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Measurement and functional validation of detect and avoid ultra wideband devices

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ABSTRACT

Ultra Wideband (UWB) radio regulations have been discussed in recent years because of the potential interference of UWB radios to other radio systems with which they share the spectrum. A mitigation technique for UWB devices named Detect and Avoid (DAA) has been proposed as a potential solution to reduce the risk of interference. DAA testing presents specific challenges related to the low emission power of UWB devices, the validation of spectrum sensing algorithms and timing considerations. This paper presents the design of a test bed to validate the correct implementation of DAA mitigation techniques by UWB devices. It describes the testing challenges and the related test bed design solutions for both radiated and conducted test methods. A number of measurement campaigns on UWB devices with detect-only capabilities were separately conducted at three different test beds facilities. The measurements results are analyzed and compared.

1. Introduction

Ultra Wideband (UWB) is a very promising technology for the broadband transmission of data using spectrum-efficient and flexible radio techniques. UWB is a rather vague term to describe the nature of a Radio Frequency (RF) signal, which occupies a large instantaneous bandwidth. Definitions of the minimum bandwidth of an UWB signal vary; while the European Telecommunication Standards Institute (ETSI) defines in [1] a minimum bandwidth of 50 MHz, the Federal Communications Commission (FCC) specifies a minimum instantaneous bandwidth of 500 MHz [2] in a frequency range from 3.1 to 10.6 GHz. Because of this large frequency span, UWB devices can operate in the same RF spectrum as many other wireless communication technologies including WiMAX™, Wi–Fi, satellite communications and others (see [3]). Fig. 1 provides an overview of the primary wireless services or incumbents operating in the same frequency range of UWB, with the allocated frequency bands, bandwidth, range and data throughput.

To address the risk of interference from UWB to other systems and services, regulatory bodies around the world have defined stringent limits for the emission power of UWB devices. In most cases, the limit is given as an Equivalent Isotropically Radiated Power (EIRP) emission mask. EIRP emission mask was defined by the FCC in 2002, the European Union in 2006, China in 2008, Japan in 2006 and Korea in 2006. The disadvantage of the EIRP mask is that UWB transmission power is limited even in the absence of WiFi or WiMAX communication.

A more flexible approach is to allow higher emission power for UWB devices when no other wireless system is

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Technology	Standard	Usage	Range	Data Throughput	Bandwidth MHz	Frequency / region	
						EU	USA
WiFi	802.11a	WLAN	Up to 150 meters	≤ 54 Mbps	20/40	2.4/5 GHz	2.4/5 GHz
Wi-Fi	802.11b	WLAN	Up to 100 meters	≤ 11 Mbps	20	2.4 GHz	2.4 GHz
Wi-Fi	802.11g	WLAN	Up to 100 meters	≤ 54 Mbps	20	2.4 GHz	2.4 GHz
WiFi	802.11n	WLAN	≤ 150 metres	288 Mbps with 20 MHz bandwidth - 600 Mbits with 40 MHz bandwidth	20/40	2.4/5 GHz	2.4/5 GHz
Wi-Fi (WAVE)	802.11p	ITS	≤ 300 metres	≤ 54 Mbps	10	5.8 GHz	5.9 GHz
WiMAX	802.16d/ 802.16e	WMAN	6-8 km (NLOS)1 6 km (LOS)	1-5 Mbps/user	PHY-dependent (1.75 - 28 MHz)	CEPT recommends:3.4 - 3.6 GHz,3.6 - 3.8 GHz(fixed, nomadic and mobile)and 5.8 GHz(fixed and nomadic).2.5 GHz for neutral	2.3 GHz(fixed and mobile)2.5 GHz(fixed and mobile)3.6 GHz(fixed and mobile)5.8 GHz(fixed and mobile)

Fig. 1. Primary wireless services in the UWB frequency bands.

transmitting within the same coverage area [4]. In this case an opportunistic approach could be used, where secondary users (e.g., UWB devices) are required to detect the transmission of primary users in specific spectrum bands and consequently refrain from transmitting in those bands or reduce their emission power. In the case of UWB, this approach is also named Detect and Avoid (DAA). Radio regulators have proposed the adoption of DAA in certain regulatory domains and for specific radio frequency bands. An important task for the deployment of UWB DAA enabled devices is to verify that the DAA mechanism is implemented according to the specifications defined by the spectrum regulators.

In this paper, we present a test bed designed to evaluate UWB DAA devices operating co-channel with WiMAX. In this paper, we limit our scope to WiMAX operating at 3.5 GHz because it is the frequency band with higher risk of interference from UWB devices. We also limit the scope to Multi Band Orthogonal Frequency Division Modulation (MB-OFDM) UWB techniques because they are used in the PHY layer specification of the WiMedia Alliance, which is the largest industry association to promote the adoption of UWB technology worldwide. The definition of the test bed and related measurement campaigns were the main focus of the FP7 project WALTER (Wireless Alliance for Testing Experiment and Research). Project WALTER (see [5]) was a project co-financed under the 7th framework program of the European Commission, whose main objective was to develop a networked test bed to validate UWB interference mitigation techniques and coexistence mechanisms including DAA. The networked test bed was based on three testing facilities based in China (TMC-MIIT), Spain (AT4 wireless) and Italy (Joint Research Project of the European Commission).

The paper is structured in the following sections: Section 2 provides a global overview of the regulatory and standardization requirements for UWB DAA enabled devices. It also provides a description of the MB-OFDM UWB DAA system. Section 3 describes the methodology to specify requirements, define test procedures and identify the main validation and testing challenges. Section 4 describes the design and implementation of the test beds (conducted and radiated) and it provides an analysis of the main factors contributing to the quality of the measurements. Section 5 describes the measurement campaigns and the results. Finally Section 6 concludes the paper.

2. DAA UWB standards and regulations

2.1. DAA UWB standards – ECMA-368

ECMA-368 standard [6] and ETSI EN 302 065 [1] define the physical and MAC layer of the MB-OFDM UWB