# Deal with WiMedia coexistence issues

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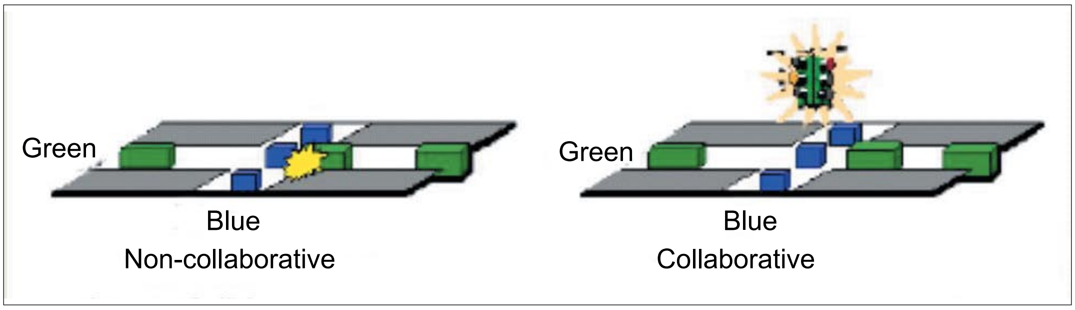


Figure 2: Collaborative coexistence for traffic arbitration of collocated systems can prevent collisions from happening.

The issue is not whether UWB can cause interference; it is possible to construct usage models that interfere with other systems. The debate is over whether these usage models are relevant and whether the interference is serious enough to warrant protection of the victim service.

**In-band coexistence**

While out-of-band emissions from WiMedia UWB systems may create negligible interference, in-band (3-5GHz) transmission levels are at -41.3dBm/MHz, so these bear further analysis. In general, there are two types of systems that we can consider as incumbent services in this band: downlink-only systems, receive-only systems that have no local uplink signal; and transceiver systems, which have both a downlink signal from a hub and a local uplink signal returning to the hub.

Downlink-only systems such as C-band satellite and radio astronomy pose unique problems for coexistence because there is no practical way to detect the presence of a receiver.

Fortunately, the power levels of UWB are very low by definition, so the potential for interference is small. More important, both of these systems require highly directional antennas, which must be located outdoors and pointed into space. Since the number of radio telescopes is small (only a few hundred worldwide) and they must be located in fairly remote areas to avoid all the other EMI that exists at far higher levels than UWB, we will mostly consider C-band TV reception.

C-band satellite (also known as TV receive-only) has been in existence for a number of years and typically uses frequencies between 3.7-4.2GHz. While still popular in some parts of the world, C-band is rapidly being replaced by Ku-band (10.7-12.75GHz), which can use smaller antennas, has more channel capacity and is in a completely separate band from UWB.

According to the Satellite Broadcasting and Communications Association, there are about 144,000 C-band subscribers remaining in the United States as of December 2005, compared to over 27 million subscribers to Ku-band satellite systems such as Dish Network and DirectTV.

C-band satellite receivers typically use parabolic dish antennas that are about 3.5m wide with a beamwidth of about 1.5°. This dish must be pointed toward a satellite in geosynchronous orbit over the equator.

Because of these physical constraints, studies have shown that coupling into the backlobes of C-band receivers is virtually impossible, and that interference coupling into the frontal sidelobes of the dish/receiver cannot be measured beyond about 6m. Since these antennas are large and outdoors, the likelihood of interference is negligible in practical UWB usage.

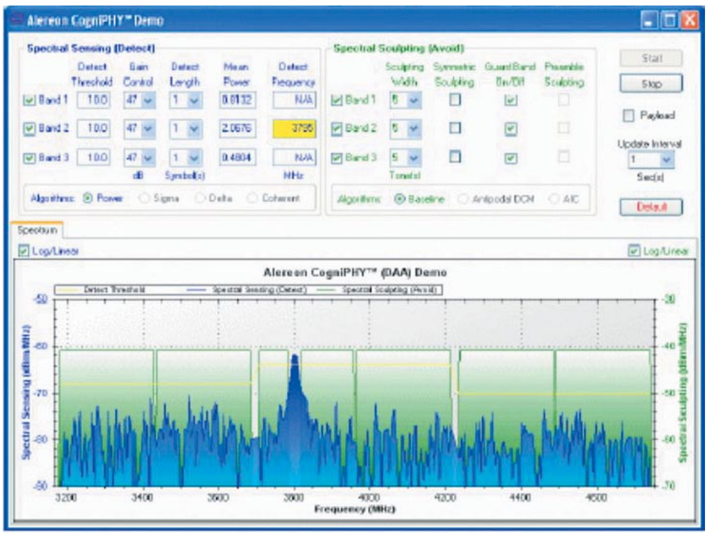


Figure 1: This DAA demo shows the 'notch' at 3,800MHz in Band 2.

**Uplink-downlink signals**

Transceiver systems such as WiMAX in the 3-5GHz band are an interesting case to analyze for interference. WiMAX systems (also called broadband fixed wireless access) are similar to cellular systems in that there is a hub mounted on a tower that communicates with subscriber terminals scattered around a cell.

Thus, there is a downlink signal that is relatively weak by the time it reaches a subscriber terminal, and an uplink signal that is fairly strong in the local environment. The uplink-downlink signals can either be on separate frequencies (called frequency division duplex) or on the same frequency but separated in time (called time division duplex or TDD).

The impact of WiMAX uplink signals can be examined in great detail, but the interference issue is one of proximity. At the distances that UWB and WiMAX could interact, there are at least two solutions that could be used: detect and avoid (DAA), and collaborative coexistence.

DAA can be used at distances of a few meters of separation between the WiMAX- and UWB-enabled devices. It is based on the idea that the WiMedia UWB PHY can be used to perform spectral analysis.

There have been a number of papers published on this that show that WiMAX signals can be detected at reasonable power levels (above -70dBm) and the WiMedia PHY can either drop a band or create a "notch" within a band whose depth is approximately 15-20dB, although greater notch depths are under study.

As an example of how this process can work, **Figure 1** shows a demonstration of a DAA system that samples the spectrum between 3-5GHz, calculates the power over each of the WiMedia bands and looks for energy a multiple (10x in this case) of this power level as a threshold. This implies that a WiMAX signal (either uplink or downlink) has been detected.

When the interference power exceeds this threshold, the UWB system creates a notch that is wider than the observed signal to protect the receiver of the WiMAX system. Clearly, this process is most effective for a TDD system, where uplink and downlink share the same frequency.

From a regulatory perspective, many of these parameters are yet to be defined, so these early demonstrations can only be used to show the concept. WiMedia will develop detailed specifications for DAA operation in response to regulatory requirements as they become available.

**Collaborative coexistence**

For WiMAX and UWB devices that are collocated, it is more effective to manage interference by controlling access to the wireless medium in the time domain. In other words, arbitration between the WiMAX and UWB systems can prevent collisions from happening at all.

These techniques have been studied extensively for coexistence between Wi-Fi and Bluetooth in IEEE 802.15.2 and IEEE 802.19. The same techniques could be used directly for WiMedia UWB and WiMAX coexistence. In general, these time arbitration techniques, such as packet traffic arbitration in 802.15.2, analyze traffic in both systems and decide which should be allowed on the air.

A way to visualize this conceptually is as a traffic model (**Figure 2**). As in any traffic arbitration system, there has to be a rule to decide which packets are allowed on the medium. For a simple traffic light, the two systems take turns allowing traffic to flow, which would correspond to alternating between UWB and WiMAX. One system is completely shut off while the other is operating, an alternation that happens at periodic intervals.

This clearly works well but limits the throughput in either system. There are more sophisticated techniques that examine each packet and decide which should be allowed on the air based on the packet type (beacon, QoS or best effort), and can be more highly optimized. Since these techniques are designed for collocated systems, it is up to the developer to decide the level of performance required based on assumed usage models.

Out-of-band emissions from a WiMedia UWB transmitter cause a negligible impact on incumbent systems such as UMTS/W-CDMA, Wi-Fi, Bluetooth, GPS and cellular systems.

For incumbent systems that share the 3-5GHz band with WiMedia UWB, there is minimal impact on incumbents in most usage models. For systems such as WiMAX that must operate in close proximity to the UWB system, there is a variety of techniques, including MAC layer arbitration, that allow performance to be optimized to high levels of coexistence.