Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Fairness Criteria and Interference Avoidance**
Date Submitted	**2005-03-11**
Source(s)	Mariana Goldhamer Alvarion Tel Aviv, 21 HaBarzel Street Israel Voice: +972 3 6456241 Fax: +972 3 645 6204 mailto:marianna.goldhammer@alvarion.com
Re:	Call for Contributions, IEEE 802.16 License-Exempt Task Group, 2005-02-10, IEEE 802.16h-05/006
Abstract	Propose fairness criteria for traffic scheduling and avoidance of interference
Purpose	Information
Notice	
Release	
Patent Policy and Procedures	

Fairness Criteria and Interference Avoidance

Mariana Goldhamer

Alvarion

Introduction

The scope of the paper is to provide text for the IEEE 802.16h standard, to be inserted inside the Chapter called "Fairness Criteria" – see [1].

Fairness criteria

The elements of the fairness criteria are addressed below.

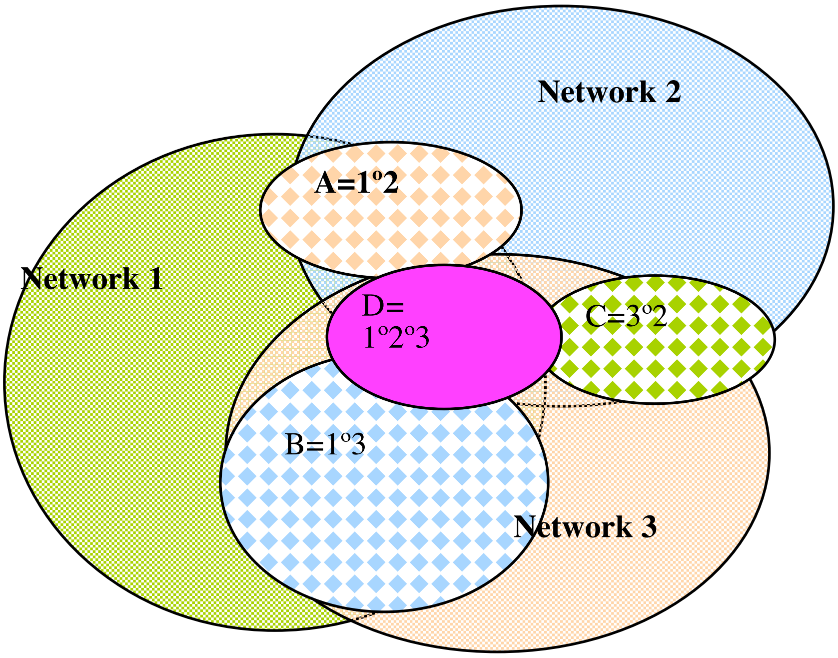
Guaranteed radio resource
Every network will have a guaranteed minimum access time for the interference free use of the radio resource, being able to transmit at the needed powers for allowing communication between its Base Station and the remote subscribers; the guaranteed minimum access time will be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

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.]

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.



Legend: Network i

Figure 1 – Int Sub-network j, k not interfering with Network i

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.

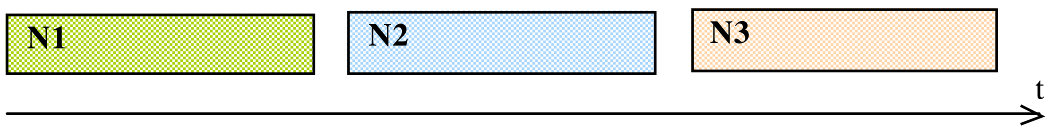


Figure 2 Equal splitting of radio resource between networks

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.

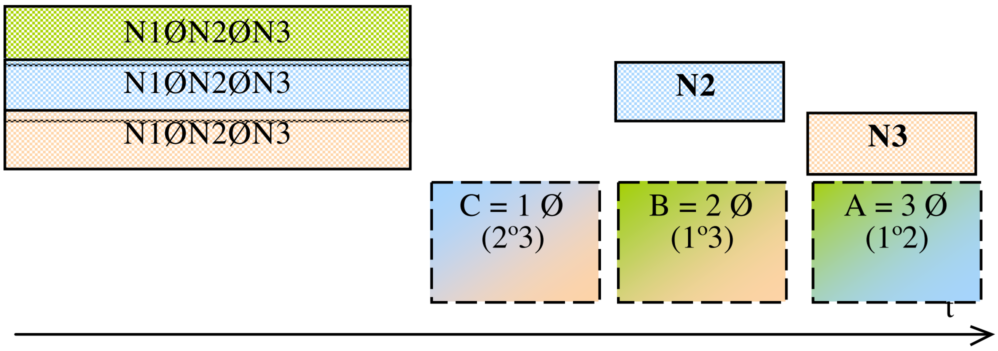


Figure 3 Usage of the spectrum by every system

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.

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.

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.

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%.

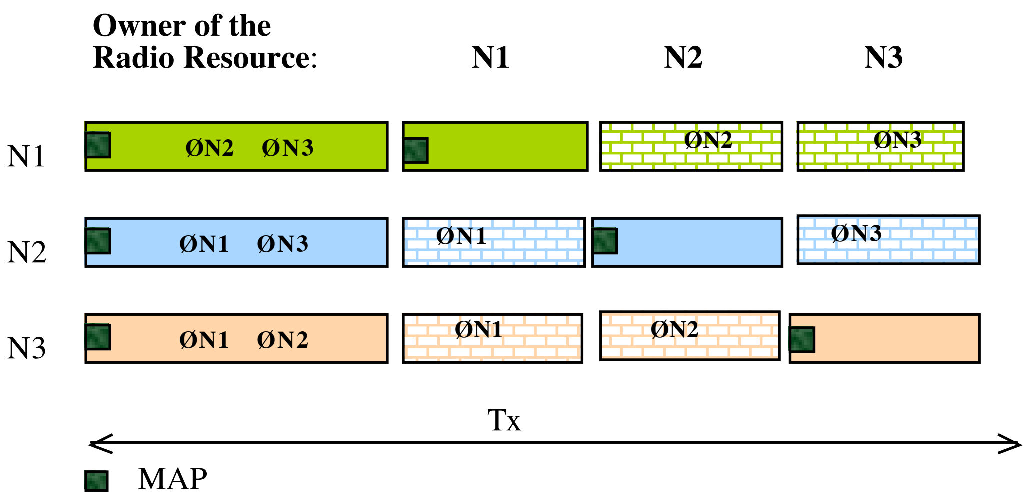


Figure 4 Sharing same MAC frame

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.

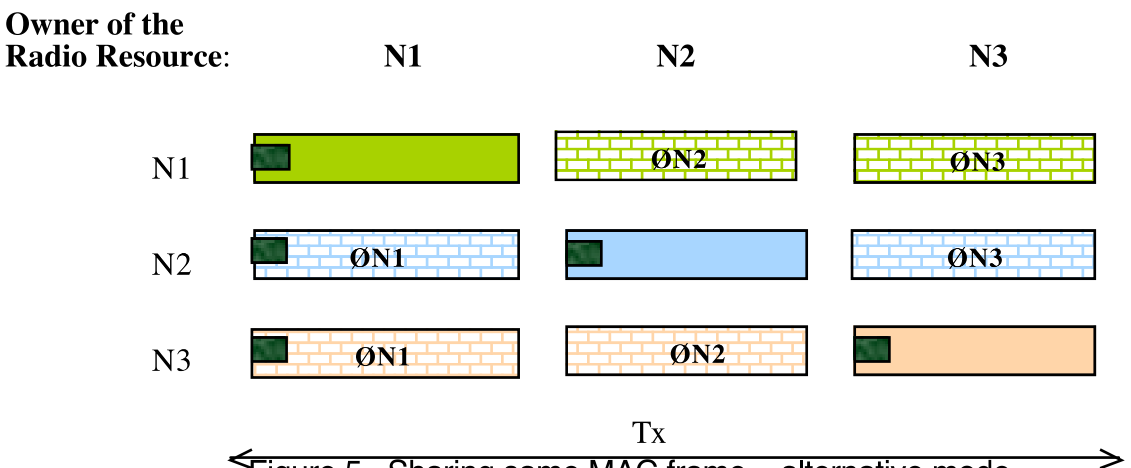


Figure 5 Sharing same MAC frame – alternative mode

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.

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:

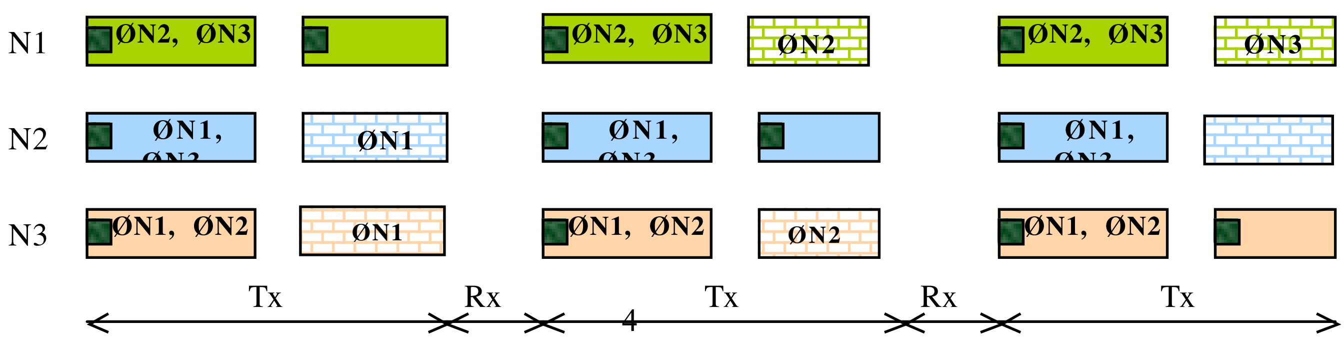


Figure 6 Repetitive scheduling

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.

Conclusion

This paper presents criteria for fairness in spectrum sharing and shows possibilities to achieve interference-free operation, through appropriate traffic scheduling, power control and transmission angle control. It is shown that high spectral efficiency is achievable in the same time.
The next step should be the finding of a small number of possible scheduling variants and the related messages that allow for dynamic Radio Resource allocation and interference control.

References

[1] IEEE 802.16h – 05/002 – Table of Contents for IEEE 802.16h, 2005-01-25