Project	**IEEE 802.16 Broadband Wireless Access Working Group** <http://ieee802.org/16>
Title	**Considerations on 802.16m Sleep mode**
Date Submitted	**2008-07-07**
Source(s)	Xin Qi, Shashikant Maheshwari, Yousuf Saifullah Nokia Siemens Networks xin.qi@nsn.com shashikant.maheshwari@nsn.com yousuf.saifullah@nsn.com Andrea Bacioccola, Zexian Li Nokia andrea.bacioccola@nokia.com zexian.li@nokia.com
Re:	IEEE 802.16m-08/024 - Call for Comments and Contributions on Project 802.16m System Description Document (SDD) Target Topic: Upper MAC concepts and methods (limited to addressing, mobility and power management)
Abstract	A power management proposal for 802.16m.
Purpose	To incorporate the proposals into the 802.16m SDD.
Notice	
Release	
Patent Policy	

Considerations on 802.16m Sleep mode

Xin Qi, Shashikant Maheshwari, Yousuf Saifullah
Nokia Siemens Networks
Andrea Bacioccola, Zexian Li
Nokia

Introduction

In 802.16 [1], sleep mode is defined to minimize MS power usage and decrease usage of serving BS air interface resources. This contribution modifies the 802.16e sleep mode according to the new 16m frame structure for achieving higher power saving efficiency.

The 802.16m frame structure

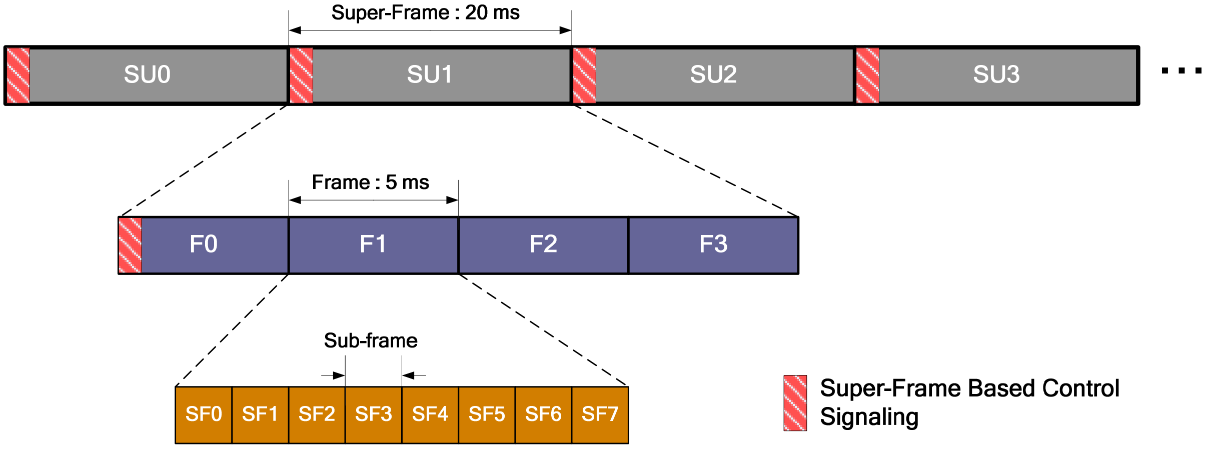

Figure 1 802.16m Basic frame structure [2]

In 802.16m frame structure [2], as shown in Figure 1, each 20 ms superframe is divided into four equally-sized 5 ms radio frames, and each frame further consists of eight subframes. A subframe shall be assigned for either DL or UL transmission. Each superframe shall begin with a DL subframe that contains a superframe header (SFH). SFH contains the broadcast channel (BCH). BCH carries essential system parameters and system configuration information, such as downlink system bandwidth, TDD DL/UL ratio, antenna configuration, DL resource allocation configuration, pilot configuration.

Unicast service control channel (a.k.a MAP message in 802.16e) is defined to transmit e.g. scheduling assignment, power control information, ACK/NACK information. Control blocks for user specific control information are located 'n' 802.16m subframes apart, where 'n' is a subset of {1,2,3,4}. This means that the MAP messages could be transmitted in each subframe or concatenated subframes to enable quicker scheduling and feedback than 802.16e.

Basic unit of the length of sleep/listening windows

In 802.16m frame structure, we have superframe, frame and subframes. We propose to use frame as the basic unit, at least for listening window. The reasons are as follows:

- Computing the window lengths based on superframe: One superframe contains 4 frames. The granularity of the windows is too large, esp. for listening window. One listening window will be multiple of 4 frames, i.e.

in each listening window MS has to keep awake for at least 4 frames, which is unnecessarily long in many cases. Note that the listening window is mainly for MS to wake up and check whether there is some new traffic arrived during the recent sleep window.

- Computing the window lengths based on subframe: One drawback of this option is that MAP messages might not be transmitted in each subframe (e.g. when there is subframe concatenation). Therefore, when MS wakes up in one subframe, it is possible that no MAP message is transmitted. In this case, related procedures need to be defined to ensure that BS could be synchronized with MS about when transmitting information to MS. E.g. MS has to stay awake until the next subframe which consists of MAP message.

Due to the drawbacks of the previous two options, we propose the following two options for computing the window length:

- Option 1 ---- Computing the window lengths based on frame.
- Option 2 ---- Computing the sleep window length based on superframe and computing the listening window length based on frame.

System configuration information acquiring method

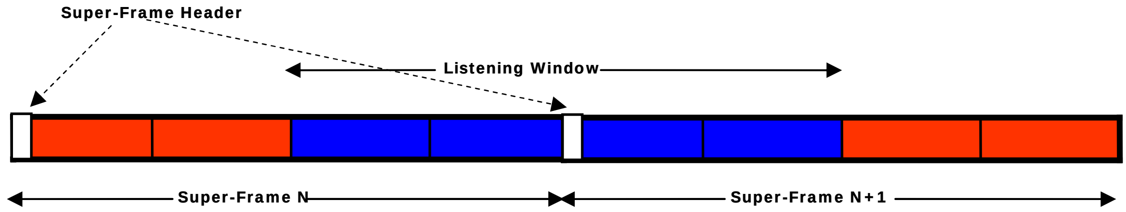

Figure 2 Example of listening window

As mentioned before, SFH contains system configuration information, e.g. superframe DL resource allocation configuration, pilot configuration, etc. Without acquiring this information, there could be troubles for MS to decode DL traffic in the right way. E.g. without subframe concatenation information, MS could not know in which subframes MAP messages are transmitted. This situation could happen when listening window overlaps with a superframe while the overlapping does not contain the SFH. See superframe N in Figure 2 as an example. Therefore, we propose the following methods to ensure that MS could acquire system configuration information when it wakes up:

- If MS finds that the 1st frame in the next listening window does not contain SFH, the MS will first wake up at the start of the superframe and decode the SFH, and then go back to sleep again, and then wake up again at the 1st frame of the listening window.

Consider the two optional methods of computing sleep/listening window length, which are proposed in the previous section. When superframe is used as the unit to compute the sleep window length, i.e. option 2 is used, there will be no problem for MSs to acquire SFH, because anyway MSs will wakeup at the start of superframes and SFH is already agreed to be transmitted at the start of superframe. This is one natural advantage of option 2, as compared with option 1. One disadvantage of option 2 would be that when all MSs' listening window contains the 1st frame of a superframe, (i.e. BS transmits traffic to all the MSs in sleep mode at the 1st frame of a superframe), the frame will probably be overloaded by traffic, esp. in the case that a number of VoIP connections are using sleep mode.

Method for improving the power saving efficiency base on subframe structure

MS is expected to receive all DL transmissions in the same way as in the state of normal operations (no sleep) during listening windows. According to 16m SDD, there could be MAP messages in multiple subframes in a frame. Therefore, MS has to decode MAP message at the start of each subframe concatenation, which means MS has to wake up several times during a frame. This is obviously inefficient in terms of power saving. We propose the following method for improvement:

- BS could notify the MS that BS will only transmit traffic related to the MS in the n^{th} “subframe concatenation” during each frame in the listening window. The parameter n is assigned by the BS during the definition of the related power saving class (PSC). There is no traffic for the MS in other subframes, where the MS is not required to listen to BS.
- There could be exceptions that in some frames, the total number of “subframe concatenations” $m<n$. In this case, MS could select to wake up at the 1^{st} “subframe concatenation” or the m^{th} “subframe concatenation”, which could also be configured during the definition of the PSC by the BS.

Method for efficient traffic indication

In 802.16e PSC of type I, BS could inform a MS that there is DL traffic in the buffer, by transmitting MOB_TRF-IND (traffic indication) message to the MS. Then MS will deactivate the sleep mode and wait for the DL traffic. Since the “traffic indication” is transmitted as a MAC message, MS has to first decode all MAP messages in the listening window and then decode MOB_TRF-IND. Note that MAP messages normally consume more than 10% of a frame’s resources, which is a large part. Thus, MS power is wasted, if the MS does not need to wake up due to no DL traffic in the buffer.

To design the 16m power saving in a more efficient way, we propose to change the location of traffic indication message. A 1-bit flag could be defined in the BCH, indicating whether traffic indication message is transmitted in the superframe. The location and transmission format of traffic indication is predetermined, e.g. in the 1^{st} subframe of the superframe. In this way, MS could decode the traffic indication without decoding MAP messages and therefore save more power. If not indicated by the traffic indication, MS will keep sleeping and bypass the listening window.

Proposed Text to SDD

10.x Power management

In 802.16m sleep mode, the length of listening window is computed in the unit of frame. The length of sleep window is computed in the unit of superframe for non-realtime traffic, and frame for realtime traffic (e.g. VoIP).

When sleep mode is activated, MS decodes the SFH in a superframe if the superframe overlaps listening window.

MS is able to wake up only in specific subframes in each frame during listening window.

The existence of traffic indication message in a superframe is indicated by BCH directly, so that MS could decode it without decoding MAP messages.

Reference

[1] IEEE 802.16Rev2/D5, "IEEE draft standard for Local and Metropolitan Area Networks – Part 16: Air interface for fixed Broadband Wireless Access systems", June 2008

[2] IEEE 802.16m-08/003r3, The Draft IEEE 802.16m System Description Document