Detect and Avoid Technology

For Ultra Wideband (UWB) Spectrum Usage

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A Wisair white paper

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Introduction

Ultra Wideband (UWB) technology has seen great debate over its possible interference to existing or future wideband wireless systems using of the same and nearby bands, such as WiMAX or 3G/4G cellular networks.

Detect and avoid techniques mitigate interference potential by searching for broadband wireless signals and then automatically switching the UWB device to another frequency to prevent any conflict. As such, 'detect and avoid' technology provides the flexibility to support regulatory measures in different areas of the world and ease concerns about interference.

This paper describes a possible 'detect and avoid' methodology which ensures that UWB devices can coexist with other systems without any conflicts. It then illustrates Wisair's 'detect and avoid' technology, which was demonstrated at the European CEPT Electronic Communications Committee meeting (ECC TG3).

This white paper is based on a contribution paper provided by Wisair at a CEPT Electronic Communications Committee meeting (ECC TG3) in September 05, as well as an Intel contribution for the same committee. For details, please refer to http://www.ero.dk/.

Requirements for a Detect and Avoid Implementation

To coexist with broadband wireless networks, a UWB 'detect and avoid' implementation should answer the following requirements:

1. The UWB device should employ a narrowband signal detection function that allows it to detect active broadband networks in the 3.1–4.2 GHz frequency range, serving indoor terminals.
2. Before initiating a UWB network in the frequency range 3.1-4.2 GHz, the UWB device should perform a narrowband signal existence test. This test should be performed for a minimum duration and reliably to ensure that there are no broadband networks operating in that frequency range. If a signal is detected, a specific procedure (described in step 4) should be followed.
3. During normal operation in the 3.1-4.2 GHz frequency range, the UWB device should monitor the frequency band to ensure there are no operating broadband networks using the detection function described in Step 1. The UWB device may perform this monitoring function during periods when it is not transmitting UWB signals, and can continue using the available channels until the presence of a broadband network signal is detected.
4. If the results of either the initial channel availability check or the in-service monitoring indicate the presence of active broadband networks serving indoor clients in any of the bands (e.g. 3.4-3.6, 3.6-3.8, 3.8-4.0, 4.0-4.2 GHz), the UWB emissions levels over those respective bands should be reduced to a lower level. Optionally, the UWB device may also transmit standardized messages to other compatible UWB devices indicating the identity of these frequency bands.
5. Once a positive determination is made (step 2 or 3) regarding presence of broadband transmissions in a particular frequency band, the emissions level in the detected band should be reduced to a lower level.

In addition to UWB devices which perform monitoring and detection, as described in the above scenario, an additional class of UWB Slave devices may be defined, which:

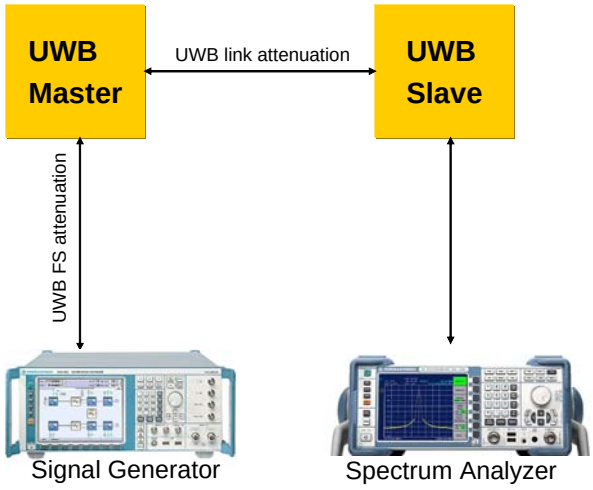
- Do not transmit before receiving an appropriate enabling signal from a UWB device that is not a slave device.
- Stop all transmissions whenever instructed by a non-slave device, and do not resume transmissions unless instructed.
- Ensure that emissions levels are reduced to the Narrowband Signal Protection Level over frequency bands communicated to it in standardized messages from compatible non-slave UWB devices.

Detect and Avoid Demo Scenario

In an attempt to study the behavior of a typical 'detect and avoid' scenario and the interaction between UWB and other radios when detect and avoid techniques are being utilized, Wisair has developed a technology demonstration, which includes three elements:

- **UWB Master device ("Master")**. The device is an active UWB transceiver in charge of performing DAA of broadband signals before and during the transmission of UWB signals. In addition, it informs a UWB slave device ("Slave") on its findings to make sure the Slave does not use the spectrum if a broadband signal is detected.
- **UWB Slave device: ("Slave")**. The device is an active UWB transceiver which does not perform DAA activity (this is equivalent, for example, to a scenario in which only one device has noticed the broadband system). The Slave follows notifications from the Master device and only transmits on the same band that the Master is using.
- **Signal generator.** The signal generator emulates a WiMAX signal, enabling the control of the signal's time and frequency parameters.

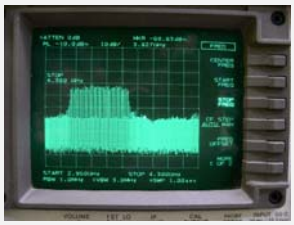
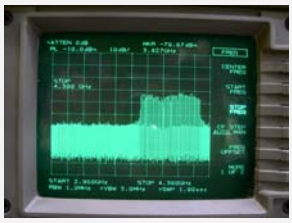
The figure below illustrates the demonstration setup. The attenuations were set to imitate a typical scenario (see next section).



The demonstration attempts to study the behavior of DAA in a typical scenario, with a specific focus on studying the possible range of values for specific parameters described further on in this section.

- A typical link was set up between the UWB Master and Slave, using attenuators. The broadband signal from the signal generator is added to the input of the UWB Master. The signal power level can be varied through the signal generator. The spectrum analyzer is connected to the UWB Slave to validate that the UWB Slave follows the UWB Master notifications.
- The UWB Master was instructed to start with a continuous detection operation in Band #1 (3.4 – 3.6 GHz). If a signal is detected in Band #1 the UWB Master avoids the use of this band and switches to a UWB channel which does not include band #1.

- In the demonstration, the UWB Master does not perform a test inside the new channel before using it. This is meant to emulate a case in which there is a UWB channel in which DAA does not have to be performed. In practice, once the DAA procedure is fully developed, there may be other mechanisms to address the general case. For example, during the initial channel availability check, the Master may create an initial "spectral map" identifying potential broadband systems operating in the vicinity. It can then use this information to decide which UWB channel to switch operation to. Upon commencing operations in the selected new UWB channel, in-service monitoring would reveal the presence of any broadband systems that may have moved within interference range after the initial spectral map was constructed.
- If no broadband signal is detected inside Band #1, the UWB Master starts transmission in a channel which contains Band #1. The UWB Master defines a "quiet period" in which both UWB Master and Slave devices stop transmissions in a synchronized manner. The Master uses this "quiet period" to periodically detect broadband signals. If a signal is detected in Band #1, a procedure of moving to a new channel is performed, similar to the procedure described in the previous paragraph.

1		The UWB devices communicate through a UWB link on Band #1 (3.4 – 3.6 GHz). The Master device continuously detects for a broadband signal on Band #1.
2		A signal generator generates a signal in Band #1, emulating a broadband signal.
3		The UWB master device detects the signal. It automatically switches to transmit in Band #2, as well as notifies the Slave device about the switch.

The table below describes the parameters and values studied using the demonstration described in earlier paragraphs.

Parameter	Value	Remarks
Narrowband signal detection threshold	-90 [dBm]	This value was achieved during the “quiet period” without any other signal but the broadband signal. A detection reliability better than 99.99% (measured under continuous detection and broadband signal to speed up the test), while keeping a very low level of false positives.
Initial channel availability check time	50 ms	This value depends mainly on the activity and frame length of the broadband signal.
In-service Channel availability check time	20 sec	This time can be shorter based on the required Detection Threshold. A more advanced mechanism which detects stronger signals faster will be studied in the future. This can improve the co-existence for both the broadband and UWB radios.
Detection Reliability	99.99%	We recommend that the test will be specified with 99% as a target and with half the [In-service Channel availability check time]. This gives equivalent results but can be tested 100 times faster.
Narrowband Signal Protection Level	-65 [dBm/MHz]	This is achieved by switching to a different UWB channel
Mitigation Time Period	N/A	Was not included in the demonstration but can be added easily.
UWB signal level	-41.3 [dBm/MHz]	Based on FCC limit for UWB signals

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