# IEEE P802.19
# Wireless Coexistence

## System Design Document

**Date:** 2010-03-18

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## Abstract

This document is a system design document of 802.19 Task Group 1. The document contains system requirements, terminology, architecture and tentative outline of the draft. The document describes also in which clause order proposals are presented and voted in the task group as per the draft development process (19-10/0029).

# Introduction

The IEEE 802.19 TG1 was approved by the 802.19WG, ExCom and Nescom with the PAR available at http://ieee802.org/19/pub/TG1.html. The PAR scope and purpose are copied below:

**PAR Scope:** *The standard specifies radio technology independent methods for coexistence among dissimilar or independently operated TV Band Device (TVBD) networks and dissimilar TV Band Devices.*

**PAR Purpose:** *The purpose of the standard is to enable the family of IEEE 802 Wireless Standards to most effectively use TV White Space by providing standard coexistence methods among dissimilar or independently operated TVBD networks and dissimilar TVBDs. This standard addresses coexistence for IEEE 802 networks and devices and will also be useful for non IEEE 802 networks and TVBDs.*

The group approved a process document 19-10/0029 to complete the draft standard. According to process document a system design document (SDD) should be adopted by the group to assist standardization process. SDD does not put any limitation on future contributions. The SDD shall include the 802.19.1 system architecture, system requirements, terminology and draft outline of the specification. The SDD describes also in which clause order proposals are presented and voted in the task group. TG1 decided to have ad hoc committees for the 802.19.1 system architecture, system requirements, terminology of the SDD.

According to discussion in TG1, the 802.19.1 system architecture part of SDD should define define entities of the system with their high level functions, exposed interfaces and their major information flow items. All external entities should be identified. Architecture should show external boundaries.

Contributions to Architecture Ad Hoc group were:
19-10/0019r0  High Level Architecture View
19-10/0020r0  P802.19.1 Assumptions and Architecture
19-10/0037r0  SDD_Architecture
19-10/0041r0  High level system architecture proposal
19-10/0046r1  Updated P802.19.1 System Architecture

TG1 used 19-10/0046r1 as basis for the system architecture part.

System requirements part of the SDD treats 802.19.1 system as a single entity and provides general functional requirements.

Contributions to Requirements Ad Hoc group were:

19-10/0031r0  P802.19.1 Requirements
19-10/0031r0  Comments on Requirements
19-10/0035r0  P802.19.1 System Requirements
19-10/0039r0  System Requirements
19-10/0043r0  System Requirements

19-10/0051r0   802.19.1 requirements

TG1 used 19-10/0051r0 as basis for the requirements part.

Draft outline and clause order provides possible contents of the standard and the tentative schedule for proposals. Contributions for draft outline and clause order were:

19-10/0052r1   Proposed Table of Content of P802.19.1 Draft Standard
19-10/0052r2   Proposed Table of Content of P802.19.1 Draft Standard

Terminology part of the SDD provides defitions of terms related to coexistence to help contributors.

Contributions to Terminology Ad Hoc group were:

19-10/0026r0   TerminologyAdHoc_Template
19-10/0038r0   Suggested definitions for terminology document
19-10/0049r0   Terminologyadhoc_Extra_Terms
19-10/0026r3   TerminologyAdHoc_Template
19-10/0054r1   SDD-Terminology-Strawpoll-Results

TG1 used 19-10/0054r1 as basis for the terminology part of the SDD.

Below is the list of main contributors to the SDD.

| | |
|---|---|
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# 1. <u>System Requirements</u>

This section provides requirements for 802.19.1 system. There are 9 system requirements (R1-R9) that can be grouped into four different categories: General, Discovery, Communication and Algorithm. The requirements can be also grouped from the view point of whether they relate to the system's internal operation or interactions with world outside the system. Both these aspects are illustrated in the Figure 1 below that provides an overview of the system requirements.
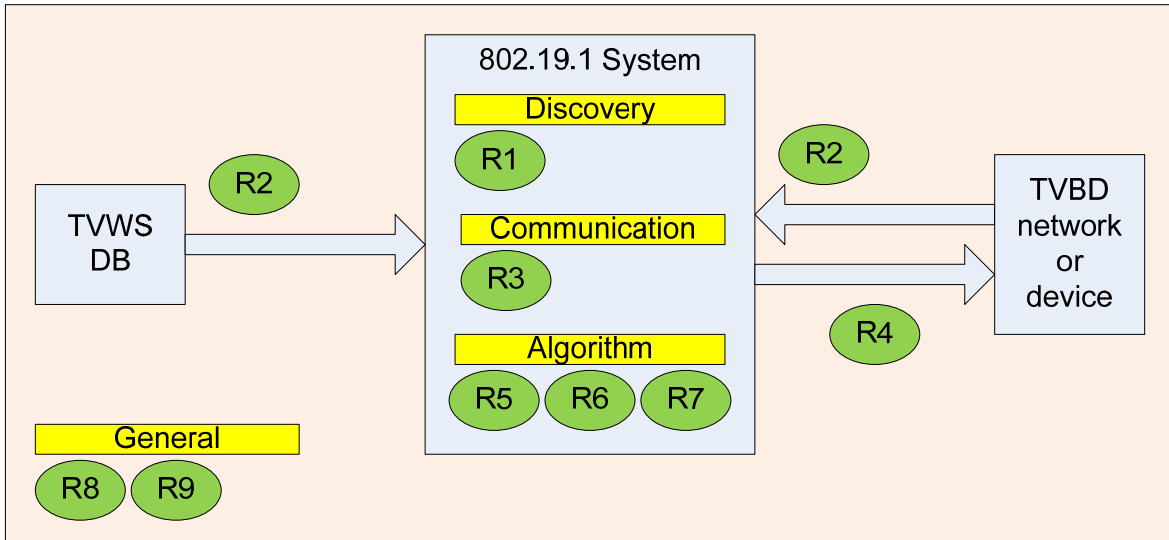


**Figure 1. Overview of system requirements**

# <u>R1</u>

802.19.1 system **shall** enable discovery for 802.19.1 compliant TVBD networks and devices.

Explanatory notes:
- 802.19.1 system needs to identify potential 802.19.1 compliant TVBD networks or devices that need to coexist as a crucial step in order to achieve coexistence

# <u>R2</u>

802.19.1 system **shall** be able to obtain and update information required for TVWS coexistence.

Explanatory notes:
- 802.19.1 system obtains this information from outside  the 802.19.1 system, for example, from TVWS database, from 802.19.1 compliant TVBD networks/devices
- This requirement also highlights the capacity to update/refresh coexistence related information, such as location information of TVBD networks and devices, spectrum utilization by TVBD networks and devices.

# <u>R3</u>

802.19.1 system **shall** have means to exchange obtained information.

Explanatory notes:
- Without constraining the mechanism of communication, this requirement puts a high level requirement to provide means of exchanging information necessary for TVWS coexistence.

# R4

802.19.1 system **shall** be able to provide reconfiguration requests and/or commands as well as corresponding control information to 802.19.1 compliant TVBD networks and devices to implement TVWS coexistence decisions.

Explanatory notes:
- Examples of reconfiguration requests/commands are: to change center frequency, to adjust transmit power, affect time scheduling
- Reconfiguration requests and/or commands and corresponding control information are provided from 802.19.1 system to TVBD networks or devices, for example
  - From a part of 802.19.1 system deployed in TVBD device to device management system via a SAP internal for the TVBD device
  - From a part of 802.19.1 system deployed in TVBD network (e.g. in network management system) to radio nodes of TVBD network, e.g. base stations, access points

# R5

802.19.1 system **shall** analyze obtained information.

Explanatory notes:
- An example of analysis is the processing of raw data to generate a set of new data for assisting decision making.

# R6

802.19.1 system **shall** be capable of making TVWS coexistence decisions.

Explanatory notes:
- As an example of decision making, deciding on which actions should be taken by TVBD networks/devices to solve coexistence problem

# R7

802.19.1 system **shall** support different topologies of decision making for TVWS coexistence (e.g. centralized, distributed and autonomous).

Explanatory notes:
- This requirement underlines the possibility of having various approaches to implement decision making in coexistence scenarios.
- It also underlines that 802.19.1 system must be capable to support these different approaches of decision making for coexistence.

## R8

802.19.1 system **shall** support appropriate security mechanisms. This **shall** include user/device authentication, integrity and confidentiality of open exchanges, and data privacy and policy correctness attestation and enforcement.

Explanatory notes:
- 802.19.1 system shall be able to authenticate, provide integrity and/or confidentiality to all entities involved in 802.19.1 data exchange
- 802.19.1 system shall support privacy of sensitive data, and secure means to store and process such data while it resides in 802.19.1 entities
  - Sensitive data may be geolocation, user and device credentials, and time alignment
- 802.19.1 system shall enable enforcement of coexistence policies for the 802.19.1 compliant TVBD networks or devices
  - This includes secure means to detect and/or to remediate compromised behavior

## R9

802.19.1 system **shall** utilize a set of mechanisms to achieve coexistence of TVBD networks and devices.

## 2. The 802.19.1 System Architecture

The 802.19.1 system architecture has three logical entities and six logical interfaces. An 802.19.1 logical entity is defined by its functional role(s) and its interfaces with other 802.19.1 logical entities and with external elements.

The three logical entities are:
- Coexistence Manager (CM)
- Coexistence Enabler (CE)
- Coexistence Discovery and Information Server (CDIS)

The six logical interfaces are:
- Interface A
- Interface B1
- Interface B2
- Interface B3
- Interface C
- Interface D

Additionally, the 802.19.1 system interacts with three external elements:
- TVWS database
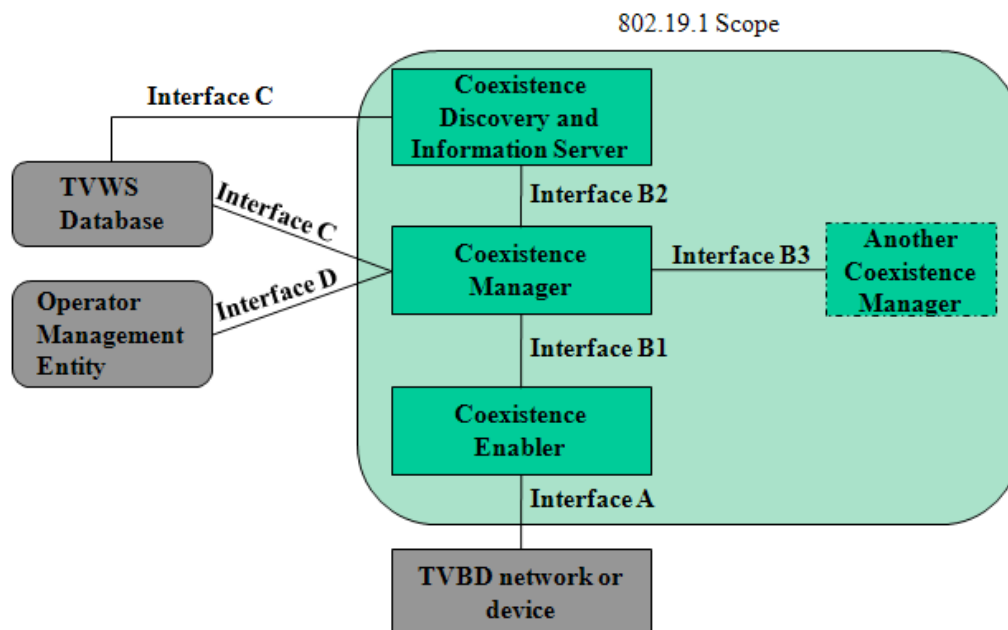- TVBD network or device
- Operator Management Entity (OME)



**Figure 2. 802.19.1 system architecture**

## 3.1 Logical Entities

### Coexistence Enabler (CE)

Functional roles:
- Request and obtain information, required for coexistence, from TVBD network or device
- Translate reconfiguration requests/commands and control information received from the CM into TVBD-specific reconfiguration requests/commands and send them to the TVBD network or device

### Coexistence Manager (CM)

Functional roles:
- Discovery of other CMs
  - To solve coexistence problems between TVBD networks they serve
- Coexistence decision making
  - This includes generating and providing corresponding coexistence requests/commands and control information to CE(s)
- Support exchange of information required for coexistence among CMs
  - This may include hierarchical and/or peer-to-peer decision making capabilities in CM deployments
- Assist network operators in management related to TVWS coexistence

### Coexistence Discovery and Information Server (CDIS)

Functional roles:
- Support discovery of CMs
  - Facilitates opening interfaces between CMs
- Collect, aggregate, and provide information facilitating coexistence
  - This includes data storage, data processing, etc.

## 3.2 Logical Interfaces

The six logical interfaces in 802.19.1 system architecture can be split into three groups:
- Interfaces between 802.19.1 entities
  - Interface B1
  - Interface B2
  - Interface B3
- Interface between an 802.19.1 entity and TVBD network/device
  - Interface A
- Interfaces between 802.19.1 entities and TVWD database or OME
  - Interface C
  - Interface D

Different interfaces in each group are distinguished by their usage, types of information exchanged, and underlying protocols.

### Interface A

Interface between CE and TVBD network or device
- From TVBD network or device
  - Information required for coexistence

- o Configuration/information requests for coexistence
- o Configuration/measurement/information responses for coexistence
- o And other information as needed
- From CE to TVBD network or device
    - o Reconfiguration requests/commands and control information (corresponding to coexistence requests/commands and control information received from CM)
    - o Requests/commands related to control of measurements performed by TVBD network or device
    - o And other information as needed

## Interface B1

Interface between CE and CM
- From CE to CM
    - o Information required for coexistence (information obtained from TVBD network or device)
    - o And other information as needed
- From CM to CE
    - o Coexistence requests/commands and control information
    - o And other information as needed

## Interface B2

Interface between CM and CDIS
- From CM to CDIS
    - o Information required for discovery (obtained by this CM)
    - o Information required for coexistence (obtained by this CM)
    - o And other information as needed
- From CDIS to CM
    - o Information required for discovery (obtained by other CMs)
    - o Information required for coexistence (obtained by other CMs)
    - o And other information as needed

## Interface B3

Interface between CM and CM
- From CM to CM
    - o Information and message required for discovery and coexistence
    - o And other information as needed

## Interface C

Interface between CM/CDIS and TVWS database
- From TVWS database to CM/CDIS
    - o Information required for coexistence (information on available TV channels)
    - o And other information as needed

## Interface D

Interface between CM and OME
- From OME to CM

- o Network operator related information e.g. spectrum policy/limitations concerning operator networks
- o And other information as needed

# 3. <u>Tentative Outline and Clause Order for Development of 802.19.1 Draft</u>

This section provides a tentative outline of 802.19.1 draft to help proposers to prepare proposals for the task group for considerations.

**1. Overview**
1.1 Scope
1.2 Purpose
1.3 Sample application areas
1.4 Conformance
**2. Normative references**
**3. Definitions, acronyms and abbreviations**
3.1 Definitions
3.2 Acronyms and aabreviations
**4. System description**
4.1 Architecture
4.2 Logical entities
4.3 Interfaces
**5. The IEEE 802.19.1 reference model**
5.1 General description
5.2 Service Access Points (SAPs)
5.2.1 Data formats and parameters
**6. Procedures and protocols**
6.1 Generic procedures for information exchange
6.2 Protocols
**7. Coexistence mechanisms and algorithms**
Annex A: Use cases
Annex B: Evaluation methodology
Annex C: Coexistence Enabler (CE) software reference design

# 4. <u>Clause Order for Development of 802.19.1 Draft</u>

From the outline provided in previous section, TG1 selected four main clauses to issue call for proposals:

- System description
- The 802.19.1 reference model
- Procedures and protocols
- Coexistence mechanisms and algorithms

Proposals on clauses that are not mentioned in the outline are also allowed. Tentative schedule for proposals of the four main clauses of the tentative outline is as follows:

*September 2010*: System description
*September 2010*: The 802.19.1 reference model
*September 2010-November 2010*: Procedures and protocols
*September 2010-November 2010*: Coexistence mechanisms and algorithms

## 5. <u>Terminology</u>

| Term | Definition |
|---|---|
| Acceptable Interference | An interference caused by an interference signal that does not degrade the current selection of modulation and coding at a victim receiver. |
| Aggregated Interference Power | The total power of interference observed at a particular location as received all interferers. |
| Algorithm | An effective method for solving a problem using a finite sequence of well defined instructions. |
| Architecture | A framework for the specification of a system's physical components and their functional organization and configuration, its operational principles and procedures, as well as data formats used in its operation. |
| Authentication | Authentication is a security measure to verify the identity of a subscriber. This verification is usually based on a username and password. In GSM the SIM is used to identify a subscriber for authentication.. |
| Authorization | Authorization is the process of granting or denying a subscriber access to a network or to certain services after the user has been authenticated. |
| Awareness | The capability of knowing the existence of a TVWS network/device. |
| Backhaul | In telecommunications, the intermediate communication link(s) between the end user and the core communications network. For example, for cellular transmissions, the backhaul is the link(s) between the cellular tower and the core communications system. |
| Carrier Sense Multiple Access | Carrier Sense Multiple Access is a media access control scheme in which a transmitter verifies the absence of other traffic before transmitting. CSMA is often combined with a mechanism to detect collisions if two stations happen to send data at the same time. If this mechanism is used, it is called CSMA/CD. |
| Channel Reselection | The process of selecting a new radio frequency channel for operation. |
| Channel Selection | The act of determining one or more channels to access for operation |
| Channel Sharing | The act of using a given physical channel by several entities or networks |
| Channel Switching | The act of leaving one channel and utilizing another channel to continue operation |
| Clear Channel Assessment | A logical function which determines the current state of use of a wireless medium. |
| Coexistence | The act of two or more TVBD networks/devices sharing resources without causing destructive interference to one another |
| Coexistence Enabler | A logical entity in 802.19.1 system usually implemented with in TVBD devices that interacts with other 802.19.1 logical entities in order to enable coexistence solutions |
| Coexistence Mechanism | a method of realizing coexistence among TV white space network/devices |
| Coexistence Metric | A measurable quantity that can be used to indicate how well two or more networks or devices are coexisting |
| Coexistence Service | Functions and solutions as well as methods provide to TV white space networks to achieve coexistence |
| Coexistence Service Provider | An entity which provides services enabling devices or networks better coexist. |
| Coverage Area | An area within which the received signal power is above a certain reception threshold and service is obtained |
| Device Configuration | The setting of operational parameters of a device or network |
| Device Reconfiguration | The act of setting new operational parameters for a device or network |
| Discovery | Determining the presence of TVBD network or device and identifying its attribute such as ID |

| | |
|---|---|
| Dynamic Frequency Selection | The ability of a system to switch to a different frequency (physical operating channel) based on channel measurements avoiding interference to regulatory protected devices. |
| Fairness | Principle of non discriminatory, uniform application of rules in allocating or dividing a competitive resource such as spectrum.  Simple fairness is based on equal division of resources among all users.  Rules for fairness may also consider specific user requirements (user load, QoS, priority, etc), aggregate spectral efficiency, etiquette (first come first served, etc.), and user or network policies. |
| Fixed | A type of devices that is not moved from location to location. |
| Frequency Division Multiple Access | Channel access method used in multiple-access protocols as a channelization protocol. It gives users an individual allocation of one or several frequency bands, or channels. |
| Geolocation | A geographic location on the earth specified in three spherical coordinates, latitude, longitude, and altitude.  Geolocation may include uncertainty or error metrics. |
| Harmful Interference | An interference caused by an interference signal that seriously degrades, obstructs, or repeatedly interrupts the radio communication at a victim receiver. |
| Independently Operated | Networks which are operated independent from one another regardless of their underlying air interface similarity  (we count find could definition at the moment) |
| Interference | The effect of unwanted energy due to one or a combination of emission(s), radiation(s), or induction(s) on reception in a radio communications system, manifested by any performance degradation, misinterpretation, or loss of information that could be extracted in the absence of such unwanted energy. |
| Interference Area | An area bounded by a contour where the received signal power is above a certain interference threshold |
| Interference Threshold | A power level of unwanted RF signal above which can cause service degradation |
| Internet Protocol | The Internet Protocol is used in interconnected systems of packet-switched computer communication networks, it provides for transmitting blocks of data called datagrams from sources to destinations, where sources and destinations are hosts identified by fixed length addresses; it also provides for fragmentation and reassembly of long datagrams, if necessary, for transmission through "small packet" networks. |
| Listen Before Talk | Listen Before Talk (LBT) is a technique used in radio communications whereby a radio transmitter first senses its radio environment before it starts a transmission. LBT can be used by a radio device to find a network the device is allowed to operate on or to find a free radio channel to operate on. Synonym:  Listen Before Transmit |
| Mobile | A type of device that uses network communication while in motion. |
| Policy | A set of coexistence rules or procedures which are (mandatory) followed by all entities in the IEEE 802.19.1 system |
| Portable | A type of device that may be moved from location to location, but that only uses network communications while at a fixed location. |
| Quality of Service | The Quality of Service (QoS) refers to the capability of a network to offer a service with a certain quality. The quality of a service can be related to a number of different parameters. Some commonly used parameters are: Availability of a link, Number of bit errors, Latency (delay in the network), Jitter.<br>The ITU has defined four different categories of services. Each with it's own quality of service associated to it: Conversational, Streaming, Interactive, Background. |
| Radio Technology Independent | Refers to the fact that the implementation is conditioned on the specific radio technology implemented by the platform. |
| Security | A condition that results from the establishment and maintenance of protective measures that ensures a state of inviolability from hostile acts or influences. |

| Sensing | The act of scanning the frequency spectrum in order to detect the presence of primary signals |
|---|---|
| Sensing area | An area within which sensing can be performed with a predetermined performance |
| Sensing Data | Data of which purpose is to facilitate the act of sensing |
| Spectrum Etiquette | Is a set of rules governing how spectrum resources should be shared between different parties in a beneficial manner |
| Time Division Multiple Access | Channel access method for shared medium networks. It allows several users to share the same frequency channel by dividing the signal into different time slots. |
| Transmit Power Control | Transmit Power Control (TPC) or sometimes called Dynamic Power Control (DPC) is a mechanism used in radio communications to reduce the power of a radio transmitter to the minimum necessary to maintain the link with a certain quality. TPC is used to avoid interference into other devices and/or to extend the battery life. |
| TV white space | Broadcast television spectrum which is locally unused by licensed services. |
| TV white space coexistence database | A repository that can collect and provide information necessary for coexistence decision making. |
| TV white space device | An unlicensed radio transmitter that operates in the broadcast television spectrum at locations where that spectrum is not being used by licensed services (this unused TV spectrum is often termed "white spaces") |
| TV white space network | A wireless network where the interconnections of nodes are established by radio communication in TV white space. |
| TV white space regulatory database or Geo-location Database | A database repository of any type (centralized or decentralized) containing various pieces of information needed to create conformance to the services rules and/or laws governing operation in the TV white space spectrum bands.  Note that said data can be used by any number of actors such as regulators, operators, manufacturers, and even spectrum users to effect the best and highest use of the spectrum according to laws governing its use. |