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Abstract	Comment on selective forwarding in an RS group
Purpose	Text proposal for 802.16j Draft Document.
Notice	
Release	
Patent Policy	

Comment on selective forwarding in RS group

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Problem Statement

There are three basic data forwarding schemes defined in P802-16j/D5 (1) CID based forwarding for DL/UL, (2) CID based forwarding assisted by inserting DL Allocation Reference IEs in the MAPs for RS with centralized scheduling and variable forwarding delay (3) burst-based forwarding for UL during IR, BR and HR.

The CID based forwarding schemes require CID forwarding rules for DL/UL maintains at each RS, which has the benefit of zero signaling overhead to execute the forwarding operation. However, in a dynamic environment where the CID forwarding rules require frequent changes, updating CID tables via a MAC messages incurs overheads and causes disruption in the service. The service outage increases forwarding latency that is proportional to the frame duration, the RS hop count and the message lost probability. This is particularly troublesome for transparent RSs and the RS group. In both environments, the frequent changes of connections for an MS, which requires updating CID forwarding rules, could be caused by either the MS mobility or the CDMA ranging (PR and BR). Every time the MS sends a CDMA code for PR or BR, the access station (transparent RS or member of the RS group) may be re-selected by the MR-BS.

This is particularly important in RS group operations when selective forwarding is enabled. That is, not all of RS group members are configured by the MR-BS to forward the same data to the MS. For example, in case of too many connections required to be updated or included in a dynamic manner, connection list update based on the RS_Member_List_Update message may pose significant overheads, which consume valuable bandwidth. Moreover, some RS members of RS group may fail to decode the RS_Member_List_Update message before the designated Frame Action Number. As a result, the inconsistent data forwarding rules among members in the RS group could severely degrade the system performance especially when the same radio resource is re-used for different RS group members to forward different data to different MSs.

Proposed Solution

In order to solve the data forwarding and signaling overhead problem in relatively faster varying environments as well as the inconsistent data forwarding problem, we propose to include a burst-based forwarding scheme devised for the RS group, which includes a DL_Transmit_Reference IE in the MAP that will provide the selective forwarding information to RSs. The overhead incurred based on this method does not depend directly on the number of connections, but rather depends on number of bursts which can be minimized by proper resource allocation methods.

The proposed method optimizes the control signaling overhead for resource allocation on the R-link and enables efficient data forwarding from transparent RSs and/or RS group members to their subordinate MSs.

Assume we have N RS members and K connections to be served by this group. There are 2^N-1 non-empty RS group subsets. Any connection can be forwarded by any RS in the group. Thus, we can group all connections into 2^N-1 subsets, probably with overlapping connections, such that each connection group is forwarded by the members of one of the subsets.

Example: Consider RS group with 2 members and 6 connections served by this group. We have 3 non-empty subsets:

S_1 = {RS 0} forwards 2 connections
S_2 = {RS 1} forwards no connection
S_3 = {RS 0, RS 1} forwards 4 connections.

The example Venn diagram in Figure 1 exhibits a sample connection served by different subsets of the RS group. For instance, some 2 connections are forwarded only by RS 0, 4 connections are only by RS 0 & RS 1.

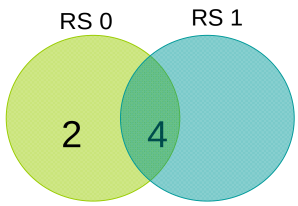

Figure 1 Three connection type according to the RSs forwarding the traffic for an RS group with 2 members.

With the classification above, we have at most 2^N-1 sets of connections. The connections served by a subset can be mapped to unique bursts in a frame, e.g., connections served by the members of subset S_k can be mapped to separate bursts. This enables an efficient forwarding scheme in which only the subset index and the length of the bursts to be forwarded by the member RSs of the corresponding subset are indicated.

According to this method, we first enumerate RSs as RS 0, RS 1, ... , RS N-1, and let A = { RS 0, RS 1,..,RS N-1} denote the set of all group members. Denote S_k the k'th subset of A, where S_k contains RS j, where {j : u_j = 1 with u_j the j'th bit of [u_{N-1} … u_1 u_0]=binary(k,N). Here, binary(k,N) denotes the binary representation of k with N bits. Next, let L_k be the size of the bursts to be forwarded by members of Subset-k. For each subset, we provide the burst length (in bytes) to be forwarded by the members of that subset. Thus, the overall information to be revealed to an RS is (i) its enumerated identity in constructing the numbered subsets, and (ii) the bursts that it shall forward, e.g., subset – connection relation. A new extended MAP IE, named MR_Transmit_Reference_IE, is recommended to provide this information to the subordinate RSs. The size of this MAP IE is independent of number of connections carried with the bursts indicated by this MAP IE.

Example (cont'd): A sample bursts structure is depicted in Figure 2 for the connection set given in Figure 1. There are 2 connections to be forwarded only by RS 0 (Subset 1), and 4 connections to be forwarded by both RS 0 and RS 1 (Subset 3). In MR_Transmit_Reference_IE, first we list reduced basic CID of RS 0 and then that of RS 1. This listing indicates that Subset 1 contains RS 0, Subset 2 contains RS 1 and Subset 3 contains both RS 0 and RS 1. The bursts S 1 and S 3 for Subset 1 and Subset 3, respectively, can be indicated by the MAP IE(s) designated by the MR_Transmit_Reference_IE. We provide the size of the bursts (in bytes) to be forwarded by each subset. The Number_of_Subset for this example is 2. The L_1 bytes of the burst indicated by the MAP IE designated by the MR_Transmit_Reference_IE is forwarded by members of Subset 1, e.g., R 0, and the next L_3 bytes of the burst is to be transmitted by members of S 3, e.g., RS 0 and RS 1. The way that the burst is processed is given by the MAP IEs designated by the MR_Transmit_Reference_IE.

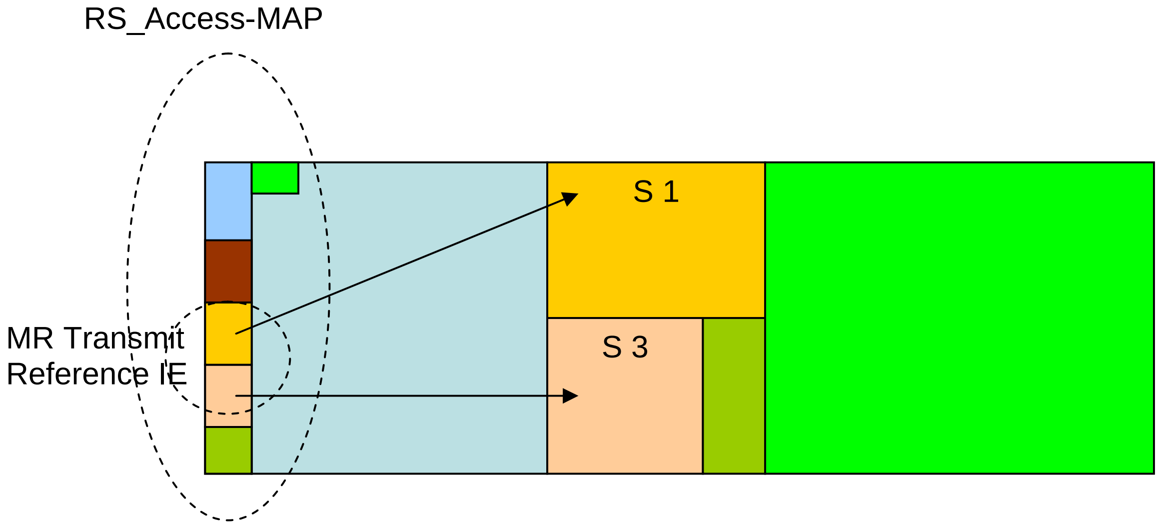

Figure 2 The MR_Transmit_Reference IE provides the size of the bursts to be forwarded by members of the sets S 1 and S 3, where S 1 = {RS 0}, and S 3 = {RS 0, RS 1}. The bursts can be indicated by the MAP_ IEs designated by the MR_Transmit_Reference IE

The data forwarding in the RS group could utilize either CID based forwarding scheme with RS_Member_List_Update, or burst based forwarding scheme with DL_Transmit_Reference IE, or combination of both. When RS_Member_List_Update is used for the selective forwarding, before the MR-BS successfully receive the ACK message from all RSs designated in the RS_Member_List_Update message, the burst based forwarding scheme may be used to substitute RS's original forwarding rules to forward the data to the MS such that there is no disruption in the services.

The burst based forwarding scheme optimize the CID based forwarding by eliminating at least one round-trip message latency caused by MR-BS sending RS_Member_List_Update and receiving all required ACK messages.

Many optional features in 16j/D5 have been designed for optimization by just eliminating the round-trip message latency. For example, the RS-assisted HARQ as described in section 6.3.17.4.2.2 was designed to reduce the re-transmission latency of the HARQ, whose latency reduction is even less than the tow-way handshake latency eliminated by the burst-based forwarding. Another example is the dedicated BR that intends to reduce just one round-trip message delay during the BR process through RS, whose latency reduction is equivalent to the tow-way handshake latency eliminated by the BB forwarding for the two hops case. There are many other features in 16j that were designed to reduce just one round-trip message latency.

In summary, we believe that the burst based forwarding is a viable optional feature to optimize the data forwarding in 16j for the RS group, whose cost/benefit justification is better or equal to many existing optional features in 16j/D5.

In order to facilitate the incorporation of this proposal into IEEE 802.16j standard, specific changes to the draft standard P802.16j/D4 are listed below.

Spec changes

6.3.2.3.87 RS access MAP (RS_Access-MAP) message

Table 183z—RS Access MAP message format

Syntax	Size	Note
RS _Access-MAP_Message_Format{	-	-
Indicator	8bits	Bit 0: 0: Parameters of DL_Frame_Prefix remain same with the latest Configuration. 1: The parameters of DL_Frame_Prefix are updated. Bit 1: 0: RS shall use Normal map format, 1: RS shall use Compressed map format Bit 2: 0: DL-MAP not included 1: DL-MAP included Bit 3: 0: UL-MAP not included 1: UL-MAP included Bit 4: 0: SUB-DL-UL-MAP not included 1: SUB-DL-UL-MAP included Bit 5: 0: HARQ-MAP not included 1: HARQ-MAP included Bit 6-~~7~~: reserved Bit 7: 0: DL_Transmit_Reference_IE not include 1: DL_Transmit_Reference_IE include
If(bit #7 of Indicator == 1) {		
RCID type	2bits	0b00: Normal CID 0b01: RCID11 Ob10:RCID7 0b11:RCID3
CID_based_forwarding_enable	1 bits	0b0: disable 0b1: enable
Nr of IE	4 bits	Number of IE
For (i = 0; i < Nr. of IE; i++) {		
DL_Transmit_Reference_IE ()	*variable*	
}		
}		
Padding	*variable*	Padding to reach byte boundary
}		

An MR-BS or RS may send RS_Access-MAP including DL_Transmit_Reference_IE to the immediate subordinate RSs to indicate the bursts to be forwarded by Ns and Nr in the IE. If CID_based_forwarding_enable is set to 1, the CID-based forwarding scheme shall be used by encoding the CID table in the CID loop of the MAP IE(s) to be forwarded. Otherwise, the data forwarding shall be performed as follows. The first L_k included in DL_Transmit_Reference IE refers to number of bytes in the burst which is forwarded by Subset-k. The second Lk refers to the next L_k bytes after the bytes indicated by the first L_k, etc..

Table 496n—DL Transmit Reference IE format

Syntax	**Size**	**Notes**

DL_Transmit_Reference_IE{	-	-
Number_RS	4 bits	Number of RSs involved in the DL Transmit Reference IE
for(i=0;i<Number_RS;i++) {		
RCID_IE()	variable	Reduced RS basic CID
}		
Ns	8 bits	The first DL-MAP IE number in the RS_Access-MAP the RS(s) shall forward
Nr	8 bits	Indicate the number of subsets in the lists as well as the number of MAP IEs in RS_Access-MAP the RS(s) shall forward
For (k=1; k<=Nr; k++) {		
Subset_Index	Number_RS bits	The index, k, of the subset S_k.
}		
If(CID_based_forwarding_enable == 0){		
for(k=1; k<=Nr; k++){	-	-
L_k	16 bits	Burst length in bytes to be forwarded by members of subset S_k
}		
}		
Padding	variable	Shall be set to 0
}		

RCID_IE(): This field indicates the reduced basic CID of the RS. RSs are enumerated according to the order they are listed, e.g., the first RCID_IE() in the list becomes RS 0, etc., to be used as reference to the subset members.

Subset_Index: This field indicates the subset members of which will forward the burst indicated by L_k or the designated MAP IEs. Subset-k contains RS j, where {j : u_j = 1 with u_j the j'th bit of [u_{N-1} … u_1 u_0]=binary(k,N). Here, binary(k,N) denotes the binary representation of k with N bits, e.g., for N=2, Subset-1 = {RS 0}, Subset-2 = {RS 1}, and Subset-3 = {RS 0, RS 1}. For example, if Subsets 1 and 3 are included and CID-based forwarding is disabled, the bursts lengths L_1 and L_2 for Subsets 1 and 3, respectively, are included in the MAP IE.

6.3.33 RS Grouping

[Modify the following text in line 44 of Page 174 as indicated]

— Data forwarding within RS group: For DL, the members of an RS group may be configured to forward traffic data for only specific subordinate terminal stations. This may be done on a per-connection basis. In this way, by specifying scheduling times, two RSs belonging to the same RS group may transmit to two different MSs/SSs at the same time. In addition, transmissions may be scheduled such that multiple RSs in the RS group may transmit to the same MS to exploit macro-diversity. This scheduling may be achieved for RSs operating in centralized scheduling mode by keeping CID list associated with each RS. Each RS would look for the data bound to its subordinated stations or data coming from the subordinate stations in the uplink and forward in the assigned times indicated in the MAP. The list may be updated by the RS_Member_List_Update message defined in 6.3.2.3.83 or DL_Transmit_Reference_IE defined in 6.3.2.3.87. If the MR-BS does not receive MR_Generic-ACK message from all RS group members designated in the RS_Member_List_Update message after the Frame Action Number, DL_Transmit_Reference IE should be used to encode the forwarding rules for the RS group members. The RS group members shall follow the forwarding rules encoded in DL_Transmit_Reference IE, if present, instead of its original forwarding rules to forward the data to the MS. If the RS_Member_List_Update message is not provided by the superordinate ~~RS~~ station to the RSs members of the RS group, then all RSs members of the group shall transmit according to the MAPs received, without using the per CID transmission. Data forwarding may also follow the procedure defined in Section 6.3.17.7 for DL HARQ for RS groups.