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| Re: | Call for Contributions: Multi-tier Networks (16-13-0108-01-000q) |
| Abstract | This contribution proposes to change operation of duty-cycle mode in IEEE P802.16q |
| Purpose | To discuss and adopt the proposed texts in IEEE P802.16q AWD |
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# Proposed Modification of Duty-Cycle Mode

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# Introduction

Duty-cycle mode has been defined in IEEE P802.16q AWD as one of BS power saving operation mode but the current duty-cycle mode may have bad impacts on the legacy MS’s operation. In this contribution, we propose to change the operation of the duty-cycle mode in order to minimize the impact on the legacy MSs.

# Proposed changes

## Operation during Inactive Interval of the duty-cycle mode

In general, MSs keep synchronization with a serving BS using DL preambles transmitted by the serving BS and perform cell detection and cell reselection by measuring DL preambles transmitted by neighbor BSs. However, if some neighbor BSs operate in duty-cycle mode, then MSs may not be able to detect those neighbor BSs because they do not transmit anything on the air interface during inactive intervals. In order to prevent this problem, a BS has to provide information on which BSs are currently in the duty-cycle mode and when their inactive intervals start and end, and MSs shall perform scanning of neighbor BSs based on the received information. By sacrificing some radio resource to provide such information, impacts on cell detection and reselection of 16q MSs can be minimized. However, there are still impacts on legacy MSs’ operation because they can’t decode the new information defined in 16q standard.

In this contribution, we propose to change the operation of the duty-cycle mode to allow a BS to transmit DL preambles during inactive intervals to prevent the aforementioned problem. Since a BS transmits DL preambles even when it operates in the duty-cycle mode, legacy MSs in neighbor cells can perform cell detection and reselection as defined in the base standard. Moreover, radio resources can be saved because a BS doesn’t need to provide information on the duty-cycle mode of neighbor BSs.

## Support of active MSs during the duty-cycle mode

According to the current definition of the duty-cycle mode, active MSs can be supported even when a BS operates in the duty-cycle mode. For example, if the number of active MSs connected to the BS is very small and operation modes of all MSs are sleep mode, the BS may enter the duty-cycle mode after adjusting sleep cycles of all MSs. However, backward compatibility can’t be guaranteed in this case. According to the sleep mode operation defined in the base standard, an MS in sleep mode can perform periodic ranging or BW request ranging during listening window as well as sleep window. However, in case the BS operates in the duty-cycle mode, UL access of the MS in the sleep mode can’t be guaranteed because the BS transmits nothing during the inactive interval.

If a BS activates the duty-cycle mode only when all active MSs are 16q MSs and UL access of the 16q MSs during inactive interval is restricted, then there will be no backward compatibility problem. However, restriction on UL access during inactive period may cause UL access delay.

In this contribution, we propose not to support active MSs during the duty-cycle mode to keep backward compatibility and to avoid performance degradation. If a BS power controller may request a BS to activate the duty-cycle mode when there are active MSs connected to the BS, the BS shall perform BS-initiated HO to ensure service continuity of the MSs prior to activating duty-cycle mode.

## Other changes

In addition to changes described in 2.1 and 2.2, there are additional minor changes;

* ‘duty-cycled mode’ has been changed to ‘duty-cycle mode’
* ‘active period’ and ‘inactive period’ have been changed to ‘active interval’ and ‘inactive interval’, respectively to keep consistency with terms used in 16m standard.
* The first active interval is same as normal operation mode. So, we have changed the operation of duty-cycle mode so that the duty-cycle mode starts with inactive interval.

# Editorial Instruction

* Black text: the text is existing in the base standard
* ~~Red text: with strike-through~~: the texts is removed from the amendment standard
* Blue text without underline: the text is added in the amendment standard without underline
* Blue text with underline: the text is added in the amendment standard and underline shall be added under the added text

# Proposed Texts

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

[*Change subclause 17.4.2 on page 31 as follows:*]

**17.4.2 ~~Duty-cycled~~Duty-cycle Mode**

Besides the normal operation mode, BSs may support ~~duty-cycled~~duty-cycle mode to reduce interference to neighbor cells and to conserve its power consumption. ~~Duty-cycled mode is a BS operation mode in which a BS disables its air interface periodically and consists of active periods and inactive periods.~~ The support of ~~duty-cycled~~duty-cycle mode is negotiated with a BS power controller during the BS initialization and configuration. ~~Duty-cycled~~Duty-cycle mode can be activated through negotiation between the BS and NCMS when the BS is in normal operation mode.

The duty-cycle mode consists of Active Intervals (AI) and Inactive Intervals (IAI). When ~~duty-cycled~~duty-cycle mode is active for the BS, the BS shall be in either ~~active period or inactive period~~AI or IAI. During ~~an~~the ~~active period~~AI, the BS becomes active on the air interface for activities such as paging, transmitting system information, ranging, or data traffic transmission. During ~~an~~the ~~inactive period~~IAI, the BS does not transmit anything on the air interface except DL preambles and may power down one or more physical operation components or perform other activities such as synchronization with the overlay macro BS or measurement of the interference from neighbor cells.

If a 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 BS when it receives the request, the 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 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 BS, the BS shall transmit a request for cancellation of the duty-cycle mode to the BS power controller and continue to stay in normal operation mode. If there aren’t active MSs connected to the BS when the BS receives the request from the BS power controller and there is no new MS that attempts initial network entry or handover to the BS until the Action time, the BS enters duty-cycle mode at the Action time. Otherwise, the BS shall transmit a request for cancellation of the duty-cycle mode to the BS power controller and continue to stay in normal operation mode.

~~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 BS in the duty-cycle mode~~inactive period~~ shall support ~~an~~all available intervals of a paging cycle if it supports idle mode operation. Figure xxx provides an example where a BS in the duty-cycle mode supports a single paging cycle.



Figure xxx – Example of operation in duty-cycle mode

**17.4.2.1 Duty-cycle pattern**

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

The duty-cycle pattern parameters include the following:

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

The ~~active period~~inactive interval starts at the frame number “N”,
 where N modulo (active interval~~period~~ + inactive interval~~period~~) == Start frame Offset

Once a BS enters ~~duty-cycled~~duty-cycle mode, the duty-cycle pattern of the BS is activated. The duty-cycle pattern parameters are assigned by a BS power controller when the BS power controller requests a BS in normal mode to activate the duty-cycle mode or requests a BS in duty-cycle mode to change the current active duty-cycle pattern.~~The duty-cycle pattern parameters may be pre-provisioned or unicasted to the MS during initial network entry with the BS in the TBD message. The duty-cycle parameters may be broadcast in the TBD message by the BS when they are changed, for certain duration of time as decided by the network.~~

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