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Title	**Improvement to clause 15.4.5**	
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Re:	IEEE 80216h-08/026 (recirc LB #29c)	
Abstract	This contribution proposes text improvement for section 15.4.5 on CT-CXP to take into account updates on MAC messages and primitives.	
Purpose	Improve clause 15.4.5 text.	
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Improvement to clause 15.4.5

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Introduction

This contribution proposes text improvement for section 15.4.5 on CT-CXP to take into account updates on MAC messages and primitives.

Specific editorial changes

This section provides a list of changes to the draft document.

Blue text represents specific editorial additions.

~~Red strikethrough~~ text is to be deleted.

Black text is text already in the draft.

Bold italic text is editorial instructions to the editor.

Proposed text

[Update the text of subclause 15.4.5 as indicate:]

15.4.5 Credit Token based Coexistence Protocol (CT-CXP)

In some traffic conditions circumstances, some master sub-frames are temporally under-used by some BS (offering BS, namely offeror) due to some low traffic activity while some of its neighboring BSs (requesting BS, namely requester) require temporally some additional master sub frame capacity to face some traffic increase. With respect to this, master sub frame sharing between neigbhouring systems contributes for better spectrum efficiency. The typically operation of sharing is illustrated in Master sub-frame (OFDM symbols) sharing within CX-Frame and Master sub-frame (OFDM symbols) sharing over T_renting_epoch where system S1 proposes to rent out its assigned last OFDM symbols (for a time duration T_renting_sub-frame per master sub-frame over several consecutive CX-Frames of total time duration T_renting_epoch) to system S2 and S3. This master sub frame sharing is supported by the credit token based coexistence protocol (CT-CXP). CT-CXP provides the means for an offeror to rent out temporally some of its master sub frame capacity to some competing requester(s) willing to rent in simultaneously this proposed additional resource. CT-CXP guarantees exclusive access of the offeror's unused master sub-frame resource to the requester(s) for an agreed time period between the offeror and the requester. During this agreed period, the requester is granted with the resource during which the offeror will not use the resource. Also, CT-CXP ensures over time a fair access of the offeror's master sub-frame available resource between competing requesters.

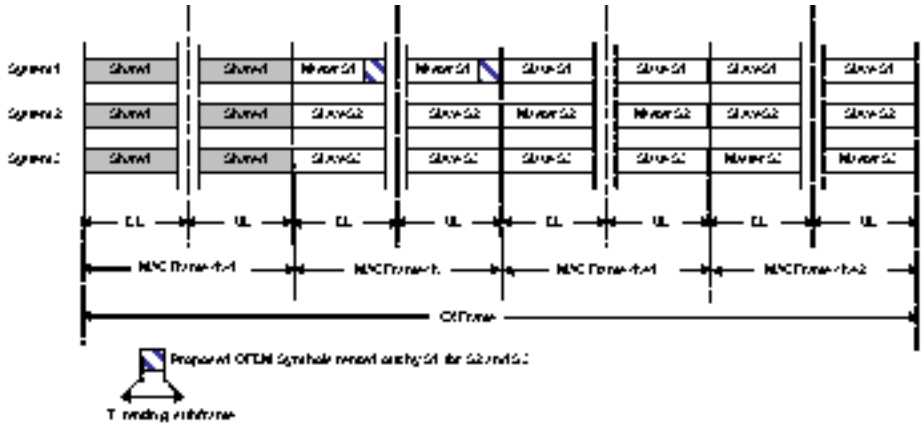


Figure h53—Master sub-frame (OFDM symbols) sharing within CX-Frame

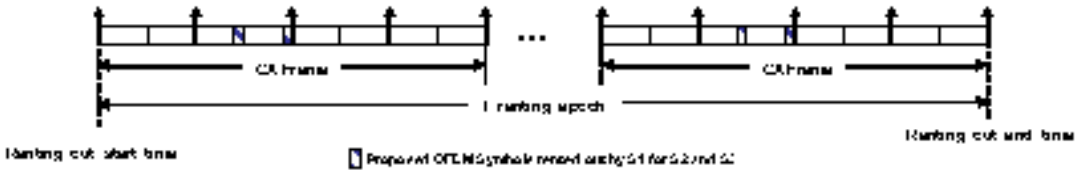


Figure h54—Master sub-frame (OFDM symbols) sharing over T_renting_epoch

15.4.5.1 CT-CXP Procedures

15.4.5.1.1 Whole CT-CXP Procedure

CT-CXP can be instantiated either in a non-negotiated mode or in a negotiated mode. This allows CT-CXP to be flexibly executed as a function of the context (e.g time constraints for negotiation, regulatory spectrum sharing policies and so forth). The followed approach is flexible in that it is scalable and it allows a vendor differentiated implementation of non-negotiated or negotiated (of any types) based CT-CXP.

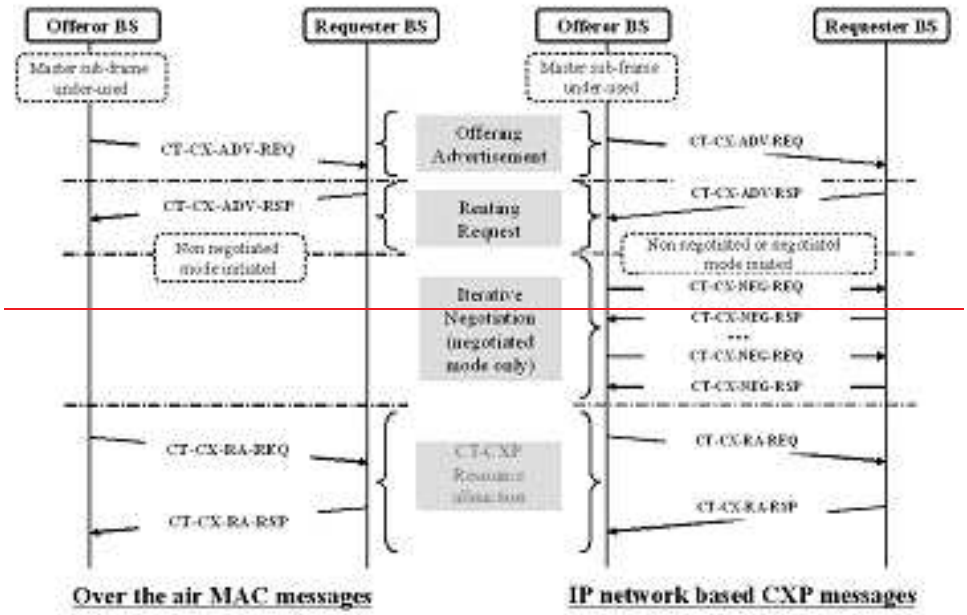
The non-negotiated mode requires the minimum messages exchange to support CT-CXP between the offeror and requester(s). This mode requires no negotiation iteration between the offeror and requester. This mode can be applied when time availability is very limited to handle several iterations for the negotiations and/or when the CT-CXP is executed over the air through over the air inter-BSs communications.

The negotiated mode is used when time availability is enough to handle several iterations for the negotiation. This mode is operated through network based inter-BSs communications.

CT-CXP is composed of several consecutive procedures (offering advertisement, renting request, iterative negotiation, and CT-CXP resource allocation) as shown in ~~Whole CT-CXP Procedure~~*Figure h55*. For the sake of simplicity, this figure is only depicted for one (among multiple) requesters. Over the air based instantiation of CT-CXP for the non negotiated mode is depicted on the left hand side of

Whole CT-CXP Procedure. The over network based instantiation of CT-CXP for the negotiation or non negotiated mode is depicted on the right hand side of Whole CT-CXP Procedure. Inter system over the air messages are encapsulated within CX-REQ-MAC and CX-RSP-MAC messages (section ***Error! Reference source not found.***). Inter system over the air communications mechanisms are described in subclause ***Error! Reference source not found.***. Pprimitives related to network based instantiation are specified in section ***Error! Reference source not found.***. ~~The offering advertisement message (CT-CX-ADV-REQ)~~ The primitive C-CX-REQ (Action_Type = Token Advertisement) specifies which negotiation mode is used by the CT-CXP. The iterative negotiation procedure is executed only with the negotiated mode and not with the non-negotiated mode.

Within CT-CXP, a renting resource unit (RRU) is defined as the minimum time x frequency unit (e.g. OFDM symbol, or a minimum number of symbols and subcarriers in OFDMA) that can be rented in/out between the offeror and a requester. RRU time duration is denoted RRU_duration. A master sub-frame is composed of a fixed amount of RRUs. The part of the offeror's available master sub-frame to be rented out is named rented resource. Consequently, an offeror's rented resource is defined as an amount of RRUs. A credit token (CT) is the pseudo monetary unit used by CT-CXP allowing the requester to rent in a RRU to the offeror. A RRU is charged as a number of CTs. Each BS is intially assigned with a CT budget, i.e. a maximum number of CTs. This maximum number can be normalized to the total number of RRUs per master sub-frame. Also, this number can be dynamically specified by policy issued by the RAIS via the BSIS (see subclause ***Error! Reference source not found.*** *– section 15.8*).



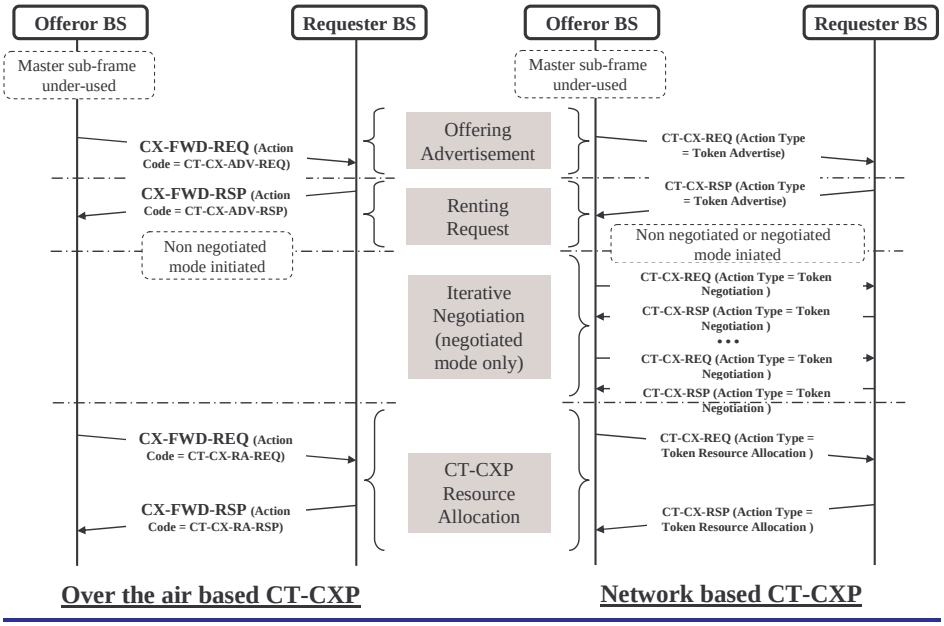


Figure h55—Whole CT-CXP Procedure

The details of these procedures are specified in subsections here after.

15.4.5.1.2 CT-CXP Offering Procedure

The over the air and network based CT-CXP offering procedures are respectively depicted hereafter.~~in Over the air based CT-CXP offering procedure and Network based CT-CXP offering procedure.~~

a) The over the air procedure described in ~~Over the air based CT-CXP offering procedure~~*Figure h56* is as follows:

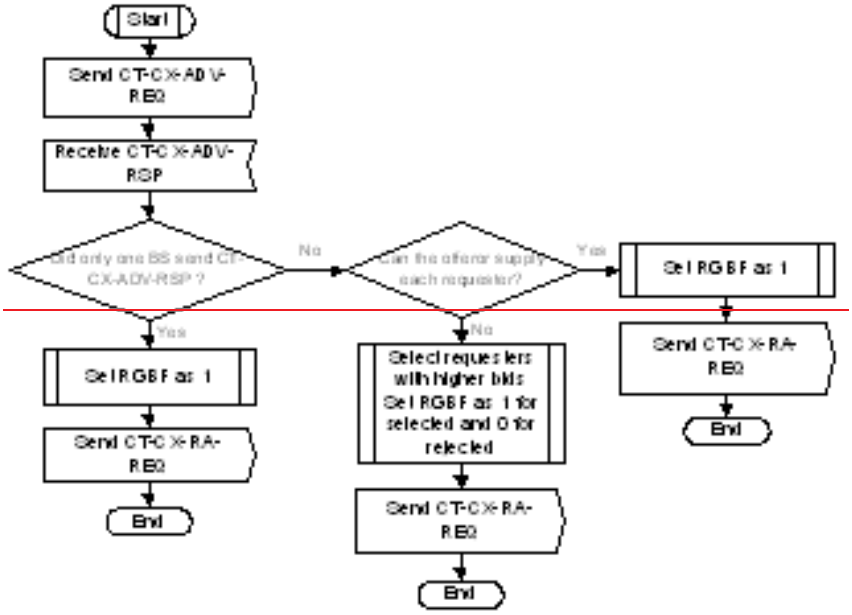
- A BS identifies that a part of its master sub-frame is going to be under-used and can be rented out. With respect to this, this BS becomes an offeror BS and initiates the renting advertisement by broadcasting the ~~CT-CX-ADV-REQ~~ CX-FWD-REQ (Action code = CT-CX-ADV-REQ) message. In particular, this message includes information related to the available resource (T_renting_sub-frame, Renting_out_start_time, Renting_out_end_time) as well as the renting conditions (MNCT: Minimum number of credit tokens per RRU required per requester's bid), and also a list (LC: List of Channels) of other channels (frequency domain) proposed by the offeror BS for renting.
- If the offeror BS receives one single ~~CT-CX-ADV-RSP~~ CX-FWD-RSP (Action code = CT-CX-ADV-RSP) ~~message~~, then the offeror BS grants the renting resource to the single requester by setting the Resource Granting Bit Flag (RGBF) to 1 in ~~the~~ CX-FWD-REQ (Action code = CT-CX-RA-REQ)~~CT-CX-RA-REQ message~~. The granted requester is not charged with credit token since it is not competing with some other requesters. The offeror provides to the granted requester with the list of the BSIDs of the systems belonging to the offeror's community. This list is provided within CX-FWD-REQ (Action code = CT-CX-RA-REQ) ~~the CT-CX-RA-REQ message~~.

— If the offeror BS receives more than one ~~CT-CX-ADV-RSP message~~ CX-FWD-RSP (Action code = CT-CX-ADV-RSP), then it assesses whether he can supply each requester or not:

- If it can supply, the offeror BS grants the renting resource to all requesters by setting the Resource Granting Bit Flag (RGBF) to 1 in ~~the CT-CX-RA-REQ message~~CX-FWD-REQ (Action code = CT-CX-RA-REQ).
- If it cannot, the offeror BS derives and selects requesters with higher bids based on the information received from competing requesters. The offeror BS grants the resource to the selected requesters by setting the Resource Granting Bit Flag (RGBF) to 1 in CX-FWD-REQ (Action code = CT-CX-RA-REQ)~~the CT-CX-RA-REQ message~~. These selected requesters can access to their requested resource Rented_resource_amount from Renting_sub-frame_start_time to Renting_sub-frame_end_time during the guaranteed requested time period (Renting_in_start_time, and Renting_in_end_time). RGBT is set to 0 for the non selected requesters.

In both cases, the offeror provides to the selected requesters with the list of the BSIDs of the systems belonging to the offeror's community. This list is provided within CX-FWD-REQ (Action code = CT-CX-RA-REQ).~~the CT-CX-RA-REQ message.~~

— CX-FWD-REQ (Action code = CT-CX-RA-REQ)~~The CT-CX-RA-REQ message~~ includes the clearing price (Clearing_price). Derived from the selection process, the clearing price corresponds to the number of credit tokens per RRU has to be frozen to acquire the granted resources. The procedure to derive the clearing price is established by operator coordination.



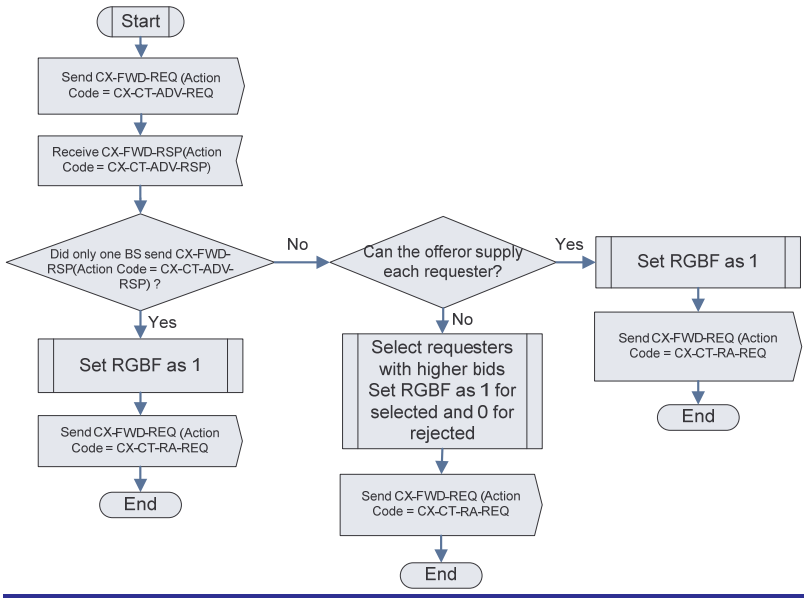


Figure h56—Over the air based CT-CXP offering procedure

b) The network procedure described in ~~Network based CT-CXP offering procedure~~*Figure h57* is as follows:

- A BS identifies that a part of its master sub-frame is going to be under-used and can be rented out. With respect to this, this BS becomes an offeror BS and initiates the renting advertisement by broadcasting ~~the CT-CX-ADV-REQ message~~C-CX-REQ (Action Type = Token Advertisement). In particular, this message includes information related to:
  - The available resource (T_renting_sub-frame, Renting_out_start_time, Renting_out_end_time)
  - The negotiation mode (NMBF == 0: non negotiated mode is active, NMBF == 1: negotiated mode is active)
  - The renting conditions (Start_negotiation_time, End_negotiation_time, MNCT, LC)
  - The pricing method in case NMBF == 1
- If the offeror BS receives one single ~~CT-CX-ADV-RSP message~~C-CX-RSP (Action_Type = Token Advertisement), then the offeror BS grants the renting resource to the single requester by setting the Resource Granting Bit Flag (RGBF) to 1 in ~~the CT-CX-RA-REQ message~~ C-CX-REQ (Action_Type = Token Resource Allocation). The granted requester is not charged with credit token since it is not competing with some other requesters. The offeror provides to the granted requester with the list of the BSIDs of the systems belonging to the offeror's community. This list is provided within C-CX-REQ (Action_Type = Token Resource Allocation). ~~the CT-CX-RA-REQ message.~~
- If the offeror BS receives more than one C-CX-REQ (Action_Type = Token Advertisement)~~CT-CX-ADV-REQ message~~, then it assesses whether he can supply each requester or not:
  - If it can supply, the offeror BS grants the renting resource to all requesters by setting the Resource Granting Bit Flag (RGBF) to 1 in C-CX-REQ (Action_Type = Token Resource Allocation)~~the CT-CX-RA-REQ message~~. The offeror provides to the granted requesters with the list of the BSIDs of the systems belonging to the offeror's community. This list is

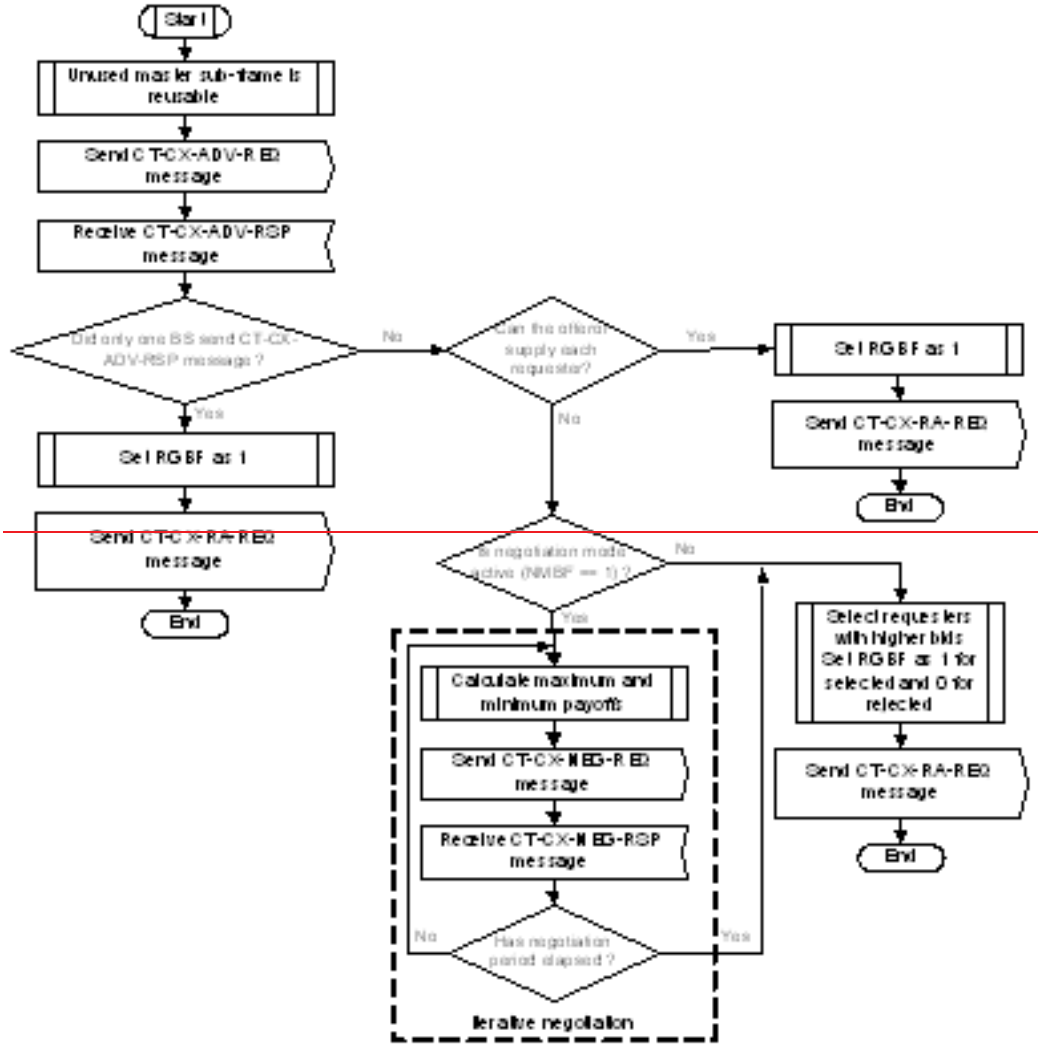
provided within C-CX-REQ (Action_Type = Token Resource Allocation)~~the CT-CX-RA-REQ message~~.

- If it cannot, the offeror BS follows the negotiated mode under consideration:

  — If NMBF = 0, same procedure as a) is executed. The Offeror BS derives and selects requesters with higher bids based on the information received from competing requesters. The offeror BS grants the resource to the selected requesters by setting the Resource Granting Bit Flag (RGBF) to 1 in C-CX-REQ (Action_Type = Token Resource Allocation)~~the CT-CX-RA-REQ message~~. These selected requesters can access to their requested resource Rented_resource_amount from Renting_sub-frame_start_time to Renting_sub-frame_end_time during the guaranteed requested time period (Renting_in_start_time, and Renting_in_end_time). RGBT is set to 0 for the non selected requesters.

  — If NMBF = 1, iterative negotiation occurs between the offeror BS and each requester BS. Based on the infomation received within C-CX-RSP (Action_Type = Token Advertisement)~~the CT-CX-ADV-RSP message~~, the offeror BS calculates respectively a minimum and maximum payoff (Minimal_payoff and Maximal_payoff) at each iteration. These payoffs allow selecting the remaining requesters at each iteration. An example of payoff calculation is given in section Payoff calculation. At each iteration, Minimal_payoff and Maximal_payoff are sent within C-CX-REQ (Action_Type = Token Negotiation)~~the CT-CX-NEG-REQ message~~. The iterative negotiation occurs until the negotiation period (bounded by End_negotiation_time) is elapsed. At the end of the negotiation, the final requesters are selected by the offeror BS. The offeror BS grants the resource to the selected requesters by setting the Resource Granting Bit Flag (RGBF) to 1 in C-CX-REQ (Action_Type = Token Resource Allocation)~~the CT-CX-RA-REQ message~~. These selected requesters can access to their requested resource Rented_resource_amount from Renting_sub-frame_start_time to Renting_sub-frame_end_time during the guaranteed requested bounded time period (Renting_in_start_time, and Renting_in_end_time). RGBT is set to 0 for the non selected requesters.

In both cases, the offeror provides to the granted requesters with the list of the BSIDs of the systems belonging to the offeror's community. This list is provided within C-CX-REQ (Action_Type = Token Resource Allocation)~~the CT-CX-RA-REQ message~~.


Start
Unused master sub-frame is reusable
Send CT-CX-ADV-REQ message
Receive CT-CX-ADV-RSP message
Did only one BS send CT-CX-ADV-RSP message ?
No
Can the offered supply each requester?
Yes
Set RGBF as 1
Send CT-CX-RA-REQ message
End
Yes
Set RGBF as 1
Send CT-CX-RA-REQ message
End
No
Is negotiation mode active (NMBF == 1) ?
No
Yes
Select requesters with higher bids Set RGBF as 1 for selected and 0 for relected
Send CT-CX-RA-REQ message
End
Calculate maximum and minimum payoffs
Send CT-CX-NEG-REQ message
Receive CT-CX-NEG-RSP message
No
Has negotiation period elapsed ?
Yes
Iterative negotiation

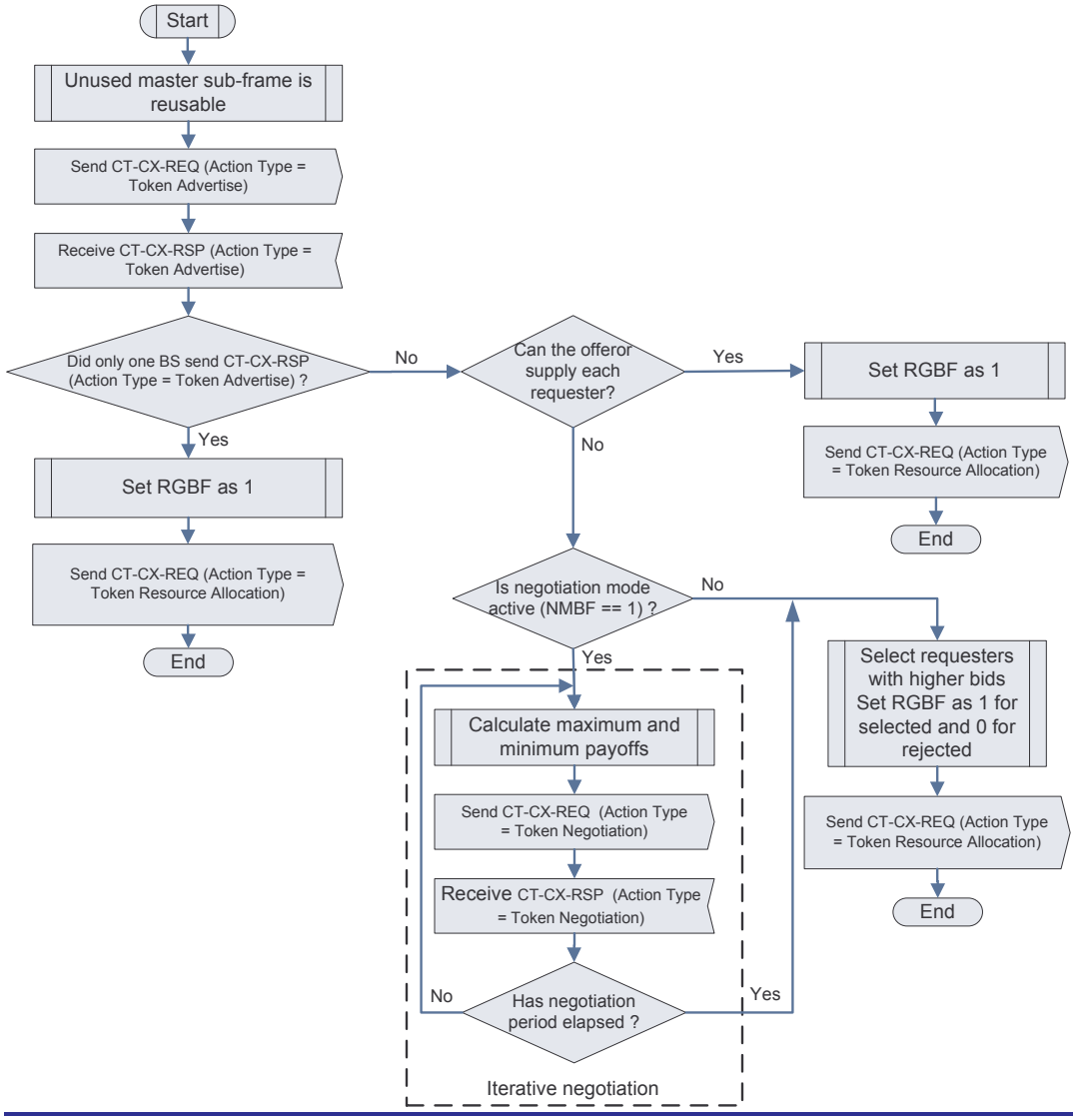


Figure h57—Network based CT-CXP offering procedure

15.4.5.1.3 CT-CXP Requesting Procedure

The over the air and network based CT-CXP requesting procedures are respectively depicted ~~in Over the air based CT-CXP requesting procedure and network based CT-CXP requesting procedure~~hereafter.

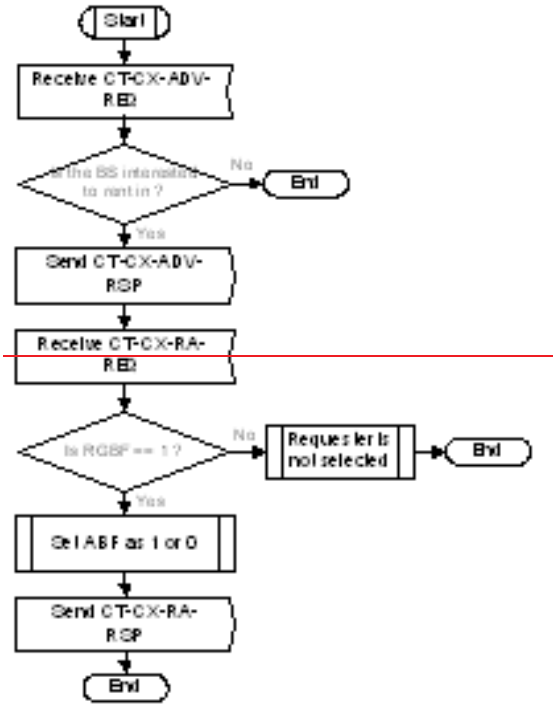
a) The over the air procedure described in ~~Over the air based CT-CXP requesting procedure~~*Figure h58* is as follows:

— If a BS is in need of additional resource and can meet MNCT requirements, he can make a request CX-FWD-RSP (Action code = CT-CX-ADV-RSP) ~~(CT-CX-ADV-RSP message)~~ upon the reception of CX-FWD-REQ (Action code = CT-CX-ADV-REQ). ~~CT-CX-ADV-REQ.~~

— Within CX-FWD-RSP (Action code = CT-CX-ADV-RSP)~~CT-CX-ADV-RSP~~, the requester informs about the amount of required resource (Rented_resoure_amount), the rented in start

and end time (Renting_in_start_time, Renting_in_end_time) and the requester's bid (Requester_bid) in term of number of credit tokens bidded per RRU.

- Upon reception of CX-FWD-REQ (Action code = CT-CX-RA-RSP)~~CT-CX-RA-REQ message~~, the requester BS knows whether it has been selected or not. If RGBF is set to 1, the requester BS is selected, otherwise (RGBF set to 0) the requester is rejected.
- The requester decides to accept (Acceptation Bit Flag ABF set to 1) or to reject (ABF set to 0) the resource granting based on the Clearing_price information. This information is sent within CX-FWD-RSP (Action code = CT-CX-RA-RSP) ~~the CT-CX-RA-RSP message~~.
- If ABF is set to 1, a number of credit tokens equal to *Clearing_price* Rented_resource_amount*T_renting_sub-frame*[(Renting_in_end_time-Renting_in_start_time)/CX_Frame_duration]/RRU_duration* will not be usable (for some further renting requests by this same requester) for a time duration equal to [Renting_in_start_time; Renting_in_end_time + $^{\delta}$] where $^{\delta}$ is a frozen period margin. This ensures fairness over time between competing requester BSs to access to some other renting offers.
- Once the requester is granted with the resources, the granted requester informs the other members of its community and the members of the offeror's community about its identity and when he will use the granted resources. This information is provided within ~~CT-CX-FRSU message~~C-CX-IND (Action_Type = Token Frame Status Update) through the backhaul



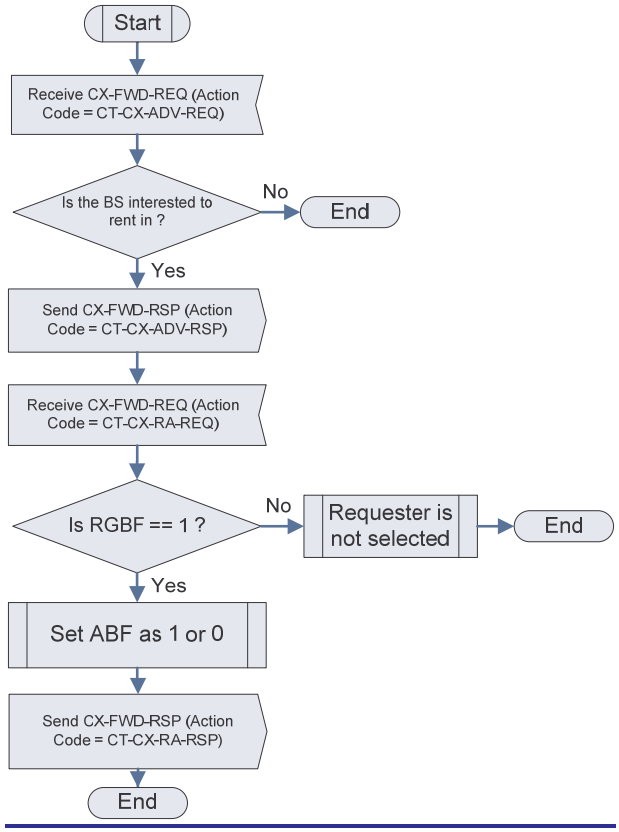


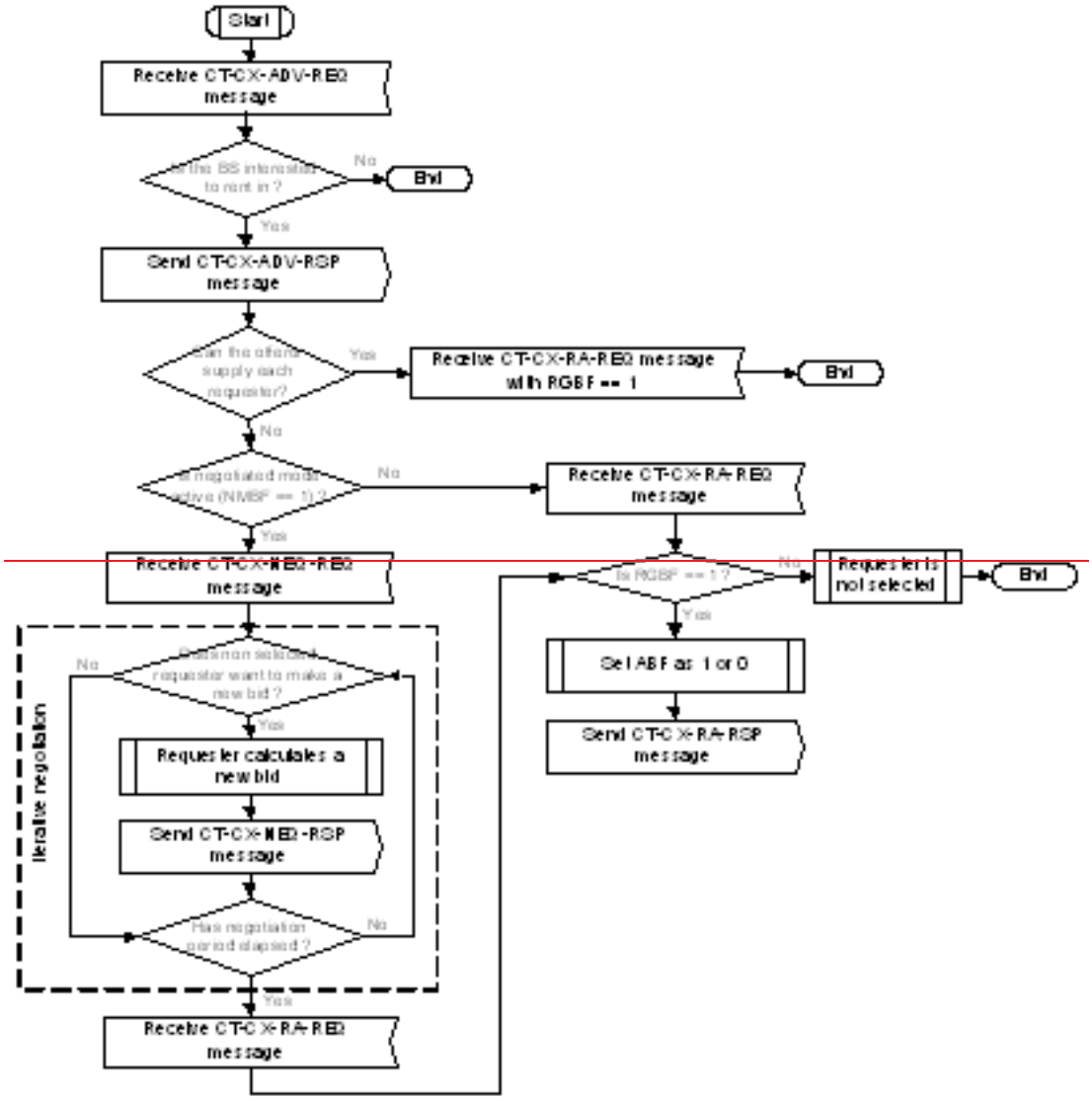
Figure h58—Over the air based CT-CXP requesting procedure

b) The network procedure described in ~~network based CT-CXP requesting procedure~~*Figure h59* is as follows:

- If a BS is in need of additional resource, meets MNCT requirements, and agrees with the proposed negotiation mode (NMBF) and pricing method (PBF) specified within ~~the CT-CX-ADV-REQ message~~ C-CX-REQ (Action_Type = Token Advertisement), he can submit a bid (within ~~CT-CX-ADV-RSP message~~ C-CX-RSP (Action_Type = Token Advertisement)) upon the reception of the ~~CT-CX-ADV-REQ message.~~ C-CX-REQ (Action_Type = Token Advertisement).
- Within ~~the CT-CX-ADV-RSP message~~ C-CX-RSP (Action_Type = Token Advertisement), the requester informs about the amount of required resource (Rented_resoure_amount), the rented in start and end time (Renting_in_start_time, Renting_in_end_time) and its bid (Requester_bid) in term of number of credit tokens bidded per RRU.
  - If the non negotiation mode is active (NMBF == 0), same procedure as a) is executed. If the offerer BS can supply to the requester BS, the offeror BS grants the renting resource by setting the Resource Granting Bit Flag (RGBF) to 1 in ~~the CT-CX-RA-REQ message.~~ C-CX-REQ (Action_Type = Token Resource Allocation).
  - If the negotiation mode is active (NMBF == 1), iterative negotiation occurs between the offeror BS and each requester BS. At each iteration, based on the information Minimum_payoff and Maximal_payoff received from ~~the CT-CX-NEG-REQ message~~ C-CX-REQ (Action_Type = Token Negotiation), the requester decides to submit a new bid (Requester_bid_update) or not. Requester_bid_update is sent within C-CX-RSP

(Action_Type = Token Negotiation). ~~the CT-CX-NEG-RSP message.~~ The iterative negotiation occurs until the negotiation period (bounded by End_negotiation_time) is elapsed.

- Upon reception of C-CX-REQ (Action_Type = Token Resource Allocation).~~the CT-CX-RA-REQ message~~, the requester BS knows whether it has been selected or not. If RGBF is set to 1, the requester BS is selected, otherwise (RGBF set to 0) the requester is rejected.
- The requester decides to accept (Acceptation Bit Flag ABF set to 1) or to reject (ABF set to 0) the resource granting based on the Clearing_price information. This information is sent within the C-CX-RSP (Action_Type = Token Resource Allocation).~~CT-CX-RA-RSP message.~~ The method to derive the clearing price is open for the implementation.
- If ABF is set to 1:
  - If PBF = 0, a number of CTs equal to Clearing_price*Rented_resource_amount*T_renting_sub-frame*[(Renting_in_end_time-Renting_in_start_time)/CX_Frame_duration]/RRU_duration is transferred from the requester's ownership to the offeror's one. This calculation is an example and it is open for implementation.
  - If PBF == 1, the CT are not transferred but remains to the requester ownership. However, a number of credit tokens equal to the previous number (as calculated in the previous bullet point) will not be usable (for some further renting requests by this same requester) for a time duration equal to [Renting_in_start_time; Renting_in_end_time + δ] where δ is a frozen period margin. This ensures fairness over time between competing requester BSs to access to some other renting offers.
- Once the requester is granted with the resources, the granted requester informs the other members of its community and the members of the offeror's community about its identity and when he will use the granted resources. This information is provided within C-CX-IND (Action_Type = Token Frame Status Update) ~~CT-CX-FRSU message~~ through the backhaul.


Start
Receive CT-CX-ADV-REQ message
Will the BS interested to rent in ?
No
End
Yes
Send CT-CX-ADV-RSP message
Can the others supply each requester?
Yes
Receive CT-CX-RA-REQ message with RGBF == 1
End
No
Is negotiated mode active (NMBF == 1) ?
No
Receive CT-CX-RA-REQ message
Yes
Receive CT-CX-REQ-REQ message
Is RGBF == 1 ?
No
Requester is not selected
End
Yes
Set ABF as 1 or 0
Send CT-CX-RA-RSP message
Iterative negotiation
No
Condition satisfied requestor want to make a new bid ?
Yes
Requester calculates a new bid
Send CT-CX-NEG-RSP message
Has negotiation period elapsed ?
No
Yes
Receive CT-CX-RA-REQ message

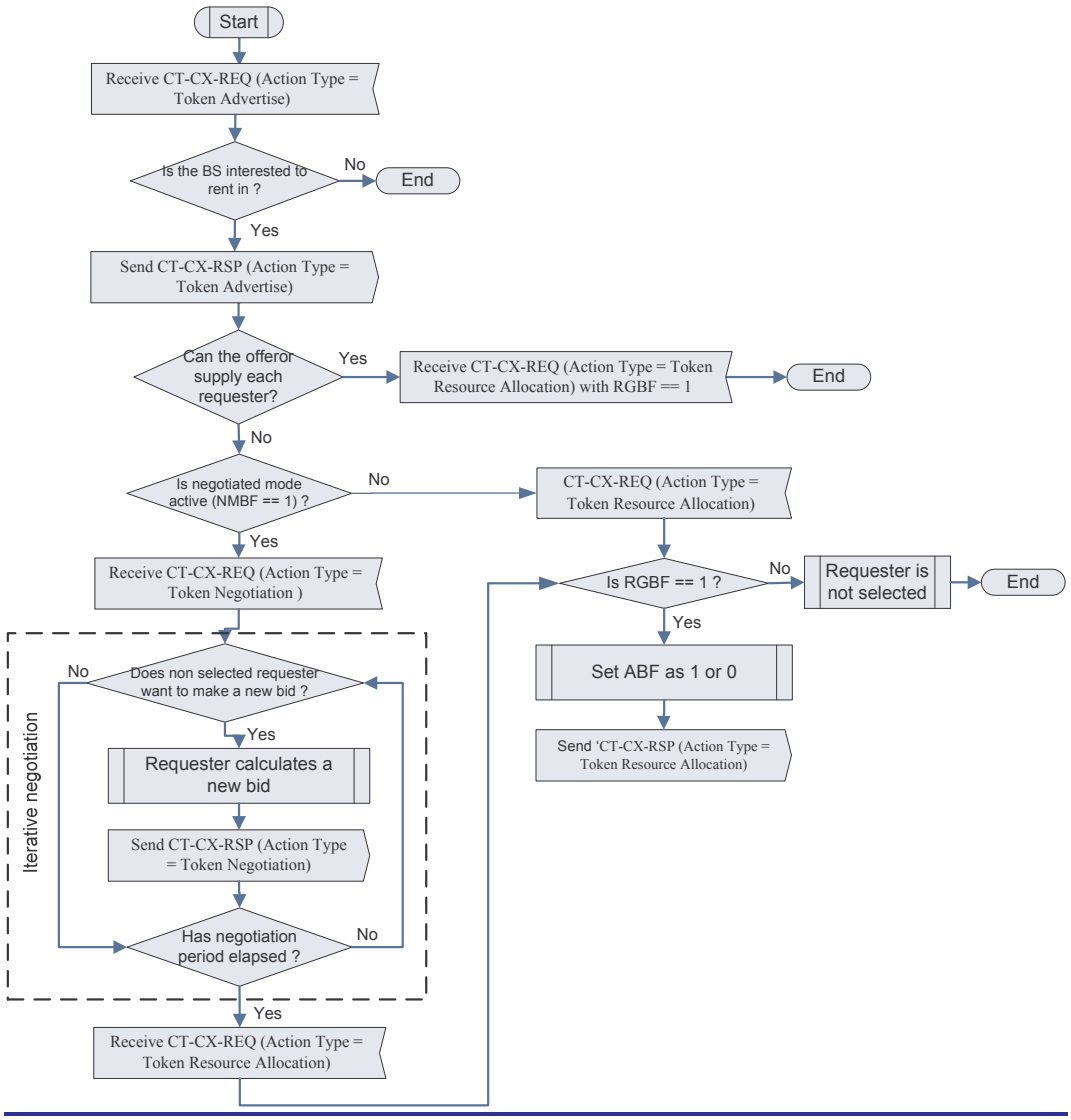


Figure h59—N~~n~~etwork based CT-CXP requesting procedure

15.4.5.2 Payoff calculation

This section provides an example on how the payoff in section ~~CT-CXP Offering Procedure~~*15.4.5.1.2* can be calculated. This method is an example and the implementation is vendor specific.

At each iteration:

- i) The offeror BS calculates the payoff (Payoff_requester) corresponding to each remaining requester as follows:
- ii) Payoff_requester = Requester_bid_update* Rented_resource_amount*[T_renting_sub-frame *(Renting_in_end_time - Renting_in_start_time)/CX_Frame_duration]/RRU_duration.

- iii) The offeror selects the requesters that maximise jointly sum(Rented_resource_amount) and sum(Payoff_requester) over all the remaining requesters.
- iv) The offeror BS derives the Minimal_payoff and Maximal_payoff from the selected requesters and sends this information to all initial remaining requesters.
- v) Based on this information, each requester knows whether it has been selected or not by comparing its own Payoff_requester with Minimal_payoff.
- vi) Based on this comparison, the non selected requester decides to make a new bid (Requester_bid_update) or not for the next iteration of the negotiation.

15.4.5.3 Inter BSs communications for CT-CXP

CT-CXP requires inter BSs communication between different systems. These inter BS communications are necessary to exchange the parameters (***Error! Reference source not found.***) related to the CT-CXP procedures described in section 15.4.5.1~~CT-CXP Procedures~~.

The parameters related to CT-CXP (***Error! Reference source not found.***) are stored into the BSIS and into the database of each WirelessMAN-CX BS of the shared distributed system architecture (section ***Error! Reference source not found.***).

The exchange of these parameters between BSs is supported through network inter-BS communications for the negotiated and non-negotiated modes. The related primitives are defined in section ***Error! Reference source not found.***.

The exchange of these parameters and related primitives (section ***Error! Reference source not found.***) between BSs is also supported with over the air MAC messages for the non-negotiated mode. These CXP messages are encapsulated within the CX-REQ and CX-RSP MAC messages defined in section ***Error! Reference source not found.***. Inter system over the air communications mechanisms are detailed within clause ***Error! Reference source not found.***.

References

[1] IEEE 802.16h/D5: Part 16: Air Interface for Fixed Broadband Wireless Access Systems Amendment for Improved Coexistence Mechanisms for License-Exempt Operation, March 2008