Proposal for IEEE 802.16m Control Structure Framework

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Mo-Han Fong, Hang Zhang, Sophie Vrzic, Robert Novak, Jun Yuan, Dongsheng Yu, Anna Tee, Sang-Youb Kim, Kathiravetpillai Sivanesan

Nortel Networks E-mail: mhfong@nortel.com

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Re: IEEE 802.16m-08/005 – Call for Contributions on Project 802.16m System Description Document (SDD), on the topic of "Downlink Control Structures"

Purpose: Adopt the proposal into the IEEE 802.16m System Description Document

Introduction

- The design of 802.16m control structure is highly dependent on the types of control information (and their characteristics) that need to be sent from the BS to the MS in the case of DL for proper system operation including system access, transmission/reception of traffic packets, power saving modes, handover etc..
- Different types of control information has different characteristics in terms of the frequency of change, broadcast, multicast or unicast information, importance to initial system access, etc. Therefore, different types of control information should be treated differently.
- This contribution categorizes the different types of DL control information and propose the control structure suitable to support each type of control information.

IEEE 802.16m System Requirements

- The TGm SRD (IEEE 802.16m-07/002r4) specifies the following requirements:
  - Section 6.2.2 State transition latency:
    - As shown in Table 3, the maximum allowable IDLE to ACTIVE transition latency is 100ms
  - Section 6.10 System overhead:
    - "Overhead, including overhead for control signaling as well as overhead related to bearer data transfer, for all applications shall be reduced as far as feasible without compromising overall performance and ensuring proper support of systems features."
  - Section 6.11 Enhanced power saving:
    - "IEEE 802.16m shall provide support for enhanced power saving functionality to help reduce power consumption in devices for all services and applications."
- The proposed control structure framework targets the above requirements

Control Structure in the Legacy System (1/2)

- There are quite some redundancy in the control information transmission in the legacy system as summarized below. The goal of the proposed 802.16m control structure framework is to minimize the redundancy in control information transmission, thus reduce the overall system overhead.
- In the legacy system, burst allocation information is sent in MAPs, while system information is sent in DCD/UCD. In addition, neighbor BS information and paging information are sent on broadcast MAC messages.
- Some of the information sent on MAPs does not change dynamically and therefore can be sent in less frequent manner to reduce overhead.
  - E.g., STC zone switch IE, ranging region definition, fast feedback region definition, ranging backoff parameters etc.
- Some of the information in DCD/UCD are static system information, thus does not need to be periodically broadcast to MSs that have already entered the network or can be broadcast with a relatively long period to improve reliability
  - E.g., BS ID, operator ID, TDD ratio/guard time, frame duration, MAC version, etc.
- Some of the information in DCD/UCD are semi-static system configuration information, thus does not need to be periodically broadcast to MSs that have already entered the network if the configuration hasn't been changed or can be broadcast with a relatively long period to improve reliability
  - E.g., burst profile, handover parameters, HARQ parameters etc.
- Similarly, neighbor BS information which is semi-static information does not need to be periodically broadcast to MSs that have already entered the network if the configuration has not changed. Updated information can be sent to a MS who initiates handover process.

Control Structure in the Legacy System (2/2)

- In the legacy system, an MS in sleep mode or idle mode will miss the DCD/UCD transmission if it is in sleep window or paging unavailable interval. When the MS wakes up in listening window or paging listening interval, if the configuration change count has changed, the MS has to stay awake until proper reception of the next DCD/UCD transmission from the BS. In addition, the next occurrence of the DCD/UCD transmission is not known or indicated to the MS.
- There are a number of broadcast messages sent by the BS, e.g. DCD/UCD, MOB_NBR-ADV, MOB_SLP-RSP, MOB_PAG-ADV, FPC etc.. Some information is only relevant to MSs in certain mode (Sleep, Idle, Normal), e.g. MOB_PAG-ADV is only relevant to MSs in Idle Mode. Since an MS has no way to identify the message type before decoding the message, the MS has to decode all the traffic bursts with Broadcast CID. This incurs unncessary processing and power consumption at the MS.

Categorization of DL Control Information (1/3)

Control information type	Examples of information carried	Characteristics	Control channel design
(1) Essential static system-wide PHY information for decoding of DL PHY frames/sub-frames	Bandwidth configurations, CP sizes, multi-carrier configuration, system time, TDD ratio, guard tones.	Static system-wide deployment specific parameters. Required for fast initial access during network entry. MS should be able to decode these information after synchronization.	Information should be broadcast periodically in relatively frequent manner to allow fast initial access. Information should be delivered with very high reliability. Since this is essential PHY information, **it should be carried in a fixed resource location and fixed MCS within a superframe**.
(2) Essential pseudo-dynamic sector-wide PHY information for decoding of DL PHY frames/sub-frames (i.e., superframe configuration control information)	Channelization (partitioning of diversity zone, localized zone, pilot structure etc.), legacy/16m resource partition, sub-frame control configuration etc. Contain initial ranging region/codes information for MS to do fast initial access procedure.	Information can change from one superframe to another. Required for fast initial access during network entry and handover. MS should be able to decode these information after synchronization.	Information should be broadcast periodically every superframe. Information should be delivered with very high reliability. Since this is essential PHY information, **it should be carried in a fixed resource location and fixed MCS within a superframe**.

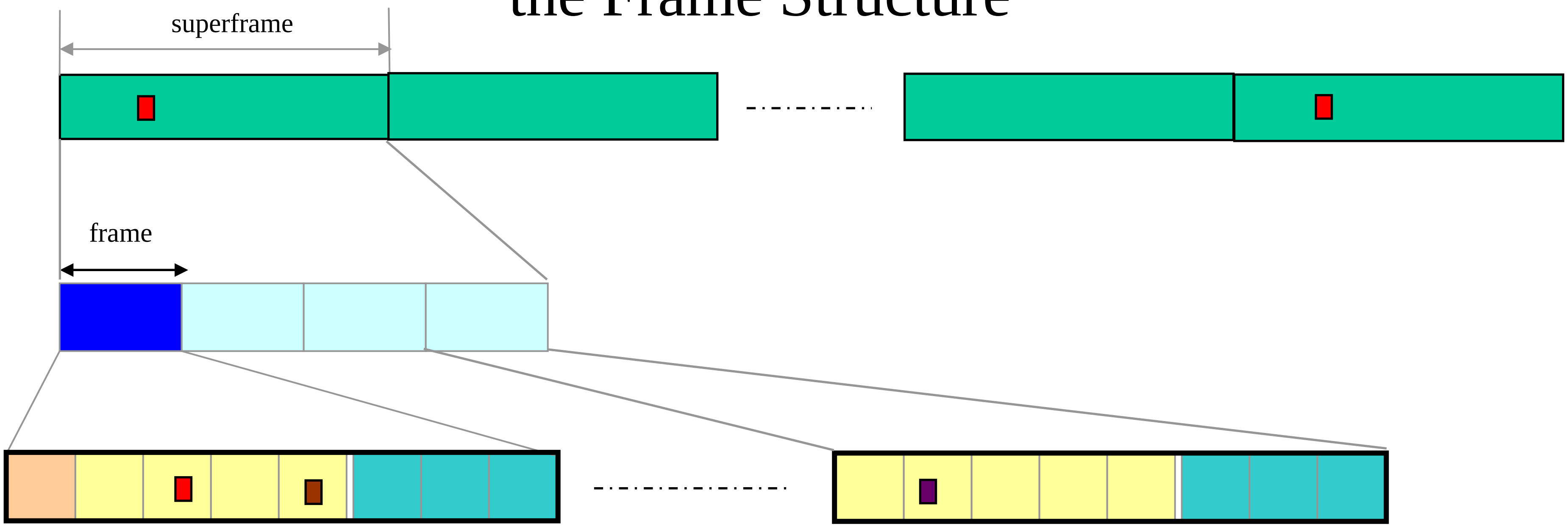
Categorization of DL Control Information (2/3)

Control information type	**Examples of information carried**	**Characteristics**	**Control channel design**
(3) Non-PHY system information	BSID, operator ID, MAC version etc.	Static system information	Since information is static. It doesn’t have to be periodically broadcast to MSs. It can be sent by unicast to a MS during initial network entry process. These information does not have to be carried in a fixed resource location. **It can be carried in the unicast MAC management message**.
(4) PHY/MAC system configuration information	Handover parameters, power control parameters, HARQ parameters, fast feedback region, ranging region except for initial ranging etc.	Semi-static system configuration information. Configuration parameters values can change in a slow fashion (in order of seconds/minutes/hours).	For MS already entered the network, there is no need to broadcast the information in a frequent manner if the information hasn’t changed. The control channel design should support efficient power saving for sleep mode and idle mode MS while ensuring any changes in the system configuration is received by the MS in timely fashion. **The information can be sent periodically as broadcast MAC management message in an infrequent manner.** For MS performing initial network entry, the system configuration information is **sent as unicast MAC management message to the MS during network entry procedure** to expedite the network entry.

Categorization of DL Control Information (3/3)

Control information type	**Examples of information carried**	**Characteristics**	**Control channel design**
(5) Neighbor BS information	Information types 3) and 4) of neighbor BSs	Same as indicated in previous slide for type 3) and 4)	Information can be broadcast periodically or event triggered as **broadcast MAC management message**. The information can also be sent as **unicast MAC management message** to MS who wants to add a neighbor BS to the active set.
(6) Paging information	Paging information for MSs being paged.	Non-periodic information. Event driven.	Information should be **sent as broadcast paging message** whenever there is one or more MS to page.
(7) Dynamic DL and UL resource allocation and control information related to traffic burst assignment	Burst assignment related information: MCS, MIMO mode, resource location, user ID ACK/NAK of UL traffic UL power control command	Dynamically changes every sub-frame	Control information can be sent as **multicast or unicast** every sub-frame depending on the nature of the information. Refer to contributions C802.16m-08/176, 177, 178 for details of the proposed resource allocation and control structure.

Mapping of Different Types of DL Control Information to Control Channels and MAC Management Message in the Frame Structure



First frame in the superframe containing the superframe header

Superframe header sub-frame: contains sync channel and system broadcast channel for information types (1) and (2). Type (1) information may not be broadcast every superframe.

DL sub-frame containing resource allocation and control channels for information type (7)

UL sub-frame

Information types (4), (5) sent as either unicast message or periodic broadcast message

Information type (6) sent as broadcast message on as needed basis

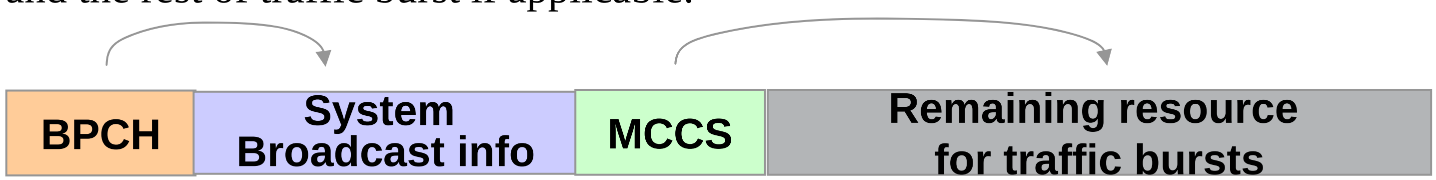
Information type (3) sent as unicast message on for MS performing network entry

Broadcast Pointer Channel (BPCH) (1/2)

- The broadcast of control information types (4), (5), (6) may or may not be present in a sub-frame. To efficiently indicate the presence/absence of these type of information block, a 16m Broadcast Pointer Channel (BPCH) is introduced.
- The 16m BPCH contains the following:
  - Information blocks presence flags
  - Length of each information block that is present
- Examples of information blocks are:
  - System information types (4), (5). In this information block, multiple MAC management messages for the different information types can be encapsulated.
  - Paging information (type (6))
- The benefit of BPCH is to allow sleep mode and idle mode MS to only decode the BPCH to find out if broadcast information is present and whether the broadcast information present is relevant or not (e.g. paging information is not relevant to sleep mode MS).
  - If the broadcast information is not present or the broadcast information is not relevant, the MS can go back to sleep without the need to decode the rest of the sub-frame and the resource allocation/control information, i.e. type (7).
  - If the broadcast information is present and relevant, the MS just needs to decode the relevant broadcast information and go back to sleep without the need to decode the rest of the sub-frame and the resource allocation/control information, i.e. type (7).

Broadcast Pointer Channel (BPCH) (2/2)

- BPCH may or may not be present in each sub-frame. When there is no broadcast information to send, BPCH does not need to be present. This reduces the system overhead.
- If present, BPCH is located at a fixed location within the diversity zone in a sub-frame (see contribution C802.16m-08/175 for details of the proposed channelization). BPCH has a fixed length and modulation/coding. MS performs blind detection to decide if BPCH is present or not.
  – An MS first attempts to decode BPCH. If decoding successful, the information contained in BPCH will allow the MS to decode the system broadcast information that follows. The remaining resource in the sub-frame contains the resource allocation/control information for traffic bursts, i.e. the Multicast Control Segment (MCCS) and resource for traffic bursts. The partitioning of the resource for traffic burst is signaled by the MCCS. Note that MCCS is of fixed length and modulation/coding. Details of MCCS is provided in contribution C802.16m-08/176.
  – If MS does not successfully decode the BPCH, the MS will assume that both BPCH and the system broadcast information are not present. The MS proceeds to decode the MCCS and the rest of traffic burst if applicable.



Multi-Carrier Support (1/2)

- In the case of contiguous spectrum, multi-carrier mode is used to support MSs with different bandwidth capability. For example, a 10MHz spectrum can be divided into two 5MHz carriers in order to simultaneously support MSs with 5MHz bandwidth capability and 10MHz bandwidth capability.
- Not all the carriers need to carry all the system broadcast information, as system-wide and sector-wide system information are common to all carriers. Repeating the information over multiple carriers increases the system overhead.
- Two types of carriers can be defined:
  - **Primary carrier**: this is a carrier that carries the synchronization channel (or preamble), all the system information, neighbor BS information, paging information and resource allocation/control information, i.e information type (1) to type (7) described in previous slides
  - **Secondary carrier**: this is a carrier that carries a subset of the system information, i.e, information type (2) for information related to superframe configuration on that carrier; as well as the resource allocation/control information of each sub-frame within the carrier, i.e. type (7). This type of carrier may also carry the synchronization channel (or preamble).

Multi-Carrier Support (2/2)

- One or multiple carriers within the spectrum can be designated as primary carriers. One or multiple carriers within the spectrum can be designated as secondary carriers.
- A narrowband MS, i.e. an MS that has bandwidth capability to transmit/receive on only one carrier at a time, is assigned to a primary carrier.
- A wideband MS, i.e., an MS that has bandwidth capability to transmit/receive on multiple carriers at a time, is assigned to one or multiple primary carriers.
- A wideband MS monitors only the assigned primary carrier(s) for system broadcast information, i.e. type (1) to type (6), and resource allocation/control information, i.e. type (7), for new traffic packet transmission. The wideband MS also monitors secondary carrier(s) for superframe configuration broadcast information, i.e. type (2) at the superframe boundary.
  - The MS may monitor the resource allocation/control information, i.e. type (7), on secondary carrier(s) for HARQ retransmissions. Details of HARQ ACK/NAK and retransmission for multi-carrier operation is given in contribution C802.16m-08/178.

Proposed Text for SDD (1/2)

- Section 11.x: DL Control Structure
  - The DL control structure supports different types of broadcast, multicast and unicast control information
  - Essential PHY system information are sent on the system broadcast channels in the superframe header sub-frame
  - Other types of non-essential PHY/MAC system information and system configuration information, neighbor BS information and paging information are sent as unicast or broadcast MAC management messages as part of regular traffic bursts
  - Resource allocation and control information is sent per sub-frame for dynamic traffic bursts assignment.
  - [*Add content in slide 9*]
- Section 11.x.x: DL Broadcast Pointer Channel
  - [*Copy the content of slides 10 and 11 into this section*]

Proposed Text for SDD (2/2)

- Section 11.y: Multi-Carrier Support
  - [*Copy the content of slides 12 and 13 into this section*]