Operations for Citizens Broadband Radio Service (CBRS); GAA Spectrum Coordination - Approach 2

Document WINNF-TR-2004

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Contents

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Contributors

The following individuals made significant contributions to this document:

Editor: Sho Furuichi (Sony), Zaheer Syed (CableLabs)

Other Member Representatives:

- Naotaka Sato (Sony)

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GAA Spectrum Coordination - Approach 2

1 Introduction

2 Scope

This Technical Report (TR) provides one of potential solutions of Spectrum Use Coordination for CBSDs operating on General Authorized Access (GAA) basis. Especially, this document focuses on Spectrum Use Coordination for GAA among different Coexistence Groups (CxGs) with the Autonomous Decision-Making topology.

This Technical Report (TR) summarizes one of the outcomes of the study.

3 References

3.1 Normative References

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

[n.1] WINNF-SSC-0011-V.1.0.0: "Spectrum Sharing Committee Policy and Procedure SSC Abbreviations and Definitions", Wireless Innovation Forum

3.2 Informative References

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

[i.1] West, D. B. (1996), Introduction to Graph Theory, Prentice-Hall.

[i.2] WINNF-TS-0112: "Requirements for Commercial Operation in the U.S. 3550-3700 MHz Citizens Broadband Radio Service Band", Wireless Innovation Forum

[i.3] CBRSA-TS-2001-V1.0.0: "CBRS Coexistence Technical Specification", CBRS Alliance™, February 1, 2018

[i.4] Electronic Code of Federal Regulations, Title 47, Chapter I, Subchapter D, Part 96, https://www.ecfr.gov/cgi-bin/text-idx?node=pt47.5.96

[i.5] WINNF-SSC-0010: "WInnForum Recognized CBRS Grouping Parameters", Wireless Innovation Forum

[i.6] WINNF-SSC-0002: "Signaling Protocols and Procedures for Citizens Broadband Radio Service (CBRS): WInnForum Recognized CBRS Air Interfaces and Measurements", Wireless Innovation Forum

[i.7] WINNF-TS-0016: "Signaling Protocols and Procedures for Citizens Broadband Radio Service (CBRS): Spectrum Access System (SAS) – Citizens Broadband Radio Service Device (CBSD) Interface Technical Specification", Wireless Innovation Forum

[i.8] WINNF-TS-0096: "Signaling Protocols and Procedures for Citizens Broadband Radio Service (CBRS): Spectrum Access System (SAS) – SAS Interface Technical Specification", Wireless Innovation Forum

[i.9] WINNF-SSC-0008: "Spectrum Sharing Committee Policy and Procedure; Coordinated Periodic Activities Policy", Wireless Innovation Forum

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NOTE 1: As for technical specifications published by WInnForum, the latest versions of the CBRS Baseline Standards (i.e. Release 1) apply.

NOTE 2: As for Policy and Procedure documents published by WInnForum, the latest versions of the documents apply.

4 Definitions and Abbreviations

4.1 Definitions

For the purposes of the present document, the acronyms and definitions given in [n.1] and the following apply. An acronym defined in the present document takes precedence over the definition of the same acronym, if any, in [n.1].

Autonomous Decision-Making: A decision-making topology where one Decision-Making Entity makes its decisions independently from another Decision-Making Entity.

Available Channel: A frequency channel where CBSD is allowed to use at its location without causing harmful interference to higher tiers.

Centralized Decision-Making: A decision-making topology where one Decision-Making Entity relegates its decisions to another Decision-Making Entity.

Distributed Decision-Making: A decision-making topology where one Decision-Making Entity makes its decisions in coordination with another Decision-Making Entity.

Spectrum Use Coordination: To reduce the potential for interference among CBSDs that operate in the same tier.

Recommended Channel: A frequency channel where a CBSD is suggested by its managing SAS to use at its location so as to reduce the potential for interference to/from other CBSDs that operate in the same tier.

4.2 Abbreviations

For the purposes of the present document, the abbreviations given in [n.1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in [n.1].

- CxG Coexistence Group
- CxM Coexistence Manager
- RAT Radio Access Technology
- SAS Spectrum Access System

5 Possible Functional Architecture and Decision-Making Topologies considering Coexistence Groups

5.1 Possible Scenarios of Spectrum Use Coordination for GAA considering Coexistence Groups

According to [i.2], CxG is defined to consist of one or more CBSDs that coordinate their own interference within the CxG according to a common interference management policy. Therefore, any GAA Users can establish its own CxG following their own interference management policy.

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EXAMPLE: In [i.3], CBRS Alliance™ defined its own CxG having interference management policy specific to LTE-TDD CBSDs.

CBSDs in a CxG could be managed by its own coordination entity for the Spectrum Use Coordination.

EXAMPLE: Within the CBRS Alliance™ CxG, Coexistence Manager (CxM) manages the use of spectrum among LTE-TDD CBSDs operating on GAA basis.

If a CxG does not own such coordination entity, it could relegate the Spectrum Use Coordination for the members of the CxG to its managing SAS.

With that, there are two possible scenarios of Spectrum Use Coordination for GAA considering CxGs as follows:

- **Scenario 1**: the SAS implements and operates both Intra-CxG Coordination Function and Inter-CxG Coordination Function;

- **Scenario 2**: a CxG owns and operates an Intra-CxG Coordination Function as a physical entity by itself and the SAS does not implement it. The SAS implements Inter-CxG Coordination Function and makes decisions cooperatively with the Intra-CxG Coordination Functions.

5.2 Possible Functional Architecture

5.2.1 Inter- and Intra-CxG Coordination Functions

Intra-CxG Coordination Function is a functional block that makes decisions about the Spectrum Use Coordination within a specific CxG according to the interference management policy of the CxG.

Inter-CxG Coordination Function is a functional block that makes decisions on the Spectrum Use Coordination among CBSDs belonging to different CxGs.

Inter- and Intra-CxG Coordination Functions can have decision-making capability concerning the following:

- Identification of Potential Interference Relationship between CBSDs
- Mitigation of Potential for Interference
- Generation of the Recommended Channel Information
- Interference Resolution

5.2.2 Possible Functional Architecture for Scenario 1

Figure 1 shows the possible logical functional architecture in the Scenario 1.

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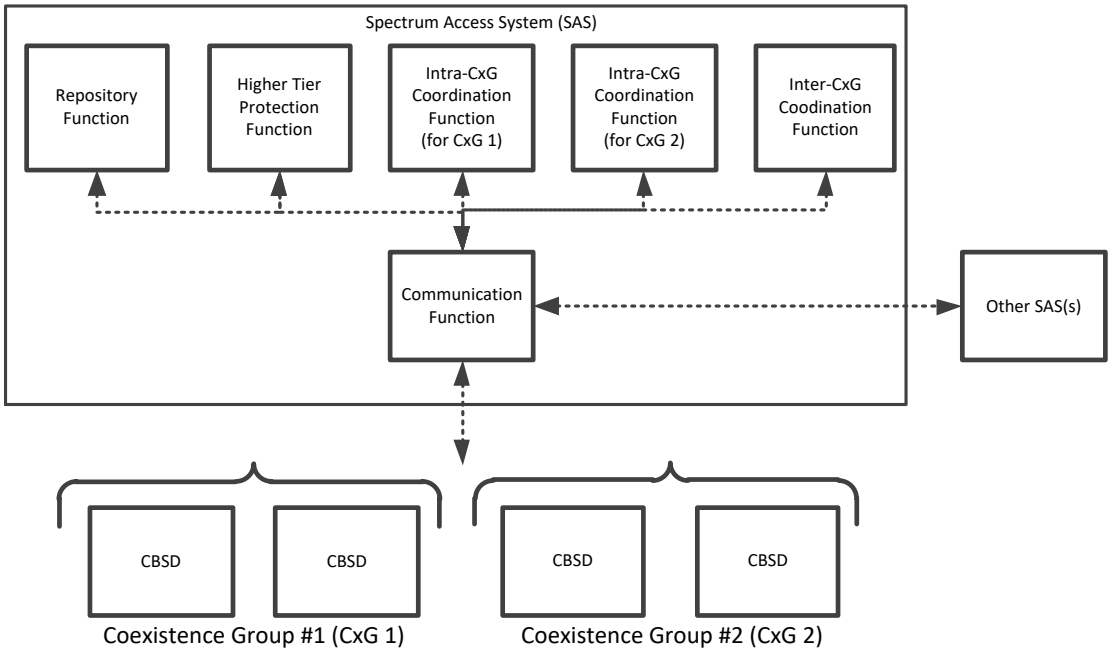

Figure 1: Possible Functional Architecture in Scenario 1

A SAS can consist of, at least, five types of functional blocks including Inter- and Intra-CxG Coordination Functions.

Communication function is a functional block that enables SAS to communicate with other entities, such as other SASs, CBSDs and so on by using the standardized (i.e. SAS-SAS and SAS-CBSD Protocols) and non-standardized means.

Repository Function is a functional block that stores, at least, data records specified in [i.6] and dataset retrieved from External Databases. Repository Function can also store the calculation results of Higher Tier Protection Function, Intra-CxG Coordination Function and Inter-CxG Coordination Function.

Higher Tier Protection Function is a functional block that executes Incumbent and Priority Access License (PAL) protection in accordance with the CBRS Baseline Standards (i.e. Rel.1) published by WInnForum.

5.2.3 Possible Functional Architecture for Scenario 2

Figure 2 shows the possible functional architecture in the Scenario 2.

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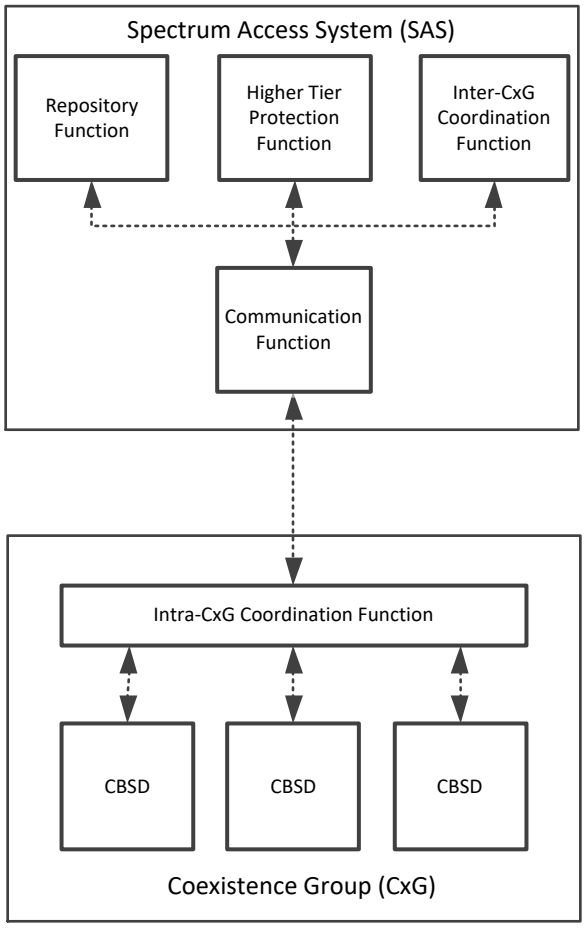

Figure 2: Possible Functional Architecture in Scenario 2

5.3 Possible Decision-Making Topologies

The following decision-making topologies could be applied to Spectrum Use Coordination for GAA:

- Autonomous
- Distributed
- Centralized

Autonomous Decision-Making could be applied when, for example, a SAS makes decisions on Spectrum Use Coordination for GAA independently from other SASs in Scenario 1.

Distributed Decision-Making could be applied when, for example, a SAS negotiates with other SASs about decisions and they try to reach reconciliation in Scenario 1.

Centralized Decision-Making could be applied when, for example, one SAS controls decision-making of one or more other SASs which do not have Inter- and Intra-CxG Coordination Functions. The SAS that controls the decision-making can be called a master SAS. The SASs that are controlled by a master SAS can be called a slave SAS in Scenario 1.

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Considering possibility of various CxGs in multi-SAS environment, it might be difficult to make "consistent" decisions among SASs or to reach agreements on the decisions. Therefore, the remainder of this document focuses on the Autonomous Decision-Making.

6 Possible Basic Principles and Solutions of Spectrum Use Coordination for GAA

6.1 Identification of Potential Interference Relationship between CBSDs

6.1.1 Possible Basic Principles

A SAS needs to identify the potential interference relationship between each pair of CBSDs belonging to different CxGs in order to find which CBSDs are to be coordinated.

NOTE: Potential interference relationship can be referred to as "edge" used in the Graph Theory [i.1].

The criteria applied by the Inter-CxG Coordination Function to determine if there is the potential interference relationship could be dependedent on the functional architecture.

In Scenario 1, the criteria could be dependent on the operational and interference management policy of the SAS or the CBSD Users.

In Scenario 2, the criteria could be dependent on the operational and interference management policy of the operator of the Intra-CxG Coordination Function.

6.1.2 Possible Basic Solution

SAS can utilize the following criteria to identify the potential interference relationship:

- Separation distance;
- Estimated CBSD coverage;
- Estimated interference at the received antenna port of the CBSD.

The factors listed below can be utilized by the SAS to calculate the above criteria:

- Registration information of the CBSDs
  - ➢ Installation parameters
    - ✧ Antenna location (i.e. latitude, longitude, height)
    - ✧ Antenna related information (i.e. orientation, antenna gain and pattern)
    - ✧ EIRP-capability declared by the CBSD
    - ✧ CBSD grouping information [i.5]
    - ✧ Air Interface information
      - Radio Access Technology (RAT) indicator
      - RAT-specific information
- Propagation models

NOTE 1: RAT-specific information is not defined and not supported in [i.6].

NOTE 2: No standardized propagation model exists for the purpose of the Spectrum Use Coordination for GAA. It could be dependent on the operational policy of CBSD, CBSD User, SAS or SAS Administrator.

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6.1.2.1 Separation Distance based Identification

One possible approach is to check the separation distance between two CBSDs. The SAS can identify the pairs of the CBSDs to be coordinated that are separated by less than the arbitrary threshold distance.

6.1.2.2 Estimated Coverage based Identification

The SAS can assess the degree of coverage overlap between two CBSDs and the SAS can determine if there is the potential interference relationship between them if the degree exceeds the coverage overlap criteria.

6.1.2.3 Estimated Received Interference based Identification

The SAS can estimate the potential interference at the received antenna port of the CBSD. The SAS can determine if there is the potential interference relationship between them if the estimated value exceeds the interference threshold.

6.2 Mitigation of Potential for Interference and Recommendation

6.2.1 Possible Basic Principles

Either or both of the following approaches could be taken for the purpose of mitigating the potential interference;

- Allocation of non-overlapping spectrum between two CBSDs.
- Suggestion for the maximum EIRP for the Grants of either or both CBSDs;

NOTE: In the latter approach, overlapping spectrum could be allocated to two CBSDs.

According to [i.7], a CBSD can retrieve a list of Available Channels from its managing SAS via the CBSD Spectrum Inquiry Procedure. Available Channel information (i.e. *AvailableChannel* object) contains the following information:

- Available frequency range at its location
- Maximum permissible EIRP in an available frequency range at its location

Similar to this concept, it is important for SAS to provide a list of Recommended Channels to a CBSD, which can be derived from the results of the mitigation of the potential for interference described in section 6.2. Recommended Channel information can contain the following information:

- Frequency range suggested by the SAS to use at its location
- Suggested maximum EIRP in a suggested frequency range at its location

These information can help for CBSDs to make Grant requests to the SAS.

6.2.2 Possible Basic Solutions

For the simplicity of explanation, the model described in Figure 3 is considered.

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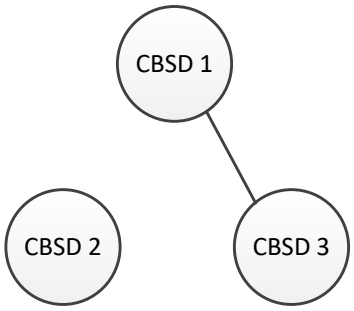

Figure 3: Assumed model

Figure 3 represents the followings:

- There are three CBSDs belonging to different CxGs (i.e. one CxG for each).
- A pair of CBSD 1 and CBSD 3 has potential interference relationship.
- CBSD 2 has no potential interference relationship with other CBSDs.

In this assumed model, for example, the Recommended Channels for each CBSD can be identified for the purpose of mitigating the potential for interference among them as shown in Figure 4, where 10 MHz channelization is assumed and the first channel is assumed not available for reason of Higher Tier Protection.

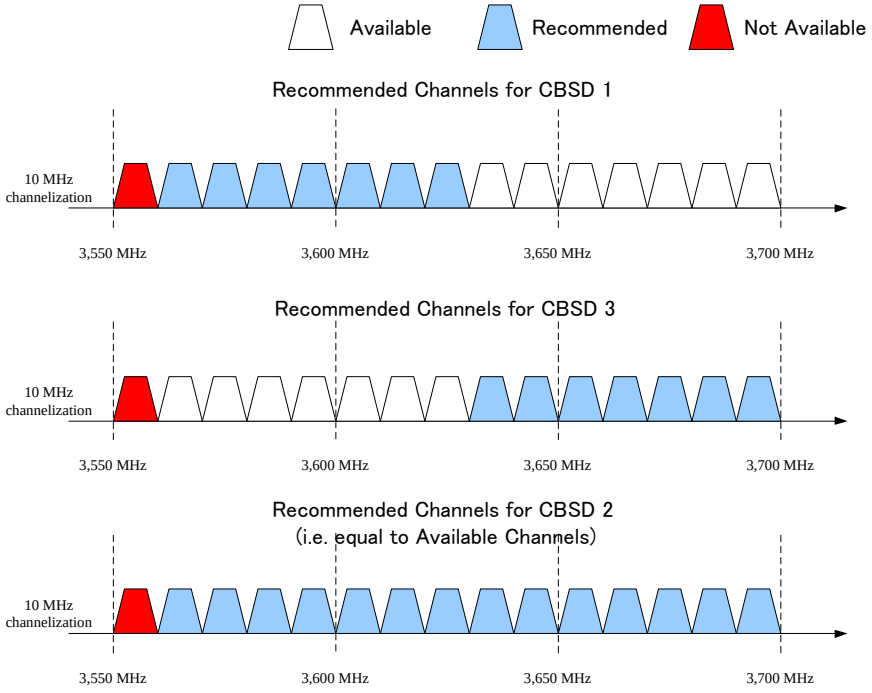

Figure 4: Example of Recommended Channels for Each CBSD

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If there are only a few amount of Available Channels or there are large number of CBSDs, it is difficult to partition the spectrum as shown in Figure 4. In this case, SAS can attempt to reduce the maximum EIRP of the Grants of the CBSDs for recommendation to reduce the potential for interference.

6.3 Interference Resolution

6.3.1 Possible Basic Principles

In Autonomous Decision-Making Topology, decision-making results on the Recommended Channel information could be differerent among SASs. In this situation, detection-based interference avoidance could be a possible basic principle for interference resolution.

6.3.2 Possible Basic Solutions

Measurement reports by CBSDs could be utilized by each managing SAS for its autonomous decision to resolve interference occurred at its managed CBSD. The possible solutions could be but are not limited to the following:

- Option 1: Authorize but Instruct Measurement Reporting

  During the CBSD Heartbeat Procedure, SAS authorizes the radio transmission of CBSD associated with the Grant, but can instruct to provide measurement report (RECEIVED_POWER_WITH_GRANT) using *measReportConfig* parameter. If no harmful interference is observed at the CBSD, no further action required. The CBSD can continue to use the Grant. If harmful interference is observed by the CBSD, the SAS can suggest another operation parameter based on the list of Recommended Channel for the CBSD. The CBSD can obtain new Grant and the Grant can be authorized by the SAS (within the constraint of headroom margin).

- Option 2: Terminate and Instruct Measurement Reporting

  During the CBSD Heartbeat Procedure, SAS terminates the Grant of CBSD, and instruct to provide measurement report (RECEIVED_POWER_WITHOUT_GRANT) using *measReportConfig* parameter. The measurement report can be provided through Spectrum Inquiry Request. The report can be useful for the SAS to choose new operation parameter for suggestion (i.e. Recommended Channel information).

7 Example Operations

This section describes example operations based on the possible basic principles and solutions.

According to [i.9], SAS Administrators agreed to run Coordinated Periodic Activities among SASs (CPAS) once a day for the purpose of the synchronized Higher Tier Protection calculation. Therefore, the following three time frames are considered to describe the example operations in the following sections.

- Time Frame 1: Before CPAS
- Time Frame 2: During CPAS
- Time Frame 3: After CPAS

7.1 Time Frame 1: Before CPAS

For the simplicity and brief consideration, it is assumed that a Repository Function in the SAS stores only the information retrieved from the External Databases in the beginning (i.e. no registered CBSDs, no Full Activity Dump records obtained from other SASs).

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7.1.1 Procedure Overview

In the daytime, CBSDs are registered with the SAS. During this CBSD Registration Procedure, CBSDs can declare its belonging to a specific CxG. Figure 5 shows the example deployment of the registered CBSDs.

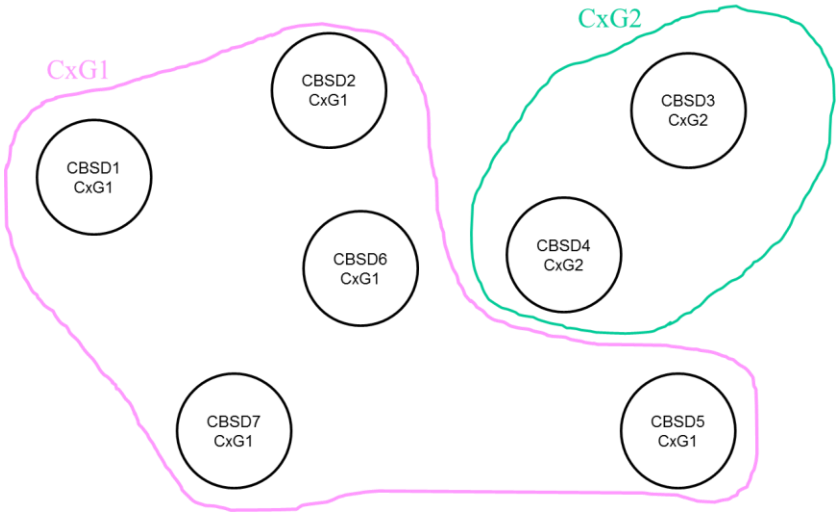

Figure 5: Example deployment of the registered CBSDs

In this example, CBSDs 1, 2, 5, 6 and CBSD 7 declare that they belong to CxG 1 and others declare that they belong to CxG 2, where CxG 1 and CxG 2 are different CxGs.

After the CBSD Registration Procedure, in both scenarios, the Inter-CxG Coordination Function can start identifying if the mutual interference among CxGs exists by using the registration information of the CBSDs. Figure 6 shows the example result of mutual interference identification.

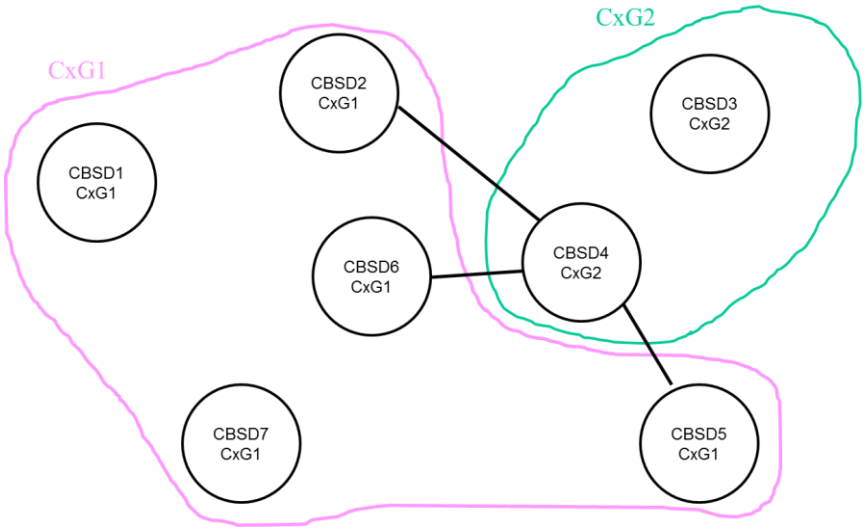

Figure 6: Example of identified potential interference relationship between two CxGs

In this example, the solid line represents that there is potential interference relationship between CBSDs belonging to different CxGs.

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Figure 7 shows the example result of the mutual interference identification by each Intra-CxG Coorindation Function, where dashed line represents the mutual interference in CxG 1 and dot-dashed line represents the mutual interference in CxG 2.

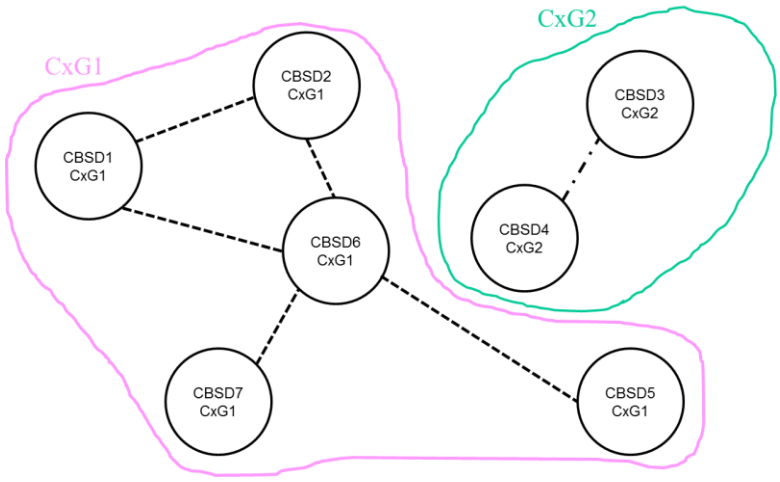

Figure 7: Example of identified potential interference relationship by Intra-CxG Coordination Function

Based on the identified potential interference relationship, the Inter- and the Intra-CxG Coordination Functions can cooperatively provide the Recommended Channel information to CBSDs through the CBSD Spectrum Inquiry Procedure. CBSDs can use the Recommended Channel information to choose the desired operational parameters for the Grant request.

After receiving the Registration Response Message, the CBSDs can initiate the Spectrum Inquiry Procedure anytime by sending the Spectrum Inquiry Request Message. In the Scenario 1, the message is sent to the SAS directly. In the Scenario 2, the message can be sent to the SAS indirectly via the managing Intra-CxG Coordination Function.

After receiving the Spectrum Inquiry Request Message, the Higher Tier Protection Function assesses the availability of the inquired spectrum to generate the list of Available Channels (i.e. the *availableChannel* parameter whose type is array of *AvailableChannel* object). The Higher Tier Protection Function can pass the list of Available Channels to the Inter-CxG Coordination Function via the SAS-internal interface (i.e. Interface Function). The Inter-CxG Coordination Function can modify the list of Available Channels to generate the list of Recommended Channels in considering the identified potential interference relationship among different CxGs.

In the Scenario 1, the Inter-CxG Coordination Function can pass the list of Allocable Channels to the Intra-CxG Coordination Function via the SAS-internal interface so that the Intra-CxG Coordination Function further modifies the list of Recommended Channels by considering the identified potential interference relationship within its managed CxG. Then, the list of Recommended Channels (i.e. modified *availableChannel* parameter) can be provided to the CBSDs by using the Spectrum Inquiry Response Message. Figure 8 describes this process flow.

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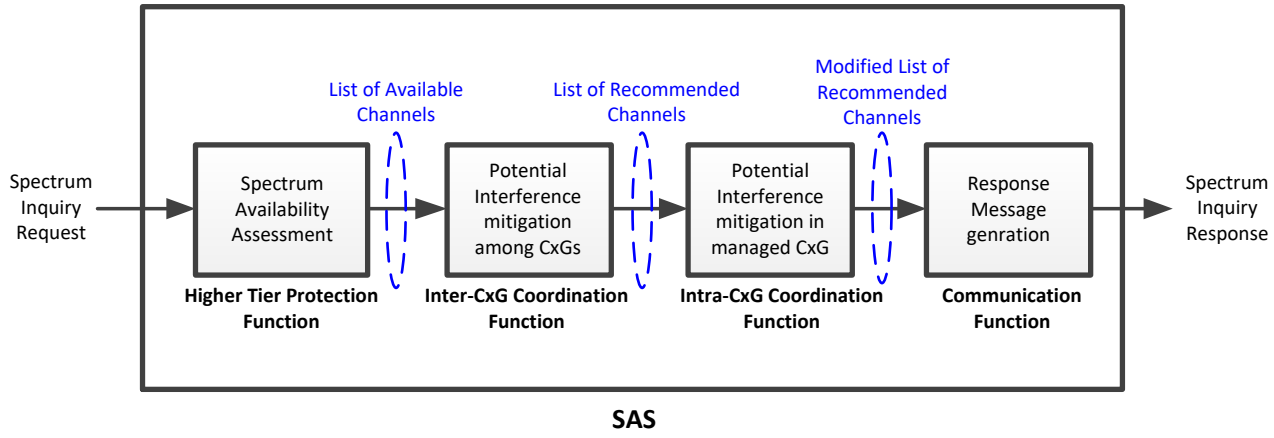

Figure 8: Example Process for CBSD Spectrum Inquiry Procedure in Scenario 1

In the Scenario 2, the Spectrum Inquiry Response Message containing the list of Recommended Channels (i.e. the *availableChannel* parameter modified by the Inter-CxG Coordination Function) is sent to the Intra-CxG Coordination Function. Before forwarding the message to the CBSDs, the Intra-CxG Coordination Function can modify the list of Recommended Channels by considering the identified potential interference relationship within its managed CxG.

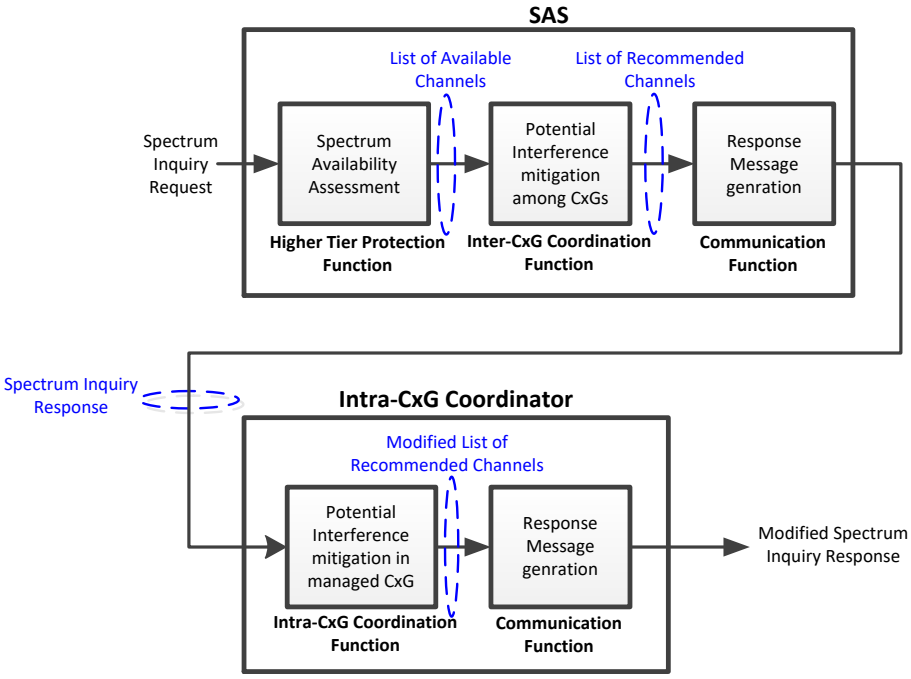

Figure 9: CBSD Spectrum Inquiry Procedure in Scenario 2

After completing the CBSD Spectrum Inquiry Procedure, CBSDs can initiate the CBSD Grant Procedure by using the Recommended Channel information. After approval of the Grant request, the CBSD can send the Heartbeat Request Message for authorization. If there is headroom interference margin or the CBSD is not

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located in any neighborhood of protected entities (e.g. incumbents), the SAS can authorize the radio transmission associated with the Grants. Otherwise, the SAS cannot authorize the radio transmission associated with the Grants. The CBSDs needs to wait until the completion of the very next CPAS.

7.1.1.1 Example List of Recommended Channels

After receiving the Spectrum Inquiry Request Message, the Inter-CxG Coordination Function generates the list of Recommended Channels by using the list of Available Channels provided by the Higher Tier Protection Function. In this process, the Inter-CxG Coordination Function considers the potential interference mitigation between different CxGs.

If the identified potential interference relationship can be described as Figure 6, example list of Recommended Channels can be described as Figure 10.

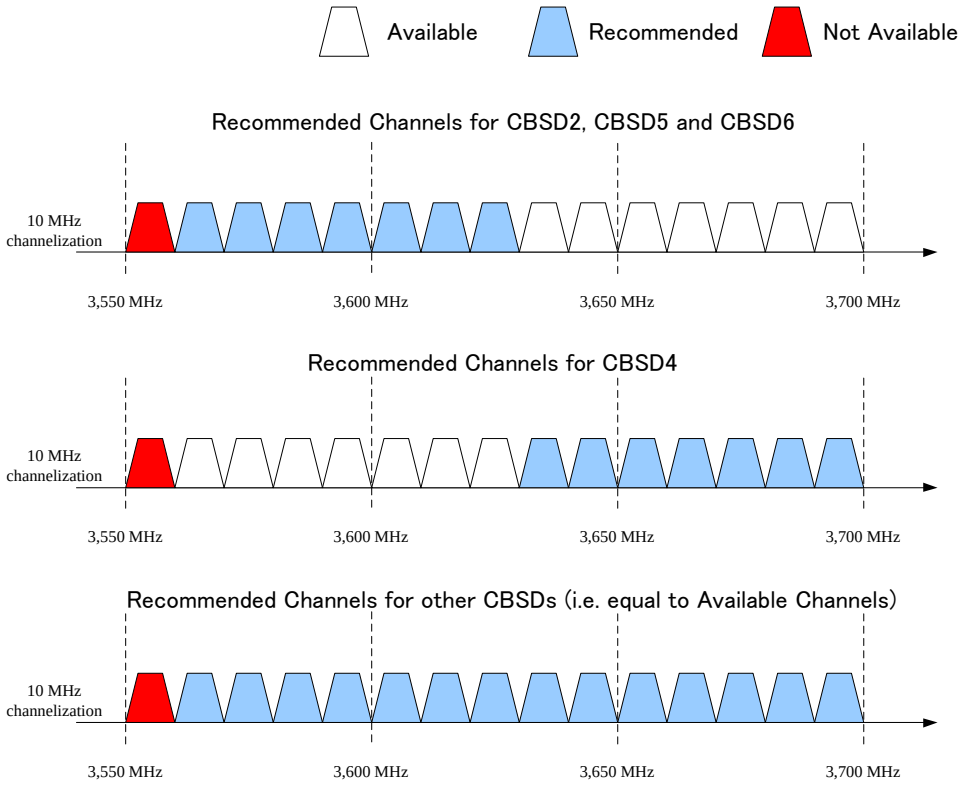

Figure 10: Example Allocable Channels for CBSDs

By using this list of Recommended Channels, the Intra-CxG Coordination Function can determine the spectrum allocation within its managed CxG so as to mitigate the potential for interference among the CBSDs belonging to the CxG. This spectrum allocation result can be provided to the CBSDs as a modified list of Recommended Channels. The CBSDs make Grant requests by using the list of Recommended Channels and get approval from their managing SAS.

7.1.2 Time Frame 2: During CPAS

In the beginning of CPAS, all SASs exchange Full Activity Dump Message for the purpose of higher tier protection calculation synchronized with others. Full Activity Dump record contains the Record of CBSDs which are registered with other SAS and have one or more Grants. Therefore, the Inter-CxG Coordination Function and the Intra-CxG Coordination Functions can attempt to identify the CBSDs which could receive

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interference from other CBSDs managed by other SASs. In this identification process, Inter-CxG Coordination Function and Intra-CxG Coordination Function can utilize the coverage information of the CBSDs managed by other SASs if available. Even if not available, they can estimate it.

Figure 11 shows the overall mutual interference relationship in considering the CBSDs managed by other SAS, where CBSDs 8 and 9 (dot-circles) are managed by other SASs which are identified as the potential interferers to the CBSDs 7 and 4 respectively, and where each color represents a specific GAA Resource used by each CBSD. Inter-CxG Coordination Function can either determine new suggested operational parameters of CBSD4 based on the principles described in section 6.2.1 or rely on interference resolution as described in section 7.1.3. For Scenario 2, SAS would need to provide some of CBSD8 information to Intra-CxG Coordination Function for help of interference resolution which could be performed after CPAS (section 7.1.3). Detail of such information is outside the scope of this TR.

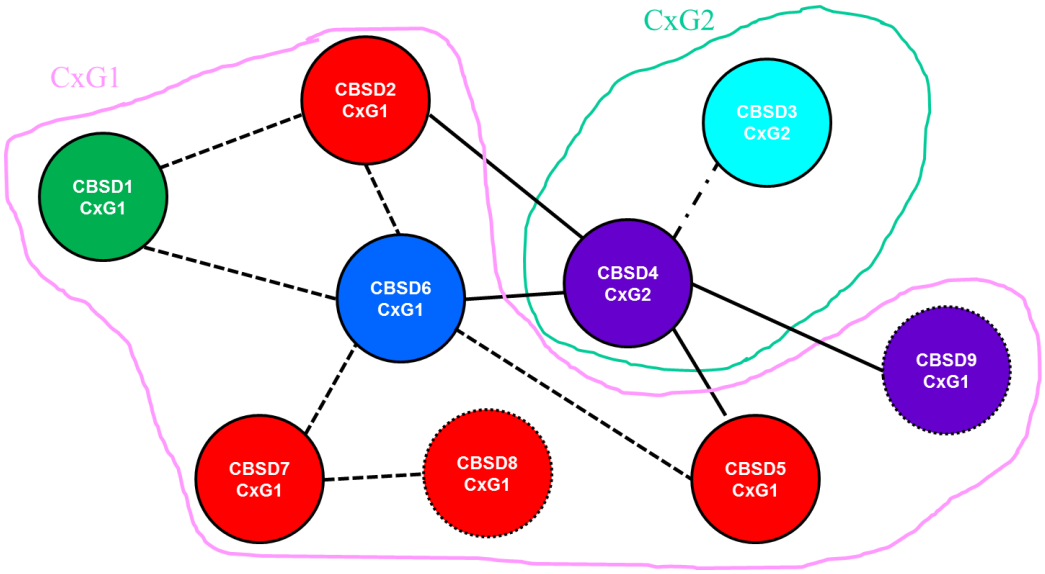

Figure 11: Overall Interference Relationship in considering the CBSDs managed by other SASs

7.1.3 Time Frame 3: After CPAS

After the CPAS, the SAS (i.e. Higher Tier Protection Function) can authorize the Grants of CBSDs subject to the results of CPAS. For the simplicity, it is assumed in this section that the SAS (i.e. Higher Tier Protection Function) does not need to terminate all the Grants for the purpose of higher tier protection.

Inter-CxG Coordination Function can either provide new suggested operational parameters to CBSD4 if it determined the parameters in during CPAS (section 7.1.2) or utilize either of options described in 6.3.2 for interference resolution of CBSD4.

Both options described in 6.3.2 can be utilized also by Intra-CxG Coordination Function for the potential interference resolution of CBSD 7.

After the interference resolution, the Time Frame 1 operation is repeated, but basically the potential interference relationship is newly identified only for new entrant CBSDs with the existing CBSDs and other new entrant CBSDs.

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8 Document History

Document history		
V1.0.0	16 May 2019	▪ Initial Release

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