Power-Saving Mechanisms in IEEE Std 1904.1 (SIEPON)

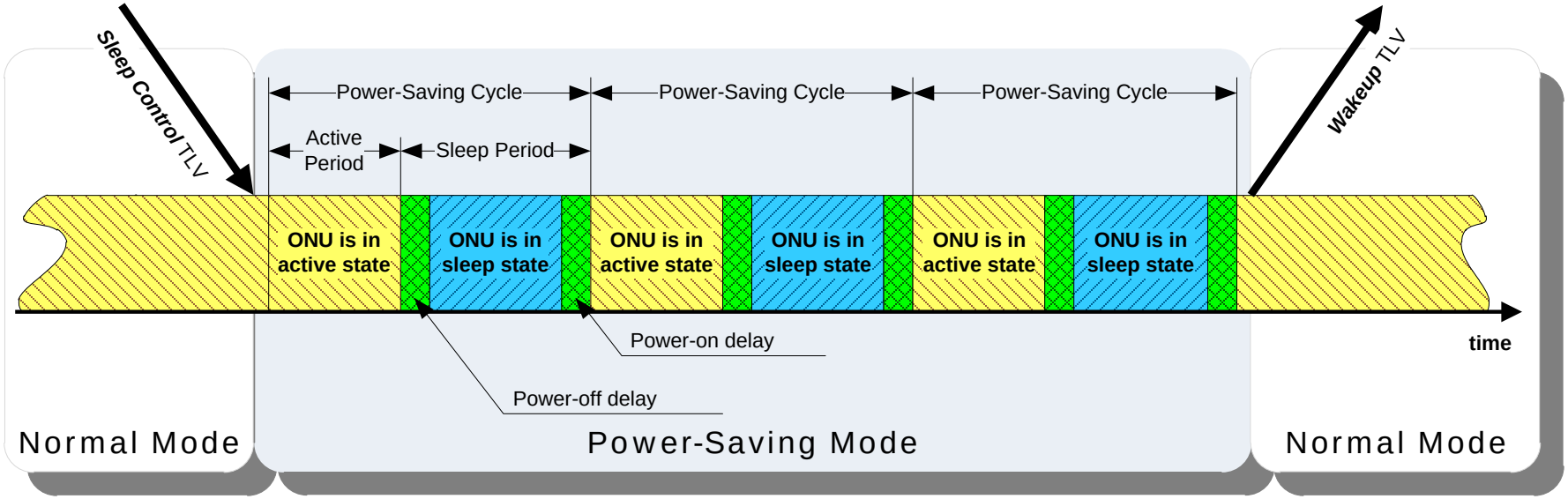
Marek Hajduczenia, PhD
ZTE Corporation
marek.hajduczenia@zte.pt

Takizawa, Motoyuki
Fujitsu
takizawa.motoyu@jp.fujitsu.com

Background Information

- IEEE Std 1904.1 defines mandatory power-saving mechanism for Package A, Package B, and Package C
- Each power-saving mechanism has particular features, addressing specific operator requirements in terms of management, operating principles and the use of control channel
- Individual power-saving mechanisms are summarized in the following slides

Power-saving mode

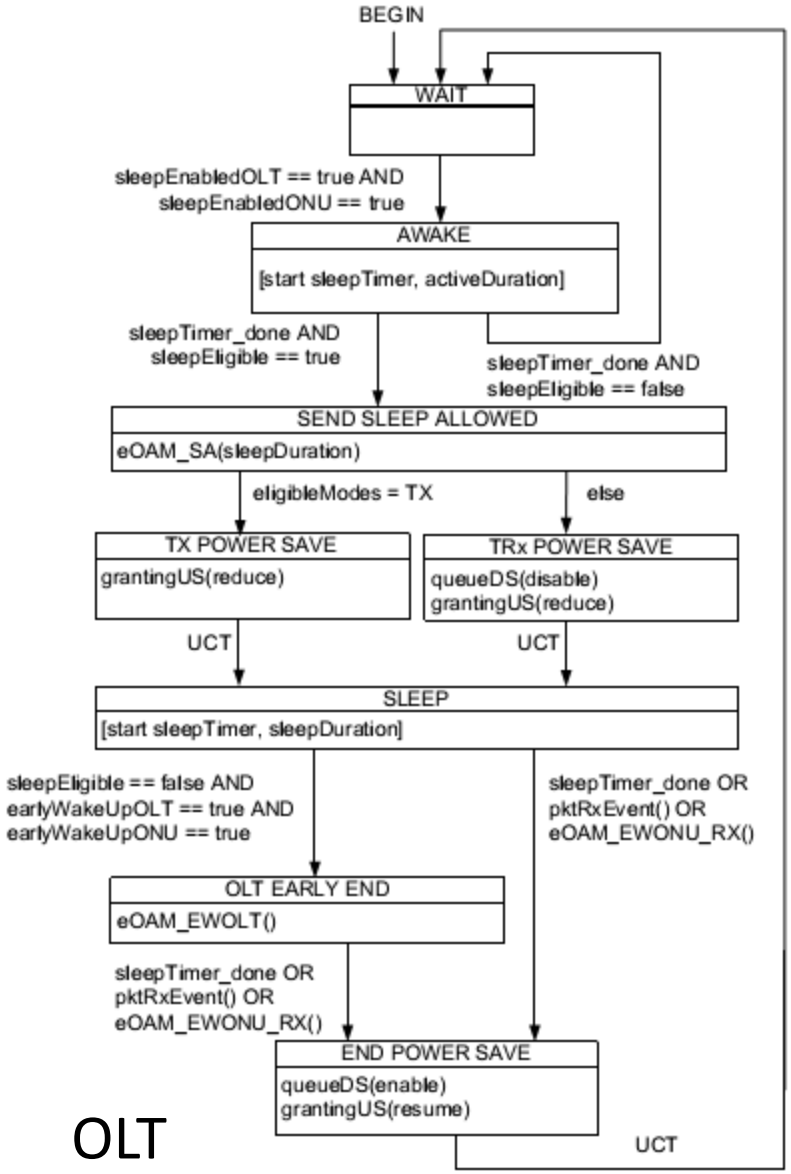


- Active state: The ONU's state within a power-saving cycle in which all of its sub-systems in the transmit and receive paths are powered up and fully functional
- Sleep state: The ONU's state within a power-saving cycle in which some of its sub-systems or components are powered down to save energy.
  Depending on the selected sleep mode, Tx path, Rx path, or both Tx and Rx path may be put to sleep.

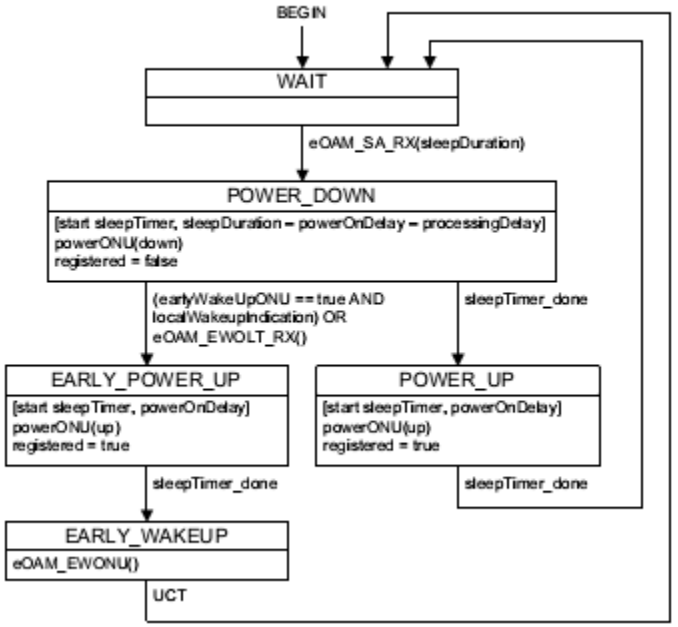
Power-saving modes

- Individual packages in SIEPON use up to four different power-saving modes:
  - Tx sleep mode: in which only the transmit path in the ONU enters the sleep mode, while the receive path remains fully powered on and synchronized to downstream data
  - Rx sleep mode: in which only the receive path in the ONU enters the sleep mode, while the transmit path remains fully powered
  - TRx sleep mode: in which both the transmit and receive paths in the ONU enter the sleep mode. The ONU may have to re-acquire synchronization to downstream data when leaving the sleep mode.
  - TxOrTRx sleep mode: in which the ONU is allowed to choose whether to enter the Tx or TRx sleep mode, depending on its local conditions

Package A - State Diagrams



OLT



ONU

Package A – Main Features (1)

- ONU supports Tx and TRx sleep modes
- OLT buffers unicast traffic directed to the given ONU as along as it remains in the sleep state.
- OLT buffers broadcast traffic as long as all ONUs are in the sleep state (combined with synchronized wake-up).
- OLT buffers multicast traffic as long as all ONUs in the given service group are in the sleep state.
- ONU is allowed to enter the sleep state of the selected sleep mode for a specific period of time. Once the configured sleep period expires, ONU transitions to the active state.
- ONU may wake up ahead of scheduled time, when detecting user activity, video session starts, etc. (specific conditions are implementation-dependent)

Package A – Main Features (2)

- OLT controls the ONU via a set of extended OAM messages
- OLT discovers ONU capabilities to support specific sleep modes (Tx, TRx) and power-saving mechanism via exchange of TLVs defined in Clause 14. TLVs are also used to configure parameters associated with the power-saving mechanism on the ONU
- ONU is allowed to enter the power-saving mode with the specific durations of sleep/active periods. OLT grants individual sleep/active periods independently from each other.

Package A – Operation Examples

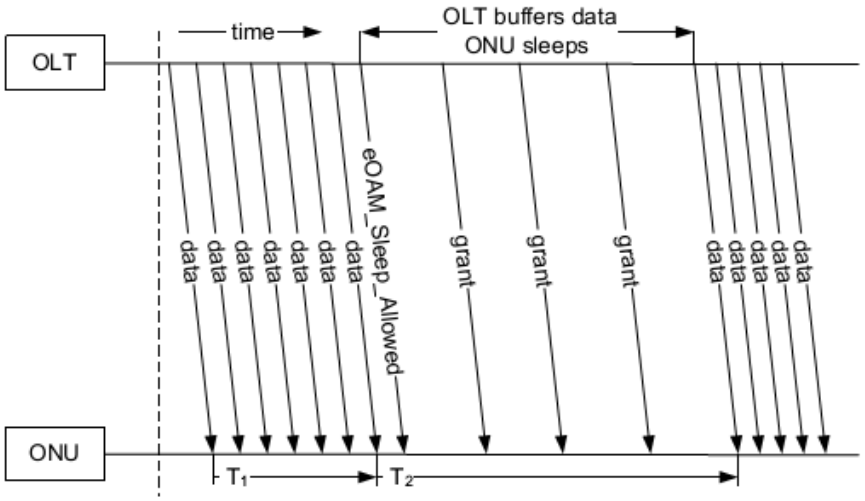


Figure 10-4—Example of TRx power saving cycle with gratuitous grants, ONU does not wake up

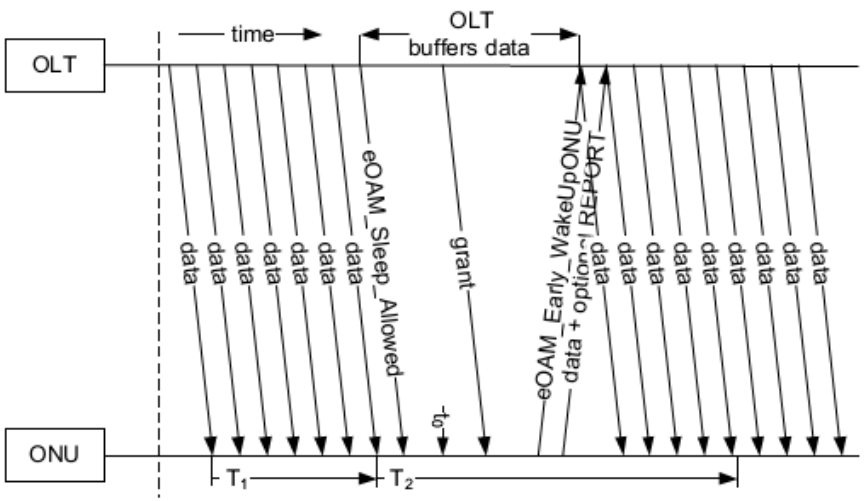


Figure 10-5—Example of TRx power saving cycle with gratuitous grants, ONU early wake-up function is enabled

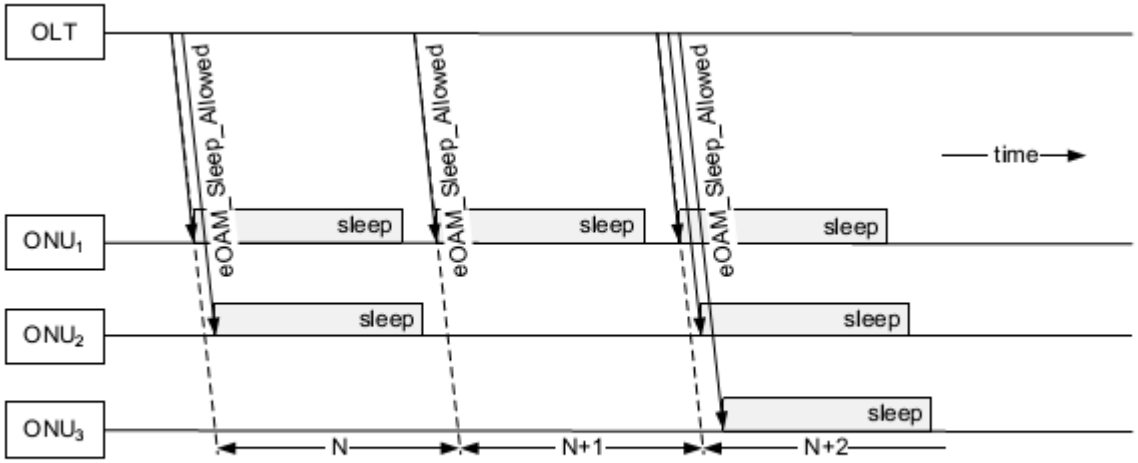


Figure 10-3—Example of OLT-driven power saving mechanism with three ONUs

Package B - State Diagrams

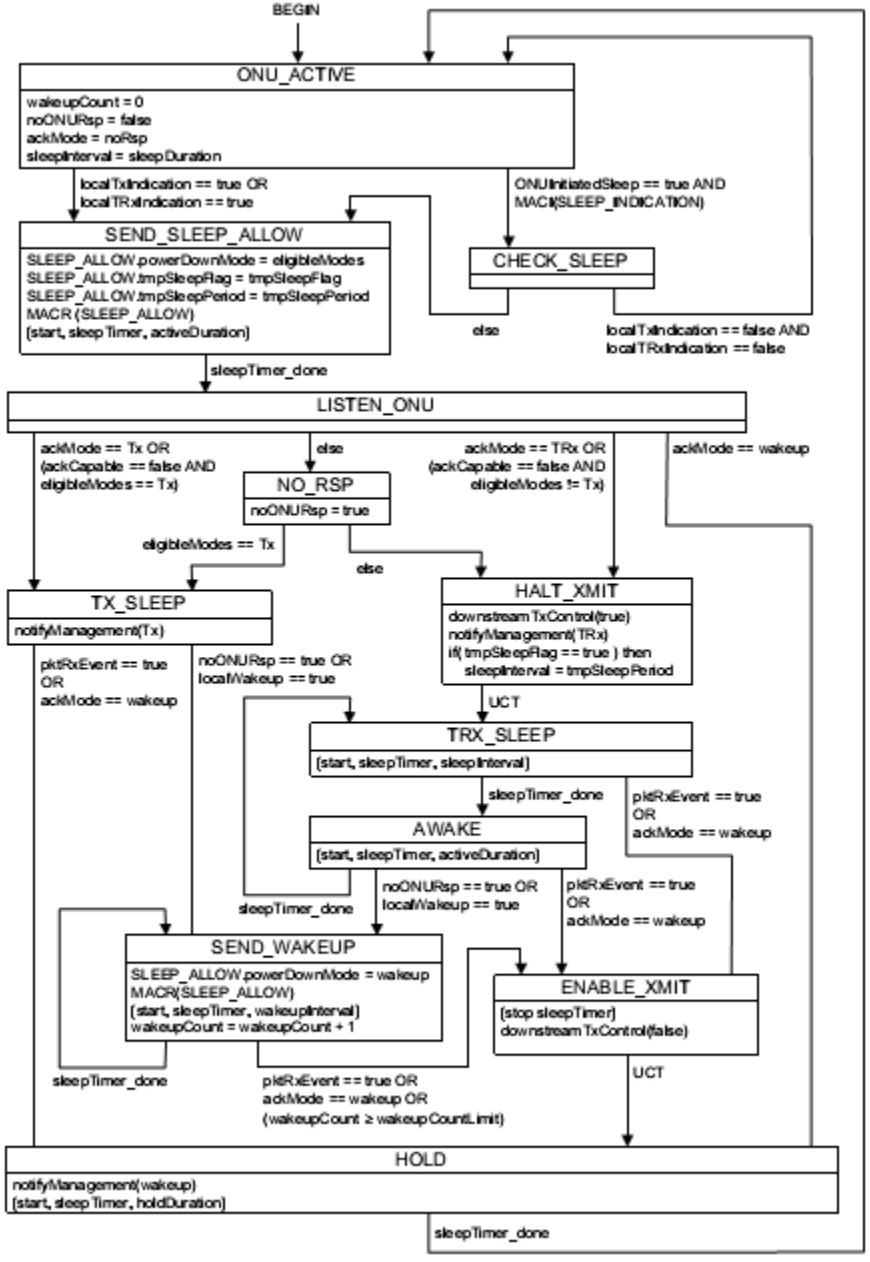


Figure 10-14—OLT power saving mechanism state diagram

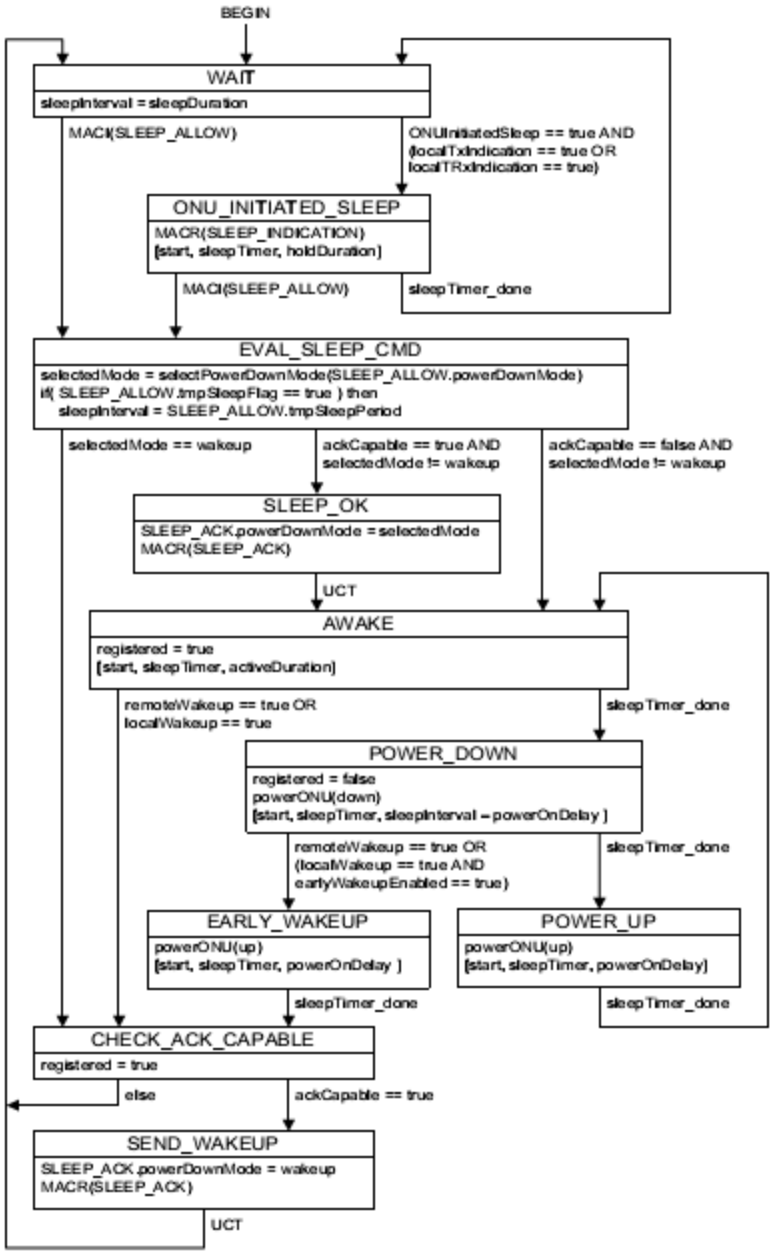


Figure 10-15—ONU power saving mechanism state diagram

Package B – Main Features (1)

- ONU supports Tx and TRx sleep modes
- In the TRx sleep mode, where the receive path of ONU is inactive:
  - OLT buffers unicast traffic directed to the given ONU as along as it remains in the sleep state.
  - OLT buffers broadcast traffic as long as all ONUs are in the sleep state (combined with synchronized wake-up).
  - OLT buffers multicast traffic as long as all ONUs in the given service group are in the sleep state.
- ONU is allowed to enter the sleep state in the selected sleep mode for a specific period of time. Once the configured sleep period expires, ONU transitions to the active state.
- ONU may wake up ahead of scheduled time, when detecting user activity, video session starts, etc. (specific conditions are implementation-dependent)

Package B – Main Features (2)

- OLT initially provisions the ONU via a set of extended OAM messages and controls the ONU in real time via Extension MAC Control frames
- OLT discovers ONU capabilities to support specific sleep modes (Tx, TRx, TxOrTRx) and power-saving mechanism via exchange of TLVs defined in Clause 14. TLVs are also used to configure parameters associated with the power-saving mechanism on the ONU
- ONU is allowed to enter the power-saving mode with the specific durations of sleep/active periods. OLT grants individual sleep/active periods independently from each other.
- ONU may be able to solicit OLT for initiation of power-saving cycles by sending the specific Extension MAC Control frame

Package B – Operation Examples

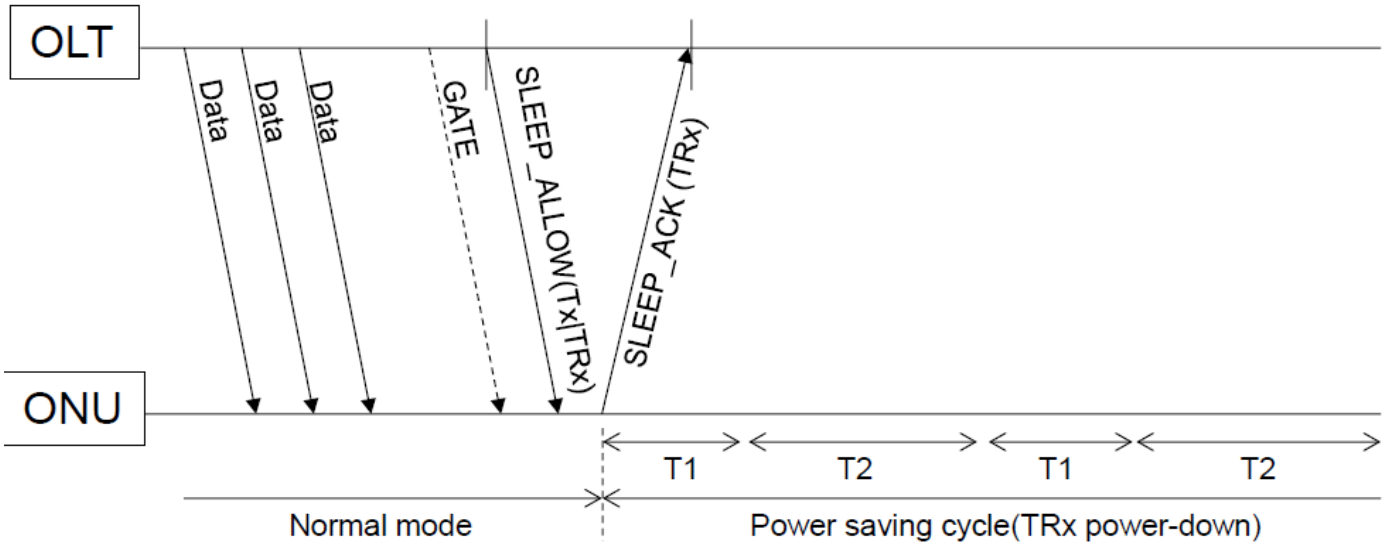


Figure 10-8—Example of OLT-initiated power saving cycle

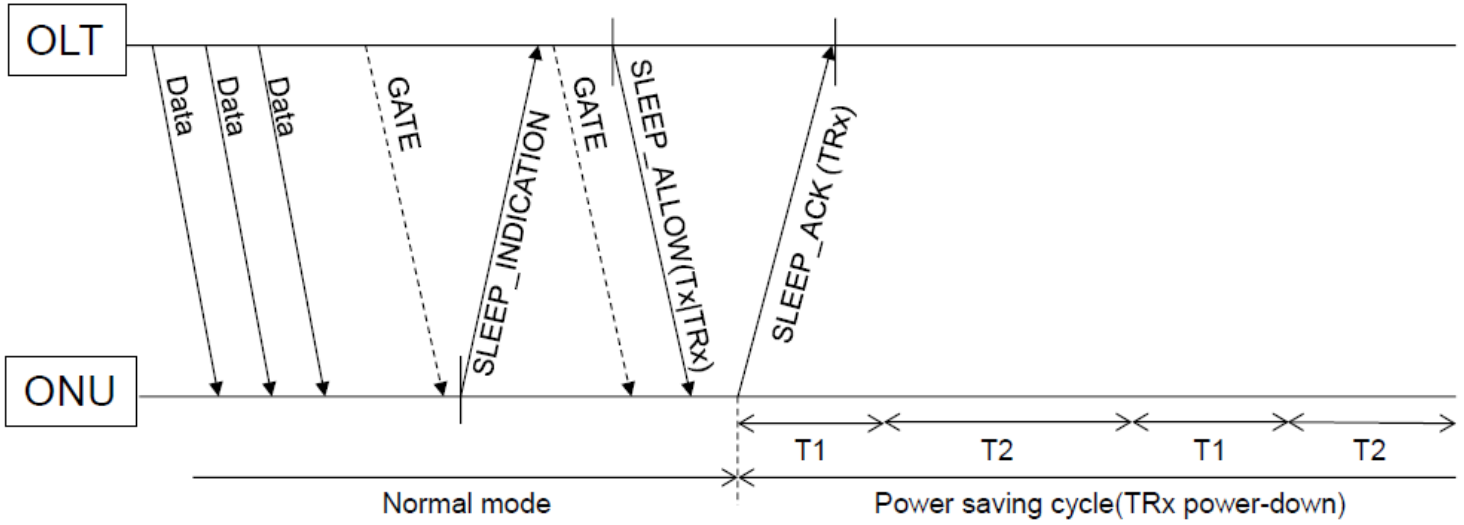


Figure 10-9—Example of ONU initiated power saving cycle

Package C - State Diagrams

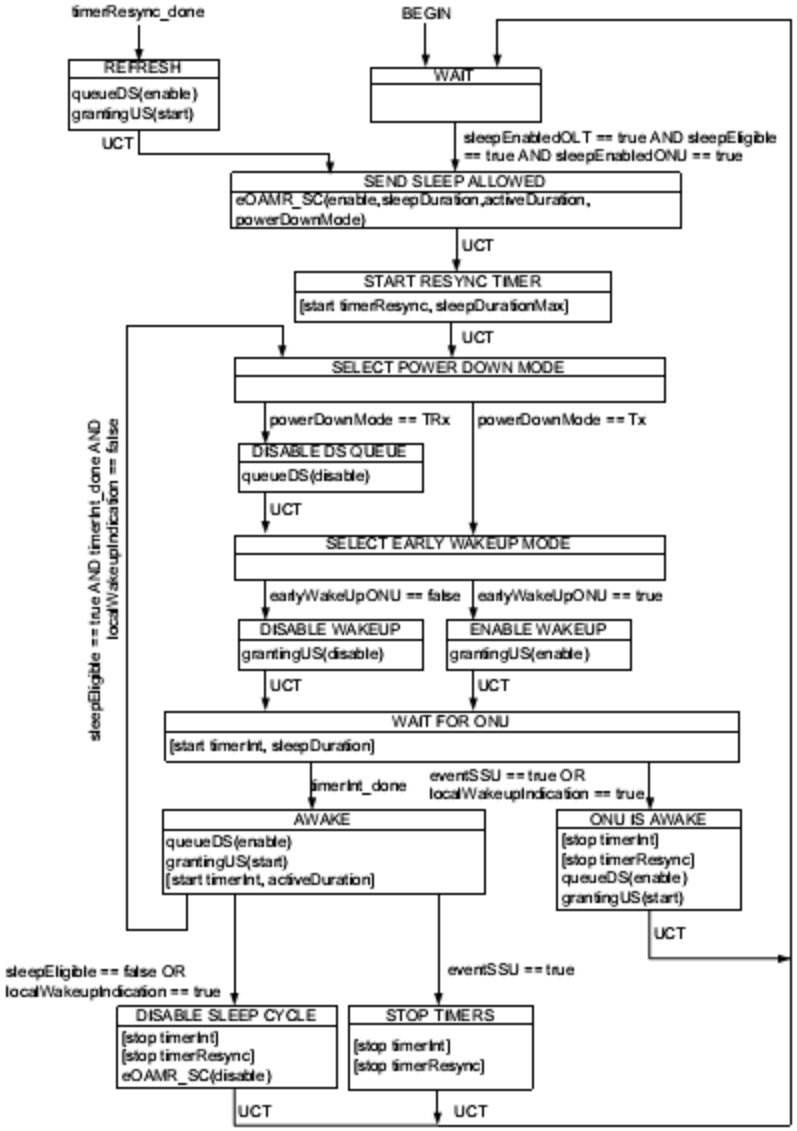


Figure 10-17—OLT power saving mechanism state diagram

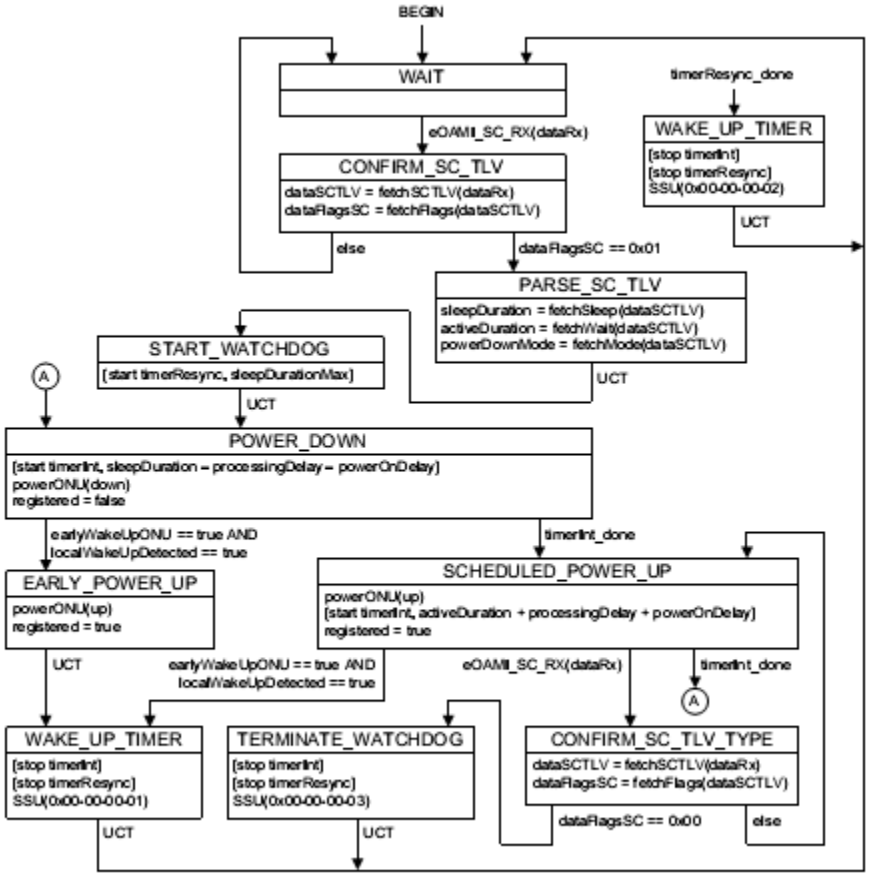


Figure 10-18—ONU power saving mechanism state diagram

Package C – Main Features (1)

- ONU supports Tx and TRx sleep modes
- OLT buffers unicast traffic directed to the given ONU as along as it remains in the sleep state.
- OLT buffers broadcast traffic as long as all ONUs are in the sleep state (combined with synchronized wake-up).
- OLT buffers multicast traffic as long as all ONUs in the given service group are in the sleep state.
- ONU is allowed to enter the sleep state of the selected sleep modefor a specific period of time. Once the configured sleep period expires, ONU wakes up and enters the active mode. Unless power-saving mode parameters are changed, the ONU re-enters the configured sleep mode until configuration is changed by the OLT.
- ONU may wake up ahead of scheduled time, when detecting user activity, video session starts, etc. (specific conditions are implementation-dependent)

Package C – Main Features (2)

- OLT controls the ONU via a set of extended OAM messages
- OLT discovers ONU capabilities to support specific sleep modes (Tx, TRx) and power-saving mechanism via exchange of TLVs defined in Clause 14. TLVs are also used to configure parameters associated with the power-saving mechanism on the ONU
- ONU is allowed to enter the power-saving mode with the specific durations of sleep/active periods for at least one sleep period.
- ONU cycles between active and sleep modes based on OLT configuration until the power-saving mode is disabled, or its configuration is changed.

Package C – Operation Example

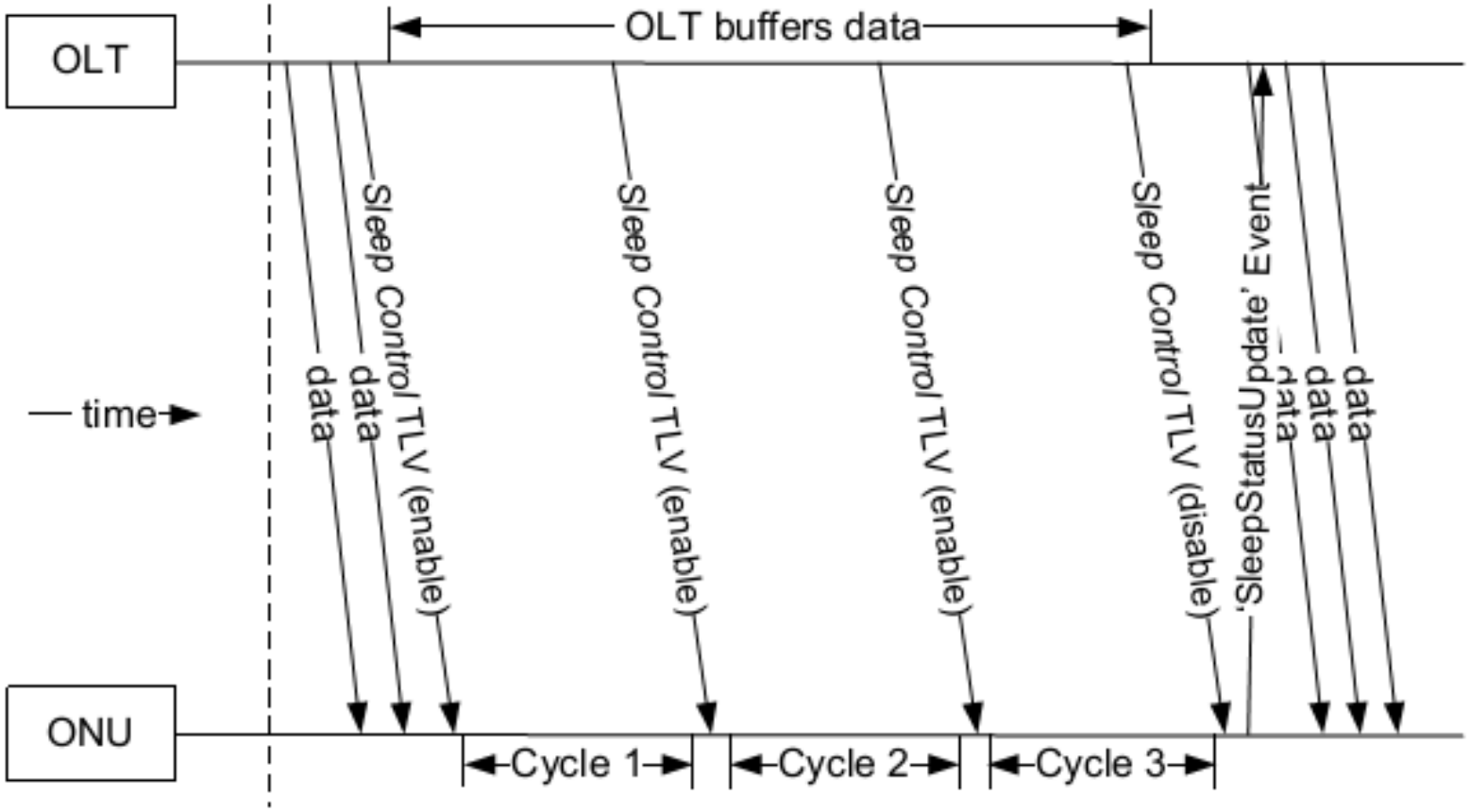


Figure 10-16—Example of the TRx power saving cycle

Summary

- Individual power-saving mechanisms are designed to address specific operational requirements of the given profile
- The potential to save power in individual sleep modes depends on configuration parameters, ONU's ability to use the early wake-up function, time taken to power down / up sub-components as well as network activity.
- These mechanisms could be reused in any P2MP network using management and control schemes similar to those used in EPON