IEEE 802.19.1a
Wireless Coexistence

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| Proposed resolution to CID 11 for D1.0Spectrum allocation considering interference aggregation effect |
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Abstract

This contribution provides resolutions to comment CID 109.

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| Comment ID | **Page No.** | **Section** | **Line No.** | **Type (General, Editorial, Technical)** | **Comments** | **Proposed changes** |
| 11 | 180 | 7.2.2.19 | 4 | Technical | The spectrum allocation only considers the relationship among GCOs (interference among each other). However, different GCO spectrum allocation solutions, even under the spectrum availability limit, incur different aggregate interference levels at the reference point. This should have been considered |  |

6.3.4.14 Obtaining operating frequency information procedure

When a CM requires to obtain operating frequency information of GCOs that are served by the other CM, the CM shall perform the obtaining operating frequency information procedure described in 5.2.18. The CM shall generate and send the ***OperatingFreqInformationRequest*** message to the other CM.

The following table shows ***CxMessage*** fields in ***OperatingFreqInformationRequest*** message.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***header*** | ***CxHeader*** | ***requestID*** |
| ***payload*** | ***CxPayload*** | ***operatingFreqInformationRequest*** |

The following table shows ***OperatingFreqInformationRequest*** payload element.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***cmID*** | ***CxID*** | CM ID |
| ***region*** | ***Region*** | Shall be set to indicate the geographical region where CM would like to obtain operating frequency information of GCOs. |
| ***targetGCOForSpectrumAllocation*** | ***GCODescriptor*** | Optional. If present, this parameter shall describe the profile of a target GCO for obtaining spectrum allocation supporting information given by another CM. |
| ***listOfSpecUsageInfoOfRefPoints*** | ***ListOfSpecUsageInfo*** | Optional. If present, this parameter shall describe the reference point information including location and spectrum. |

After the CM has received a ***OperatingFreqInformationRequest*** message from the other CM, the CM shall process this ***OperatingFreqInformationRequest*** message. The CM shall generate and send the ***OperatingFreqInformationResponse*** message to the source CM.

The following table shows ***CxMessage*** fields in ***OperatingFreqInformationResponse*** message.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***header*** | ***CxHeader*** | ***requestID*** |
| ***payload*** | ***CxPayload*** | ***operatingFreqInformationResponse*** |

The following table shows ***OperatingFreqInformationResponse*** payload element.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***status*** | ***Status*** | status |
| ***listOfCoexistenceReports*** | ***ListOfCoexistenceReports*** | Shall be set to indicate the operating frequency information corresponding to the region information included in the *OperatingFreqInformationRequest*. No need to be included when “status” shows error or rejected. |
| ***specAllocationSupportingInfo*** | ***SpecAllocationSupportingInfo*** | Shall be set to indicate the information supporting the spectrum allocation decision making for a target GCO, if and only if parameter ***targetGCOForSpectrumAllocation*** and/or parameter ***listOfSpecUsageInfoOfRefPoints*** are present in the request message. |

The following table shows ***ListOfCoexistenceReports*** information element.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***region*** | ***Region*** | Shall be set to indicate the region that GCOs are operating within. |
| ***listOfOperatingFrequencies*** | ***ListOfOperatingFrequencies*** | Shall be set to indicate the operating frequencies of the GCOs as specified in the below table. |

The following table shows ***ListOfOperatingFrequencies*** information element.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***frequencyRange*** | ***FrequenyRange*** | Shall be set to indicate the frequency range in which the GCO currently operates.  |

The following table shows ***specAllocationSupportingInfo*** information element.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***specAllocationCoefficient*** | ***REAL*** | Shall be set to indicate spectrum allocation coefficient a pair of a target GCO and an operating GCO as defined in 7.2.2.xx. |
| ***gcoSpecAllocation*** | ***ListOfOperatingFrequencies*** | Shall be set to indicate existing operating frequencies of operating GCO as defined in 7.2.2.xx. |

6.3.4.15 Obtaining operating frequency information procedure over COE

When a CM requires to obtain operating frequency information of GCOs that are served by the other CM within different coexistence system, the CM shall perform the obtaining operating frequency information procedure over COE described in 5.2.19. The CM shall generate and send the ***OperatingFreqInformationRequest*** message to the COE within the same coexistence system.

The following table shows ***CxMessage*** fields in ***OperatingFreqInformationRequest*** message.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***header*** | ***CxHeader*** | ***requestID*** |
| ***payload*** | ***CxPayload*** | ***operatingFreqInformationRequest*** |

The following table shows ***OperatingFreqInformationRequest*** payload element.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***cmID*** | ***CxID*** | CM ID |
| ***region*** | ***Region*** | Shall be set to indicate the geographical region where CM would like to obtain operating frequency information of GCOs. |
| ***targetGCOForSpectrumAllocation*** | ***GCODescriptor*** | Optional. If present, this parameter shall describe the profile of a target GCO for obtaining spectrum allocation supporting information given by another CM. |
| ***listOfSpecUsageInfoOfRefPoints*** | ***ListOfSpecUsageInfo*** | Optional. If present, this parameter shall describe the reference point information including location and spectrum. |

After the CM has received a ***OperatingFreqInformationRequest*** message from the other CM via the COE within the same coexistence system, the CM shall process this ***OperatingFreqInformationRequest*** message. The CM shall generate and send the ***OperatingFreqInformationResponse*** message to the source CM via the COE within the same coexistence system.

The following table shows ***CxMessage*** fields in ***OperatingFreqInformationResponse*** message.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***header*** | ***CxHeader*** | ***requestID*** |
| ***payload*** | ***CxPayload*** | ***operatingFreqInformationResponse*** |
| ***specAllocationSupportingInfo*** | ***SpecAllocationSupportingInfo*** | Shall be set to indicate the information supporting the spectrum allocation decision making for a target GCO, if and only if parameter ***targetGCOForSpectrumAllocation*** and/or parameter ***listOfSpecUsageInfoOfRefPoints*** are present in the request message. |

The following table shows ***OperatingFreqInformationResponse*** payload element.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***status*** | ***Status*** | status |
| ***listOfCoexistenceReports*** | ***ListOfCoexistenceReports*** | Shall be set to indicate the operating frequency information corresponding to the region information included in the *OperatingFreqInformationRequest*. No need to be included when “status” shows error or rejected. |

The following table shows ***ListOfCoexistenceReports*** information element.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***region*** | ***Region*** | Shall be set to indicate the region that GCOs are operating within. |
| ***listOfOperatingFrequencies*** | ***ListOfOperatingFrequencies*** | Shall be set to indicate the operating frequencies of the GCOs as specified in the below table. |

The following table shows ***ListOfOperatingFrequencies*** information element.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***frequencyRange*** | ***FrequenyRange*** | Shall be set to indicate the frequency range in which the GCO currently operates.  |

The following table shows ***specAllocationSupportingInfo*** information element.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***specAllocationCoefficient*** | ***REAL*** | Shall be set to indicate spectrum allocation coefficient a pair of a target GCO and an operating GCO as defined in 7.2.2.xx. |
| ***gcoSpecAllocation*** | ***ListOfOperatingFrequencies*** | Shall be set to indicate existing operating frequencies of operating GCO as defined in 7.2.2.xx. |

Proposed to add the following section

7.2.2.xx Algorithm for spectrum allocation considering interference aggregation effect at reference points

7.2.2.xx.1 Introduction

Spectrum allocation of GCOs shall consider the interference aggregation effect at the reference point. The reference point can be location where a GCO with a higher spectrum access right that needs protection from the GCOs with a lower spectrum access right. The reference point can also be the victim reference point at the incumbent service area, which is the closest location to the target GCO. Spectrum allocation considering only the interference among GCOs might bring high interference level at the reference point due to the aggregation effect. This might lead to the situation where the interference margin at the reference point is reduced thus prohibiting new GCOs from sharing the spectrum.

7.2.2.xx.2 Interference aggregation effect coefficient

As shown in Figure xx, there are three GCOs managed by two different CMs. GCOs 1 and 2 are managed by CM1 GCO3 is managed by CM2. From the figure it can be seen that GCOs 2 and 3 are far from each other but they are both close to the reference point 1. If spectrum allocation is done considering the interference among GCOs, GCO2 and GCO3 will probability be assigned to the same channel. However, since they are close to reference point 1 the interference level at the reference point will be high due to the aggregate effect. Such effect is described by the spectrum allocation coefficient $w\_{ij}$, for example assuming equal transmit power, as

$$w\_{ij}=\frac{1}{L\_{iP\_{k}}^{α}}+\frac{1}{L\_{jP\_{k}}^{α}}$$

where *i* and *j* are the index of the GCO, *Pk* is the index of the reference point and *α* is the pathloss exponent. The high coefficient value means a high aggregate interference effect of a pair of GCOs.



**Figure XX Scenario of the aggregate interference effect**

In a situation of multiple CMs as shown in the figure, before one CM chooses a particular channel for a target GCO from the available channels, this CM can send the location with/without reference point information to another CM. The recipient CM will calculate the coefficients between the target GCO with other GCOs that are managed by the recipient CM. After that the recipient CM will send back the coefficient for different pairs of GCOs and channel utilization of the existing GCOs. For example as shown in Figure XX. If CM1 sends location of GCO2 to CM2. CM2 will return $w\_{23}$ and channel utilization of GCO3. Then, CM1 can opt to use same or different channel that is used by GCO3 for GCO2 based on the value of $w\_{23}$.

Using the coefficient in the resource allocation in the graph based resource allocation, the coefficient can be used as the weight on the edge. Given the channel utilization information of the existing GCOs and the spectrum allocation coefficient, the spectrum allocation will result in allocating different channels to a pair of GCOs that have a high coefficient. Such procedure will reduce the aggregate interference level at the reference points. Thus, when accommodating new GCOs the information exchange between CMs for adjusting existing GCOs is reduced.

7.2.2.19.3 Algorithm description

The processes are as shown in Figure YY.

* P#1
P#1 is the procedure operated at the CDIS where the CDIS receives the location information of the GCO through the GCO registration procedure as specified in 5.2.3.1.
* P#2
In this process, if one CM needs to determine the spectrum allocation of a target GCO, this CM uses the location information of its managing operating GCOs to determine the spectrum allocation coefficient.
* P#3

In this process, the CM sends the ***targetGCOForSpectrumAllocation*** parameter of the target GCO with or without its reference point to the other CMs requesting calculation of spectrum allocation coefficient through the 5.2.18 Obtaining operating frequency information procedure or 5.2.19 Obtaining operating frequency information procedure over coordination enabler (COE).

* P#4

Then the recipient CMs determine the pairs of target GCO with other GCOs managed by the recipient CM. Then, based on the GCOs location and the reference point the spectrum allocation coefficient can be determined.

* P#5
In this process, the recipient CMs send back the ***specAllocationSupportingInfo*** for each pair GCOs including the target GCO and the GCO managed by the recipient through 5.2.18 Obtaining operating frequency information procedure or 5.2.19 Obtaining operating frequency information procedure over coordination enabler (COE). The spectrum utilization of the GCO managed by the recipient CM is also fed back together with the spectrum allocation coefficient for each pair.
* P#6
Allocate the spectrum of the target GCO avoiding using the same channels as of the existing GCOs.
* P#7
The channel assignment result will be sent in GCO Reconfiguration Procedure in 5.2.10.1.
* P#8
No configuration is made.

The branch conditions are as follows.

* BC#1
This branch condition shall be conducted based on the information of GCOs registered at the CDIS. If coexistence is needed, go to BC#2. If not go to P#6. No reconfiguration is needed.
* BC#1
This branch condition shall be conducted based on association of CMs. If there are multiple CMs, go to P#3. If not, go to P#2.



**Figure YY Algorithm of spectrum allocation considering interference aggregation effect**

Add new data type

A2.2 Profile 3

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--Spectrum allocation Supporting Information

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--Spectrum allocation supporting information

SpecAllocationSupportingInfo ::= SEQUENCE {

 --Spectrum allocation coefficient indicates the interference aggregation effect of a pair of a target GCO and an existing GCO

 spectrumAllocationCoefficient REAL,

 --existing GCO spectrum allocation information gives the spectrum allocation of the GCO as in a given pair

 gcoSpecAllocation ListOfOperatingFrequencies

 }

Revise the message as follows

-- OperatingFreqInformationRequest

OperatingFreqInformationRequest ::= SEQUENCE {

--CM ID

cmID CxID,

--region information

region Region,

--target GCO for spectrum allocation

targetGCOForSpectrumAllocation GCODescriptor OPTIONAL,

--reference point information including location and spectrum

listOfSpecUsageInfoOfRefPoints ListOfSpecUsageInfo OPTIONAL

}

-- OperatingFreqInformationResponse

OperatingFreqInformationResponse ::= SEQUENCE {

--Status of request processing

status Status,

--List of coexistence reports

listOfCoexistenceReports ListOfCoexistenceReports,

--supporting information for spectrum allocation

specAllocationSupportingInfo SpecAllocationSupportingInfo

}