Proposal for IEEE 802.16m Power Saving Schemes

Document Number: IEEE C802.16m-08/620

Date Submitted: 2008-07-07

Source:

Mo-Han Fong, Hang Zhang, Sophie Vrzic, Robert Novak, Jun Yuan, Dongsheng Yu, Hosein Nikopourdeilami, Kathiravetpillai Sivanesan

Nortel Networks E-mail: mhfong@nortel.com

*<http://standards.ieee.org/faqs/affiliationFAQ.html>

Re: IEEE 802.16m-08/024 – Call for Contributions on Project 802.16m System Description Document (SDD), on the topic of "Upper MAC – Power Management"

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

Introduction

- This contribution proposes the power saving schemes that address the following TGm SRD (IEEE 802.16m-07/002r4) 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."

Issues that Reduce the Effectiveness of Power Saving in the Legacy System

- 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.
  - Both the above issues incur unnecessary power consumption
  - In addition, they cause unnecessary delay for sleep-to-active and idle-to-active transition
- 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 unnecessary processing and power consumption at the MS.
- The sleep window or paging unavailable interval can be quite large. During this time, BS cannot transmit data to the MS and cannot trigger the MS to perform state transition to active mode. To reduce state transition latency, the sleep window or paging unavailable interval can be set of a small value, however, at the expense of increased power consumption.

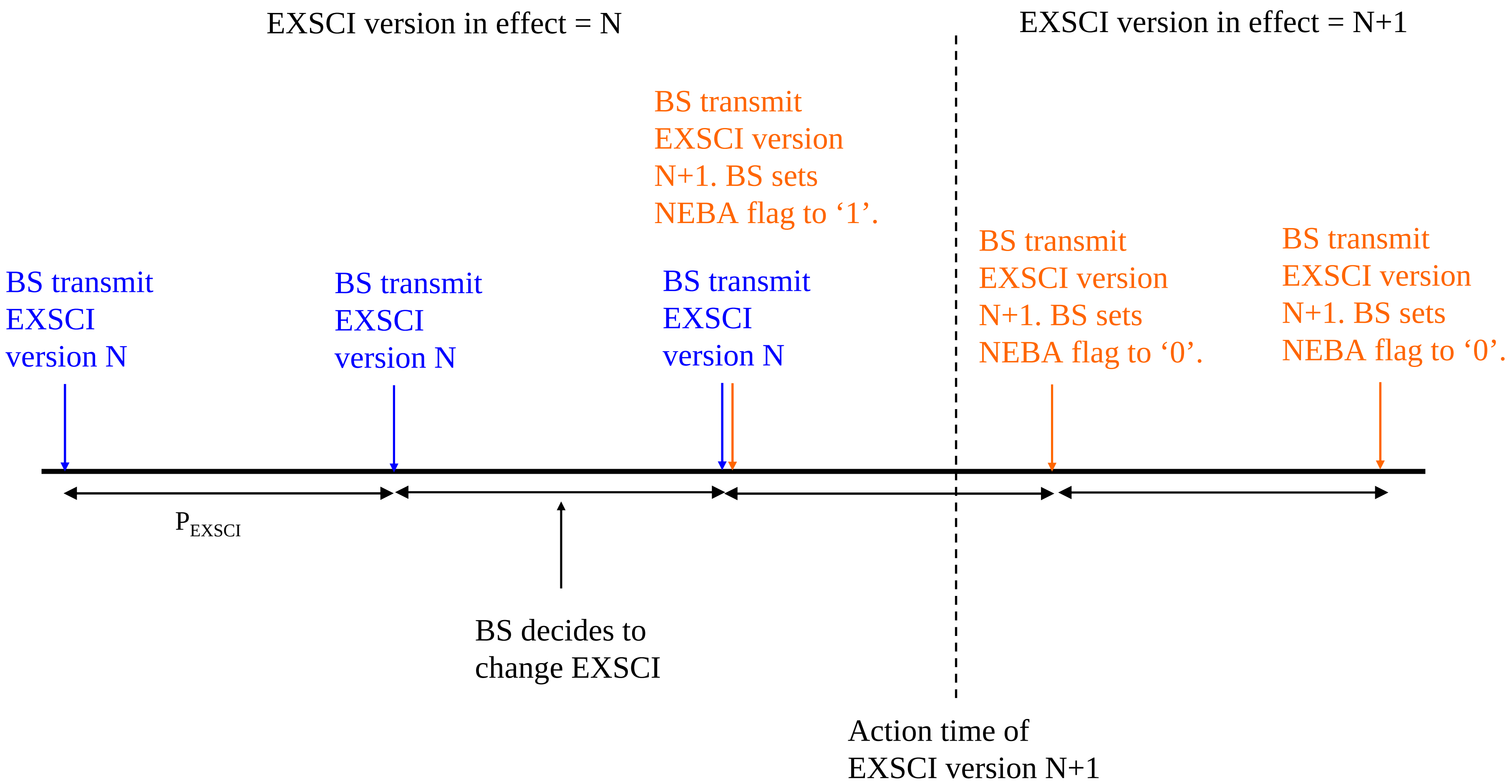
Efficient Transmission of Extended System Configuration Information (1/2)

- In the current SDD text (IEEE 802.16m-08/003r3) superframe header (SFH) contains BCH which carries the essential system configuration information (ESCI). The mapping to physical channel/location and transmission frequency of the extended system configuration information (EXSCI) is TBD.
- We propose the following information be included in the BCH to enable efficient detection of the EXSCI and power saving for users in active, sleep and idle modes:
  - **Period (P_{EXSCI}) of the EXSCI broadcast**: the EXSCI is broadcast at the superframe number N, where (N mod P_{EXSCI}) equals to zero
  - **EXSCI presence indicator (EPI)**: to indicator the presence of EXSCI, including the length and type
  - **EXSCI version number (EVN)**: version number of the system configuration currently in effect
  - **New EXSCI broadcast alert (NEBA)**: a flag to indicate if BS has broadcast a new version of the EXSCI than the one currently in effect
  - **Traffic indication information block (TFIB) presence indicator (TPI)**: to indicate the presence of TFIB, including the length
  - **Paging information block (PGIB) presence indicator (PPI)**: to indicate the presence of PGIB, including the length
- We propose the following information be included in the EXSCI:
  - **EXSCI version number (EVN)**
  - **Action time** of when the associated configuration will take effect
- The details of how the above parameters are applied to users in active, sleep and idle modes are described in later slides

Efficient Transmission of Extended System Configuration Information (2/2)

- The BS transmits the current version of EXSCI periodically where the period is indicated in P_{EXSCI} field in the BCH
- When the BS intends to change the EXSCI, it broadcast the new version of EXSCI periodically prior to the action time. The BS sets the NEBA flag to ‘1’ so that an MS knows that it should attempt to decode the new version of EXSCI.
- The periodic transmission of current version and new version of EXSCI allows an MS in sleep mode or idle mode to receive the information even if it misses the initial broadcast of EXSCI.
- The period of the EXSCI transmission can be configured to a relatively large value without affecting the network entry latency since the EXSCI can be unicast to an MS performing network entry.
- BS can send additional aperiodic EXSCI on as-needed basis, which is implementation dependent, to expedite the detection of the information by MSs in sleep mode and idle mode. For example, BS may transmit the EXSCI at the wake-up time of an MS.

Illustration of the EXSCI Transmission



Power Saving Modes

- The following power saving modes are proposed for 802.16m:
  - Connected state:
    - Active mode: this mode is for MS that has DL and/or UL traffic
    - Sleep mode: this mode is for MS that does not have DL or UL traffic. It enables fast transition back to active mode.
  - Idle state: this is for MS that does not have DL or UL traffic. It has slower state transition back to active mode than sleep mode
- The Active mode is further divided into two categories:
  - Fully active mode
  - Intermittently active mode

Active Mode

- Fully active mode: an MS in this mode decode the control information in each sub-frame
- Intermittently active mode: an MS in this mode decode the control information on pre-configured sub-frame(s) or HARQ interlace(s)
- While in either of the above modes, an MS decodes the BCH in the SFH and the EXSCI if present as indicated by the EPI in the BCH.

Sleep Mode

- An MS in sleep mode wakes up periodically to decode the SFH. The period is configured by the BS on a per-MS basis. In addition, the MS also wakes up on the superframe where the BS broadcast the EXSCI, i.e., at the superframe number N, where (N mod P_{EXSCI}) equals to zero.
  - There is no need for sleep window and listening window as in the legacy system due to the issues indicated in slide 3
  - There is no need for different power saving classes as in the legacy system as such definition incurs unnecessary complexity and state synchronization between BS and MS
- A sleep mode traffic indication information block (TFIB) is used to indicate to one or multiple MSs to transition back to active mode
  - The presence (and length) of TFIB is indicated in the BCH by the TPI field (refer to slide 4).
  - When the MS wakes up periodically to decode the SFH (BCH), and if the TPI indicates the presence of TFIB, the MS shall decode the TFIB. If the TFIB includes the MS' user ID, then the MS shall transition to active mode.
  - The location and MCS of TFIB is predefined, e.g., TFIB follows the EXSCI if present.
- Since an MS only needs to decode the SFH when it wakes up periodically, rather than decoding all the sub-frames (and all the broadcast messages) within a listening window as in the case of legacy system, an MS can be configured to wake-up more frequently than that of the legacy system, while allowing power saving as well as fast state transition.

Sleep Mode – Efficient Decoding of EXSCI Update

- When MS wakes up at P_{EXSCI} intervals to decode the SFH (BCH), it reads the EVN, NEBA, EPI fields in the BCH
  - If the MS detects that EVN has not changed from what the MS has stored and NEBA is set to ‘0’, the MS does not need to decode the EXSCI
  - If the MS detects that EVN has not changed from what the MS has stored, but NEBA is set to ‘1’, and the MS has not previously received new version of EXSCI from the BS, the MS shall decode the EXSCI pointed by the EPI. If MS fails to decode EXSCI, the MS shall stay awake to decode SFHs/EXSCI of sub-sequent superframe. If MS fails to decode EXSCI after a pre-defined number of trials, the MS shall perform network re-entry.
  - If the MS detects that EVN has not changed from what the MS has stored, but NEBA is set to ‘1’, and the MS has previously received new version of EXSCI from the BS, the MS does not need to decode the EXSCI.

Idle State

- An MS in Idle mode wakes up periodically to decode the SFH. The period is configured by the BS on a per-MS basis. In addition, the MS also wakes up on the superframe where the BS broadcast the EXSCI, i.e., at the superframe number N, where (N mod P_{EXSCI}) equals to zero.
  - There is no need for paging listening interval and paging unavailable interval as in the legacy system due to the issues indicated in slide 3
- A paging information block (PGIB) is used to page one or multiple MSs to transition back to active mode
  - The presence (and length) of PGIB is indicated in the BCH by the PPI field (refer to slide 4).
  - When the MS wakes up periodically to decode the SFH (BCH), and if the PPI indicates the presence of PGIB, the MS shall decode the PGIB. If the PGIB includes the MS' user ID and other paging information, then the MS shall transition to active mode and proceed with subsequent network re-entry procedure.
  - The location and MCS of PGIB is predefined, e.g., PGIB follows the EXSCI and TFIB if present.
- Since an MS only needs to decode the SFH when it wakes up periodically, rather than decoding all the sub-frames (and the all the broadcast messages) within a paging listening window as in the case of the legacy system, an MS can be configured to wake-up more frequently than that of the legacy system, while allowing power saving as well as fast state transition.

Idle State – Efficient Decoding of EXSCI Update

- The procedure is similar to an MS in sleep mode described in previous slide.
- When MS wakes up at P_{EXSCI} intervals to decode the SFH (BCH), it reads the EVN, NEBA, EPI fields in the BCH
  - If the MS detects that EVN has not changed from what the MS has stored and NEBA is set to ‘0’, the MS does not need to decode the EXSCI
  - If the MS detects that EVN has not changed from what the MS has stored, but NEBA is set to ‘1’, and the MS has not previously received new version of EXSCI from the BS, the MS shall decode the EXSCI pointed by the EPI. If MS fails to decode EXSCI, the MS shall stay awake to decode SFHs/EXSCI of sub-sequent superframe. If MS fails to decode EXSCI after a pre-defined number of trials, the MS shall perform network re-entry.
  - If the MS detects that EVN has not changed from what the MS has stored, but NEBA is set to ‘1’, and the MS has previously received new version of EXSCI from the BS, the MS does not need to decode the EXSCI.

Proposed Text for SDD (1/2)

- Section 10.x: System Parameters and System Configuration Information
- Section 10.x.1: Essential System Parameter and System Configuration Information
- Section 10.x.2: Extended System Parameter and System Configuration Information
  - [*Copy the content in slides 4, 5, 6 into this section*]
- Section 10.y: Power Saving Modes
  - [*Copy the content of slides 7 and 12 into this section*]