IEEE 802.19.1a
Wireless Coexistence

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| --- |
| CID12 resolution: Text proposal on algorithm for selection of candidate serving CMs for moving GCOs |
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Abstract

This contribution provides comment resolution on CID12. This text proposal includes new algorithm of coexistence management based on 802.19.1 standard and approved text, which introduces new parameter of *candidate* *serving CMs*.



=================== Text starts here ==========================

1. Entity operation
	1. CM operation
		1. Profile 3

**6.3.4.5 ~~WSO~~GCO registration**

*Revise the table of* ***RegistrationResponse*** payload element.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***status***  | ***Status***  | status  |
| ***registrationUpdateDuration***  | ***REAL***  | Optionally present. This value shall be set to indicate the registration update duration if the CM/CDIS needs regular update.  |
| ***listOfCandidateServingCMs*** | ***ListOfCandateServingCMs*** | This parameter may be set to indicate the list of recommended candidate serving CMs for GCO if the corresponding Registration Request includes *mobilityInformation*. |

The following table specifies ***ListOfCandidateServingCMs*** parameter element.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***cmID*** | ***CxID*** | Shall be set to indicate the ID of candidate serving CM recommended for the GCO |
| ***arrivalTime*** | ***GeneralizedTime*** | Shall be set to indicate the estimated arrival time of GCO at the serving area of the candidate serving CM |
| ***residenceDuration*** | ***REAL*** | Shall be set to indicate the estimated residence duration of GCO within the serving area of the candidate serving CM |
| ***selectionPriorityLevel*** | ***INTEGER***  | Shall be set to indicate the selection priority level in serving CM selection, where the level shall be determined based on its estimated amount of available resource for the GCO. |

**6.3.4.6 ~~WSO~~GCO registration update**

*Revise the table of* ***RegistrationResponse*** payload element.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***status***  | ***Status***  | status  |
| ***registrationUpdateDuration***  | ***REAL***  | Optionally present. This value shall be set to indicate the registration update duration if the CM/CDIS needs regular update.  |
| ***listOfCandidateServingCMs*** | ***ListOfCandateServingCMs*** | This parameter may be set to indicate the list of candidate serving CMs for GCO if the corresponding Registration Request includes *mobilityInformation*. |

The following table specifies ***ListOfCandidateServingCMs*** parameter element.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***cmID*** | ***CxID*** | Shall be set to indicate the ID of candidate serving CM recommended for the GCO |
| ***arrivalTime*** | ***GeneralizedTime*** | Shall be set to indicate the estimated arrival time of GCO at the serving area of the candidate serving CM |
| ***residenceDuration*** | ***REAL*** | Shall be set to indicate the estimated residence duration of GCO within the serving area of the candidate serving CM |
| ***selectionPriorityLevel*** | ***INTEGER***  | Shall be set to indicate the selection priority level in serving CM selection, where the level shall be determined based on its expected amount of available resource for the GCO. |

**6.3.4.12 Inter-CM association procedure**

*Revise the table of* ***InterCMAssociationRequest*** payload element.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***cmID***  | ***CxID***  | Shall be set to indicate CM ID  |
| ***managementRegion***  | ***Region***  | Shall be set to indicate the geographical region that CM manages, if available.  |
| ***listOfMovingGCOs*** | ***ListOfMovingGCOs*** | Shall be set to indicate the information of moving GCOs, which are estimated to move within the serving area of the CM |
| ***listOfCandidateServedGCOs*** | ***ListOfCandidateServedGCOs*** | Shall be set to indicate the information of moving GCOs, for which the CM is selected as candidate serving CM |

The following table specifies ***ListOfMovingGCOs*** parameter element.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***gcoID*** | ***CxID*** | Shall be set to indicate the ID of moving GCO |
| ***arrivalTime*** | ***GeneralizedTime*** | Shall be set to indicate the estimated arrival time of GCO at the serving area of CM |
| ***residenceDuration*** | ***REAL*** | Shall be set to indicate the estimated residence duration of GCO within the serving area of CM |
| ***desiredBandwidth*** | ***REAL*** | Shall be set to indicate the desired bandwidth [MHz] of GCO |

The following table specifies ***ListOfCandidateServedGCOs*** parameter element.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***gcoID*** | ***CxID*** | Shall be set to indicate the ID of moving GCO |
| ***mobilityInformation***  | ***MobilityInformation***  | Shall be set to indicate the GCO mobility information |
| ***desiredBandwidth*** | ***REAL*** | Shall be set to indicate the desired bandwidth [MHz] of GCO |

*Revise the table of* ***InterCMAssociationResponse*** payload element.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***status***  | ***Status***  | status  |
| ***listOfAccessibleCM***  | ***ListOfAccessibleCM***  | Optionally present to indicate list of the accessible CM. If the CM cannot accept the request, accessible CM information may be included in this message.  |
| ***listOfEstimatedAvailableBandwidth*** | ***ListOfEstimatedAvailableBandwidth*** | Shall be set to indicate the estimated amount of available resource for the GCOs, which are estimated to move within the serving area of the CM |

The following table specifies ***listOfEstimatedAvailableBandwidth*** parameter element.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***gcoID*** | ***CxID*** | Shall be set to indicate the ID of moving GCO |
| ***estimatedBandwidth*** | ***REAL*** | Estimated available bandwidth [MHz] for the moving GCO |

**6.3.4.13 Inter-CM association procedure over COE**

*Revise the table of* ***InterCMAssociationRequest*** payload element.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***cmID***  | ***CxID***  | Shall be set to indicate CM ID  |
| ***managementRegion***  | ***Region***  | Shall be set to indicate the geographical region that CM manages, if available.  |
| ***listOfMovingGCOs*** | ***ListOfMovingGCOs*** | Shall be set to indicate the information of moving GCOs, which are estimated to move within the serving area of the CM |
| ***listOfCandidateServedGCOs*** | ***ListOfCandidateServedGCOs*** | Shall be set to indicate the information of moving GCOs, for which the CM is selected as candidate serving CM |

The following table specifies ***ListOfMovingGCOs*** parameter element.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***gcoID*** | ***CxID*** | Shall be set to indicate the ID of moving GCO |
| ***arrivalTime*** | ***GeneralizedTime*** | Shall be set to indicate the estimated arrival time of GCO at the serving area of CM |
| ***residenceDuration*** | ***REAL*** | Shall be set to indicate the estimated residence duration of GCO within the serving area of CM |
| ***desiredBandwidth*** | ***REAL*** | Shall be set to indicate the desired bandwidth [MHz] of GCO |

The following table specifies ***ListOfCandidateServedGCOs*** parameter element.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***gcoID*** | ***CxID*** | Shall be set to indicate the ID of moving GCO |
| ***mobilityInformation***  | ***MobilityInformation***  | Shall be set to indicate the GCO mobility information |
| ***desiredBandwidth*** | ***REAL*** | Shall be set to indicate the desired bandwidth [MHz] of GCO |

*Revise the table of* ***InterCMAssociationResponse*** payload element.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***status***  | ***Status***  | status  |
| ***listOfAccessibleCMs***  | ***ListOfAccessibleCMs***  | Optionally present to indicate list of the accessible CM. If the CM cannot accept the request, accessible CM information may be included in this message.  |
| ***listOfEstimatedAvailableBandwidth*** | ***listOfEstimatedAvailableBandwidth*** | Shall be set to indicate the estimated amount of available resource for the GCOs, which are estimated to move within the serving area of the CM |

The following table specifies ***listOfEstimatedAvailableBandwidth*** parameter element.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***gcoID*** | ***CxID*** | Shall be set to indicate the ID of moving GCO |
| ***estimatedBandwidth*** | ***REAL*** | Estimated available bandwidth [MHz] for the moving GCO |

* 1. CE operation

6.4.3 Profile 3

**6.4.3.5 ~~WSO~~GCO registration**

*Revise the table of* ***CxMediaRegistrationConfirm*** *primitive as follows*

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***cxMediaStatus***  | ***cxMediaStatus*** | *cxMediaStatus* |
| ***listOfCandidateServingCMs*** | ***ListOfCandateServingCMs*** | This parameter may be set to indicate the list of candidate serving CMs for GCO if the corresponding Registration Request includes *mobilityInformation*. |

The following table specifies ***ListOfCandateServingCMs*** parameter element.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***cmID*** | ***CxID*** | Shall be set to indicate the candidate serving CM ID recommended for the GCO |
| ***arrivalTime*** | ***GeneralizedTime*** | Shall be set to indicate the estimated arrival time of GCO at the serving area of the candidate serving CM |
| ***residenceDuration*** | ***REAL*** | Shall be set to indicate the estimated residence duration of GCO within the serving area of the candidate serving CM |
| ***selectionPriorityLevel*** | ***INTEGER***  | Shall be set to indicate the selection priority level in serving CM selection, where the level shall be determined based on its estimated amount of available resource for the GCO. |

**6.4.3.6 ~~WSO~~GCO registration update**

*Revise the table of* ***CxMediaRegistrationConfirm*** *primitive as follows*

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***cxMediaStatus***  | ***cxMediaStatus*** | *cxMediaStatus* |
| ***listOfCandidateServingCMs*** | ***ListOfCandateServingCMs*** | This parameter may be set to indicate the list of candidate serving CMs for GCO if the corresponding Registration Request includes *mobilityInformation*. |

The following table specifies ***ListOfCandateServingCMs*** parameter element.

|  |  |  |
| --- | --- | --- |
| *Parameter* | *Data type* | *Value* |
| ***cmID*** | ***CxID*** | Shall be set to indicate the candidate serving CM ID recommended for the GCO |
| ***arrivalTime*** | ***GeneralizedTime*** | Shall be set to indicate the estimated arrival time of GCOat the serving area of the candidate serving CM |
| ***residenceDuration*** | ***REAL*** | Shall be set to indicate the estimated residence duration of GCO within the serving area of the candidate serving CM |
| ***selectionPriorityLevel*** | ***INTEGER***  | Shall be set to indicate the selection priority level in serving CM selection, where the level shall be determined based on its expected amount of available resource for the GCO. |

1. Coexistence mechanisms and algorithms
	1. Coexistence algorithms

7.2.5 Information service for moving GCO

***Insert the following text***

7.2.5.x Algorithm for selection of candidate serving CMs for moving GCOs

7.2.5.x.1 Introduction

Having the information of candidate serving CMs enables moving GCO to efficiently select a CM as its serving CM which can provide better spectrum environment for coexistence with the co-located GCOs and to avoid interaction consumed to associate with the CMs which cannot provide enough resource service. On the other hand, the information of candidate served GCOs is also beneficial for CM to provide proxy coexistence service efficiently. 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.

7.2.5.x.2 Selection of candidate serving CMs for moving GCOs

Figure aa shows an example where selection of candidate serving CMs based on mobility information of GCO can be considered. In this example, a GCO with CE is supposed to move along the route L, depicted by red line. The GCO is moving from the position of *p*0 at time $T\_{0}^{a}$ with a direction angle of ** degree (against longitude facing north N in clockwise direction) and a speed of *v* [km/h]. Current serving CM of the GCO is CM0. There exist six CMs ahead, denoted by $CM\_{i}, i\in [1..6]$, close to the route. For the sake of simplicity, it is assumed that the serving area of each CM is a circle. For each CMi whose serving area is crossed by the route, its serving area border has two intersection points with the route L: $p\_{i}^{e}$denotes the first point for GCO to enter the serving area of CMi, $p\_{i}^{l}$ denotes the last point for GCO to leave the serving area of CMi.



Figure aa Example case of candidate serving CMs selection for moving GCO

Without the information of candidate serving CMs on the route, the moving GCO has to select serving CM one by one along the route when moving close to the serving area of the CMs. In that case, six CMs could be candidate serving CMs of the moving GCO, which are CM1, CM2, CM3, CM4, CM5, and CM6. Wherein, after association with CM2, the moving GCO may change to be served by CM3 quickly. Similarly, after association with CM5, the GCO may change back to be served by CM3 soon. Contrarily, if having the information of candidate serving CMs prior to its move, the moving GCO is able to efficiently select its serving CM at each location. Also for CM, knowing the information of moving GCOs enables CM to deduce its served GCOs that might be impacted by the moving GCOs and make better planning for resource assignment.

In this algorithm, the following three processes are conducted.

1. Identify the initial serving CMs of moving GCO based on the mobility information of GCO and the serving area information of other CMs.

A set of initial serving CMs is formed by the CM(s) whose serving area is crossed by the predicted route L. The route L can be predicted based on speed/direction in mobility information of the GCO. If the route information is also provided in the mobility information, the route L can be predicted more precisely. Through inter-CM information exchange, current serving CM (CM0) of the moving GCO can obtain the serving area information of other CMs. By utilizing the serving area information, CM0 identifies the initial serving CMs of moving GCO that satisfy the condition to be initial. In Figure aa, for example, the set of initial serving CMs is comprised of CM1, CM2, CM3, CM5, and CM6. Besides, CM0 estimates the arrival time of the moving GCO at serving area of each CMi as $T\_{i}^{a}=T\_{0}^{a}+{\left|p\_{i}^{e}-p\_{0}\right|}/{v}$, and the residence duration of the moving GCO within serving area of each CMi as $T\_{i}^{r}={\left|p\_{i}^{l}-p\_{i}^{e}\right|}/{v}$, where $\left|\*\right|$ is the Euclidean distance between two points.

1. Determine selection priority level of the identified initial serving CMs based on their estimated available resource for moving GCO

CM0 sends request to each of the identified initial serving CMs to obtain their amount of available resource for the moving GCO. The request includes estimated arrival time $T\_{i}^{a}$, residence duration $T\_{i}^{r}$, and desired resource (bandwidth). Upon receiving request, each of the initial serving CMs estimates its available resource and responds to CM0. Then CM0 ranks the initial serving CMs with a selection priority level, denoted by $w\_{i}$. The larger the amount of available resource can be provided, the higher the selection priority level is.

1. Select the candidate serving CMs of moving GCO from the identified initial serving CMs

One method to select the candidate serving CMs for moving GCO with desired performance target is to model the relation among the initial serving CMs by utilizing an association graph.

Figure bb shows an example association graph G, which is corresponding to the case of Figure aa. Each vertex represents an initial serving CM. Directed arc, depicted by $CM\_{i}\rightarrow CM\_{j}$, represents that serving area of the two CMs are overlapped on the route L and the moving GCO is supposed to move from the serving area of $CM\_{i}$ to that of $CM\_{j}$. Each $CM\_{i}$ has the estimated residence duration $T\_{i}^{r}$ as a first weight and the selection priority level $w\_{i} $as a second weight. In this figure, CM1 and CM6 are labeled as source vertex and destination vertex, respectively.

The candidate serving CMs can be obtained by searching a directed path from source (CM1) to destination (CM6) in graph G. The directed path is constrained by the desired optimization target. For example, if the target is to minimize the number of CMs on the route, then the directed path with shortest length from source vertex to destination vertex should be selected. The length of a directed path is defined as the number of arcs along the path. During the searching, CM0 places a high priority on the CM which has higher residence duration of $T\_{i}^{r}$ and higher priority level of $w\_{i}$. Consequently, less association operation and more resource for the GCO could be achieved.



Figure bb Example association graph corresponding to the case in Figure aa

In Figure bb, the shortest directed path is from CM1 to CM6 with length of 2 as: $CM\_{1}\rightarrow CM\_{3}\rightarrow CM\_{6}$. If the residence duration $T\_{i}^{r}$ of these three CMs is long enough, and the selection priority level $w\_{i}$ of these three CMs can satisfy desired resource of the moving GCO, then a set of these CMs can be selected as the set of candidate serving CMs for the moving GCO. CM0 can provide the results of this prioritization also to the candidate serving CMs. For the candidate serving CMs, this information helps to make better planning for resource assignment accordingly.

7.2.5.x.3 Algorithm description

The flowchart of the algorithm is depicted in Figure cc. The processes are as follows.

* (P#1):

In P#1, CM obtains the mobility informationfor each target moving GCO. The information shall be obtained through GCO Registration Procedure in 5.2.2.1 or GCO registration update procedure in 5.2.2.2.

* (P#2):

In P#2, CM obtains serving area information of other CMs. This information is involved in the parameter of ***managementRegion***, which is obtained through Inter-CM association procedure in 5.2.16 or Inter-CM association procedure over COE in 5.2.17.

* (P#3):

 In P#3, CM identifies the initial serving CMs of moving GCO based on the mobility information of the moving GCO and the serving area information of other CMs.

* (P#4):

In P#4, CM determines selection priority level of the initial serving CMs for the moving GCO based on their estimated amount of available resource. In this process, the current serving CM sends arrival and residence information as well as desired resource of moving GCO to each element in the set of initial serving CMs. Then each of initial serving CMs responds with estimated amount of available resource for the moving GCO. This information shall be exchanged through Inter-CM association procedure in 5.2.16 or Inter-CM association procedure over COE in 5.2.17.

* (P#5):

In P#5, CM selects candidate serving CMs within the idenditfied intitial serving CMs based on the estimated residence duration and selection priority level.

* (P#6):

In P#6, CM indicates other CMs that they are selected as one elment in the set of candidate serving CMs for the moving GCO. Also CM provides the mobility information of the GCO to selected candidate serving CMs. This information shall be provided through Inter-CM association procedure in 5.2.16 or Inter-CM association procedure over COE in 5.2.17.

* (P#7):

In P#7, CE sends the information of candidate serving CMs to GCO via CE through the registration response in GCO Registration Procedure in 5.2.2.1 or GCO registration update procedure in 5.2.2.2.



Figure cc Flowchart of candidate serving CMs selection for moving GCOs

**A.2 Data Types for IEEE802.19.1a**

**A.2.2 Profile 3**

--List of serving CM

ListOfCandidateServingCMs ::= SEQUENCE OF SEQUENCE{

 -- CM ID

 cmID CxID OPTIONAL,

 -- Estimated arrival time

 arrivalTime GeneralizedTime OPTIONAL,

 -- Estimated residence duration [s]

 residenceDuration REAL OPTIONAL,

 -- Resource serving priority

 selectionPriorityLevel INTEGER OPTIONAL

}

--List of moving GCOs

ListOfMovingGCOs ::= SEQUENCE OF SEQUENCE{

 -- GCO ID

 gcoID CxID OPTIONAL,

 -- Estimated arrival time

 arrivalTime GeneralizedTime OPTIONAL,

 -- Estimated residence duration [s]

 residenceDuration REAL OPTIONAL,

 -- Desired Bandwidth [MHz]

 desiredBandwidth REAL OPTIONAL

}

--List of candidate served GCOs

ListOfCandidateServedGCOs::= SEQUENCE OF SEQUENCE{

 -- GCO ID

 gcoID CxID OPTIONAL,

 -- Mobility information

 mobilityInformation MobilityInformation OPTIONAL,

 -- Desired Bandwidth [MHz]

 desiredBandwidth REAL OPTIONAL

}

--List of expected available bandwidth

listOfExpectedAvailableBandwidth::= SEQUENCE OF SEQUENCE{

 -- GCO ID

 gcoID CxID OPTIONAL,

 -- Estimated Available Bandwidth [MHz]

 estimatedAvailableBandwidth REAL OPTIONAL

}

**B.2 Primitives for IEEE 802.19.1a**

**B.2.2 Profile 3**

**B.2.2.2 Coexistence Media SAP**

--Registration confirmation

CxMediaRegistrationConfirm ::= SEQUENCE {

 --CxMedis status

 cxMediaStatus CxMediaStatus OPTIONAL,

 --Registration update duration [s]

 registrationUpdateDuration REAL OPTIONAL,

 --List of candidate serving CMs

 listOfCandidateServingCMs ListOfCandidateServingCMs OPTIONAL

}

**C.2 Messages for IEEE 802.19.1a**

**C.2.2 Profile 3**

--Registration response

RegistrationResponse ::= SEQUENCE {

 --Registration status

 status Status OPTIONAL,

 --Registration update duration [s]

 registrationUpdateDuration REAL OPTIONAL,

 --List of candidate serving CMs

 listOfCandidateServingCMs ListOfCandidateServingCMs OPTIONAL

}

--InterCMAssociationRequest

InterCMAssociationRequest ::= SEQUENCE {

 --CM ID

 cmID CxID,

 --Management region of the CM

 managementRegion Region OPTIONAL,

 --List of moving GCOs

 listOfMovingGCOs ListOfMovingGCOs OPTIONAL,

 --List of candidate served GCOs

 listOfCandidateServedGCOs ListOfCandidateServedGCOs OPTIONAL

}

--InterCMAssociationResponse

InterCMAssociationResponse ::= SEQUENCE {

--status of request processing

status Status,

--List of accessible CMs

listOfAccessibleCMs ListOfAccessibleCMs OPTIONAL,

--List of estimated available bandwidth

listOfEstimatedAvailableBandwidth ListOfEstimatedAvailableBandwidth OPTIONAL

}