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| Re: | This document is in response to call for technical proposals IEEE 80216-06/027 dated 15 October 2006. |
| Abstract | This document describes the route update procedures with efficient CID management. |
| Purpose | This contribution is provided as input for the IEEE 802.16j baseline document. |
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# Route Update with Efficient CID Management

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## 1 Introduction

In 802.16e, each connection (both management and data) is identified by a Connection ID (CID). Connections are identified by a 16-bit CID [2]. At MS initialization, management connections (basic connection and primary management connection) are established. The basic connection is for short, time-urgent MAC management messages and the primary management connection is for longer, more delay tolerant MAC management messages. In addition, transport connections for downlink and uplink are established to transfer data flows. There is no routing required; data is transmitted solely between the BS and the MS.

In a centralized multi-hop relay system, the routing for each MS is decided by the BS. The routing path is based on a number of factors such as measured channel qualities, QoS of each connection, fairness, etc. Each RS must be informed of which packets to detect and forward in order to provide the correct route for the packets. For wireless mobile networks, however, the topology of the network and the channel conditions change rapidly. Therefore, creating the routing structure and maintaining it are quite challenging.

This contribution proposes to use CID assignment in a multi-hop relay system as a mean to indicate routing structure. CID assignment is used to provide routing information, in order to reduce management overhead, and legacy messages, such as CID changes, can be used to update the routing structure. In this scheme, each relay station is assigned a range of CIDs for which the relay is responsible for decoding and forwarding. The parent node will control a superset of this CID range, and any child nodes will be assigned disjoint subsets of the CID range. Because of the structure of this CID assignment, the path from the BS to the terminal node can be uniquely determined by the CID. Each relay station can recognize which packets it is responsible for forwarding and will transmit them to corresponding child nodes. In this way, the routing can be maintained automatically along with CID assignment.

The proposal for this implementation has the following advantages:

- Simplified operation of the relay
- Reduction of overhead and delay in route updates
- Reuse of existing signaling to reflect topological changes due to mobile MSs or RSs

## 2 General Description

A unidirectional connection between BS and MS or between BS and RS is established for service flow traffic, and each connection is identified by a connection identifier (CID) [2][3]. The CID for each connection is inserted within the MAC header of a packet. When it is received, first each station checks whether the CID of the packet is for itself. Each station accepts the packet and does the process if the packet is intended to itself. Otherwise, it ignores the packet and does nothing.

Each station can distinguish the received packets by examining the CID in the MAC header and this can be used to maintain the routing structure. By combining CIDs with the routing for each connection, the routing structure can be updated and maintained easily along with CIDs, and the overall overheads for the routing can be reduced.

In the legacy 802.16e standard, each management and data connection for a particular MS is assigned a connection ID (CID) by the BS. The DL-MAP contains information about the CIDs in each allocated burst. By decoding this DL-MAP, the MS can identify which bursts it should listen to. This functionality should not be changed with the addition of relays.

# 3 CID Assignment

Figure 1 depicts an example scenario of the topology in a cell with relay support.

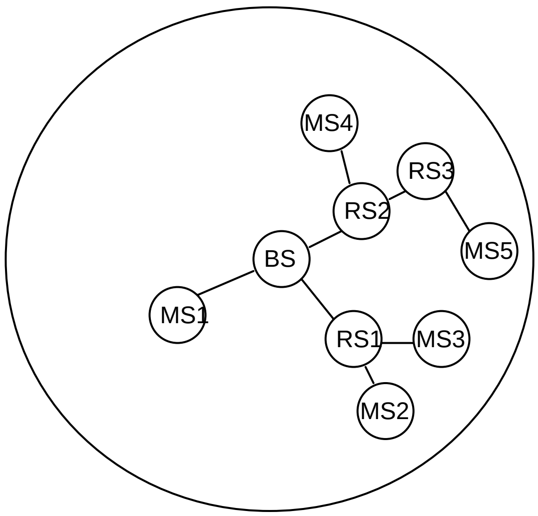


Figure 1 Relay System Topology Example

It is proposed to use CIDs in the following manner:

- The BS is responsible for managing the entire CID range.
- Each RS manages a subset of the CIDs managed by its parent node. During operation, the RS is only responsible for listening to CIDs transmitted in this range. The assignment of CIDs will fall into one of the following categories:
  - The CID is in use, and belongs to the RS. That is, the BS has assigned the CID to the RS.
  - The CID belongs to a child node of the RS (e.g., another RS). That is, a child node is responsible for managing this CID. The parent node (the RS) delegates all responsibility to the child node, which is accomplished by forwarding the packet to the appropriate node.
  - The CID is not used but is reserved in the case of topological changes.
- For a particular node, the subsets for management by all child nodes are pairwise disjoint. This is to prevent duplication of CIDs.

Possible implementation details:

- Each relay station decodes and forwards all packets with CIDs in its range (subset), unless the CID belongs to the RS itself.
- Each relay station ignores all packets with CIDs outside its assigned range.

For this contribution, we allow these subsets at all nodes be a contiguous range of values. This allows for a simple comparison mechanism to determine whether a packet should be forwarded or not at a RS, based a comparison between the packet's CID and the RS's CID subset range.

In the following example, for simplicity, we assume that each node (both RS and MS) has only one connection (CID).

### 3.1 Implementation 1

We perform this CID assignment scheme for the entire tree, that is, from the BS to all MS.

The base station is responsible for all CIDs. RS1 manages CIDs of 100-199, and RS2 manages CIDs of 200-299. In addition, RS3 which is connected to the BS through RS2 is assigned a CID range of 250-299, a subset of RS2's CID range, as shown in Figure 2.

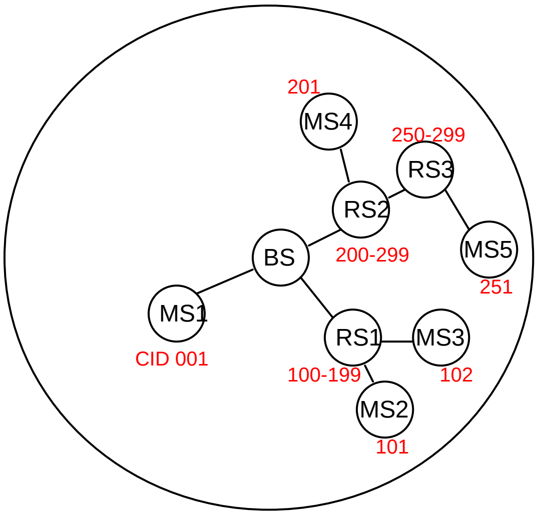


Figure 2 CID Assignment for Example 3.1

MS2 and MS3 are connected through RS1, and are given CIDs of 101 and 102 (both which lie in the subset of RS1's range). By a similar argument, MS1, MS4, and MS5 have CIDs of 001, 201, and 251 respectively.

The following example describes how the relay operation is performed if the same CID is maintained for every hop involved in the transmission. Relay involving the changing of CIDs, or relay involving encapsulation of CIDs [1] can be done in a similar manner.

Consider the transmission of a packet with CID 251. RS2 decodes and forwards the message to RS3, and RS1 ignores this transmission because the CID does not belong to its CID range 100-199. Then, RS3 is able to decode and forward this packet because CID 251 is within its forwarding range. Finally, the packet with CID 251 is received by MS5. The uplink transmission from each MS can be delivered to BS through RS in a similar way.

Once the routing decision is made by the BS, CIDs of MS are assigned according to the procedures described above. Each RS only listens to the packets with CIDs which are within its CID range and ignores otherwise. This removes the need for maintaining and broadcasting routing information.

### 3.2 Implementation 2

We perform this CID assignment scheme *ignoring the MS in the topology*. This method is compatible with the notion of encapsulating CIDs [4] or tunneling CIDs [5] or embedded MAP IE. [5].

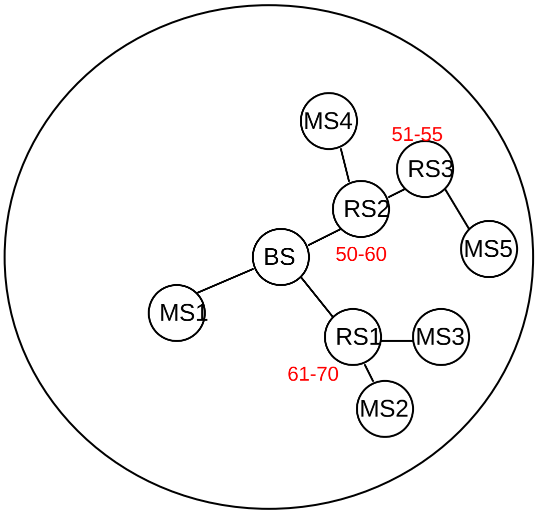


Figure 3: CID Assignment for Figure 3.2

In Figure 3, at each RS, we indicate the range of CIDs that each RS is responsible for, as well as the CID for the connection for each RS node. The same argument as in Example 3.1 applies with the exception that the BS now maintain the efficient CID structure of all RSs. The assignment of MS's CID is not included here. The benefits resulting from the removal of MS in this CID assignment scheme include:

- If this method is concatenated with encapsulated CIDs or tunneling CIDs, topological changes due to movement of mobile MS do not imply a need to change the MS CIDs.
- A lower number of CID changes is required to maintain the CID assignment structure when topological changes due to RS mobility occur.
- The CID range required for assignment can be made low due to the relatively low number of RSs as compared with MSs.

## 3.3 Topological changes

In addition, the handover of moving MS (or even RS) from one RS to another RS within a cell can be handled easily. For example, if MS3 moves close to RS2 and BS decides to serve MS3 through RS2, then BS changes MS3's CID from 102 to 202 directly. Then RS2 knows automatically that it should detect and decode the packets for MS3. This handover within a cell is done transparently to MS. In other words, MS only knows that BS changes its CID and does not know that the routing path has been changed. The BS can request the change of CID using BS-initiated DSC procedures as specified in subclause 6.3.14.9.4.2 of [2], which is summarized in Figure 3. A DSC-REQ is sent by BS to dynamically change the service flow (SF) parameters, including CID, of an existing SF according to the specified SFID. Once the SS receives the DSC-REQ and validates the request, the SF parameters will be changed and DSC-RSP will be sent by MS. After receiving the DSC-RSP, the BS will update the service flow profile accordingly, and send DSC-ACK to confirm. The whole procedure is completed once the SS receives DSC-ACK and finalizes the adjustment.

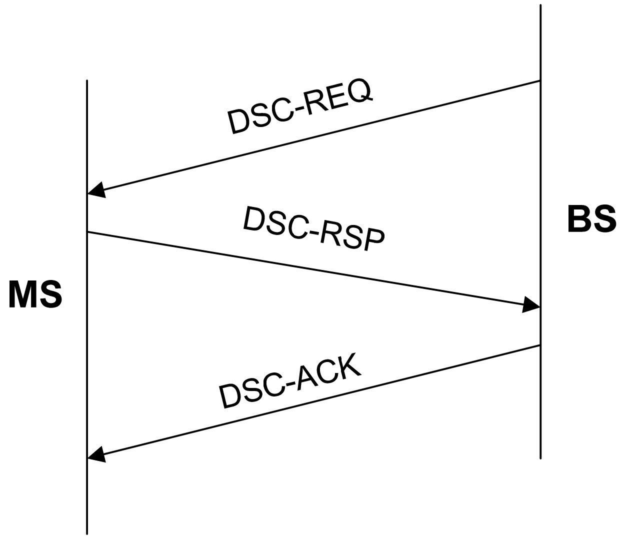


Figure 3 BS-initiated DSC

CID ranges that have to be used by RS are assigned by BS and transmitted to RSs via CIDRNG-REQ and CIDRNG-RSP management messages as specified in Section 4.

# 4 Proposed Text

---------------------------Beginning of Text Changes-------------------------------------------------------------------------

6.3.2.3 MAC management messages

[*Insert the following text into Table 14.*]

| Type | Message name | Message description | Connection |
|---|---|---|---|
| 67 | CIDRNG-REQ | CID range assignment request | Basic |
| 68 | CIDRNG-RSP | CID range assignment response | Basic |

*[Add a new subclause 6.3.2.3.62]*

6.3.2.3.62 CID Range Assignment Request (CIDRNG-REQ) message

Table *** -- CIDRNG-REQ message format

| **Syntax** | **Size** | **Notes** |
|---|---|---|
| CIDRNG-REQ message format { | – | – |
| **Management Message Type = 67** | 8 bits | Type = 67 |
| **CID min** | 16 bits | The minimum value of CID range |
| **CID max** | 16 bits | The maximum value of CID range |
| } | | |

*[Add a new subclause 6.3.2.3.63]*

6.3.2.3.63 CID Range Assignment Response (CIDRNG-RSP) message

Table *** -- CIDRNG-RSP message format

| Syntax | Size | Notes |
|---|---|---|
| CIDRNG-RSP message format { | – | – |
| **Management Message Type = 68** | 8 bits | Type = 68 |
| **Confirmation** | 1 bit | 1: the CID range has been changed successfully<br>0: error |
| *Reserved* | 7 bits | Shall be set to zero |
| } | | |

6.3.25 Relay path management and routing

Each relay station is assigned a range of CIDs for which the relay is responsible for decoding and forwarding. The minimum and maximum of the CID range are assigned by the BS, and are transmitted to RSs via CIDRNG-REQ and CIDRNG-RSP management messages. During operation, the RS is only responsible for listening to CIDs transmitted within this range.

The BS is responsible for managing the entire CID range. Each RS connected to a parent node (BS or RS) is assigned a subset of the CIDs assigned to the parent node. These subsets are non-overlapping.

By Due to this CID range assignment to RSs, the BS implicitly specifies the relay routing path of the connection by assigning a CID to an active service flow.

# 5 References

[1] IEEE C802.16j-06/004r1, “Recommendations on IEEE 802.16j”.

[2] IEEE 802.16-2004, “Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems”.

[3] IEEE 802.16e-2005, “Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems, Amendment 2: Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands *and* Corrigendum 1”.

[4] IEEE C802.16j-06/254, “Fast Connection Establishment and Maintenance with Relays”.

[5] IEEE C802.16j-06/274, “Proposal on addresses, identifiers and types of connections for 802.16j”.