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| Project | **IEEE 802.16 Broadband Wireless Access Working Group <**<http://ieee802.org/16>**>** | |
| Title | **Proposal to add semi-active period in duty-cycled mode** | |
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| Re: | In response to the IEEE 802.16 Working Group Call for Contributions: IEEE Project P802.16q Multi-tier Networks (IEEE 802.16-13-0064-01-000q) | |
| Abstract | The contribution proposes the text changes related to the BS power management to add semi-active period in duty-cycled mode. | |
| Purpose | To discuss and adopt the proposed texts in IEEE P802.16q AWD | |
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**Proposal to add semi-active period in duty-cycled mode**

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1. **Introduction**

This contribution proposes the text changes to the BS power management defined in draft AWD document [1] in response to the IEEE 802.16 Working Group Call for Contributions on IEEE Project P802.16q Multi-tier Networks (IEEE 802.16-13-0064-01-000q).

In multi-tier networks, the various small cells such as pico, relay, micro and femto including macro has been needed to increase the capacity of the system in downtown, office, home, school, express highway, railway, etc. However, it may increase the energy consumption of the BS as well as cause interference problem among multi-tier cells, although it can improve the system capacity. Specially, if these multi-tier or neighbor BSs don’t cooperate with each other, it may make interference and be waste of energy in the system. In specific periods of time, there may be no attached mobile stations including idle state or very small traffic load of the system by different reason of going to sleep, leaving the places, etc. Moreover, there may be almost blank radio frames or subframes in DL and UL except for DL control signals (preamble, midamble, common pilot, common control information, etc.).

In above mentioned case with cooperation among BSs, multi-tier access network architecture consisting of macro cell and a variety of overlaid smaller cells is good approach to save the BS transmission power through the BS power management by duty-cycled mode and standby mode [1][2]. The duty-cycled operation mode is specified to two operation periods with the inactive period to turn off the power of the BS transmission devices and the active period to operate as normal mode. The inactive period during specific time interval is effective in the case of the wholly empty frame or the absence of MSs. A BS may apply the inactive period for small traffic load to short time interval, an example, odd or even frame duration.

Although the BS is in inactive period of duty-cycled period for energy saving operation, it may be needed to consider for supporting small traffic load to be enabled to HARQ operation, Band AMC, channel quality measurements and reducing mobility latency of an MS trying network reentry into the cell.

* If HARQ operation is enabled, retransmission latency may be increased in DL/UL. In addition, the short interval of inactive period should be carefully considered due to different frame numbering in time relevance of DL/UL MAP and HARQ timing for TDD, FDD and H-FDD mode.
* In order to increase throughput using link adaptation mechanisms such as Band AMC, a BS may try to allocate the resource of DL and UL to an MS using the selected subchannel that may be limited according to the channel condition. This mechanism may be more effective when the resource is allocated on continuous frame.
* For channel measurement operation, the BS may dynamically schedule signaling for that, and the MS should discard any signal and not perform channel measurement using preamble or pilot in inactive period. These instances and procedures may hardly apply the BS to change the duty-cycled operation mode into inactive period with short interval for small traffic load of a few MSs.
* For support MS mobility, DL control signals such as preamble, common control information etc., may be needed to assist any MS to enter the cell or try to perform measurement, although there is no the traffic load or there are no attached MSs. An MS may access randomly or liberally the various small cells including macro for any purpose and at any time. However, if the BS is in progress of inactive period turning off the power of BS transceiver devices, the MS may not fast or wholly migrate into the cell, or cannot newly enter the network in the inactive interval. Then the MS may miss the opportunity to improve its throughput or not access directly the BS in the time interval of inactive period. Moreover, if any MS frequently enters or exits in a cell, it is also not easy to transition to inactive period although the BS has few the MSs.

Due to the above-mentioned cases such as serving small traffic load and reducing mobility latency, the BS may fail to change to the inactive period in order to save the transmission power.

So, the contribution proposes the text change to add semi-active period as middle step of duty-cycled operation between active period and inactive period for supporting small traffic load and reducing mobility latency of the MSs to solve above cases on the base station power management in the current draft AWD document.

1. **Semi-active period**

A base station in the Duty-cycled mode may go into the semi-active period, when there is no attached mobile stations including idle state or there is small traffic load of the system.

In the semi-active period, the base station may allocate the burst or control channels of DL and UL in a resource allocation region per a frame, and shall not allocate any burst or control channels in a zero energy region of DL and UL per a frame.

In a zero energy region of the semi-active period, a base station shall not modulate and transmit data subcarriers and common pilots to its subordinate mobile stations except preamble and midamble. The BS shall also indicate the information of the zero energy region to all MSs, and the MSs shall discard any signal and not perform measurement using pilot in the zero energy region. The signal information of semi-active period may indicate through broadcast every frame or intermittently. The BS in semi-active period may turn off the power of BS transceiver devices in time interval of the zero energy region.

1. **References**
2. IEEE P802.16q, Part 16: Air Interface for Broadband Wireless Access Systems: Amendment for Multi-tier Networks, Jan. 16, 2013
3. IEEE 802.16-13-0020-00-000q, [Draft Working Document] IEEE P802.16q System Requirement Document, Jan. 16, 2013
4. **Proposed Texts on IEEE 802.16q AWD**

[Added texts and figures marked in blue font with underline and removed texts and figures ~~marked in red font with strikeout~~]

------------------------------------------- Start of Proposed Text Changes --------------------------------------------

***[Remedy #1: Adopt the following modification text in line 7 on page 11 section 7.4 in draft AWD*** 1 ***]***

1. 1. **Base Station Power Management**
      1. **General Description**

This subclause describes the power management functions of 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.

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

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

## Duty-cycled Mode

Duty-cycled mode is one of power saving operation mode in which a base station changes its operation state among active period, semi-active period and inactive period.

A base station in the inactive period does not transmit/receive data to/from its subordinate mobile stations. A base station may enter Duty-cycled mode when the base station has small number of subordinate mobile stations and small traffic demands from the mobile stations.

The base station in the Duty-cycled mode goes into the inactive period when all of its associated mobile stations are in unavailability interval. The inactive period of the base station shall be informed to the mobile stations to prevent UL attempts of mobile stations during inactive period of the base station.

To increase the inactive period of the base station (i.e. a common unavailability interval of mobile stations), base station may adjust the configurations of Sleep mode (i.e. start frame number, window sizes, etc.) of associated mobile stations.

A base station in the Duty-cycled mode may go into the semi-active period, when there is no attached mobile stations including idle state or there is small traffic load of the system. In the semi-active period, the base station may allocate the burst or control channels of DL and UL in a resource allocation region per a frame, and shall not allocate any burst or control channels in a zero energy region of DL and UL per a frame.

In zero energy region of the semi-active period, a base station shall not modulate and transmit data subcarriers and common pilots to its subordinate mobile stations except preamble and midamble. The BS shall also indicate the information of the zero energy region to all MSs, and the MSs shall discard any signal and not perform measurement using pilot in the zero energy region. The signal information of semi-active period may indicate through broadcast every frame or intermittently. The BS in semi-active period may turn off the power of BS transceiver devices in time interval of zero energy region.

## Standby Mode

Standby mode is ~~an~~ another power saving operation mode in which a base station deactives its air interface to conserve energy consumption. A base station may enter Standby mode when the base station has no subordinate mobile stations.

Base stations in Standby mode wake up (i.e. change its operation mode into the Normal mode), when predefined ~~inactive period~~ Standby mode timer expires or the network requests changes of state of the base station.

## Cooperation of Base Stations for Power Management

The base stations cooperate with other adjacent base stations and/or NCMS (Network Control and Management System) to increase the power saving performance and to prevent the performance degradation (e.g. throughput decreases and coverage holes) due to the power saving operation of base stations.

------------------------------------------- End of Proposed Text Changes --------------------------------------------