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Reconfigurable Radio Systems (RRS); System Architecture and High Level Procedures for Coordinated and Uncoordinated Use of TV White Spaces

Reference
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Foreword

This draft European Standard (EN) has been produced by ETSI Technical Committee Reconfigurable Radio Systems (RRS), and is now submitted for the combined Public Enquiry and Vote phase of the ETSI standards EN Approval Procedure.

Proposed national transposition dates	
Date of latest announcement of this EN (doa):	3 months after ETSI publication
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	6 months after doa
Date of withdrawal of any conflicting National Standard (dow):	6 months after doa

Modal verbs terminology

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1 Scope

The present document defines the system architecture for the use of spectrum by White Space Devices (WSDs), specifically in the UHF TV Bands. The architecture stems from ETSI TS 102 946 [1]. The scope of the present document is to define the architecture of a system which can allow operation of WSDs based on information obtained from Geo-location databases. The architecture will consider both uncoordinated use of White Space (where there is no attempt to manage the usage of channels by different WSDs) as well as coordinated use of White Space (where some form of channel management and/or coexistence techniques are employed to efficiently use the White Space).

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

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The following referenced documents are necessary for the application of the present document.

[1] ETSI TS 102 946: "Reconfigurable Radio Systems (RRS); System requirements for Operation in UHF TV Band White Spaces".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI TR 103 067: "Reconfigurable Radio Systems (RRS); Feasibility study on Radio Frequency (RF) performance for Cognitive Radio Systems operating in UHF TV band White Spaces".

[i.2] ECC Report 186: "Technical and operational requirements for the operation of white space devices under geo-location approach".

[i.3] IEEE™ 802.22: "Cognitive Radio Wireless Regional Area Networks (WRAN) Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Policies and Procedures for Operation in the Bands that Allow Spectrum Sharing where the Communications Devices may Opportunistically Operate in the Spectrum of the Primary Service".

[i.4] IEEE™ 802.11: "Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications".

[i.5] ETSI EN 301 598 (V1.1.1): "White Space Devices (WSD);Wireless Access Systems operating in the 470 MHz to 790 MHz TV broadcast band; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

coexistence: situation in which one radio system operates in an environment where another radio system having potentially different characteristics (e.g. RAT) may be using the same or different channels, and both radio systems are able to operate with some tolerable impact to each other

coordinated use of white spaces: case when each CRS uses available white space resources obtained with the help of the geo-location database and with additional knowledge of spectrum usage by its neighbour CRSs by the SC

NOTE: The case in which the SC assigns directly channels to the CRSs is also part of the coordinated use of white spaces.

coordination: ability of managing two or more CRSs to allow them to follow pre-determined operation policies such as coexistence among coordinated CRSs

coordination report: information to the CRS to make coordination decisions on its operational parameters in the information service

NOTE: This includes channel usage information, output power level, channel availability time, sensing information, as well as some initial ranking of the available channels.

coordination set: set of CRSs which may affect the performance of the CRS they are associated to

Geo-Location Database (GLDB): database approved by the relevant national regulatory authority which can communicate with WSDs and provide information on TVWS channel availability

NOTE 1: Information provided by a GLDB will include the available frequencies and associated maximum EIRP values that the WSD is permitted to use which allow for protection of the incumbent service and are derived from information provided by the WSD and the minimum required ACLR of the WSD.

NOTE 2: The GLDB consists of database and geo-location functions.

priority-based channel assignment: assignment of a channel by the SC to a CRS in such a way that the CRS can operate *alone* in such channel for a specific reservation period and in a specific area based on particular minimum protection requirements of the CRS

NOTE: CRSs assigned such channels with therefore have priority over other CRSs.

Spectrum Coordinator (SC): entity that coordinates spectrum usage of CRS based on the information obtained from geo-location database as well as supplemental spectrum usage data from different CRSs using its service

uncoordinated use of white spaces: case when each CRS independently uses available white space resources obtained with the help of the geo-location database without any help from the spectrum coordination function to coordinate spectrum usage with its neighbour CRSs

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ACLR	Adjacent Channel Leakage Ratio
BC	Branch Condition
Com-SAP	Communication Service Access Point
CR	Cognitive Radio
CRS	Cogitative Radio System
C-SAP	Control Service Access Point
CSMA	Carrier Sense Multiple Access
DB-SAP	DataBase-Service Access Point
DS	Decision Status
DTV	Digital TV

EIRP	Effective Isotropic Radiated Power
GLDB	Geo-Location Database
GL-SAP	GeoLocation-Service Access Point
NAV	Network Allocation Vector
NRA	National Regulatory Authority
QoS	Quality of Service
RAT	Radio Access Technology
SAP	Service Access Point
SC	Spectrum Coordinator
SC-SAP	Spectrum Coordinator Service Access Point
SINR	Signal to Interference plus Noise Ratio
TV	TeleVision
TVWS	TV White Space
UHF	Ultra High Frequency
WSD	White Space Device

4 Functional Architecture

4.1 Overview of Functional Architecture

Figure 4.1 shows the high level functional architecture of a white space system. All the system requirements specified in ETSI TS 102 946 [1] shall be supported.

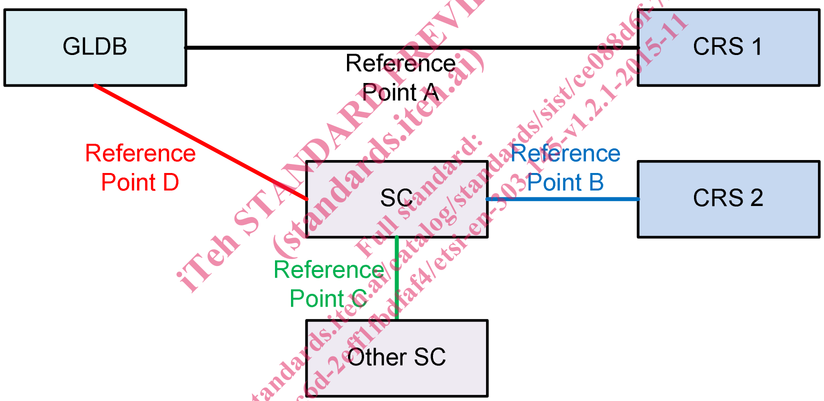

Figure 4.1: Overview of TV white spaces system

The TV white space system has three entities:

- Cognitive Radio System (CRS);
- Spectrum Coordinator (SC);
- Geolocation Database (GLDB);

and four reference points (A, B, C, and D), as shown in figure 4.1.

Each entity is defined by its functional roles and reference points with other entities.

The cognitive radio system (CRS) represents a white spaces device (WSD) or network of WSDs (i.e. a master WSD and some slave WSDs). The CRS uses available white space resources obtained with the help of geo-location database (GLDB) and/or with additional knowledge of spectrum usage by its neighbour CRSs provided by the spectrum coordinator (SC).

The GLDB provides a WSD in a CRS with location specific information on the available frequencies and associated maximum EIRP values that the WSD is permitted to use. This will allow for protection of the incumbent service and is derived from information provided by the WSD and the minimum required Adjacent Channel Leakage Ratio (ACLR) of the WSD itself.

The SC is responsible for coordinating spectrum usage of CRSs based on the information obtained from GLDB as well as additional spectrum usage data from different CRSs using its service. Different SCs are capable of communicating with each other.

The reference point A that is related to the uncoordinated usage of White Spaces is described in ETSI EN 301 598 [i.5].

4.2 Coordinated Usage of White Spaces

4.2.1 Spectrum coordination

4.2.1.1 Overview

Spectrum coordination is the mechanism with which an SC serves CRSs so that they can operate efficiently in available spectrum resources of white spaces. The SC coordinates how to manage radio resources among a set of CRSs that are potentially interfering with each other (coexistence) and allows for channel assignment requested by a CRS that wishes to operate alone on a channel and with priority over other CRSs (priority-based channel assignment). The priority-based channel assignment is managed by the SC based on some minimum protection requirements requested by the CRS, which includes minimum bandwidth, minimum SINR (or maximum allowable interference) and some guaranteed minimum availability time. The SC translates these requirements into protection criteria, which are used by the GLDB to ensure that the priority-based channel assignment is maintained in the presence of other WSDs not using the SC. The algorithms to enable coexistence and/or priority-based channel assignment are described in Annex A. From the perspective of the CRSs, coexistence and priority-based channel assignment are provided as a set of two available SC services: the information service (for coexistence only) and the management service (for both coexistence and priority-based channel assignment). Each SC shall provide at least the information service or the management service for CRSs but can also provide both of them. The information service and the management service are described in clauses 4.2.1.2 and 4.2.1.3.

4.2.1.2 Information service

For CRSs that are subscribed to the information service, an SC provides information about useful operational parameters (e.g. the operational parameters of other CRS in the available spectrum resources). In the information service, an SC does not make decision on the operational parameters to be used by those CRSs, but rather, all decisions are made by the CRS itself. However, the SC may process information about the current usage of spectrum to provide to the CRS in a manner which may facilitate the CRS decision (such as ranking the potential operational parameters according to the resulting expected performance).

4.2.1.3 Management service

For CRSs that are subscribed to the management service, a SC provides the operational parameters to be used by a CRS based on its requests and, potentially, certain QoS and usage time requirements. A CRS does not make any decision for its operational parameters (e.g. channel and transmit power) but they are determined by the SC itself.

4.2.2 High level operation sequence

An overview of coordinated usage of white spaces is shown in figure 4.2.

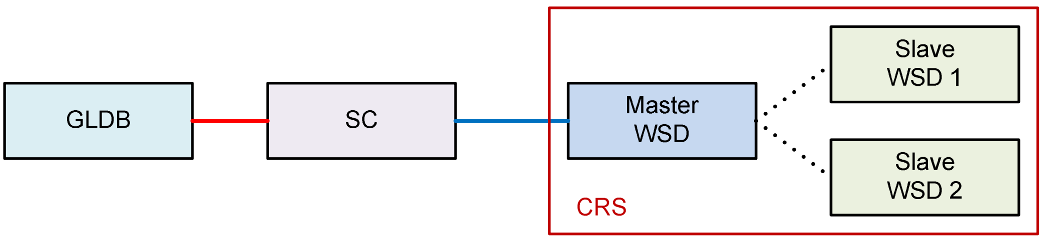

Figure 4.2: Overview of coordinated usage of white spaces system

A CRS consists of a master WSD and one or more slave WSDs. The master WSD sends device parameters to a GLDB via the SC. The SC shall act as relay and can also store the device parameters of the master WSD. The SC, during the process, maintains additional data about spectrum usage of the different CRSs using its service. This additional data contains information that reflects the current state of spectrum usage, including spectrum measurement data from WSDs, and usage maps or areas of occupancy of the different CRSs. It also contains parameters specific to the Radio Access Technology of each CRS that facilitates coexistence. A GLDB shall receive information from the master WSD about the characteristics of that WSD in order to generate operational parameters for that WSD. The GLDB provides specific operational parameters to the master WSD via the SC. During this process, the SC determines the operational parameters using the information obtained from the GLDB as well as the additional data about spectrum usage of the different CRSs, and sends these operational parameters to the master WSD in response to the request for white space access. The operational parameters determined by the SC shall not violate the protection criteria of the incumbent, and are therefore compliant with the information obtained from the GLDB. The master WSD then sends the selected channel usage parameter to the GLDB via the SC [i.2]. The SC will also update its additional spectrum usage data based on information sent by the WSD. At any time in the process of assigning channels to the CRSs, the SC could reconfigure the channel usage of the CRSs to ensure an efficient use of spectrum, such as reducing fragmentation in the available spectrum. The GLDB can use channel usage parameters sent by the SC to ensure that WSDs can operate in the presence of other WSDs not using the SC.

4.3 Uncoordinated Usage of White Spaces

4.3.1 High level operation sequence

An overview of uncoordinated usage of white spaces is shown in figure 4.3.

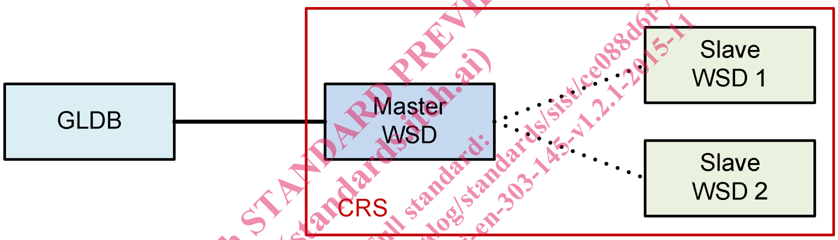

Figure 4.3: Overview of uncoordinated usage of white spaces system

A CRS consists of a master WSD and one or more slave WSDs. The master WSD shall communicate with a GLDB to obtain its operational parameters in white spaces. A GLDB shall receive information from a WSD about the characteristics of that WSD in order to generate operational parameter for that WSD. A GLDB shall maintain a record of the actual usage of the white spaces. This information could be used to enable WSDs to be readily identified if interference to incumbent users were to occur, and to allow the GLDB to know the extent to which available white spaces are being used.

5 Detailed Functional Architecture

5.1 Architecture Description

The overall system reference model is shown in figure 5.1.

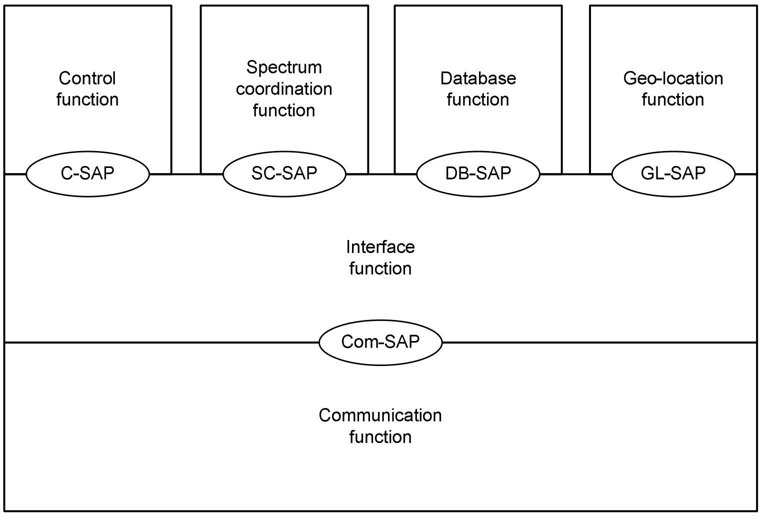

Figure 5.1: Overall system reference model

There are six logical functions for operating white space system: control function, spectrum coordination function, database function and geo-location function are the 4 key components for the system. Two additional functions (the interface function and the communication function) are general components for the system. Physical implementation examples of the overall system reference model are shown in annex B. Clause 5.2 describes in more detail the six identified logical functions.

5.2 Functional Description of Components

5.2.1 Database function

A database function is a software/hardware module that stores necessary information provided by regulators for calculating the available spectrum that a WSD in a CRS can operate on (with protection to incumbent services) as well as registration of the WSDs under regulatory requirements and for the purposes of protecting incumbent services. The reference model of database function is shown in figure 5.2.

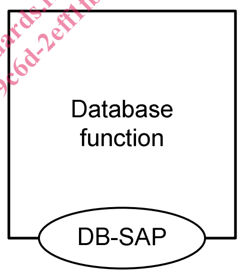

Figure 5.2: Reference model of a database function

The database function service access point (SAP) is the database SAP (DB-SAP). The DB-SAP is used by the interface function to access the services provided by the database function such as registration of CRS and provision of incumbent information.

5.2.2 Geo-location function

A geo-location function is a software/hardware module that supports the following functions:

- To calculate location specific available frequency band and associated maximum EIRP that a WSD in a CRS can use based on the information on incumbents stored in database function.
- To Interact with the SC for management of uncoordinated CRSs when considering priority usage coordinated CRSs.

The reference model of the geo-location function is shown in figure 5.3.

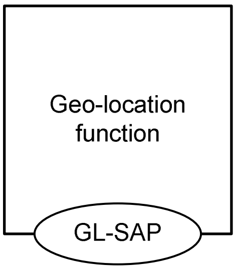

Figure 5.3: Reference model of a geo-location function

The geo-location function service access point (SAP) is the geo-location SAP (GL-SAP). GL-SAP is used by the interface function to access the services provided by the geo-location function such as calculation of location specific EIRP of a frequency band and that a WSD in a CRS can use.

5.2.3 Spectrum coordination function

A spectrum coordination function is a software/hardware module that coordinates spectrum usage of CRSs based on the information obtained from geo-location database and additional data about the spectrum usage of the different CRSs using the services of the SC. The reference model of spectrum coordination function is shown in figure 5.4. Depending on the implementation and location of the spectrum coordination function in the system (see annex B for examples) the spectrum coordination function will have one or more of the following functionalities:

Coexistence functionality: This functionality assures proper operation between different WSDs that utilize the white space, and avoidance of harmful interference between different CRSs using the same and/or adjacent channels.

Sensing and measurement functionality: The sensing functionality is responsible for the configuration of sensing in the CRS as well as the collection and combined processing of the sensing results and the measurements specific of the RAT that the CRS is using.

Priority-Based Channel assignment and negotiation functionality: This functionality allows certain CRSs or other spectrum coordination functions to assign channels and provides the necessary means for negotiation between different CRSs which may request a priority-based channel assignment for periods of time.

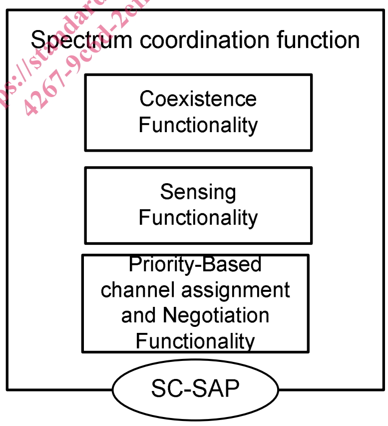

Figure 5.4: Reference model of spectrum coordination function

The spectrum coordination function service access point is the spectrum coordination SAP (SC-SAP). The coexistence functionality, sensing functionality, and priority usage and negotiation functionality all communicate with functions outside of the spectrum coordination function using the same SC-SAP. SC-SAP is used by the interface function to access the services provided by the spectrum function such as calculation of coordination parameters based on coexistence algorithms, priority-based channel assignment algorithms, etc. that a WSD in a CRS can use.