Broadcom Energy Efficiency Initiatives

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Enable end-to-end networks that allow Broadcom’s strategic customers to lead the industry in performance and features in a cost- and energy-competitive framework.
Industry and Regulatory Trends

• Government and Industry Recognition
  – April 19, 2006 “Green Grid” formed
  – December 20, 2006 House Resolution 5646 signed into law
  – European code of conduct
  – Japanese government initiative “Top Runner”

• IEEE P802.3az – Energy Efficient Ethernet
  – Broadcom heavily involved in launching the project in 802.3
  – Project objectives based on Broadcom presentation. Continues to be largest contributor

• Energy Star
  – EEE requirements for Servers planned in future draft (2010) once P802.3az is ratified
  – EEE requirements for PCs planned in future draft (2010) once P802.3az is ratified
  – Historically, EU and other countries will follow suit
  – Energy Star has kicked off an enterprise storage elements specification
  – Discussion on starting a networking equipment specification to cover switches

• Lower energy usage means lower operating costs
Broadcom’s Energy Efficiency Solutions

Energy Efficient Ethernet (EEE)
- Phy level power savings
- Standards based compliance and interoperability

Energy Efficient Networking (EEN)
- Deeper power savings utilizing EEE as a foundation
- Higher level protocol and coordination of power savings

Process and Integration Power Efficiency Benefits
- Move to 40nm CMOS and higher levels of integration
- Lower power per unit of BW and Functionality

Off-load Technologies within Server Controllers (NIC’s)
- Off-load engine is more efficient than CPU in Networking functions
- Saved capacity can reduce power or increase Power Utilization Efficiency
IEEE P802.3az (EEE) Progress and Timeline

Draft Progress
Successful initial Working Group Ballot & Recirc (D2.0 - D2.3)

All comments against D2.0, D2.1, D2.2 and D2.3 considered

D2.4 will be published April 2010
EEE Low Power Idle Overview

- Low Power Idle (LPI) – PHY powers down during idle periods
- During power-down, maintain coefficients and synchronization to allow rapid return to Active state
- Wake times for the respective twisted-pair PHYS
  - 100BASE-TX: $T_{\text{w PHY}} \leq 30 \text{ usec}$
  - 1000BASE-T: $T_{\text{w PHY}} \leq 16.5 \text{ usec}$
  - 10GBASE-T: $T_{\text{w PHY}} < \sim 8 \text{ usec (2 modes)}$

Wait a minimum of $T_{\text{w sys}}$ before sending data ($T_{\text{w sys}} \geq T_{\text{w PHY}}$)
Comprehensive Energy-Efficient Ethernet portfolio includes

- 10/100/1000BASE-T PHYs
- 10GBASE-T PHYs
- Gig E and 10GE controllers
- Switches
- SMB switches

The green grid™ member

Lowers Power by 75%

Without EEE  With EEE

Server  Switch  Storage  PC
Broadcom’s EEN: End-to-End Savings

END POINT

Application
OS
Controller SW
Controller
MAC
PHY
EEE

SWITCH

Coordinated and Optimized End-to-End Control Policy
OS
NWSW SW
NWSW
MAC
802.3az PHY

Well Integrated Control Policy and EEE Within a Box
Broadcom’s In-System Control Policy

No Control Policy

Link State:

Power: ~75%

Data: ~45%
Broadcom’s In-System Control Policy

With Broadcom EEE Control Policy

Link State:

Power: ~55%

Data: ~45%
Broadcom’s EEN: End-to-End Savings

**END POINT**

- Application
- OS
- Controller SW
- Controller
- MAC
- PHY

**SWITCH**

- Application
- OS
- Controller SW
- NWSW SW
- NWSW
- MAC
- PHY

- Broadcom Customizable and Optimized Control Policy

- Broadcom Enabled
- Broadcom Enabled

- Maximize energy efficiency by maximizing operation in saving states
- Minimize performance, latency impact by avoiding unnecessary transitions
- Customizable via FastPATH/SmartPATH Software
EEE Enhanced Layer 2 Operations

- Opportunity to save additional power within a box (link partner)
  - Additional circuits beyond the PHY can be turned off

- Additional RX wakeup time negotiated using 802.3az’s Layer 2 — Standards based
10GBASE-T Efficiency Trend

Dedicated Racks for 10G SFP+ & 1000BT

1000BT Top of Rack Switches
10G SFP+ Top of Rack Switches

RJ45 CAT5/6e SFP+ Copper
SFP+ Fiber (100m)

10GBASE-T link is cost competitive vs. SFP+

6 port 1000Base-T installation

1G Top of Rack Switches

Better cable management More efficient bandwidth

400mW/Gbit

10GBase-T double power efficiency of 1000BT

Lowest cost 10G PHY option
Preserve 100 / 1000base-T backward compatibility
Less Switches = Less Power
Low power – 2W for TOR with EEN

Easy Mix of 1G and 10G Racks with 1/10Gbase-T

1000BT / 10GT Top of Rack Switches

RJ45 CAT6e

CAT 6e 100m

200mW/Gbit
Improve Data Center Power Efficiency

Offload Significantly Improves Performance / Watt

Data Center Power

- Improved PUE (Power Utilization Efficiency)
- Permanent power savings for right-sizing
  - 50-70% additional power savings
  - Lowers non-IT infrastructure CAPEX

Broadcom hardware offload saves ~60W per port of power while delivering higher throughput
Broadcom Improves Power Utilization

Reduced power across full spectrum of data traffic patterns

120W per server

~4000W per Rack

Stateful Offloads

~60W per port!

Energy Efficient Networking

Control Policy Driven (L2-L4)

PHY Level – 802.3az

Server, Storage, Switch

Power and performance optimization for Maximum Link Utilization

Power optimization for Low Link Utilization including Tunable Latency

Data Centers #1 Consumer of US Power by 2011 @ 120B kWh
Thank You