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10 Power saving

10.1 Introduction

Power conservation and reduction of the carbon footprint of access networks is globally recognized as one of the technical targets for the next generation of optical access networks. EPON power-saving mechanisms are defined in this clause, with the focus on reducing the power within the EPON MAC/PHY subsystem. Further power reduction may be achieved by the use of Energy Efficient Ethernet interfaces (introduced in IEEE Std 802.3az™) as well as low-power design methodologies throughout the system.

The objectives of the power-saving mechanisms are to reduce ecological impact, reduce operating cost, and extend battery backup time, while minimizing any degradation of network performance. It is also recognized that the gross power-saving capabilities lie on the ONU side, whereas the specification of the ability of the OLT to power down any of its subsystems remains outside the scope of this standard.

10.2 Overview of operation

The power-saving mode in 25G-EPON and 50G-EPON targets the power consumption of the upstream transmission channel. The energy conservation is achieved primarily through the elemination of non-essentail upstream transmissions.

The power-saving mode is analogous to the TX-mode with early wakeup, as described in IEEE Std 1904.1, 10.5.2. However, the key distinction of the power-saving mode for 25G-EPON and 50G-EPON is that it is always enabled and activate under the normal operating conditions. This mode relies on the following mechanisms, all of which can be employed concurrently:

— Reduction of power consumption between the upstream bursts (10.3.1),

— Suppression of certain upstream bursts (10.3.2),

— Turning off some of the upstream and/or downstream channels (10.3.3),

— Upstream burst aggregation (10.3.4).

This standard specifies neither the target power consumption values for ONU/OLT devices nor target power-saving levels achievable for such devices; instead it focuses exclusively on the aspects of the power-saving mechanisms directly affecting the interoperability between EPON ONU and OLT devices.

The power saving mode does not interfere with the provisioned Service-Level Specifications (SLS) and all the QoS parameters remain within the allowed bounds.

The power-saving mechanism does not interfere with the operation of MPCP and higher-layer protocols. The ONUs remain registered and synchronized at the MPCP clock level at all times during the power-saving mode.

10.3 Power-saving mechanisms

10.3.1 Power conservation between the upstream bursts

In EPON, the upstream transmission is controlled by the OLT MPCP Client. ONUs are not allowed to transmit any upstream data unless explicitly granted by the OLT via GATE MPCPDUs (see 8.4.1). The OLT allocates the grants in chronological order. This means that once the ONU has received a GATE MPCPDU with a start time value of T_i, there may not be a later-arriving GATE MPCPDU with start time T_j that is earlier than the time T_i. Therefore, after all the previously scheduled envelopes are served (i.e.,

transmitted by the ONU), and if the time interval until the next scheduled transmission time T_i is large enough, the ONU may place the upstream data path in a low power state.

It is ONU's design/implementation decision whether various functional blocks in the transmission path are shut down completely or placed in a reduced power consumption mode (i.e., sleep mode). It is expected that the longer is the interval until the next burst, the more functional blocks may be shut down, or otherwise be placed into a deeper sleep mode.

During the low subscriber activity periods on a given ONU, the OLT should increase the interval between grants to this ONU to facilitate the power saving mode at the ONU. However, the OLT shall not increase the granting interval beyond the limit dictated by the SLS parameters, in particular, by the strictest frame latency bound of any LLIDs provisioned in the given ONU.

The increased GATE spacing during a low activity period and the resulting ONU states of reduced power consumption are illustrated in Figure 10-1.

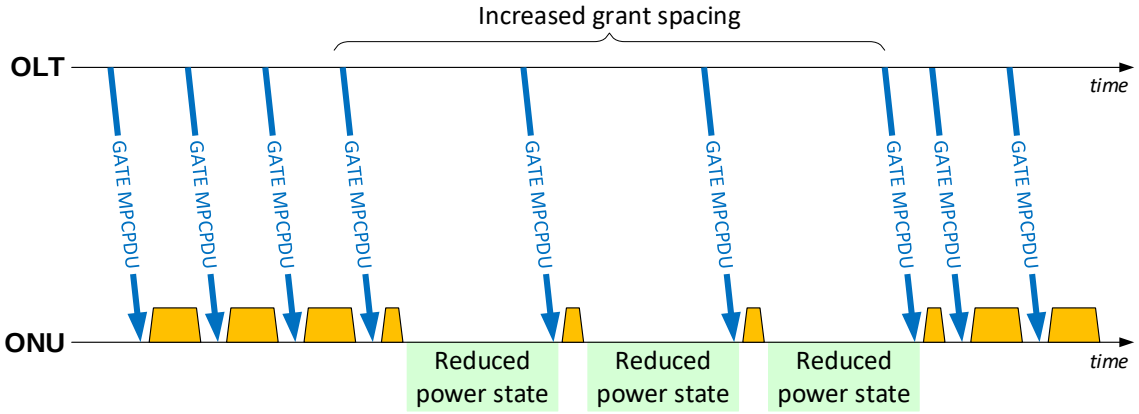

Figure 10-1: Increased GATE MPCPDU spacing during a low activity period

10.3.2 Suppression of upstream bursts

The OLT is able to signal to ONUs that the generation of the REPORT MPCPDUs is optional. If a set of conditions described in 8.4.4.1 and 8.4.4.2 is met, the ONU suppresses the entire upstream burst. Such conditions are especially prevalent during the periods of low activity.

As the result of the burst suppression, the effective interval between the served (i.e., non-suppressed) bursts greatly increases, allowing for more significant power savings at the ONU. Critically, the burst suppression mechanism is opportunistic and is closely coupled with the state of upstream queues at the ONU, such that no SLS parameters are negatively affected by this mechanism. If new upstream data frames become available at the ONU, the ONU generates a burst to transmit at least a REPORT MPCPDU and possibly some of the data frames, if granted so by the OLT scheduler.

An absense of the upstream burst (including the non-reception of the optional REPORT MPCPDU) indicates to the OLT that there were no changes in operational conditions (i.e., no new Alarm or Information OAMPDUs are pending) or in traffic conditions (i.e., no data frames waiting in upstream queues) at the ONU. In the absense of user traffic, the maxumum interval between the served (i.e., non-suppressed) bursts is limited by the OAM keep-alive process to be around 1 second (see 13.3.3).

The burst suppression during a low activity period and the resulting ONU states of reduced power consumption are illustrated in Figure 10-2.

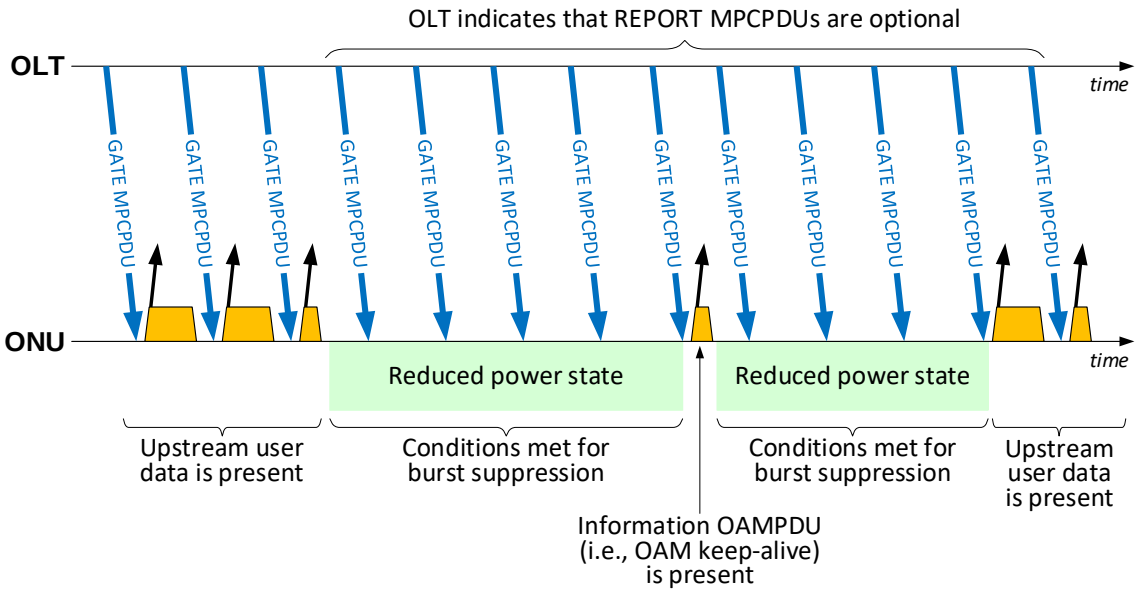

Figure 10-2: Burst suppression during a low activity period

10.3.3 Turning off upstream/downstream channels

During the periods of low subscriber activity, all the traffic in 50G-EPON may be served by a single downstream and a single upstream channel. The Channel Control Protocol (CCP) defined in IEEE Std 802.3, 144.4, allows the NMS to shut down the unutilized downstream and/or upstream channels in order to reduce the power consumption.

It is ONU's design/implementation decision whether various functional blocks in the transmit/receive paths associated with the turned-off channels are shut down completely or placed in a reduced power consumption mode (i.e., sleep mode).

10.3.4 Upstream burst aggregation

Empirical observations show that even during the periods of low activity overall, often a low level of background traffic is still present. This traffic typically consists of individual frames or small group of frames with larger inter-frame (or inter-group) gaps. Often this background traffic doesn't have strict latency bounds. A significant power saving can be achieved if rather than transmitting a burst as soon as a frame or a few frames become available, the ONU delays some of the frames within the allowed latency window in order to aggregate more frames into a single burst.

The upstream burst aggregating mechanim is optional and may be activated by ONU at its own discretion. When the upstream burst aggregation mechanism is activated, the ONU shall not delay any frame by more than the provisioned latency bound for the LLID associated with the given frame.