Energy Management in EPoC

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Slides on EEE were adapted from bennett_01_0311.pdf with permission of the author.
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The Need for Energy Management in EPoC

U.S. Cable Industry Launches New Energy Efficiency Initiative

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CableLabs® - Energy Lab Facility Dedicated to Improving Energy Conservation

WASHINGTON, D.C. / LOUISVILLE, CO – The U.S. cable industry today announced a new initiative dedicated to improving the energy efficiency of consumer set-top boxes and other devices and developing advanced cable-enabled services designed to promote innovative consumer energy conservation measures. A key element of the initiative is the "CableLabs® - Energy Lab," a new facility within the cable industry's R&D consortium that will concentrate exclusively on improving energy efficiency, the National Cable & Telecommunications Association (NCTA) and CableLabs® announced today.

- Details at:
  http://www.ncta.com/ReleaseType/MediaRelease/US-Cable-Industry-Launches-New-Energy-Efficiency-Initiative.aspx

# Energy Management with Set-top Boxes

- The first HD DVRs (10 years ago) used around 45 Watts
- The ENERGY STAR® program has been active for the last several years defining set-top efficiency goals and encouraging participation by Service Providers
  - http://www.energystar.gov/index.cfm?c=revisions.settop_box_spec
- In the first quarter of 2011, 95 percent of Comcast's and 100 percent of Time Warner Cable's STBs were ENERGY STAR
- Digital set-top boxes being deployed by the U.S. cable industry this year are projected to offer energy savings of 20 percent or more when the devices shift into a "light sleep" mode
  - http://www.cablelabs.com/news/pr/2012/12_pr_SetTop_Light_Sleep_031912.html
  - Deep Sleep mode being investigated for additional power savings

Energy Management in DOCSIS®

- CableLabs has worked with suppliers to innovate around a "Deep Sleep" mode for DOCSIS cable modems.
  - CMTS instructs the CM to sleep via a DOCSIS MAC Management Message for a defined period of time (could be on order of minutes) or until kicked on by local process
  - The CMTS maintains Registration state of the CM while it is hibernating, but does not queue packets

- Details at: http://www.cablelabs.com/about/inventions/downloads/60341-published.pdf

Periodicity of TV Viewing

Usage is periodic, with opportunities to save energy at non-peak hours
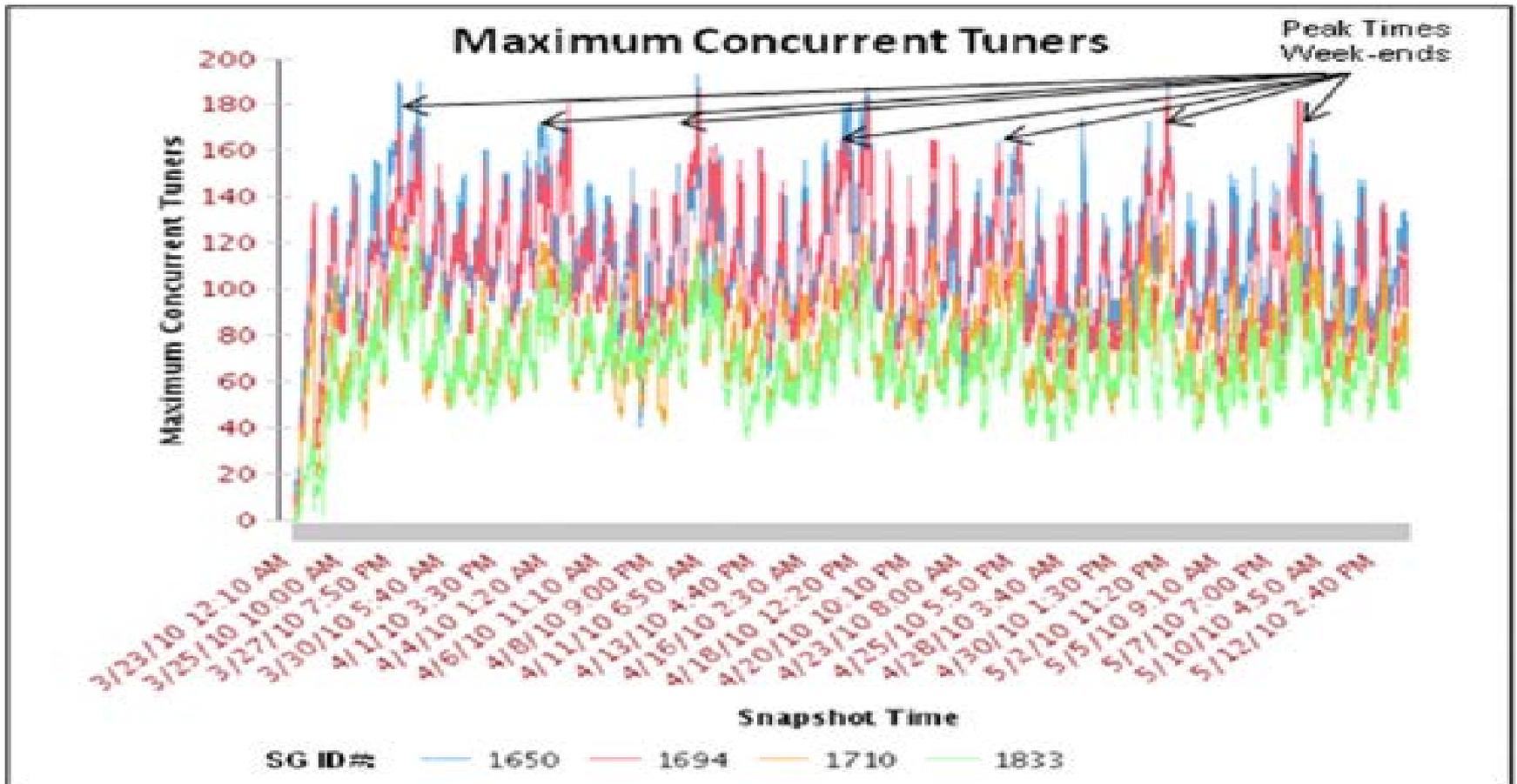
- SWITCHED INFINITY: SUPPORTINGAN INFINITE HD LINEUP WITH SDV, Civiletto, J. and Milin, L., Proceedings of 2010 SCTE Cable-Tec Expo

Potential for power saving in EPoC

- Even in high transaction-rate networks, utilization is not 100% 24 hours/day 365 days/year = opportunity to save energy[1]
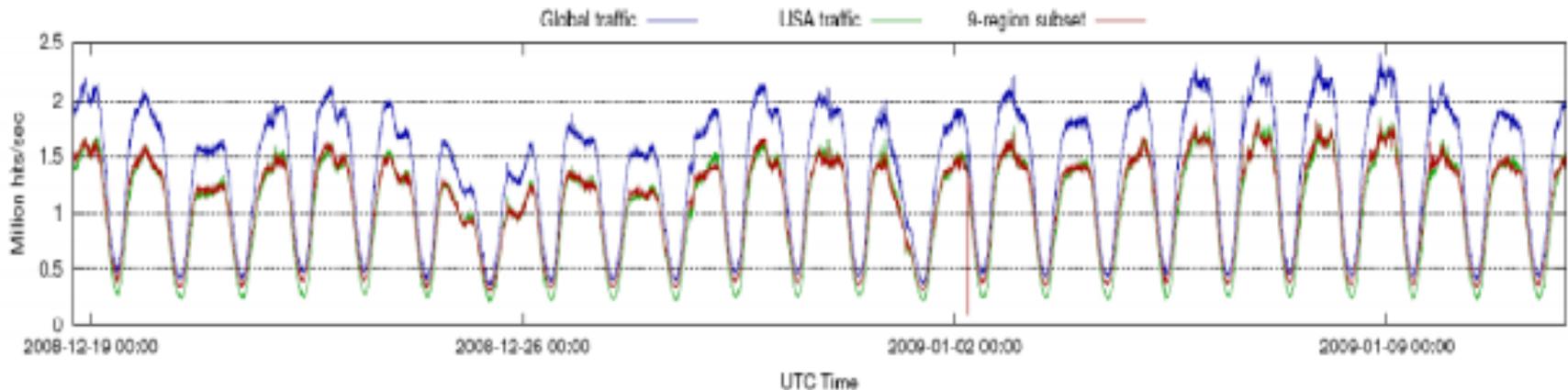

Figure 14: Traffic in the Akamai data set. We see a peak hit rate of over 2 million hits per second. Of this, about 1.25 million hits come from the US. The traffic in this data set comes from roughly half of the servers Akamai runs. In comparison, in total, Akamai sees around 275 billion hits/day.

- Cutting the Electric Bill for Internet-Scale Systems, Qureshi et. al, SIGCOMM '09 Proceedings of the ACM SIGCOMM 2009 conference on Data communication, ISBN: 978-1-60558-594-9

Power saving in EPoC

- There are both regulatory, environmental and financial incentives for implementing and using power saving mechanisms in access networks.

- Power saving mechanism are already supported in EPON (see IEEE 802.3az™-2010 and IEEE P1904.1 specifications) and used in commercial products. Adaptation of these mechanisms to EPoC should not represent substantial technical challenges.

Adding power saving in EPoC

- Suggested path for adding support for adding power saving in EPoC:
  - Do not modify existing objectives. TF can always do more than covered by objectives, as long as there is technical consensus to do so. Treat power saving as a baseline proposal.
  - Investigate applicability of both 802.3az (Energy Efficient Ethernet) and mechanisms defined in IEEE P1904.1
    - 802.3az mechanism impacts PHY / PCS design within the scope of EPoC TF
    - 1904.1 mechanism impacts layers above MAC Control but requires that layers within the scope of EPOC TF do not prevent their operation (OAM / MPCP flows), timing, etc..

What is EEE ?
(Energy Efficient Ethernet, 802.3az)

- Energy Efficient Ethernet (EEE) is a method to reduce energy used by an Ethernet device during periods of low link utilization
  - Specified in IEEE 802.3az-2010™
  - The premise for EEE is that Ethernet links have idle time and thus opportunity to save energy
- Specified for copper interfaces
  - "BASE-T's'
  - Backplane (except 40G)
- The method is called Low Power Idle (LPI)

EEE operating principles

- LPI – PHY non-essential circuits shut down during idle periods
- During power-down, maintain coefficients and sync to allow rapid return to Active state
- Wake times for the respective backplane PHYs:
  - 1000BASE-KX: $Tw\_PHY_{(min)}$ = 11.25 usec
  - 10GBASE-KX4 $Tw\_PHY_{(min)}$ = 9.25 usec
  - 10GBASE-KR: $Tw\_PHY_{(min\ w/o\ FEC)}$ = 12.25 usec
  - 10GBASE-KR: $Tw\_PHY_{(min\ w/FEC)}$ = 14.25 usec

Wait a minimum of Tw_Sys before sending data (Tw_sys >= Tw_PHY)
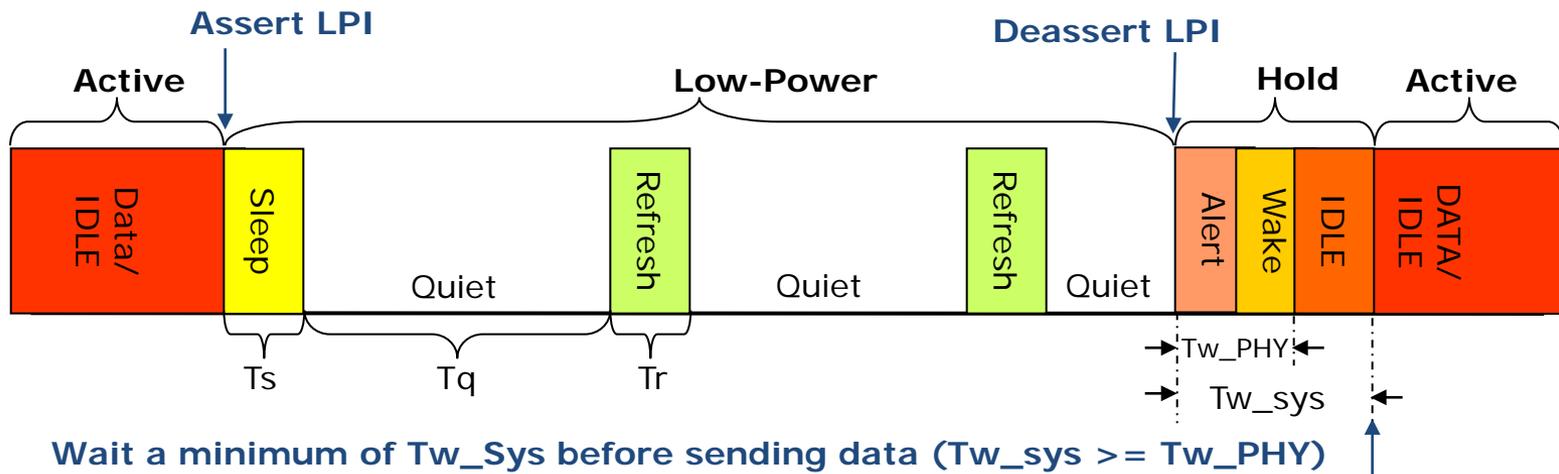
What is LPI?
(Low Power Idle)

- Concept: Transmit data as fast as possible, return to Low-Power Idle

- Saves energy by cycling between Active and Low Power Idle

  – Power reduced by turning off unused circuits during LPI

 – Energy use scales with bandwidth utilization

11
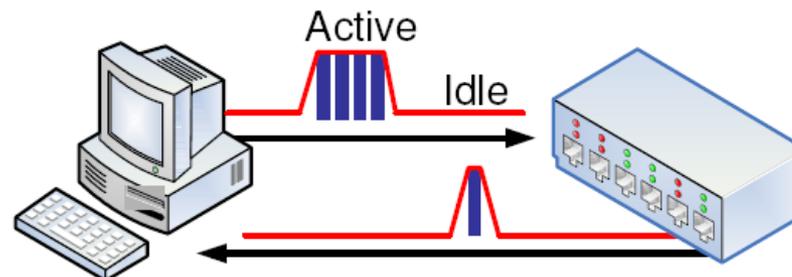
EEE and EPoC

- EPoC operates on coaxial media, thus the principle of LPI can be reused with no changes

- Impact on link training, switching between high and low power states and potential power saving needs to be evaluated before decision to support EEE is taken.

- Detailed study will be needed to demonstrate impact of potential EEE implementation on link latency, expected power savings and link setup times in function on LPI duration.

P1904.1 power saving mechanisms

- ONU switched between active and sleep modes either autonomously (once allowed by the OLT) or under direct control of the OLT (using OAMPDUs or MAC Control messages)

- Duration of sleep / active cycles is either pre-configured and static, or changes dynamically based on traffic conditions detected by ONU (autonomous mode) or depending on the OLT control (centralized mode)
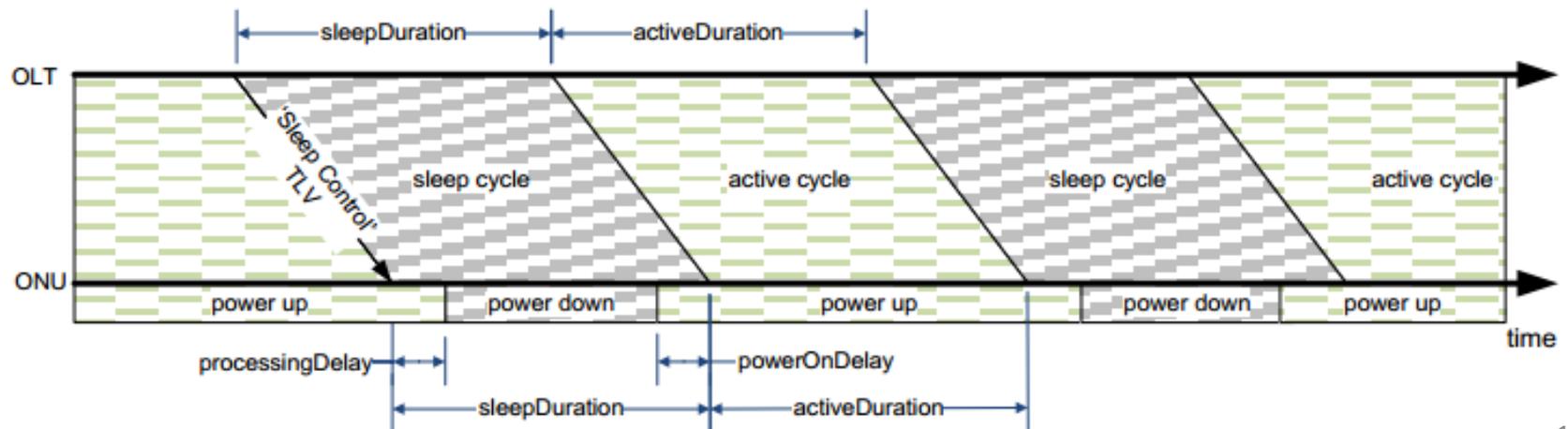
Proposal

- Given where EPoC SG is at this time (ready to turn into TF), we suggest that objectives are not modified to keep the timeline intact.

- However, we would suggest that support for power saving mechanisms is adopted as one of baselines (potentially, optional feature) once P802.3bn Task Force is formed and starts accepting baseline proposals.

- To decouple work on power saving mechanism for EPoC from the main scope of the P802.3bn TF, we suggest that work is developed by a dedicated ad-hoc and progress is reported at each meeting, while making sure that technical choices for PHY development do not prevent support for power saving mechanisms in the future.

THANK YOU