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Re:	This contribution is a response to " IEEE 802.16j-06/027 Call for Technical Proposals regarding IEEE Project 802.16j" (2006-10-15) .
Abstract	This contribution described the proposed distributed scheduling in 802.16j system.
Purpose	This document is provided in response for Call for Technical Proposals regarding IEEE Project 802.16j .
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Scheduling Service and Distributed Scheduling for 802.16j System

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Introduction

In the 802.16j system, k-hop link (k>1) leads to more delay time of traffic transfer. In this document, a technical solution is proposed to accelerate traffic transfer.

Proposed distributed scheduling in 802.16j

In the 802.16j system, when RSs are able to schedule the uplink bandwidth, distributed scheduling may be used.

Assuming the 802.16j system takes out-of-band relay frame structure and the MMR-BS decides to set up one service flow on the k-hop link between the MMR-BS and a MS which is k-hop away from the MMR-BS, some optimization mechanism should be taken.

One example:

To create UGS service, obeying the rule of 802.16e, the MMR-BS and RSs along link between the MMR-BS and this MS should grant fixed bandwidth to its next hop node on a real-time periodic basis. If the MMR-BS and RSs grant the bandwidth fully independently, it comes to the following fact:

After UGS data arrives at a RS, however, the RS has no adequate uplink bandwidth to send UGS data. This RS should store these UGS data until it gets the bandwidth granted to itself. As an extreme case, if the MMR-BS and RSs grant the bandwidth at the same time, the granting frequency is one time per f frame and the MS is k hop away from the MMR-BS. Then the delay time between the MS sending UGS data and the MMR-BS receiving the same UGS data is f*(k-1) frames. (See figure 1)

To prevent the long delay time incurred by multi-hop link, the MMR-BS should arrange RSs to grant bandwidth in order. When f>1, for the first time granting, the RS being MS's anchor station grants the bandwidth firstly, then the RS which is two hops away from the MS grants the MS's anchor station and so on. At last, the MMR-BS grants the bandwidth to its next hop RS. In this order, the delay time can be decreased to only k frames. (See figure 2)

Therefore, a new message is defined ---SCH_WAIT message to notify RSs along the link between the MMR-BS and the MS when to grant bandwidth for the first time.

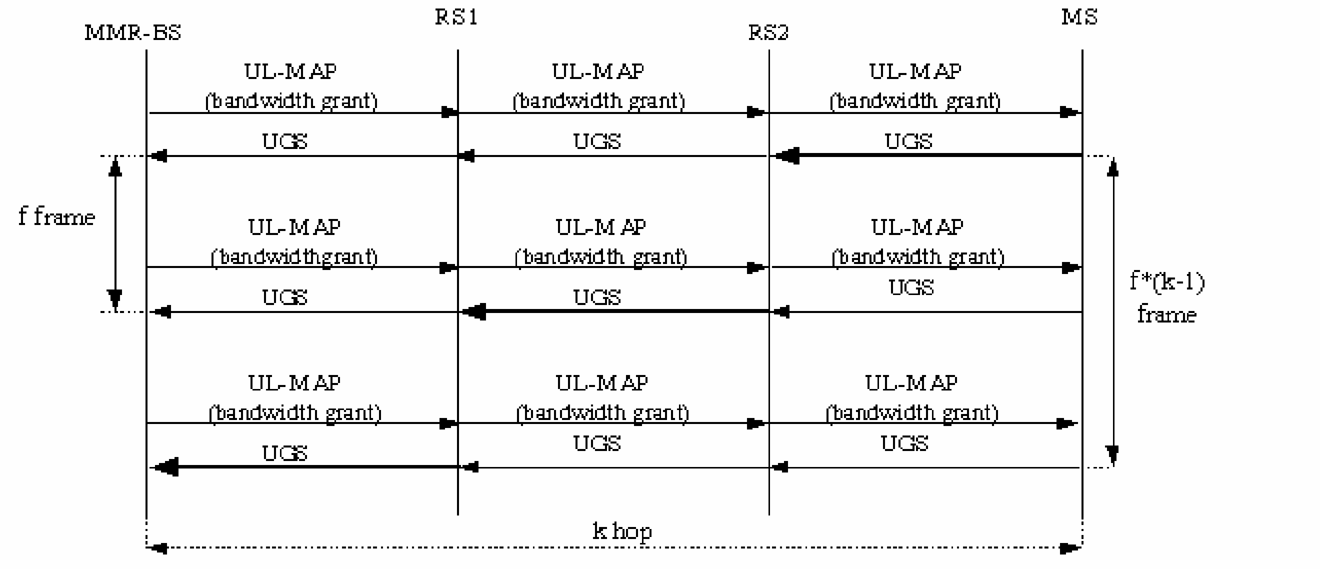

Figure 1- an example of UGS transfer in a k-hop link

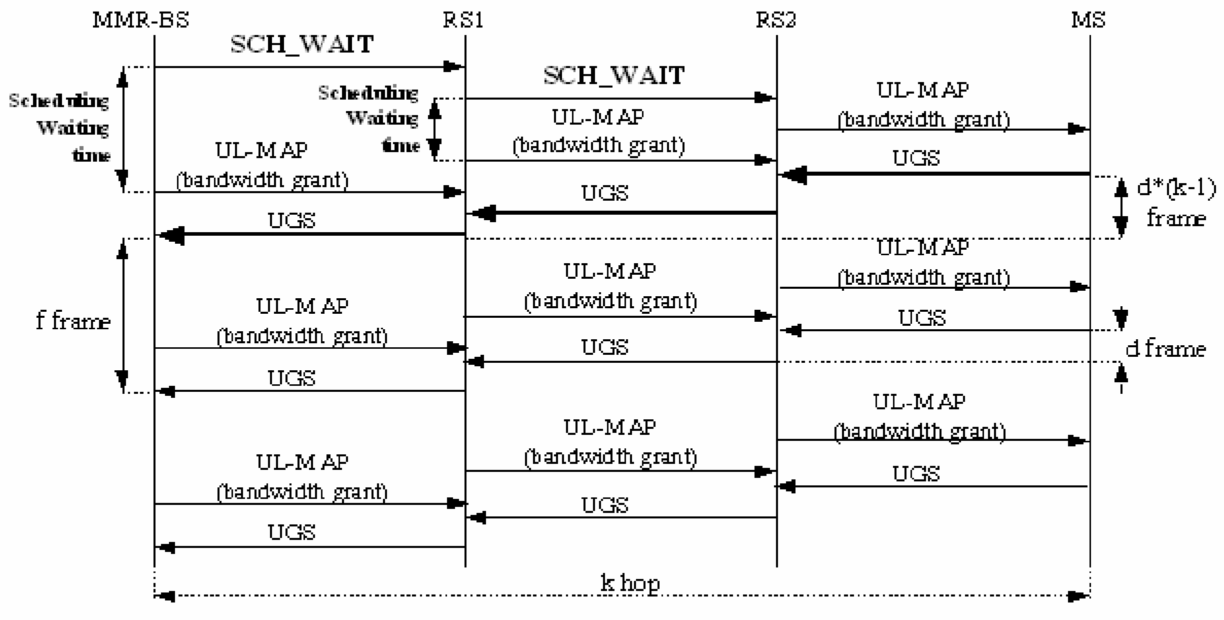

Figure 2- optimized UGS transfer in a k-hop link

Another example:

To create rtPS service flow, the RS being the MS's anchor station should supply unicast request opportunity to the MS on the real-time periodic basis. To accelerate setting up link for rtPS service flow, the first packet of rtPS service flow shall be transferred on bandwidth requested through unicast polling opportunity. Furthermore,

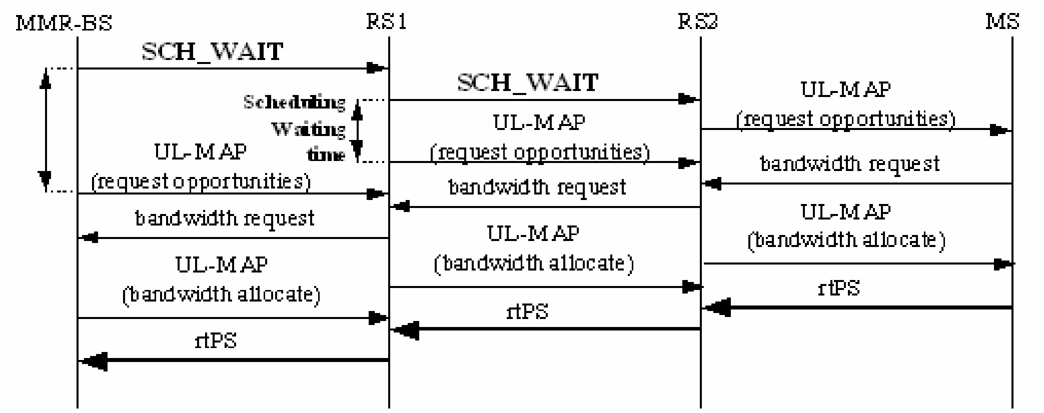

Figure 3- optimized rtPS transfer in a k-hop link

to ensure the QoS of rtPS service more sufficiently, it is proposed that intermediate RSs and MMR-BS may supply unicast request opportunities to the next hop node on real-time periodic basis after the first packet transfer.

To save the latency of data transfer on the k-hop link, SCH_WAIT message is also used to notify RSs when to polling the next hop node (for the first time, when polling is periodic). (See figure 3)

When the MMR-BS decides to set up link for a special service flow, it sends the SCH_WAIT message to the RSs along the k-hop link firstly. In SCH-WAIT message, it includes the Scheduling Waiting time for the RSs except the RS that is MS's anchor station. When SCH-WAIT message arrives at MS's anchor station, it is only to notify this RS to grant bandwidth or pooling immediately.

Scheduling Waiting time should be set not so large as to delay the data/message transfer , and not so short as the RS has no data/message to send when granting bandwidth or the RS doesn't know how much bandwidth needed when polling. Scheduling Waiting time in a RS which is n hop away from the MS should be subject to the following:

---Minimum value: Scheduling Waiting time >=(n-1)*2 (frame)

Proposed text

6.3.2.3 MAC management message

Add one row into to Table 14:

Type	Message name	Message Description	Connection
67	SCH_WAIT	Scheduling Waiting	Basic

Insert new subclause 6.3.2.3.62:

6.3.2.3.62 SCH-WAIT message

A MMR-BS or RS sends SCH-WAIT message to the RSs to notify them when to allocate bandwidth to the next hop node.

Table 109z-SCH-WAIT message format

Syntax	Size	Notes
SCH-WAIT_Message_format () {	-	-
Management Message Type=66	8bit	-
CID	16bit	Referring to the connection which a service flow is associated.
Num_RS	4bit	Number of RSs along the link except MS's anchor station
for (i=0; i<Num_RS; i++){	-	-
RS MAC address	48bit	RS 48 bit MAC address
Scheduling Waiting time	4bit	Indicating how many frames the RS should wait
}	-	-
Padding	Variable	Padding bit ti ensure byte aligned
TLV encoded information	4bit	
}	-	-

CID

The value of this field specifies the CID assigned by the MMR-BS to a service flow with a non-null AdmittedQosParamSet or ActiveQosParamSet.(See 11.13.2)

NUM_RS

Number of RSs along the link except MS's anchor station.

Scheduling Waiting time

It is the number of frames that MMR-BS suggests a RS waits before polling or grant for the first time. If the Scheduling Waiting Time is equal to 0, the RS polls or grants in the next frame, which follows the frame where the SCH-WAIT message is received.

Scheduling Waiting time should be set not so large as to delay the data/message transfer , and not so short as the RS has no data/message to send when it is be granted bandwidth or the RS doesn't know how much bandwidth needed when it is be polled. Scheduling Waiting time in a RS which is n hop away from the MS should be subject to the following:

---Minimum value: Scheduling Waiting time >=(n-1)*2 (frame)

The SCH_WAIT message shall include the following parameters encoded as TLV tuples:

HMAC/CMAC Tuple (See 11.1.2.)

6.3.5 Scheduling services

6.3.5.2.1 UGS

Insert the follow at the end of this clause:

In the 802.16j system, when distributed scheduling is used, to create a UGS service flow in a k-hop link, the MMR- BS and RSs along the link grant fixed size bandwidth to its next hop node on the real-time periodic basis.

By specifying a UGS service with its associated QoS parameters and knowing the routing information of the link on which the UGS service is transferred, the MMR-BS scheduler can arrange the granting sequence between the MMR-BS and RSs. Before the MMR-BS and RSs grant bandwidth to their next hop node, the MMR-BS sends SCH-WAIT message to RSs along the link. When the RSs except MS's anchor station receive the message, they set their each scheduling_waiting-timer. As the timers expire, they can grant the bandwidth to their next hop node for the first time. When the MS's anchor station gets the SCH-WAIT message, it grants the bandwidth immediately.

6.3.5.2.1 rtPS

Insert the follow at the end of this clause:

In the 802.16j system, when distributed scheduling is used, to create a rtPS service flow in a k-hop link, the RS being the MS's anchor station should supply unicast request opportunities to the MS on the real-time periodic basis. To accelerate setting up link for rtPS service flow, the first packet shall be transferred on bandwidth requested through unicast polling opportunity. As for the following packet, intermediate RSs, between MMR-BS and RS being MS's anchor station, and the MMR-BS may supply unicast request opportunities to the next hop node on real-time periodic basis.

The MMR-BS scheduler can arrange the polling sequence between the MMR-BS and RSs. Before the MMR-BS and RSs poll their next hop node, the MMR-BS sends SCH-WAIT message to RSs along the link. When the RSs except MS's anchor station receive the message, they set their each scheduling_waiting-timer. As the timers expire, they can poll their next hop node for the first time. When the MS's anchor station gets the SCH-WAIT message, it polls the MS immediately.

6.3.5.2.2.1 Extended rtPS

Insert the follow at the end of this clause:

In the 802.16j system, when distributed scheduling is used, to create an extended rtPS service flow in a k-hop link, the MMR- BS and RSs along the link grant variable size bandwidth to its next hop node on the real-time periodic basis.

The MMR-BS scheduler can arrange the granting sequence between the MMR-BS and RSs. Before the MMR-BS and RSs grant bandwidth to their next hop node, the MMR-BS sends SCH-WAIT message to RSs along the link. When the RSs except MS's anchor station receive the message, they set their each scheduling_waiting-timer. As the timers expire, they can grant the bandwidth to their next hop node for the first time. When the MS's anchor station gets the SCH-WAIT message, it grants the bandwidth immediately.

In case that no unicast bandwidth request opportunities are available, the MS may use contention request opportunities for that connection, or send the CQICH codeword to inform the MMR-BS of its having the data to send. If the MMR-BS receives the CQICH codeword, the MMR-BS shall start allocating the UL grant corresponding to the current Maximum Sustained Traffic Rate value by sending a new SCH-WAIT message.

Insert new subclause 6.3.7.6.1:

6.3.7.6.1. Distributed Scheduling

In the 802.16j system, distributed scheduling is an optional scheduling mechanism. To use distributed scheduling, the 802.16j system takes the out-of-band relay frame structure and a RS should schedule the uplink bandwidth.

6.3.7.6.1.1 Requests

In the 802.16j system, a RS may request the bandwidth to send its message originated by itself and message/data originated by MS. A Request may come as a stand-alone bandwidth request header, a PiggyBack Request or CDMA bandwidth request.

RS’s bandwidth request is dressed on connection basis

6.3.7.6.1.2 Grants

In the 802.16j system, the bandwidth grant is addressed to the RS/MS Basic CID.

When k links in a k-hop link need to be granted bandwidth to transfer a service flow, granting sequence should be arranged by SCH-WAIT message.

6.3.7.6.1.3 Polling

Polling is done on RS/MS basis.

When k links in a k-hop link need to be pooled in order to transfer a service flow, polling sequence should be arranged by SCH-WAIT message.

References

[1] IEEE 802.16mmr-06/002r1, “Draft P802.16j PAR and Five Criteria: Mobile Multihop Reply"
[2] IEEE 802.16j-06/016r1, “Proposed Technical Requirements Guideline for IEEE 802.16 Relay TG"
[3] IEEE 802.16j-06/017r2, “Table of Contents of Task Group Working Document"