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Re:	IEEE 802.16m-08/024 Call for Comments and Contributions on Project 802.16m System Description Document (SDD), on the topic of "Upper MAC concepts - mobility management".	
Abstract	Proposal for IEEE 802.16m Interruption Free Overlay Handover	
Purpose	Discussion and Approval	
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Proposal for IEEE 802.16m Interruption Free Overlay Handover

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1. Introduction and Background

Handover (HO) is a key mobility feature especially important for delay-sensitive voice and video services in any mobile wireless network. Voice/Video performance is a very important factor in customer satisfaction and viability of the network business model. It is very important not to have significant transport data flow interruptions during the handover process.

In this contribution we propose a new handover type for interruption free overlay handover.

2. Handover Design Considerations in overlay network

The 16m Handover (HO) mechanism should be designed to support minimum handover interruption time (time during Handover when data flow is not possible). In rel 1.x, a seamless handover procedure has been adopted, which achieves minimal service interruption time under the condition that uplink synchronization for intra-frequency HO is optional.

However, this condition is not necessarily true in an overlay network, which IEEE 802.16m shall support for the purpose of capacity enhancement or load balancing. An example of overlay network is shown in Figure 1, where different types of cells have overlapped coverage areas. In such a deployment, even if cells are deployed with the same radio frequency, with possible fractional frequency reuse (FFR), uplink synchronization is necessary as the arrival time will be very different due to different cell sizes. Depending on radio capability, uplink synchronization takes around 50ms and this service interruption time could be larger when ranging opportunity is not immediately available.

An overlay network also poses challenges to network topology acquisition. In the IEEE 802.16e reference system, the BS broadcasts MOB_NBR-ADV messages periodically, which provides the information on network topology and neighbor BS configuration (mainly DCD/UCD) to mobile stations (MSs) in its cell. Obtaining NBR-ADV message is critical to ensure optimized handover in mobility management. However broadcasting MOB_NBR-ADV in an overlay network incurs a huge overhead for MOB_NBR-ADV broadcast. This is because

- There are many neighbors that MOB_NBR-ADV needs to include. For example for a macro-cell BS, in addition to neighbor macro cells, it also needs include overlay relay cells, pico cells in its MOB_NBR-ADV message.
- Many of these neighbors are not of the same cell type and thus may have quite different configurations from serving BS, which the delta information is not likely able to compress the information much. This makes broadcast of the configuration information very expensive.

When the overhead is large, the servicing BS can not broadcast NBR-ADV very frequently, making MS less likely prepared for an optimized handover and leads to poor handover performance in the network.

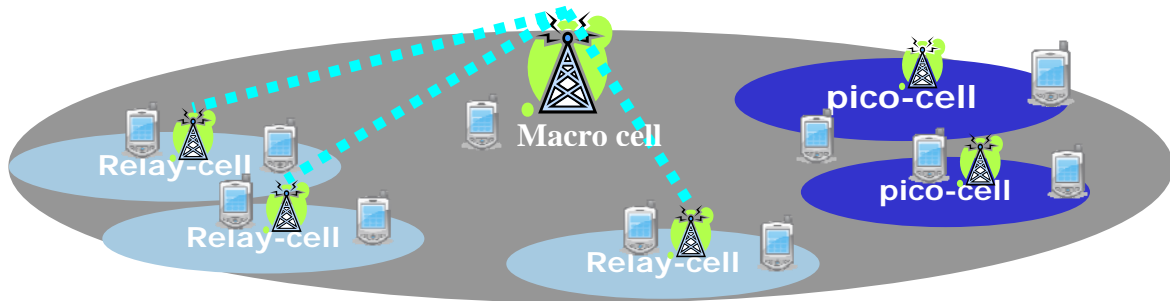


Figure 1 A heterogeneous overlay network

To improve the HO performance in an overlay network, improvements have to be made on all steps of the handover procedure, including network acquisition, HO preparation and HO execution.

3. Co-Frame Processing Capability of MS

An MS always receives a composite signal composed of the signal from the Serving Base Station (SBS) and signals from neighboring BSs on the co-channel.

The MS usually only processes its sample buffer (samples of the composite signal) once per frame using the SBS subcarriers. MS can however process the same buffer using the subcarriers for one or two existing co-channel BSs. This is the basis for the handover improvement IFHO introduced in Section 4.

Figure 2 shows sample co-frame processing. MS may or may not need to process DL-MAP and UL-MAP (not needed for static allocation). MS continues to send and receive to/from the SBS. Additionally, MS performs actions necessary for HO with the TBS:

- CDMA ranging (FFS if this is required)
- Signal presence to TBS with updated MS identifier and most likely uplink TX power indication

Once MS gets confirmation that TBS recognizes its presence, MS will recognize the TBS as the new SBS.

SBS and TBS exchange messages about MS presence and MS context including HO complete.

Note that during Handover, SBS and MS (may) exchange transport data while TBS and MS exchange control information.

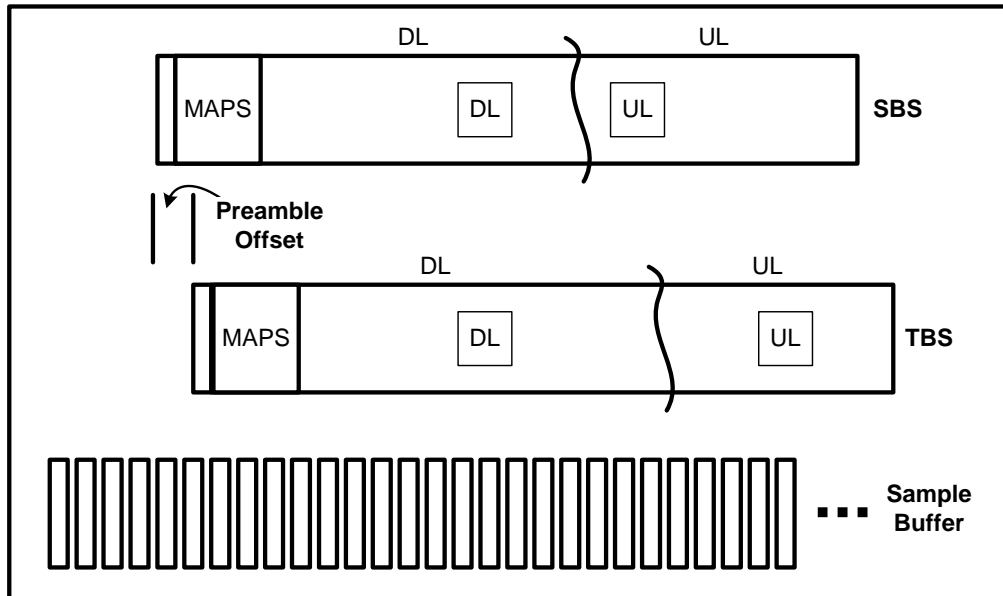


Figure 2 Co-Frame Processing

4. Interruption Free Overlay Handover (IFHO) Process

Interruption Free Overlay Handover (IFHO) is a new intra-frequency handover type that takes advantage of co-channels that exist in overlay networks. For example, with frequency reuse 3, there may be up to three BSs on the same carrier frequency, each using a different set of subcarriers for preambles and maps. Such BSs must be time-synchronized in order for IFHO to work (for example, GPS).

Figure 3 shows high level flow for IFHO. (1) MS receives neighbor BS information from SBS. (2, 3) At some time, MS performs scanning to determine existence of co-channel BSs and to determine signal strength and quality. (Not shown) Either MS or BS requests Handover. (4) SBS negotiates with TBS for handover resources. (5) BS sends handover response to MS. (6) MS sends HO-IND message to SBS. (7) SBS sends HO confirmation to TBS. (8) HO starts. (9, 10) Co-frame processing and SBS/TBS messaging (may be repeated several times). (11) HO complete.

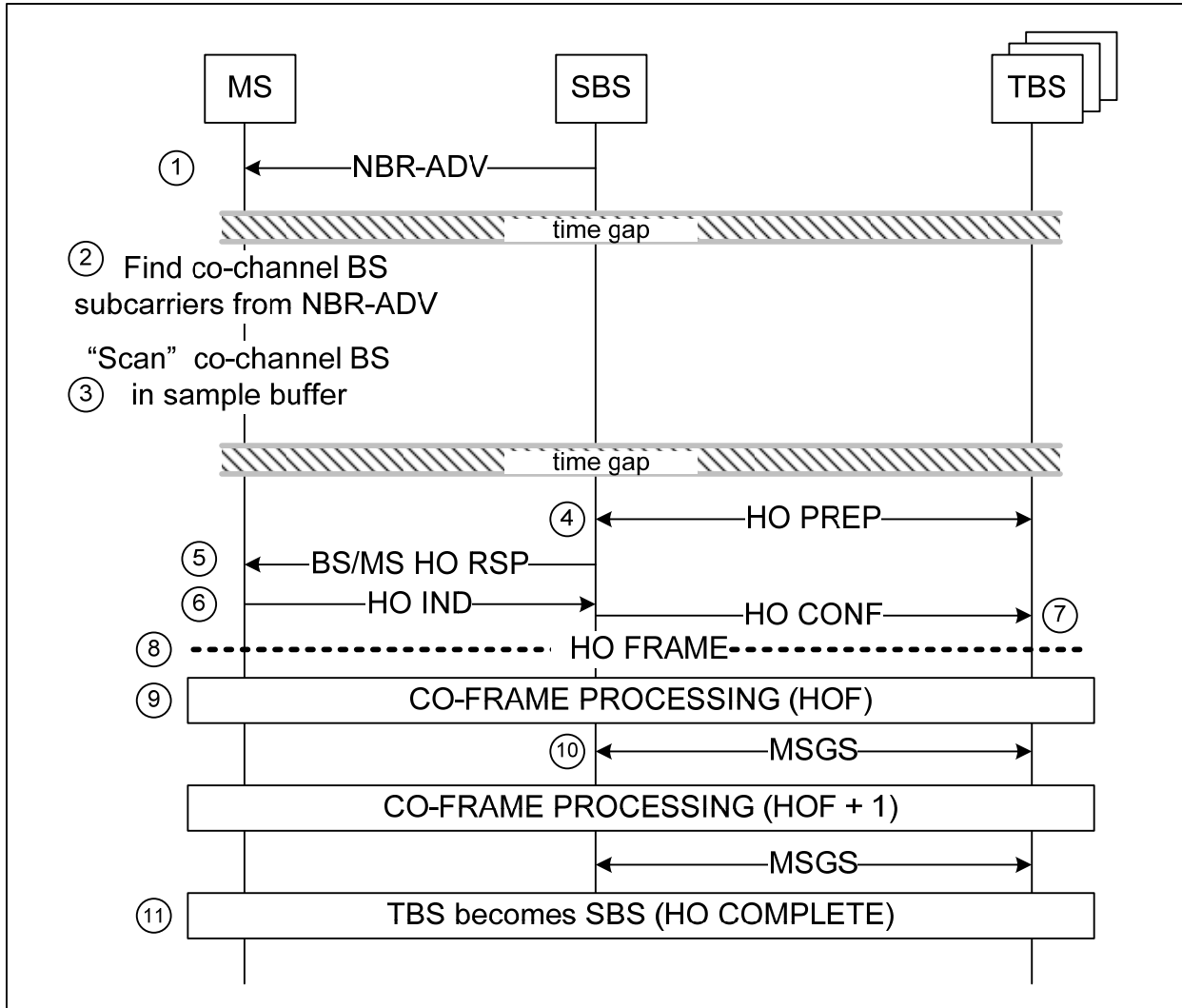


Figure 3 Interruption Free Overlay Handover Flow

5. "Scan" for Co-Channel BS

The MS determines the existence of co-channel BSs using the neighbor information from the SBS's MOB_NBR-ADV broadcast. This neighbor information includes the subcarriers used by any existing co-channel BSs (BS1, BS2). The "scan" is done as follows:

- MS collects signal samples and processes using the SBS subcarrier
- MS temporarily saves signal samples (enough for processing co-channel subcarriers)
- MS re-processes signal samples using BS1 subcarrier. MS determines signal strength and quality
- MS re-processes signal samples using BS2 subcarrier. MS determines signal strength and quality

During this “scan” processing, MS continues to process the SBS frame as usual.

6. Handover Preparation by SBS and TBSs

Handover is triggered either by the MS or the SBS. For MS-initiated HO, MS determines Handover type based on scanning. For BS-initiated HO, BS determines Handover type using the scan results provided by the MS.

SBS negotiates with one or more TBSs for HO start frame, MS identification update, and pre-allocated SBS/TBS bandwidth grants for MS. The SBS and TBS must agree on non-overlapping uplink bandwidth allocations (downlink bursts can overlap).

There are options for MS resource grants during HO depending on MS capabilities. If the MS is capable of processing both the SBS and TBS DL-MAP and UL-MAP in time to receive and transmit to the SBS and TBS, then dynamic bandwidth grants (specified in MAPs) can be used. If not, then bandwidth grants during HO must be static (specified before HO). This is FFS.

7. Network topology acquisition with improved MOB_NBR-ADV broadcast

In a network deployment, most parts of the DCD/UCD, are almost the same when two cells are of the same type, e.g. pico-cell, micro-cell, macro-cell etc, for which we refer as the [common part]. Note some [common part] parameters may even be shared across the whole network, regardless of cell type. Some common parts such as carrier frequency, bandwidth, OFDMA symbol structure etc are not likely to change over time. MSS can assume these common parts to be unchanged even if they may not get this information in the latest NBR-ADV broadcast, without compromising any service or functionality when roaming in the network of same operator. Some common parts, such as DL/UL ratio, may be changed from time to time but common across the network. Fields like this can be a single shared field inside the MOB_NBR-ADV message.

On the other hand, it is important to carefully define the rest of fields that may change across cells, which is referred as the [unique part] (for each BS or relay station), such that MS will not miss any possible difference in configurations. For the unique part, one can use either fixed-length encoding or type-length-value (TLV) definition. Both are

necessary for overhead reduction purpose and the encoding format for each parameter is FFS.

With the above classification, we propose the following MOB_NBR-ADV format as shown in Figure 4. We group BSs according to their cell type. Therefore, within each cell type, common parts can be easily captured by a shared [common part]. The unique part for each BS(RS) is encoded by type-length-value (TLV) fields or some other predefined format. Overhead compression via delta information for BSs of the same cell type and similar configurations is still possible since for each cell type a typical BS is chosen. It is clear the proposed MOB_NBR-ADV significantly compresses the overhead by removing redundancies existing among BSs belonging to the same cell type.

Based on the proposed MOB_NBR-ADV message format, BS can adaptively broadcast unique and common parts with different intervals, as shown in Figure 5. The rules for broadcasting MOB_NBR-ADV, in order to balance signaling overheads and HO delay performance, are as follows:

1. BS broadcasts common parts with large intervals T_1 , to reduce overheads without compromising any functionality.
2. BS broadcasts unique parts more frequently with small intervals T_2 , to allow MSS obtain necessary information for HO more quickly
3. Optionally, BS may broadcast a version number (if necessary, one version number for network-wide common part and one version number for cell-type specific common part) for common part with interval T_2 , along with the unique part; MS can be sure that the cache common part is valid.
4. BS immediately broadcasts the unique part if any changes happened or notified by neighboring BS from the backbone communications, which helps MS who likely to perform HO to obtain the up-to-date information of potential TBS candidates.

NBR-ADV

```
{
  [Common part (shared by the network)]
  For cell-type = 0:m
  {
    [common part (cell specific)]
    //A typical BS in this cell type
    BS_index = 1
    {
      BS-ID
      cell-type specific [configuration type];
      other configuration info in TLV;
    }
    //other BS in this cell type
    For BS_index = 2 to k
    {
      BS-ID
      Cell-type specific [configuration type];
      Delta (from BS1) TLV;
    }
  }
}
```

Loop by cell types allows compression

A typical cell in this type

More compression when configuration TLVs are almost the same as the typical BS

Figure 4 Proposed MOB_NBR-ADV format

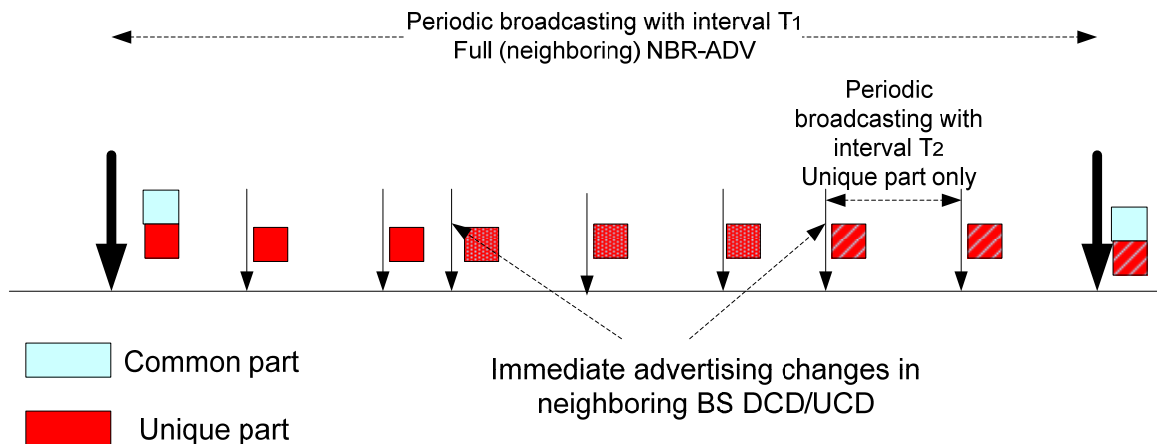


Figure 5 Broadcast MOB_NBR-ADV with common and unique parts, with different broadcast periods

Note that since femto-cell deployment is likely to be dense and non-public access, a macro-cell BS shall not broadcast neighbor femto-cells' configuration in its MOB_NBR-ADV message.

8. Proposed Text for SDD

Insert the following text into Medium Access Control sub-layer sub-clause (i.e. Chapter 10 in [3]):

----- Text Start -----

10.x Handover

Overlay handover is supported to allow load balancing across different cell types.

10.x.1 Network topology acquisition

10.x.1.1 Network topology advertisement

The serving BS periodically broadcasts NBR-ADV message so that MS may learn the network topology for handover preparation. The NBR-ADV message sorts neighbor BSs(RSs) according to their cell types. Within each cell type, configuration parameters are classified into common part and unique part. Either fixed-length or TLV encoding is used and the format mapping for each parameter is FFS. In NBR-ADV broadcast, a typical cell is chosen for each cell type so that other entries in the same cell type only requires delta information for overhead reduction. The BS can adaptively broadcast common part and unique part at different frequencies for overhead reduction.

NBR-ADV broadcast does not include femto-cells.

10.x.1.2 Scanning procedure

In single carrier overlay network, the MS has the option to perform interruption-free scanning. The MS process the composite signal it receives with both the SBS subcarriers and the TBS subcarriers. With the neighbor configuration received from SBS MOB_NBR-ADV broadcast, the MS can measure the neighbor BS signal quality while continuing communication with SBS.

10.x.2.x Interruption Free Overlay Handover

IEEE 802.16m supports an interruption free overlay handover procedure in single carrier overlay network. The MS processes the (same) composite signal it receives with both the SBS subcarriers and the TBS subcarriers. The MS is able to continue sending

and receiving data with the SBS while performing control signaling with the TBS until the handover is complete. Uplink bandwidth allocations for the MS during Handover must be non-overlapping.

----- Text End -----

9. References

[1] IEEE Std. 802.16e-2005, IEEE Standard for Local and metropolitan area networks, 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 P802.16Rev2/D3 (February 2008).

[2] WiMAX Forum™ Mobile System Profile, Release 1.0 Approved Specification (Revision 1.4.0: 2007-05-02), <http://www.wimaxforum.org/technology/documents>.

[3] IEEE 802.16m-08/003r1, “The Draft IEEE 802.16m System Description Document”