

IEEE Standard for Information technology— Telecommunications and information exchange between systems— Local and metropolitan area networks— Specific requirements— Part 19: Wireless Network Coexistence Methods

IEEE Computer Society

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LAN/MAN Standards Committee

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IEEE Std 802.19.1™-2018
(Revision of
IEEE Std 802.19.1-2014)

**IEEE Standard for
Information technology—
Telecommunications and information
exchange between systems—
Local and metropolitan area networks—
Specific requirements—
Part 19: Wireless Network Coexistence Methods**

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Approved 27 September 2018

IEEE-SA Standards Board

Abstract: Radio-technology-independent methods for network-based coexistence among dissimilar or independently operated networks of unlicensed devices and dissimilar unlicensed devices are specified in this standard. The standard is written for geolocation-capable devices operating under general authorization such as television white spaces (TVWS), the 5 GHz license-exempt bands, and the general authorized access in the 3.5 GHz bands.

Keywords: 5 GHz license-exempt bands, coexistence service, database, general authorized access in 3.5 GHz bands, geolocation, IEEE 802®, IEEE 802.19™, IEEE 802.19.1™, network-based coexistence, radio coexistence, spectrum management, television white spaces

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Introduction

This introduction is not part of IEEE Std 802.19.1-2018, IEEE Standard for Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements—Part 19: Wireless Network Coexistence Methods.

This standard is a revision of IEEE Std 802.19.1-2014 and incorporates the amendment published in 2017 (IEEE Std 802.19.1a™-2017 [B3]).¹ The standard specifies radio-technology-independent methods for network-based coexistence among dissimilar or independently operated networks of unlicensed devices and dissimilar unlicensed devices. The standard is written for geolocation-capable devices operating under general authorization such as television white spaces (TVWS), the 5 GHz license-exempt bands, and the general authorized access in the 3.5 GHz bands. The standard addresses coexistence for IEEE 802® networks and devices and will also be useful for non-IEEE 802 networks and television band devices (TVBDs).

¹ Numbers in brackets correspond to the numbers in the bibliography in Annex H.

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IEEE Standard for Information technology— Telecommunications and information exchange between systems— Local and metropolitan area networks— Specific requirements— Part 19: Wireless Network Coexistence Methods

1. Overview

1.1 Scope

This standard specifies radio technology independent methods for network-based coexistence among dissimilar or independently operated networks of unlicensed devices and dissimilar unlicensed devices. The standard is defined for geolocation-capable devices operating under general authorization such as television white spaces (TVWS), the 5 GHz license-exempt bands, and the general authorized access in the 3.5 GHz bands.

1.2 Purpose

The purpose of the standard is to enable the family of IEEE 802® wireless standards to most effectively use, under general authorization, frequency bands such as TVWS, the 5 GHz license-exempt frequency bands, and the general authorized access in the 3.5 GHz frequency bands by providing standard network-based coexistence methods among dissimilar or independently operated unlicensed devices and dissimilar unlicensed devices with geolocation capability. This standard addresses coexistence for IEEE 802 networks and devices and will also be useful for non-IEEE 802 networks and devices.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used; therefore, each referenced document is cited in text, and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

47 CFR Part 96, Citizens Broadband Radio Service.¹

ECC Report 186, Technical and Operational Requirements for White Space Devices under Geo-location Approach, Jan. 2013.²

ETSI EN 301 598, V2.1.1 (2018-01), White Space Devices (WSD); Wireless Access Systems operating in the 470 MHz to 790 MHz TV broadcast band; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU.³

ISO/IEC 8824-1:1995, Information technology—Abstract Syntax Notation One (ASN.1): Specification of basic notation.⁴

ISO/IEC 8824-2:1995, Information technology—Abstract Syntax Notation One (ASN.1): Information object specification.

ISO/IEC 8824-3:1995, Information technology—Abstract Syntax Notation One (ASN.1): Constraint specification.

ISO/IEC 8824-4:1995, Information technology—Abstract Syntax Notation One (ASN.1): Parameterization of ASN.1 specifications.

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.⁵

autonomous decision making: A decision-making topology where one coexistence manager (CM) makes its decisions independently from another CM.

basic procedures: Authentication, subscription, and registration procedures.

centralized decision making: A decision-making topology where one coexistence manager (CM) relegates its decisions to another CM.

¹ The online version of Title 47 of the Code of Federal Regulations (CFR) Part 96 is available at http://www.ecfr.gov/cgi-bin/text-idx?c=ecfr&tpl=/ecfrbrowse/Title47/47cfrv5_02.tpl.

² This report is available from the Electronic Communications Committee at <https://www.ecodoedb.dk/download/124023a2-73ee/ECCREP186.PDF>.

³ ETSI publications are available at <https://www.etsi.org/standards>.

⁴ ISO/IEC documents are available from the International Organization for Standardization (<https://www.iso.org/>). ISO/IEC publications are also available in the United States from Global Engineering Documents (<https://global.ihs.com/>). Electronic copies are available in the United States from the American National Standards Institute (<https://www.ansi.org/>).

⁵ *IEEE Standards Dictionary Online* is available at <http://dictionary.ieee.org>.

coexistence: The ability of two or more spectrum-dependent devices or networks to operate without harmful interference to each other under the same frequency authorization in the same frequency band.

coexistence discovery: The procedure executed inside the coexistence system to determine a coexistence set for a coexistence enabler (CE) and its white space/geolocation-capable objects (WSOs/GCOs).

coexistence discovery and information server (CDIS): An entity that is responsible for determining for coexistence managers (CMs) the white space/geolocation-capable objects (WSOs/GCOs) that may affect performance of the WSOs/GCOs that the CMs serve.

coexistence enabler (CE): An entity that represents a white space object (WSO) in the coexistence system and serves one WSO at a time.

coexistence manager (CM): An entity that is responsible for making coexistence decisions related to reconfiguration of white space/geolocation-capable objects (WSOs/GCOs) to solve coexistence problems among them.

coexistence services: Services provided by the coexistence system to dissimilar or independently operated white space/geolocation-capable objects (WSOs/GCOs) as well as services provided by the entities of the coexistence system to other entities of the coexistence system.

coexistence set: A set of white space/geolocation-capable objects (WSOs/GCOs) associated to a WSO/GCO containing the WSOs/GCOs that may affect performance of the WSO/GCO.

coexistence set element: One white space/geolocation-capable object (WSO/GCO) of a coexistence set.

coexistence system: A set of one or more coexistence enablers (CEs), coexistence managers (CMs), coordination enablers (COEs), and a coexistence discovery and information server (CDIS).

coordination enabler (COE): An entity that can communicate with the coexistence manager (CM) within the same coexistence system and with the COE within the other coexistence system.

distributed decision making: A decision-making topology where one coexistence manager (CM) makes its decisions in coordination with another CM.

general authorization: Frequency authorization entitling a device to use the spectrum with no individual frequency planning/coordination (in other words, not entitling the device to interference protection from the others).

geolocation capability: The ability of a device to identify its geographical coordinate with certain accuracy.

geolocation-capable object (GCO): An entity that represents a device or network of devices operating under general authorization with geolocation capability.

interference: The effect of unwanted energy due to one or a combination of emissions, radiations, or inductions upon reception in a radiocommunication system, manifested by any performance degradation, misinterpretation, or loss of information that could be extracted in the absence of such unwanted energy.

neighbor coexistence managers: At least two coexistence managers (CMs) that serve white space/geolocation-capable objects (WSOs/GCOs) that may affect performance of each other.

profile: A statement of the mandatory and optional procedures, messages, and parameters for the implementation of a compliant coexistence system entity.

registered location secure server (RLSS): An entity that accesses and manages a database that organizes storage of information by geolocation and securely holds the location and some operating parameters of one or more basic service sets. *Source:* adapted from IEEE Std 802.11af™ [B2].⁶

sensing: To measure the radio signal emitted by incumbent system.

spectrum management database (SMDB): A database system approved by the relevant national regulatory authority that can communicate with geolocation-capable objects (GCOs) and provide information on spectrum availability taking into account any operational changes from the protected incumbents. SMDB includes television white space database (TVWSDB), geolocation database, spectrum access system database, and similar kinds of database systems.

white space object (WSO): An entity that represents a television white spaces (TVWS) device or network of TVWS devices. The entity is connected to a coexistence enabler (CE) to consume coexistence services.

3.2 Acronyms and abbreviations

ACIR	adjacent channel interference ratio
CDIS	coexistence discovery and information server
CE	coexistence enabler
CM	coexistence manager
COE	coordination enabler
COEX_MEDIA_SAP	coexistence media service access point
COEX_TR_SAP	coexistence transport service access point
CV	coexistence value
EIRP	equivalent isotropically radiated power
FBMC	filter bank multicarrier
FER	frame error rate/frame error ratio
GCO	geolocation-capable object
IP	Internet Protocol
IPNF	interference plus noise floor
NAV	network allocation vector
OBSS	overlapping basic service set
QoS	quality of service
RAT	radio access technology
RLSS	registered location secure server
SAP	service access point
SIC	successive interference cancellation
SINR	signal-to-interference-plus-noise ratio
SMDB	spectrum management database
TCP	Transmission Control Protocol
TVBD	television band device

⁶ Numbers in brackets correspond to the numbers in the bibliography in Annex H.

TVWS	television white spaces
TVWSDB	television white space database
WSO	white space object

4. System description

4.1 System architecture

A coexistence system defined in this standard has four logical entities (CE, COE, CM, and CDIS) and seven logical interfaces (Interfaces A, B1, B2, B3, B4, B5, and C). Two independent coexistence systems use one logical interface for information exchange, as shown in Figure 1. Each logical entity is defined by its functional roles and interfaces with other logical entities. System architecture is used to describe functional components of the coexistence system. The architectural descriptions are not intended to represent any specific physical implementation of the coexistence system.

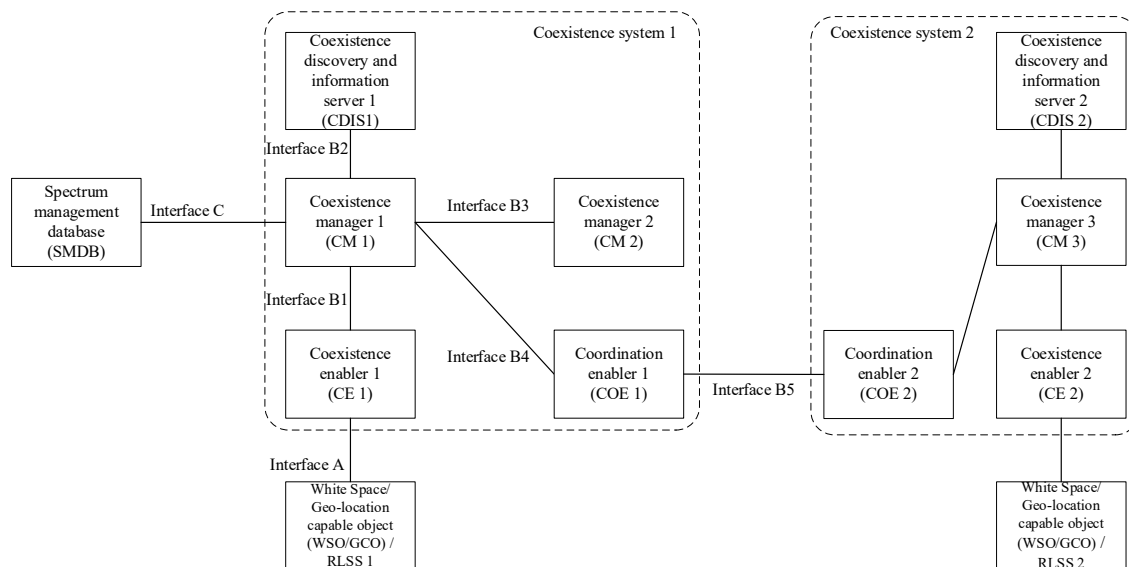


Figure 1—System architecture

The coexistence discovery and information server (CDIS) provides coexistence discovery service to the coexistence managers (CMs) it serves. Within this service the CDIS informs the CMs about potential neighbors of the white space/geolocation-capable objects (WSOs/GCOs) served by these CMs. WSO is under an umbrella of GCO. Also, the CDIS supports the discovery of CMs by other CMs in order to open interfaces between them. In order to provide the coexistence discovery service, the CDIS obtains all necessary information and performs coexistence discovery. There can be more than one CM in one coexistence system.

The CM provides either information or management service to the WSOs/GCOs it serves. Communication between the CM and the WSOs/GCOs is performed via their coexistence enablers (CEs). Within the information service the CM provides the WSO/GCO information about its potential neighbors including their operating frequencies, potential interference levels, etc. Within the management service the CM provides the WSO/GCO reconfiguration requests that create such configuration of this WSO/GCO that its

operation is improved according to some criteria. In order to provide these information and management coexistence services, the CM obtains all necessary information and makes coexistence decisions.

The CE is an interface element that represents one or several WSOs/GCOs of the same type in the coexistence system.

The coordination enabler (COE) is an interface element that represents one or more CMs to communicate with the other COE in another independent coexistence system.

Interface A between a CE and its WSO/GCO is defined in a generic format.

Interface B1 is between a CE and a CM. Interface B2 is between a CM and a CDIS. Interface B3 is between two CMs. Interface B4 is between a CM and a COE within the same coexistence system. Interface B5 is between two COEs in independent coexistence systems.

Interface C between a CM and a spectrum management database (SMDB) is not specified in this standard and is implementation dependent. Thus, the interface C is optional and is not utilized in the frequency band in which SMDB is not required. One of the implementation examples of interface C is the protocol to access white space (PAWS) database specification for TVWS operation (IETF RFC 7545 [B5]).

4.2 Reference model

The coexistence system reference model has two service access points: the coexistence transport service access point (SAP) (COEX_TR_SAP) and the coexistence media SAP (COEX_MEDIA_SAP).

The COEX_TR_SAP provides means for a CE, a CM, a COE, and a CDIS to communicate with each other and with external entities by using transport services provided by underlying layers.

Example reference model of a CE and a CM describing example of using COEX_TR_SAP for interface B1 is shown Figure 2. Information required for coexistence and reconfiguration commands that are exchanged between a CE and a CM over the interface B1 are forwarded to transport layer (Transmission Control Protocol (TCP)) for transmission. This is done using the COEX_TR_SAP of the CE and the CM.

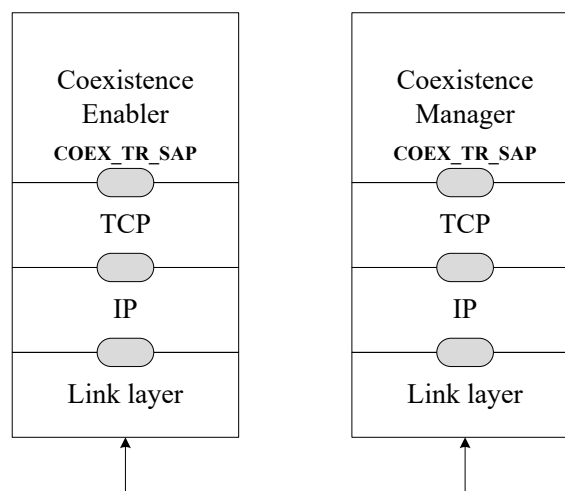


Figure 2—Example of using the COEX_TR_SAP for interface B1

The COEX_MEDIA_SAP defines the interface A between a CE and a WSO/GCO.

An example reference model of a CE describing an example implementation of the interface A inside a base station is shown in Figure 3.

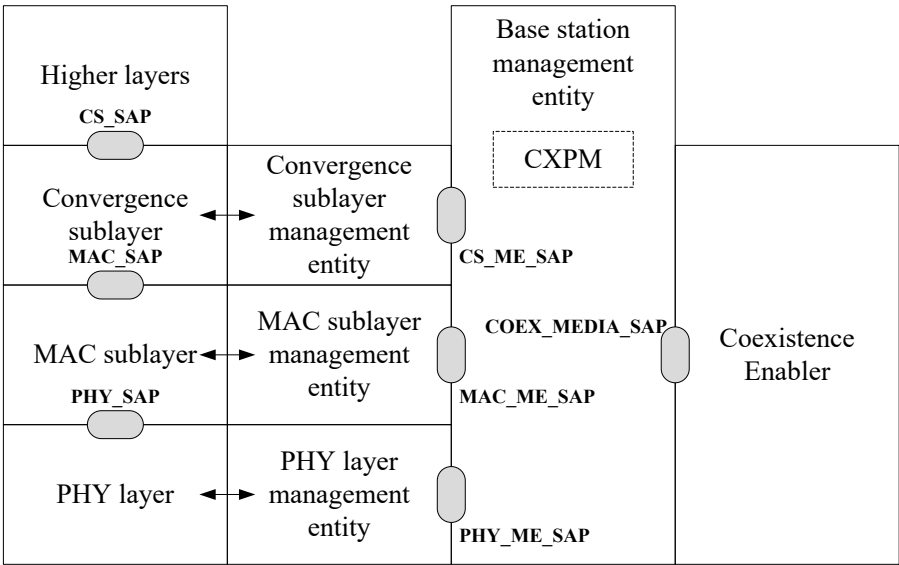


Figure 3—Example reference model for the interface A

Typically, the radio interface is implemented in such a way that it provides a management interface for the WSO/GCO management entity. In Figure 3, such interface is represented by the PHY_ME_SAP, MAC_ME_SAP, and CS_ME_SAP, corresponding to the physical layer, the Media Access Control (MAC) sublayer, and the convergence sublayer. These SAPs can be used to obtain information from the radio interface and to request reconfiguration of the radio interface. Correspondingly, the CE can use these SAPs to implement the interface A using the COEX_MEDIA_SAP. Communication between the radio interface management service access points PHY_ME_SAP, MAC_ME_SAP, and CS_ME_SAP and the COEX_MEDIA_SAP is done via the WSO/GCO management entity. The WSO/GCO management entity provides the coexistence primitive mapping (CXPM) service. The CXPM converts COEX_MEDIA_SAP primitives into WSO/GCO-specific management/control primitives. A one-to-one mapping is highly desirable to fully support this standard, but feasibility of such an implementation depends on the standard the WSO/GCO complies to and the WSO/GCO implementation. The CXPM implementation is out of scope of this standard.

Different logical entities of the coexistence system have different reference models. Figure 4 shows the CE reference model. Figure 5 shows the reference model for the CM and CDIS.

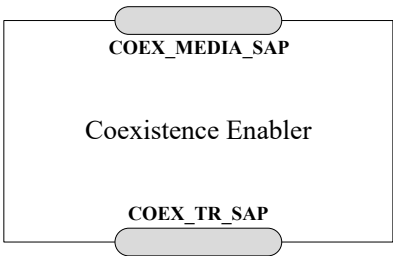


Figure 4—CE reference model

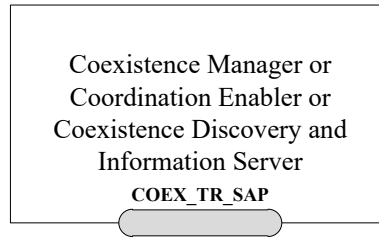


Figure 5—CM, COE, and CDIS reference model

4.3 System profiles and interoperability

The coexistence system defined in this standard has four logical entities: CDIS, CM, COE, and CE. This standard defines several profiles determining operation of these entities.

The profiles are defined as follows: The standard defines common set of the data types, primitives, messages, and procedures. Each of the profiles uses only a specific part of the defined data types, primitives, messages, and procedures as defined in Clause 6.

However, profiles are designed in such way that required level of interoperability is verified among entities operating according to different profiles. The defined profiles follow the following principles:

- Any CDIS shall be able to provide coexistence discovery service to any type of CM.
- Any CM shall be able to exchange information with any other type of CM.
- Any CM shall support at least one of the profiles specified in this specification.
- Any CM shall support both management service and information service.
- Any COE shall support at least one of the profiles specified in this specification.
- Any CE shall support at least one of the profiles specified in this specification.
- Any CE shall support at least management service or information service and may support both.

4.4 Coexistence services

4.4.1 Introduction

Coexistence services are services provided by the coexistence system to WSOs/GCOs as well as services provided by the CDIS to the CMs. Correspondingly, the categories of the coexistence services are services provided to WSOs/GCOs and services provided to CMs.

The coexistence services are illustrated in Figure 6.

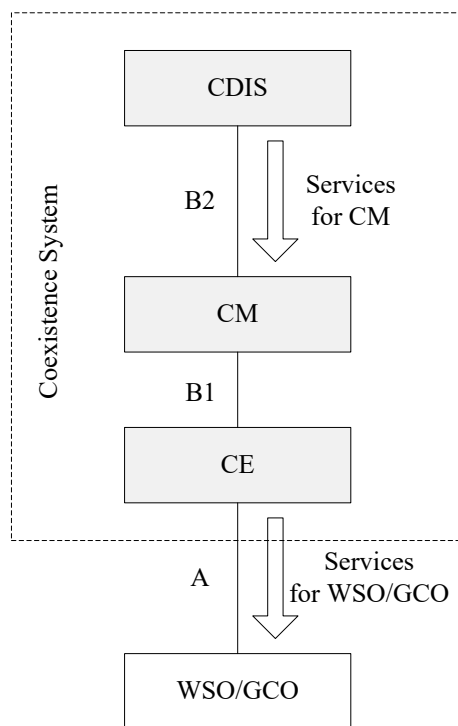


Figure 6—Summary of coexistence services

4.4.2 Services for WSOs/GCOs

The coexistence system provides coexistence services to a WSO/GCO via interface A. To obtain services from the coexistence system, a WSO/GCO needs to subscribe to the coexistence services and register to the coexistence system.

After the registration, the WSO/GCO may get information services and/or management services.

A WSO may subscribe to only one service at a time.

Within the information service, the WSO/GCO gets coexistence report from the coexistence system. Such coexistence report provides enough information to the WSO to make autonomous coexistence decision on its operating parameters.

Within the management service, the WSO/GCO gets reconfiguration requests generated by the coexistence system. The WSO/GCO needs to provide information to the coexistence system while using this service. Also, the WSO/GCO needs to perform measurements according to requests from the coexistence system. Both the information and measurement reports are used by the coexistence system to make coexistence decisions.

4.4.3 Services for CM

A CDIS provides coexistence services to CMs via interface B2. A CM gets coexistence discovery service from a CDIS after it has subscribed to the CDIS coexistence discovery service and has registered to the CDIS.

The coexistence discovery service provides coexistence set information to the CM for WSOs/GCOs served by this CM. Two types of coexistence discovery service are provided by the CDIS to the CM. With one type of service, the CM gets coexistence set information only for the WSOs/GCOs that are served by other CMs. This is called inter-CM coexistence discovery. In this case, the CM performs intra-CM coexistence discovery by itself. With the other type of coexistence discovery service, the CM gets coexistence set information regardless of which CM serves the WSOs/GCOs in the coexistence set. In this case the CDIS performs both inter-CM coexistence discovery and intra-CM coexistence discovery.

4.5 Coexistence algorithms

4.5.1 Introduction

Coexistence algorithms are procedures executed inside the coexistence system in order to provide the coexistence services. The two classes of coexistence algorithms are coexistence discovery algorithms and coexistence decision algorithms.

Coexistence discovery algorithms are used by CDIS and CM to discover WSOs/GCOs that may affect each other performance.

Coexistence decision algorithms are used by a CM to make coexistence decisions related to WSO/GCO reconfiguration.

The standard describes several algorithms for each class. Implementation is not intended to be limited to a particular algorithm.

4.5.2 Coexistence discovery algorithms

4.5.2.1 Algorithm based on statistical analysis of the expected interference

This coexistence discovery algorithm (see 7.2.1.1) considers pairs of WSOs and determines whether they will provide harmful interference to each other when using the same or overlapping operating frequencies.

First, the cumulative distribution function of the potential interference from WSO B to WSO A is estimated by the coexistence system. The minimum interference level experienced by 90% of devices of the WSO A is then taken as the potential interference value from WSO B to WSO A. The potential interference value from WSO A to WSO B is determined in the same way.

Then, the potential interference value from WSO B to WSO A is compared to a threshold. If the interference value is greater than the threshold, then WSO B is potential interferer to WSO A and is included into the coexistence set of WSO A. Similar rule is applied for inclusion of the WSO A into the coexistence set of WSO B.

Updated coexistence set of a WSO is then announced to the CM serving this WSO.

4.5.2.2 Algorithm based on coverage and interference analysis

This coexistence discovery algorithm (see 7.2.1.2) considers pairs of WSOs and determines whether they will provide harmful interference to each other when using the same or overlapping operating frequencies.

First, the normalized distance between WSO A and WSO B is calculated based on geographical distance and estimated coverage areas.

Then the normalized distance is compared to the specific thresholds. The thresholds depend on the radio interface type of WSOs A and B. If they use different technologies, then the threshold for potential interference from WSO A to WSO B could be different from the threshold from WSO B to WSO A. If the normalized distance between WSOs A and B is less than the potential interference threshold from WSO B to WSO A, then WSO B is included in the coexistence set of the WSO A, similar for the coexistence set of WSO B.

Updated coexistence set of a WSO is then announced to the CM serving this WSO.

4.5.2.3 Algorithm for GCOs under geolocation uncertainty

Geolocation information not always provide accurate hidden neighbor information because geolocation uncertainty. This algorithm (see 7.2.1.3) increases the accuracy of hidden neighbor discovery. A CM shall make good use of results of spectrum sensing (or radio measurement) by GCO master and GCO slave.

4.5.2.4 Algorithm for multi-band operating GCOs under geolocation uncertainty

This algorithm (see 7.2.1.4) provides a method for a hidden master GCO discovery among master GCOs using multi-bands. It is preferentially executed in a channel in which a sub-channel exists based on a channel width extension scheme by channel (width) information and a master GCO like AP in WLAN included in a primary channel when the multi-bands are used in each master GCO and slave GCO to enable an inter-adjacent master GCO discovery using the multi-bands to be effectively performed.

4.5.3 Coexistence decision algorithms

4.5.3.1 Algorithm based on operating channel selection

In this algorithm (see 7.2.2.1), the channel classification and channel set transition algorithm uses TV channel classification and channel set transition to maintain channel availability information by the CM. All TV channels are classified in the following sets:

- Disallowed channels
- Allowed channels
- Available channels
- Protected channels
- Restricted channels
- Unclassified channels
- Operating channels
- Coexistent channels

The disallowed set is a set of channels disallowed for any WSOs by regulation, or by the request of incumbents. It is provided by TVWS database and will be updated if necessary. For example, in the United States, the TV channels 3, 4, and 37 are disallowed by regulation. Also, a TV channel registered in the TVWS database by a licensed wireless microphone is disallowed for any WSOs.

The allowed set is a set of channels allowed for WSOs. It is provided by TVWS database and is updated as necessary. All WSOs first obtain a list of the allowed channels before their operating over TV channels.

The available set is a set of free channels available for WSOs.

The restricted set is a set of channels restricted to use with limitations due to regulation. It is used by WSOs under limited conditions predefined by regulation. For example, in the United States, a portable/personal TV band device (TVBD) can use “the first adjacent channel of the incumbent activating channel” with limited transmit power (less than 40 mW equivalent isotropically radiated power (EIRP)) by Federal Communications Commission (FCC) regulation.

The protected set is a set of channels to be protected due to incumbent activity. It cannot be used by any WSOs.

The unclassified set is a set of channels has not been classified as one of disallowed set, available set, or protected set.

The operating set is a set of operating channels being used by each WSO. If each WSO has a different operating channel, then spectrum etiquette, i.e., frequency division multiplexing (FDM), among WSOs is achievable.

The coexistent set is a set of channels being shared by two or more WSOs as an operating channel. WSOs might need a coexistence mechanism to resolve co-channel interference among them.

Figure 7 shows Venn diagram of TV channels.

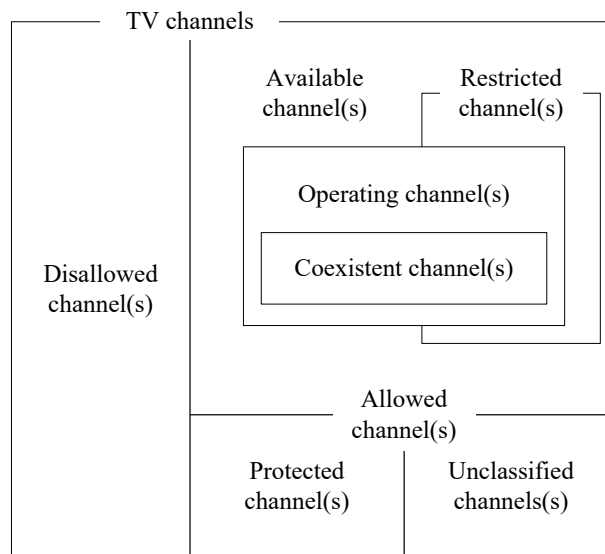


Figure 7—Venn diagram of TV channels

The operating channel selection algorithm allocates a proper operating channel to WSOs. The following three channel allocation methods for operating channel selection are considered:

- Individual TV channel allocation
- Shared TV channel allocation by WSOs of the same type
- Shared TV channel allocation by WSOs of the dissimilar type

In the individual TV channel allocation, TV channels are dynamically assigned to each WSO that uses different TV channels. Therefore, it is possible that non-overlapped TV channels are allocated to WSOs.

This guarantees co-channel-interference-free TV channel use; therefore, the coexistence problem can be eliminated through a proper TV channel allocation.

In shared TV channel allocation, two or more WSOs share the one or more TV channels. If a TV channel is shared by WSOs of the same type, self-coexistence mechanisms are applied to mitigate co-channel interference. If a TV channel is shared by WSOs of the dissimilar type, inter-system coexistence mechanisms are applied to mitigate co-channel interference.

4.5.3.2 Algorithm based on negotiation among CMs

The negotiation among neighbor CMs algorithm (see 7.2.2.2) enables the coexistence system to share the frequency bands effectively when two or more WSOs may affect each other's performance and they are served by different CMs. Then the WSOs are registered to the different CMs and interfere with each other when operating in the same operating channel due to their geolocation, transmission range, interference range, etc. The key processing components, which are conducted in CM, are determining the operating channel list, round-robin mode parameters and competition mode parameters.

When all neighbor CMs allow independent use of the channels, the coexistence set elements served by different CMs use independent operating channels, which is referred to as an etiquette mode. On the other hand, when some neighbor CMs disallow the independent use, the coexistence set elements served by different CMs share operating channels. Based on this technique, time slots are assigned sequentially to all coexistence set elements served by different CMs, which is referred to as round-robin mode, or assigned to particular coexistence set elements served by different CMs through competition among those coexistence set elements, which is referred to as competition mode.

4.5.3.3 Resource allocation with fairness constraint

This algorithm (see 7.2.2.3) shall be applied to coexistence set elements that subscribe to the management service and registered to different CMs. In this case fair resource allocation between coexistence set elements is important. This algorithm addresses fairness by employing Jain's fairness index and Max-min algorithm.

4.5.3.4 Master CM selection

Master/Slave CM selection algorithm (see 7.2.2.4) is focused on providing a method to reorganize CMs autonomously.

Other benefits from selecting a master CM and making slave CMs include the following:

- Load balancing among CMs
- Reduced overhead communication among CMs

4.5.3.5 Channel priority allocation

This mechanism (see 7.2.2.5) is intended for a target WSO subscribed in information service which has no interference-free channels such as available or restricted channel and has operating channels occupied by its coexistence set elements. In this case, performance of the target WSO is degraded by interference of coexistence set elements. Thus, the operating channel priority information is useful to select appropriate operating channels for the target WSO employing operating channels occupied by its coexistence set elements.

This operating channel priority allocation shall be initiated by a CE that subscribes to the information service, and the CM shall provide prioritized channel information to the corresponding CE. The channel priority allocation shall consist of two stages, i.e., coarse channel priority and fine channel priority. The coarse channel priority shall use selection criterion of license type, network technology, total occupancy and the number of coexistence set elements. The fine channel priority shall use selection criteria of interference level. The specific explanation of two-stage channel priority allocation is given in following subclauses.

4.5.3.6 Algorithm based on neighbor report and radio environment information

In the coexistence report and radio environment information algorithm (see 7.2.2.6) the CM first selects one WSO. Next the CM selects the WSO with the maximum unsatisfied demand for resources. Finally, the CM tries to allocate necessary spectrum resources to the selected WSO.

The algorithm considers at most coexistence elements of coexistence elements of the selected WSO to keep the complexity low. The algorithm takes into account operational frequency bands, interference margins, total interference level from coexistence elements, transmit powers, and support for scheduling.

The key principle of the algorithm is to enable acceptable performance for all WSOs while minimizing the number of required reconfigurations. Following this principle, the CM checks the possibility to reconfigure the selected WSO only. If this is impossible, the CM tries solutions that require reconfiguration of coexistence elements.

Priority is given to the solutions that do not reduce the capacity of currently operating WSOs. Also, power control is left to the last stages of the algorithm because providing the largest range for devices is desirable.

The result of the algorithm is the operating frequencies, transmission power limits, channel sharing, and sharing schedule to the selected WSO and to other affected WSOs.

4.5.3.7 Algorithm based on per-coordinate optimization

This algorithm (see 7.2.2.7) allows a CM to decide operating parameters of the WSOs served by this CM and subscribed to the management service. Also, it allows negotiating with the neighbor CM on possible reconfiguration of the neighbor WSOs.

The algorithm uses several iterations to select the WSO operating parameters. Also, within each iteration, all WSO operating parameters are optimized on per WSO basis.

Two target functions are used as examples: total throughput and total interference target functions.

4.5.3.8 Algorithm based on load balancing

The processing load balancing algorithm (see 7.2.2.8) uses the distributed processing power of the CMs effectively and maximizes the number of registered GCOs in accordance with the conditions of the coexistence system operation. The key component is to adapt different channel selection policies (which are centralized coordination by the master CM, cooperative coordination between the CM and GCO itself, and autonomous/distributed coordination by different CMs) to the conditions of the coexistence system operation.

In the centralized coordination method, the master CM makes final decisions on channel selections for its GCOs and for all GCOs of its slave CMs. With the cooperative coordination method, the CM has capability

to ask GCOs to make final decisions required for coexistence. In the autonomous/distributed coordination method the CM individually makes final decisions on channel selections for its GCOs.

4.5.3.9 Algorithm based on output power control

The output power level control algorithm (see 7.2.2.9) addresses the aggregated interference problem in the target protection service contour due to the multiple simultaneous transmission of coexistence set elements. The calculation basis may be applicable in conducting an information service on a potential aggregated interference power level or a management service on power control of GCOs.

4.5.3.10 Algorithm based on co-channel sharing via GCO network geometry classification

The co-channel sharing via GCO network geometry classification algorithm (see 7.2.2.10) optimizes the efficiency of the frequency utilization as much as possible in managing GCOs operating under general authorization, when the system cannot assign different channels among GCOs in a coexistence set. The key processing parts, which are conducted in CDIS or CM, are as follows:

- Coexistence discovery process based on network geometry classification
- Network coexistence protocol check process
- Interference power level check process
- Backhaul connection check process

4.5.3.11 Algorithm for centralized control of energy detection

There are GCOs that employ energy detection, i.e., the measurement of signal energy to check the availability of spectrum before utilizing the spectrum for transmission. Through such listen-before-talk procedure, the interference among GCOs can be avoided to a certain extent. A higher detection threshold leads to less protection to other coexisting GCOs but gives a higher probability of obtaining the spectrum. The centralized control of energy detection algorithm adjusts the threshold of different GCOs to control the spectrum utilization and interference condition of coexisting GCOs (see 7.2.2.11).

4.5.3.12 Algorithm for interference-alignment-based coexistence management

The interference-alignment-based coexistence management algorithm (see 7.2.2.12) optimizes the spectrum utilization of multiple GCOs by considering the interference leakage from each GCO to the others. By adjusting the weight factor on the interference leakage, the algorithm can provide a better performance for a high-priority GCO than that of a low-priority GCO.

4.5.3.13 Algorithm for successive interference cancellation coordination

Utilizing the receiver's information and the geolocation information, the algorithm (see 7.2.2.13) can decide the order of interference cancellation at each individual GCO to improve the demodulation performance in the presence of coexisting GCOs. For the GCO receivers close to the interferer, the interference signal is demodulated first. And for the GCO receivers far from the interferer, the desired signal is demodulated directly.

4.5.3.14 Coexistence management considering spectrum release

When one of the low-priority GCOs finishes the spectrum utilization before the validity time of the available spectrum, this spectrum resource can be released. In such situations, the aggregate interference at the reference point of the high-priority GCOs is reduced. The algorithm (see 7.2.2.14) controls the spectrum reallocation by considering the relationship of the spectrum utilization and the contribution to the total interference at the reference point.

4.5.3.15 Algorithm for coexistence management over a region by controlling the number of co-channel GCOs

This algorithm (see 7.2.2.15) controls the maximum number of GCOs over a given region. Given the expected quality of service (QoS) from the GCOs, the CM can determine the maximum number of GCOs and the minimum number of assigned channels to GCOs while achieving a satisfactory QoS of individual GCO and sum capacities of GCOs.

4.5.3.16 Algorithm for coexistence management with spectrum request modification

When an aggregate interference-based calculation method is used, the available channels would be different when different GCOs request the available spectrum. This algorithm (see 7.2.2.16) can optimize the grouping of GCOs in order to obtain the maximum available spectrum and suggest the spectrum request of GCOs.

4.5.3.17 Algorithm for low-complexity resource reassignment for coexistence management

This algorithm (see 7.2.2.17) reassigns the spectrum utilization of GCOs in order to achieve the maximum spectrum efficiency. The GCOs exchange their spectrum following instruction by the algorithm in a manner that the number of changes is minimized.

4.5.3.18 Algorithm for spectrum allocation of system spectrum with different priority levels

This algorithm (see 7.2.2.18) allocates spectrum of high-priority GCO while considering the interference relationship between the high- and low-priority systems, thus increasing the spectrum of the low-priority system.

4.5.3.19 Algorithm for spectrum allocation based on graph information

This algorithm (see 7.2.2.19) makes spectrum allocation of GCOs that have different QoS requirements. Graph is used to describe the interference relationship among GCOs. The weight of the graph edge takes into account the desired QoS of different GCOs.

4.5.3.20 Algorithm for GCOs operating over overlapped service coverage area

This algorithm (see 7.2.2.20) provides a method for avoiding interference among GCOs operating over overlapped service coverage area according to a distribution state of master GCOs (i.e., APs) and slave GCOs (i.e., STAs) in a master GCO constituting an overlapping service coverage area (i.e., overlapping basic service set (OBSS)).

4.5.3.21 Algorithm for spectrum allocation considering interference aggregation effect at reference points

This algorithm (see 7.2.2.21) considers the interference aggregation effect at a common reference point of multiple GCOs. Using the spectrum allocation coefficient parameter to describe such effect, the algorithm avoids allocating the same spectrum for any pair of the GCOs that have a relatively high spectrum allocation coefficient value.

4.5.3.22 Algorithm for coexistence service based on frequency utilization pattern

This algorithm (see 7.2.2.22) presents a coexistence service scheme that ranks frequencies based on frequency utilization pattern of GCOs. The frequency utilization pattern captures the behavioral pattern on the frequency usage of GCOs. The frequency utilization pattern is defined in 7.2.2.22.2, followed by estimation and utilization of such information to do resource allocation in 7.2.2.22.3. In 7.2.2.22.4, the associated resource allocation algorithm is introduced.

4.5.4 Other algorithms related to coexistence

4.5.4.1 Algorithm based on balanced sharing

This algorithm is based on balanced sharing for coexistence decisions in a CM that builds upon a basic concept according to which the CM serves both the CEs subscribed to it and the CEs in the coexistence sets the CM has for its own CEs. The CM shall make coexistence decisions on those CEs that subscribe to the management service. The CEs that subscribe to the information service or other coexistence decision algorithms are taken into account in the coexistence decisions but for them coexistence decisions are not made.

This coexistence decision algorithm has been designed to be effective in the situations with spectrum scarcity. As a part of the algorithm the CM estimates whether the resource allocation outcome to the CE and to the elements of its coexistence set meets the balanced sharing criterion. This algorithm is based on the coexistence value (CV) parameter and considers balanced sharing in the coexistence decisions on the CE and its coexistence set elements. The design is intended to avoid a WSO to take resources of another WSO even if it is not eligible to those resources. Similarly, the algorithm is designed to avoid a WSO to keep too many resources when other WSOs are lacking resources. This algorithm also generates slowness to resource changes in the environment.

4.5.4.2 Temporarily released resource

A CE that subscribes to the management service may release temporarily a portion of the resources that are allocated to it and to the WSO that it represents, by using the following mechanisms:

- Temporary release of the resources
- Temporary use of released resources
- Reclamation of the temporarily released resources

4.5.4.3 Proxy coexistence service

The proxy coexistence service algorithm provides coexistence service for the moving GCO by establishing connection between the serving CM of the moving GCO managing the GCO-located region and the CMs managing the adjacent region. For the CM managing region by region, the moving GCO has to change its serving CM, and the candidate serving CM might not be able to serve the new GCO due to its capacity. In proxy coexistence service, the previous serving CM can provide information service to the moving GCO on behalf of the CM that should manage the GCO.

4.5.4.4 Algorithm for priority-based coexistence management

This algorithm presents a fine-grained resource allocation solution that ranks frequencies to be used for a certain GCO according to prospective impact of their usage to higher priority GCOs. The metric of interest in the algorithm is the interference incurred to higher priority GCOs when the frequency is used by the target GCO with a pre-assumed power level.

4.5.4.5 Algorithm for selection of candidate serving CMs for moving GCOs

This algorithm designs a way to select and provide the information of candidate serving CMs to moving GCOs. The information of candidate serving CMs can be updated at least as often as the mobility information update from the GCO to the CM.

5. Procedures and protocols

5.1 General

This clause defines typical procedures and protocols among coexistence system entities (CE, CM, COE, and CDIS) and with external entities (SMDB and WSO/GCO). Data types are defined in Annex A, primitives between a CE and a WSO/GCO are defined in Annex B, messages between coexistence system entities are defined in Annex C. The coexistence system entities shall use TCP/IP in all the exposed interfaces B1, B2 and B3, B4 and B5 to communicate with peer entities. The entities shall support both the Secure Shell Protocol and the Transport Layer Security Protocol in all the exposed interfaces.

5.2 Procedures

5.2.1 Coexistence service subscription procedures

5.2.1.1 WSO subscription procedure

A CE shall perform the WSO subscription procedure when it has received a request to start operation. The WSO/registered location secure server (RLSS) shall subscribe to either information service or management service. An illustrative example of this procedure is shown in Figure 8. The *SubscriptionRequest* and *SubscriptionResponse* messages are defined in Annex C.

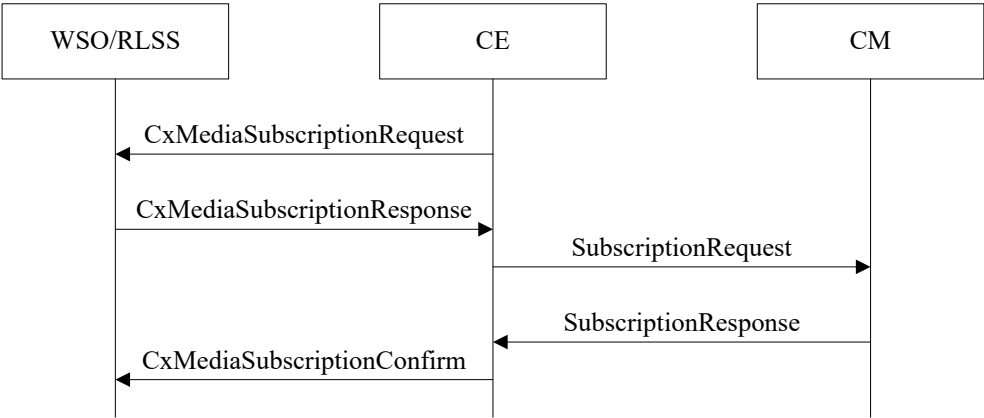


Figure 8—WSO subscription procedure

After the CE has received a request to start operation, it shall obtain WSO/RLSS subscription information. After the WSO/RLSS subscription information has been obtained, the CE shall generate a *SubscriptionRequest* message and shall send this *SubscriptionRequest* message to the CM that serves this CE. CE operation related to generating and sending a *SubscriptionRequest* message is specified in 6.4.

After the CM has received the *SubscriptionRequest* message from the CE, the CM shall perform WSO/RLSS subscription, shall generate a *SubscriptionResponse* message and shall send this *SubscriptionResponse* message to the CE. CM operation related to WSO/RLSS subscription, generating and sending a *SubscriptionResponse* message is specified in 6.3.

After the CE has received the *SubscriptionResponse* message from the CM, the CE shall process the *SubscriptionResponse* message. CE operation related to processing the *SubscriptionResponse* message is specified in 6.4.

5.2.1.2 WSO subscription update procedure

A CE shall perform the WSO subscription update procedure when it has received new WSO/RLSS subscription information indicating that the WSO/RLSS wants to change the type of coexistence service provided by the coexistence system. An illustrative example of this procedure is shown in Figure 9. The *SubscriptionRequest* and *SubscriptionResponse* messages are defined in Annex C.

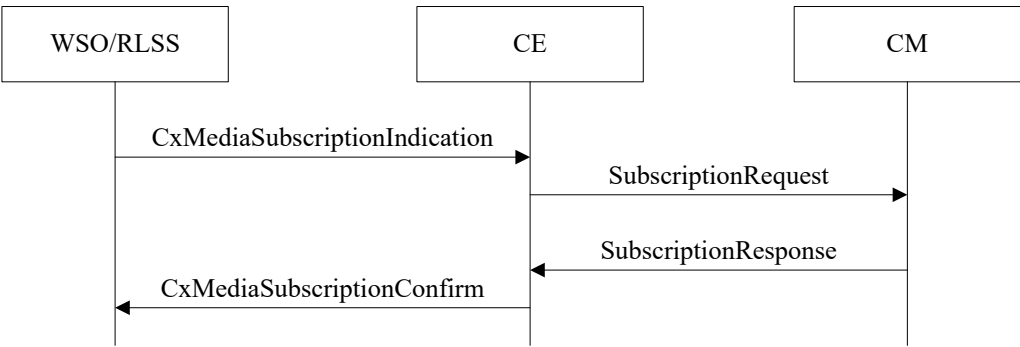


Figure 9—WSO subscription update procedure

After a CE has received new WSO/RLSS subscription information, the CE shall generate a ***SubscriptionRequest*** message and shall send this ***SubscriptionRequest*** message to the CM that serves this CE. CE operations related to generating and sending a ***SubscriptionRequest*** message are specified in 6.4.

After the CM has received the ***SubscriptionRequest*** message from the CE, the CM shall perform WSO/RLSS subscription, shall generate a ***SubscriptionResponse*** message and shall send this ***SubscriptionResponse*** message to the CE. CM operations related to WSO/RLSS subscription, generating and sending a ***SubscriptionResponse*** message are specified in 6.3.

After the CE has received the ***SubscriptionResponse*** message from the CM, the CE shall process the ***SubscriptionResponse*** message. CE operations related to processing a ***SubscriptionResponse*** message are specified in 6.4.

5.2.1.3 CM subscription procedure

A CM shall perform this procedure in order to subscribe to discovery service provided by the CDIS. The CM shall subscribe to either inter-CM coexistence discovery or full coexistence discovery. An illustrative example of this procedure is shown in Figure 10. ***SubscriptionRequest*** and ***SubscriptionResponse*** messages are defined in Annex C.

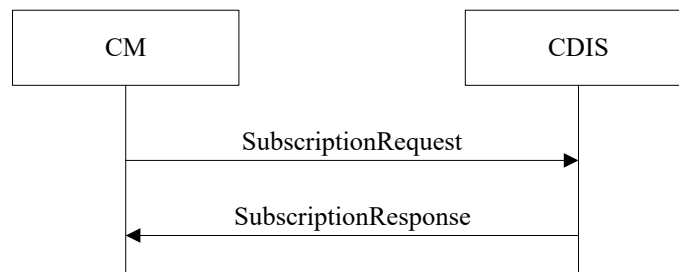


Figure 10—CM subscription procedure

After generating the CM subscription information, the CM shall send the ***SubscriptionRequest*** message to the CDIS. CM operation related to generating and sending the ***SubscriptionRequest*** message is specified in 6.3.

After the CDIS receives the ***SubscriptionRequest*** message from the CM, the CDIS shall perform CM subscription, and shall generate the ***SubscriptionResponse*** message. CDIS operation related to CM subscription and generating ***SubscriptionResponse*** message is specified in 6.2.

After the CDIS generates the ***SubscriptionResponse*** message, the CDIS shall send the ***SubscriptionResponse*** message to the CM. CDIS operation related to generating and sending ***SubscriptionResponse*** message is specified in 6.2.

After the CM has received the ***SubscriptionResponse*** message from the CDIS, the CM shall process the ***SubscriptionResponse*** message. CM operation related to processing the ***SubscriptionResponse*** message is specified in 6.3.

5.2.1.4 CM subscription update procedure

A CM shall perform this procedure when CM needs to change the type of discovery service provided by the CDIS. An illustrative example of this procedure is shown in Figure 11. *SubscriptionRequest* and *SubscriptionResponse* messages are defined in Annex C.

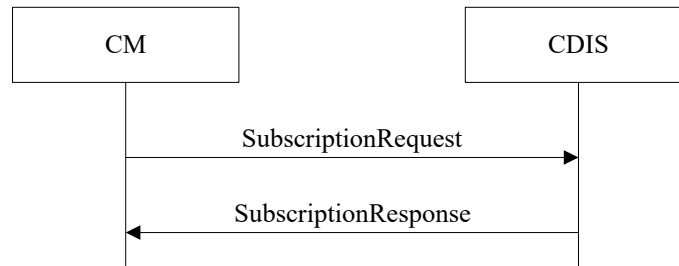


Figure 11—CM subscription update procedure

After generating the new CM subscription information, the CM shall send the *SubscriptionRequest* message to the CDIS. CM operation related to generating and sending the *SubscriptionRequest* message is specified in 6.3.

After the CDIS receives the *SubscriptionRequest* message from the CM, the CDIS shall perform CM subscription, and shall generate the *SubscriptionResponse* message. CDIS operation related to CM subscription update and generating *SubscriptionResponse* message is specified in 6.2.

After the CDIS generates the *SubscriptionResponse* message, the CDIS shall send the *SubscriptionResponse* message to the CM. CDIS operation related to generating and sending *SubscriptionResponse* message is specified in 6.2.

After the CM has received the *SubscriptionResponse* message from the CDIS, the CM shall process the *SubscriptionResponse* message. CM operation related to processing the *SubscriptionResponse* message is specified in 6.3.

5.2.1.5 WSO subscription change procedure

A CM shall perform this procedure when CM wants to ask a WSO to change the type of coexistence service provided by the CM. An illustrative example of this procedure is shown in Figure 12. *SubscriptionChangeRequest* and *SubscriptionChangeResponse* messages are defined in Annex C.

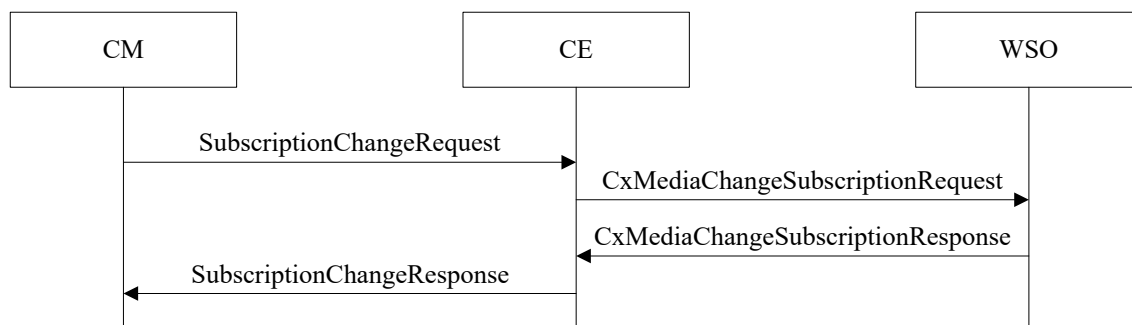


Figure 12—WSO subscription change procedure

CM operation related to generating and sending the *SubscriptionChangeRequest* message is specified in 6.3.

After the CE receives the *SubscriptionChangeRequest* message from the CM, the CE shall generate *CxMediaChangeSubscriptionRequest* primitive and shall send it to the WSO. CE operation related to generating and sending the *CxMediaChangeSubscriptionRequest* primitive is specified in 6.4.

After the WSO receives the *CxMediaChangeSubscriptionRequest* primitive from the CE, the WSO shall determine either acceptance or rejection of the request to change its subscription to the coexistence service by the CM, shall generate the *CxMediaChangeSubscriptionResponse* primitive, and shall send it to the CE.

After the CE receive the *CxMediaChangeSubscriptionResponse* primitive from the WSO, the CE shall generate the *SubscriptionChangeResponse* message and shall send it to the CM. CE operation related to generating and sending the *SubscriptionChangeResponse* message is specified in 6.4.

5.2.2 Providing registration information procedures

5.2.2.1 WSO/GCO registration procedure

A CE shall perform the WSO/GCO registration procedure when it has successfully finished the WSO/RLSS subscription procedure. An illustrative example of this procedure is shown in Figure 13. The *CERegistrationRequest*, *RegistrationResponse*, and *CMRegistrationRequest* messages are defined in Annex C.

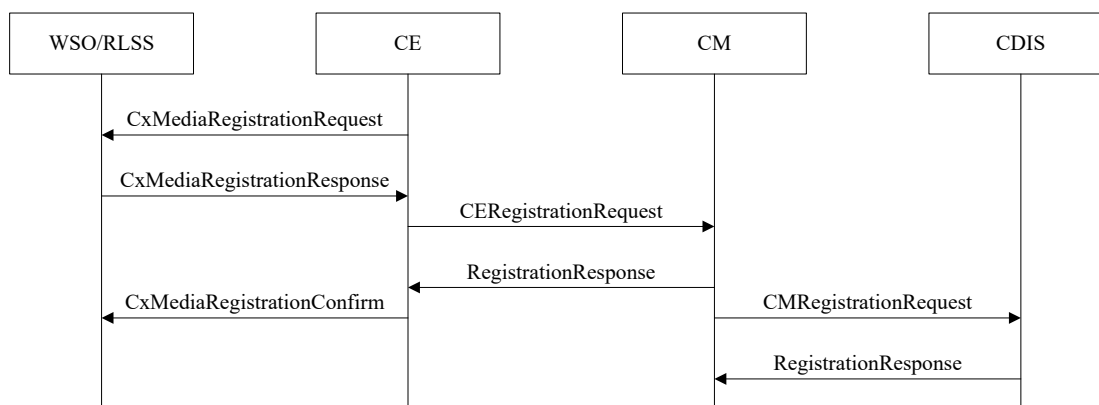


Figure 13—WSO/GCO registration procedure

After a CE has successfully finished a WSO subscription procedure, it shall obtain WSO/GCO registration information. After the WSO/GCO registration information has been obtained, the CE shall generate a *CERegistrationRequest* message and shall send this *CERegistrationRequest* message to the CM that serves this CE. CE operations related to generating and sending a *CERegistrationRequest* message are specified in 6.4.

After the CM has received the *CERegistrationRequest* message from the CE, the CM shall perform WSO/GCO registration, shall generate a *RegistrationResponse* message, and shall send this *RegistrationResponse* message to the CE. CM operations related to WSO/GCO registration, generating and sending a *RegistrationResponse* message are specified in 6.3.

After the CE has received the **RegistrationResponse** message from the CM, the CE shall process the **RegistrationResponse** message. CE operations related to processing a **RegistrationResponse** message are specified in 6.4.

After the CM has sent the **RegistrationResponse** message to the CE, the CM shall generate a **CMRegistrationRequest** message and shall send this **CMRegistrationRequest** message to the CDIS that serves this CM. CM operations related to generating and sending a **CMRegistrationRequest** message are specified in 6.3.

After the CDIS has received the **CMRegistrationRequest** message from the CM, the CDIS shall perform CM registration, shall generate a **RegistrationResponse** message, and shall send this **RegistrationResponse** message to the CM. CDIS operations related to CM registration, generating and sending a **RegistrationResponse** message are specified in 6.2.

After the CM has received the **RegistrationResponse** message from the CDIS, the CM shall process the **RegistrationResponse** message. CM operations related to processing a **RegistrationResponse** message are specified in 6.3.

5.2.2.2 WSO/GCO registration update procedure

A CE shall perform the WSO/GCO registration update procedure when it has received new WSO/GCO registration information. An illustrative example of this procedure is shown in Figure 14. The **CERegistrationRequest**, **RegistrationResponse**, and **CMRegistrationRequest** messages are defined in Annex C.

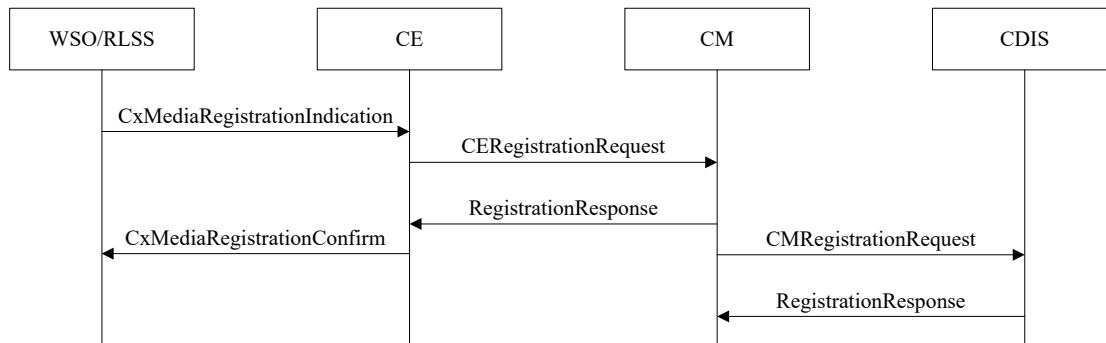


Figure 14—WSO/GCO registration update procedure

After a CE has received new WSO/GCO registration information, the CE shall generate a **CERegistrationRequest** message and shall send this **CERegistrationRequest** message to the CM that serves this CE. CE operations related to generating and sending a **CERegistrationRequest** message are specified in 6.4.

After the CM has received the **CERegistrationRequest** message from the CE, the CM shall perform WSO/GCO registration, shall generate a **RegistrationResponse** message, and shall send this **RegistrationResponse** message to the CE. CM operations related to WSO/GCO registration, generating and sending a **RegistrationResponse** message are specified in 6.3.

After the CE has received the **RegistrationResponse** message from the CM, the CE shall process the **RegistrationResponse** message. CE operations related to processing the **RegistrationResponse** message are specified in 6.4.

After the CM has sent the **RegistrationResponse** message to the CE, the CM shall generate a **CMRegistrationRequest** message and shall send this **CMRegistrationRequest** message to the CDIS that serves this CM. CM operations related to generating and sending a **CMRegistrationRequest** message are specified in 6.3.

After the CDIS has received the **CMRegistrationRequest** message from the CM, the CDIS shall perform CM registration, shall generate a **RegistrationResponse** message, and shall send this **RegistrationResponse** message to the CM. CDIS operations related to CM registration, generating and sending a **RegistrationResponse** message are specified in 6.2.

After the CM has received the **RegistrationResponse** message from the CDIS, the CM shall process the **RegistrationResponse** message. CM operations related to processing a **RegistrationResponse** message are specified in 6.3.

5.2.2.3 WSO deregistration procedure

A CM shall perform this procedure when the CM needs to deregister a WSO from the CM. An illustrative example of this procedure is shown in Figure 15. **WsoDeregistrationRequest**, **WsoDeregistrationResponse**, **CMRegistrationRequest**, and **RegistrationResponse** messages are defined in Annex C.

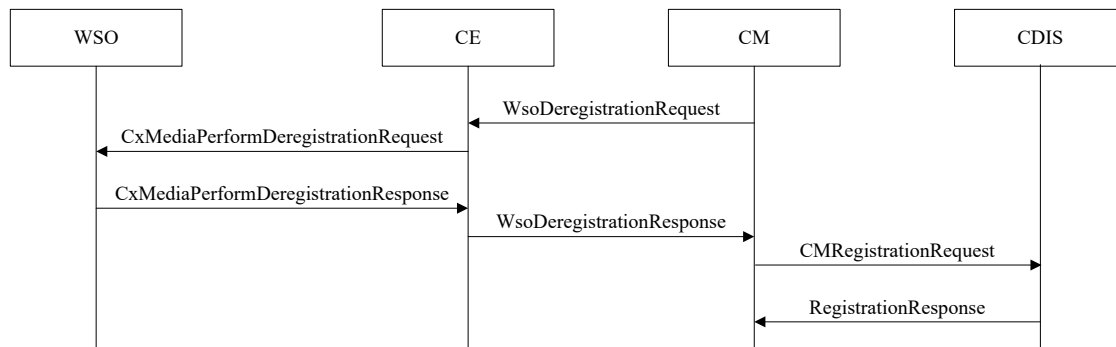


Figure 15—WSO deregistration procedure

CM operations related to generating and sending the **WsoDeregistrationRequest** message are specified in 6.3.

After the CE receives the **WsoDeregistrationRequest** message from the CM, the CE shall process the **WsoDeregistrationRequest** message. CE operations related to processing the **WsoDeregistrationRequest** message are specified in 6.4.

After the CE receives deregistration response from the WSO, the CE shall generate and send a **WsoDeregistrationResponse** message to the CM. CE operations related to generating and sending the **DeregistrationResponse** message are specified in 6.4.

After the CM receives the **WsoDeregistrationResponse** message from the CE, the CM shall generate and send the **CMRegistrationRequest** message to the CDIS. CM operation related to generating and sending **CMRegistrationRequest** message is specified in 6.3.

After the CDIS receives the **CMRegistrationRequest** message from the CM, the CDIS shall generate and send the **RegistrationResponse** message to the CM. CDIS operation related to generating and sending **RegistrationResponse** message is specified in 6.2.

5.2.3 Obtaining coexistence set information procedures

5.2.3.1 Obtaining coexistence set information

A CM shall perform this procedure when the CM needs to obtain coexistence set information from the CDIS. Based on the CM's subscription to the CDIS, the CM shall get the information for inter-CM coexistence set elements only or for all coexistence set elements including both intra-CM and inter-CM ones. An illustrative example of this procedure is shown in Figure 16. *CoexistenceSetInformationRequest* and *CoexistenceSetInformationResponse* messages are defined in Annex C.

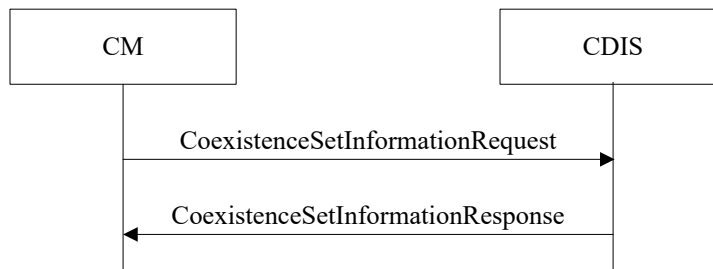


Figure 16—Obtaining coexistence set information

CM operation related to generating and sending the *CoexistenceSetInformationRequest* message is specified in 6.3.

After a CDIS receives the *CoexistenceSetInformationRequest* message from the CM, the CDIS shall obtain coexistence set information, and shall send the *CoexistenceSetInformationResponse* message to the CM. CDIS operation related to generating and sending *CoexistenceSetInformationResponse* message is specified in 6.2.

After the CM has received the *CoexistenceSetInformationResponse* message from the CDIS, the CM shall process the *CoexistenceSetInformationResponse* message. CM operation related to processing the *CoexistenceSetInformationResponse* message is specified in 6.3.

5.2.3.2 Providing coexistence set information

A CDIS shall perform the providing coexistence set information procedure when coexistence set information has been changed for one or several WSOs served by one or several CMs. The CDIS shall provide coexistence set information based on the type of the discovery service to which a particular CM is subscribed. An illustrative example of this procedure is shown in Figure 17. The *CoexistenceSetInformationAnnouncement* message is defined in Annex C.



Figure 17—Providing coexistence set information

After coexistence set information has been changed for one or several WSOs served by one or several CMs, the CDIS shall generate one or several ***CoexistenceSetInformationAnnouncement*** messages. Number of the generated ***CoexistenceSetInformationAnnouncement*** messages is equal to the number of CMs serving WSOs for which coexistence set information has been changed. After the ***CoexistenceSetInformationAnnouncement*** messages has been generated, the CDIS shall send these ***CoexistenceSetInformationAnnouncement*** messages to the CMs serving WSOs for which coexistence set information has been changed. CDIS operations related to generating and sending a ***CoexistenceSetInformationAnnouncement*** message are specified in 6.2.

After a CM has received the ***CoexistenceSetInformationAnnouncement*** message from the CDIS, the CM shall process the ***CoexistenceSetInformationAnnouncement*** message. CM operations related to processing a ***CoexistenceSetInformationAnnouncement*** message are specified in 6.3.

5.2.3.3 Obtaining coexistence set element information

A CM shall perform this procedure to obtain coexistence set information from another CM. An illustrative example of this procedure is shown in Figure 18. ***CoexistenceSetElementInformationRequest*** and ***CoexistenceSetElementInformationResponse*** messages are defined in Annex C.

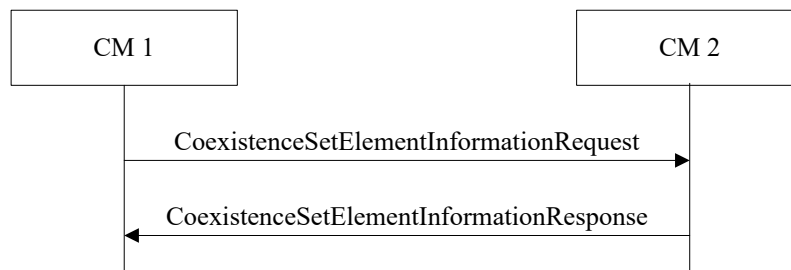


Figure 18—Obtaining coexistence set element information

In order to start the procedure CM1 shall generate a ***CoexistenceSetElementInformationRequest*** message and send this message to CM2. CM operations related to generating and sending a ***CoexistenceSetElementInformationRequest*** message are specified in 6.3.

After CM2 has received a ***CoexistenceSetElementInformationRequest*** message from CM1, CM2 shall obtain coexistence set element information, and shall generate a ***CoexistenceSetElementInformationResponse*** message send this ***CoexistenceSetElementInformationResponse*** message to CM1. CM operations related to obtaining coexistence set element information and generating and sending a ***CoexistenceSetElementInformationResponse*** message are specified in 6.3.

After CM1 has received a ***CoexistenceSetElementInformationResponse*** message from CM2, CM1 shall process the ***CoexistenceSetElementInformationResponse*** message. CM operations related to processing a ***CoexistenceSetElementInformationResponse*** message are specified in 6.3.

5.2.3.4 Providing coexistence set element information procedure

A CM shall perform the sharing coexistence set information procedure when coexistence set information has been changed for one or several WSOs which the CM serves and which have in their coexistence set WSOs served by one or several other CMs. An illustrative example of this procedure is shown in Figure 19.

The *CoexistenceSetElementInformationAnnouncement* and *CoexistenceSetElementInformationConfirm* messages are defined in Annex C.

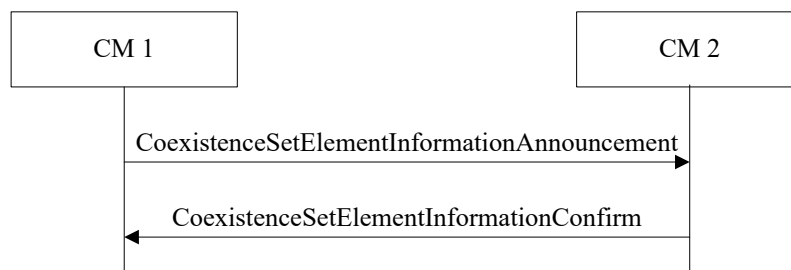


Figure 19—Sharing coexistence set information procedure

After coexistence set information has changed for one or several WSOs which CM1 serves and which have in their coexistence set WSOs served by one or several CM2s, the CM shall generate one or several *CoexistenceSetElementInformationAnnouncement* messages. Number of the generated *CoexistenceSetElementInformationAnnouncement* messages is equal to the number of CM2s serving WSOs that are in the coexistence set of the WSOs which coexistence set information has changed. After the *CoexistenceSetElementInformationAnnouncement* messages has been generated, CM1 shall send these *CoexistenceSetElementInformationAnnouncement* messages to CM2s serving WSOs that are in the coexistence set of the WSOs which coexistence set information has changed. CM operations related to generating and sending a *CoexistenceSetElementInformationAnnouncement* message are specified in 6.3.

After CM2 has received the *CoexistenceSetElementInformationAnnouncement* message, CM2 shall process the *CoexistenceSetElementInformationAnnouncement* message, shall generate a *CoexistenceSetElementInformationConfirm* message, and shall send this *CoexistenceSetElementInformationConfirm* message to CM1 from which it received the *CoexistenceSetElementInformationAnnouncement* message. CM operations related to processing a *CoexistenceSetElementInformationAnnouncement* message, generating and sending a *CoexistenceSetElementInformationConfirm* message are specified in 6.3.

5.2.3.5 Obtaining coexistence report

A CE shall perform this procedure when the WSO needs to obtain coexistence report information from the CM. An illustrative example of this procedure is shown in Figure 20. *CoexistenceReportRequest* and *CoexistenceReportResponse* messages are defined in Annex C.

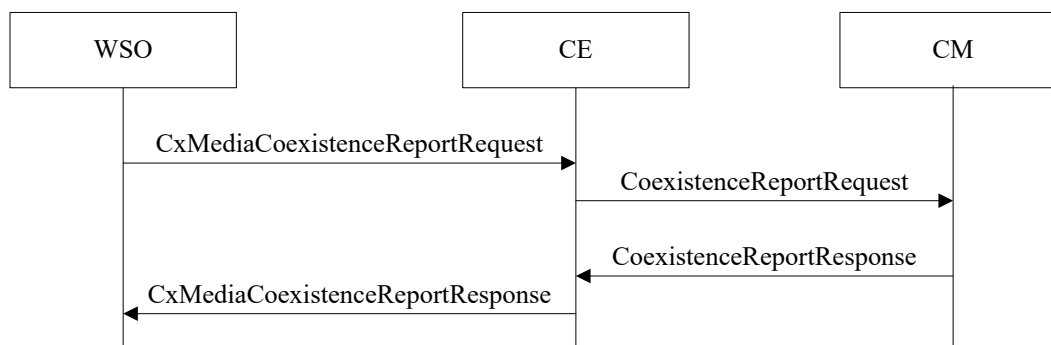


Figure 20—Obtaining coexistence report

After the CE receives a primitive request for a coexistence report from the WSO, the CE shall send the **CoexistenceReportRequest** message to the CM. CE operations related to generating and sending **CoexistenceReportRequest** message are specified in 6.4.

After the CM receives the **CoexistenceReportRequest** message from the CE, the CM shall obtain coexistence report information, and shall send **CoexistenceReportResponse** message to the CE. CM operations related to generating and sending **CoexistenceReportResponse** message are specified in 6.3.

After the CE receives the **CoexistenceReportResponse** message from the CM, the CE shall send the received coexistence report to the WSO. CE operations related to receiving the **CoexistenceReportResponse** message and sending the coexistence report to the WSO are specified in 6.4.

5.2.3.6 Providing coexistence report

A CM shall perform the providing coexistence report procedure when coexistence report information has been changed for one or several WSOs subscribed to information service and served by this CM. An illustrative example of this procedure is shown in Figure 21. The **CoexistenceReportAnnouncement** message is defined in Annex C.

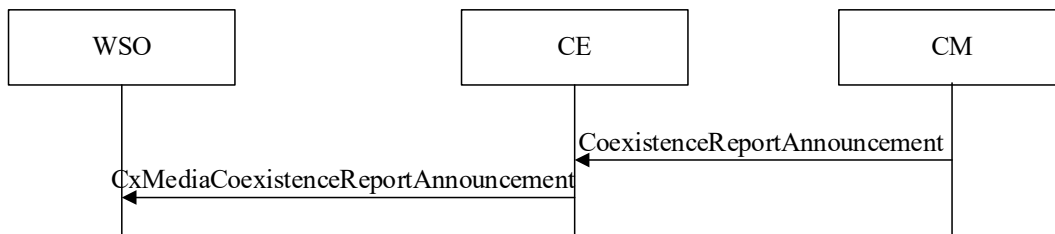


Figure 21—Providing coexistence report

After coexistence report information has been changed for one or several WSOs subscribed by information service and served by a CM, the CM shall generate one or several **CoexistenceReportAnnouncement** messages. Number of the generated **CoexistenceReportAnnouncement** messages is equal to the number of WSOs for which coexistence report information has been changed. After the **CoexistenceReportAnnouncement** messages has been generated, the CM shall send these **CoexistenceReportAnnouncement** messages to the WSOs for which coexistence report information has been changed. CM operations related to generating and sending a **CoexistenceReportAnnouncement** message are specified in 6.3.

After a CE has received the **CoexistenceReportAnnouncement** message from the CM, the CE shall process the **CoexistenceReportAnnouncement** message. CE operations related to processing a **CoexistenceReportAnnouncement** message are specified in 6.4.

5.2.4 Obtaining available channel list from WSO procedure

A CM shall perform the obtaining available channel list from WSO procedure when the CM wants to obtain available channel list from a WSO. An illustrative example of this procedure is shown in Figure 22. **AvailableChannelsRequest** and **AvailableChannelsResponse** messages are defined in Annex C.

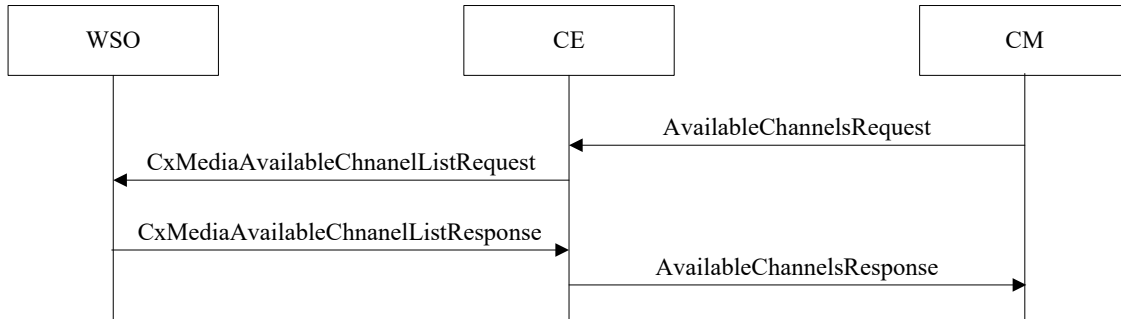


Figure 22—Obtaining available channel list from WSO procedure

When the CM wants to obtain available channel list from the WSO, the CM shall generate and send the *AvailableChannelsRequest* message to the CE. CM operations related to generating and sending the *AvailableChannelsRequest* message is specified in 6.3.

After the CE has received the *AvailableChannelsRequest* message from the CM, the CE shall process the *AvailableChannelsRequest* message. CE operations related to processing the *AvailableChannelsRequest* message is specified in 6.4.

After the CE has received available channel list from a WSO, the CE shall generate and send the *AvailableChannelsResponse* message to the CM. CE operations related to generating and sending the *AvailableChannelsResponse* message is specified in 6.4.

After the CM has received the *AvailableChannelsResponse* message from the CE, the CM shall process the *AvailableChannelsResponse* message. CM operations related to processing the *AvailableChannelsResponse* message is specified in 6.3.

5.2.5 Obtaining channel classification information procedures

5.2.5.1 Obtaining channel classification information by CM procedure

A CM shall perform this procedure when it needs to obtain channel classification information from another CM. Channel classification information shall include classified channel lists based on channel status: available, restricted, protected, unclassified, operating, and coexistent. Definition of each channel is specified in 4.5.3.1. An illustrative example of this procedure is shown in Figure 23. *CMChannelClassificationRequest* and *CMChannelClassificationResponse* messages are defined in Annex C.

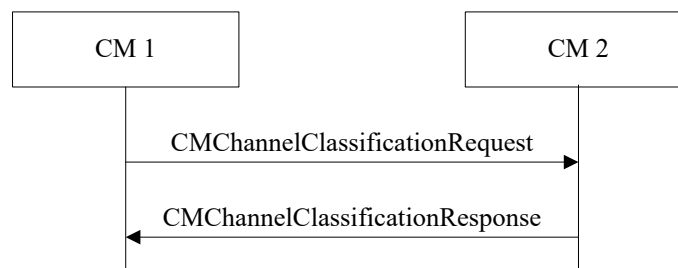


Figure 23—Obtaining channel classification information by CM procedure

After CM1 sends the *CMChannelClassificationRequest* message to CM2, CM2 shall obtain channel classification information based on its registered WSOs, and shall send the *CMChannelClassificationResponse* message to CM1. CM operations related to generating and sending *CMChannelClassificationRequest* and *CMChannelClassificationResponse* messages are specified in 6.3.

After CM1 has received the *CMChannelClassificationResponse* message from CM2, CM1 shall process the *CMChannelClassificationResponse* message. CM operations related to processing the *CMChannelClassificationResponse* message are specified in 6.3.

5.2.5.2 Obtaining channel classification information by CE procedure

A CE shall perform this procedure when the WSO needs to obtain channel classification information from a CM via a CE. An illustrative example of this procedure is shown in Figure 24. *ChannelClassificationRequest* and *ChannelClassificationResponse* messages are defined in Annex C.

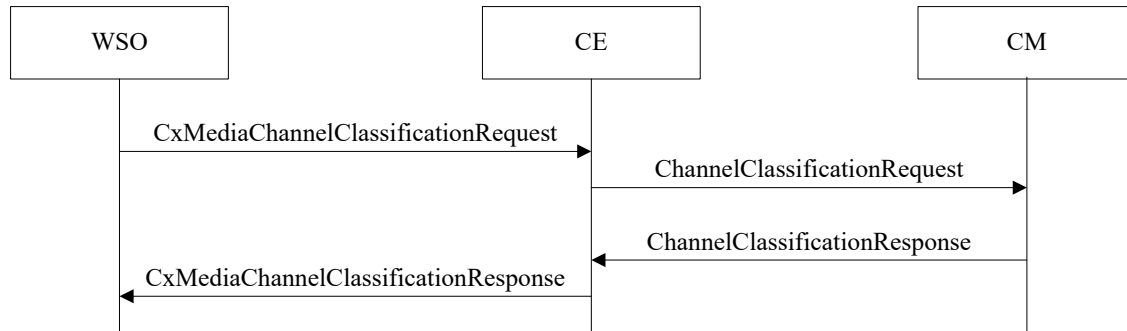


Figure 24—Obtaining channel classification information by CE procedure

After the CE receives a primitive request for channel classification from the WSO, the CE shall send the *ChannelClassificationRequest* message to the CM. CE operations related to generating and sending *ChannelClassificationRequest* message are specified in 6.4.

After the CM receives the *ChannelClassificationRequest* message from the CE, the CM shall obtain channel classification information and shall send the *ChannelClassificationResponse* message to the CE. CM operations related to generating and sending *ChannelClassificationResponse* message are specified in 6.3.

After the CE receives the *ChannelClassificationResponse* message from the CM, the CE shall send the channel classification information to the WSO. CE operations related to processing the *ChannelClassificationResponse* message are specified in 6.4.

5.2.5.3 Announcing channel classification information update to CM procedure

A CM shall perform this procedure when channel classification information has been changed for the CM. An illustrative example of this procedure is shown in Figure 25. The CM shall send the updated channel classification information to all neighbor CMs. The *ChannelClassificationAnnouncement* message is defined in Annex C.

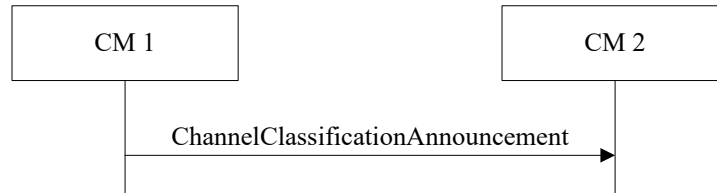


Figure 25—Announcing channel classification information update to CM procedure

After channel classification information has been changed for CM1, CM1 shall generate a **ChannelClassificationAnnouncement** message, and shall send this **ChannelClassificationAnnouncement** message to all neighbor CM2s. CM operations related to generating and sending a **ChannelClassificationAnnouncement** message are specified in 6.3.

After CM2 has received the **ChannelClassificationAnnouncement** message from CM1, CM2 shall process the **ChannelClassificationAnnouncement** message. CM operations related to processing a **ChannelClassificationAnnouncement** message are specified in 6.3.

5.2.5.4 Announcing channel classification information update to CE procedure

A CM shall perform this procedure when channel classification information has been changed for the WSO. The CM shall send updated channel classification information to the WSO via the CE. An illustrative example of this procedure is shown in Figure 26. The **ChannelClassificationAnnouncement** message is defined in Annex C.

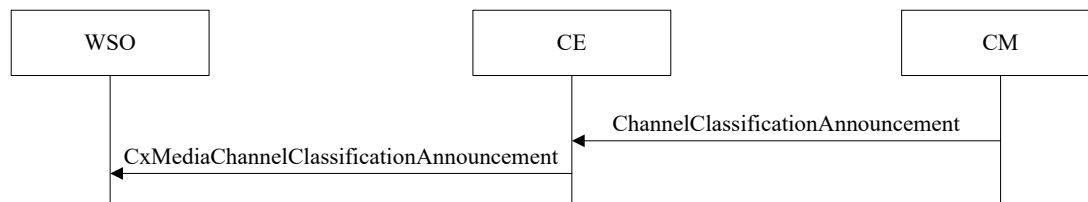


Figure 26—Announcing channel classification information update to CE procedure

After channel classification information has been changed for the WSO, the CM shall generate the **ChannelClassificationAnnouncement** message, and shall send the **ChannelClassificationAnnouncement** message to the CE. CM operations related to generating and sending **ChannelClassificationAnnouncement** message are specified in 6.3.

After the CE has received the **ChannelClassificationAnnouncement** message from the CM, the CE shall send the updated channel classification information it to the WSO. CE operations related to processing the **ChannelClassificationAnnouncement** message are specified in 6.4.

5.2.6 Obtaining information procedures

5.2.6.1 Obtaining information from WSO procedure

A CM shall perform the obtaining information from WSO procedure when a CM wants to obtain information from a WSO. An illustrative example of this procedure is shown in Figure 27. *InfoAcquiringRequest* and *InfoAcquiringResponse* messages are defined in Annex C.

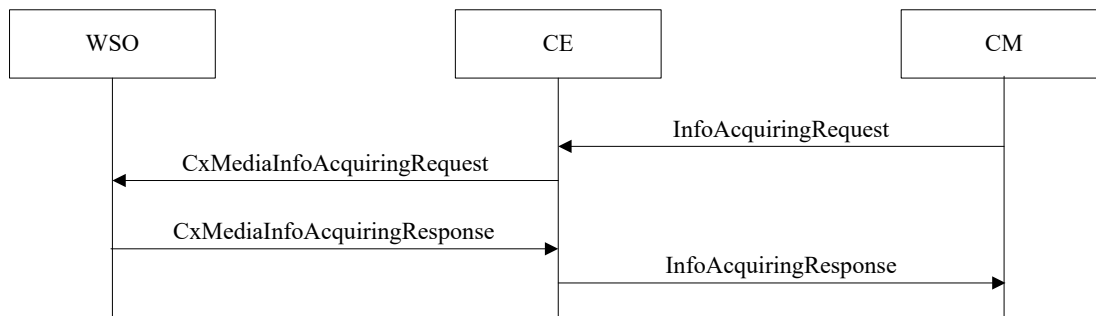


Figure 27—Obtaining information from WSO procedure

When the CM wants to obtain information from a WSO, the CM shall generate and send the *InfoAcquiringRequest* message to the CE. CM operations related to generating and sending the *InfoAcquiringRequest* message are specified in 6.3.

After the CE has received the *InfoAcquiringRequest* message from the CM, the CE shall process the *InfoAcquiringRequest* message. CE operations related to processing the *InfoAcquiringRequest* message are specified in 6.4.

After the CE has received required information from the WSO, the CE shall generate and send the *InfoAcquiringResponse* message to the CM. CE operations related to generating and sending the *InfoAcquiringResponse* message are specified in 6.4.

After the CM has received the *InfoAcquiringResponse* message from the CE, the CM shall process the *InfoAcquiringResponse* message. CM operations related to processing the *InfoAcquiringResponse* message are specified in 6.3.

5.2.6.2 Obtaining information from another CM procedure

A CM shall perform the obtaining information from another CM procedure when the CM wants to obtain information from another CM. An illustrative example of this procedure is shown in Figure 28. *InfoAcquiringRequest* and *InfoAcquiringResponse* messages are defined in Annex C.

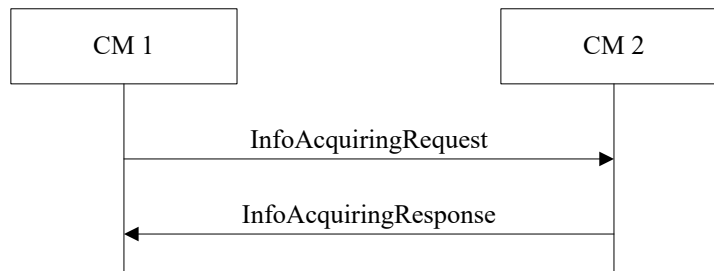


Figure 28—Obtaining information from another CM procedure

When CM1 wants to obtain information from CM2, CM1 shall generate an *InfoAcquiringRequest* message and shall send this *InfoAcquiringRequest* message to CM2. CM operations related to generating and sending an *InfoAcquiringRequest* message are specified in 6.3.

After CM2 has received *InfoAcquiringRequest* message from CM1, CM2 shall generate an *InfoAcquiringResponse* message, and shall send the *InfoAcquiringResponse* message to CM1. CM operations related to generating and sending an *InfoAcquiringResponse* message are specified in 6.3.

After CM1 has received the *InfoAcquiringResponse* message from CM2, CM1 shall process the *InfoAcquiringResponse* message. CM operations related to processing the *InfoAcquiringResponse* message are specified in 6.3.

5.2.7 Requesting and obtaining measurements procedures

5.2.7.1 Requesting measurements procedure

A CM shall perform the requesting measurements procedure to request a WSO which is represented by a CE which the CM serves to perform measurements and to request the CE to provide subsequently measurement reports. The CM requests the WSO to perform measurements and the CE to provide measurement reports either once per the request or on schedule basis. When the request is to provide a one-time measurement report the reporting procedure is as specified in 5.2.7.2. When the request is to provide scheduled measurement reports the reporting procedure is as specified in 5.2.7.3. An illustrative example of this procedure is shown in Figure 29. *MeasurementRequest* and *MeasurementConfirm* messages are defined in Annex C.

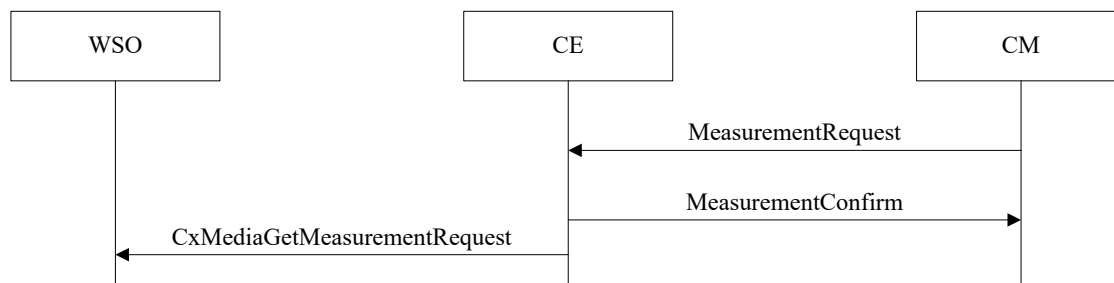


Figure 29—Requesting measurements procedure

In order for a CM to request measurements from a WSO and to obtain related measurement reports from a CE which represents the WSO and which the CM serves, the CM shall generate a *MeasurementRequest* message and send this *MeasurementRequest* message to the CE. CM operations related to generating and sending a *MeasurementRequest* message are specified in 6.3.

After the CE has received a *MeasurementRequest* message from the CM, the CE shall process the message, generate a *MeasurementConfirm* message and send this message to the CM. CE operations related to processing a *MeasurementRequest* message and generating and sending a *MeasurementConfirm* message are specified in 6.4.

After the CM has received a *MeasurementConfirm* message from the CE, the CM shall process the message. CM operations related to processing a *MeasurementConfirm* message are specified in 6.3.

5.2.7.2 Providing one-time measurement procedure

A CE shall perform the providing one-time measurement report procedure when the CM has requested one-time measurement report from the CE. An illustrative example of this procedure is shown in Figure 30. *MeasurementResponse* and *MeasurementConfirm* messages are defined in Annex C.

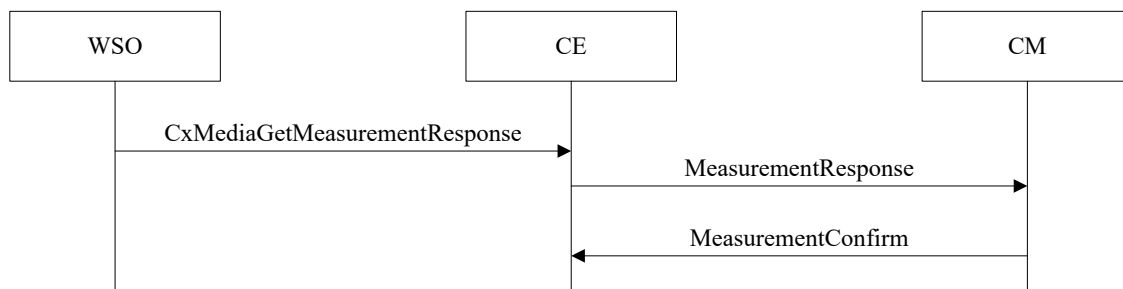


Figure 30—Providing one-time measurement procedure

In order for a CE to provide a one-time measurement report to the CM which has earlier requested this measurement report, the CE shall generate a *MeasurementResponse* message and send this *MeasurementResponse* message to the CM. CE operations related to generating and sending a *MeasurementResponse* message are specified in 6.4.

After the CM has received a *MeasurementResponse* message from the CE, the CM shall process the message, generate a *MeasurementConfirm* message to acknowledge reception of the *MeasurementResponse* message and send this *MeasurementConfirm* message to the CE. CM operations related to processing a *MeasurementResponse* message, generating and sending a *MeasurementConfirm* message are specified in 6.3.

After the CE has received a *MeasurementConfirm* message from the CM, the CE shall process the message. CE operations related to processing a *MeasurementConfirm* message are specified in 6.4.

5.2.7.3 Providing scheduled measurements procedure

A CE shall perform the providing scheduled measurements procedure when the CM has requested scheduled measurement reports from the CE. An illustrative example of this procedure is shown in Figure 31. *MeasurementResponse* and *MeasurementConfirm* messages are defined in Annex C.

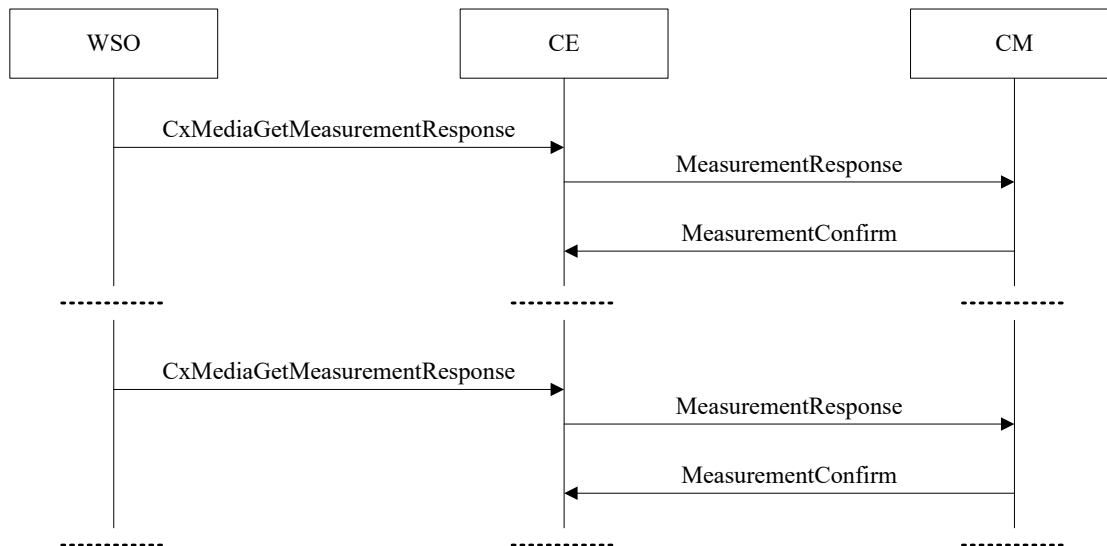


Figure 31 —Providing scheduled measurement procedure

In order for a CE to provide one of the scheduled measurement reports to the CM which has earlier requested scheduled measurement reports, the CE shall generate a *MeasurementResponse* message and send this *MeasurementResponse* message to the CM. The CE shall continue generating and sending *MeasurementResponse* messages to the CM as long as the request for scheduled measurement reports is valid. CE operations related to generating and sending a *MeasurementResponse* message are specified in 6.4.

After the CM has received a *MeasurementResponse* message from the CE, the CM shall process the message, generate a *MeasurementConfirm* message to acknowledge reception of the *MeasurementResponse* message and send this *MeasurementConfirm* message to the CE. CM operations related to processing a *MeasurementResponse* message, generating and sending a *MeasurementConfirm* message are specified in 6.3.

After the CE has received a *MeasurementConfirm* message from the CM, the CE shall process the message. CE operations related to processing a *MeasurementConfirm* message are specified in 6.4.

5.2.8 Negotiation between CMs procedure

A CM shall perform the negotiation procedure when it has made coexistence decision of coexistence set elements. This set shall include the following procedures as shown in Figure 32 and Figure 33:

- Negotiation between CMs without announcement
- Negotiation between CMs with announcement

NegotiationRequest and *NegotiationAnnouncement* messages are defined in Annex C.

5.2.8.1 Negotiation between CMs without announcement

This procedure, illustrated in Figure 32, shall be used to negotiate between CMs based on request only message. After making coexistence decision, CM1 shall generate a *NegotiationRequest* message and shall send this *NegotiationRequest* message to CM2 which includes negotiation status and negotiation information, as defined in 6.3.

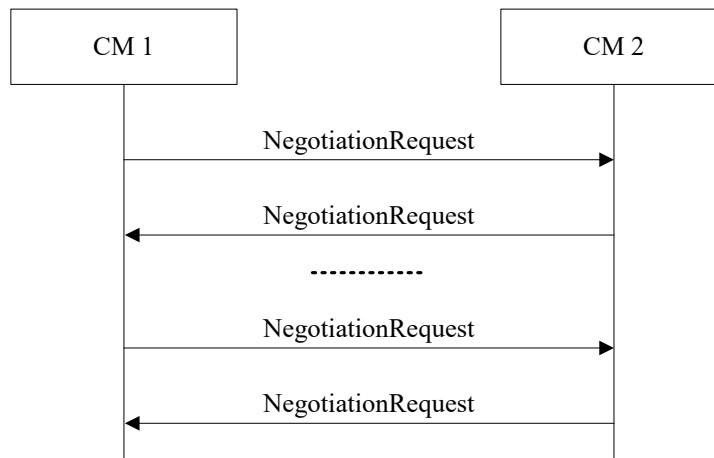


Figure 32 —Negotiations between CMs without announcement

After receiving the *NegotiationRequest* message from CM1, CM2 shall perform coexistence decision making, shall generate a *NegotiationRequest* message and shall send the *NegotiationRequest* message to CM1. When negotiation status in the *NegotiationRequest* message received from CM2 is successful, CM1 shall finish a negotiation. If not, CM1 shall perform decision making again and shall send the *NegotiationRequest* message to CM2.

NegotiationRequest message shall be exchanged between CM1 and CM2 until negotiation status is successful. The total number or time for request message exchanges between CM1 and CM2 shall be limited to save negotiation time. CM operations related to generating and sending a *NegotiationRequest* message are specified in 6.3.

After CM1 has received the *NegotiationRequest* message with negotiation status of success from CM2, CM1 shall process the *NegotiationRequest* message. CM operations related to processing the *NegotiationRequest* message are specified in 6.3.

5.2.8.2 Negotiation between CMs with announcement

This procedure, illustrated in Figure 33, shall be used to negotiate between CMs based on request and announcement messages. After making coexistence decision, each CM shall send and receive the *NegotiationRequest* message which includes negotiation status and negotiation information, as defined in 6.3.

When negotiation status in the *NegotiationRequest* message received from CM2 is successful, CM1 shall send a *NegotiationAnnouncement* message to notify list of winner CM ID and list of slot time position, as defined in 6.3. If not, CM1 shall perform coexistence decision making again and shall send the *NegotiationRequest* message to CM2.

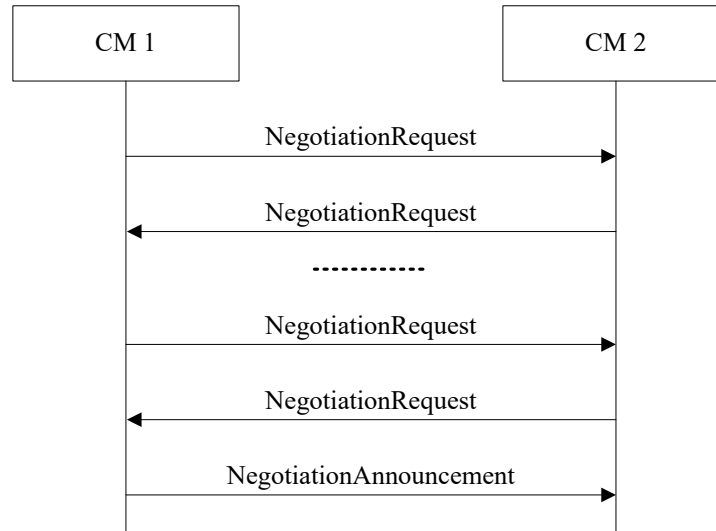


Figure 33—Negotiation between CMs with announcement

NegotiationRequest message shall be exchanged between CM1 and CM2 until negotiation status is successful. The total number or time for request message exchanges between CM1 and CM2 shall be limited to save negotiation time. CM operations related to generating and sending *NegotiationRequest* and *NegotiationAnnouncement* messages are specified in 6.3.

After CM2 has received *NegotiationAnnouncement* message from CM1, CM2 shall process the *NegotiationAnnouncement* message. CM operations related to processing the *NegotiationAnnouncement* message are specified in 6.3.

5.2.9 Master CM selection procedures

5.2.9.1 Master/slave CM selection procedure

A CM shall perform this procedure when the CM needs to select a master CM and a slave CM for centralized decision making. An illustrative example of this procedure is shown in Figure 34. *MasterCMRequest* and *MasterCMResponse* messages are defined in Annex C.

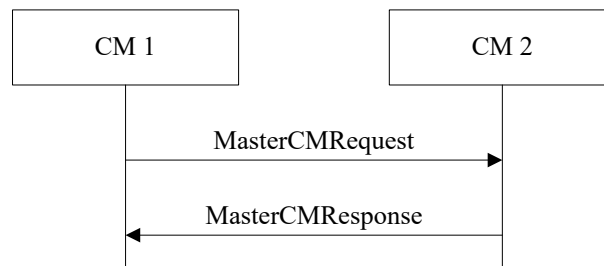


Figure 34—Master/slave CM selection procedure

CM operations related to generating and sending a *MasterCMRequest* message are specified in 6.3.

After CM2 receives the *MasterCMRequest* message from CM1, CM2 shall generate and send a *MasterCMResponse* message to CM1. CM operations related to generating and sending the *MasterCMResponse* message are specified in 6.3.

5.2.9.2 Master/slave CM configuration procedure

A CM shall perform this procedure when the CM needs to configure a master CM and a slave CM for centralized decision making. An illustrative example of this procedure is shown in Figure 35. *MasterSlaveCMConfigurationRequest* and *MasterSlaveCMConfigurationResponse* messages are defined in Annex C.

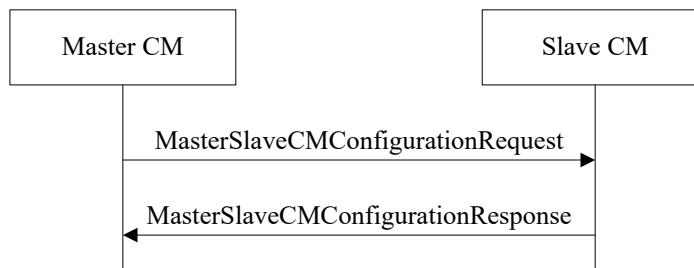


Figure 35—Master/slave CM configuration procedure

CM operations related to generating and sending the *MasterSlaveCMConfigurationRequest* message are specified in 6.3.

After another CM receives the *MasterSlaveCMConfigurationRequest* message from the CM, another CM shall generate and send the *MasterSlaveCMConfigurationResponse* message to the CE. CM operations related to generating and sending the Perform *MasterSlaveCMConfigurationResponse* message are specified in 6.3.

5.2.10 Reconfiguration procedures

5.2.10.1 WSO reconfiguration procedure

A CM shall perform the WSO reconfiguration procedure when it has generated a new coexistence decision that requires reconfiguration of one or several WSOs subscribed to management service and served by this CM. An illustrative example of this procedure is shown in Figure 36. The *ReconfigurationRequest* and *ReconfigurationResponse* messages are defined in Annex C.

After a CM has generated a new coexistence decision that requires reconfiguration of one or several WSOs subscribed to management service and served by this CM, the CM shall generate one or several *ReconfigurationRequest* messages. The number of *ReconfigurationRequest* messages is equal to the number of WSOs that require reconfiguration. If several WSOs are managed by the same RLSS, only one *ReconfigurationRequest* message is sent to RLSS. After the CM has generated the *ReconfigurationRequest* messages, the CM shall send these *ReconfigurationRequest* messages to the CE serving WSOs that require reconfiguration. CM operations related to generating and sending a *ReconfigurationRequest* message are specified in 6.3.

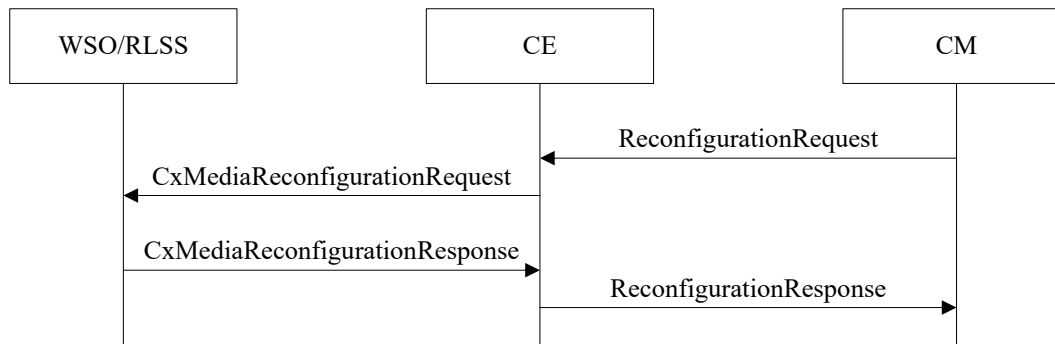


Figure 36—WSO reconfiguration procedure

After a CE has received the **ReconfigurationRequest** message from the CM, the CE shall perform requested reconfiguration of the WSO it serves, shall generate a **ReconfigurationResponse** message, and shall send this **ReconfigurationResponse** message to the CM. CE operations related to performing WSO reconfiguration, generating and sending a **ReconfigurationResponse** message are specified in 6.4.

After the CM has received the **ReconfigurationResponse** message from the CE, the CM shall process the **ReconfigurationResponse** message. CM operations related to processing a **ReconfigurationResponse** message are specified in 6.3.

5.2.10.2 Sending reconfiguration request from CM to another CM

A CM shall perform the sending reconfiguration request from CM to another CM procedure when CM1 has made a coexistence decision that requires reconfiguration of a WSO registered to CM2. An illustrative example of this procedure is shown in Figure 37. **CMReconfigurationRequest** and **CMReconfigurationResponse** messages are defined in Annex C.

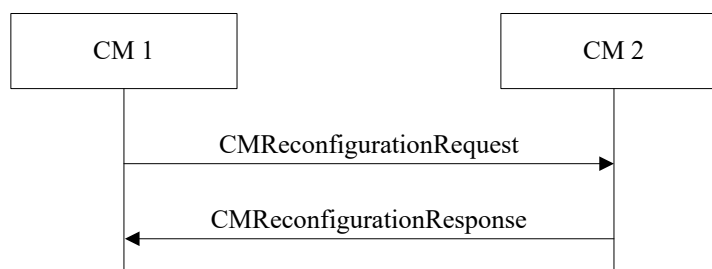


Figure 37—Sending reconfiguration request from CM to another CM

After making a coexistence decision of a WSO registered to CM2, CM1 shall generate a **CMReconfigurationRequest** message and shall send this **CMReconfigurationRequest** message to CM2. CM operations related to generating and sending a **CMReconfigurationRequest** message are specified in 6.3.

After CM2 has received a **CMReconfigurationRequest** message from CM1, CM2 shall perform WSO reconfiguration using the reconfiguration information in the **CMReconfigurationRequest** message, generate a **CMReconfigurationResponse** message, and shall send this **CMReconfigurationResponse** message to CM1. CM operations related to generating and sending a **CMReconfigurationResponse** message are specified in 6.3.

After CM1 has received a *CMReconfigurationResponse* message from CM2 to which it sent the *CMReconfigurationRequest* message, CM1 shall process the *CMReconfigurationResponse* message. CM operations related to processing a *CMReconfigurationResponse* message are specified in 6.3.

5.2.11 Event procedures

5.2.11.1 Sending event indication from CE to CM

A CE shall perform the sending event indication from CE to CM procedure in order to inform the CM about issues related to the WSO. With an event indication a CE notifies the CM about issues like degraded QoS and instance of surpassing signal-to-interference-plus-noise ratio (SINR) threshold. An illustrative example of this procedure is shown in Figure 38. *EventIndication* and *EventConfirm* messages are defined in Annex C.

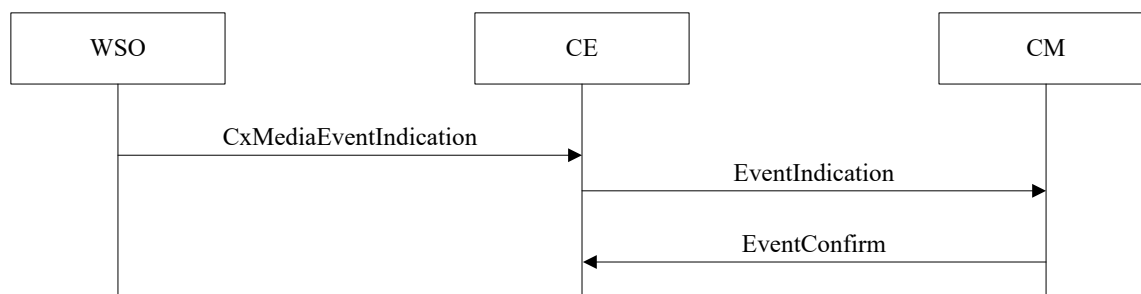


Figure 38—Sending event indication from CE to CM

Once a CE needs to inform the CM which serves it about an issue related to the WSO interfaced to the CE, the CE shall generate an *EventIndication* message and shall send this *EventIndication* message to the CM. CE operations related to generating and sending an *EventIndication* message are specified in 6.4.

After the CM has received an *EventIndication* message from the CE, the CM shall process the *EventIndication* message, generate an *EventConfirm* message and send this *EventConfirm* message to the CE as an acknowledgement. CM operations related to processing an *EventIndication* message, generating and sending an *EventConfirm* message are specified in 6.3.

After the CE has received the *EventConfirm* message from the CM, the CE shall process the *EventConfirm* message. CE operations related to processing an *EventConfirm* message are specified in 6.4.

5.2.11.2 Sending event indication from CM to another CM

A CM shall perform the sending event indication from CM to another CM procedure in order to inform the other CM about coexistence system related issue. An illustrative example of this procedure is shown in Figure 39. *EventIndication* and *EventConfirm* messages are defined in Annex C.

When CM1 wants to send an event indication to CM2, CM1 shall generate an *EventIndication* message and shall send this *EventIndication* message to CM2. CM operations related to generating and sending an *EventIndication* message are specified in 6.3.