

# Power-Saving Mechanisms in IEEE Std 1904.1 (SIEPON)

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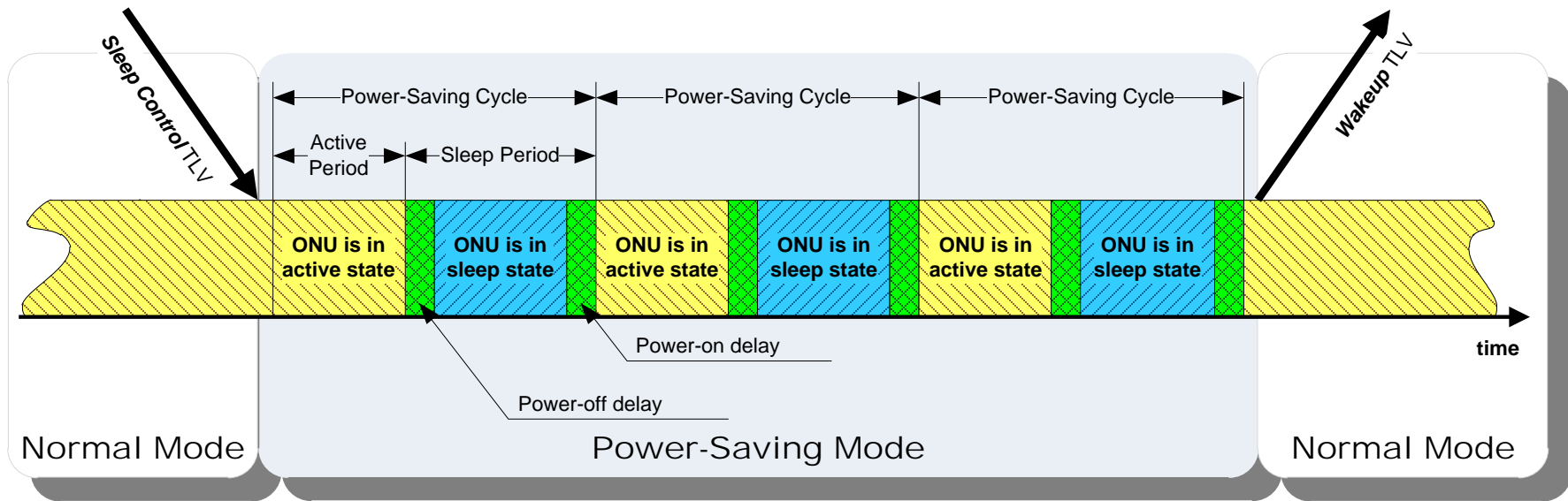
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# Background Information

- 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

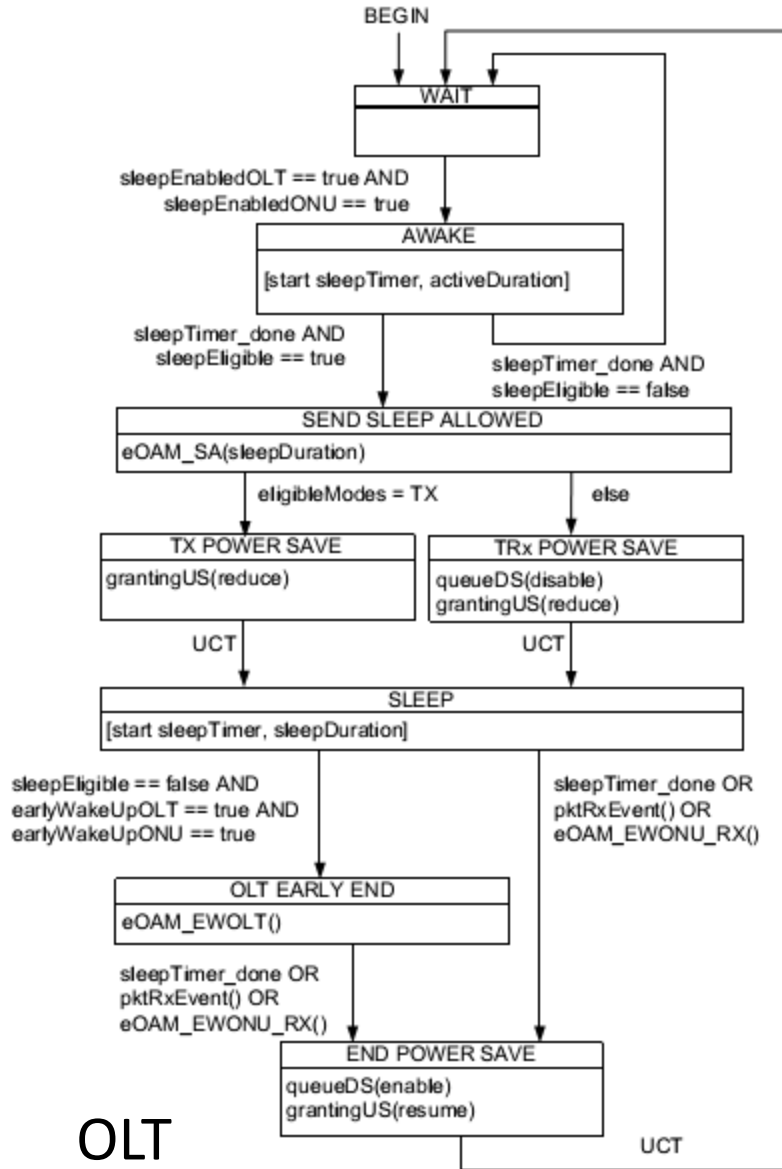


- Active state: The ONU's state within a power-saving cycle in which all of its sub-systems in the transmit and receive paths are powered up and fully functional
- Sleep state: The ONU's state within a power-saving cycle in which some of its sub-systems or components are powered down to save energy.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

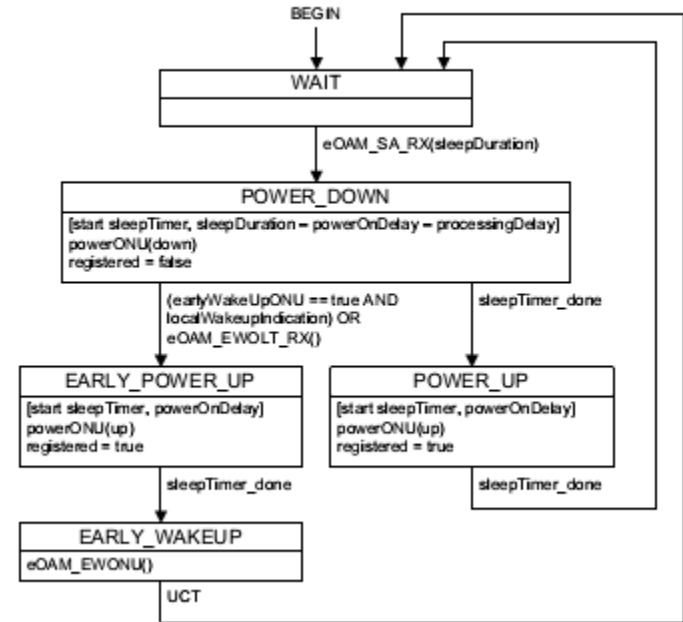
# Power-saving modes

- 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 long 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

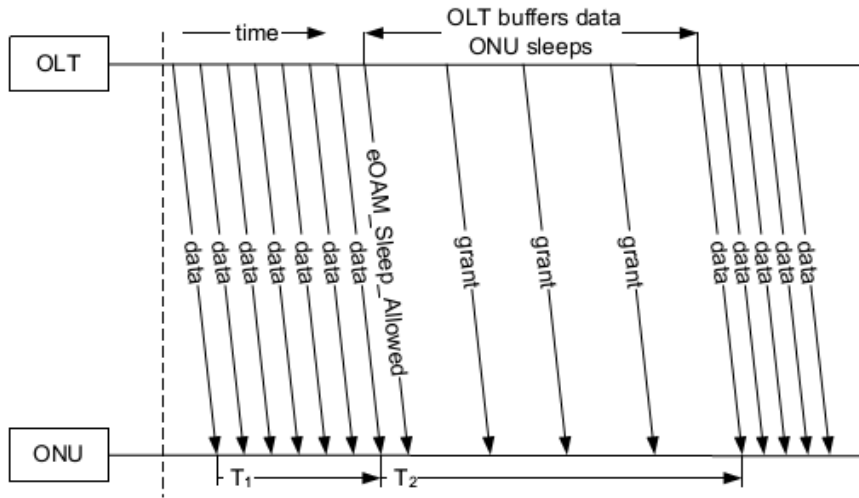


Figure 10-4—Example of TRx power saving cycle with gratuitous grants, ONU does not wake up

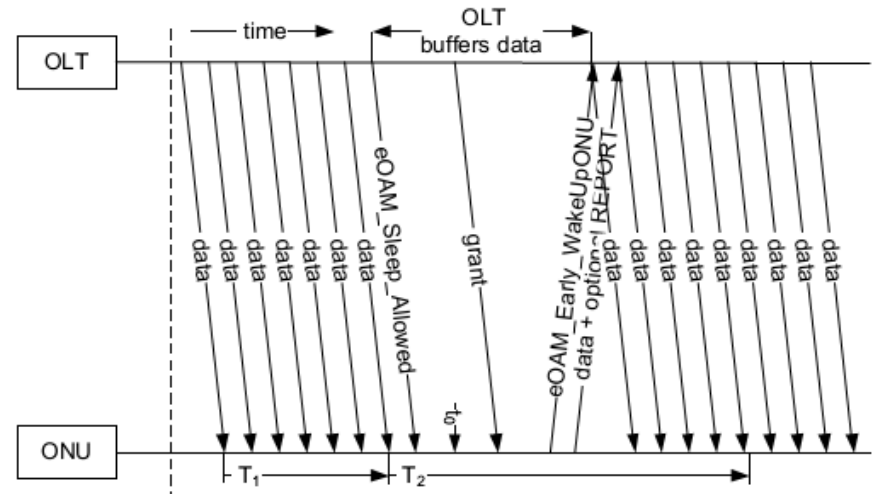


Figure 10-5—Example of TRx power saving cycle with gratuitous grants, ONU early wake-up function is enabled

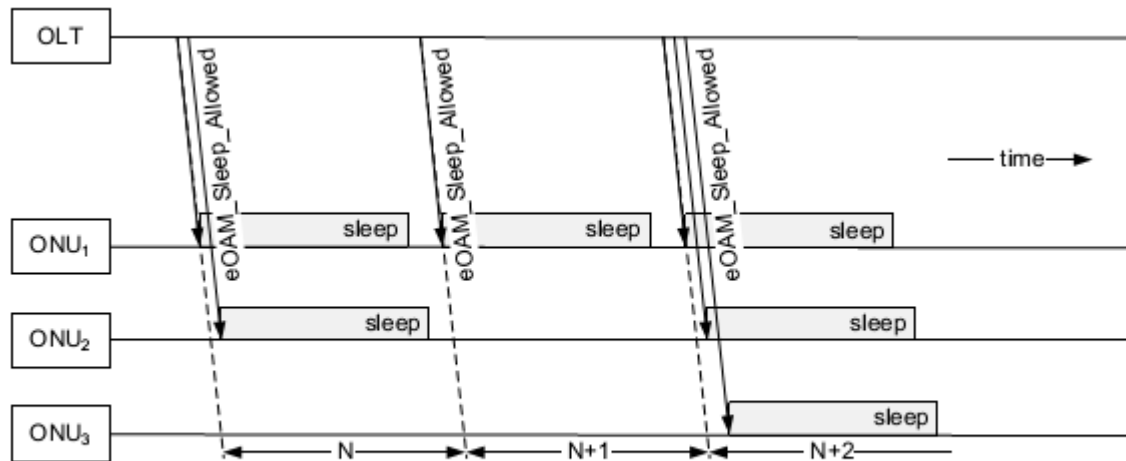


Figure 10-3—Example of OLT-driven power saving mechanism with three ONUs



# Package B - State Diagrams

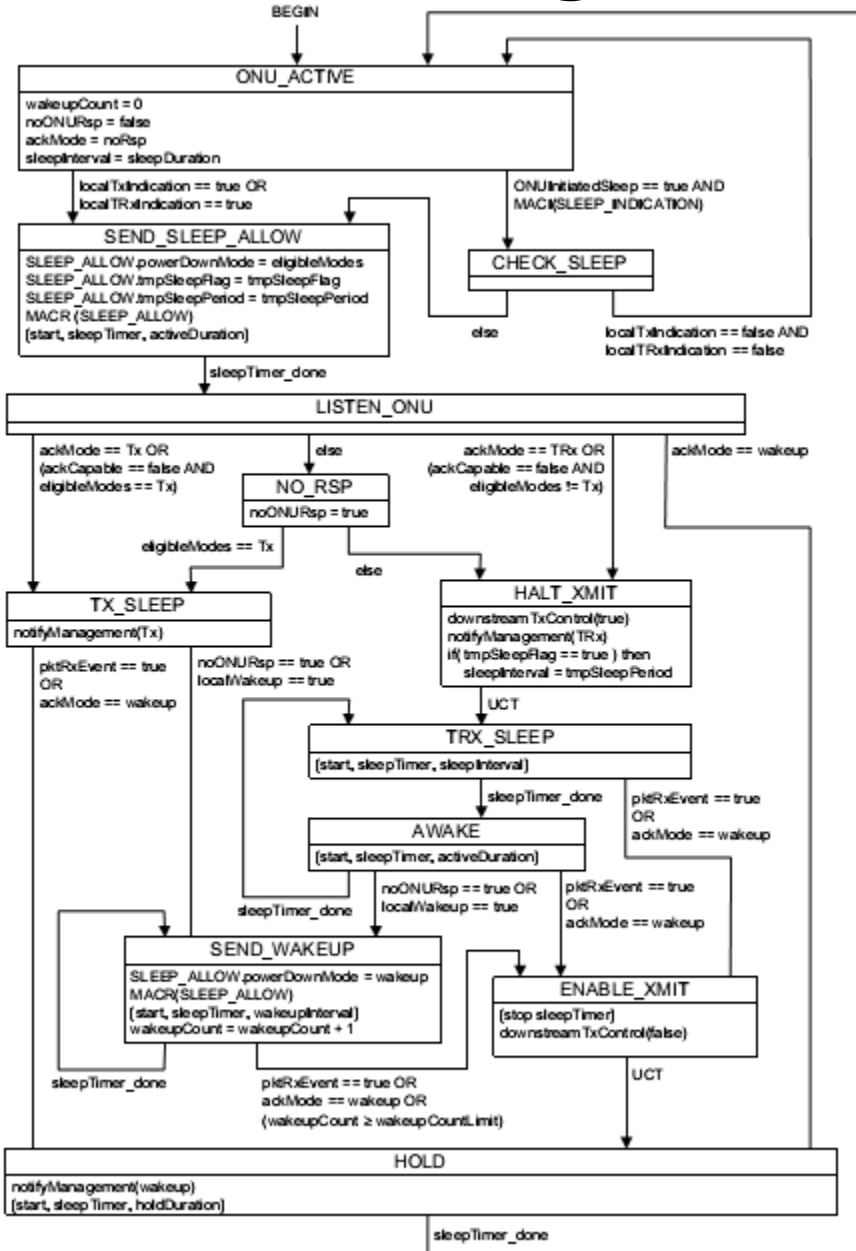


Figure 10-14—OLT power saving mechanism state diagram

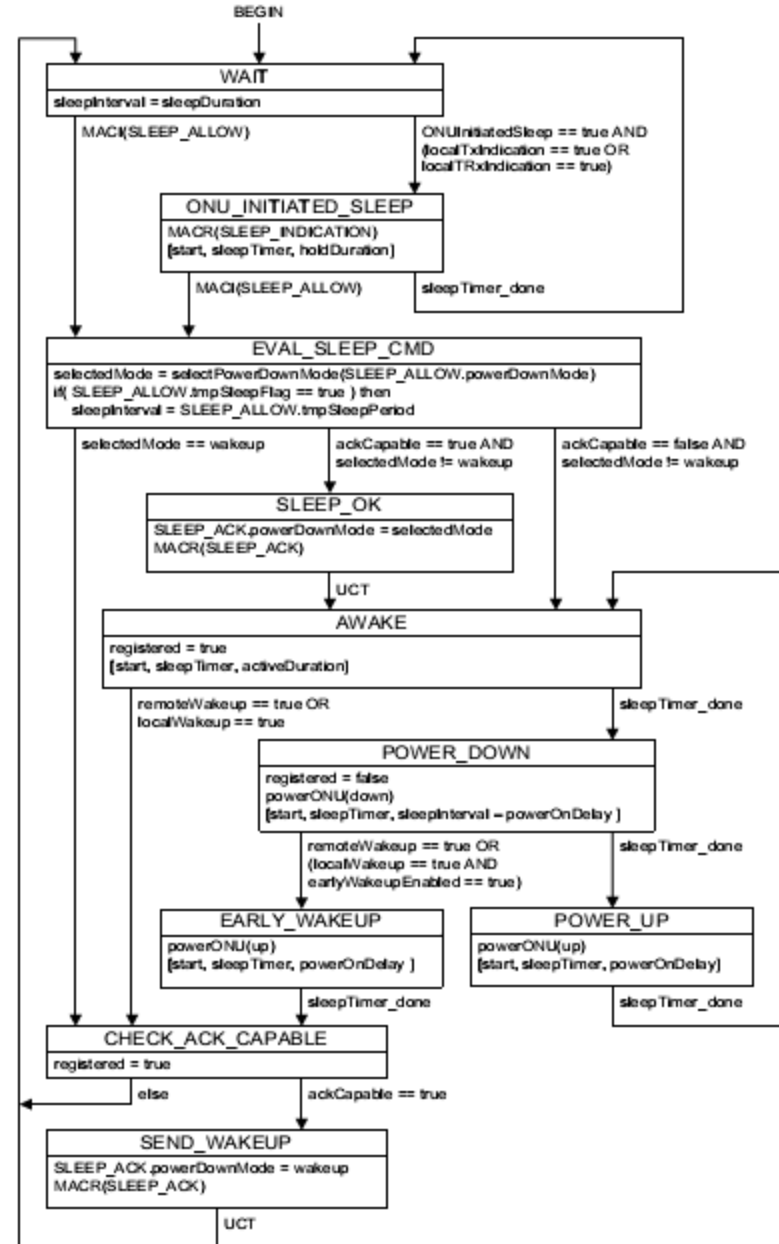


Figure 10-15—ONU power saving mechanism state diagram

# 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 long 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

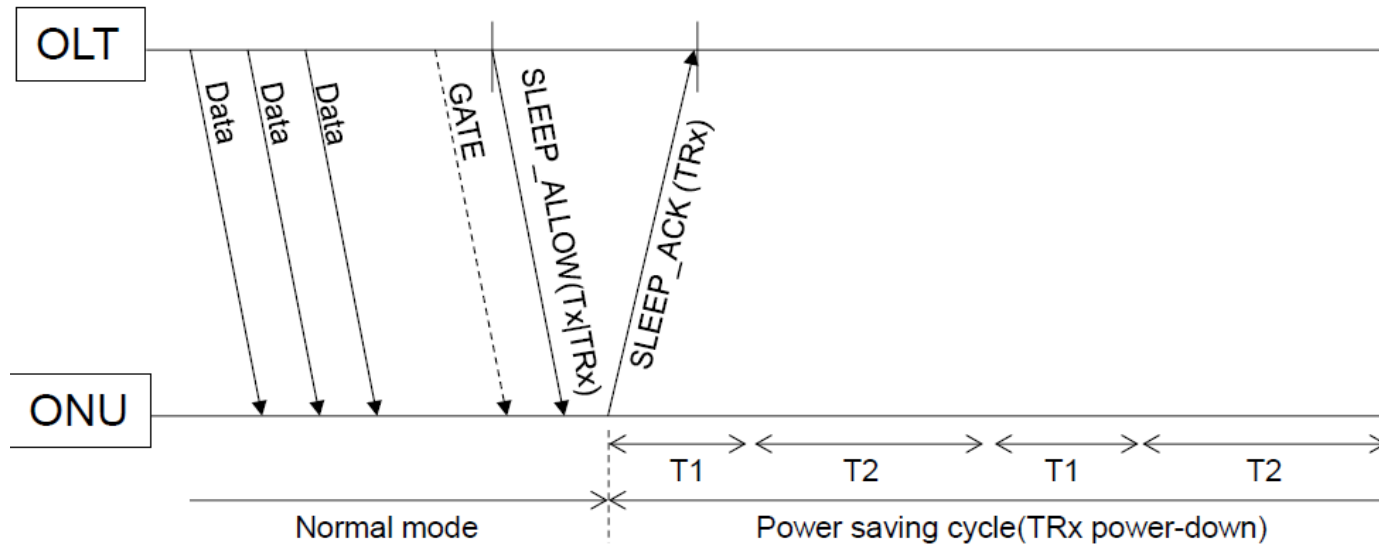


Figure 10-8—Example of OLT-initiated power saving cycle

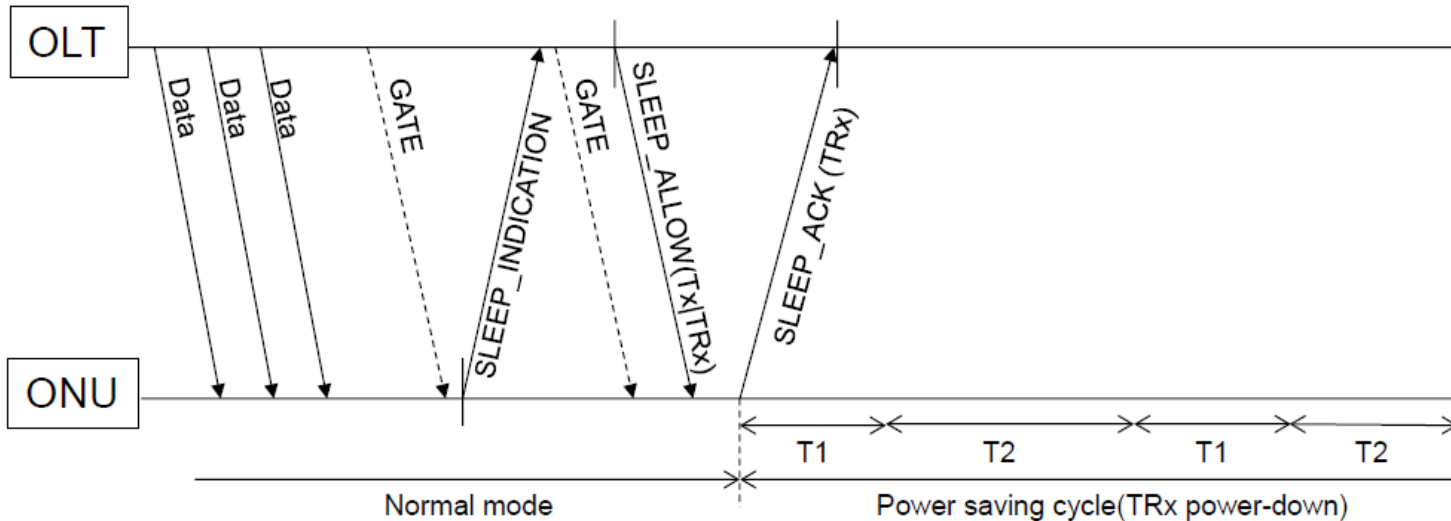


Figure 10-9—Example of ONU initiated power saving cycle

# Package C - State Diagrams

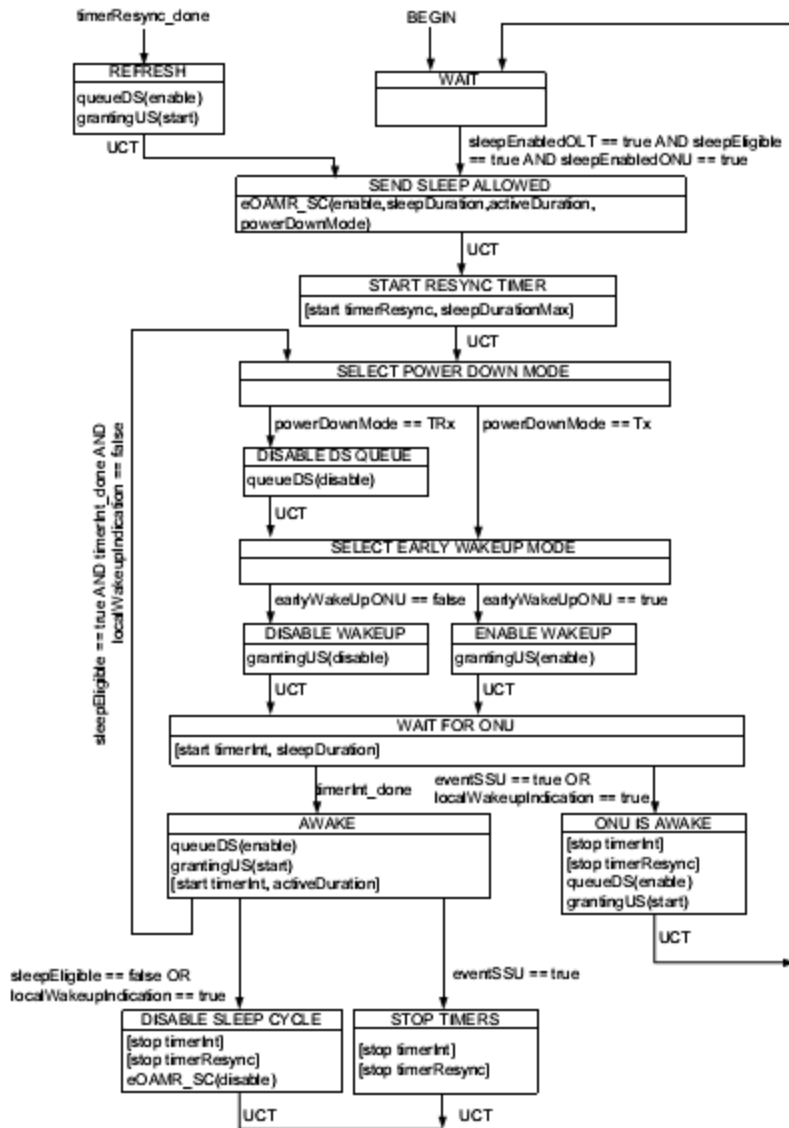


Figure 10-17—OLT power saving mechanism state diagram

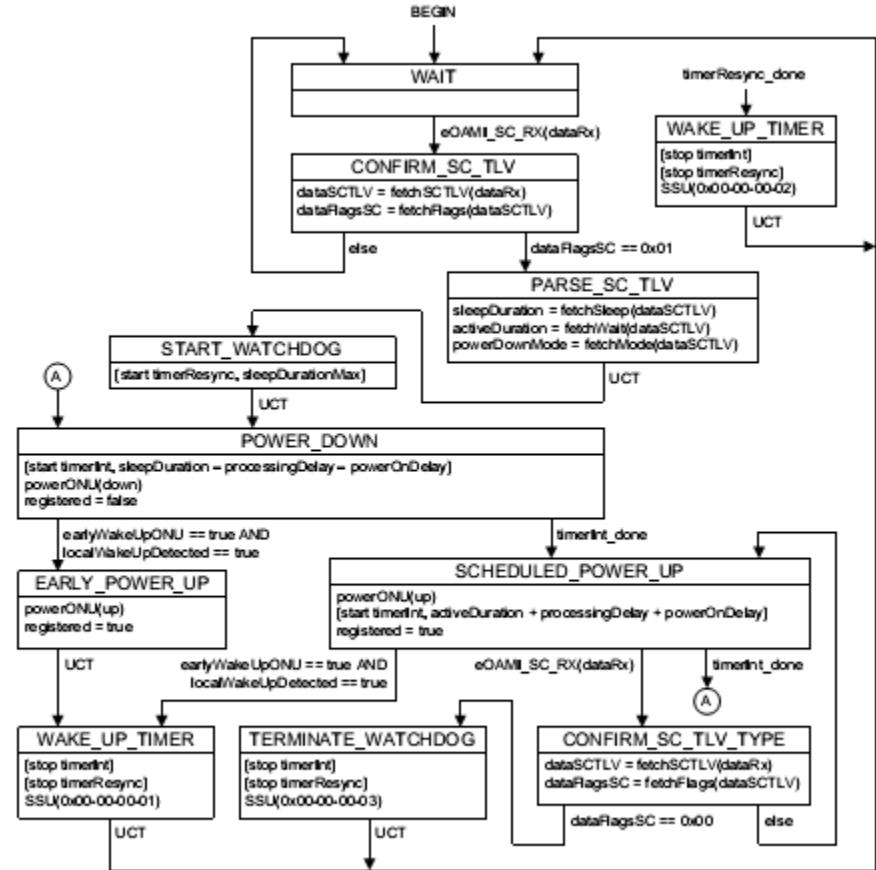


Figure 10-18—ONU power saving mechanism state diagram

# Package C – Main Features (1)

- ONU supports Tx and TRx sleep modes
- OLT buffers unicast traffic directed to the given ONU as long 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 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

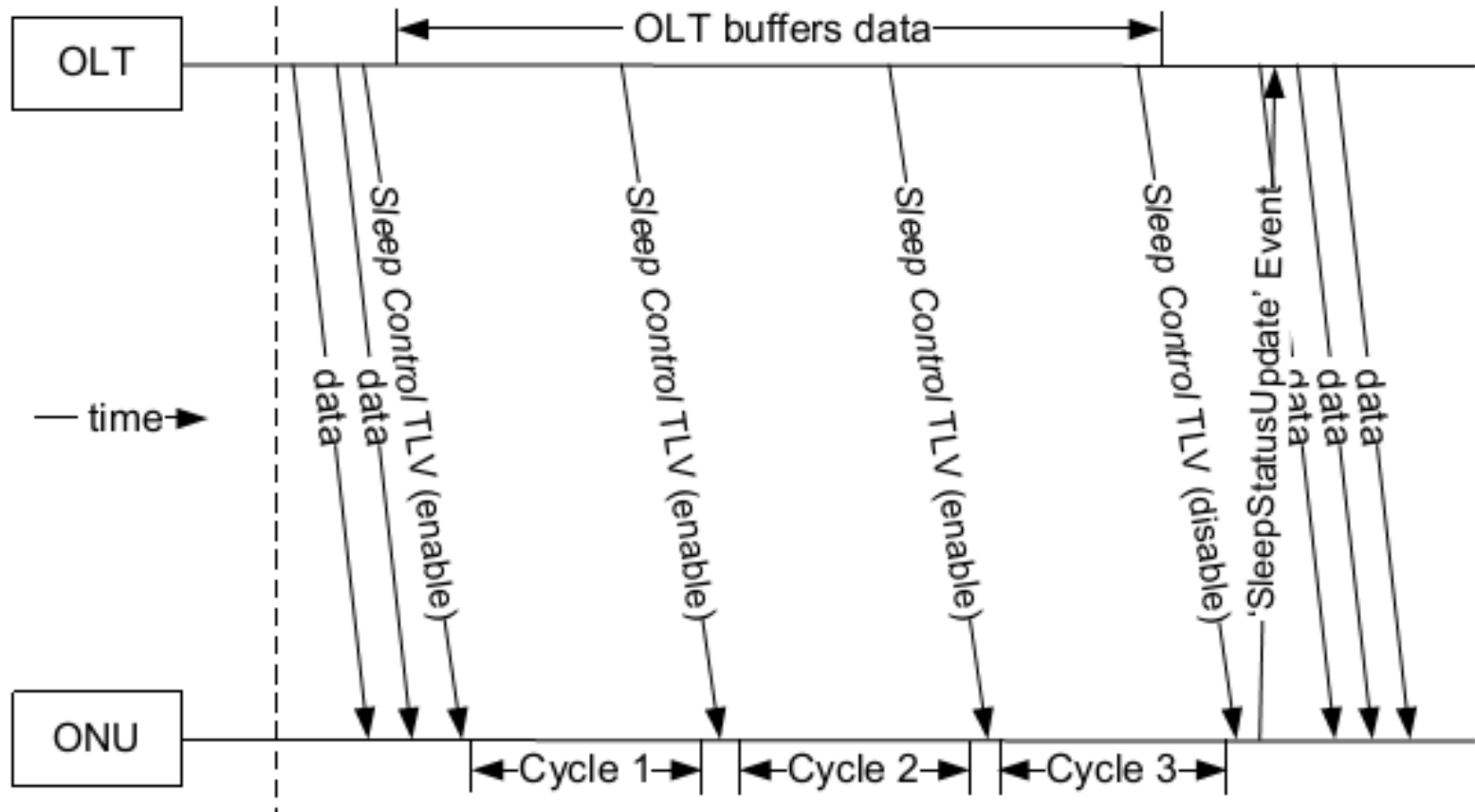


Figure 10-16—Example of the TRx power saving cycle



# 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