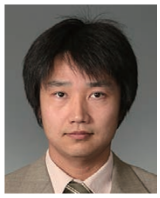
An Overview of the Ofcom (UK) White Spaces Pilot, and the Involvement of the NICT



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1. Introduction

Around the world, studies are being conducted to develop technologies and systems to use the gaps between TV frequency bands ("white spaces") for secondary purposes without interfering with TV broadcasts. If new bandwidth can be made available, then it will not only be possible to accommodate increased traffic in wireless communication, but it will also be possible to use radio waves more flexibly by using different wireless systems according to the characteristics of radio wave propagation and the like.

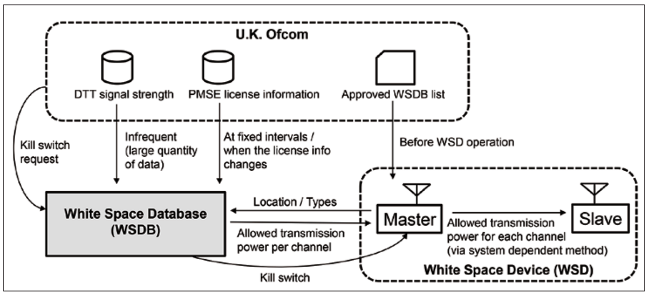
Under these circumstances, Ofcom (Office of Communications; the UK radio regulatory body) devised a project called the TV White Spaces Pilot to test and verify this framework with a view to establishing systems for the use of white space, and issued a call for participants in 2013[1]. Channels that are available for secondary use in white spaces are managed in a white space database (WSDB), and the channels that are available to a wireless communication device at a particular position are calculated based on information provided by Ofcom. A device selects one or more channels based on this information. In this pilot, Ofcom recruited external database providers and device operators to help verify these frameworks. Since the National Institute of Information and Communications Technology (NICT) has already worked to clarify technical issues by checking the performance of systems researched and developed for white space applications, we participated both as a database provider and as a device operator.

2. Overview of the UK white spaces pilot

In the UK, the 470–790 MHz frequency range is assigned to digital terrestrial television (DTT), with a bandwidth of 8 MHz per channel and a total capacity of 40 channels. In addition to the original TV broadcasts, this frequency band is now also used for so-called Program Making and Special Events (PMSE). PMSE refers to voice transmission systems that are used in program-making and other fields for purposes such as wireless microphone links and talkback from recording equipment. To use PMSE, it is necessary to apply for and purchase a license. In this pilot, it was required that there should be no interference of DTT or PMSE by white space systems.

The organization of the pilot and the flow of information are shown in Figure 1. Besides the organizer Ofcom, the pilot also includes database providers and device operators who perform testing.

■ **Figure 1: Configuration and information flow of the pilot project**



The database providers obtain DTT field strength information and PMSE channel assignment information from Ofcom. The DTT field strength information is obtained by recording the DTT field strength of each channel in every grid cell of a map divided into 100 m × 100 m squares. The quantity of information is very large (several tens of gigabytes), but has a low update frequency because it is not modified unless a TV station's broadcast specifications changes. On the other hand, the PMSE channel allocation information consists of the locations, channels, time slots and other information assigned to PMSE users by Ofcom. The database providers calculate the PMSE radio wave propagation by periodically accessing the PMSE information or receiving ad hoc updates from Ofcom, and calculate acceptable power levels for devices so that PMSE communication is unaffected.

The device operators select and connect to one database from the list of multiple Ofcom-qualified database providers when starting operations, request operational parameters including information such as the transmission power per channel allowed for the device, and start operating the device according to these operational parameters.

The device operators operate two categories of device: master and slave. A master device connects to the database to acquire operational parameters.

On the other hand, a slave device does not have a function for connecting directly to the database, but is instead assumed to be operated in the vicinity of a master device from which it can acquire operational parameters by a method particular to this system.

To handle situations where, for example, a device is found to be causing interference with DTT or PMSE services, the database providers are required to implement a function that forces the termination of radio emissions from corresponding devices when a particular region or device-specific ID is specified.

This "kill switch" function allows the operation of devices to be terminated by an instruction from Ofcom to a database provider, and by a change in the operational parameter information in the database.

3. Equipment developed by NICT

To participate in this project, NICT developed a database and devices for two types of system according to Ofcom's requirements as described below.

With regard to the database, we entered into a contract with Ofcom in December 2013, and were informed of their official approval in June 2014[2]. During this period, the NICT performed confirmation testing (offline tests) by itself based on procedures provided by Ofcom, after which an Ofcom appointee performed confirmation tests by directly querying the database via the Internet (online tests). As of December 2014, eight companies including NICT have had their databases qualified, and eight organizations including NICT, Google, Microsoft and Sony have been listed on the Ofcom web site.

One of the devices developed by NICT is a white-space-compatible LTE system that conforms to the 3GPP Release 8 standard, and another is a wireless LAN system that conforms to the IEEE 802.11af standard.

The former can perform TDD communication in a single channel, and can also use multiple channels to perform FDD mode communication with separate uplink and downlink. It can also use multiple consecutive channels simultaneously by switching between bandwidths of 5, 10 and 20 MHz in TDD and FDD mode respectively. The maximum transmission power is 1 W for a base station (eNB), and 100 mW for a user terminal (UE)[3]. The base station is connected via the Internet to an LTE control device called an Evolved Packet Core (EPC).

On the other hand, the latter has an operational bandwidth of 4.8 MHz and a maximum transmission output power of 1 W, and is able to use BPSK, QPSK, 16QAM and 64QAM modulation schemes.

Both devices pass Ofcom's Class 5 ACLR (adjacent channel leakage ratio) requirements.

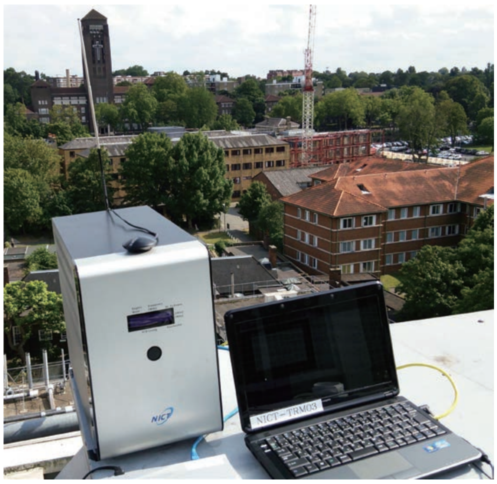
4. Test results

The devices we developed were tested in the city of London during July 2014 using two modes of communication — broadband mobile communication using an LTE system, and backhaul communication between fixed points using an IEEE 802.11af system.

The broadband mobile communication tests were performed with an LTE base station situated on the roof of a building in the Denmark Hill campus of King's College London, and transmission speed measurements were made while moving an LTE terminal around within the campus. From the results of these measurements, we found that the maximum UDP downlink transmission speed was 45.4 Mbps during FDD operation with two sets of 20 MHz bandwidth, and 19.5 Mbps during TDD operation with a 20 MHz bandwidth.

Next, in backhaul communication between fixed points, the IEEE 802.11af access point and terminal were situated in the Denmark Hill campus and Guy's campus of King's College London, respectively. The straight-line distance between the two campuses is 3.7 km, with a direct line of sight. For the antenna we used a three-element ring Yagi antenna with a gain of 7.4 dBi. During the tests, the transmitter power of the wireless device was set to 28 dBm based on transmission power value indicated by the database. According to the results of these measurements, it was possible to achieve a transmission speed of 2 Mbps with QPSK modulation (coding rate 1/2), but unlike the laboratory environment, there was a TV transmission tower situated 5 km from the Denmark Hill campus, and it was assumed that the full communication performance potential was not realized due to the effects of strong inputs received from the whole TV transmission band. Such issues are particularly important for white space communication equipment, and will need to be investigated fully in the development of future systems.

Figure 2: LTE base station installed on a roof in the university campus



5. Conclusion

This paper has presented an overview of a pilot project conducted by Ofcom in the UK to verify white space systems, and has introduced the results of tests in which NICT participated. The knowledge gained through this pilot has been fed back to Ofcom from the participating organizations, and a report based on this knowledge was published in December 2014. It is expected that the white space operating standards and technical standards drafted in Europe will also make progress in other parts of the world. It can also be used as a communication system for 5th generation mobile communications, or as a means for reinforcing propagation losses caused by defects in micrometer wave wireless systems and the like in communication between fixed points, and it is important to fully consider the value of these modes of use.

Acknowledgment

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REFERENCES

[1] Ofcom TV White Space Pilot web site: http://stakeholders.ofcom.org.uk/spectrum/tv-white-spaces/white-spaces-pilot/

[2] H. N. Tran, et al., "Evaluation of channel availability for mobile device by using a TV white space database qualified by the Ofcom," IEEE VTC Spring 2015.

[3] K. Ibuka, et al., "Development and Field Experimet of White-spaces LTE Communication System in UK Digital Terrestrial TV Band," IEEE VTC Spring 2015.