
IEEE P802.19
Wireless Coexistence Working Group

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Re:	
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Purpose	
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1 TV White Space Coexistence Methods

2 1 Overview

3 1.1 Scope

4 The standard specifies radio technology independent methods for coexistence among dissimilar or
5 independently operated TV Band Device (TVBD) networks and dissimilar TV Band Devices

6 1.2 Purpose

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

11 2 Normative references

12 The following referenced documents are indispensable for the application of this document. For dated
13 references, only the edition cited applies. For undated references, the latest edition of the referenced
14 document (including any amendments or corrigenda) applies.

15 **TBD**

16 3 Definitions, abbreviations, and acronyms

17 3.1 Definitions

18 For the purposes of this draft standard, the following terms and definitions apply. *The Authoritative*
19 *Dictionary of IEEE Standards, Seventh Edition*, should be referenced for terms not defined in this clause.

20 **TBD**

21 3.2 Abbreviations and acronyms

22 **TBD**

23

1 4 System description

2 4.1 Architecture

3 The Coexistence System architecture has three entities and five interfaces.

4

5 Three entities are:

6 — Coexistence Manager (CM)

7 — Coexistence Enabler (CE)

8 — Coexistence Discovery and Information Server (CDIS).

9

10 The CM is responsible for coexistence decision making to facilitate coexistence problems between TVBD
11 networks or devices. It generates and provides corresponding coexistence requests/commands and control
12 information to coexistence enablers. It discovers/communicates with other neighbor coexistence managers
13 to collaborate with them, to solve coexistence problems between multiple coexistence managers with
14 TVBD networks or devices they are engaged. It also assists network operators in management related to
15 TVWS coexistence. The coexistence manager shall be located inside or outside TVDB.

16

17 The CE enables the communication between coexistence manager and TVBD. It requests/obtains
18 information required for coexistence from TVBD. It also translates reconfiguration requests/commands and
19 control information received from the coexistence manager into TVBD-specific reconfiguration
20 requests/commands and sends them to the TVBD. The CE shall be located inside TVBD.

21

22 The CDIS supports discovery of other coexistence managers and opens interfaces between coexistence
23 managers to provide coexistence related information exchange among coexistence managers. It
24 collects/aggregates coexistence related information from multiple coexistence managers. It also
25 communicates with the TVWS database to obtain information on incumbents.

26

27 Five interfaces are:

28 — Interface A

29 — Interface B1

30 — Interface B2

31 — Interface B3

32 — Interface C.

33

34 The five interfaces are grouped by the following categories:

35 — Interfaces between the Coexistence System entities

36 — Interface B1

37 — Interface B2

38 — Interface B3

39 — Interfaces between the Coexistence System entity (CE) and TVBD

40 — Interface A

41 — Interfaces between the Coexistence System entities (CM or CDIS) and TVWS database

42 — Interface C

43

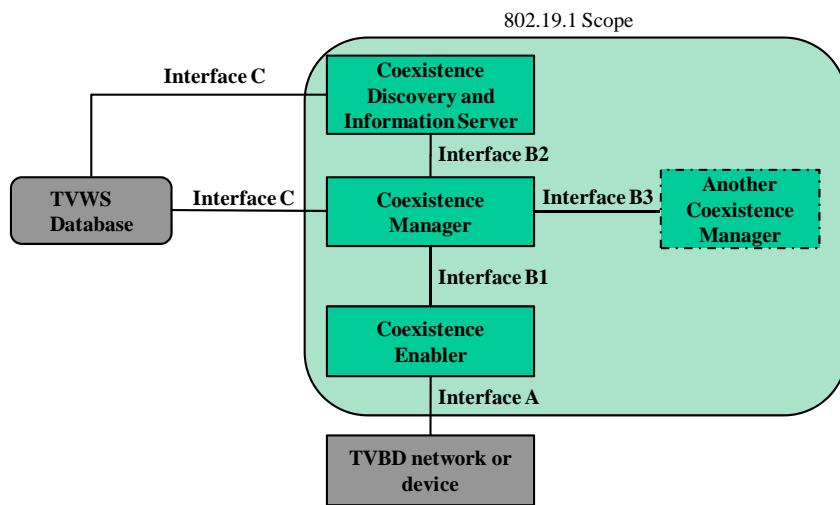
44 Different interfaces are distinguished by their usage, types of information exchanged, and underlying
45 protocols.

46

47 The Coexistence System interacts with two external elements:

- 1 — TVWS database
- 2 — TVBD network or device.
- 3
- 4 TVBD or TVBD network is the device or network, which operates with unlicensed basis in the TV bands at
- 5 locations where that TV bands are not being used by any incumbents, i.e., licensed services.
- 6
- 7 The TVWS database is the regulatory database which provides list of allowed channels for TVBD networks
- 8 or devices because they are occupied by incumbents.
- 9
- 10 TVWS database is out of scope of this standard.

11 Figure 1 shows Coexistence System architecture.



15
16 **Figure 1 Coexistence System architecture**

17

18 4.2 Entities

19 4.2.1 Coexistence manager

20 The Coexistence Manager serves as an entity that makes coexistence decisions related to TVBD network or

21 device reconfiguration.

22

23 The Coexistence Manager has the following main functions:

- 24 — Maintaining channel availability information
- 25 — Channel classification and selection
- 26 — Channel management
- 27 — Perform registration of TVBD networks and devices in the CDIS
- 28 — Exchange information required for coexistence with CEs, CDIS, and other CMs
- 29 — Request TVBD network or device to perform measurements required for coexistence
- 30 — Make coexistence decisions related to TVBD network or device reconfiguration
- 31 — Request reconfiguration of TVBD network or device according to the decisions

- 1 — Obtain information from TV WS database.
- 2 — Operation control decision
- 3 — Operating channels and corresponding maximum transmit power of TVBD
- 4 — Deenablement of TVBD
- 5 — Message exchange support
- 6 — Coexistence information and command to/from neighbour CM or CDIS
- 7

8 **4.2.1.1 Maintaining channel availability information**

9 The CM shall maintain the status of the TV channels available for TVBD operation according to the
10 policies and rules established by the regulation. The CM shall obtain information on the TV channel status
11 with respect to the presence of incumbents and other neighbor CMs in its location and it shall use this
12 information as input for its decisions for channel selection, channel management, coexistence decision
13 making, and etc.

14
15 To maintain the status of the channels availability, the CM shall be able to collect and fuse information
16 from the following sources:

- 17 — TVWS database
- 18 — CDIS
- 19 — Neighbor CMs
- 20 — Measurement report from CE
- 21

22 The channel availability information shall be defined during the initialization of CM and it shall be
23 periodically updated during the operation of CM.

25 **4.2.1.2 Channel classification and selection**

26 In order to start operation of TVBD networks or devices, CM shall select and assign a proper operating
27 channel for TVBD to mitigate coexistence problems among TVBDs. A proper operating channel shall be
28 selected from one of allowed channels. According to a regulation allowed and disallowed channels that
29 may be used by TVBD networks or devices at their location shall be given by TVWS database.

30
31 Status of given allowed channels will be dynamically changed based on incumbent activities, activities of
32 other TVBD networks or devices, relocation of TVBDs, etc. To facilitate coexistence between 802.19.1
33 compliant TVBD networks or devices, the CM shall know status of TV channels at a given location such
34 as:

- 35 — Which channel is available for TVBDs or networks
- 36 — Which channel is disallowed by regulation, or by the request of incumbents
- 37 — Which channel should be protected due to current incumbent activity
- 38 — Which channel should be restricted with limitations in order to use by TVBDs or networks
- 39 — Which channel is already being used by other TVBDs or networks
- 40 — Etc.
- 41

42 TV Channels for 802.19.1 logical entities are classified as the following 8 channels;

- 43 — Disallowed channels
- 44 — Allowed channels
- 45 — Available channels

- 1 — Protected channels
- 2 — Restricted channels
- 3 — Unclassified channels
- 4 — Operating channels
- 5 — Coexistent channels

6
7 The disallowed set is a set of channels disallowed for any TVBDs or networks by regulation, or by the
8 request of incumbents. It should be provided by TVWS database and will be updated if necessary. For
9 example, in the U.S. TV channel 3, 4, and 37 are disallowed by regulation. Also a TV channel registered at
10 TVWS database by a licensed wireless microphone is disallowed for any TVBDs or TVBD networks.

11
12 The allowed set is a set of channels allowed for TVBDs or networks. It should be provided by TVWS
13 database and will be updated if necessary. All TVBDs or TVBD networks should first obtain a list of the
14 allowed channels before their operating over TV channels.

15
16 The available set is a set of free channels available for TVBDs or TVBD networks.

17
18 The restricted set is a set of channels restricted to use with limitations due to regulation. It can be used by
19 TVBDs or TVBD networks under limited conditions predefined by regulation. For example, in the U.S. a
20 portable/personal TVBD can use “the first adjacent channel of the incumbent activating channel” with
21 limited transmit power ($\leq 40\text{mW}$ EIRP) by FCC regulation. Also in the U.S. channel 36 and 38 need more
22 stringent emission mask to protect incumbents in channel 37 by FCC regulation.

23
24 The protected set is a set of channels to be protected due to incumbent activity. It cannot be used by any
25 TVBDs or TVBD networks.

26
27 The unclassified set is a set of channels has not been classified as one of listed above three sets.

28
29 The operating set is a set of operating channels being used by one TVBD or TVBD network. It can be
30 selected from available set or restricted set. If each TVBD or TVBD network has its own operating channel,
31 spectrum etiquette with FDM (frequency division multiplexing) is achievable.

32
33 The coexistent set is a set of channels being shared by two or more TVBD networks. If two or more
34 TVBDs or TVBD networks compete for the same channel, spectrum etiquette with FDM is not achievable.

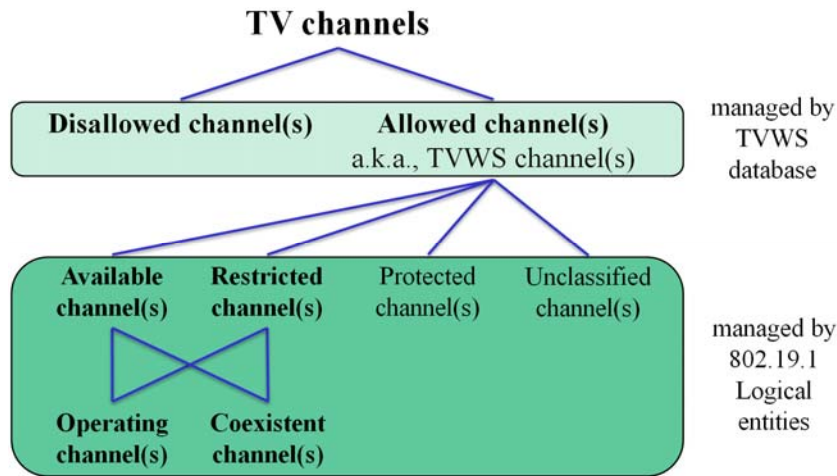
35
36 Operating channels or coexistent channels shall be selected only from available channels or restricted
37 channels.

38
39 Figure 2 shows hierarchical structure of TV channels. Allowed channels informed from TVWS database
40 are further classified into the following categories:

- 41 — Available channels
- 42 — Restricted channels
- 43 — Protected channels
- 44 — Unclassified channels

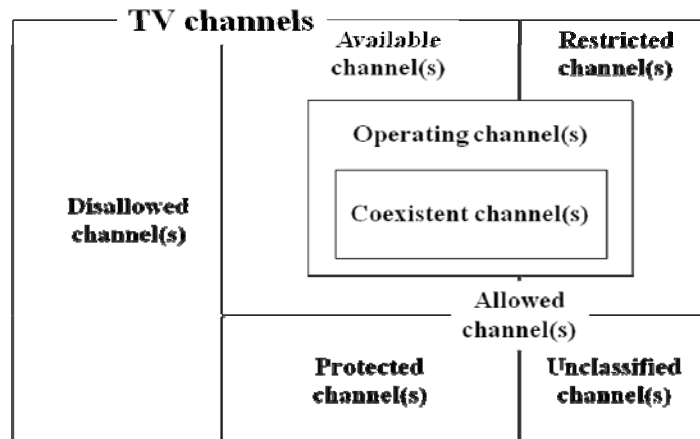
45
46 Figure 3 shows Venn diagram of TV channels to demonstrate relationship among TV channels. The
47 disallowed set is a subset of a TV channel set. It is also a complementary set of the allowed set. The
48 allowed set is a subset of a TV channel set. It is also a complementary set of the disallowed set. The
49 Available/Restricted/Protected/Unclassified set is a subset of the allowed set. Two different channel sets
50 are a complementary set each other. The operating set is a subset of the available set or the restricted set or
51 union of both. It is also a subset of a complementary set of the coexistent set. The coexistent set is a subset
52 of the operating set.

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5
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Figure 2 Hierarchy of TV Channels



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8
9

Figure 3 Venn diagram of TV channels

10 **4.2.1.3 Channel set transition diagram**

11 The transition diagram consists of 6 states and 11 events. The 6 states are defined in Section 4.2.2.2. The
 12 disallowed and allowed channels are omitted in this transition diagram because those channels are
 13 classified by TVWS database and the sum of available, restricted, protected, unclassified, operating, and
 14 coexistent channels is equal to the allowed channels. Possible events for each state transition are defined as
 15 follows:

- 16 — Event 1: If the channel already being used by one TVWS system is assigned to other TVWS system(s)
 17 so that two or more TVWS systems use the same channel as an operating channel
- 18 — Event 2: If the channel is released by other TVWS systems so that the channel is being used by only
 19 one TVWS system
- 20 — Event 3: If the channel is released and not be used by any TVWS systems due to the completion of its
 21 usage

- 1 — Event 4: If the channel is assigned to one TVWS system and not shared by any other TVWS systems
- 2 — Event 5: If the channel is assigned to two or more TVWS systems at the same time
- 3 — Event 6: If an incumbent activity has been informed on the channel
- 4 — Event 7: If the channel temporarily satisfies the condition that requires its usage with limitations due to regulation, e.g., in the U.S. if an incumbent activity has been informed on the channel (F), the first adjacent channel ($F\pm 1$) can be used by only a portable/personal TVBD with limited transmit power, say 100mW EIRP
- 5
- 6
- 7
- 8 — Event 8: If the channel is released by an incumbent due to the completion of its usage
- 9 — Event 9: If the channel is exempted from its temporary restriction and free to use without limitation, e.g., in the U.S. if the channel is released by the incumbent on the channel (F) due to the completion of its usage, the first adjacent channel ($F\pm 1$) can be used by any TVBDs and networks
- 10
- 11
- 12 — Event 10: If the channel is not occupied by an incumbent or any TVWS systems
- 13 — Event 11: If the channel is not classified or updated within the predefined time expiration
- 14
- 15
- 16

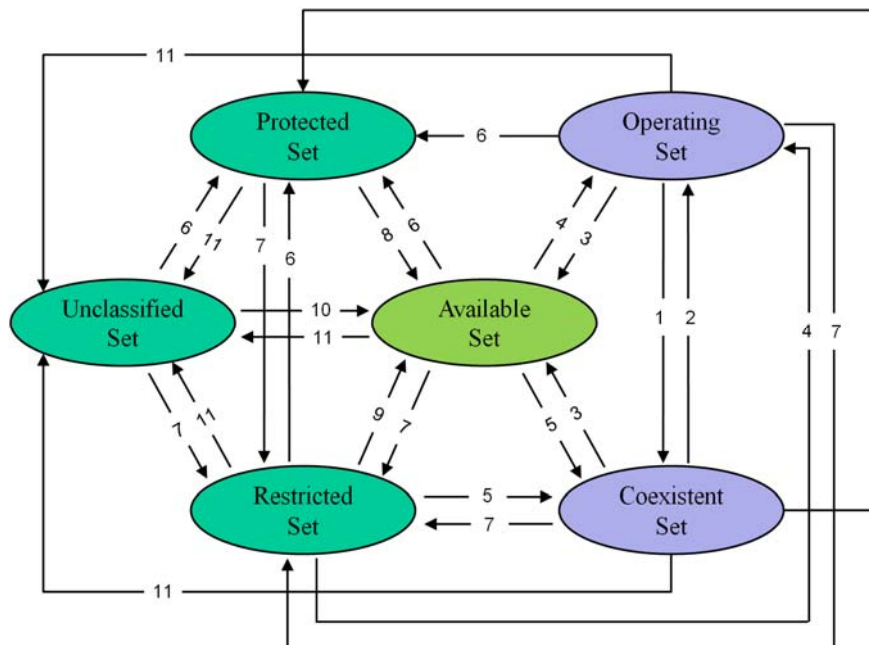


Figure 4 Channel set transition diagram

The channel set transition matrix is defined as depicted in Table 1. Each row specifies the state transition due to each event. Each column specifies state transition due to the events in each row for a particular current state. A blank cell within the transition matrix implies that either the specific event cannot or should not occur within that state. And if the event does occur, the CM shall ignore it. For example, the protected channel cannot directly transit to operating channel. Therefore, there is no operating channel in the first column (i.e., operating column).

Table 1 Channel set transition matrix

State Event	Operating	Coexistent	Available	Protected	Restricted	Unclassified
Event 1	Coexistent					
Event 2		Operating				
Event 3	Available	Available				
Event 4			Operating		Operating	
Event 5			Coexistent		Coexistent	
Event 6	Protected	Protected	Protected		Protected	Protected
Event 7	Restricted	Restricted	Restricted	Restricted		Restricted
Event 8				Available		
Event 9					Available	
Event 10						Available
Event 11	Unclassified	Unclassified	Unclassified	Unclassified	Unclassified	

4.2.2 Coexistence enabler

The Coexistence Enabler serves as an interface entity between TVBD network or device and the Coexistence System.

The Coexistence Enabler has the following main functions:

- Perform registration of TVBD network or device in the Coexistence System
- Maintaining channel availability information
- Channel classification
- Exchange information required for coexistence between TVBD network or device and the Coexistence System
- Request TVBD network or device to perform measurements required for coexistence according to commands received from CM and provide measurement results to CM
- Request TVBD network or device to perform reconfiguration required for coexistence according to commands received from CM.
- Translation of coexistence information or coexistence command message from CM
- Translation of measurement results or coexistence information from TVBD network or device into coexistence message

The registration information of TVBD network or device includes the following:

- Subscribed coexistence service
- Basic information about TVBD network or device
 - Network ID
 - Network type
 - Operating channels
 - Coverage area related information
 - Interference area related information.

1 4.2.3 Coexistence discovery and information server

2 The Coexistence Discovery and Information Server serves as an entity that makes coexistence decisions
3 related to neighbour discovery. Differnet CDISs should be synchronized with each other.

4
5 The Coexistence Discovery and Information Server has the following main functions:

- 6 — Store registration information of TVBD networks and device
- 7 — Maintaining channel availability information
- 8 — Channel classification
- 9 — Exchange information required for coexistence with CMs
- 10 — Make coexistence decisions related to neighbour discovery
- 11 — Obtain information from TV WS database.
- 12 — Neighbor discovery support
 - 13 — Computes coexistence contour
 - 14 — Master CM selection
 - 15 — Operation control decision
 - 16 — Operating channels and associated maximum transmit power of CM or TVBD
 - 17 — Deenablement of TVBD

18 4.3 Interfaces

19 Five interfaces are defined in the Coexistence System:

- 20 — Internal interfaces:
 - 21 — Interface B1 between CE and CM
 - 22 — Interface B2 between CM and CDIS
 - 23 — Interface B3 between different CMs
- 24 — External interfaces:
 - 25 — Interface A between CE and TVBD network or device
 - 26 — Interface C between CM or CDIS and TV WS database.

27

28 Each internal interface is defined by states of each entity, types of exchanged message. The state of each
29 interface consists of 4 or more of the following states:

- 30 — Inactive: the state where it is impossible to set up any interfaces with other entities. The inactive state
31 goes to the active state when initialization process is finished.
- 32 — Active: the state where it is possible to set up interface with other entities. The Active state goes to the
33 inactive state when shutdown process is finished.
- 34 — Waiting engagement: the state where one entity has requested for interface setup to the other entity,
35 and is waiting for response from it.
- 36 — Engaged: the state where two entities are ready to communicate with each other.
- 37 — Request sent: the state where the request related to “context information (CI)” or “event (EV)” or
38 “reconfiguration (RC)” has been sent from home entity to remote entity, and the home entity is
39 waiting for response from the remote entity.
- 40 — Request received: the state where the request related to “context information (CI)” or “event
41 (EV)” or “reconfiguration (RC)” has been received from remote entity to home entity, and home
42 entity is waiting for the completion of the request.

43

1 4.3.1 Interface A

2 Interface A between CE and TVBD network or device can be used to transmit the following:

- 3 — From TVBD network or device to CE:
 - 4 — Registration information
 - 5 — Information required for coexistence
 - 6 — Measurement results
 - 7 — Reconfiguration results
 - 8 — Available channel list obtained from TVWS database access
 - 9 — Results of measurement performed by TVBD network or device
 - 10 — Event results
- 11 — From CE to TVBD network or device:
 - 12 — Information required for coexistence
 - 13 — Measurement requests
 - 14 — Reconfiguration requests.
 - 15 — Command or information received from CM
 - 16 — Event requests

17 4.3.2 Interface B1

18 States of CM consist of the followings:

- 19 — Inactive
- 20 — Active
- 21 — Engaged
- 22 — Request sent

24 States of CE consist of the followings:

- 25 — Inactive
- 26 — Active
- 27 — Engaged
- 28 — Waiting engagement
- 29 — Request received

31 Interface B1 between CE and CM can be used to transmit the following:

- 32 — From CE to CM:
 - 33 — Registration information
 - 34 — Information required for coexistence
 - 35 — Measurement results
 - 36 — Reconfiguration results
 - 37 — Registration information
 - 38 — Available channel list obtained from TVBD network or device
 - 39 — Results of measurement obtained from TVBD network or device
 - 40 — Event results
- 41 — From CM to CE:

- 1 — Information required for coexistence
- 2 — Measurement requests
- 3 — Reconfiguration requests.
- 4 — Operation information such as operating channels and associated transmit power limit
- 5 — Operation command such as deenablement
- 6 — Event requests

7 **4.3.3 Interface B2**

8 States of CM consist of the followings:

- 9 — Inactive
- 10 — Active
- 11 — Waiting engagement
- 12 — Engaged
- 13 — Request sent
- 14 — Request received

15

16 States of CDIS consist of the followings:

- 17 — Inactive
- 18 — Active
- 19 — Engaged
- 20 — Request sent
- 21 — Request received

22

23 Interface B2 between CM and CDIS can be used to transmit the following:

- 24 — From CM to CDIS:
 - 25 — Registration information
 - 26 — Information requests
 - 27 — Registraion information
 - 28 — Available channel list obtained from TVBD network or device
 - 29 — Event requests or results
- 30 — From CDIS to CM:
 - 31 — Information required for coexistence.
 - 32 — Neighbour information such as a list of neighbour CM and neighbour TVBD network or device
 - 33 — Master CM indication
 - 34 — Operation information such as operating channels and associated transmit power limit
 - 35 — Operation command such as deenablement
 - 36 — Event requests or results

37 **4.3.4 Interface B3**

38 **4.3.4.1 Centralized topology**

39 In centralized topology, there is one master CM which has a number of slave CMs. The master CM
40 performs coexistence decision making and slave CMs follows it.

1 States of master CM consist of the followings:

- 2 — Inactive
- 3 — Active
- 4 — Engaged
- 5 — Request sent
- 6 — Request received

7

8 States of slave CM consist of the followings:

- 9 — Inactive
- 10 — Active
- 11 — Waiting engagement
- 12 — Engaged
- 13 — Request sent
- 14 — Request received

15

16 Interface B3 between different CMs can be used to transmit the following:

- 17 — Information required for coexistence.
- 18 — Event requests or results
- 19 — Information or command from master CM to slave CM
 - 20 — Operation information such as operating channels and associated transmit power limit
 - 21 — Operation command such as deenablement
- 22 — Information from slave CM to master CM
 - 23 — Results of measurement obtained from associated CE
 - 24 — Registration information of associated CE
- 25 — Information between CM
 - 26 — Neighbour information such as registration information of TVBD network or device or the results
 - 27 of measurement performed by TVBD network or device that the CM serves
- 28 — Negotiation between CM
 - 29 — Negotiation messages for operation control
 - 30 — Negotiation messages for master CM selection

31

32 **4.3.4.2 Distributed topology**

33 In distributed topology, any two CMs could be connected each other as a neighbor. Each CM performs
34 coexistence decision making by negotiation with its neighbor CMs.

35

36 States of CM consist of the followings:

- 37 — Inactive
- 38 — Active
- 39 — Waiting engagement
- 40 — Engaged
- 41 — Request sent
- 42 — Request received

43

- 1 Interface B3 between different CMs can be used to transmit the following:
2 — Information required for coexistence.
3 — Event requests or results
4

5 **4.3.5 Interface C**

- 6 Interface C between CM and TVWS database or between CDIS and TVWS database can be used to
7 transmit the following:
8 — From TVWS database to CM/CDIS:
9 — Information required for coexistence.
10 — Available channel list of CM or TVBD network or device
11 — From CM/CDIS to TVWS database:
12 — A. Registration information of CM or associated CE

13 **4.4 Coexistence scenarios**

14 Coexistence problems between TVBD networks or devices might occur due to the disparity between the
15 number of allocable TV channels and the number of required TV channels for TVBD networks or devices
16 over a given area.

17
18 One TVBD network might use one or more TV channels based on the demand of each TVBD network,
19 e.g., 10MHz channel bandwidth can be supported by two 6MHz TV channels in U.S.A.

20
21 The following two coexistence scenarios are possible as depicted in Figure 5:

- 22 — Individual TV channel use
23 — Shared TV channel use
24 ■ By TVBD networks of the same type
25 ■ By TVBD networks of the dissimilar type
26

27 In the individual TV channel use scenario, TV channels are dynamically assigned to each TVBD network
28 which use different TV channels. So it is possible that non-overlapped TV channels are allocated to TVBD
29 networks. This guarantee co-channel-interference-free TV channel use and coexistence problem can be
30 eliminated through a proper TV channel allocation.

31
32 In shared TV channel use scenario, two or more TVBD networks share the same TV channel. There could
33 be a number of TV channels that are being shared. If a TV channel is shared by the TVBD networks of the
34 same type, self-coexistence mechanisms might be needed to mitigate co-channel interference. If a TV
35 channel is shared by TVBD networks of the dissimilar type, inter-system coexistence mechanisms might be
36 needed to mitigate co-channel interference.
37

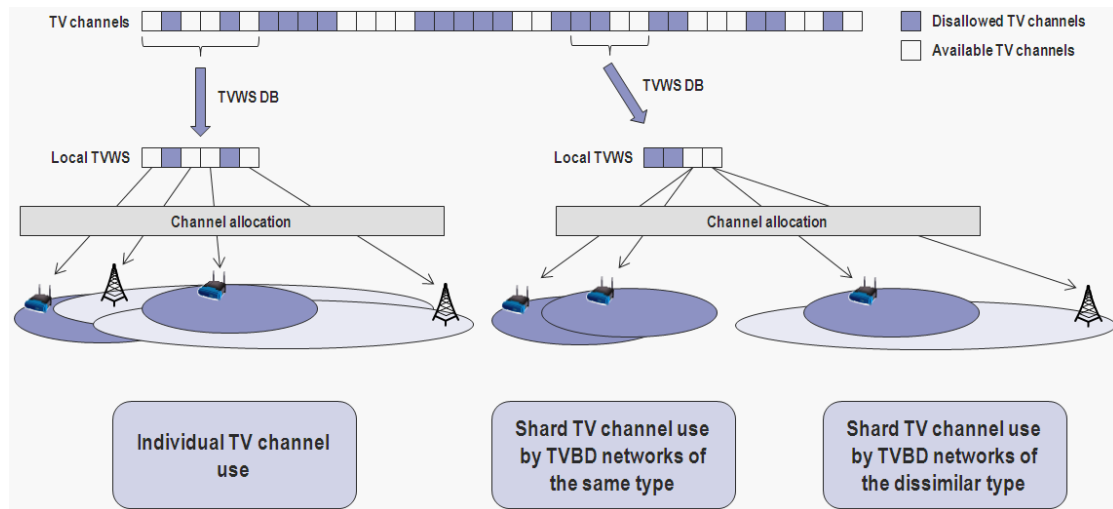


Figure 5 Coexistence Scenario

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2
3

4.5 Coexistence services

Coexistence services are services provided by the Coexistence System to dissimilar or independently operated TVBD network or device. The Coexistence System provides coexistence services to TVBD network or device via interface A.

To obtain coexistence services, TVBD network or device needs to register to the Coexistence System. During the registration, TVBD network or device needs to establish connection with the Coexistence System, authenticate itself and the Coexistence System, and provide registration information about itself to the Coexistence System.

The registration information of TVBD network or device includes the following:

- Subscribed coexistence service
- Basic information about TVBD network or device
 - Network ID
 - Network type
 - Operating channels
 - Coverage area related information
 - Interference area related information.

After the registration, TVBD network or device can get one of the following coexistence services:

- Coexistence information service
- Coexistence management service.

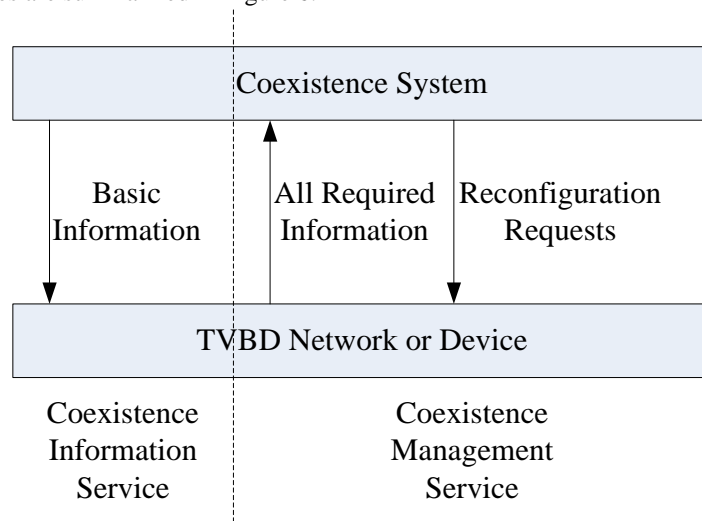
TVBD network or device can be subscribed to only one service at a time.

Within the coexistence information service, TVBD network or device gets minimum information required for making coexistence decisions themselves. The minimum information includes the following information:

- Neighbour list
- Their types

31
32

1 — Their operating channels.
2
3 Within the coexistence management service, TVBD network or device gets reconfiguration requests
4 generated by the Coexistence System. TVBD network or device will need to provide information to the
5 Coexistence System while using this service. This information will be used by the Coexistence System to
6 make coexistence decisions.
7
8 Coexistence services are summarized in Figure 6.



9
10 **Figure 6 Summary of coexistence services**
11
12