**IEEE P802.19**
Wireless Coexistence Working Group

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| Project | IEEE 802.19 Wireless Coexistence Working Group (WG) |
| Title | Coexistence Mechanisms and Algorithms |
| Date Submitted | January 17, 2011 |
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| Abstract | Proposal for Coexistence Mechanisms and Algorithms clause |
| Purpose | |
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# 7 Coexistence mechanisms and algorithms

## 7.1 General description

Coexistence mechanisms and algorithms shall enable coexistence among dissimilar or independently operated TVBD networks and dissimilar TVBDs. There are two coexistence problems to be solved related to TV channel use. One is how to allocate a proper operating channel to each TVBD or TVBD network regarding its neighbor TVBD or TVBD network. The other is how to share the same channel if two or more TVBDs or TVBD networks have the same operating channel. Regarding this, two mechanisms and algorithms are considered as the following;

- Operating channel allocation mechanism and algorithm
- Co-channel sharing mechanism and algorithm

## 7.2 Operating channel allocation mechanism and algorithm

After the interface setup as defined in section 6.1 has been done between two entities, each entity starts its operating stage. Each entity at operating stage is described by a number of designated procedures and events that triggers them. During its operating stage, CM, CE, and CDIS shall interactively operate to allocate an operating channel to each TVBD or TVBD network.

### 7.2.1 CM Operation

Figure 1 describes coexistence manger operating procedures that define a specific event and designated procedure triggered by it. At first the CM shall conduct channel classification to prepare channel allocation to its registered CEs. After that, the CM shall perform channel allocation based on channel classification and other aspects such as TVWS DB update, registered CE discovery update, neighbor CM discovery update, and registered CE's channel move request and so on. Main operating procedures of the CM consist of two parts: Channel classification and channel allocation. Including these, operating procedures of coexistence manager are as follows:

- CM_Channel_Classification
- CM_Channel_Allocation
- CM_TVWS_Channel_Update
- CM_Registered_CE_Discovery
- CM_Registered_CE_Discovery_Update
- CM_Neighbor_CM_Discovery
- CM_Neighbor_CM_Discovery_Update
- CM_Initiate_Registered_CE_Channel_Move
- CM_Initiate_Channel_Reallocation
- CM_Channel_Identification
- CM_Inform_Event

The procedure CM_Channel_Classification is triggered if flag 'Initiate_Channel_Classification' is set to be 1. This flag is set to be 1 if the CM has been initialized after power on or TVWS channels from TVWS DB have been updated. As depicted in figure 2, the CM firstly executes the procedure CM_Registered_CE_Discovery in order to find out context information of registered CEs belong to the CM. After getting context information from registered CEs, the CM accesses TVWS DB to get the list of allowed channels such as the available channel and the restricted channel that can be used by TVBD networks or devices. To do that, the CM might send FCC identifier of each TVBD as required by FCC

regulation. In case, TVWS DB is not available within a certain time limit, the CM requests each registered CE to send disconnection request to the CM.

After getting available or restricted channel lists from TVWS DB, the CM executes the procedure CM_Neighbor_CM_Discovery to get context information of neighbor CMs from the CDIS.

Once neighbor CM discovery is accomplished, the CM executes the procedure CM_Channel_Identification as depicted in figure 3. Through this procedure, the CM shall identify the available channel, the restricted channel, the operating channel already taken by the registered CE of the neighbor CM among allowed channels from TVWS DB.

The CM finally sets flag 'Initiate_Channel_Allocation' to be 1, in order to trigger the procedure CM_Channel_Allocation.

The procedure CM_Channel_Allocation is triggered if flag 'Initiate_Channel_Allocation' is set to be 1. This flag is set to be 1 if the following occurs:

- If the CM has done the procedure CM_Channel_Classification
- If the neighbor CM discovery has been updated
- If the registered CE discovery has been updated
- If the registered CE requests channel move and there are no available channels or restricted channels to allocate

As shown in figure 4, the CM firstly checks if Timer $T_{Refresh\_TVWS\_DB}$ is expired. If it is expired, the CM executes the procedure CM_TVWS_Channel_Update. If not, the CM enters the channel allocation process and checks current channel classification.

Based on current channel classification, the CM shall decide if individual channel assignment is possible for all registered CEs considering its neighbor CM. If possible, i.e., in individual channel assignment mode, the CM allocates an exclusive operating channel to each registered CE and sends reconfiguration request to registered CEs. If a registered CE does not accept the CM's reconfiguration request, the CM discards that registered CEs. The CM updates channel classification again to reflect channel allocation, and sets flag 'Initiate_Registered_CM_Channel_ Classification_Discovery' to be 1, Finally the CM sends context Information to CDIS.

If individual channel assignment mode is not possible, the CM enters co-channel sharing mode and shall apply a proper operating channel selection algorithm and a co-channel sharing mechanism to each registered CE. Negotiation might be needed if a negotiation with its neighbor CM is needed. An operating channel selection algorithm for the CM is shown in figure 5.

The procedure CM_TVWS_Channel_Update is periodically executed during the CM operation. If TVWS DB is updated, the CM executes the procedure CM_Initiate_Channel_Reallocation notifying channel shutdown to all registered CEs, and goes back to the procedure CM_Channel_Classification. In case, TVWS DB is not available within a certain time limit, the CM notifies shutdown of all operating channels to all registered CEs, and requests each registered CE to send disconnection request to the CM.

The procedure CM_Registered_CE_Discovery_Update is triggered if registered CE list of the CM has been changed. Through this procedure the CM executes the procedure CM_Registered_CE_Discovery and the procedure CM_Channel_Allocation one by one.

The procedure CM_Neighbor_CM_Discovery_Update is triggered if neighbor CM list has been changed. The CM executes the procedure CM_Neighbor_CM_Discovery and the procedure CM_Channel_ Allocation by turns.

The procedure CM_Initiate_Registered_CE_Channel_Move is triggered if a registered CE of the CM requests channel move due to failure of required quality of service (QoS) with allocated operating channel

from the CM. As depicted in figure 6 the CM shall allocate a new operating channel to the CE requesting channel move if there are available channels or restricted channels. After that the CM shall update channel classification, and send context information to the CDIS. If there are no available channels or restricted channels to allocate, the CM shall set flag 'Initiate_Channel_Allocation' to be 1 and execute the procedure CM_Channel_Allocation.

The procedure CM_Inform_Event is triggered if the CM detected an event that should inform to the CDIS or its neighbor CMs. The specific procedure and message with contents are presented in Section 6.2.9 for procedure and Section 6.3.8.5, Section 6.3.8.6, Section 6.3.8.7, and 6.3.8.8 for message, respectively.

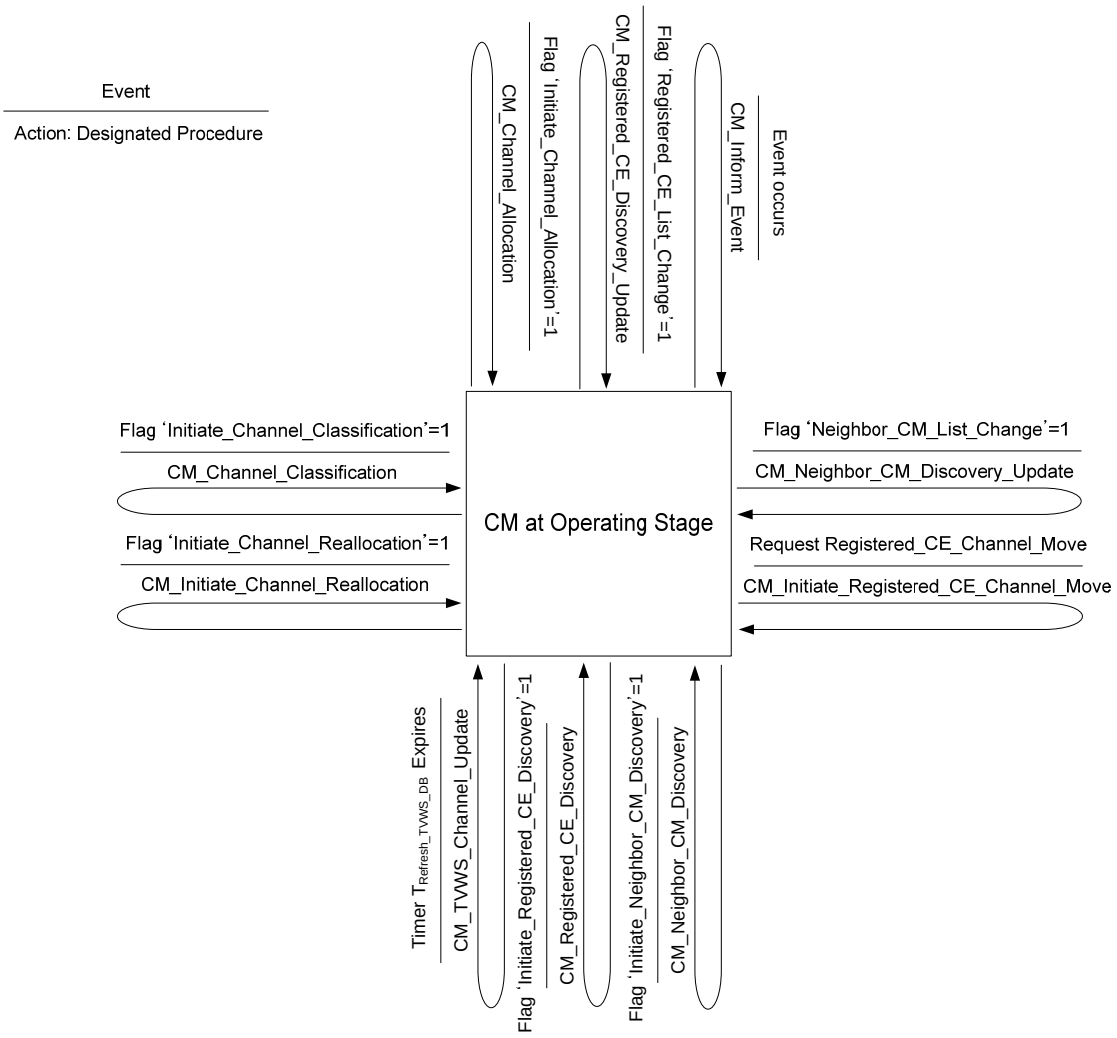


**Figure 1 CM operating procedures**

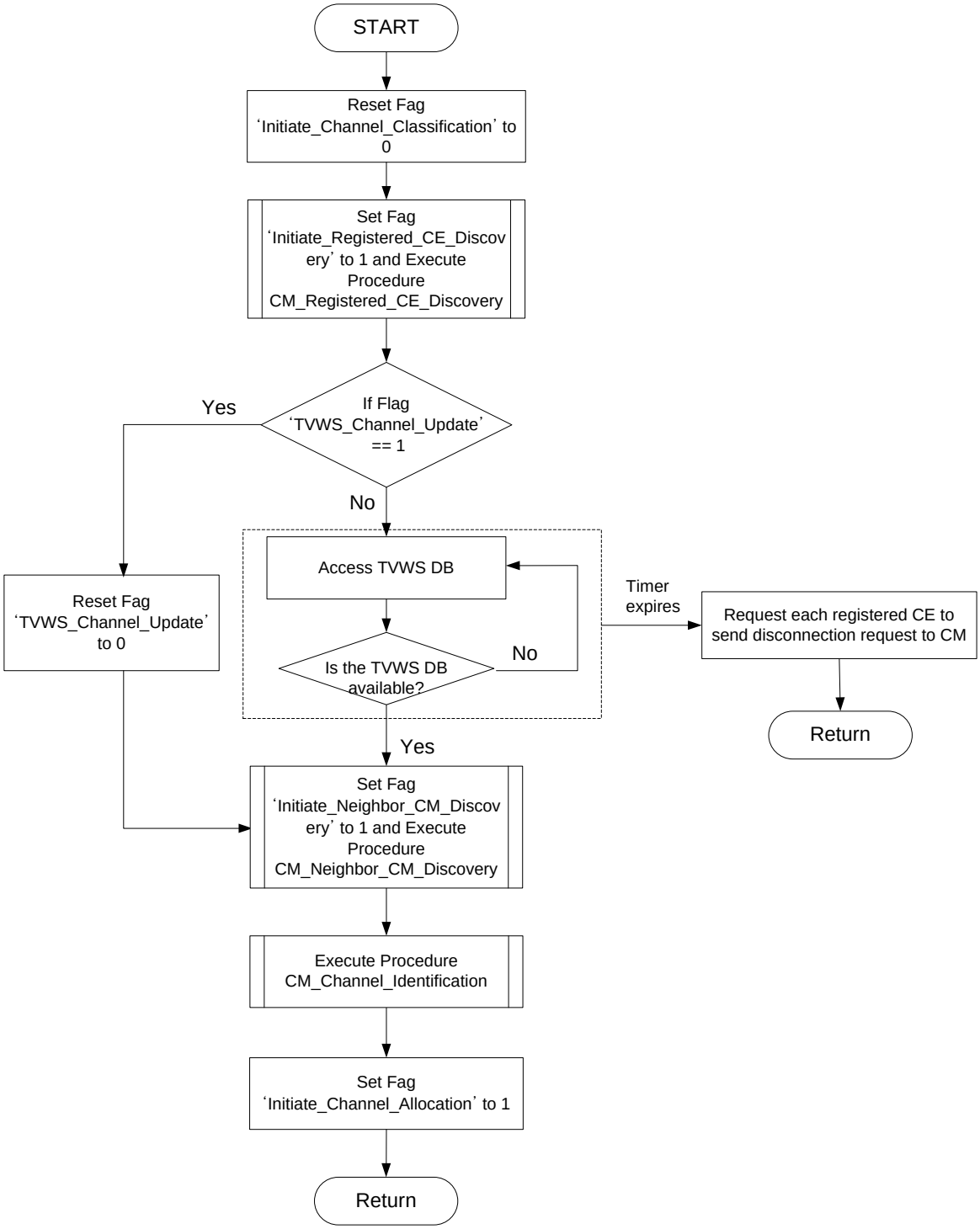


**Figure 2 Procedure CM_Channel_Classification**

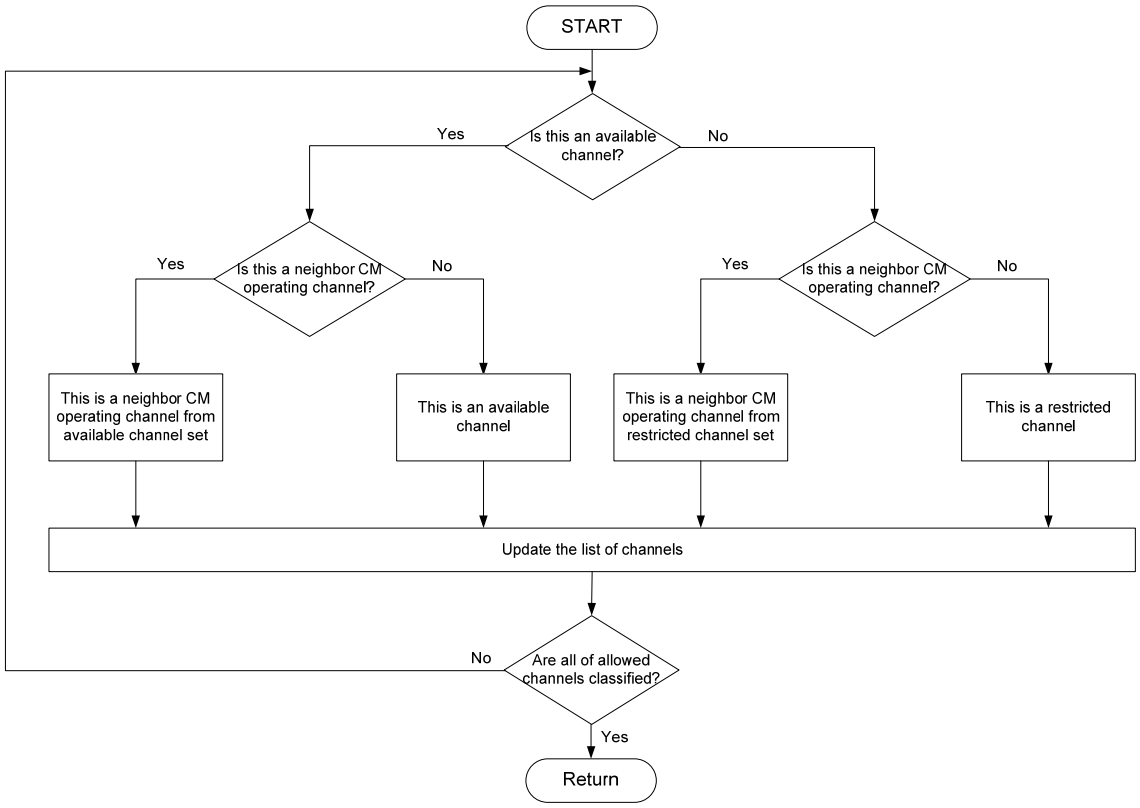


**Figure 3 Procedure CM_Channel_Identification**

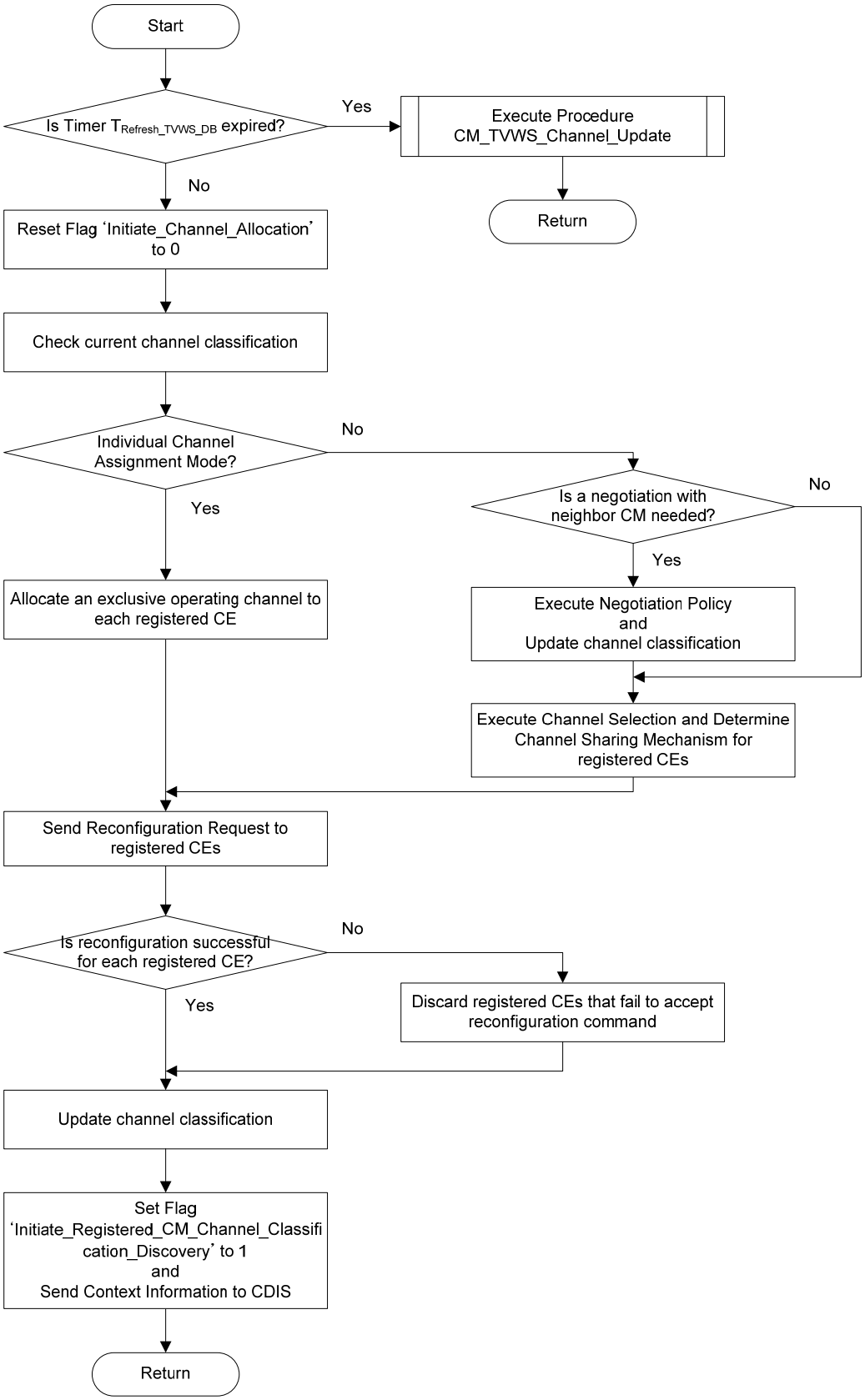


**Figure 4 Procedure CM_Channel_Allocation**

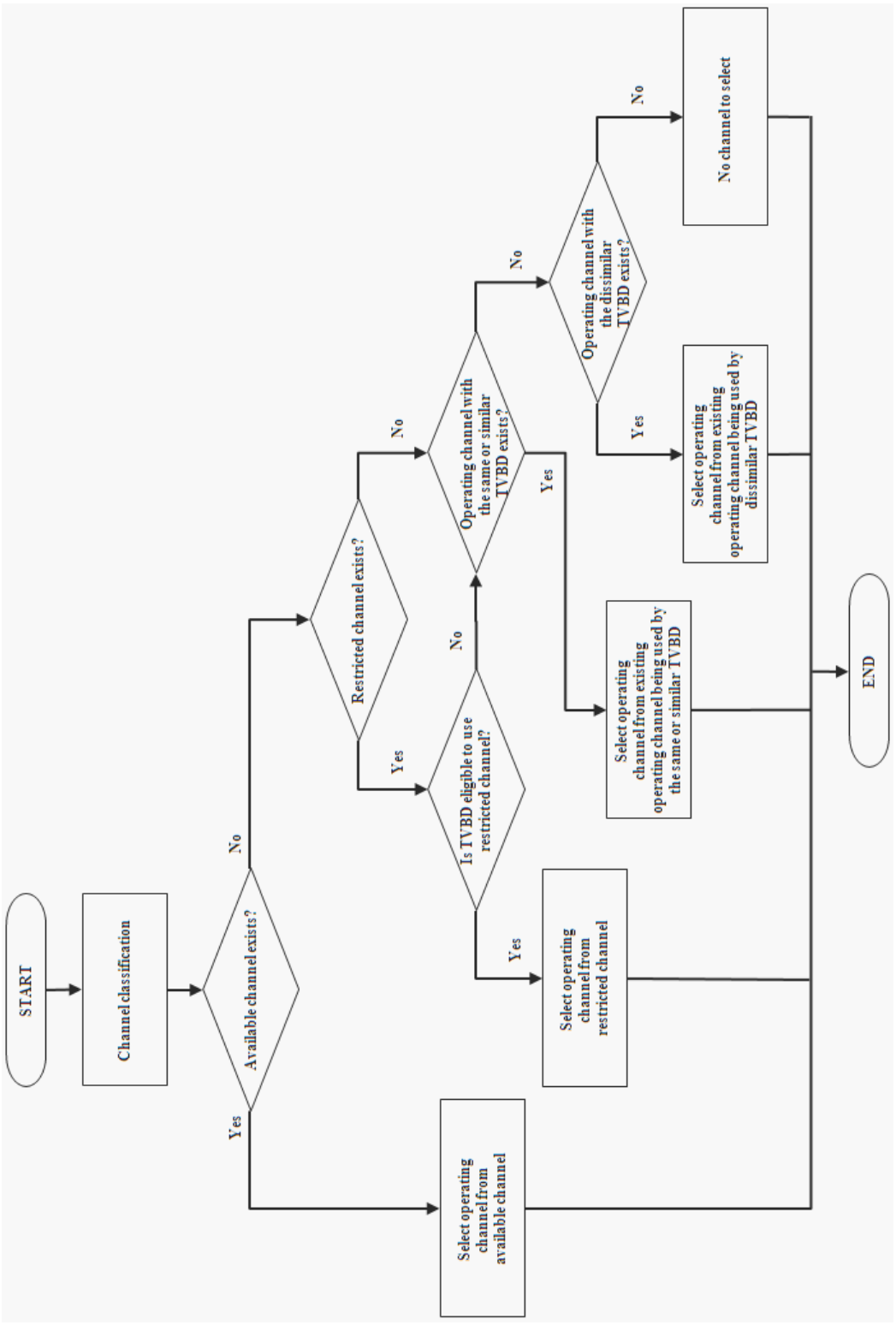


**Figure 5 Operating channel selection algorithm**

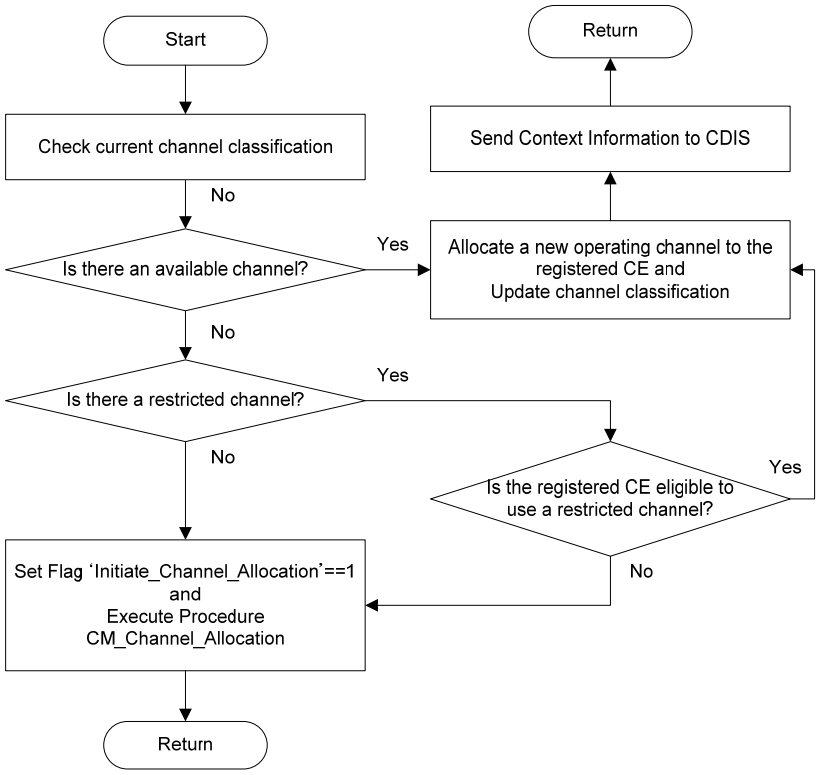


**Figure 6 Procedure CM_Initiate_Registered_CE_Channel_Move**

### 7.2.2 CE operation

Figure 7 describes coexistence enabler operating procedures that define a specific event and designated procedure triggered by it. Operating procedures of coexistence manager are as follows:

- CE_Inform_Context_Information
- CE_Request_Channel_Move
- CE_Inform_Event
- CE_TVBD_Reconfiguration

The procedure CE_Inform_Context_Information is triggered if the CE receives context information request from the CM. The main purpose of this procedure is to provide the fundamental information of the corresponding TVBD to the CM. When this procedure is triggered, the CE sends the fundamental information to the CM. The considered fundamental information of the TVBD is TVBD type, TVBD network type and TVBD geolocation, etc. The specific procedure and message with contents are presented in Section 6.2.3 for procedure and Section 6.3.2.3 and 6.3.2.4 for message, respectively.

The procedure CE_Request_Channel_Move is triggered if the CE detects failure of required quality of service (QoS) with allocated operating channel from the CM. The main purpose of this procedure is to request a new operating channel of the CE to the CM. This procedure is implemented by notifying the TVBD QoS change event of the corresponding CE to the CM where the TVBD QoS change event is triggered when QoS of the corresponding TVBD is degraded under the required reliability. Through this procedure, the CE shall request a new operating channel to the CM. The specific procedure and message

with contents are presented in Section 6.2.9 for procedure and Section 6.3.8.1 and 6.3.8.2 for message, respectively.

The procedure CE_Inform_Event is triggered if the CE event is occurred. This procedure is used to notify the detected event of the corresponding CE to CM, which gives effect on the neighbor discovery. Then, when this procedure is triggered, the CE informs the detected events to the CM. As a reported CE, we consider TVBD QoS change, TVBD geolocation change and TVBD coverage change events. As mentioned above, through the TVBD QoS change event, the CE requests a new operating channel to the CM. Further, because of having effects on the neighbor discovery, TVBD geolocation and overage change events are considered as a reported CE event. The specific procedure and message with contents are presented in Section 6.2.9 for procedure and Section 6.3.8.1 and 6.3.8.2 for message, respectively.

The procedure CE_TVBD_Reconfiguration is triggered if the CE receives reconfiguration request from the CM. Through this procedure the CE shall reconfigure TVBD as the CM requested where the considered reconfiguration parameters are coexistence mode, channel classification list and service duration, etc. The CE shall check the validity of allocated operating channel from the CM by asking TVWS DB. After then, the CE gives the reconfiguration response which provides the status information whether the corresponding reconfiguration parameter from the CM is accepted or not. The specific procedure and message with contents are presented in Section 6.2.7 for procedure and Section 6.3.6.1 and 6.3.6.2 for message, respectively.

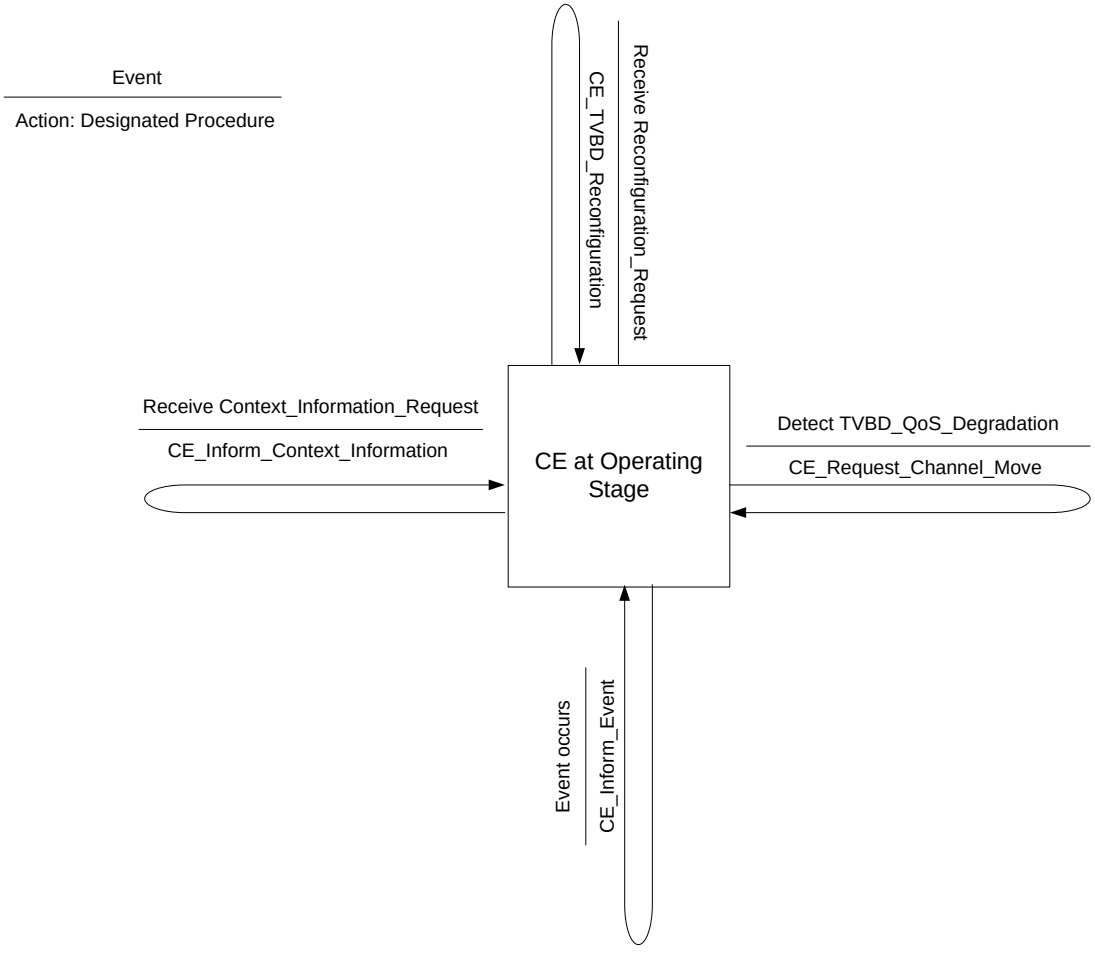


**Figure 7 CE operating procedures**

### 7.2.3 CDIS operation

Figure 8 describes coexistence enabler operating procedures that define a specific event and designated procedure triggered by it. Operating procedures of coexistence manager are as follows:

- CDIS_TVWS_Channel_Update
- CDIS_Neighbor_CM_Discovery
- CDIS_Registered_CM_Channel_Classification_Discovery
- CDIS_Inform_Event

The procedure CDIS_TVWS_Channel_Update is periodically executed during the CDIS operation whenever the refresh timer TRefresh_TVWS_DB is expired. The main purpose of this procedure is to update TVWS channel information of the CDIS from TVWS DB. Then, when this procedure is triggered, the CDIS accesses the TVWS DB and updates the TVWS channel information. The considered TVWS channel information is allowed TVWS channel list and channel use constraint. The specific procedure and message with contents are presented in Section 6.2.5 for procedure and Section 6.3.4.1 and 6.3.4.2 for message, respectively.

The procedure CDIS_Neighbor_CM_Discovery is triggered if flag 'Initiate_Neighbor_CM_Discovery' is set to be 1. This flag is set to be 1 if the registered CM list or context information of the registered CM has been updated. The main purpose of this procedure is to find inter-CM TVBD neighbor that might cause harmful co-channel interference between them. Then, this procedure is triggered, the CDIS updates the context information from all registered CMs. Using context information from all registered CMs, CDIS regards two or more TVBD as an inter-CM TVBD neighbor if they interfere each other with the same operating channel due to their geo-location, transmission range, interference range, etc. Based on this procedure, CDIS discovers the inter-CM TVBD neighbor and provides neighbor discovery information to the CMs where the considered neighbor discovery parameters are neighbor CM ID list, neighbor CE ID list and neighbor CE channel number list. The specific procedure and message with contents are presented in Section 6.2.4 for procedure and Section 6.3.3.1 and 6.3.3.2 for message, respectively.

The procedure CDIS_Registered_CM_Channel_Classification_Discovery is triggered if flag 'Initiate_CDIS_ Registered_CM_Channel_Classification_Discovery' is set to be 1. This flag is set to be 1 if channel classification of the registered CM has been updated. The main purpose of this procedure is to update the channel classification information of each registered CM. Then, when this procedure is triggered, the CDIS shall gather information on channel classification of each registered CM. The specific procedure and message with contents are presented in Section 6.2.5 for procedure and Section 6.3.4.5 and 6.3.4.6 for message, respectively.

The procedure CDIS_Inform_Event is triggered if the CDIS event is occurred. This procedure is used to notify the detected event of the corresponding CDIS to the CM, which gives effect on the resource allocation of the CM. Then, when this procedure is triggered, the CDIS informs the detected events to the CM. As a reported CDIS event, we consider TVWS channel information change, neighbor CMs information change and neighbor CEs information change events. Through the TVWS channel information change event, the CDIS informs the TVWS channel information update to the CM. Further, to check the neighbor discovery update, neighbor CMs and CEs information change events are considered. The specific procedure and message with contents are presented in Section 6.2.9 for procedure and Section 6.3.8.3 and 6.3.8.4 for message, respectively.

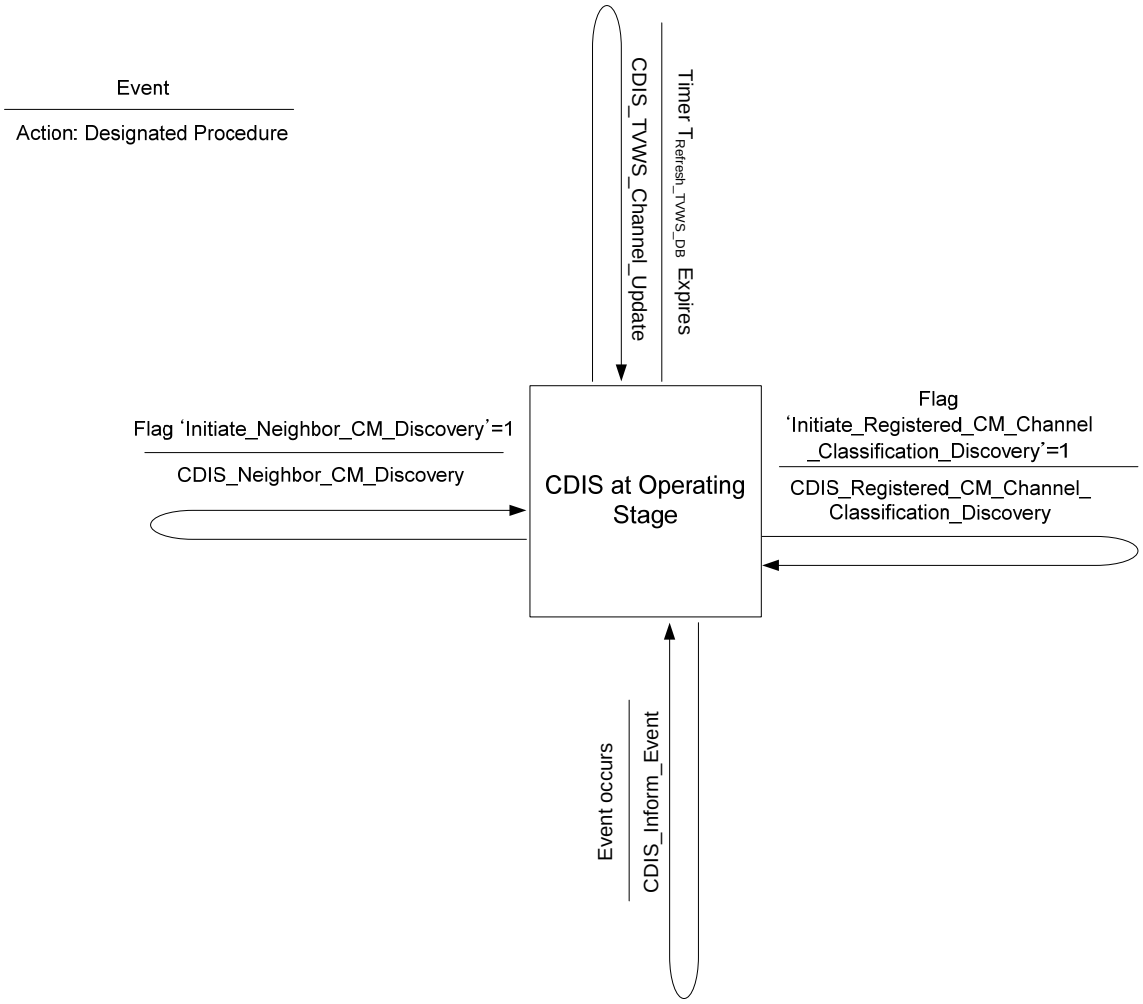


**Figure 8 CDIS operating procedures**

## 7.3 Co-channel sharing mechanism and algorithm

### 7.3.1 CE operation

CE operation is described below using SDL flowcharts.

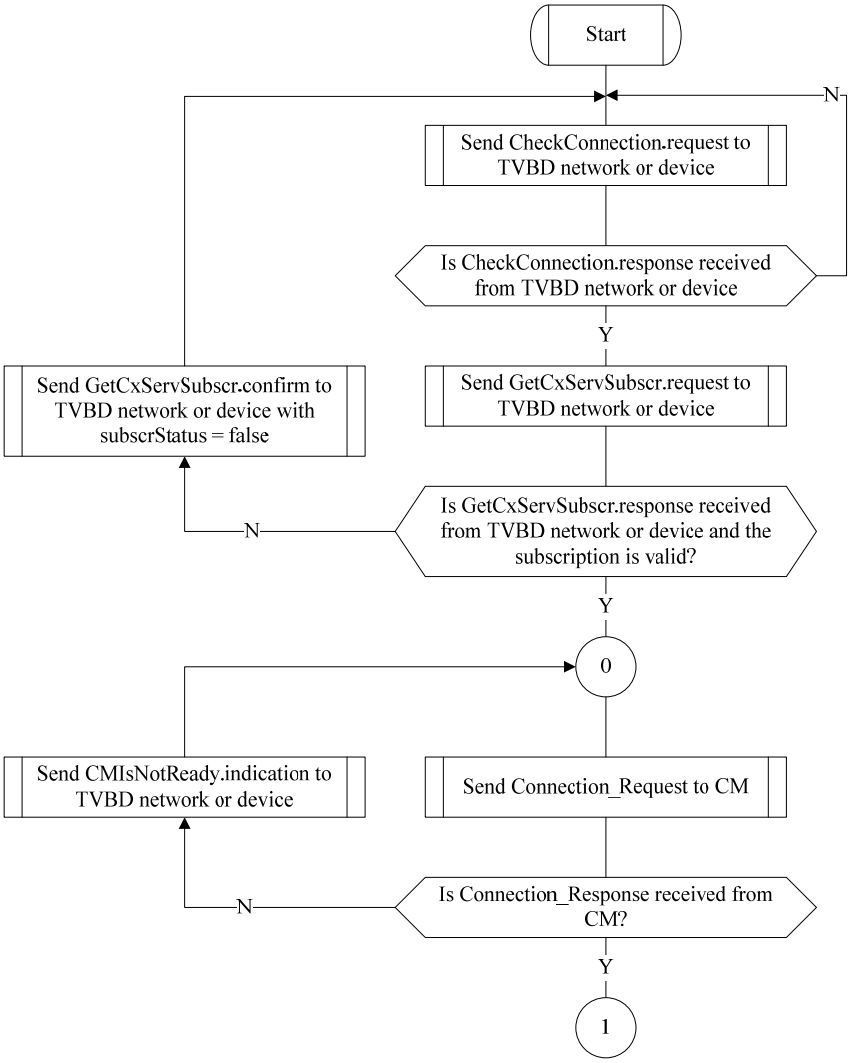


**Figure 9 CE operation**

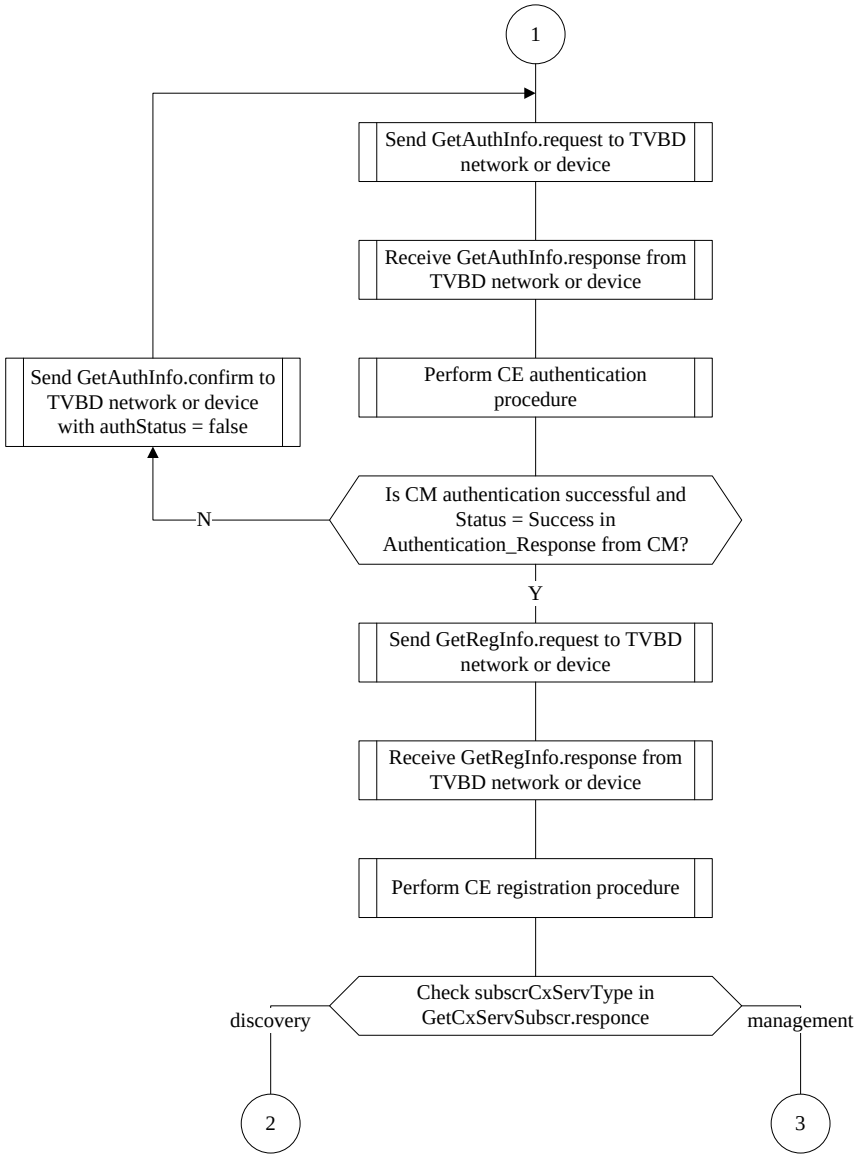


**Figure 10 CE operation**

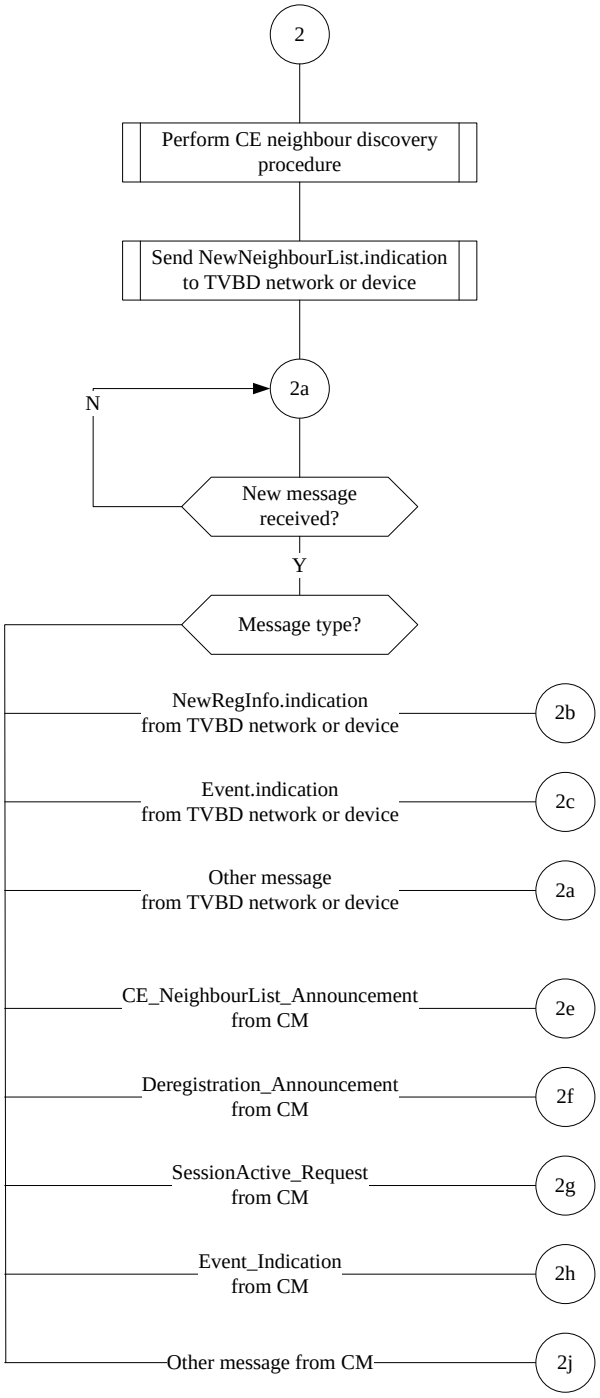


**Figure 11 CE operation**

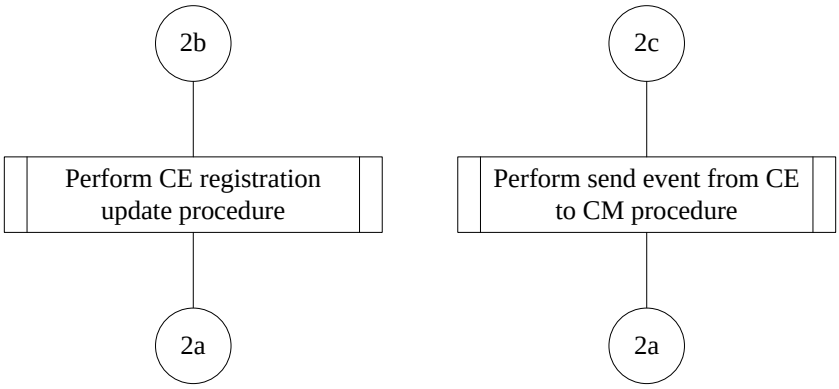


**Figure 12 CE operation**

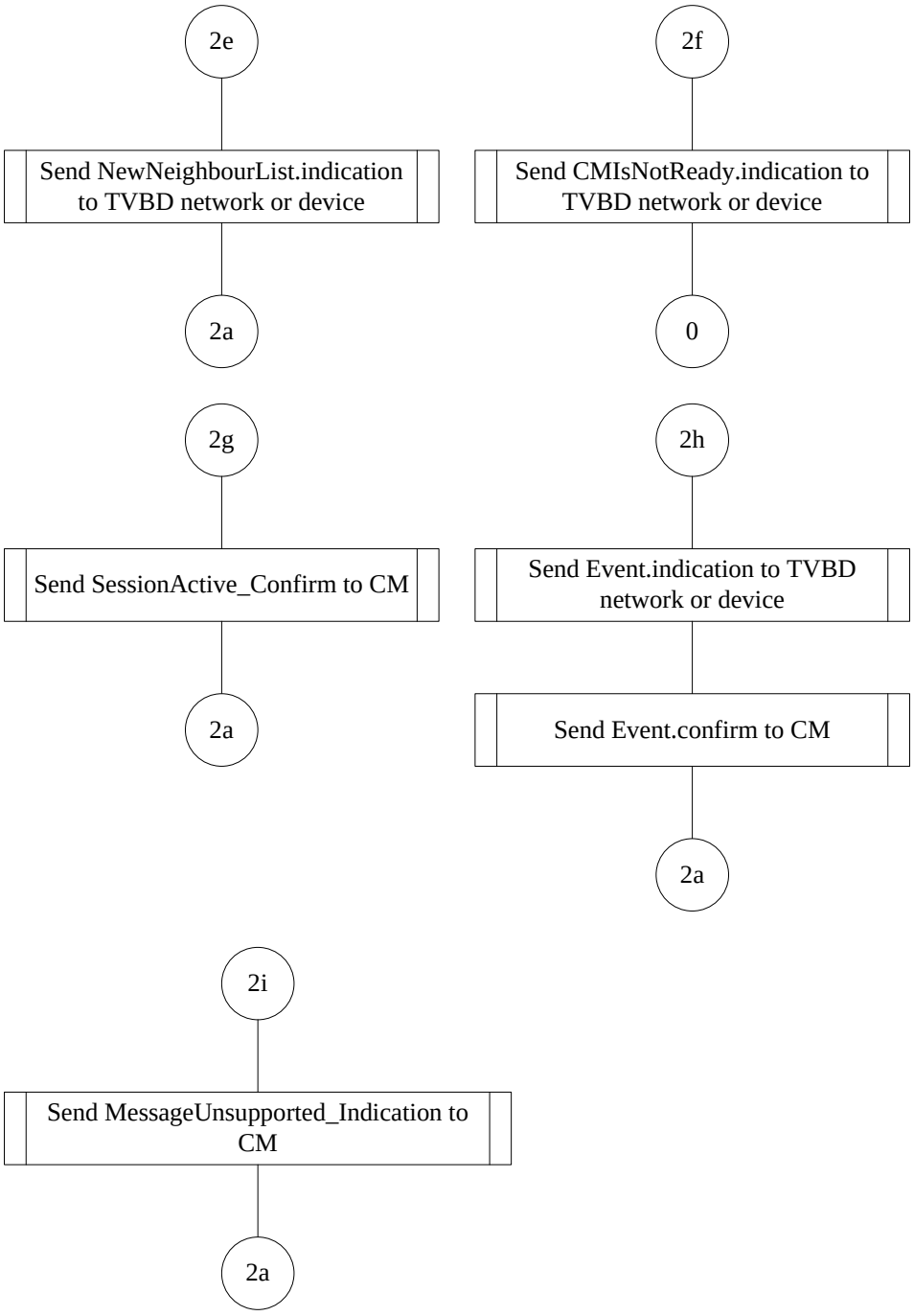


**Figure 13 CE operation**

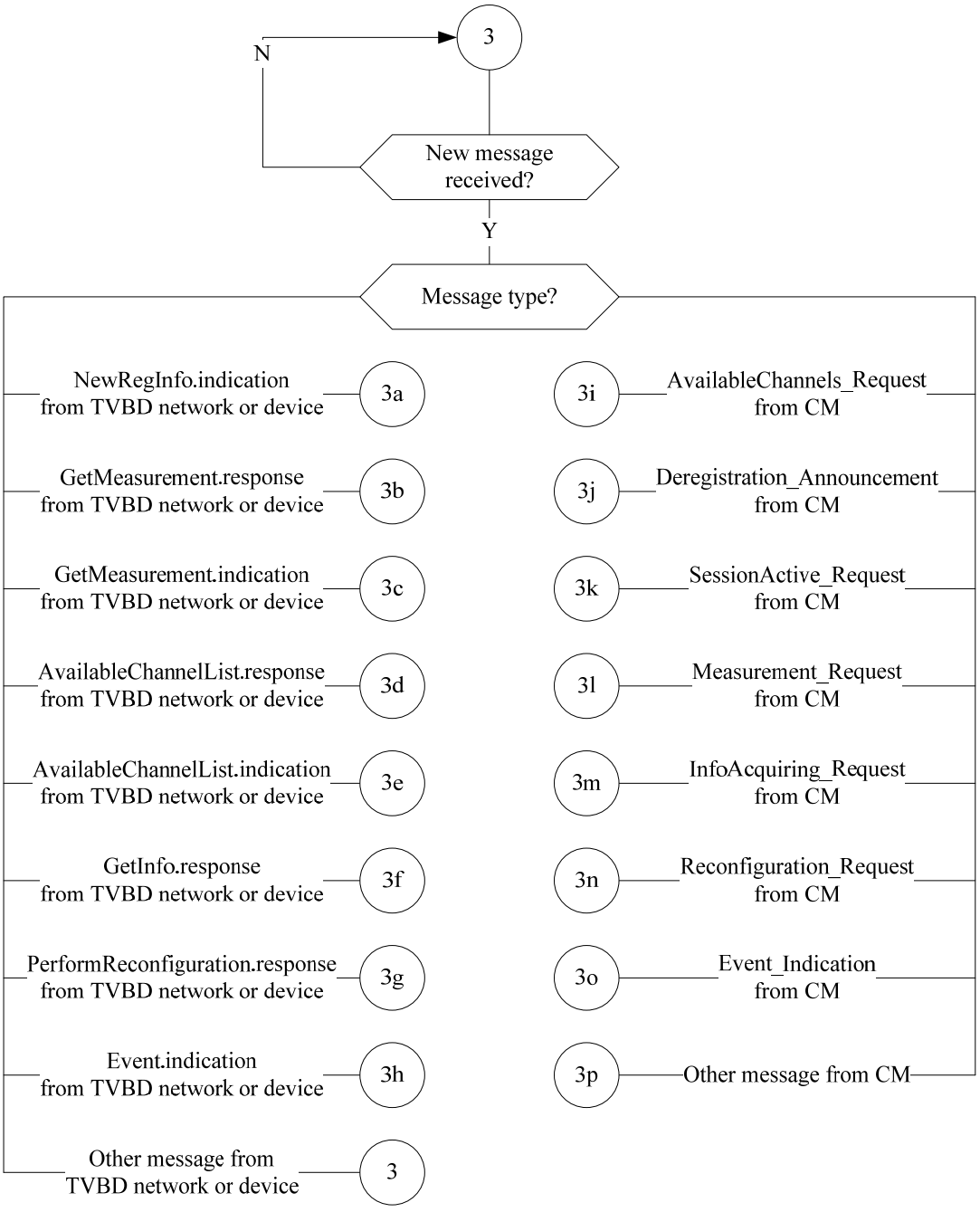


**Figure 14 CE operation**

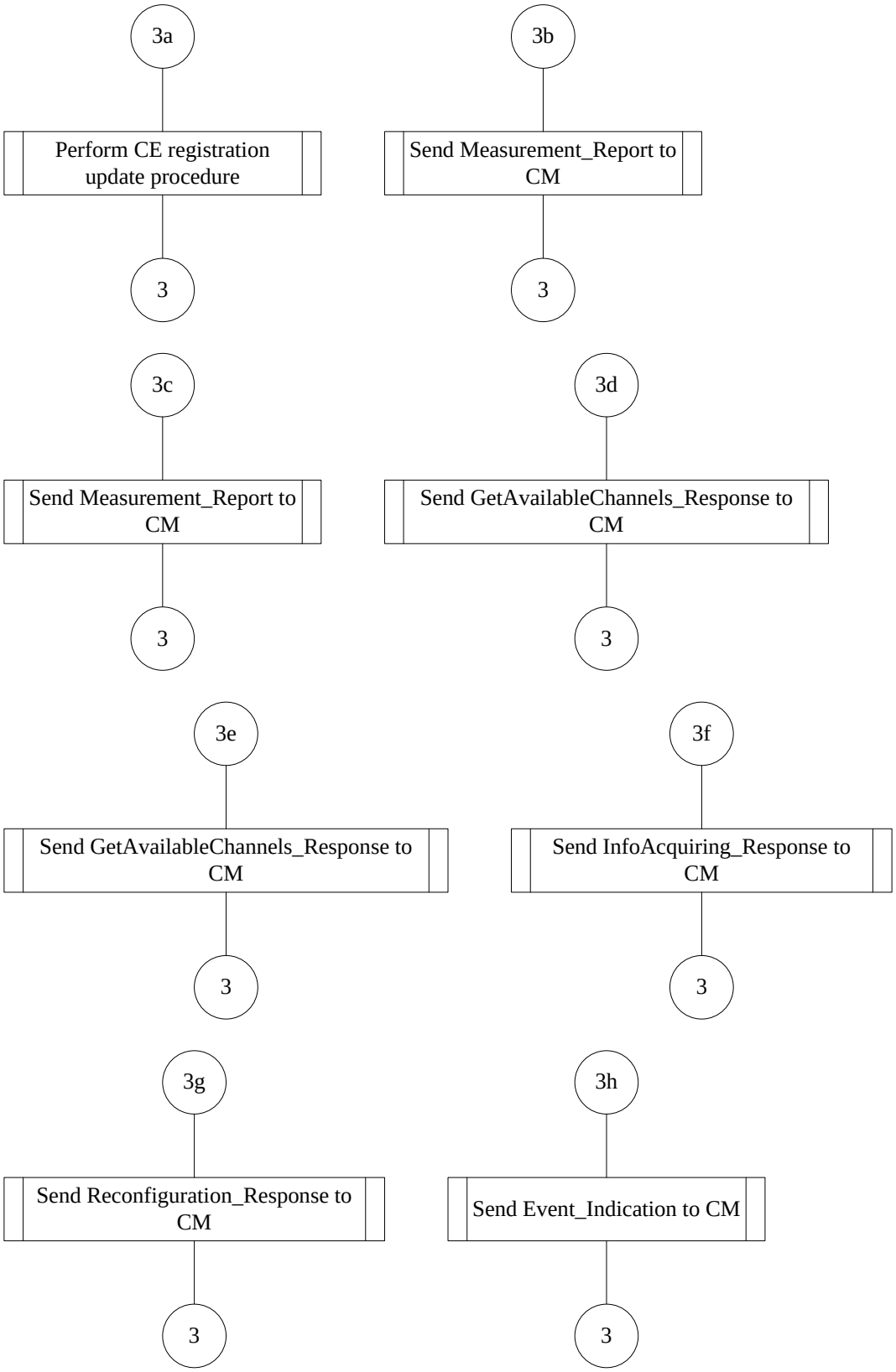


**Figure 15 CE operation**

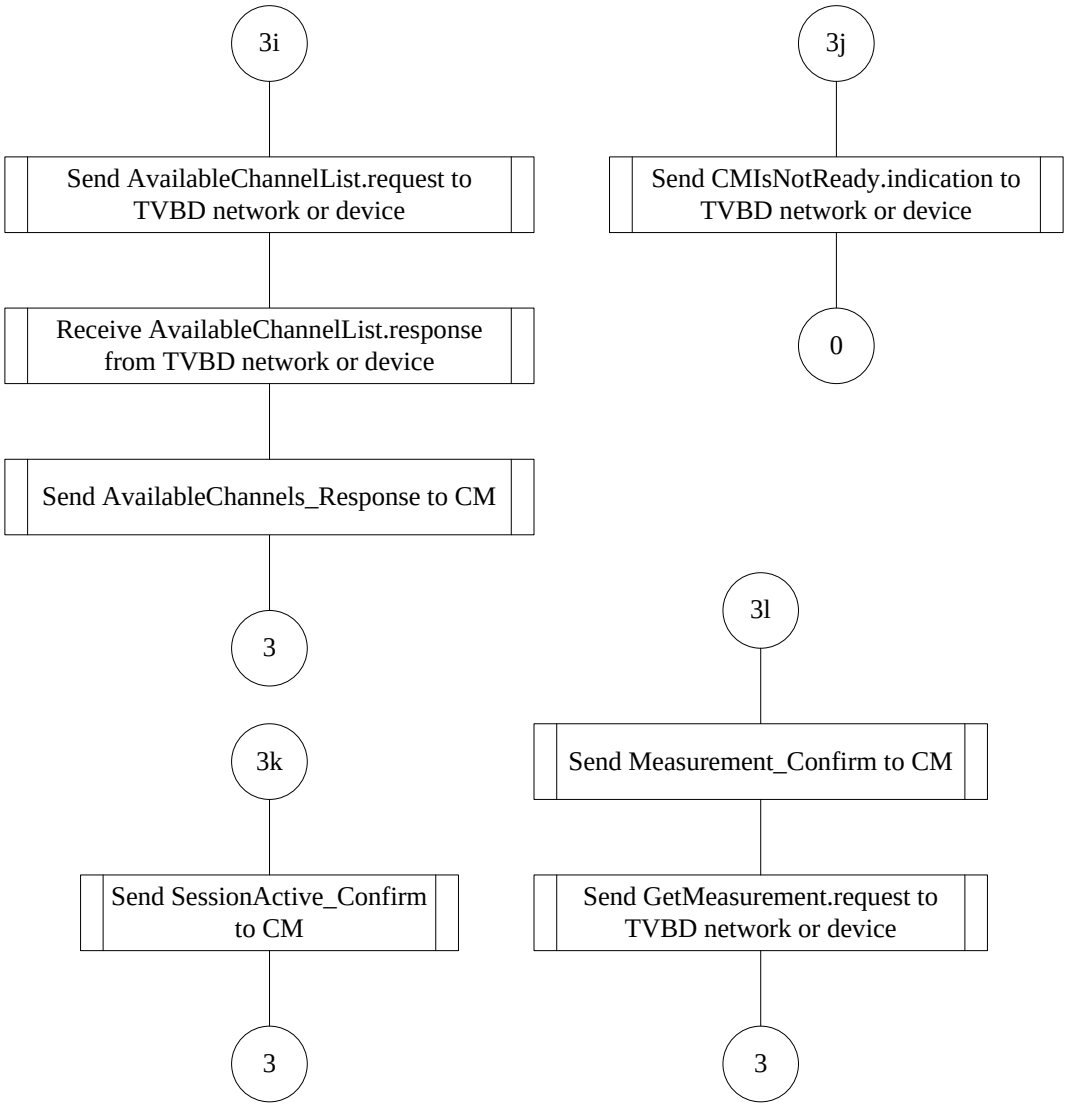


**Figure 16 CE operation**

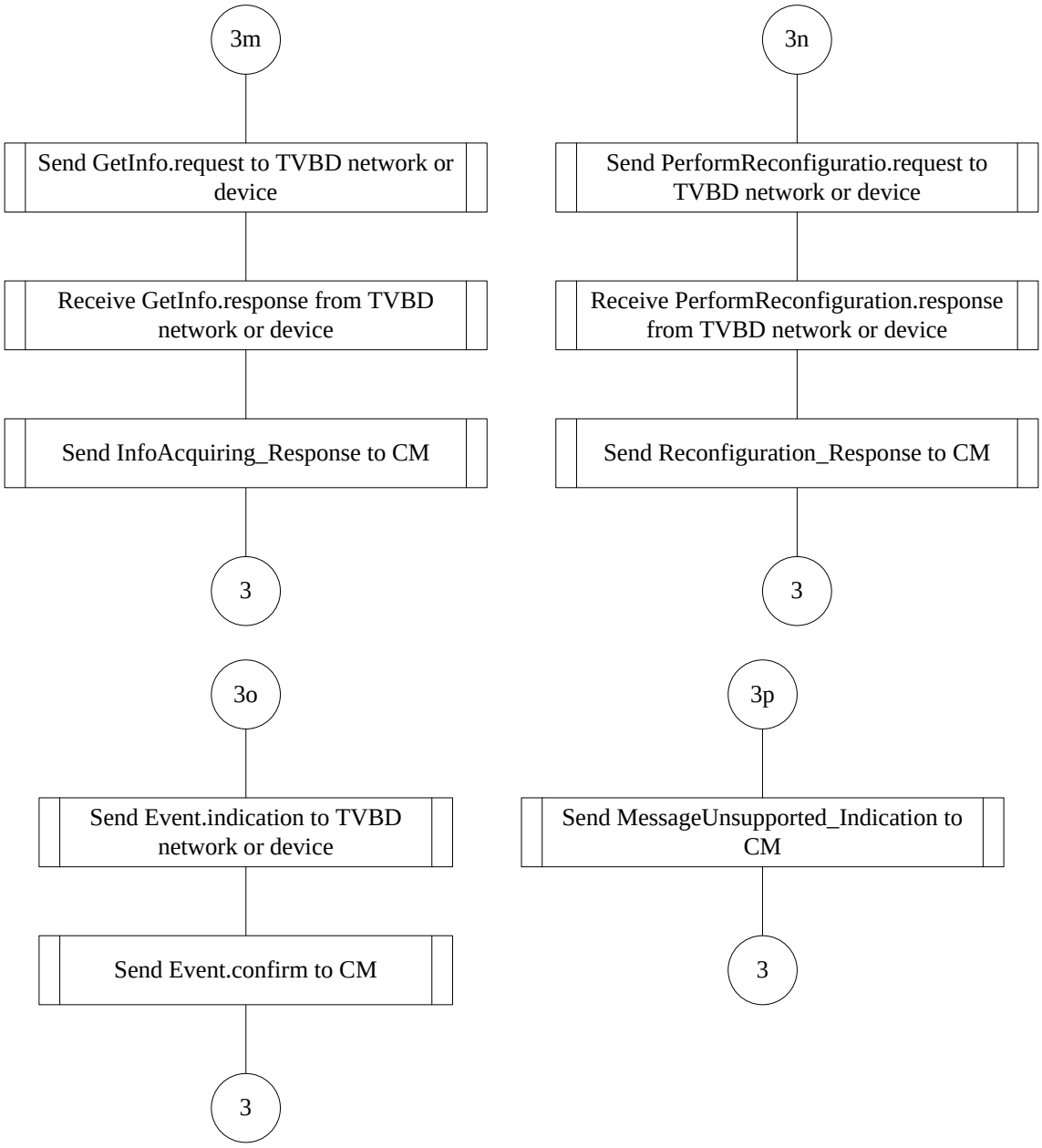


**Figure 17 CE operation**

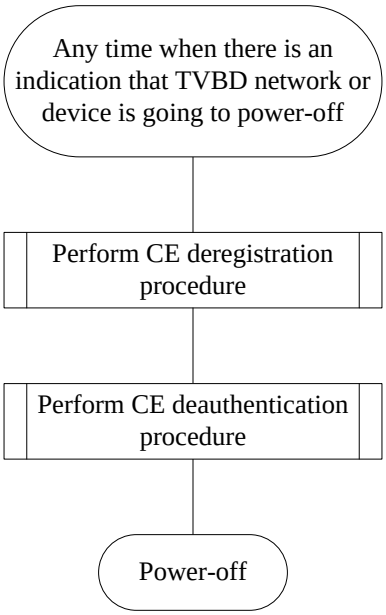


**Figure 18 CE operation**

### 7.3.2 CM operation

CM operation is described below using SDL flowcharts.

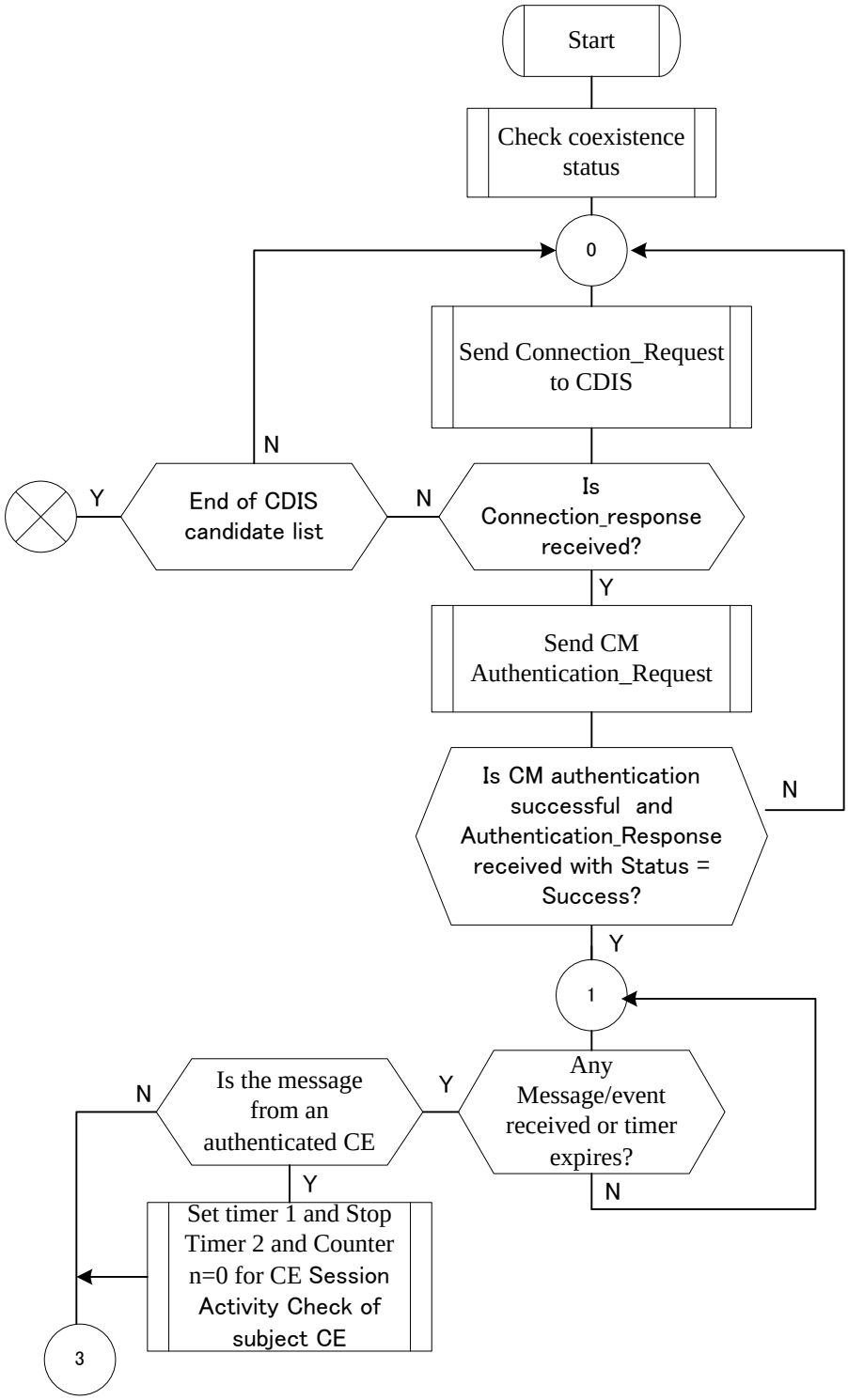


**Figure 19 CM operation**

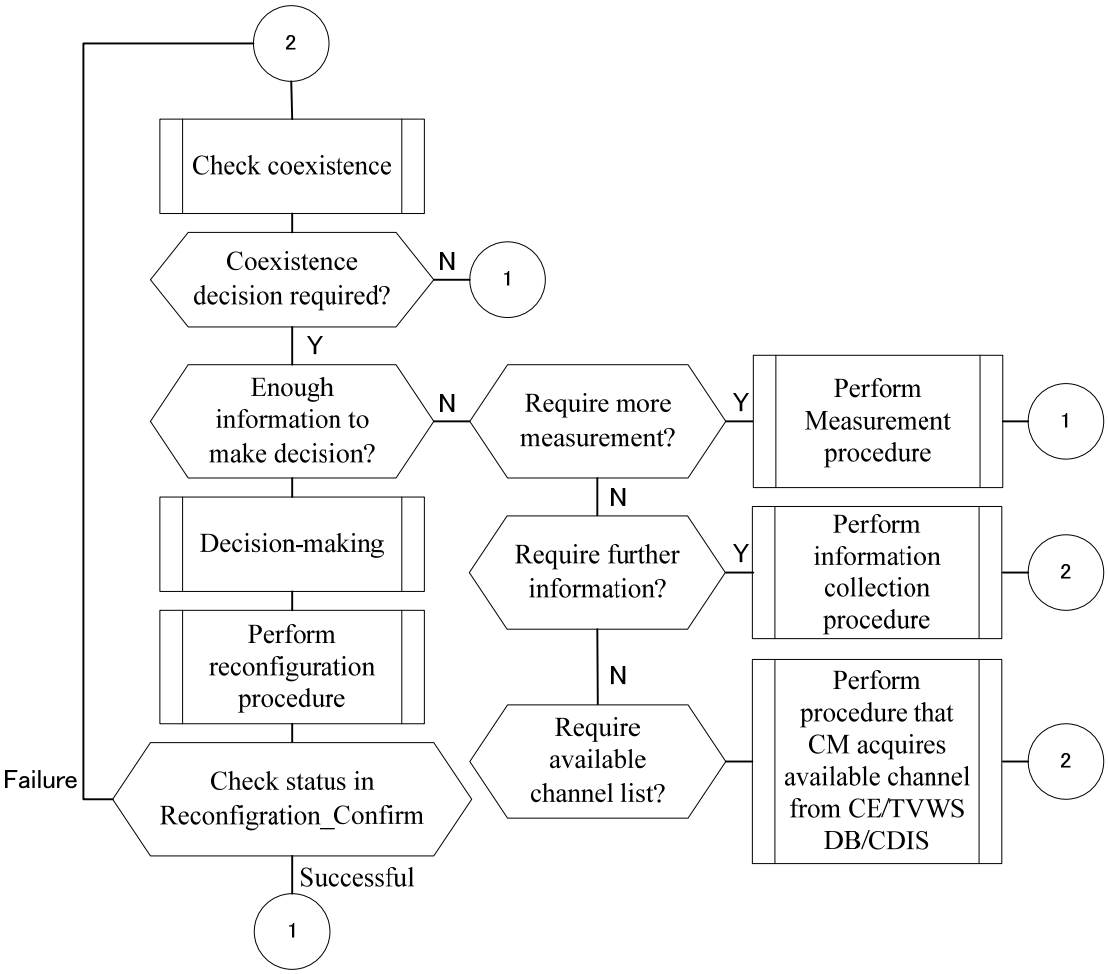


**Figure 20 CM operation**

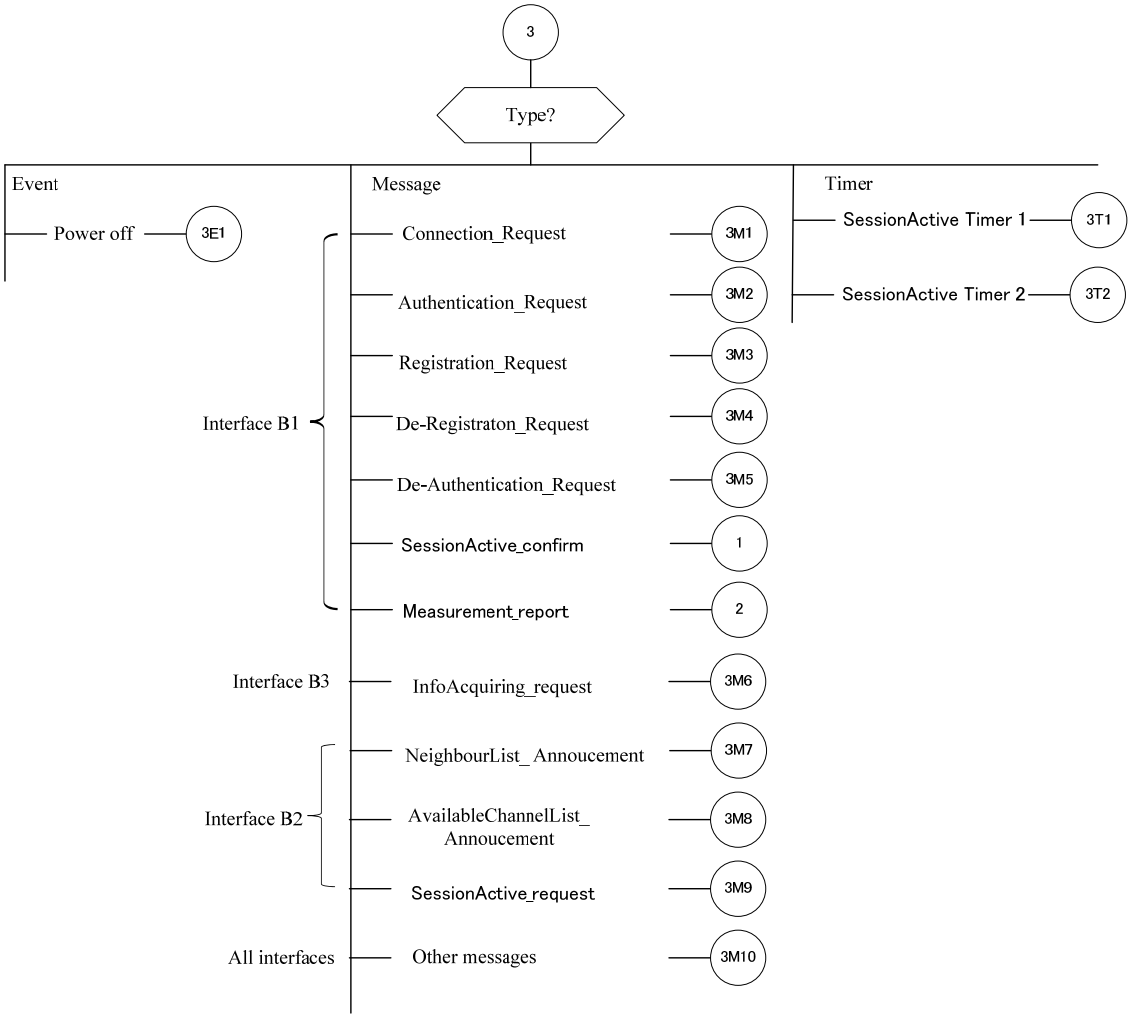


**Figure 21 CM operation**

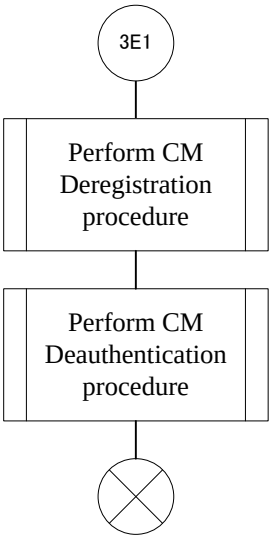


**Figure 22 CM operation**

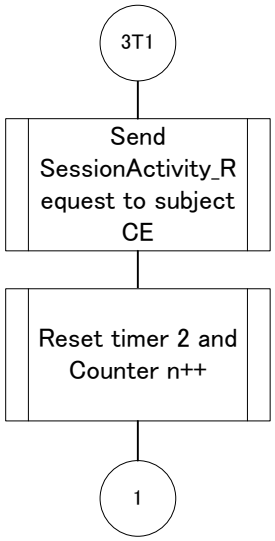


**Figure 23 CM operation**

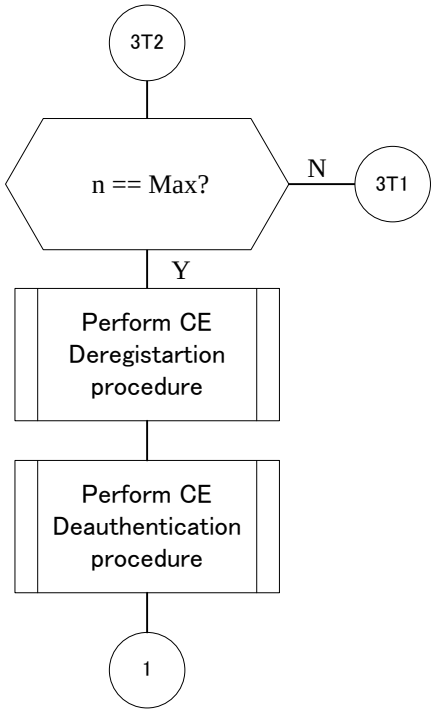


**Figure 24 CM operation**

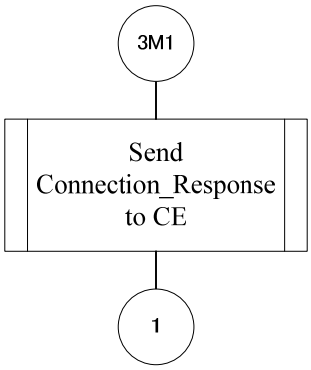


**Figure 25 CM operation**

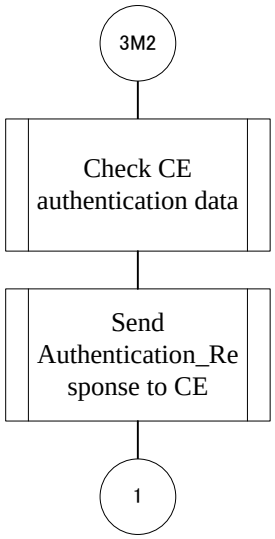


**Figure 26 CM operation**

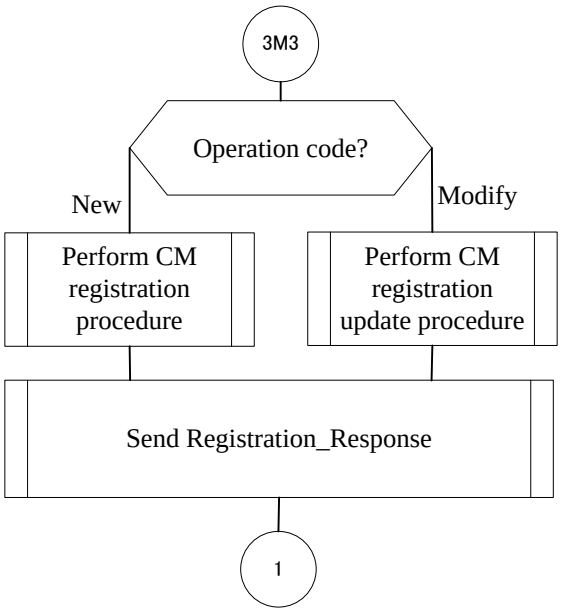

**Figure 27 CM operation**

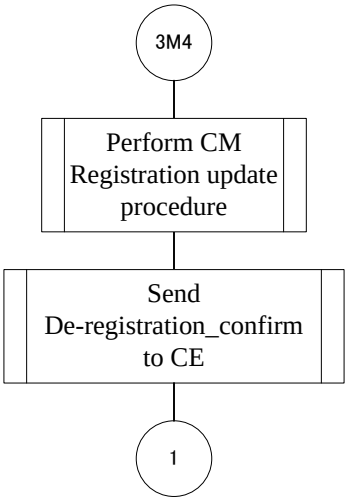


**Figure 28 CM operation**

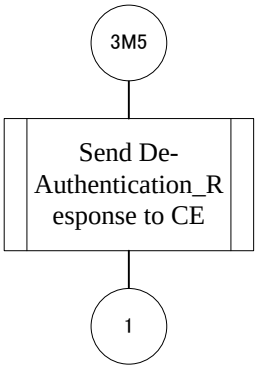


**Figure 29 CM operation**

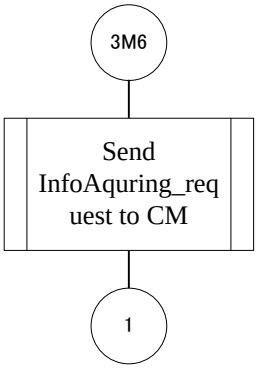


**Figure 30 CM operation**

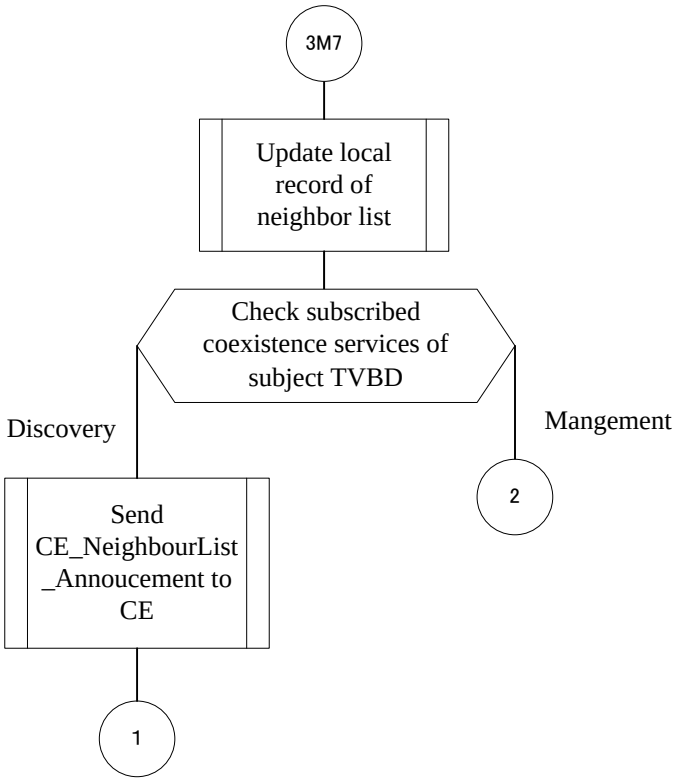


**Figure 31 CM operation**

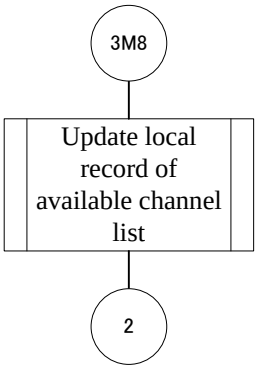


**Figure 32 CM operation**

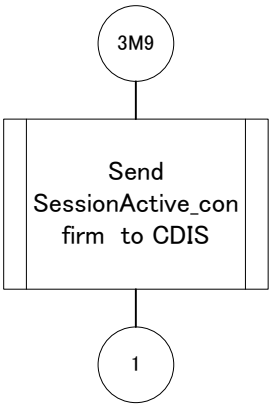


**Figure 33 CM operation**

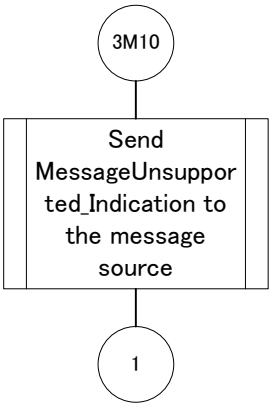


**Figure 34 CM operation**

### 7.3.3 CDIS operation

CDIS operation is described below using SDL flowcharts.

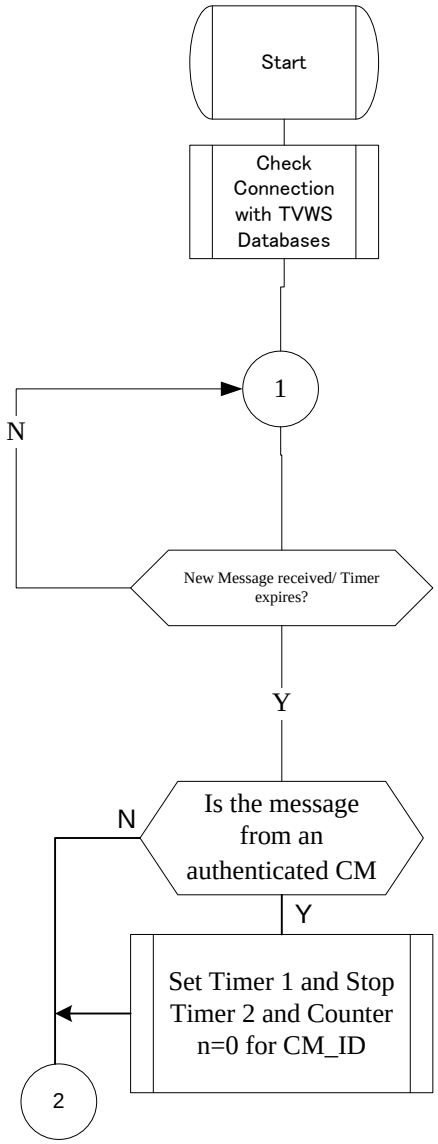


**Figure 35 CDIS operation**

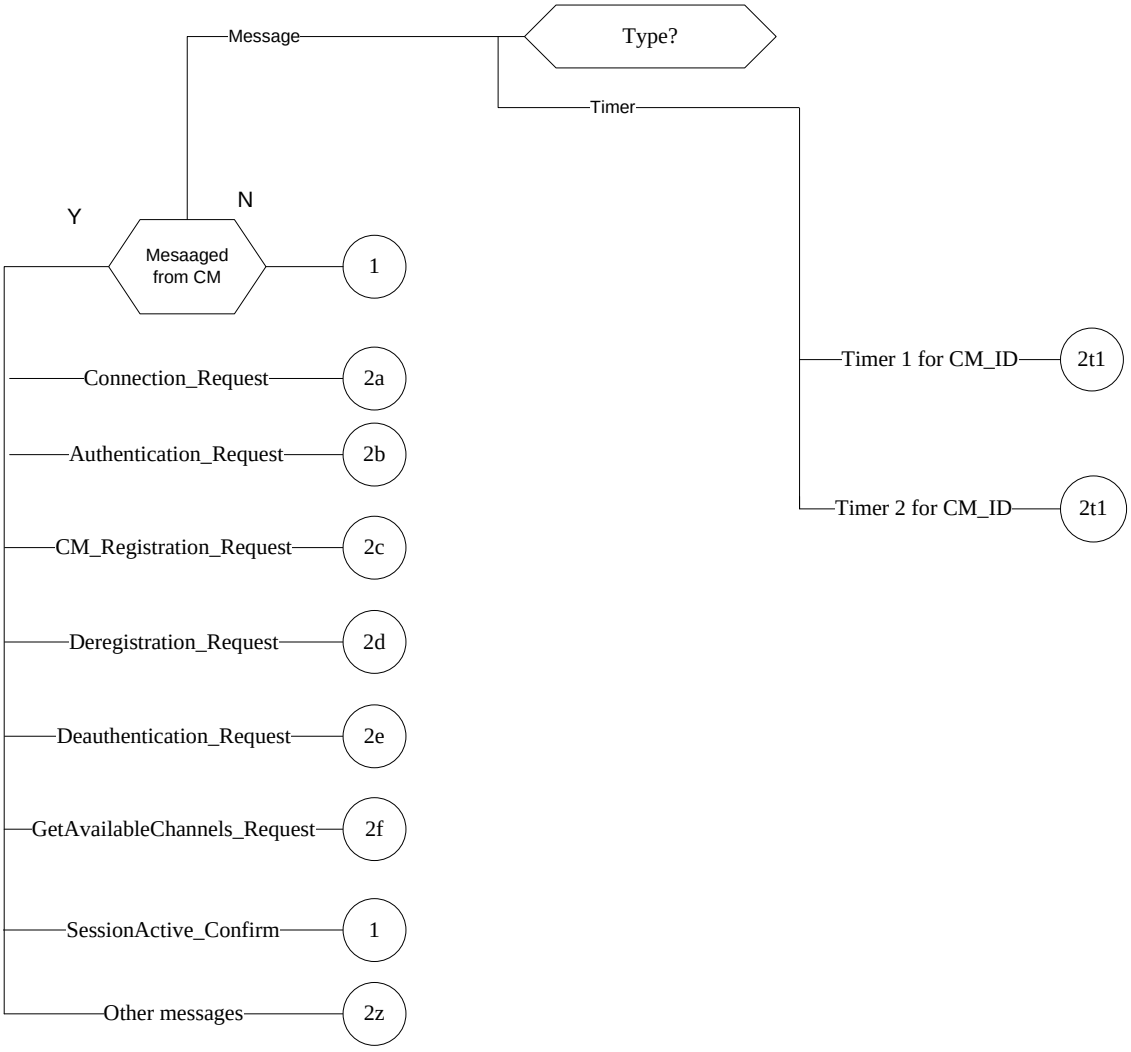


**Figure 36 CDIS operation**

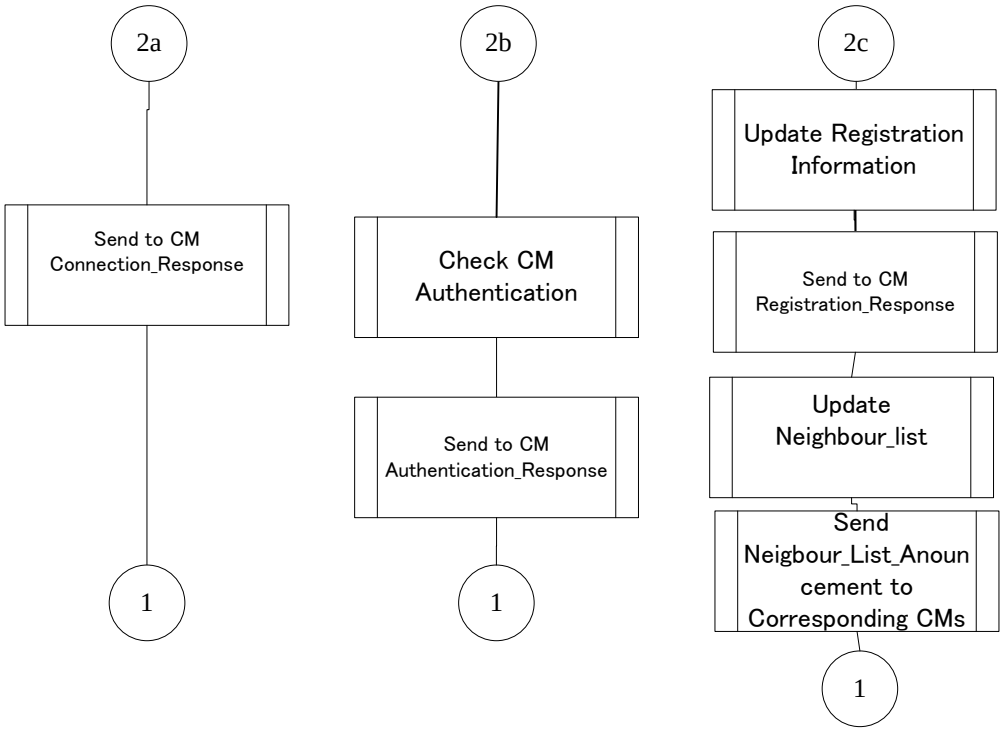


**Figure 37 CDIS operation**

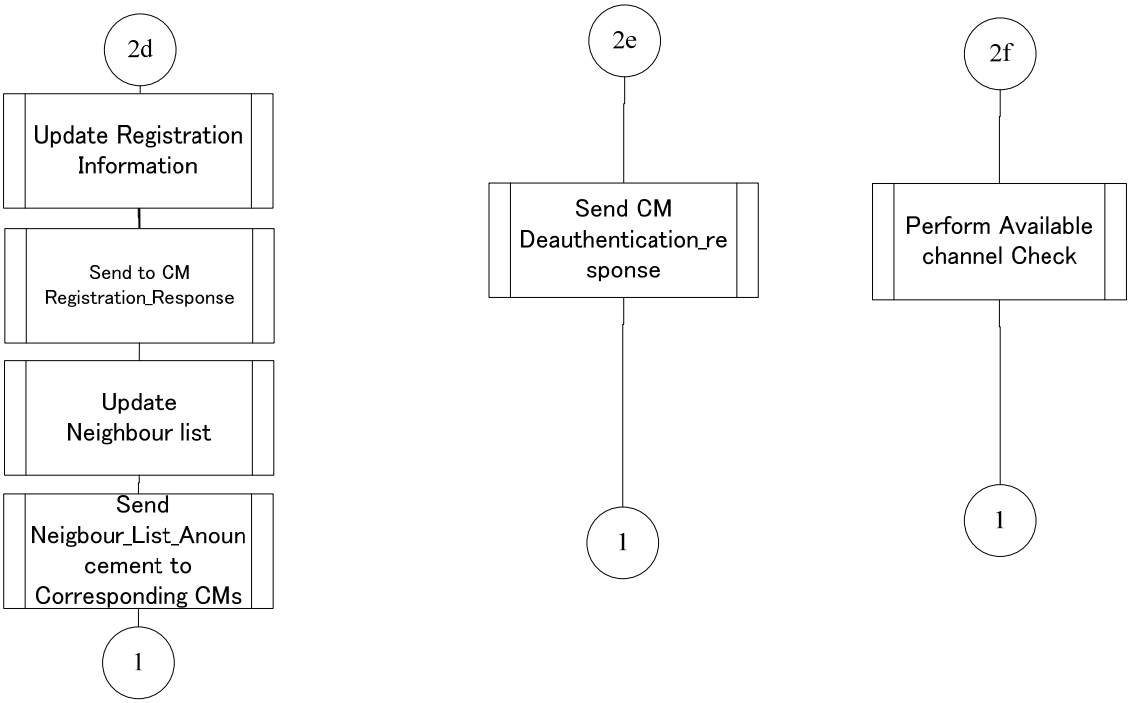


**Figure 38 CDIS operation**

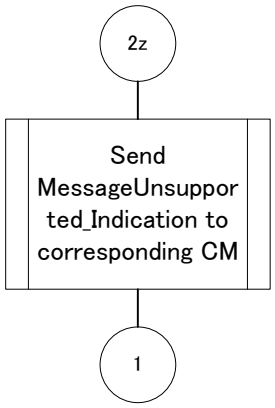


**Figure 39 CDIS operation**

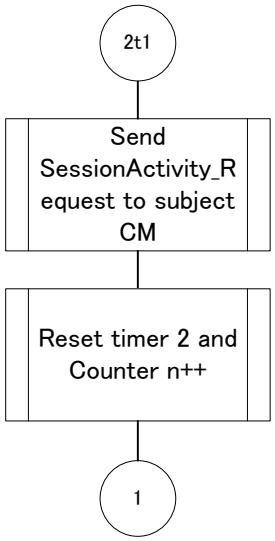


**Figure 40 CDIS operation**

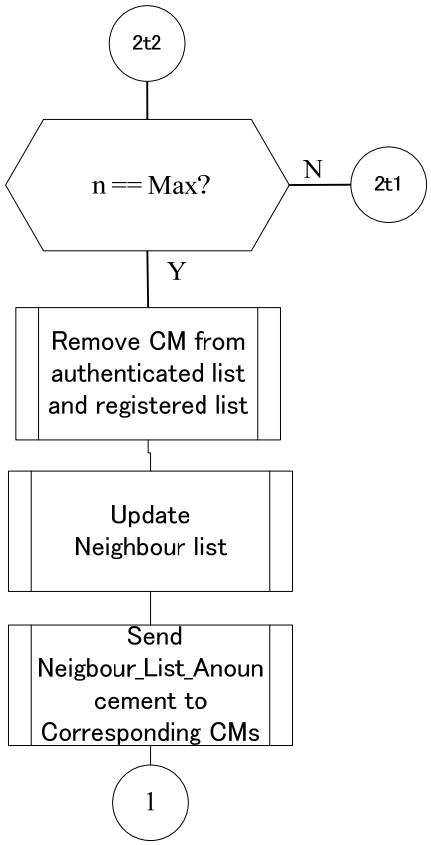


**Figure 41 CDIS operation**