Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Radio Resources Sharing Opportunities Advertisement Discovery**
Date Submitted	**2006-05-05**
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Re:	IEEE 802.16h-06/011 – Working Group Review
Abstract	This contribution proposes fast, reliable and secure over the air advertisement discovery mechanisms in support of the credit tokens based BS-BS rental protocol. Advertisement discovery information between master and slave BSs (and conversely) is conveyed by SSs acting as RF bridges. New text is proposed to be included in the IEEE 802.16h working document.
Purpose	This contribution proposes over the air advertisement discovery mechanisms in support of the credit tokens based BS-BS rental protocol.
Notice	
Release	
Patent Policy and Procedures	

Radio Resources Sharing Opportunities Advertisement Discovery

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Overview

Dynamic cooperative radio resources sharing mechanisms between BSs have been proposed [1] and included within the section 15.7.2.2.6 of the IEEE 802.16h working document [2]. The sharing is enabled by a credit tokens based negotiation protocol. This mechanism requires signaling messages between BSs during the different phases of the negotiation cycle between the master and slave BSs. All the signaling messages between the master/slave BSs can already be exchanged with IP-based wired communications via the server and local databases proposed in [2]. Over the air signaling for the first phase of the negotiation cycle would be also of great support to facilitate urgent (critical time) radio resources sharing opportunities discovery between IEEE 802.16h systems themselves, but also between IEEE 802.16h systems and non IEEE 802.16h systems. This contribution proposes over the air signaling discovery procedures so that the slave BSs are aware of master cells' offers and the slave cells can inform the master cells that they are looking for temporally some additional radio resources. The inter BS signalling messages are conveyed by the SSs that act as RF bridges between the different BSs. The text of this new contribution is intended for being added in a new section (15.7.2.2.6.5) of the IEEE 802.16h draft document [2].

Text proposal for section 15.7.2.2.6.5

Add the text below to a new section (15.7.2.2.6.5).

Over the air signaling for the first phase of the negotiation cycle would be also of great support to facilitate urgent (critical time) radio resources sharing opportunities discovery between IEEE 802.16h systems themselves, but also between IEEE 802.16h systems and non IEEE 802.16h systems. This section describes signaling discovery procedures so that:

- Master BSs can advertise periodically to the neighbouring slave BSs about their offers of radio resources for renting. This enables the slave BSs to be aware of master BSs' offers.
- Slave BSs can inform periodically the surrounding cells about their search of radio resources sharing opportunities for renting. This enables slave BSs to inform the master BSs that they are looking for temporally some additional radio resources.

MAC frame structure for advertisement discovery

On a given channel (frequency domain), Figure 1 describes the MAC frame structure enabling the support of the discovery of the temporarily radio resource sharing opportunities between the master and slave BSs. This MAC frame is structured as follows:

- An *Advertisement discovery sequence* is periodically (T_S ***TDB***) inserted in the data frame to support the discovery for two cases:
  - Discovery of the master BS' offers by the slave BSs,
  - Discovery of the slave BS' requests by the master BSs.

- The Discovery of the master BSs' offers is enabled by the usage of the Master Advertisement Time Interval (MATI).
- The Discovery of the slave BSs' requests is enabled by the usage of the Slave Advertisement Time Interval (SATI).
- The number (N_{MATI} ***TBD***) of MATI and the number (N_{SATI} ***TBD***) of SATI within the *Advertisement discovery sequence* can be adjusted in response to the context (e.g. number of active master and slave cells) to avoid to waste capacity. For example (in Figure 1), the number of MATI and SATI is the same within the sequence #n, but different numbers of MATI and SATI in a sequence can be considered. Also, the MATI and SATI are not necessary alternately interleaved as depicted in Figure 1. The total number of MATI + SATI (N_{MATI} + N_{SATI}) can be bounded by the average total number of possible neighbours in the co-existence neighbourhood.
- The *Advertisement discovery sequence* periodically occurs every *Advertisement discovery period* T_{AD}. This period T_{AD} (***TBD***) can also be adjusted in response to the context (e.g. number of master and slave cells).
- The positions of the MATI, SATI in the frame are synchronised and identified by UTC stamps.

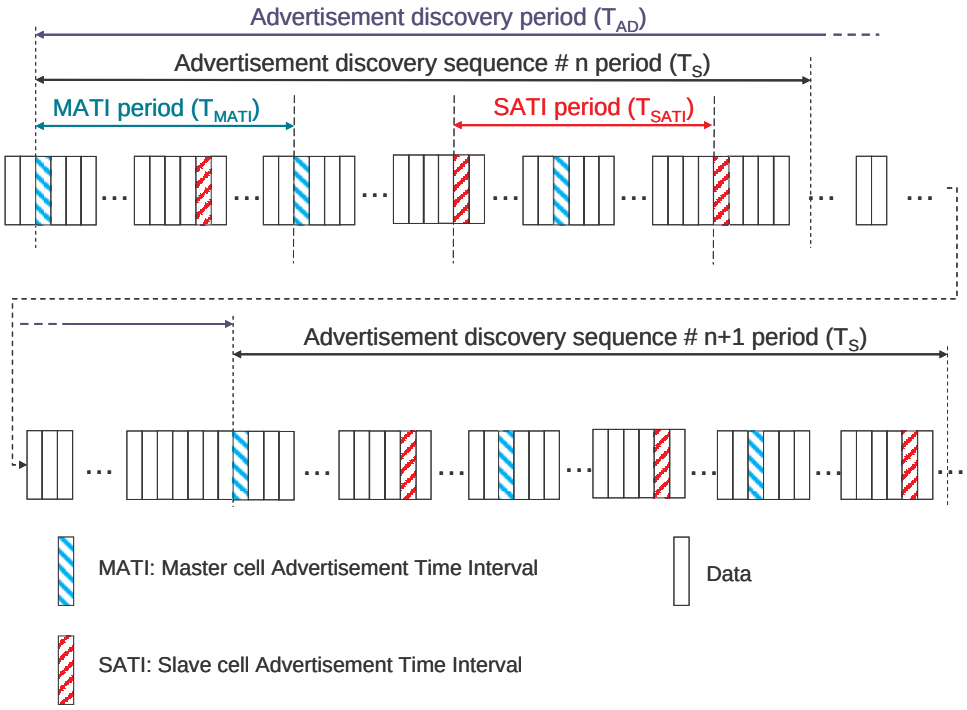


Figure 1: MAC frame structure for radio resources sharing opportunities advertisement discovery

Usage of the advertisement discovery MAC frame structure
The usage of MATI and SATI is described in this paragraph.

- The MATIs are dedicated to master BS transmissions in downlink.
- Each MATI is used by a master BS in downlink for broadcasting. At a given time, each MATI can only be used by a single BS among the co-existence neighbourhood. However, a same MATI can be used by different BSs at different times.
- Each master BS can use any MATI provided it is not already used by any other MATI BS of the co-existence neighbourhood.
- The information included in each PATI is (Table h1):
    - The IP address of the proxy of the master BS (IPid_M),
    - The master BS identity (BSid_M),
    - The Starting time of the period opened for renting (T_{Start}_M) by this master cell on that channel,
    - The Ending time of the period opened for renting (T_{End}_M) by this master cell on that channel,
    - The reserved price auctioning (RPA_P) expressed in number of credit tokens per radio resource unit on that channel,
    - A list (LC) of other channels (frequency domain) on which this master cell also opens radio resources for renting.

Table h1: MATI message format

Syntax	Size	Notes
MATI_Message_Format () {		
IPid_M	variable	IP address of the proxy of the master BS
BSid_M	48 bits	Master BS identity
T_{Start}_M	16 bits	Starting time of the period opened for renting by the master cell (in microseconds)
T_{End}_M	16 bits	Ending time of the period opened for renting by the master cell (in microseconds)
RPA_P	***TBD***	Reserved price auction
LC	***TBD***	List of other channels opened for renting of master cell
}		

- The MATIs are ranked in each *Advertisement discovery sequence* in such a way that the first MATI is assigned to the master BS whose renting period will occur first (i.e. min of the T_{Start}_M), the second MATI is assigned to the master BS whose renting period will occur in second, and so on. Re-ranking is updated dynamically each time a new master BS is arriving. This mechanism avoids the SSs of the slave cells (see paragraph "*Advertisement discovery from master cell by slave cell*" below) to scan all MATIs when the slave cells have to find very shortly some available resources to rent. In this manner, they have directly knowledge of the next available resources they can bid for.
- Each master cell releases the MATI it is using when its auctioning period starting time has elapsed. This enables new arriving master cells to use this MATI (eventually after the re-ranking) to advertise future channels reuse opportunities.
- The SATIs are dedicated to slave BS transmissions in downlink.
- Each SATI is used by a slave BS in downlink for broadcasting. Each SATI can only be used by a single BS among the co-existence neighbourhood. However, a same SATI can be used by different slave BSs at different times.
- Each slave BS can use any SATI provided it is not already used by any other slave BS of the co-existence neighbourhood.
- The information included in each SATI is (Table h2):
    - The IP address of the proxy of the slave BS (IPid_S),
    - The slave BS identity (BSid_S),
    - The Starting time from which the slave BS would be interested to rent a period opened for renting (T_{Start}_S),
    - The Ending time of the period opened for renting (T_{End}_S).

Table h2: SATI message format

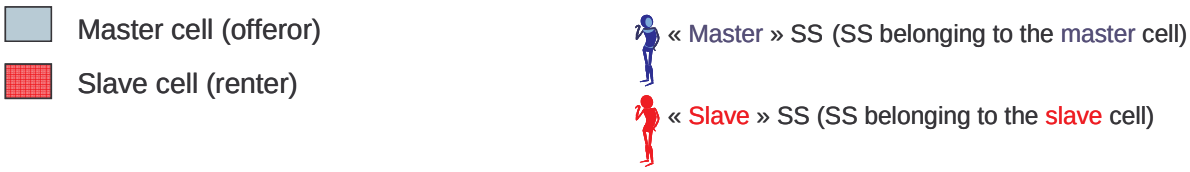
Syntax	Size	Notes
SATI_Message_Format () {		
IPid_S	variable	IP address of the proxy of the slave BS
BSid_S	48 bits	Slave BS identity
T_{Start}_S	16 bits	Starting time from which the slave BS would be interested to rent a period opened for renting (in microseconds)
T_{End}_S	16 bits	Ending time of the period opened for renting (in microseconds)
}		

- A "master" SS is a SS belonging to a master cell. A "slave" SS is a SS belonging to a slave cell.

- The MATI and SATI time positions are known by the “master” and “slave” SSs.
- There are no direct RF communications between the master and slave BSs. The master-slave BS communications are performed via master and slave SSs which act as RF bridges to convey the information as follows:
    - A “slave” SS performs the RF bridge between its slave BS and the master BS (provided the coverage of the master cell overlaps with the slave cell area, and this slave SS is located in the overlapping area).
    - A “master” SS performs the RF bridge between its master BS and the slave BS (provided the coverage of the slave cell overlaps with the master cell area, and this master SS is located in the overlapping area).
- Slave SSs in the overlapped (master/slave) cell area listen to the MATIs. Master SSs in the overlapped (master/slave) cell area listen to the SATIs.

Mechanisms enabling the discovery and the exploitation of the master cells originated advertisement discovery messages by the slave cells

This paragraph describes the mechanisms enabling the discovery and the exploitation of the master cells originated advertisement discovery messages by the slave cells. The terminology used in the following is:



These mechanisms are described by the different steps illustrated as follows:

1- Policy instructions to the slave SSs by the slave BS

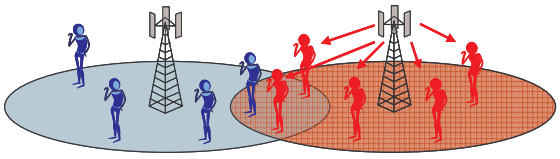


Figure 2: Policy instructions to the salve SSs by the slave BSs

- During this step, the slave BS initially instructs (by broadcasting) its SSs (in red) about the behaviours they have to adopt when some of these SSs get the messages from the different MATIs.
- In particular, the slave BS could instruct about (Table h3):
    - (a) The starting (T_{Start_S}) and ending (T_{End_S}) times (period [T_{Start_S} ; T_{End_S}]) this slave BS would be interested to rent in case some radio resources would be opened for renting by the master BSs.

- (b) The maximum admissible reserved price RPAmax_S (expressed in term of number of credit tokens number per radio resources unit) until which the slave BS would be ready to spend when entering into any auctioning cycle of the rental protocol.

If (a) and (b) are checked, the slave SSs that can hear the MATIs are the only SSs that are allowed to make the RF bridge between the master and slave cells. This means, the policy rules the transmissions from any slave SS towards the slave BS when these SSs are mandated to get feedback about the MATIs proposals. This mechanism avoids having incessant transmissions from the slave SSs towards the slave BS when the PATIs are not aligned with the slave BSs strategy. This saves bandwidth. Any policy can be established. Moreover, the policy can be adapted dynamically in time by the slave BS.

Table h3: POLICY message format

Syntax	Size	Notes
POLICY_Message_Format () {		
T_{Start}_S	16 bits	Starting time from which the slave BS would be interested to rent a period opened for renting (in microseconds)
T_{End}_S	16 bits	Ending time of the period opened for renting (in microseconds)
RPAmax_S	***TBD***	RPA max that the secondary cell targets to spend
}		

2- Detection and identification of the MATIs content by the slave SSs

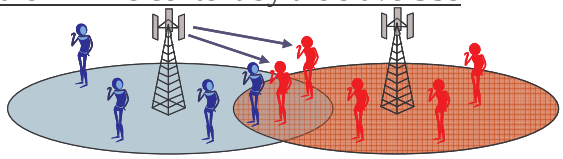


Figure 3: Detection and identification of the MATIs content by the slave SSs

- During this step, the slave SSs in the overlapping area between the master cell and their slave cell listen to the different MATIs sequentially. For each master cell, these slave SSs can get the following information: IPid_M, BSid_M, T_{Start}_M, T_{End}_M, RPA_M and LC.
- Provided the information (T_{Start}_M, T_{End}_M, RPA_M) received and the policy (about T_{Start}_S, T_{End}_S and RPAmax_S) established by the slave BS, the slave SS is able to decide whether it has to transmit this information to the slave BS or not.

3- Relaying of the MATIs content to the slave cell by the slave SSs

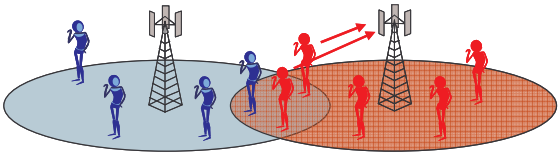


Figure 4: Relaying of the MATIs content to the slave cell by the slave SSs

- In case the policy requirements are met, the information collected by the slave SS is conveyed to the slave BS. The information the slave SS sends is: IPid_M, BSid_M, T_{Start}_M, T_{End}_M, RPA_M and LC.
- In order to ensure this information is appropriately received by the slave BS, the information is sent by several slave SSs (e.g. 2 slave SSs circulate this information to the slave BS in Figure 4). This ensures both reliability and security check.

Note: In case the policies requirements are not met, the slave SSs do not transmit the information. However, it would be possible for the slave SS to convey the information about the list LC to its slave BS since it will provide it some further information about other radio resources renting opportunities on other channel (frequency domain). This decision to send the LC information could be ruled by the policy.

4- Master BS – Slave BS communication through the backhaul

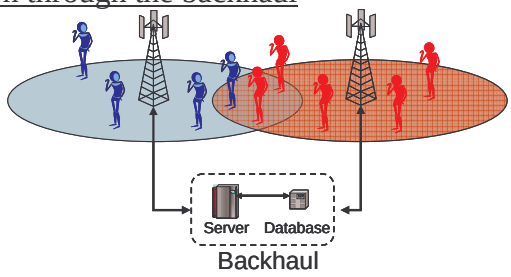


Figure 5

After step 3, the slave BS knows the IPid_M and BSid_M of the master cell. Accordingly, the communications between master and slave cells (BSs) is performed through the backhaul to make the negotiation (Figure 5) with the co-existence protocol (CP). The remaining phases of the credit tokens based auctioning/bidding cycle is performed via this backhaul with IP based communications using server(s) and database(s).

Mechanisms enabling the discovery and the exploitation of the slave cells originated requests discovery messages by the master cells

This paragraph describes the mechanisms enabling the discovery and the exploitation of the slave cells originated request discovery messages by the master cells. The terminology used in the following is the same as in the previous paragraph.

These mechanisms are described by the different steps illustrated as follows:

1- Detection and identification of the SATIs content by the master SSs

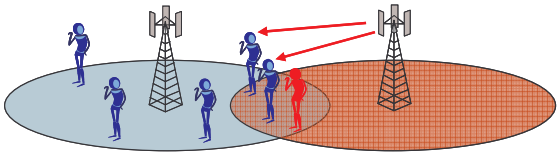


Figure 6: Detection and identification of the SATIs content by the master SSs

- During this step, the master SSs in the overlapping area between the master cell and their slave cell listen to the different SATIs sequentially. For each slave cell, these master SSs can get the following information: IPid_S, BSid_S, T_{Start}_S, T_{End}_S.
- This information is reported by the master SS to its master cell.
- In order to ensure this information is appropriately received by the master BS, the information is sent by several master (e.g. 2 master SSs convey this information to the master BS in Figure 6). This ensures both reliability and security check.

2- Master BS – Slave BS communication through the backhaul

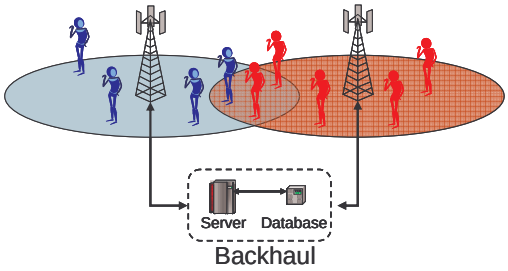


Figure 7: Master BS – Slave BS communication through the backhaul

After step 3, the master BS knows the IPid_S and BSid_S of the slave cell. Accordingly, the communications between master and slave cells (BSs) is performed through the backhaul to make the negotiation (Figure 7) with the co-existence protocol (CP). The remaining phases of the credit tokens based auctioning/bidding cycle is performed via this backhaul with IP based communications using a server and database.

References

[1] IEEE C802.16h-05/036r1 - Proposal for enhanced credit tokens based co-existence resolution and negotiation protocol, 2005-07-11

[2] IEEE 802.16h-06/010: Part 16: Air Interface for Fixed Broadband Wireless Access Systems Amendment for Improved Coexistence Mechanisms for License-Exempt Operation, Working document; 2006-03-29