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Title	Slave Hierarchy for Better Usage of Regions not Interfered by the Master Subframe	
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Abstract	Suggestion for improvement of usage of overlapping regions in the ASFA scheme, using slave hierarchy	
Purpose	Improving usage of overlapping regions by introducing priority among slaves in the ASFA algorithm. This priority will allow serving the regions where there is slave coverage overlap, without interference to the master.	
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Slave Hierarchy for Better Usage of Regions not Interfered by the Master Subframe

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Introduction

This document suggests a slave hierarchy mechanism that would enable slave systems to regulate their operations in zones where they do not cause interference to the master system, but still cause interference to each other.

The problem

The draft standard [1], suggests a structure of sub-frames, which allocates for each system a period of time during which it is guaranteed interference free operation. During this interval, it is called the master system, while no other system (slave) is allowed to interfere with it. However, the other systems are allowed to operate in regions in which they do not cause interference to the master system, thus improving the capacity of those slave systems, which would otherwise have to be totally silent.
However, the current scheme does not specify any priority between slave systems. Consider figure h18 of the draft standard, copied (and slightly modified) hereunder:

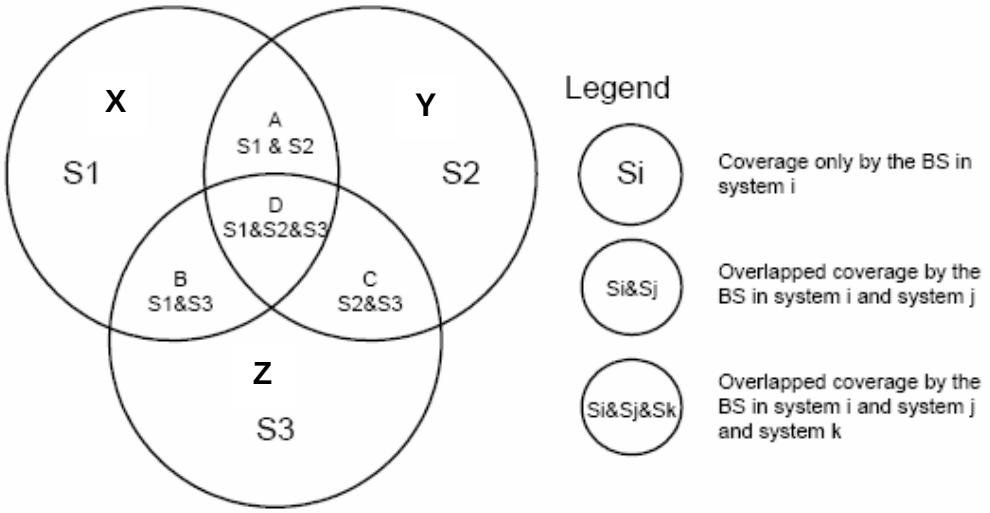

Figure1: Copy of Figure h18—Interference due to overlapping systems

And consider, for example, the type 2 sub-frame structure, as given in figure h19.

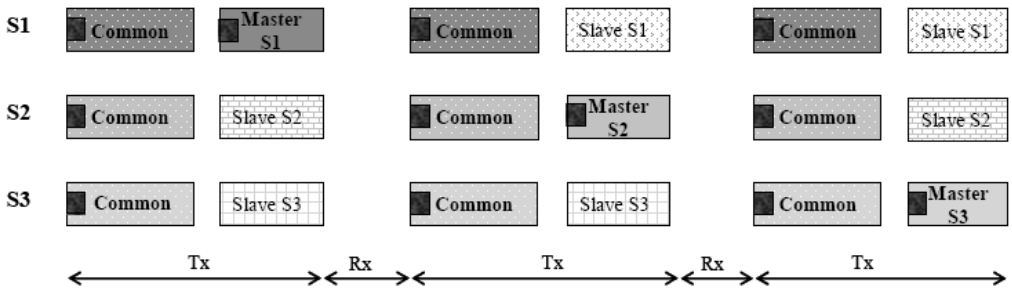

Figure 2: Type 2 structure as depicted in Figure h19—examples of WirelessMAN-CX Subframes

Figure 3 below shows the regions served by the S1, S2 and S3 systems, during the different frames. Region X, which is served by system S1, without any interference from systems S2 and S3, is served during all the subframes, namely an SS located in that region is served during the common frames as well as during the sub frames in which S1 is either a slave, or, of course, a master.
Similarly, SS's located in region Y and Z are also served by either system S2 or S3 during all the subframes.
On the other hand, S1 SS's located in region A suffer from interference from system S2, consequently they are not served during the common sub-frames but only when S1 is the master. When S2 is the master, it serves all its SS's located in region A. But the current scheme does not specify what happens to S1 or S2 SS's of region A when S3 is the master. Without such specification, either both system would refrain from serving region A (although that won't cause any interference to the master, S3) or both systems would try to serve their SS's in that region with the same end result - no service due to interference.
Similarly SS's in zones B and C will be served only during the master subframes of their corresponding system.

The solution: Slave Hierarchy

Assume now, that a certain slave hierarchy exists. For example – after being the master a system still has priority over all the other systems in the neighborhood but the new master. Thus in the second sub-frame, system S2 is the master, but system S1 has priority over system S3, in the third subframe, system S3 becomes the master, while system S2 has priority over system S1, In the fourth subframe, we go back to the structure we have in the first subframe, in which system S1 is the master, while system S3 has priority over system S2.
With this scheme the usage pattern will look as described in figure 4. Now during the 3rd subframe, system S2 has priority over system S1 and the SS's in region A can be served. Similarly S1 SS's in region B will be served during the second sub-frame and S3 SS's in region C will be served during the first subframe. The additional intervals in which a region can be served is depicted by the red rectangles.
A more complex slave hierarchy scheme, when we look at 2 cycles, and change the rule such that in the second cycle, after being the master, a system will have no priority over any other system will allow to serve the SS's in the overlapping regions more fairly, and the usage pattern will be as described in figure 5. In this case, in the first cycle S2 SS's in region A will be served, while during the second one S1 SS's in region A will be served. If there are more than 3 systems in the neighborhood, a more elaborate scheme would be required to allow for fair service in the different regions, however, as it is expected that the number of systems in a community will not exceed 3 (as specified for the type 2 case), and in order to avoid unnecessary complexity, it is recommended that only 2 simple rules will apply.

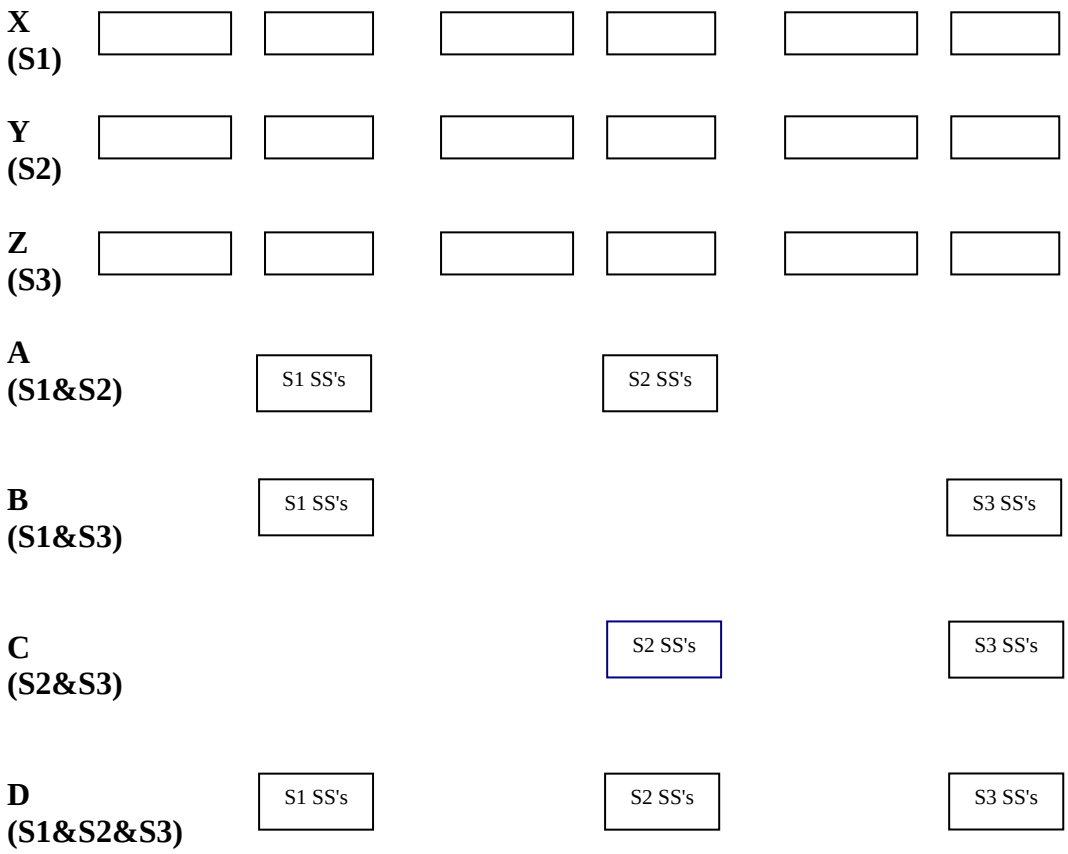

Figure 3: Regions served during the various subframes

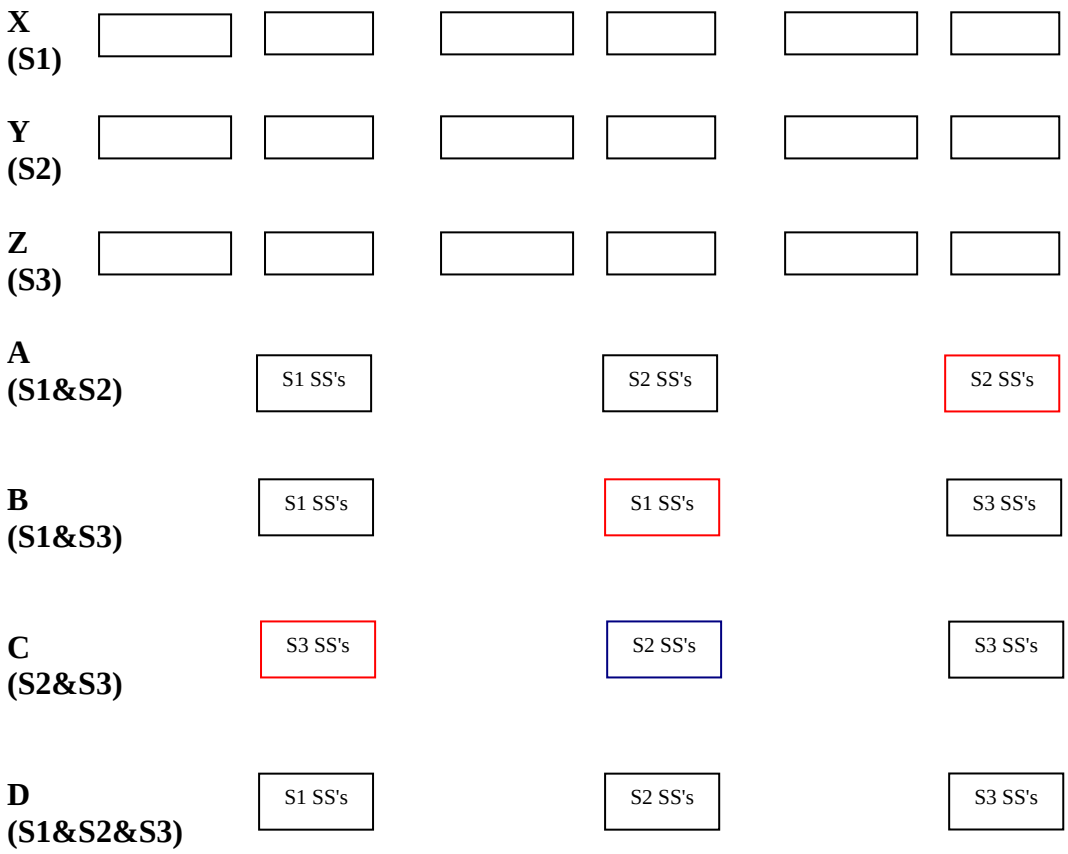

Figure 4: Regions served during the various subframes with slave hierarchy

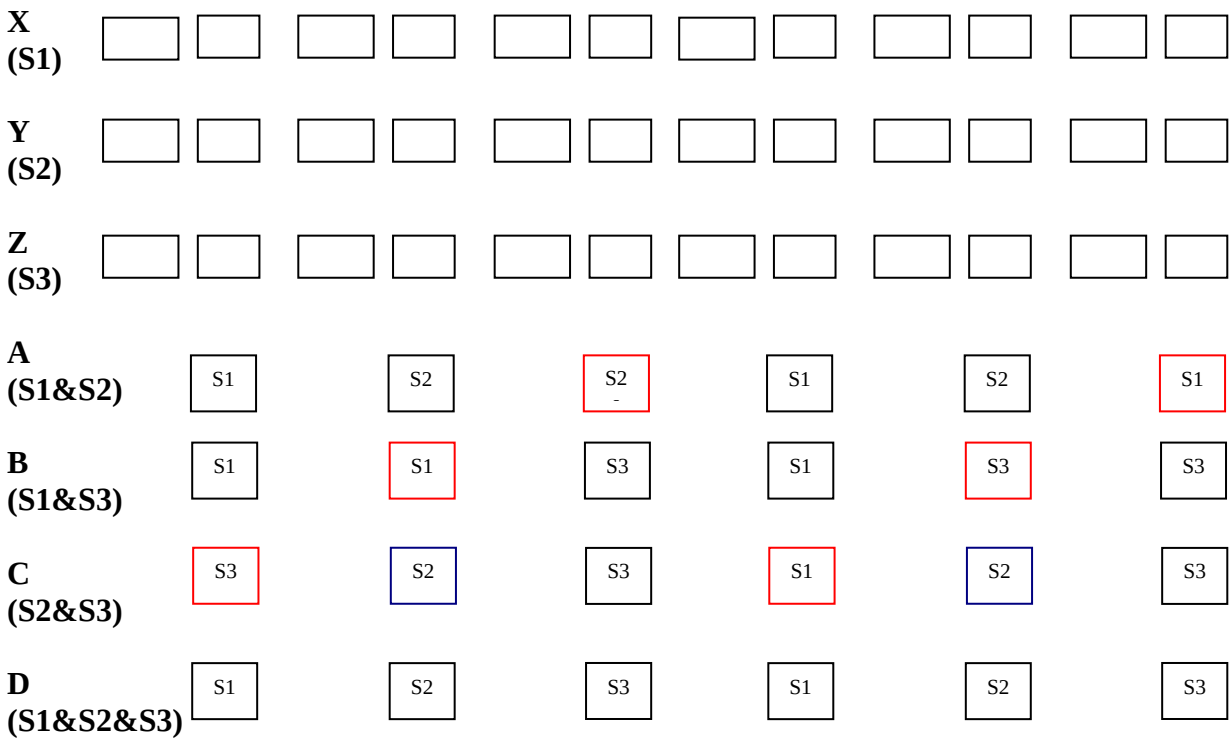

Figure 4: Regions served during the various subframes with slave hierarchy

Proposed Text Changes

Add the following text to section 15.4.2.1.2: (p. 89 l. 29 of [1]):

In order to enable service to regions in which two slave systems overlap, a hierarchy structure shall be applied among the slaves, as follows:

- In one MAC frame, in case of type 1 structure, or in the first (N+1) MAC frames, in case of type 2 structure, the system "rank" will be demoted by one in each subframe, namely, the master system of the i^{th} sub frame will in subsequent frames still have priority over all the systems that were not given the mater status till that frame.
- In the second MAC frame, in case of type 1 structure, or for the MAC frames from the $(N+2)^{th}$ till the $2(N+1)^{th}$, in case of type 2 structure, system "rank" will be promoted in each subframe, namely, the master system of the i^{th} sub frame will have in subsequent subframes priority only over systems that were given the master status after it.

Where the "rank" of the system relates to the order of priority it has over other systems.
Figure h41a shows the priority order for 3 systems in different sub frame structures. The common parts and TX/RX boundaries are omitted. The arrows show the priority demotion and promotion for system S1.

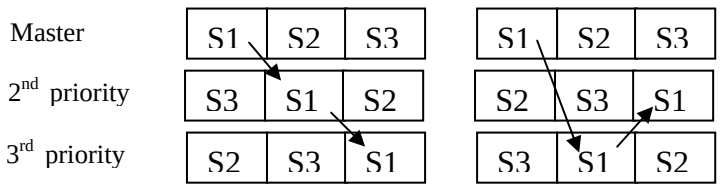

Fig. h41a: Priority Order for a 3 system community

Reference

[1] IEEE P802.16h/D1: Air Interface for Fixed Broadband Wireless Access Systems: Improved Coexistence Mechanisms for License-Exempt Operation, Draft Amendment