applications (e.g. VoIP) in wide area wireless networks.	
Purpose	Seek clarification on what applications are intended to be served well with LBT in wide area deployments. Suggest need to explore alternatives or extensions that are future proof with respect to all applications.	
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Comments on Listen-Before-Talk for Wide Area Networks

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Introduction

For a wide area wireless network (intended for urban, suburban and/or rural area coverage), the use of a Contention-Based-Protocol (CBP) based on Listen-Before-Talk (LBT) principle has been recommended by the FCC** [1]. Perhaps the most well-known and widely deployed example of a CBP has been in a wireless local area environment. It is the CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance) protocol which forms the foundation of 802.11 networks.

As part of the uncoordinated coexistence procedures, sub-clause 6.4.3.4 defines a Listen-Before-Talk like mechanism enabling the coexistence of 802.16 systems with certain non 802.16 systems. This contribution is an accompanying document to a submitted comment and aims at discussing the relevance of a LBT approach in wide area networks for an application like VoIP.

Material for discussion

Use of a CBP such as CSMA/CA in a wide area wireless network has some serious limitations some of which are highlighted in this contribution. However, successful application of CSMA/CA like protocol will be possible only when the ratio ***a/b*** is much smaller than 1 where,

a = Packet propagation delay
b = Packet transmission time

In a local area environment (distances of about 300 feet and channel speeds of 11 or 54 Mbps), the above ratio tends to be small compared to 1. However, in a wide area system (such as rural area deployments for which CBP is being considered), straightforward leveraging of CSMA/CA appears unattractive, especially, for important applications such as VoIP.

The following calculations illustrate the point.

Suppose Voice is carried using G711 or G729 codec. Packets are generated every 20 msecs.

Assume ~ 40 bits of overhead (with use of suitable header compression such as ROHC)

Packet size = 1280 bits payload (if G711 is used) (or 1320 bits with overhead)
= 160 bits payload (if G729 is used) (or 200 bits with overhead)

In rural area, let us say the maximum distance between stations = 30 miles (or ~ 50 km)
Propagation delay between such stations (with speed of light = 3×10^{10} cm/sec) = 166.6 microseconds.

Assume a design with 3.5 MHz channel and 16-QAM, transmission speed = 14 Mbps
Packet transmission time with G729 encoded packets = 14 microseconds
Packet transmission time with G711 encoded packets = 94 microseconds

A detailed analysis on performance on carrier sensing protocols may be found in [2] [3]. Clearly the propagation delay is much longer than packet transmission time and the CSMA/CA protocol will be quite useless. Even if the channel transmission speed is reduced to 7 Mbps, the ratio of propagation time to transmission time is still unacceptable.

In contrast, in a WLAN environment, if maximum distance between stations = 50 meters, then the propagation delay is reduced by a factor of 1000 with a propagation delay = 0.1666 microseconds. With such a reduced propagation delay, the CSMA/CA protocol could be effective in WLAN environment.

Perhaps a different set of traffic assumptions will make CSMA/CA viable for use in rural area coverage spanning large distances. However, until such scenarios are identified and analyzed in some detail, the viability of CSMA/CA appears dubious for such deployments.

Thus, it is not clear how far LBT (CSMA/CA based or alike) is efficient for wide area access especially to support important applications such as VoIP service since in that case the propagation delay is much longer than packet transmission and results in poor realizable throughput. How far can the current proposed LBT mechanisms in the draft support VoIP with LBT on wide area? It is necessary to clarify what are the limitations on use cases (including applications and associated coverage / speed / performance constraints), that can be supported by currently proposed LBT mechanisms.

Finally it is noted that the CSMA/CA protocol initially devised for 802.11 had to go through several modifications including reservation capabilities for handling real-time capabilities. Likewise, significant extensions or modifications to the simple LBT regime are very likely needed to provide useful solutions for handling a variety of applications, including real-time VoIP and other future applications (with short packet and/or real-time requirements).

Conclusion

Provided these observations raised for 802.11, it should be clarified what are the limitations on use cases (including applications and associated coverage / speed / performance constraints), that can be supported by currently proposed 802.16 based LBT mechanisms.

References

[1] FCC 07-99, Memorandum Opinion & Order - Petitions for Reconsideration in the 3650-3700 MHz Band Proceeding, June 7, 2007.

[2] L. Kleinrock and F. A. Tobagi, “Packet-Switching in Radio Channels: Part I – Carrier Sense Multiple-Access Modes and Their Throughput-Delay Characteristics:, IEEE Transaction on Communications, COM-23, no. 12, Dec. 1975, 1400-16.

[3] Raphael Rom and Moshe Sidi, Multiple Access Protocols, Performance and Analysis (Chapter 4 on Carrier Sensing Protocols), Springer Verlag, Heidelberg, 1990.

Note (**) The FCC defined the contention-based protocol as follows: *A protocol that allows multiple users to share the same spectrum by defining the events that must occur when two or more transmitters attempt to simultaneously access the same channel and establishing rules by which a transmitter provides reasonable opportunities for other transmitters to operate. Such a protocol may consist of procedures for initiating new transmissions, procedures for determining the state of the channel (available or unavailable), and procedures for managing retransmissions in the event of a busy channel.*