Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Radio Resources Sharing Opportunities Advertisement Discovery**
Date Submitted	**2006-05-10**
Source(s)	David Grandblaise Motorola Labs Parc Les Algorithmes Commune de Saint Aubin 91193 Gif sur Yvette, France Voice: +33 (0)1 6935 2582 Fax: +33 (0)1 6935 4801 mailto: david.grandblaise@motorola.com
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 and associated MAC messages in support of the credit tokens based BS-BS rental protocol.
Notice	
Release	
Patent Policy and Procedures	

Radio Resources Sharing Opportunities Advertisement Discovery

David Grandblaise
Motorola

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 WirelessMAN-CX~~IEEE 802.16h systems~~ and non WirelessMAN-CX ~~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]. Also new associated MAC messages are proposed to be included in section 6.3.2.3.

~~Text proposal for section 15.3.1.1~~

~~Add the text below to a new section (15.3.1.1)~~.

~~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.

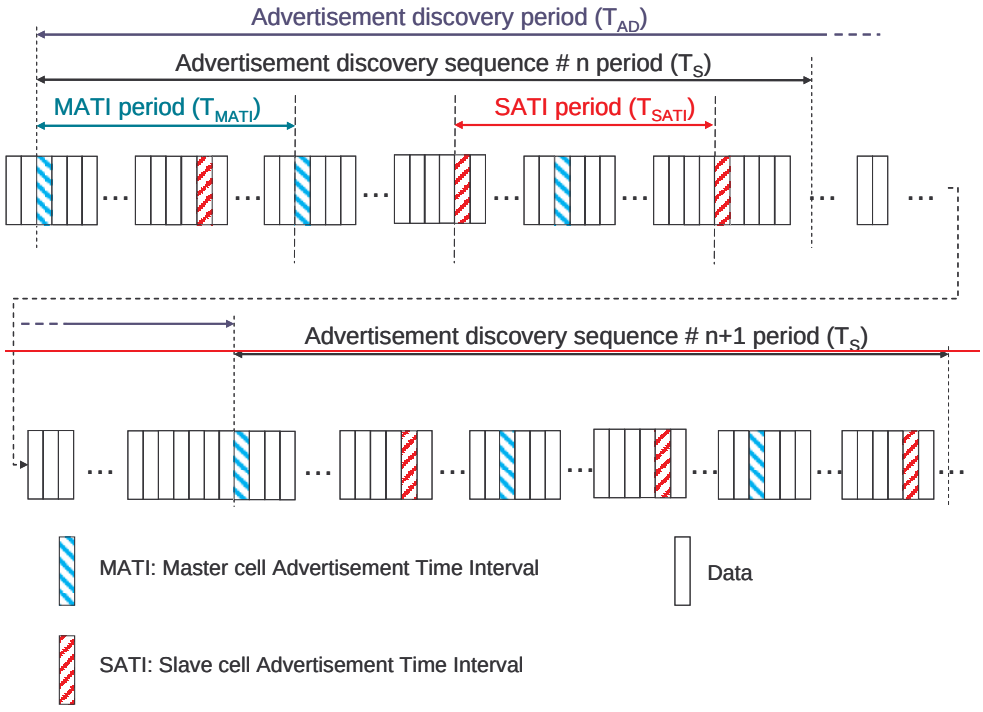


Figure 1: MAC frame structure for radio resources sharing opportunities advertisement discovery

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 (advertisement) of the negotiation cycle would be also of great support to facilitate urgent (critical time) radio resources sharing opportunities discovery between IEEE WirelessMAN-CX systems themselves, but also between IEEE WirelessMAN-CX systems and non IEEE WirelessMAN-CX 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.

Specific master BS and slave BS downlink time intervals (TBD) are used to support the over the air advertisement discovery messages in support of the credit tokens based negotiation. These messages, not yet defined, are temporary called respectively MATI (Master Advertisement Time Interval) and SATI (Slave Advertisement Time Interval).

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.
- MADD (Master Advertisement Discovery Descriptor) message is sent ~~The information included in each~~ in MATI ~~is~~ (Section 6.3.2.2.64~~Table h1~~).~~:~~
  - ~~oThe IP address of the proxy of the master BS (IPid_M),~~
  - ~~oThe master BS identity (BSid_M),~~
  - ~~oThe Starting time of the period opened for renting (T_{Start}_M) by this master cell on that channel,~~
  - ~~oThe Ending time of the period opened for renting (T_{End}_M) by this master cell on that channel,~~
  - ~~oThe reserved price auctioning (RPA_M) expressed in number of credit tokens per radio resource unit on that channel,~~
  - ~~oA 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_M	*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 propose credit tokens bid for.
- Each master cell releases the MATI it is using when its auctioning periodnegotiation starting time has elapsed. This enables new arriving master cells to use this MATI (eventually after the re-ranking) to advertise future incoming 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.
- SADD (Slave Advertisement Discovery Descriptor) message is sent The information included in each in SATI is (Section 6.3.2.2.65Table h2).:
  - oThe IP address of the proxy of the slave BS (IPid_S),
  - oThe 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}).

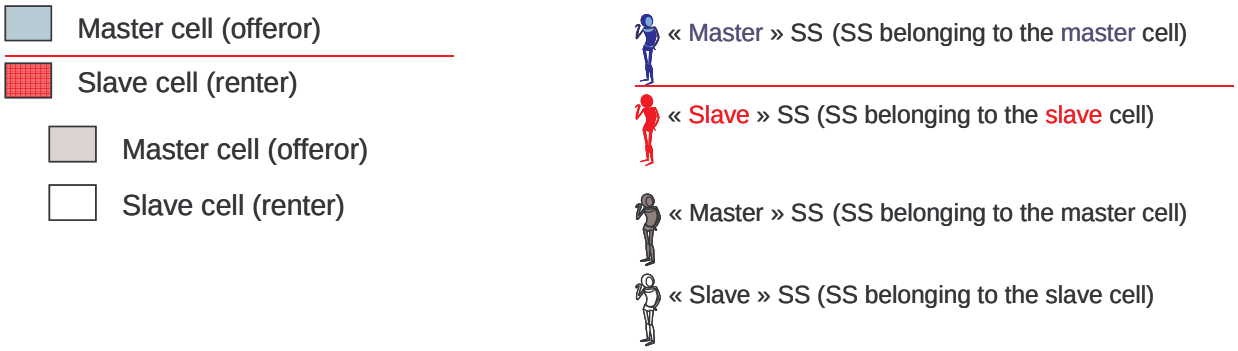
Table h2: SATI message format

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 as illustrated in the following~~as follows~~:

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

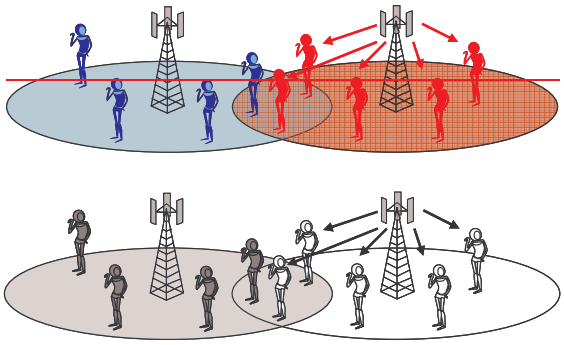


Figure 1~~2~~: Policy instructions to the sla~~al~~ve SSs by the slave BSs

- 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.
- The behaviour is instructed by the ADPD (Advertisement Discovery Policy Descriptor) message (section 6.3.2.2.66) specifies when some SSs (located in the overlapped area between this slave cell and surrounding master cells and getting MADD message from master BS) associated to this slave BS have to report the MADD information conveyed in MATI towards this slave BS.
- ~~In particular, the slave BS could instruct about (Table h3):~~
  - ~~o(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.~~

~~o(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, t~~The slave SSs that can hear the MATIs and meeting the requirements sent in ADPD 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 MATIs 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

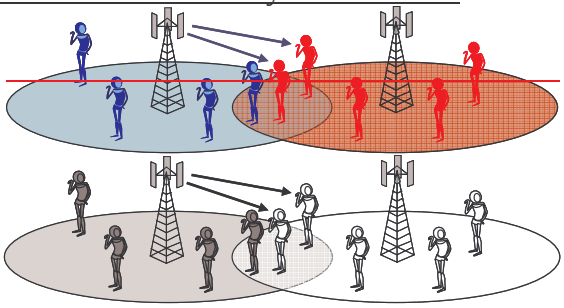


Figure 2~~3~~: Detection and identification of the MATIs content by the slave SSs

- 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 sent in the MADD message (Section 6.3.2.2.64).~~: IPid_M, BSid_M, T_{Start}_M, T_{End}_M, RPA_M and LC.~~
- Provided the MADD message information ~~(T_{Start}_M, T_{End}_M, RPA_M)~~ received and the ADAP message received about the policy (section 6.3.2.2.66) ~~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

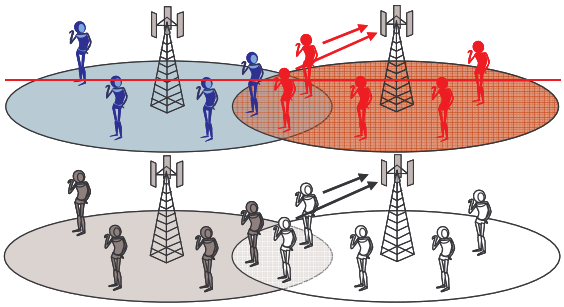


Figure 34: Relaying of the MATIs content to the slave cell by the slave SSs

- 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 to its BS is the content of the MADD message.~~: 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 3~~Figure 4~~). This ensures both reliability and security check.

Note: In case the policies requirements sent in ADAP 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 (message included in MADD) 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 can~~could~~ be ruled by the policy.

4- Master BS – Slave BS communication through the backhaul

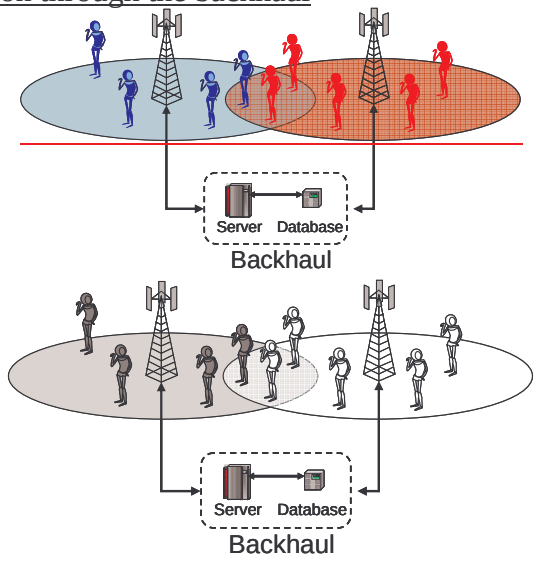


Figure 45: Master-Slave BS communication through the backhaul

After step 3, the slave BS knows the IP_Proxy_address_M (Section 6.3.2.2.64) ~~IPid_M and BSid_M~~ associated to~~of~~ the master cell. Accordingly, the communications between master and slave cells (BSs) is performed through the backhaul to make the negotiation (Figure 4~~Figure 5~~) with the co-existence protocol (CP). The remaining phases of the credit tokens based ~~auctioning/bidding cycle~~negotiation 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

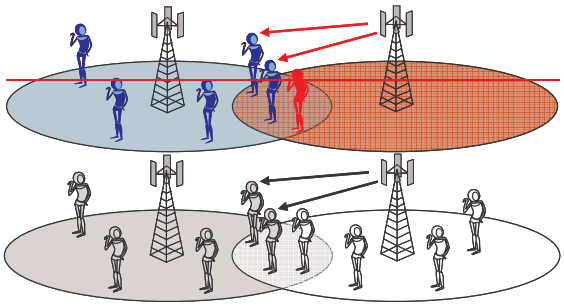


Figure 56: Detection and identification of the SATIs content by the master SSs

~~-~~During this step (Figure 5), 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 contained in the SADD message. ~~: 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- Relaying of the SATIs content to the master cell by the master SSs

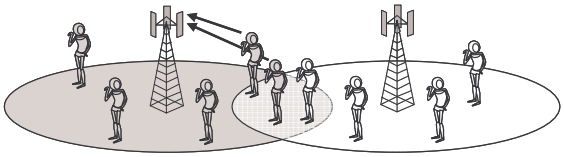


Figure 6: Relaying of the SATIs content to the master cell by the master SSs

- The SADD message information is reported by the master SS to its master cell (Figure 6).
- In order to ensure this information is appropriately received by the master BS, the information is sent by several masters (e.g. 2 master SSs convey this information to the master BS in Figure 6). This ensures both reliability and security check.

3~~2~~- Master BS – Slave BS communication through the backhaul

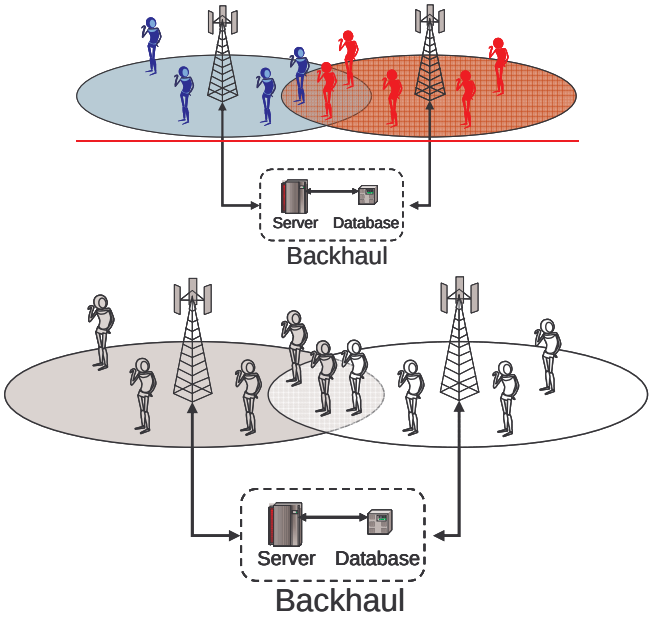


Figure 7~~7~~: Master BS – Slave BS communication through the backhaul

After step 2~~3~~, the master BS knows the IP_Proxy_address_S (Section 6.3.2.2.65) ~~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~~Figure 7~~) with the co-existence protocol (CP). The remaining phases of the credit tokens based ~~auctioning/bidding~~negotiation cycle is performed via this backhaul with IP based communications using a server and database.

Text proposal for Section 6.

[Insert the following rows into Table-14. MAC Management messages of section 6.3.2.3]

Type	Message Name	Message Description	Connection
69	MADD	Master Advertisement Discovery Descriptor	Broadcast
70	SADD	Slave Advertisement Discovery Descriptor	Broadcast
71	ADPD	Advertisement Discovery Policy Descriptor	Broadcast

[Insert the following text in section 6.3.2.3.64]

6.3.2.2.64 Master Advertisement Discovery Descriptor (MADD) message

The Master Advertisement Discovery Descriptor (MADD) message specifies the advertisement discovery information sent by the master BS towards the SSs located in the overlapped area of this master cell with the surrounding slave cells. This information is sent by the master BS in MATI in downlink (section 15.7.2.2.6.5) on a given channel (frequency domain). This information is sent every T_{MATI} in the advertisement discovery period T_S, and the advertisement discovery sequence occurs very T_{AD}. MADD provides the necessary information to the SSs of the surrounding slave cells to inform the slave BSs about possibilities of radio resources sharing with this master cell.

A MADD message shall include the following parameters:

BSID_M: ID of the master BS.

BS_ IP_Proxy_address_M: The Coexistence Proxy IP address of the master BS.

T_START_M: The Starting time of the period opened for renting by the master cell on that channel.

T_End_M: The Ending time of the period opened for renting by this master cell on that channel.

MRCTN: Minimum number of credit tokens required by the master BS to its share radio resources.

LC: List of other channels (frequency domain) of master cell opened for renting.

Table h1: MADD message format

Syntax	Size	Notes
MADD_Message_Format () {		
Management Message Type = 69		
BSID_M	48 bits	
IP_Proxy_address_M	variable	TLV specific
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)
MRCTN	*TBD*	Minimum number of credit tokens required by the master BS
LC	*TBD*	List of other channels (frequency domain) of master cell opened for renting
}		

[Insert the following text in section 6.3.2.3.65]

6.3.2.2.65 Slave Advertisement Discovery Descriptor (SADD) message

The Slave Advertisement Discovery Descriptor (SADD) message specifies the advertisement discovery information sent by the slave BS towards the SSs located in the overlapped area of this slave cell with the surrounding master cells. This information is sent by the slave BS in SATI in downlink (section 15.7.2.2.6.5) on a given channel (frequency domain). This information is sent every T_{SATI} in the advertisement discovery period T_S, and the advertisement discovery sequence occurs very T_{AD}. SADD provides the necessary information to the SSs of the surrounding master cells to inform the master BSs about possibilities of radio resources sharing with this master cell.

A SADD message shall include the following parameters:

BSID_S: ID of the slave BS.

BS_ IP_Proxy_address_S: The Coexistence Proxy IP address of the slave BS.

T_START_S: Starting time from which the slave BS would be interested to rent a period opened for renting (in microseconds).

T_End_S: Ending time of the period the slave BS would be interested to rent (in microseconds).

Table h2: SADD message format

Syntax	Size	Notes
SADD_Message_Format () {		
Management Message Type = 70		
BSID_S	48 bits	
IP_Proxy_address_S	variable	TLV specific
T_START_S	16 bits	
T_End_S	16 bits	
}		

[Insert the following text in section 6.3.2.3.66]

6.3.2.2.66 Advertisement Discovery Policy Descriptor (ADPD) message

The Advertisement Discovery Policy Descriptor (ADPD) message is sent by the slave BS in SATI in downlink (section 15.7.2.2.6.5) on a given channel (frequency domain). ADPD specifies when some SSs (located in the overlapped area between this slave cell and surrounding master cells and getting MADD message from master BS) associated to this slave BS have to report the MADD conveyed in MATI towards this BS.

ADPD message shall include the following parameters:

T_START_S: Starting time from which the slave BS would be interested to rent a period opened for renting (in microseconds). Below this value, the SSs associated to that slave BS are not allowed to report MADD content to their BS.

T_End_S: Ending time of the period the slave BS would be interested to rent (in microseconds). Beyond this value, the SSs associated to that slave BS are not allowed to report MADD content to their BS.

RCTN_MAX: Maximum admissible number of credit tokens per radio resource unit the slave BS will provide to get the radio resources rented by the master BSs. Beyond this value, the SSs associated to that slave BS are not allowed to report MADD content to their BS.

Table h3: ADPD message format

Syntax	Size	Notes
ADPD_Message_Format () {		
Management Message Type = 71		
T_START_S	16 bits	
T_End_S	16 bits	
RCTN_MAX	16 bits	
}		

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