Power-Saving Mechanism for EPoC

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Summary

- IEEE Std 1904.1 (SIEPON) defines three power-saving mechanisms, addressing specific operational requirements of the given profile.
- Each power-saving mechanism provides detailed definitions, state diagrams, and clear description of operation of individual devices.
- This presentation suggests a path forward, building on SIEPON-defined mechanism(s), and indicating what needs to be done in EPoC to support power-saving operation.
High-Level View of Power-Saving

- Plenty of moving parts, involving:
  - CNU (user activity, service types, device capabilities, etc.),
  - CLT (and its capabilities),
  - operator configuration, and
  - provisioning systems ...
What we need ...

1. A mechanism to configure power-saving parameters on CLT and CNU (provisioning system)
2. A control channel between the CLT and the ONU
   – for CLT to control the CNU (sleep / active) state
   – to assure QoS measures are still met
3. A way to discover CNU power-saving capabilities
   – including supported sleep modes, power on/off times ...
4. Support for sleep modes in hardware
   – to maximize power-saving potential and guide power-efficient implementations
5. Concise definition of interaction between CLT and CNU when entering and leaving the sleep mode in an organized manner (AKA *power-saving mechanism*)
What we have today …

• Items 1 and 3 from the previous slide are already available to us
  – See the summary slides on SIEPON power-saving mechanisms (hajduczenia_01_0313.pdf)
  – Also, see Clause 10 of SIEPON in our private directory for more details

• These two items guarantee:
  – all necessary definitions for control channel between the CLT and CNU,
  – ways to discover CNU capabilities and react to them

• SIEPON provides us with three distinct ways to handle item 5
  – Do we really need to come up with a new way to do things in EPoC?
CLT – CNU Control Channel

• SIEPON power-saving control mechanisms are
  – based on exchange of extended OAM or MAC
    Control messages
  – not tightly coupled with the PHY layer and allow
    greater implementation flexibility

• For EPoC ...
  – alternative proposals were presented, suggesting
    to use PLC to signal the CNU to enter / leave the
    sleep state

• At some point of time, we will need to take
  decision on the use of specific control channel
Control Channel – What to Choose?

• PLC control channel:
  – Capability to exchange power-saving signalling between peer PCS instances
  – Limited capability to cooperate with scheduler and MPMC layers (XGMII is in the way, all data needs to be pumped through MDIO)
  – Limited bandwidth may become a problem when controlling status of a larger number of CNUs
  – Synchronization of sleep period with scheduler is much more complex and requires quasi-real time information exchange across MDIO. Same applies to synchronized sleep for multiple stations
Control Channel – What to Choose?

- SIEPON-like control channel:
  - Relies on existing control channels
    - OAM / MAC Control, depending on the selected package
  - Allows for coordination with scheduling operations for upstream and simpler synchronized sleep for multiple subtended customer devices
  - Covers power-saving operation of PCS elements, MAC Control and MAC Clients
  - Allows for implementation flexibility while assuring interoperability in multi-vendor environment
  - Bandwidth is not a problem
    - OAM is not limited to 10 frames/second per link any more – it is operator configurable now
    - MAC Control does not have any frame rate limitations at all
Hooks in Hardware

• To optimize power-saving gains:
  – EPoC PHY must be ready to deal with switching between active state and sleep state
  – Power on and power off delay should be minimized, and time the CNU stays in sleep state must be maximized
PHY Features

• To put receiver to sleep:
  – CNU must synchronize quickly to received (downstream) data stream to reduce power on delay
  – Fast re-sync mechanism is needed to avoid searching through all possible subcarrier positions every time CNU goes to sleep

• To put transmitter to sleep:
  – Really, no special new requirements are needed, apart from a short power on time
  – CNU will operate in burst mode in upstream anyway in either TDD or FDD modes.
Higher Layer Features

• To improve power efficiency, elements other than Tx/Rx can be also put to sleep
  – (power-hungry) FEC is one of typical candidates
  – Selected MAC Clients and associated packet queues not receiving / sending data could be also powered down
  – Transmit / receive direction on XGMII could be powered down as well when not used

• With SIEPON-like control mechanism, it is also possible to signal higher layer functions (application) about PHY entering sleep mode
What do we need to do in EPoC?

• Two scenarios are possible going forward
  – Both are examined in the following slides
• The presented scenarios differ primarily in the amount of work for EPoC TF and amount of reuse from existing specs
• Since EPoC is intended to look like EPON-on-coax, reuse of EPON-like power-saving mechanisms is naturally recommended to speed-up EPoC development
Scenario 1 – Less Work Involved

• Reference power saving mechanism(s) defined in SIEPON for EPON

• SIEPON-defined management entities are generic enough to be reused by EPoC as well
  – To be confirmed by TF

• In EPoC, specify:
  – Fast re-sync for CNU Rx to minimize power on delay and data re-synchronization process
  – Consider extending the duration of keep-alive period for MPCP to maximize duration between active periods for CNU
Scenario 2 – Contain work in EPoC

• Define the whole power-saving mechanism within EPoC, limiting its applicability to 802.3 layers only (EEE-like mechanism)

• Define operation of the power-saving control channel over PLC, including associated SDs

• Capability / Control registers and new managed objects (in cooperation with 802.3.1) will have to be defined

• Fast re-sync mechanism (see previous slide) should be still specified in EPoC to optimize power-saving capabilities of our PHY
Summary and Suggestions

• EPoC project has already plenty of challenge areas to work on (see lengthy emails ... )
• Power-saving mechanism through the reuse of SIEPON-defined control channel and management entities can be added to EPoC PHY with minimum effort, with very limited new functions to PHY
• Cooperation with SIEPON will be needed to examine whether any changes are required to SIEPON power-saving definitions to apply them to EPoC
  – The time is right *now* given advanced status of SIEPON
• Power-saving functions in PHY will be proposed at the later date, when more details on PHY operation are available.