~~Draft IEEE Standard for~~

~~Local and Metropolitan Area Networks~~

Part 16: Air Interface for Fixed Broadband Wireless Access Systems

Amendment for Improved Coexistence Mechanisms for License-Exempt Operation

Sponsor
LAN MAN Standards Committee
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Participants

~~This document was developed by the IEEE 802.16 Working Group on Broadband Wireless Access, which develops the WirelessMAN™ Standard for Wireless Metropolitan Area Networks.~~

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~~*[to be determined]*~~

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1 Overview

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1.2 IEEE 802.16h scope

This amendment specifies improved mechanisms, as policies and medium access control enhancements, to enable coexistence among license-exempt systems based on IEEE Standard 802.16 and to facilitate the coexistence of such systems with primary users.

1.3 IEEE 802.16h applicability

This amendment is applicable for un-coordinated frequency operation in all bands in which 802.16-2004 is applicable, including bands allowing shared services.

2 Interference detection and prevention – general architectureShared Radio Resource Management

~~1.1.1~~2.1.1 Principles

2.1.2 Shared distributed system architecture

2.1.2.1 Architecture

The architecture for Radio Resource Management in the context of IEEE 802.16h it is a distributed one and allows communication and exchange of parameters between different networks. A network consists from a Base Station and its associated Subscriber Stations.

Every Base Station includes a Distributed Radio Resource Management entity, to apply the 802.16h spectrum sharing policies, and a Data Base to store the shared information regarding the actual usage and the intended usage of the Radio Resource.

A subscriber Station may include an instance of DRRM, adapted to SS functionality in 802.16h context.

The following figure shows the functional diagram of the IEEE 802.16h network architecture:

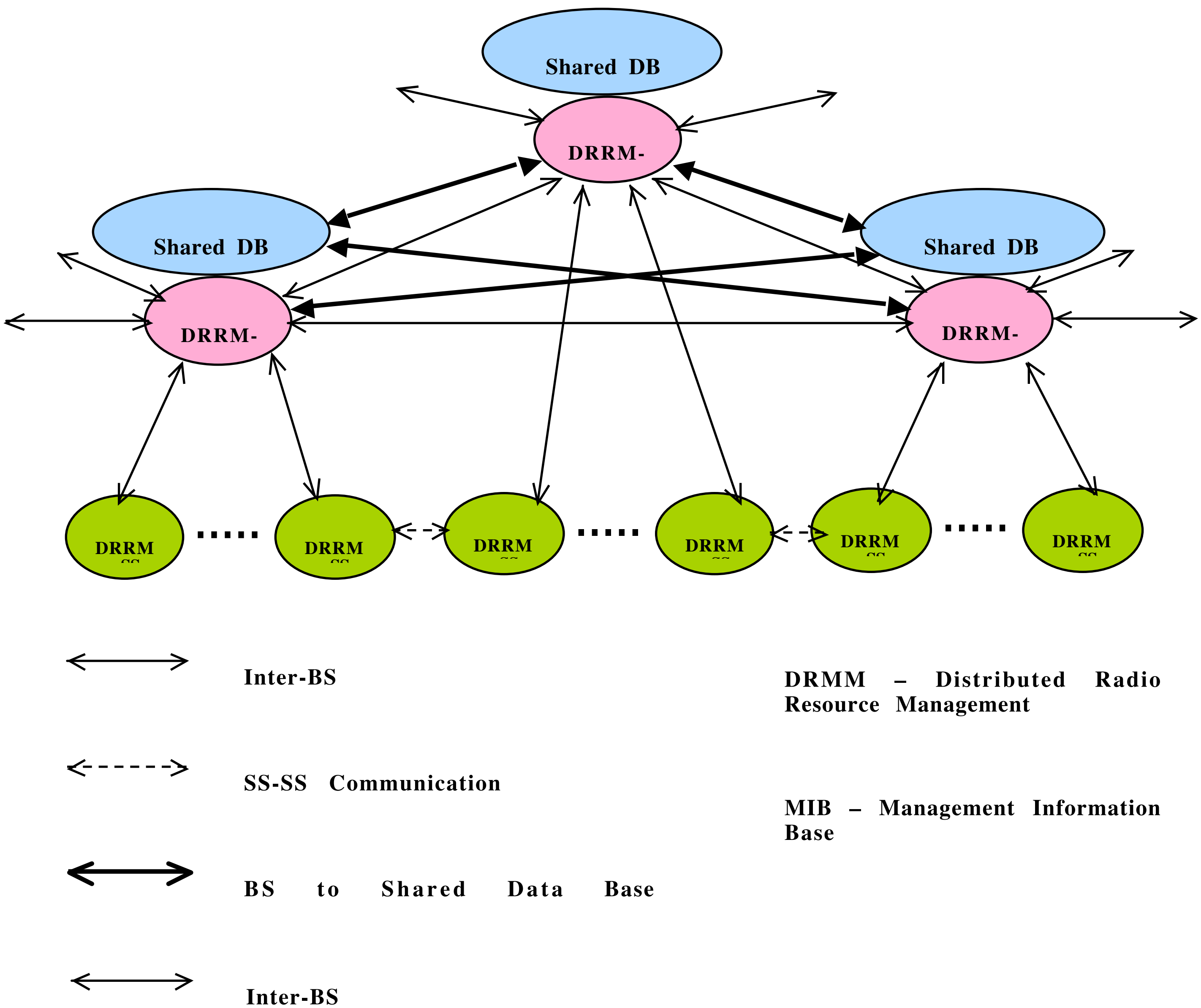

Figure 1 System Architecture

2.1.2.2 Inter-network communication

The inter-network communication consists in:

- Inter-network messages
    - Base Station to/from Base Station
    - Base Station to/from Subscriber Station to/from foreign Base Station; the subscriber Station is used as relay, if the two Base Stations are hidden one from the other
- Open access to DRRM Data Base:
    - To read the parameters of the hosting Base Station
    - To request change of the hosting Base Station operating parameters.

2.1.2.2.1 Same PHY Profile

For networks using the same 802.16 PHY Profile, including elements as:

- Channel spacing;
- PHY mode:
    - WirelessMAN-OFDM (256 FFT points)
    - WirelessMAN OFDMA 2k (in future 128, 512, 1k) FFT points
    - WirelessMAN SCa,

the inter-network communication may be done using 802.16 messages over the air, including messages defined by 802.16h amendment.

~~1.1.1.1.2~~2.1.2.2.2 Mixed-PHY Profile communication

In the case of different PHY Profiles the communication will be done at IP Level. Every Base Station should know the IP address of the DRRM of the Base Stations around, by provisioning or/and by a transmitting the IP address over-the-air. The communication shall use a real-time communication protocol – t.b.d.

Every system will:

- Broadcast the IP address of its Data Base entity, such that more elaborated inter-system communication may take place using unicast IP messages;
- Multicast to neighbor Base Stations the basic information related to the parameters of the spectrum usage, in such a way that any other system, which co-exists in the same area, will be aware of the parameters of shared spectrum usage;
- The Base Station will forward to the associated SSs the information related to DRRM.

3 Interference victims and sources

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7.2.2 Shared Radio Resource Management

7.2.2.1 Fairness criteria

The elements of the fairness criteria are addressed below.

~~1.1.1.1.1~~7.2.2.1.1 Guaranteed radio resource

Every network will have a guaranteed minimum access time for the interference free use of the radio resource, being able to transmit at the needed powers for allowing communication between its Base Station and the remote subscribers; the guaranteed minimum access time will be basically the same for all the networks sharing the radio resource.

~~1.1.1.1.2~~7.2.2.1.2 Power control

Every network will strive to reduce its transmit powers to the minimum, such that the C/I+N will be sufficient to allow the operation at the minimum common rate, considered as QPSK1/2 for all the 802.16 systems; an exception from this rule is possible only when a network is operating during its interference-free period. The power control mandatory algorithm will be defined in chap. [t.b.c.]

~~1.1.1.1.3~~7.2.2.1.3 Mutual tolerance

A network may operate during the time designated for interference – free operation of other master network, with the condition that:

- The network operating in its interference-free period perceives an interference level equal with the noise level (3dB RSL degradation);

- The network operating in its interference-free period perceives an interference level higher than the noise level (3dB RSL degradation), but explicitly agrees to operate at the created interference level; this may be the case of a small cell size or reduced traffic

- If the interference level is higher than the acceptable level, the master network may request the links operating in parallel to reduce their transmitting powers; if such a link enters the situation that will not be able to operate anymore, the link transmitter will have to operate in another sub-frame in which will not cause harmful interference.

The figures below explain possible ways of implementing the Guaranteed radio resource principle, using a example of three overlapping radio networks.

The overlapping radio networks create different interference zones, based on spatial distance between transmitters and receivers. For example, the radio receivers in Zone A, in the figure below, suffer from the interference (noted with _) between Network 1 and Network 2. Interference Zone B includes also the Base Station of the Network B.

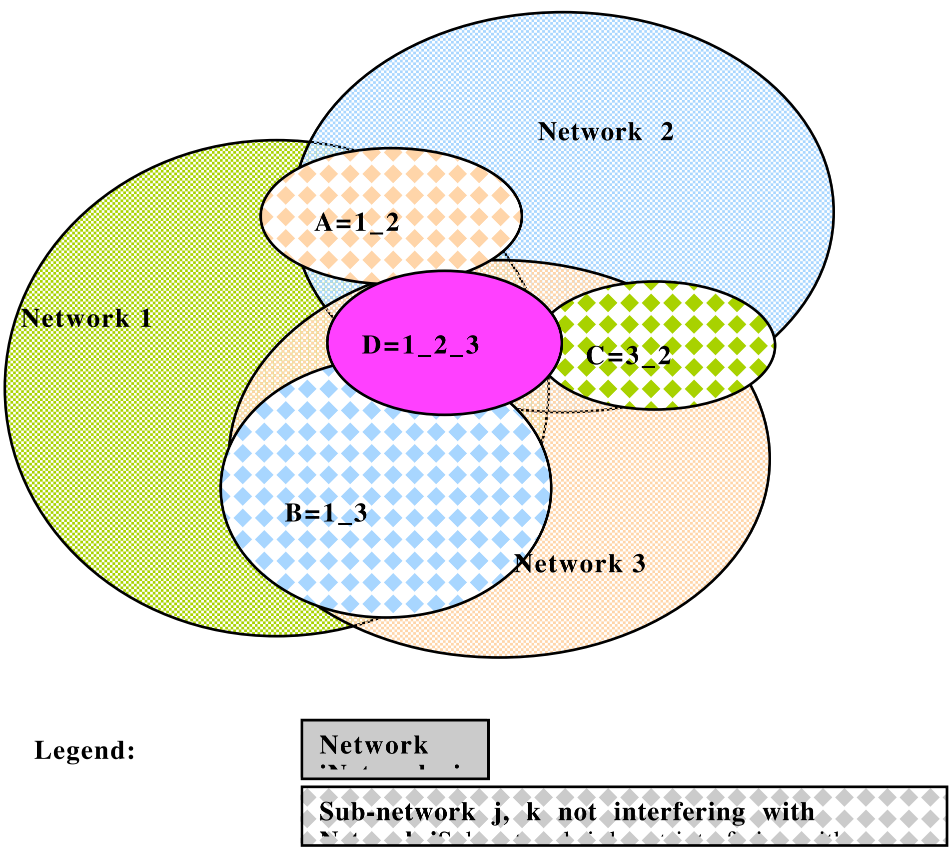

Figure 2 – Interference due to overlapping networks

The operation of the 3 networks assume the following different situations:

Networks 1,2,3 do not interfere

Zone A: Networks 1 and 2 interfere

Zone B: Networks 1 and 3 interfere

Zone C: Networks 3 and 2 interfere

Zone D: Networks 1 and 2 and 3 interfere

Now lets suppose that we split a time frame in 3 sub-frames (being 3 different networks), such that we apply the fairness criteria defined above, and every network will receive an interference free interval for operation.

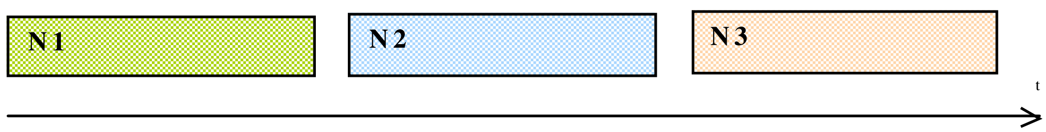

Figure 3 Equal splitting of radio resource between networks

In the figure above we resolved the interference problem, but we did not used optimally the radio resource.

Another possible approach will be to set an operating time for not interfering (noted Ø) situations, and split equally between the 3 networks the remaining resource, like shown below. It can be seen that non-interfering traffic may be scheduled in parallel, resulting a much better radio resource usage.

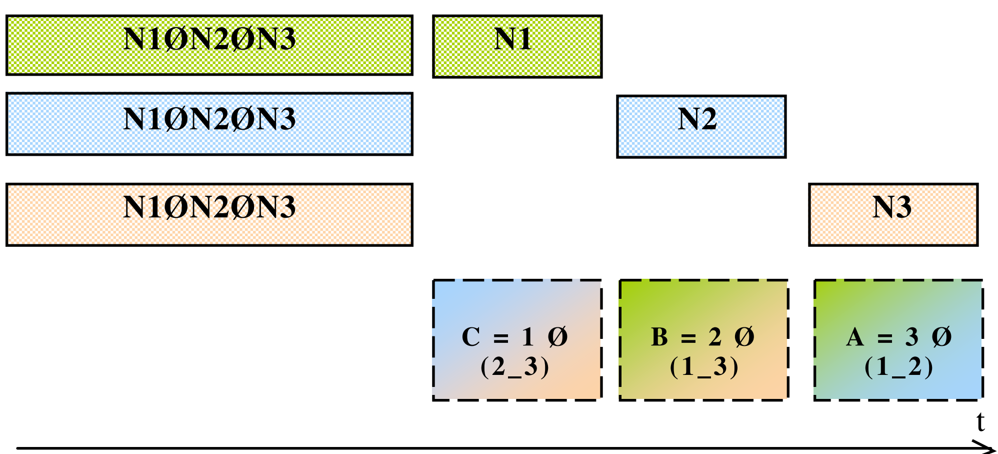

Figure 4 Usage of the spectrum by every system

Taking as example Network 1, it can be seen that this network operates in all the sub-frames, achieving in the same time interference-free operation and good spectral efficiency.

However, the networks working in the same time with the network having the control of the radio resource, shall use power control, sectorization or beam-forming in order to not create interference to that network.

7.2.2.1.3.1 Cooperation with other networks

A network may need more time resource for its BS communication with the SSs, than available for its operation in the assigned interference-free time interval. In this case, the specific network may request from one ore more adjacent networks to reduce their interference free transmission intervals. The other networks will consider the request, and when possible will accept the request, by indicating the agreed new interference-free operating interval. The duration of each sub-frame may be negotiated through inter-network communication and using the common DRRM policy.

7.2.2.1.3.2 Scheduling of interference free intervals in the context of IEEE 802.16 MAC

A number of scheduling approaches may be considered, some of them being presented below, for Tx synchronized intervals. Same approach is valid for Rx intervals.

~~1.1.1.1.1.1.1~~7.2.2.1.3.2.1 Sharing same MAC Frame

This approach considers the possibility of including sub-frames for addressing all the systems suffering from interference in the same MAC frame.

The disadvantage of this approach is that the duration of the MAC frame may be high and all the BS-SS links will suffer from the possible relatively high delay.

The advantage of this approach is that allows flexibility in changing the duration of different sub-frames, to use the radio resource in accordance to traffic load or interference level.

The possible traffic scheduling is presented in fig. 4. If, for example, the common sub-frame has a reservation of 40% of Tx duration and all the other sub-frames are 20% each, the maximum time-frame to be used is 80%.

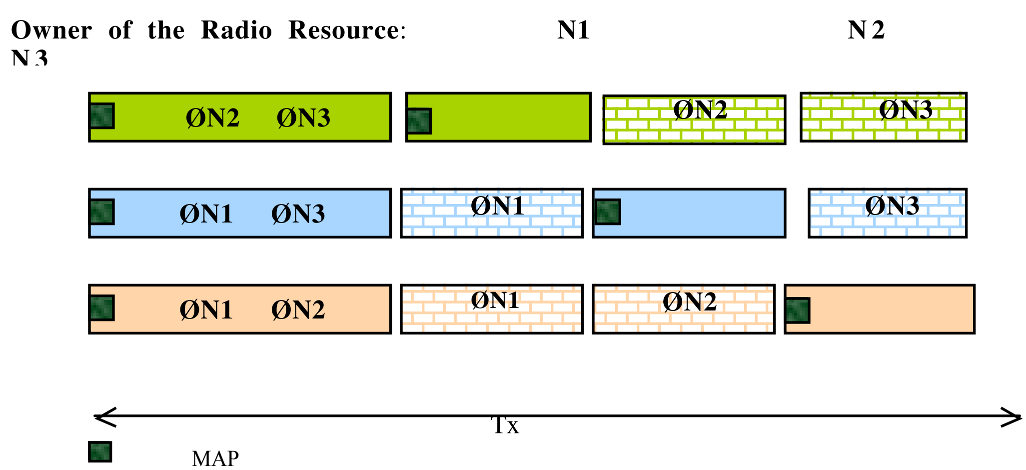

Figure 5 Sharing same MAC frame

7.2.2.1.3.2.2 Sharing the same MAC Frame – alternative mode

An alternate possibility for sharing the same MAC Frame is shown below. The MAPs are inserted at the beginning of the transmit frame for compatibility with the existing PHY/MAC.

Owner of the Radio Resource: **N1** **N2** **N3**

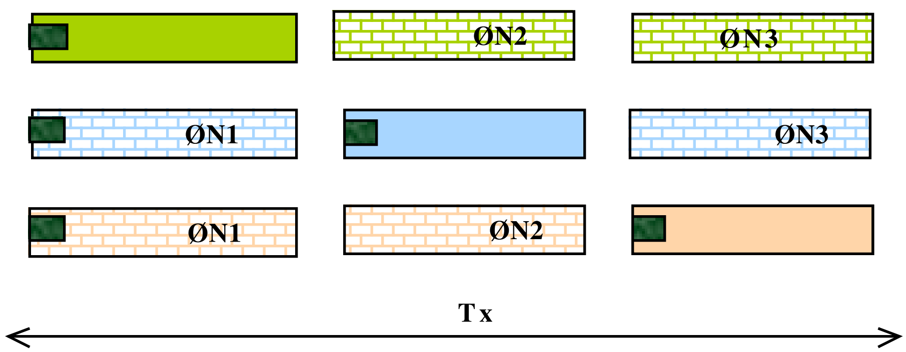

Figure 6 Sharing same MAC frame – alternative mode

The disadvantage of this mode is that for interference-free traffic there is no guaranteed interval. As a result, all the N systems will have approximately 1/N from the frame duration. For example, if every sub-frame will be 1/3 of the Tx time, every network will be able to use 66% of the time. The delay may be slightly lower than with the previous case. This mode may be useful in high interference environments.

7.2.2.1.3.2.3 Repetitive sharing approach

With this approach, a first option is to split every frame has two sub-frames:

- one sub-frame is reserved for traffic not affected by interference
- one sub-frame is reserved for Network I and the traffic not affecting Network I.

The advantage of this scheduling mode are:

- the MAC frame duration may be small and users not affected by interference will have an optimal delay;
- some flexibility exists to trade between the duration allocated for Network i and the duration of the interference-free sub-frame.

The disadvantage is that subscribers affected by interference will suffer from higher delay than subscribers not affected by interference.

The repetitive scheduling for 3 networks, every network having its interference-free traffic in one of the frames, and repeating every 3 frames the interference-free sub-frame will be:

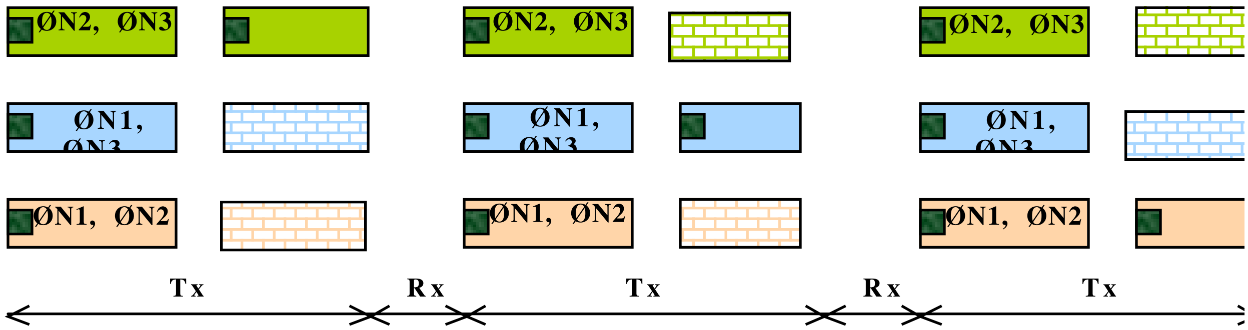

Figure 7 Repetitive scheduling

The advantage of this approach is that it is easier, per Tx frame, to negotiate the splitting between the interference-free sub-frame and the sub-frame allocated to Network i. The delay remains minimal for SSs not affected by interference.

7.2.2.2 Distributed scheduling

7.2.2.2.1 Assignments

7.2.2.3 Distributed power control

7.2.2.4 Distributed bandwidth control

7.2.2.5 Beam-forming