

Project	<b>IEEE 802.16 Broadband Wireless Access Working Group</b> < <a href="http://ieee802.org/16">http://ieee802.org/16</a> >	
Title	<b>Text remedies for credit token based co-existence protocol section</b>	
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Re:	Recirculation of Working Group Review of Working Document 80216h-06_015	
Abstract	This contribution provides remedies to comment #3 of the session #43's Working Group Review. The text remedies for credit token based co-existence protocol are proposed for section 15.6.2.2.6 of the working document [1].	
Purpose	Text remedies to comment #3 of the session #43's Working Group Review.	
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## Text remedies for credit tokens based rental protocol section

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### Overview

This contribution suggests remedies to action items from session #43's Working Group Review, namely Comment 3 of [2] – Correction of terminology in the credit token based rental protocol section. The text changes are intended to be included in the section 15.6.2.2.6 of the working document [1].

### 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.

### Text proposal for section 15.6.2.2.6

*Add the text below to update section 15.6.2.2.6*

#### 15.6.2.2.6 Negotiation between master NWs

Spectrum sharing between several networks (NW) can be achieved through the sharing of a common MAC frame between the different NWs as exemplified by Figure h44. In such a MAC frame structure, dedicated portions (denoted as “master NW sub-frames”) of the frame are periodically and exclusively allocated to a NW (denoted as the “master NW”) respectively in the forward and reverse link. The terminology used hereafter defines a slave NW as a NW that may operate during the other master NWs sub-frames. With respect to this definition, the slave NW sub-frames are the time intervals operating in parallel of the master NWs sub-frames.

Additional flexibility can be provided by such a frame structure if the length of each master sub-frame (interference free sub-frame) can be dynamically adjusted as a function of the spatial and temporal traffic load variations of each NW as stated in section 15.2.1.1.1.

To achieve this, this section proposes the dynamic coordination of the frame structure sharing between BSs when several master -NWs compete to share this common shared MAC frame.

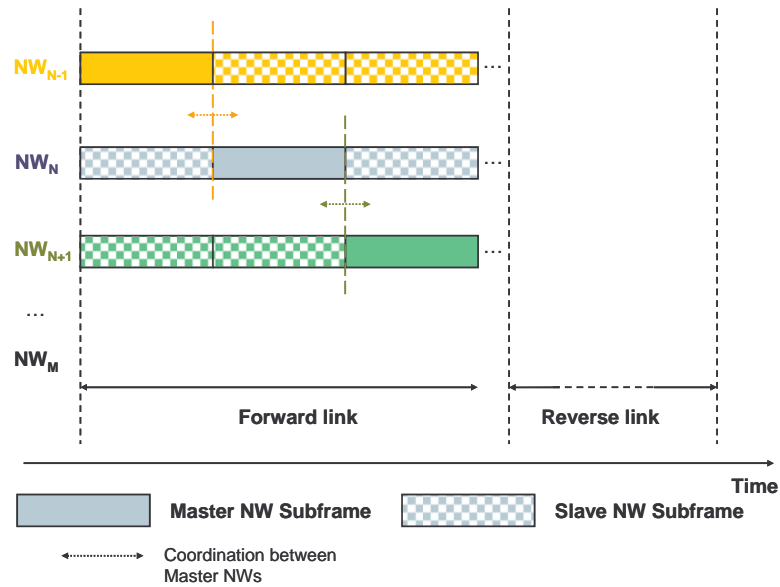


Figure h44: Example of TDD based MAC frame sharing structure between M NWs

#### 15.6.2.2.6.1 General principle

In order to solve contention access channel and resources scheduling issues between NWs, the first step consists in defining credit tokens and designing appropriate ~~reserve price auctioning and bidding~~ negotiation mechanisms. Then, on the basis of the credit tokens based mechanisms usage, the second step consists in managing dynamically (temporally) the bandwidth requests and grants mechanisms for the sharing of the master sub frames within the common MAC frame.

Based on the credit tokens transactions (~~selling~~assignment, ~~purchase~~release and awarding), these two steps provide the mechanisms to enable spectrum efficiency and a fair spectrum usage in a real time fashion, while ensuring both the master and slave NWs QoS. These two steps enable to manage spectrum sharing between master NWs themselves. The result is the dynamic shaping of the MAC frame structure sharing as a function of the space time traffic intensity variations and the dynamic credit tokens portfolio account of the master NWs. The transaction mechanisms are detailed in the following sections.

#### 15.6.2.2.6.2 Credit tokens assignment and usage principles

- Each NW is initially allocated with a given credit tokens ~~account~~budget.
- Negotiation for spectrum sharing between NWs is based on credit tokens transactions.
- Credit tokens transactions occur dynamically between a ~~credit tokens seller~~offeror (master NW owner of the radio resources during the active master sub-frame) and one or several ~~credit tokens bidders~~requesters (the other master NWs).
- The negotiation occurs dynamically between master NWs to agree the length of each master sub-frame as a function of the spatial and temporal traffic load variations need of each master NW.

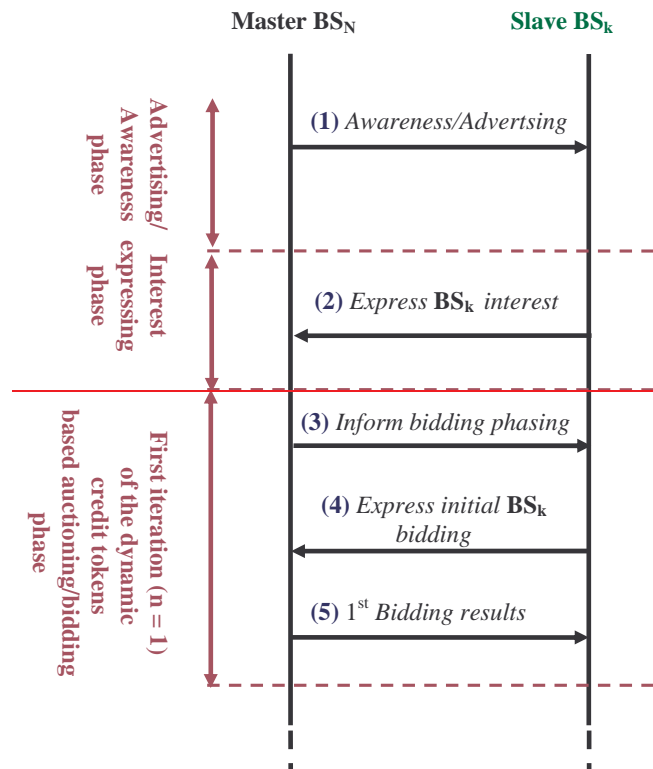
### 15.6.2.2.6.3 Negotiation between master NWs

#### 15.6.2.2.6.3.1 Definition and notation

- $BS_N$  denotes the BS belonging to the master  $NW_N$ .
- $BS_k$  denotes the BS belonging to the slave  $NW_k$ .
- Each  $BS_k$  can dynamically ~~make~~propose a ~~bid~~number of credit tokens  $BS\_CT^{(n)}_k$  at the  $n^{th}$  iteration. This ~~bid~~proposal corresponds to the ~~amount~~number of credit tokens per time unit corresponding to the  $BS_k$  during the  $n^{th}$  iteration of the ~~auctioning/bidding~~negotiation phase.
- Resource scheduling is carried out by an auction ~~like~~inspired mechanism. The ~~auction~~negotiation type used for the scheduling is dynamic in time. Starting from ~~the reserved price auction RPA~~ minimum number of credit tokens required (**MRCTN**) by the master BS to its share radio resources, ~~the price of auction~~the number -of credit tokens is ~~successfully~~iteratively ~~raised~~increased (at each iteration  $n$ ) until the winning ~~bidders~~requesters remain.

#### 15.6.2.2.6.3.2 Dynamic credit tokens based scheduling cycle

~~The contribution proposes a~~The dynamic scheduling cycle aims at coordinating between one  $BS_N$  of master  $NW_N$  and several  $BS_k$  of different slave  $NW_k$ . For the sake of simplicity, the cycle is illustrated (Figure h 45 and Figure h 46) for one  $BS_N$  and one  $BS_k$  of a given slave  $NW_k$ . The cycle is composed of different phases, and each phase can be composed of several sequences as follows.



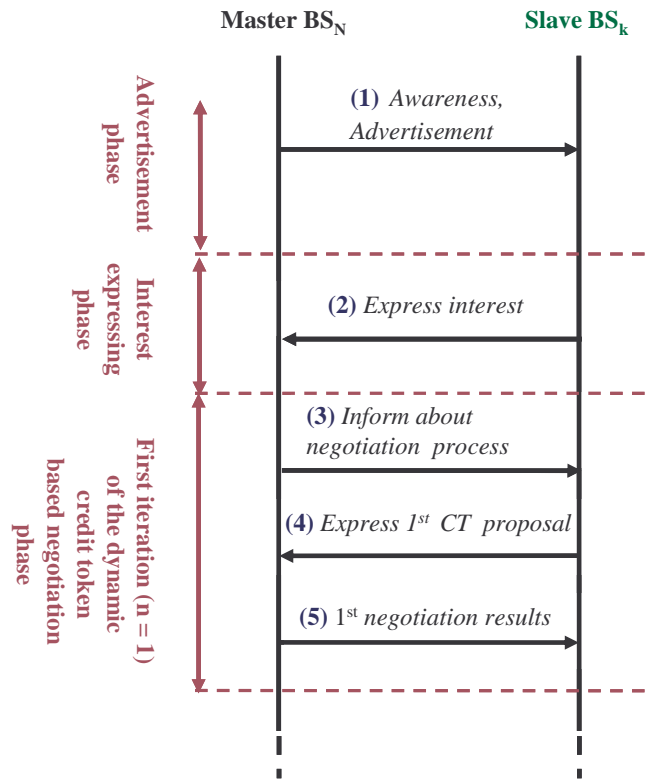
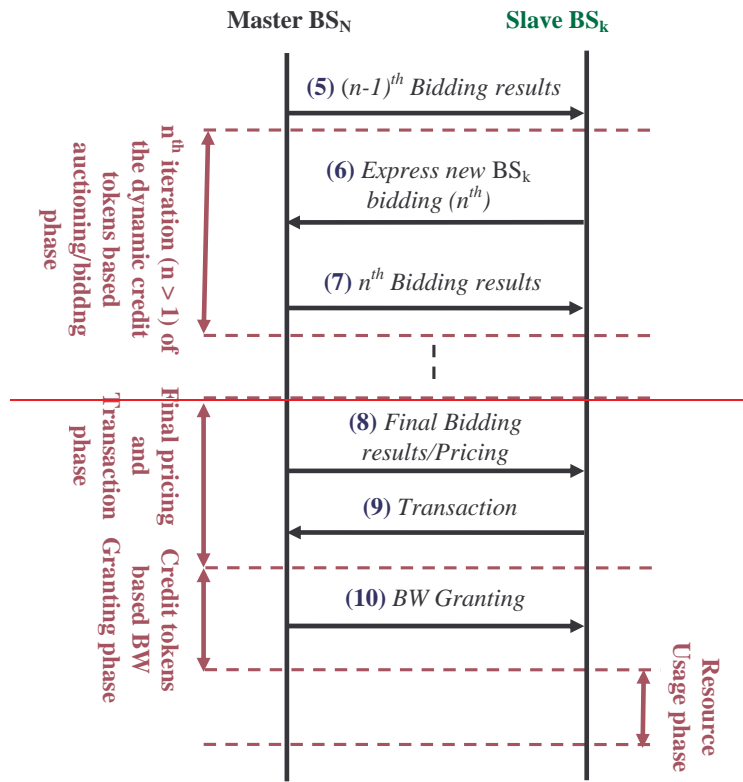


Figure 45: Dynamic (iterative) credit tokens based scheduling cycle – (sequences (1) to (5))



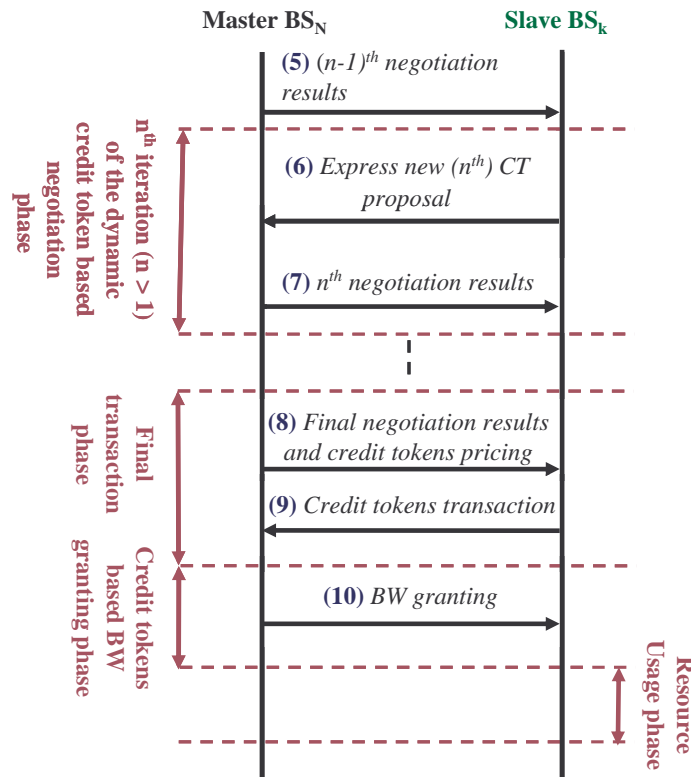


Figure 46: Dynamic (iterative) credit tokens based scheduling cycle – (sequences (5) to (10))

### 15.6.2.2.6.3.3 Negotiation mechanisms between master NWs

For each of the phase of the credit tokens based scheduling cycle presented in section 15.6.2.2.6.3.2, this section 15.6.2.2.6.3.3 describes the details of the enhanced mechanisms.

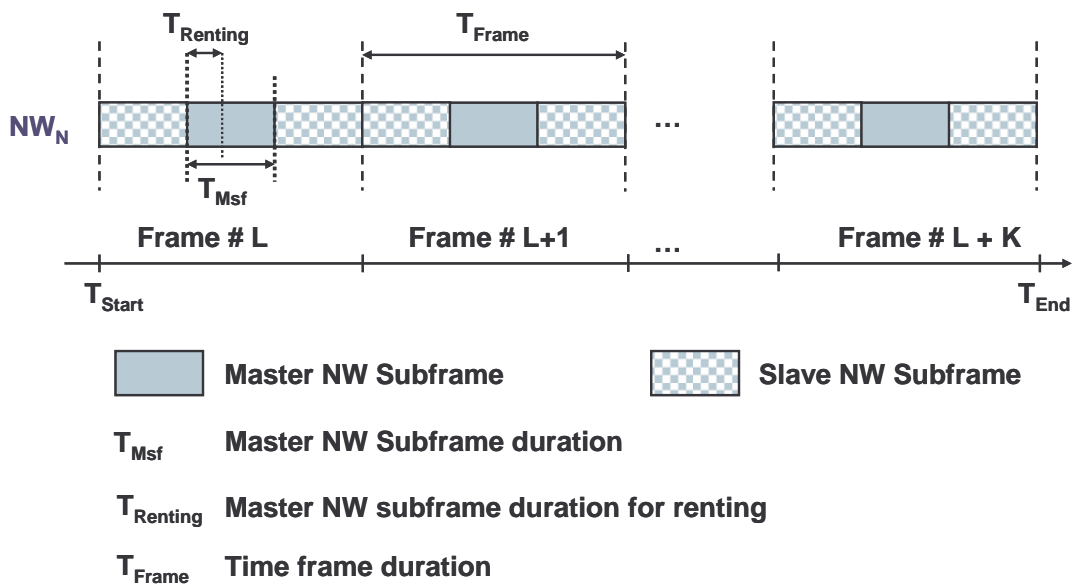


Figure h47: Simplified MAC frame structure illustrating master NW sub-frame renting principle and associated notations

### Advertising/Awareness phase

This phase is composed of the single sequence (1) as follows:

- The master  $NW_N$  (~~seller~~offeror) advertises that its periodic assigned master sub-frame is open for renting (Figure h47) from starting time  $T_{Start}$  to ending time  $T_{End}$  for a fraction ( $T_{Renting}/T_{Msf}$ ) of its master sub-frame duration  $T_{Msf}$ .  $T_{Renting} = T_{End\ Renting} - T_{Start\ Renting}$ .
- The master  $NW_N$  proposes a ~~reserve price auction RPA~~ minimum number of credit tokens required (**MRCTN**) for this renting. The **RPAMRCTN** is expressed as a number of credit tokens per time unit.

### Interest expressing phase

This phase is composed of the single sequence (2) as follows: each  $BS_k$  informs the master  $BS_N$  about its willingness (or not) to participate to the ~~bidding~~negotiation. If the  $BS_k$  is interested, it communicates its  $id_k$  to the master  $BS_N$ .

### First iteration ( $n = 1$ ) of the dynamic credit tokens based ~~auetioning~~/biddingnegotiation phase

This phase is divided into 3 sequences as follows:

- In sequence (3), the master  $BS_N$  provides the following information to the slave  $BS_k$ s that have expressed the interest to participate to the ~~bidding~~negotiation:
  - $T_{Start\ BiddingNegotiation}$ : time from which the ~~bidding~~negotiation phase will start,
  - $T_{End\ BiddingNegotiation}$ : time at which the ~~bidding~~negotiation phase will end ( $T_{End\ BiddingNegotiation} < T_{Start}$ ),

Note: For this first iteration ( $n = 1$ ), the initial  $\{id_k\}$  is noted  $\{id_k^{(1)}\}$ .

- In sequence (4), each  $BS_k$  provides the following information to  $BS_N$ :  $BIDCTP_k^{(1)} = \{BS\_CT_k^{(1)}, x_k, T_{Start\ k}, T_{End\ k}\}$  where:
  - $CTP_k^{(1)}$  is the credit tokens proposal vector of  $BS_k$  at the first ( $n = 1$ ) iteration of the negotiation with the master  $BS_N$ .  $CTP_k^{(1)}$  is composed of  $BS\_CT_k^{(1)}, x_k, T_{Start\ k}$  and  $T_{End\ k}$ .
  - $BS\_CT_k^{(1)}$  is the ~~amount~~number of ~~bided~~ credit tokens per time unit proposed by  $BS_k$  for the first iteration,
  - $x_k$  is the fraction of  $T_{Renting}$  for which ~~bid~~ $BS\_CT_k^{(1)}$  applies for,
  - $[T_{Start\ k}, T_{End\ k}]$  is the time interval for which ~~bid~~ $BS\_CT_k^{(1)}$  applies for.  $[T_{Start\ k}, T_{End\ k}] \subset [T_{Start}, T_{End}]$ .
- In sequence (5),  $BS_N$  performs the following action:
  - Given the set of intervals  $\{[T_{Start\ k}, T_{End\ k}]\}$  received from different ~~bidders~~requesters  $\{id_k^{(1)}\}$ ,  $BS_N$  partitions  $\{[T_{Start}, T_{End}]\}$  into contiguous time segments  $\{TS_m\}$ . Each  $TS_m$  corresponds to a time window (integer number of  $T_{Frame}$ ) in which a subset of intervals of  $\{[T_{Start\ k}, T_{End\ k}]\}$  overlap.
  - The different ~~bidders~~requesters  $\{id_k^{(1)}\}$  assigned to a given  $TS_m$  are identified by  $\{id_{k,m}^{(1)}\}$ .  $\{id_{k,m}^{(1)}\}$  compete for each  $TS_m$ . Each involved ~~bidding~~requester  $id_{k,m}^{(1)}$  competes with his respective  $BIDCTP_k^{(1)}$ .
  - Then, for each  $TS_m$ , the master  $BS_N$  calculates the payoff  $P_k^{(1)} = BS\_CT_k^{(1)} * x_k * T_{Renting} * N_{Frame\ m}$  for each ~~bidding~~requester  $k$ , and searches the subset ( $\{id_{k,m}^{(1)}\}_{selected}$ ) of  $\{id_{k,m}^{(1)}\}$  such as  $\sum(x_k) = 1$  and  $\sum(P_k^{(1)})$  is maximal.  $N_{Frame\ m}$  is the number of frames within  $TS_m$  ( $N_{Frame\ m} = TS_m/T_{Frame}$ ).
  - For each  $TS_m$ ,  $BS_N$  informs all  $\{id_{k,m}^{(1)}\}$  about  $P_m^{min, (1)}$  and  $P_m^{max, (1)}$  where  $P_m^{min, (1)}$  is the minimal payoff from  $\{id_{k,m}^{(1)}\}_{selected}$  and  $P_m^{max, (1)}$  is the maximal payoff from  $\{id_{k,m}^{(1)}\}_{selected}$



during the first iteration. With this approach, each  $BS_k$  is directly informed whether it has been selected or not, and has some information on how far it is from  $\mathbf{P}^{\min, (1)}_m$  while still having some information on  $\mathbf{P}^{\max, (1)}_m$ . This approach enables to keep the privacy of competing  $\{\mathbf{id}^{(1)}_{k,m}\}$  on  $TS_m$ .

### $n^{th}$ iteration of the *dynamic credit tokens based auctioning/biddingnegotiation phase*

This phase is composed of 2 sequences as follows:

- In sequence (6):
  - If  $\mathbf{P}^{(1)}_k < \mathbf{P}^{\min, (1)}_m$ , this means that  $BS_k$  has not been selected for being granted the resources he has **bidedrequested** for during the first iteration  $n = 1$ . More generally speaking, for  $n > 1$ , if  $\mathbf{P}^{(n-1)}_k < \mathbf{P}^{\min, (n-1)}_m$ , this means that  $BS_k$  has not been selected for being granted the resources he has **bidedrequested** for during the  $(n-1)^{th}$  iteration.
  - If  $\mathbf{P}^{(n-1)}_k < \mathbf{P}^{\min, (n-1)}_m$  and if  $BS_k$  is still interest to be allocated with the additional resources he initially requested for, it can propose a new  $\mathbf{BS\_CT}^{(n)}_k$  for the  $n^{th}$  iteration. Then,  $BS_k$  computes the new  $\mathbf{P}^{(n)}_k = \mathbf{BS\_CT}^{(n)}_k * \mathbf{x}_k * \mathbf{T}_{Renting} * \mathbf{N}_{Frame\ m}$  where  $\mathbf{x}_k, \mathbf{T}_{Renting}$  and  $\mathbf{N}_{Frame\ m}$  are fixed for all  $n$  on  $TS_m$ .
  - If  $\mathbf{P}^{(n)}_k > \mathbf{P}^{(n-1)}_k$  and  $\mathbf{P}^{(n)}_k > \mathbf{P}^{\min, (n-1)}_m$ ,  $BS_k$  expresses its interest to keep on participating in the **biddingnegotiation** with the new **proposalbid**  $\mathbf{P}^{(n)}_k$ . In that case, it informs  $BS_N$  with its new (update) value of  $\mathbf{BS\_CT}^{(n)}_k$ . In case  $\mathbf{P}^{(n)}_k = \mathbf{P}^{(n-1)}_k$  or  $\mathbf{P}^{(n)}_k < \mathbf{P}^{\min, (n-1)}_m$ ,  $BS_k$  leaves the **biddingnegotiation** phase and will not be granted with the additional resources he asked for.
- In sequence (7),  $BS_N$  updates  $\{\mathbf{id}^{(n-1)}_{k,m}\}$  into  $\{\mathbf{id}^{(n)}_{k,m}\}$ . Based on the new received **biddingsproposals**  $\{\mathbf{BS\_CT}^{(n)}_k\}$  for each  $TS_m$ , the master  $BS_N$  calculates the new payoff  $\mathbf{P}^{(n)}_k = \mathbf{BS\_CT}^{(n)}_k * \mathbf{x}_k * \mathbf{T}_{Renting} * \mathbf{N}_{Frame\ m}$  for each **bidderrequester**  $k$  who still participates to the **biddingnegotiation**. Then, for each  $TS_m$ ,  $BS_N$  searches the subset ( $\{\mathbf{id}^{(n)}_{k,m}\}_{selected}$ ) of  $\{\mathbf{id}^{(n)}_{k,m}\}$  such as  $\sum(\mathbf{x}_k) = \mathbf{1}$  and  $\sum(\mathbf{P}^{(n)}_k)$  is maximal. Next,  $BS_N$  performs the same actions as in sequence (5): for each  $TS_m$ ,  $BS_N$  informs all  $\{\mathbf{id}^{(n)}_{k,m}\}$  about  $\mathbf{P}^{\min, (n)}_m$  and  $\mathbf{P}^{\max, (n)}_m$  where  $\mathbf{P}^{\min, (n)}_m$  is the minimal payoff from  $\{\mathbf{id}^{(n)}_{k,m}\}_{selected}$  and  $\mathbf{P}^{\max, (n)}_m$  is the maximal payoff from  $\{\mathbf{id}^{(n)}_{k,m}\}_{selected}$  during the  $n^{th}$  iteration.

### *Final pricing and credit tokens transaction phase* *Final negotiation results and credit tokens pricing*

This phase is composed of two sequences as follows:

- In sequence (8):
  - As long as  $\mathbf{T}_{End\ Bidding} - \mathbf{T}_{Start\ BiddingNegotiation}$  has not been reached  $> 0$  (i.e. the **biddingnegotiation** phase duration has not yet elapsed),  $n$  is increased and the credit tokens based **biddingnegotiation** phase mechanisms of the previous paragraph “ $n^{th}$  iteration of the *dynamic credit tokens based auctioning/biddingnegotiation phase*” are applied.
  - When  $\mathbf{T}_{End\ Bidding} - \mathbf{T}_{Start\ BiddingNegotiation}$  has been reached  $= 0$ , **biddingnegotiation** phase is over. None  $BS_k$  can propose a new **bidcredit tokens proposal**.  $\{\mathbf{id}^{(n\ final)}_{k,m}\}_{selected}$  is derived. At this point,  $BS_N$  derives the **final credit tokens priceclearing-price-auction**  $\mathbf{BS\_CPA}_k$  (expressed as a number of credit tokens per time unit) for each  $TS_m$  and each  $k$  from  $\{\mathbf{id}^{(n\ final)}_{k,m}\}$ . For each  $k$  and  $m$ ,  $\mathbf{BS\_CPA}_k$  can correspond to the  $\mathbf{BS\_CT}^{(final)}_k$ , or for example can follow another **price auction-derivation** method.
- In sequence (9), each  $BS_k$  is requested to **providepay**  $\mathbf{Pr}_k = \mathbf{BS\_CPA}_k * \mathbf{x}_k * \mathbf{T}_{Renting} * \mathbf{N}_{Frame\ m}$  **credit tokens** to  $BS_N$  to be allowed to use the resources it has been assigned **won** after the negotiation on its



corresponding  $\mathbf{TS}_m$ . Provided that  $\mathbf{Pr}_k$  does not exceed the credit tokens ~~account~~budget of  $\mathbf{BS}_k$ , the credit tokens transaction between  $\mathbf{BS}_N$  and each  $\mathbf{BS}_k$  is performed.

#### *Credit tokens based bandwidth granting phase*

This phase is composed of the single sequence (10). During this phase,  $\mathbf{BS}_N$  grants the resource to each  $\mathbf{BS}_k$  who has successfully performed the credit transaction operation in sequence (9).

#### *Resource usage phase*

After  $\mathbf{BS}_k$  has been granted with the resources,  $\mathbf{BS}_k$  can use them during during  $x_k * T_{Renting}$  time unit of  $\mathbf{NW}_N$  and for  $\mathbf{N}_{Frame\ m}$  frames from the beginning on its corresponding  $\mathbf{TS}_m$ .

## References

- [1] IEEE 802.16h-06/015: Part 16: Air Interface for Fixed Broadband Wireless Access Systems Amendment for Improved Coexistence Mechanisms for License-Exempt Operation, Working document; 2006-05-31
- [2] 80216h-06\_012r1: Working Group Review Commentary file from session #43.