Discussion on 1904.4 big ticket items

Glen Kramer, Broadcom

Big ticket items as of 5/3/2022

#	Item	Category	Description of required changes	Big ticket?	Status	Assigned to
1	Develop and approve project timeline	Project management			Completed	
2	**Create draft D0.1 from 1904.1-2017 package A.**	Project management		YES	Completed	
3	**ULID provisioning**	LLID provisioning		YES	Completed	Glen Kramer
4	**GLID provisioning**	LLID provisioning		YES	Assigned	Glen Kramer
5	**Multicast ULID provisioning**	LLID provisioning		YES	Completed	Glen Kramer
6	**Report format and queue length**	Granting/Reporting	New behavior: gratuitous reports, dynamic reporting priorities	YES	Completed	Glen Kramer
7	**Multicast operation**	New 802.3ca behavior	Based on multicast ULID	YES	Completed	Glen Kramer
10	**Optical link protection**	New 802.3ca behavior	New behavior in multi-channel PON. See slide 22 in tf4_2102_kramer_1.pdf	YES	Assigned	Marek Hajduczenia
11	**Data encryption**	New 802.3ca behavior	1) Zero-overhead encryption as in SIEPON, pkg.A, but envelope-based instead of frame-based. 2) Add support for 256-bit keys. 3) Specify encryption using one key per ONU, not per LLID	YES	Unassigned	
12	**Power saving**	New 802.3ca behavior	Consider additional multi-channel mode	YES	Assigned	Marek Hajduczenia
13	Device and capability discovery	New 802.3ca behavior	New capabilities (fragmentation, multiple channels, etc.)		Completed	Marek Hajduczenia
14	**Low latency x-haul (AKA cooperative transport interface, mobile/PON coordination, Cooperative DBA)**	New feature		YES	Cancelled	Curtis Knittle

Open items

#	Item	Category	Description of required changes	Big ticket?	Status	Assigned to
4	**GLID provisioning**	LLID provisioning		YES	Assigned	Glen Kramer
10	**Optical link protection**	New 802.3ca behavior	New behavior in multi-channel PON. See slide 22 in tf4_2102_kramer_1.pdf	YES	Assigned	Marek Hajduczenia
11	**Data encryption**	New 802.3ca behavior	1) Zero-overhead encryption as in SIEPON, pkg.A, but envelope-based instead of frame-based. 2) Add support for 256-bit keys. 3) Specify encryption using one key per ONU, not per LLID	YES	Unassigned	
12	**Power saving**	New 802.3ca behavior	Consider additional multi-channel mode	YES	Assigned	Marek Hajduczenia

GLID Provisioning

- Preliminary discussion took place in 802.3ca.
  - kramer_3ca_1b_0916.pdf (slides 9-12)
  - remein_3ca_3b_0317.pdf
  - kramer_3ca_3_0317.pdf
  - zhangweiliang_3ca_2_0317.pdf
  - kramer_3ca_4_0317.pdf (slide 5 - examples of GLID scheduling policies)

- No major roadblocks. Just a lot of wring/drawing to illustrate the OLT and ONU behavior.

Data Encryption

#	Item	Category	Description of required changes	Big ticket?	Status	Assigned to
11	**Data encryption**	New 802.3ca behavior	1) Zero-overhead encryption as in SIEPON, pkg.A, but envelope-based instead of frame-based. 2) Add support for 256-bit keys. 3) Specify encryption using one key per ONU, not per LLID	YES	Unassigned	

11.2.2 Data encryption in DPoE

Devices conforming to this profile shall implement data encryption and integrity protection mechanisms, as defined in DPoE-SP-SEC and DPoE-SP-OSSI.

- IEEE 1904.1 does not specify the encryption for Package A. Instead, it points to DPoE-SP-SEC
- DPoE-SP-SECv2.0-I06-180228 is 86 pages long. Most of the material can be reused, but needs to be adapted to envelopes.
- Will CableLabs create a new specification, or should it be done in 1904.4?
- The MCRS and new MPCP are optimized for large number of LLIDs per ONU. Initial thought were that it was impractical and unnecessary to encrypt each LLID with a separate key.
- But one key per ONU may not be enough. A single key means that all the traffic to/from a given ONU is encrypted using the same key. That means that multicast traffic has to be in clear text.

Data Encryption

Discussion:

- Support per-ONU encryption for all unicast flows, and per LLID for all multicast flows.
  - Complexity?
  - How would ONU know if a provisioned ULID is unicast or multicast?
- AES-256 must be supported (MH, GK)
- CK – encryption strength must match DOCSIS
- Consider moving to D1.0 without encryption and adding it later.

Consensus:

Optical Link Protection

- What happens when only one of two channels detects LoS (switching, no switching?).
- Do we define a 2-to-1 tree protection method where we have two primary channels, but only a single backup channel?

From tf4_2102_Kramer_1.pdf

Optical Link Protection

0x09-00	aOnuProtectionCapability	OK
0x09-01	aOnuConfigProtection	OK
0x09-02	aOnuConfigPonActive	OK
0x09-03	aONUConfigHoldoverPeriod	OK

- In multi-channel 50G-EPON, an ONU has a capability to distinguish fiber cut from laser or receiver failure by comparing signals on two channels.
  - Failure of a single channel does not need to trigger protection switching, but needs to alarm the OLT
- In 802.3ca, the Channel Control Protocol provides capabilities for the OLT to query, enable, or disable individual channels in an ONU.
- ONU may also use CCPDU for alarms:
  - *"Furthermore, the ONU may send an unsolicited CC_RESPONSE CCPDU to notify the OLT about any local changes in the channel status, including imminent transceiver element (transmitter and/or receiver) failure, local channel disabling, power failure and resulting channel shutdown."*

Optical Link Protection

- What happens when only one of two channels detects LoS (switching, no switching?).
  - Trunk protection, ONU detected LoS on one of two channels
    - ONU sends alarm to the OLT (using CC_RESPONSE CCPDU). ONU does not enter HOLDOVER state
    - If OLT gets the same alarm from multiple ONUs, it may switch to the backup trunk.
  - Trunk protection, OLT detected LoS on one of two channels
    - LoS from a single ONU? Do nothing
    - LoS from multiple ONUs? Switch to backup trunk
  - Tree protection, ONU detected LoS on one of two channels
    - ONU sends alarm to the OLT (using CC_RESPONSE CCPDU). ONU does not enter HOLDOVER state
    - If OLT gets the same alarm from multiple ONUs, it may switch to the backup tree.
  - Tree protection, OLT detected LoS on one of two channels
    - LoS from a single ONU? Do nothing
    - LoS from multiple ONUs? Switch to backup trunk

Optical Link Protection

Discussion:

- Keep it the same as in 1904.1. Don’t worry about new 802.3ca capability to distinguish fiber/optic failures.
- Failure of any channel triggers protection switching. In other words, treat both channels as one.
- MH will clean up subclause 9.4 draft and submit for June mtg.

Side note:

- Transceiver monitoring needs review. Existing standards referenced from 1904.1 are not applicable.

Consensus:

Power Saving

- Previous discussion:
  - tf4_2110_kramer_2a.pdf (captures and analysis of night traffic)
  - tf4_2111_consensus_call_notes.pdf (notes from 11/2/21 consensus call)
  - tf4_2112_kramer_1_power_saving.pdf (presented on 11/9/21 consensus call. Not on the reflector?)
- Decisions made:
  - No reason to require operators to explicitly turn power-saving on. Power saving should always be on and ONU should enter Tx power saving mode when opportunity presents itself.
  - This mode relies on burst suppression and the mechanism is already described in 8. in D0.9.

8.4.4.2 Upstream burst suppression

If the conditions are met for the REPORT MPCPDU suppression per 8.4.4.1 and all other LLIDs (if there are any) allocated within the same grant have no data to transmit, the ONU shall suppress the entire upstream burst, i.e., for the given grant (burst), it does not turn on the optical transmitter at all.

The power saving mechanism (TX-mode) relies on the ONU's upstream burst suppression feature (see <TBD>).

From 11/9/21 call

- ONU is always in TX power saving mode
- If the next grant is far enough in the future, the ONU will turn off the transmitter and some of the functional blocks in the Tx path.
- If OLT does not request a REPORT for MPCP keep-alive and ONU has no traffic to send or report, it will suppress the upstream burst.

Other optimizations for power saving

- In addition to slowing down, the ONU should avoid unnecessary transmissions. For example, if all queues are empty, there is no point of sending a REPORT. In other words, absence of a REPORT is as useful information as a REPORT with all zeros.
- However, REPORTs are also used as MPCP keep-alive messages. Thus, the OLT and ONUs need to agree on REPORT optionality.
- How can this be done?

"Silence suppression" for PON

- *ForceReport* (FR) flag is used in MLID or ULID EnvAlloc to request queue status of a given LLID.
- FR flag is not used in PLID EnvAlloc because the upstream PLID queue is always empty (REPORTs are generated just in time for their transmission. The presence of PLID EnvAlloc itself indicates to the ONU that it must generate at least one REPORT MPCPDU.
- The PLID FR flag may be re-purposed as the "*silence-suppression*" flag.
  - **If PLID FR == 1**, ONU must generate at least one REPORT MPCPDU
  - **If PLID FR == 0**
    - **If all upstream queues are empty**, ONU does not transmit anything (i.e., the TX channel remains in sleep state).
    - **Else (i.e., any queue is not empty)**, the ONU shall send at least one REPORT MPCPDU.
- If the OLT issued a GATE with PLID FR == 0, and it has not received a REPORT from the ONU, it should…
  a) Surmise that all ONU's queues are empty
  b) Not increment the *MissedReportCount*.
  (NOTE: A received REPORT still resets the *MissedReportCount* to zero.)

Questions to answer (1/2)

- Should 1904.4 support TRX mode, where the downstream channel is shut down?
  - OLT tells ONU it is allowed to sleep for x ms. Once ONU's receiver is shut down, ONU does not see any commands from the OLT to wake up early if the OLT gets DS frames for this ONU.
  - ONU may wake up early on its own if it sees upstream frames.
  - ONU needs to resynchronize when it wakes up (ONU needs to receive a unicast GATE)
  - TRX mode is described in 1904.1. Unknown if implemented by any vendor.

Questions to answer (2/2)

- Should 1904.4 require power consumption measurement and self-reporting by the ONU?

Discussion on the previous call

Missing features

- ONU should report its current power consumption
  - Instantaneous, average?
  - Attribute to report power
  - Attribute to configure averaging window
  - Attribute is valid only under ONU context
  - Sample before the power supply
  - Make power measuring circuitry optional. Vendors should be interested in implementing it.

Answers we need

- Real ONU power measurements by CL (Curtis)
- Check what power saving modes are used in GPON/XGS-PON (Curtis)
- Review EU CoC for Power Consumption (all)
- Hardware impact of supporting the power level attribute (Glen)
- ONU vendors view on power savings (Mike)
- High level power-saving protocol without cyclic control by OLT (Glen)

- To measure power on DC side (power supply output), the ONU will need to include a shunt resistor, an amplifier, ADC, a register to latch ADC values, an accumulating register/logic for averaging over a predefined window.
- The circuitry to measure power on the AC side has to be integrated into the power supply unit. The power supply will need a digital interface to allow the values to be read into accumulating logic.
- Today's ONUs do not include any such circuits

Issues with measuring power

- What constitutes "ONU" is not defined
  - ONU-in-a-stick
    - SoC , PMD driver, BOSA
    - Powered by host device
  - Media-converter ONU
    - One PON port and one UNI
      - » BOSA-on-board or pluggable
    - Power supply internal or external
  - PON-connected fully integrated HGW
    - PON functions + router + WiFi + VoIP
    - Multiple Ethernet UNIs
  - MDU ONU
    - From 4 to 48 users
    - Build-in managed L2 switch or L3 router
    - Optical or copper UNIs
    - Redundant power supplies
    - Optical protection (redundant PON ports)
  - ONUs specialized for industrial applications
    - Surveillance/monitoring
    - IOT devices with built-in PON interfaces
  - Countless other variations

- ONU power consumption value is ambiguous
  - ONU device may or may not have a built-in power supply
    - Power-supply efficiency is 85-90%
  - ONUs may have different functionality
  - ONUs may serve different numbers of users

- No universal point to measure power consumption

- Unclear how the power consumption values may be compared between different ONUs

Selection criteria vs. run-time reporting

- Power consumption is important
- Power efficiency comes from ONU design considerations
- RFPs may and should specify power targets for the specific ONU configurations requested by these RFPs
- RFP selection process should use power consumption as one of the evaluation criteria
  - In the lab, power consumption can be measured externally to DUT
  - Various ONUs can be evaluated under identical test conditions
- Power consumption is not a parameter that needs to be measured/reported dynamically after ONUs are deployed.
  - No easy way to interpret or compare the measured values
  - ONU conditions that affected power measurement may not be known
  - Confusion and incorrect conclusions may lead to mis-configurations

Power Saving

- **Discussion:**
- MH: stay with TX mode only. If TRX mode ever becomes necessary, it can be added via amendment.
- GK: It is undesirable to complicate ONUs with additional power consumption measurement circuitry. Discuss again on next call.

- **Consensus:**

Thank you

Problem statement

- In 1904.1, the "Normal Mode" is considered the opposite of the "Power Saving Mode" (see Fig 10-1).
- Why is the power saving mode not the normal mode?

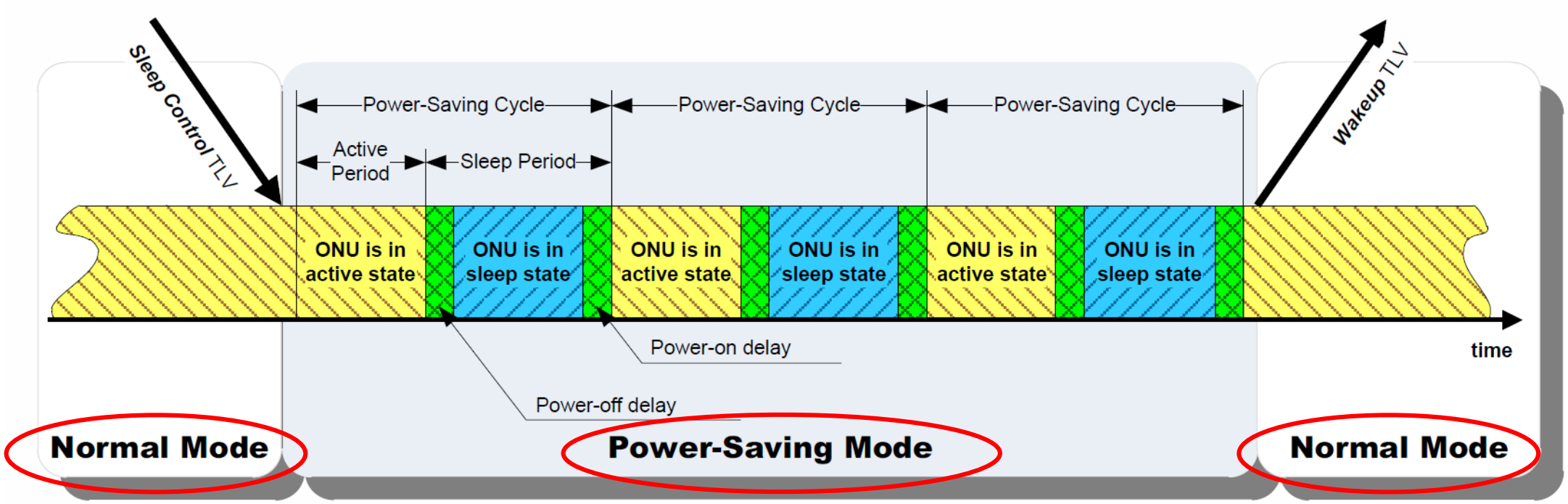


Figure 10-1—Timing diagram of the power-saving mode

Always-on power saving

- Functional objectives
  - Power saving in EPON is achieved without increasing the frame loss rate, delay, or jitter beyond the limits established in the SLS for the given service.
  - The power-saving mechanism accounts for data load on the given ONU, configured services, active services, user activity cycles, etc.
  - The ONU remains registered during the power-saving mode, maintaining its configuration and management states, allowing the ONU to return from the sleep state to the active state.

- If the above objectives are achieved, what would be the reason to ever turn the power saving mode off?

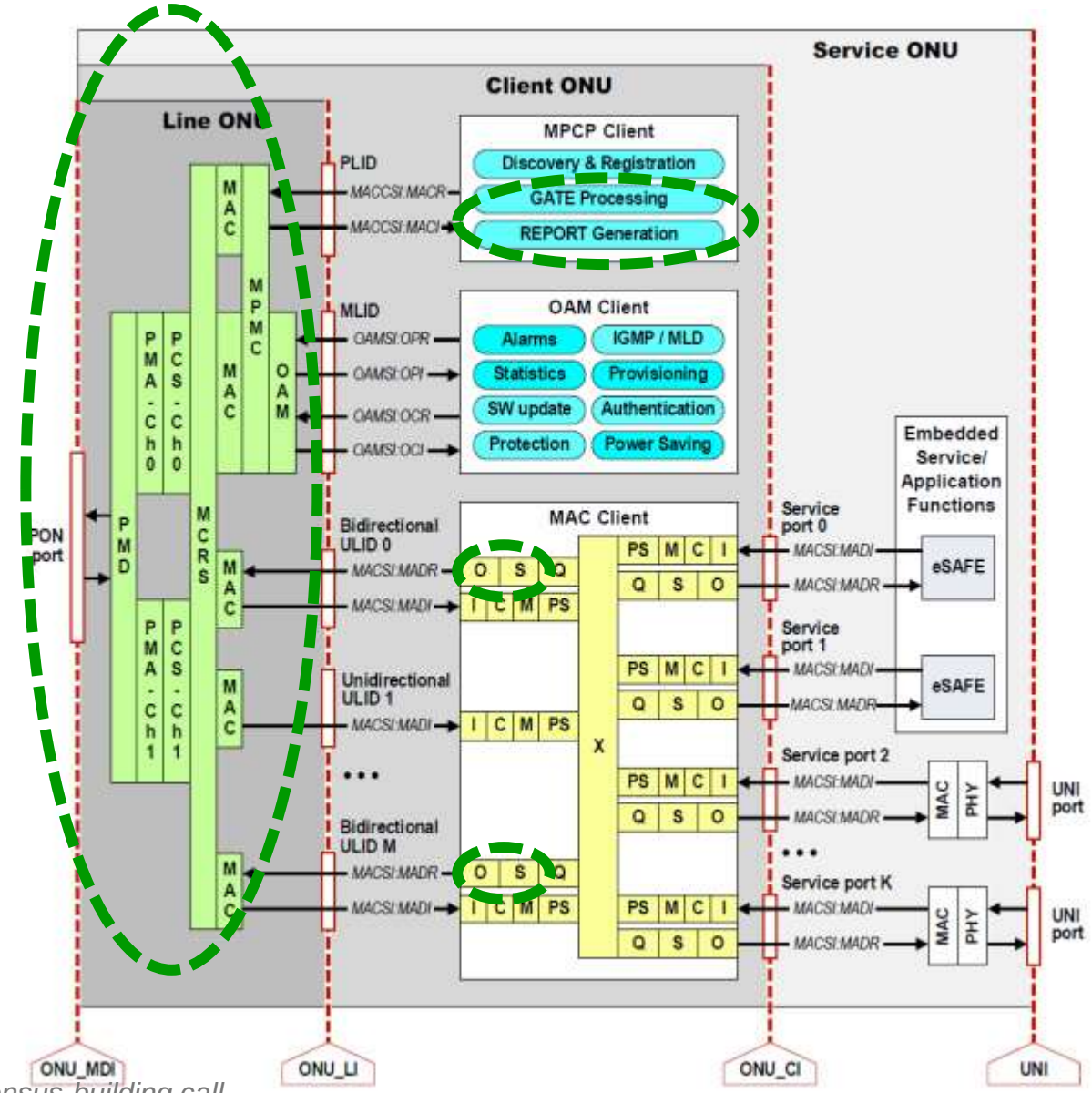
Opportunistic power saving model

- To place an ONU into the power saving mode, the OLT has to do two things:
  1. Alter its granting behavior (temporary suspend grants or increase grant spacing)
  2. Issue the SleepAllowed command

- Why cannot ONU enter the power saving mode automatically every time it sees an opportunity?
  - For example, if a grant start time > 20 ms in the future, enter the sleep state and wake up just in time for the scheduled transmission.

Targets for sleep mode (TX path)

- What functional blocks can be put to sleep?
  - ✓ TX path of L-ONU: Mostly yes, but MPCP timers and the queue holding pending envelopes must remain active.
  - ✘ MAC Client: All blocks except [S] and [O] blocks in TX data path (abstract blocks with no equivalents in typical implementations) must remain operational to receive user data, classify/modify it, and place it in proper upstream queues.
  - ✓ MPCP Client: Possible to suspend GATE processing and REPORT generation. Still needs to be able to receive REGISTER requests. Negligible power consumption impact.
  - ✘ OAM Client: CPU still should run to be able to process downstream OAMPDUs, CCPDUs, gather statistics, and monitor for various alarms
  - ✘ eSAFE: depends on the service. Generally, not controlled by EPON sleep modes and out of scope for 1904.4.



Sleep mode vs. dream mode

- It is hard or impossible to shut down the majority of the functional blocks in an ONU. But during the low-usage intervals, these blocks may be slowed down.

- Data-driven clock allows the ONU to slow down and thus reduce the power consumption during the periods of decreased data load. When load increases, the clock increases automatically and ONU transitions into an active state.

- Data-driven clock is an ONU architectural decision implemented at design time. No run-time protocol to control power-saving mode is needed.

Notes from 10/19/21

- Is there a power-saving mode in ITU-T PON standards.
  - Review ITU-T spec.
  - Do ITU-T PON operators enable power saving modes.
- If ONUs are already under the required consumption limits, do we need any extra mechanisms?
- Vendors don’t implement hooks that enable operators to enable power saving modes.
- Are there any specifications for power consumptions (CableLabs, others?)
- EU CoC document

Missing features

- ONU should report its current power consumption
  - Instantaneous, average?
  - Attribute to report power
  - Attribute to configure averaging window
  - Attribute is valid only under ONU context
  - Sample before the power supply
  - Make power measuring circuitry optional. Vendors should be interested in implementing it.

Notes from 5/3/21

- For enterprise customers, SLA is highest priority. Power saving is not used because it affects SLA.

- Power savings should focus on Residential market
- PS for OLT shelf
  - Uplink port will never go to sleep (telemetry)

- In the OLT shelf, power consumption by the OLT SoC and optics is much smaller than the backplane and uplink switch.

- PS control – periodic vs. one-time command.
- ONU should be able to decide what blocks to shut down, for how long, and when to wake up.

- How much power the RX path in optical module consumes compared to TX?

Answers we need

- Real ONU power measurements by CL (Curtis)
- Check what power saving modes are used in GPON/XGS-PON (Curtis)
- Review EU CoC for Power Consumption (all)
- Hardware impact of supporting the power level attribute (Glen)
- ONU vendors view on power savings (Mike)
- High level power-saving protocol without cyclic control by OLT (Glen)

Power Saving (1904.4 reflector, 11/3/21)

JC: I went in our lab and measured the power consumption of a 10G ONU SFP+ 20Km transceiver. I am talking about just the transceiver that can be plugged into an ONU. I could measure the power consumption with Laser ON and with Laser OFF. I repeated the experiment with various brands and got consistent results.

Laser	Input Voltage	Input Current	Output Optical Power
OFF	3.3V	0.36A	-50dBm
ON	3.3V	0.50A	+5dBm

The way I measured power is simple: we have a small test board that pretty much consists of a SFP+ cage. I could read the Voltage and Current from the power supply feeding the test board. The test board itself has no active components so that we can safely neglect its own power consumption. This board is also equipped with few dip-switches controlling some input pins of the SFP+ module. In particular, it can control the SFP_TX_DIS pin which allowed me to turn laser ON and OFF.

Now let's consider a very simplistic 10G EPON 'power saving' approach where all we do is slow down the polling activity at night.
For our calculations, I will assume the following:

- night is between 11PM and 5AM (6 hours)
- FEC Enabled
- Laser ON : 32TQ
- Laser OFF: 32TQ
- Sync Time: 16TQ
- Cost kWh : 12.55 cents (2021 US average)
- ONU is polled at constant frequency with force report set
- No traffic is going through the ONU during the night period

Power Saving (1904.4 reflector, 11/3/21)

The simplistic power saving approach is to change the polling period from 1ms (very aggressive setting) to 50ms (very slow setting). Let's now compare the cost of doing nothing (keep fast polling) and slow polling during night time. Of course the data will be about existing 10G (not 25G) and restricted to TX laser savings but it will help us getting some idea about what to expect.

With a fast polling, we would have a total of 2.16E7 bursts (6h * 3600s/h * 1000burst/s) per night.
Each burst being about 95TQ (based on optical overhead I selected).
This means that during the night, the laser will be ON for 32.83s (2.16E7burst/night * 95TQ/burst * 16ns/TQ / 1E9s/ns)
Compared to laser being OFF for that time, it corresponds to a cost of 5.29E-5cent/night (12.55cent/kWh * 3/3V * (0.50A - 0.36A) * 32.83s/night / 3600s/h / 1000W/kW)

Same calculation with a slow polling, all numbers are basically divided by 50 since we poll every 50ms instead of every ms.
So cost of slow polling at night is 1.06E-6cent/night compared to never turning laser ON at night.

So, under the above assumptions, and aggregating the cost for 126 million US households:
- Having fast polling at night costs $24.3K per year (5.29E-5cent/night * 365night/year * 126E6households / 100cent/$)
- Having slow polling at night costs $486 per year (1/50 of previous number)

Again, both numbers are in comparison with never turning laser at night.

From this, it is not clear to me if implementing this simplistic approach is worth it, nor is it for me to judge but:
- It can be implemented easily with existing equipments (Polling period is likely available to network management system).
- Its impact on latency is low and controllable. 50ms polling is just an example.
- Implementing full blown power saving feature seems to hit diminishing returns unless we can demonstrate that further savings (beyond TX Laser) can be implemented.

Please let me know if you see a problem in my experiment or its results.