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| Source(s) | Jaesun Cha, Eunkyung Kim, Jae-joon Park, Seungkwon Baek, Sungcheol ChangETRI | E-mail: jscha@etri.re.kr \*<<http://standards.ieee.org/faqs/affiliationFAQ.html>> |
| Re: | Working Group Letter Ballot #39 on IEEE P802.16q/D1 |
| Abstract | This contribution proposes to apply BS power management functions only to a small BS. In addition, this contribution proposes some text changes to clarify the BS power management functions and procedures. |
| Purpose | To discuss and adopt the proposed texts in IEEE P802.16q draft |
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# Clarification of BS Power Management

Jaesun Cha, Eunkyung Kim, Jae-joon Park, Seungkwon Baek, Sungcheol Chang

ETRI

# Introduction

Duty-cycle mode and standby mode have been defined to support BS power management functions. According to the description included in subclause 17.1.2, they are additional operational modes that are applicable to a small BS. But, the texts included in subclause 17.4 describe as if the BS power management can be applicable to a macro BS as well as a small BS. They conflicts with each other.

Duty-cycle mode and standby mode are helpful to reduce interference to neighbor BSs but they should not be applicable to a macro BS because the macro BS shall always provide cell coverage. If two operational modes are applied to a macro BS, then the macro BS can’t provide cell coverage during an inactive interval of the duty-cycle mode and the entire standby mode.

The purpose of text changes included in this contribution is to clarify that the BS power management functions are only applicable to a small BS and to refine the description of the BS power management functions and procedures.

# Proposed Texts

----------------- Start of the text proposal --------------------------------------------------------------------------------------

[*Remedy: Change the texts in subclause 17.4 as follows:*]

**17.4 Small BS power management**

**17.4.1 General Description**

This subclause describes the power management functions of small base stations for energy efficient operation. The power management function under this subclause details not only operation of single base station but also cooperative operations of adjacent base stations.

A small base ~~Base~~ stations ~~including macro and small base stations~~ always operate in Normal mode when the base station power management is not supported at the small base stations.

A small base ~~Base~~ stations supporting the base station power management described in this subclause operate in one of the power saving operation modes such as Duty-cycled mode or Standby mode when the operation condition is met.

**17.4.2 Duty-cycle Mode**

Besides the normal operation mode, a small BS~~s~~ may support duty-cycle mode to reduce interference to neighbor cells and to conserve its power consumption. The support of duty-cycle mode is negotiated with a BS power controller during the BS initialization and configuration. Duty-cycle mode can be activated through primitive handshaking~~negotia­tion~~ between the BS and NCMS when the BS is in normal operation mode.

If a small BS enters the duty-cycle mode, a duty-cycle pattern that consists of Active Interval (AI) and Inactive Interval (IAI) is iterated unless the small BS exits from the duty-cycle mode. While the duty-cycle mode is active, ~~The duty-cycle mode consists of Active Intervals (AI) and Inactive Intervals (IAI). When duty-cycle mode is active for the BS,~~ the small BS shall be in either AI or IAI. During the AI, the small BS becomes active on the air interface for activities such as paging, transmitting system information, ranging, or data traffic transmission. During the IAI, the small BS does not transmit anything on the air interface except DL preamble and may power down one or more physical operation components after the first symbol occupied by the DL preamble or perform other activities such as synchronization with the overlay macro BS or measurement of the interference from neighbor cells. Figure 17-3 depicts an example of frame structure during duty-cycle mode operation



Figure 17-3 – Example of frame structure during duty-cycle mode operation

If a small BS that supports duty-cycle mode receives a request from a BS power controller to enter duty-cycle mode, it shall respond to the request and perform the operations described below. If there are active MSs connected to the small BS when it receives the request, the small BS shall perform the BS-initiated handover as specified in 6.3.20.2 to ensure service continuity of the MSs prior to activating duty-cycle mode. After completion of handovers for the MSs, the small BS activates duty-cycle mode at Action time specified in the received request. If the handovers are not completed before the Action time or if any MSs cancel or reject the handover requested by the small BS, the small BS shall transmit a response to notify the BS power controller of the failure and continue to stay in normal operation mode. If there aren’t active MSs connected to the small BS when the small BS receives the request from the BS power controller and there is no new MS that attempts initial network entry or handover to the small BS until the Action time, the BS enters duty-cycle mode at the Action time. Otherwise, the small BS shall notify the BS power controller of the failure and continue to stay in normal operation mode.

If a small BS in duty-cycle mode receives a request from the BS power controller to terminate the duty-cycle mode, it shall terminate the duty-cycle mode and go back to the normal mode after transmitting a response to the BS power controller.

If a small BS in duty-cycle mode receives a RNG-REQ message from an MS that performs initial network entry or network reentry during an AI of the duty-cycle mode, it shall transmit a request for termination of duty-cycle mode to the BS power controller. When the BS power controller receives the request from the small BS, it deter­mines whether the requesting BS has to terminate the duty-cycle mode or not. Criteria for termination of the duty-cycle mode may include factors such as MS performance degradation, BS power saving performance, and inter-cell interference. For example, the BS power controller may accept the request triggered by net­work reentry from HO and may reject the request triggered by initial network entry. Algorithms or policies for determining the termination of duty-cycle mode are out of scope of this standard.

If the request is accepted by the BS power controller, the small BS transits to the normal mode and proceed with initial network entry or network reentry by transmitting a RNG-RSP message with “Ranging Status” set to Success or Continue. If the request is rejected by the BS power controller, the small BS continues to stay in duty-cycle mode and transmits the RNG-RSP message with “Ranging Status” set to Abort. In case the BS power controller rejects the request for termination of the duty-cycle mode, the small BS may redirect the MS to a nearby BS by including the information of the nearby BS in the RNG-RSP message.

A small BS in the duty-cycle mode shall support all available intervals of a paging cycle if it supports idle mode operation. Figure 17-4 provides an example where a BS in the duty-cycle mode supports a single paging cycle.

**17.4.2.1 Duty-cycle pattern**

A sequence of active and inactive intervals of forms a duty-cycle pattern and the~~. The duty-cycle pattern is the iteration of one inactive interval and one active interval.~~

~~The~~ duty-cycle pattern parameters include the following:

* Length of an active interval (in unit of frames)
* Length of an inactive interval (in units of frames)
* Start frame offset

The inactive interval starts at the frame number “N”,

Where N modulo (active interval + inactive interval) = Start frame Offset

Once a small BS enters duty-cycle mode, the duty-cycle pattern of the BS is iterated unless the small BS exits from the duty-cycle mode~~activated~~. The duty-cycle pattern parameters are assigned by a BS power controller when the BS power controller requests a small BS in normal mode to activate the duty-cycle mode or requests a small BS in the duty-cycle mode to change the current active duty-cycle pattern.



Figure 17-4 – Example of operation in duty-cycle mode

**17.4.3 Standby Mode**

Besides the normal mode and duty-cycled mode, a small BS may support standby mode to reduce power con­sumption and interference to neighbor cell. The small BS may enter standby mode if there are no MSs attached to the BS or a small number of MSs are attached to the small BS. If the small BS enters standby mode, it deactivates its air interface to conserve energy consumption and to reduce interference to neighbor cells, but keeps its network interface active to exchange control informa­tion with neighbor BSs or network entities.

**17.4.3.1 Standby mode initiation**

A small BS that supports standby mode shall receive configuration information of standby mode from a BS power controller during its initialization or re-configuration phase, prior to operating in normal mode. If a time-based transition included in the configuration information is enabled, the small BS shall initiate and terminate the standby mode at~~based on~~ activation and deactivation time indicated by ~~included in~~ the configuration information. If an event-based transition included in the configuration information is enabled, the small BS shall initiate and terminate the standby mode when it receives~~based on~~ a request from the BS power controller. A small BS may support the time-based transition and event-based transition simultaneously. If the time-based transition is enabled, the BS power controller shall assign activation and deactivation time of the standby mode to the small BS. The activation and deactivation time for the BS is determined based on an algorithm that is outside the scope of this standard. This algorithm may use, for example, statistical information on user density, traffic load, interference to/from neighbor cells, etc. ~~Algorithms or policies for determining activation/deactivation time of the standby mode are out of scope of this standard.~~ If the time-based mode transition is enabled and activation and deactivation time of standby mode is specified during configuration phase, the small BS shall activate Standby\_Mode\_Activation timer with the assigned activation time as soon as it starts normal operation. If only event-based transition is enabled, the small BS stays in normal mode until it receives a request from the BS power controller to transit to standby mode. When the Standby\_Mode\_Activation timer expires or the small BS is requested by the~~a request is received from a~~ BS power controller to enter the standby mode~~Standby Mode~~ immediately, the small BS shall complete the operations described below and disable its air interface. Before disabling the air interface, the small BS shall set the cell bar TLV in UCD message to 1 to prevent MS (re)entry and may perform BS-initiated HO procedure as defined in 6.3.20 to hand over active MSs attached to the small BS to neighbor BSs. When HO procedures for all MSs attached to the small BS are completed, the small BS shall disable the air interface and notify the BS power controller of the completion of the mode transition from normal mode to standby mode. If the mode transition is triggered by the expiration of Standby\_Mode\_Activation timer, the BS shall activate Standby\_Mode\_Deactivation timer with the deactivation time assigned by the BS power controller during configuration phase as soon as it enters the standby mode. During standby mode, the air interface of the BS is disabled and the small BS does not perform any PHY/MAC operation. But, the small BS shall not disable a network interface with neighbor BSs or network entities to perform management operation.

**17.4.3.2 Standby mode termination**

A small BS in standby mode shall go back to normal mode if Standby\_Mode\_Deactivation timer is expired or it receives a transition request from the BS power controller. The BS shall initialize and activate the air inter­face as specified in 17.1.4 before going back to normal mode. The small BS shall activate Standby\_Mode\_Activation timer after the mode transition is completed if time-based transition is enabled.

----------------- End of the text proposal --------------------------------------------------------------------------------------