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Title	Relay Support for Scheduling, Bandwidth Request and Allocation Mechanism
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Re:	This is in response to the call for proposals 80216j-06_027.pdf .
Abstract	This contribution proposes scheduling, bandwidth allocation and request mechanism for multi-hop relay system
Purpose	Add proposed spec changes in P802.16j Baseline Document (IEEE 802.16j-06/026)
Notice	
Release	
Patent Policy and Procedures	

Relay Support for Scheduling, Bandwidth Request and Allocation Mechanism

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1. Introduction

As RSs are introduced between BS and MS, modifications in the specification are required to support scheduling service, bandwidth allocation and request mechanisms. Two control models could be used in 802.16j system: centralized control by MMR-BS and distributed control in RS with coordination in MMR-BS. This contribution proposes the scheduling service for both models, and bandwidth allocation and request mechanism for the distributed model. The bandwidth allocation and request mechanism for the centralized model is proposed in another contribution [1].

2. Scheduling service

Scheduling service in 802.16j system could be centralized in MMR-BS or distributed to each RS, depending on the control model and RS capability. The centralized scheduling is applied to the centralized control model and is suggested for the RSs with limited capability. The distributed scheduling is applied to the distributed control model with MMR-BS coordination and is recommended for the RSs with high capability. The type of scheduling services (i.e., UGS, rtPS, ertPS, nrtPS, and BE) for both scheduling service remains the same in 802.16j system.

2.1 Centralized Scheduling Service

With the centralized scheduling service, the scheduled transmission for MSs and RSs shall be defined by the MMR-BS. MMR-BS uses MAP to specify resource allocation and time schedule to each MS or RS. RS just follows the instruction based on the MAP information and relays traffic accordingly. Centralized scheduling is more suitable for the same frame relay structure (i.e., data sent by MMR-BS, RSs and MS are all included in a single frame).

2.2 Distributed Scheduling Service

With distributed scheduling services, MMR-BS only schedules the traffic transmitted on its direct link. Each RS generates its own MAP and schedules the traffic it received based on the QoS requirement of the service flow. RSs shall not change the CID and SFID originally assigned by the MMR-BS to the flow.

The downlink traffic is scheduled by MMR-BS or a RS and transmitted to its direct downlink neighbor on a relay path. After receiving the traffic, the direct downlink neighbor then makes its own scheduling decision, generates the DL-MAP and transmits the traffic accordingly.

Since the traffic scheduled by the MMR-BS or a RS over a certain relay path will be received by its direct downlink neighbor, the MMR-BS or the RS should schedule the traffic considering the factors such as capacity, current load condition, and potential resource to be used for retransmission for all the remaining downlink nodes on the relay path. The scheduling algorithm is out of the scope of this contribution.

3. Bandwidth Allocation and Request Mechanisms for Distributed Scheduling

With distributed scheduling, the bandwidth grant mechanism for RSs is slightly different from the existing spec.

3.1 Bandwidth Request

Bandwidth request is sent from MS to the MMR-BS via one or more RS on the relay path. RS doesn't process the request and simply forwards it to the MMR-BS. The request may come as a stand-alone bandwidth request header or a PiggyBack Request or a contention based CDMA bandwidth request defined for WirelessMAN-OFDMA.

3.2 Bandwidth Grant

In a single hop OFDMA system, a bandwidth grant is issued in the next frame. With distributed scheduling, bandwidth grant is issued on hop-by-hop basis, i.e., each station including MMR-BS and each RS on a relay path issues the bandwidth grant to its direct downlink station. The problem is when the uplink traffic reaches a RS, the grant to the RS has already expired.

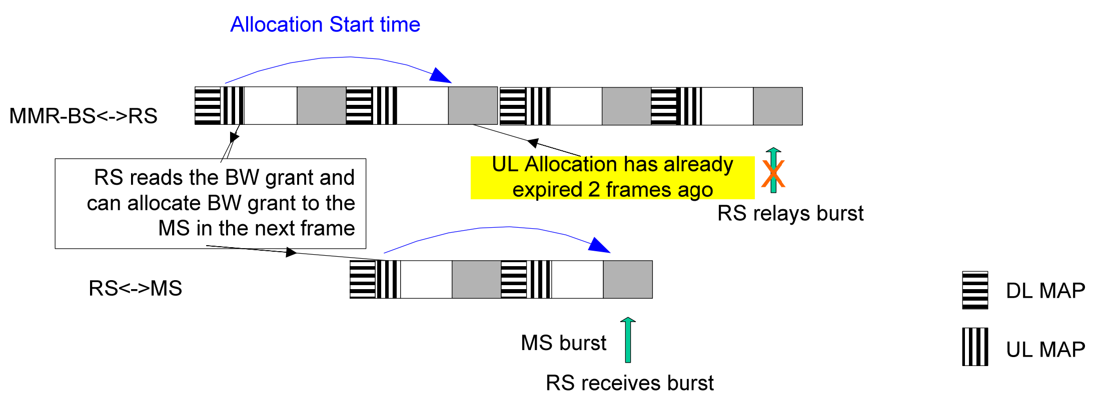

Figure 1: UL Allocation synchronization problem with relays

In order to synchronize bandwidth grant for the uplink bursts over multiple hops, the frame offset containing UL allocation for each RS should vary on the path such that the bandwidth grant is available when the uplink burst is relayed. The solution is explained in Figure 44a, under Section 4. RS UL allocation frame IE is proposed as an UL MAP IE for indicating the frame offset where the bandwidth grant is available for a direct downlink RS. It also provides the duration for the bandwidth grant. This allows the direct downlink RS to set the duration for the bandwidth grants to its downlink stations. The RS UL allocation frame IE can be sent either on the MS/SS basic CID or the RS basic CID. In the later case, it provides the flexibility to the direct downlink RS for aggregating multiple MS in the same bandwidth grant. It also reduces overhead in the signaling.

The RS UL allocation frame IE is set by the station issuing the bandwidth grant using the relay path [2] information. Each station on the relay path sets the offset considering the number of hops to the MS. This enhancement only applies to the MMR-BS or a RS. There is no change to UL-MAP for MS.

3.3 Polling

Similar to the bandwidth grant, polling is issued on hop-by-hop basis, i.e., MMR-BS or RS issues the poll (specified in UL-MAP) to its direct downlink neighbor (e.g., RS or MS) on one particular relay path from MMR-BS to MS.

Since the poll is not an explicit message, but bandwidth allocated in the UL-MAP, the bandwidth grant synchronization issue and its solution apply to polling as well (section 3.2). The MMR-BS sends poll for an MS/SS attached to a RS, by sending RS UL allocation frame IE to the RS. If there are multiple RS between MMR-BS and MS/SS, then each RS uses RS UL allocation frame IE to indicate the poll for its direct downlink station.

3.4 Advantages

- Minimal changes: Only one UL MAP IE is defined for achieving synchronization.
- Flexible Solution: Bandwidth grant or polling can be assigned on the basis of RS basic CID or MS/SS basic CID. The former case provides flexibility to RS for distributing bandwidth grants to its direct downlink stations.
- No changes on the air interface.

4. Changes to the specification

Insert new subclause 6.3.5.3

6.3.5.3 Relay Scheduling Service

Scheduling service for relays could be centralized in MMR-BS or distributed to each RS. With the centralized scheduling service, the scheduled transmission for MSs and RSs are defined by the MMR-BS. MMR-BS uses MAP to specify resource allocation for each MS or RS. RS just follows the instruction based on the MAP and relays accordingly.

With distributed scheduling services, MMR-BS only schedules on its direct link. Each RS generates its own MAP and schedules based on the QoS requirement. RSs shall not change the CID and SFID originally assigned by the MMR-BS to the flow. The MMR-BS or the RS may schedule the traffic considering the factors such as capacity, current load condition, and potential resources to be used for retransmission for all the remaining downlink stations on the relay path.

The type of scheduling services (i.e., UGS, rtPS, ertPS, nrtPS, BE) for both centralized and distributed scheduling service remains the same in 802.16j system.

Insert new subclause 6.3.6.7

6.3.6.7 Relay Bandwidth allocation and request mechanism

The bandwidth allocation and request mechanism for MS needs support from RS.

6.3.6.7.2 Bandwidth Allocation and Request Mechanisms for Distributed Scheduling

6.3.6.7.2.1 Bandwidth Request

Bandwidth request sent from MS to the MMR-BS is relayed by one or more RS on the relay path. RS doesn’t process the request and simply forwards it to the MMR-BS. The request may come as a stand-alone bandwidth request header, PiggyBack Request or a contention based CDMA bandwidth request defined for WirelessMAN-OFDMA.

6.3.6.7.2.2 Bandwidth Grant

Due to the nature of distributed scheduling, an uplink burst experiences delay in number of frames at each hop. Therefore, bandwidth grant by MMR-BS/RS needs to be synchronized over multiple hops, such that the bandwidth grant is available when the uplink burst is relayed to the MMR-BS. This synchronization is achieved by indicating the bandwidth grant over multiple frames as indicated in Figure 44a.

The MMR-BS indicates the frame (containing the bandwidth grant) to the direct downlink RS by using the RS UL allocation frame IE. The RS reads the UL MAP at the RS UL allocation frame IE, and relays the burst in the granted bandwidth. If there are more than one RS in the path to the MS/SS, then each RS issues RS UL allocation frame IE appropriately to its downlink RS. The RS UL allocation frame IE is not needed for the access link, and the allocation start time field in the UL-MAP is used to indicate the UL sub-frame.

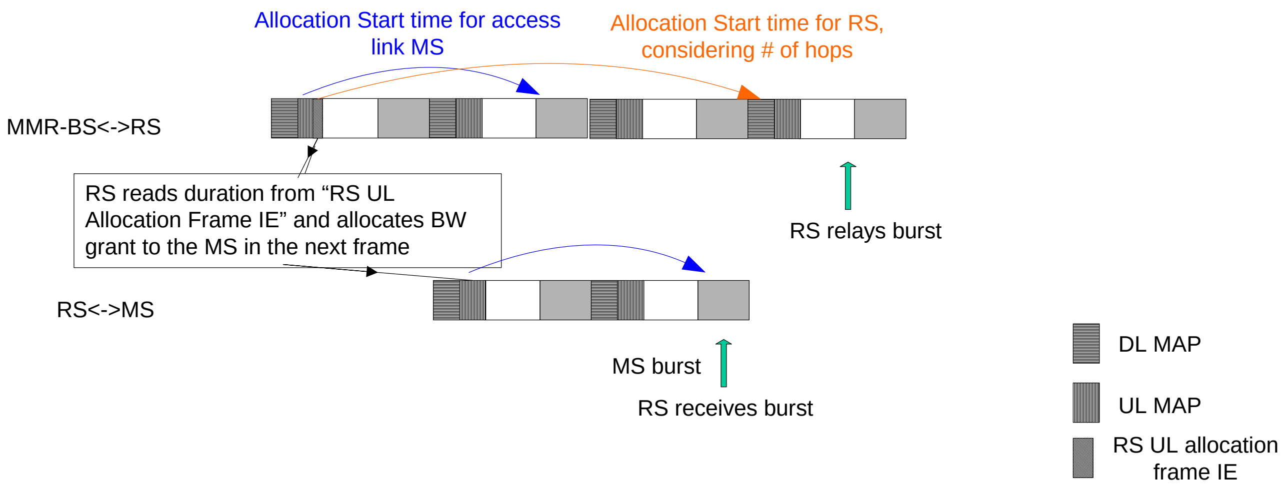

Figure 44a: UL allocation synchronization across relays

6.3.6.7.2.3 Polling

Similar to the bandwidth grant, the polling is issued on hop-by-hop basis, i.e., MMR-BS and each RS on a relay path issues the poll to its direct downlink neighbor. The polling is also synchronized across multiple hops using the same procedure mentioned in section 6.3.6.7.2.2.
The polling is indicated by the RS UL allocation frame IE to a direct downlink RS. The receiving RS uses the IE as a trigger for sending poll to its access link using the procedure described in section 6.3.6.3.

Update Table 290c as indicated in the following Table.

Table 290c – Extended-2 UIUC Code Assignment for UIUC=11

Extended UIUC (Hexadecimal)	Usage
~~09 – 0D~~	~~Reserved~~
09	RS UL Allocation Start Time IE
0A … 0D	*Reserved*

Insert new subclause 8.4.5.4.29

8.4.5.4.29 RS UL Allocation Frame IE

This IE indicates the frame containing uplink allocation for the receiving RS used for relaying bursts in the distributed scheduling. It is not applicable to MS/SS. It can be sent either on the MS/SS basic CID or the RS basic CID. In the later case, it provides the flexibility to the direct downlink RS for aggregating multiple MS in the same bandwidth grant. This IE also provides the duration for the bandwidth grant. This allows the direct downlink RS to set the duration for the bandwidth grants to its downlink stations.

Table T1 – RS UL Allocation Frame IE format

Syntax	Size	Notes
RS UL Allocation Frame IE() {		
Extended-2 UIUC	8 bits	RS_UL_Allocation_Start_Time_IE() = 0x09
Length	8 bits	
RS UL Allocation Frame Offset	8 bits	In terms of number of frames
Duration	8 bits	In OFDMA slots (see 8.4.3.1)
}		

RS UL Allocation Frame Offset
Indicates the number of frame, starting from the next frame, containing bandwidth grant for RS

Duration
Indicates the duration of allocation, in units of OFDMA slots

5. References

[1] Resource Request for Bandwidth, C80216j-06_189.doc; Yousuf Saifullah, Shashikant Maheshwari, and Haihong Zheng; Nokia
[2] Topology Discovery and Path Management in multi-hop Relay Systems, C80216j-06_195.doc; Haihong Zheng, Yousuf Saifullah, and Shashikant Maheshwari; Nokia