Broadcom Energy Efficiency Initiatives

April 1st, 2010
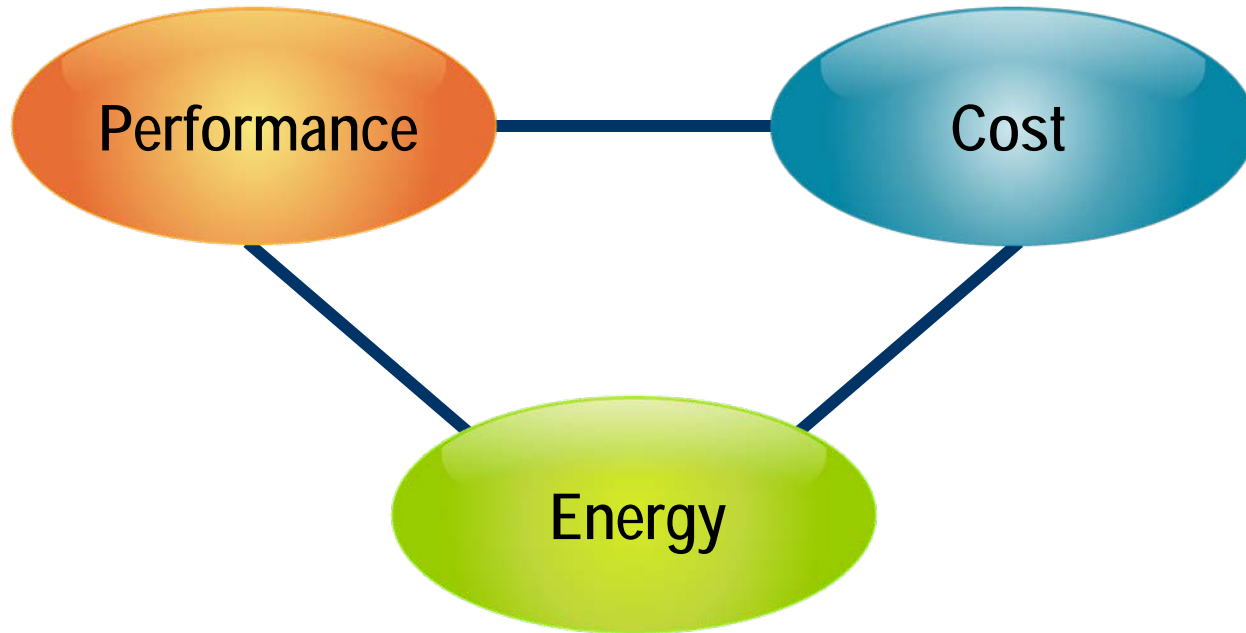
Nicholas (Nick) Ilyadis

VP and CTO

Broadcom Enterprise Networking Group

www.broadcom.com

Broadcom Energy Efficiency Vision and Mission

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

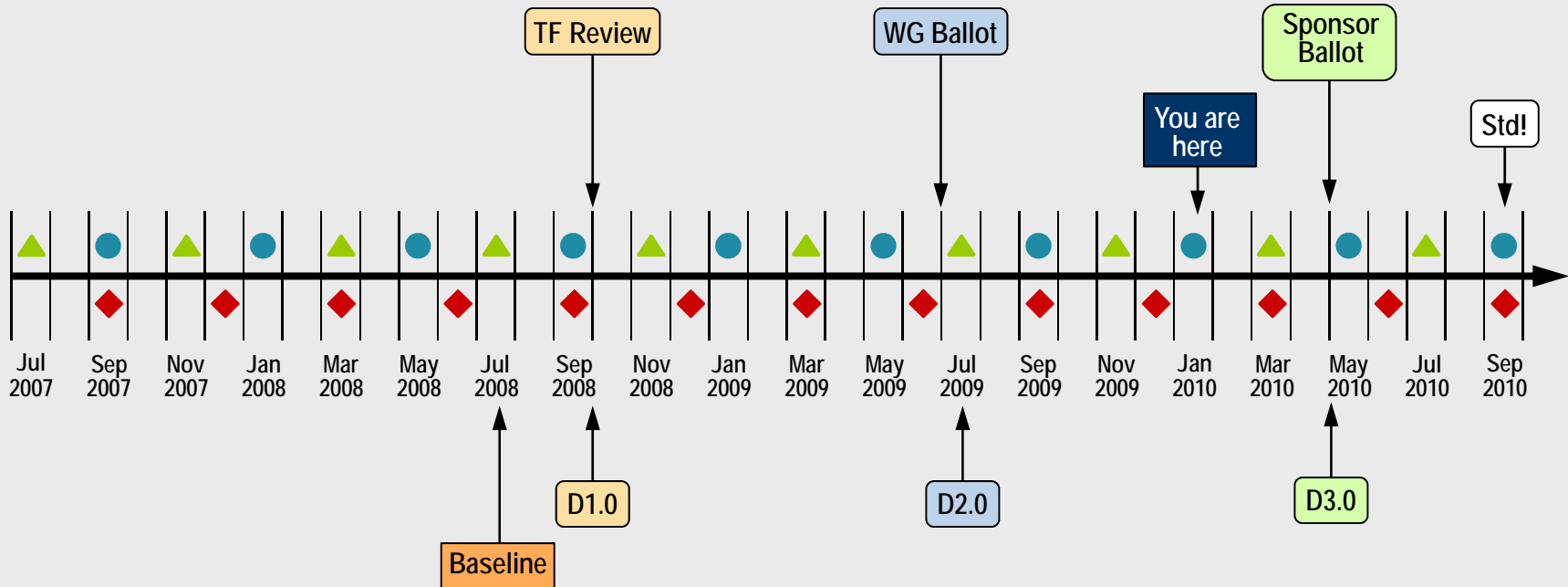## Process and Integration Power Efficiency Benefits

- 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

Task Force

TF Review — WG Ballot — Sponsor Ballot — You are here — Std!

Jul 2007 · Sep 2007 · Nov 2007 · Jan 2008 · Mar 2008 · May 2008 · Jul 2008 · Sep 2008 · Nov 2008 · Jan 2009 · Mar 2009 · May 2009 · Jul 2009 · Sep 2009 · Nov 2009 · Jan 2010 · Mar 2010 · May 2010 · Jul 2010 · Sep 2010

Baseline — D1.0 — D2.0 — D3.0

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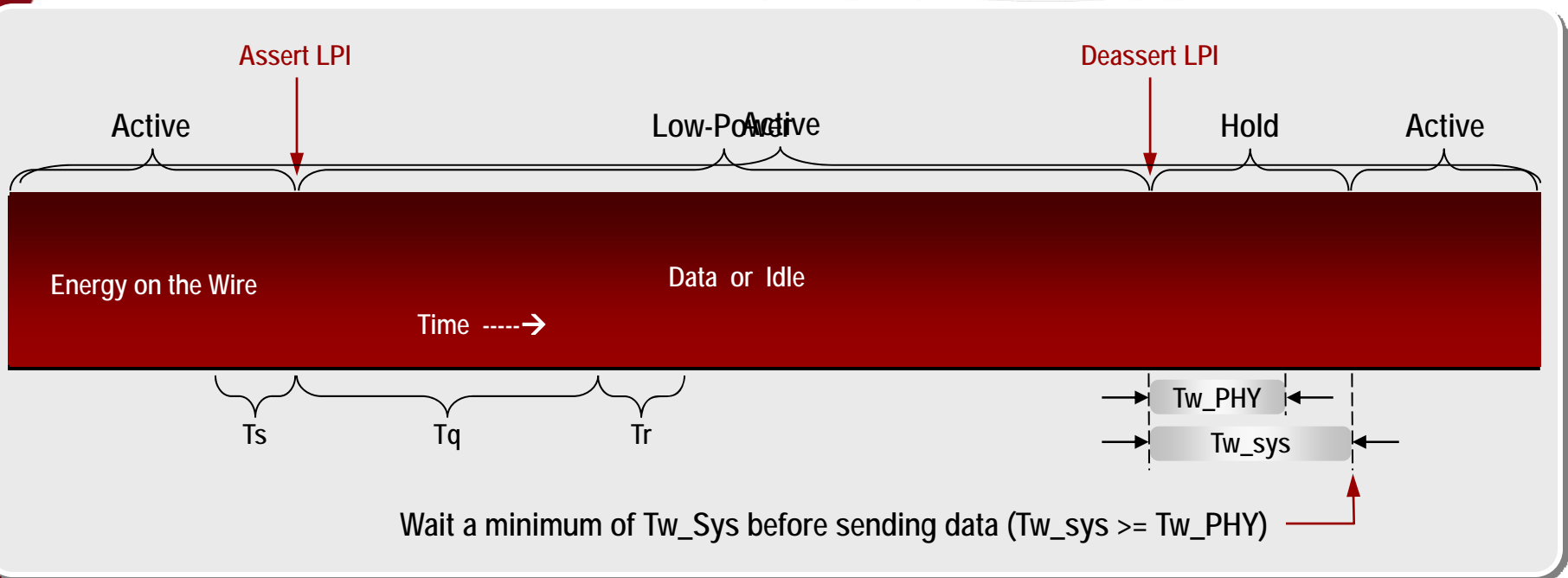Successful initial Working Group Ballot & Recirc (D2.0 - D2.3)

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

D2.4 will be published April 2010

Legend
- ▲ IEEE 802 Plenary
- ● IEEE 802 Interim
- ◆ IEEE-SA Standards Board

EEE Low Power Idle Overview

Assert LPI · Deassert LPI

| Active | Low-Power Active | Hold | Active |

Energy on the Wire

Data or Idle

Time ----->

Ts · Tq · Tr

Tw_PHY
Tw_sys

Wait a minimum of Tw_Sys before sending data (Tw_sys >= Tw_PHY)

- 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: $Tw\_PHY <= 30$ usec
    - 1000BASE-T: $Tw\_PHY <= 16.5$ usec
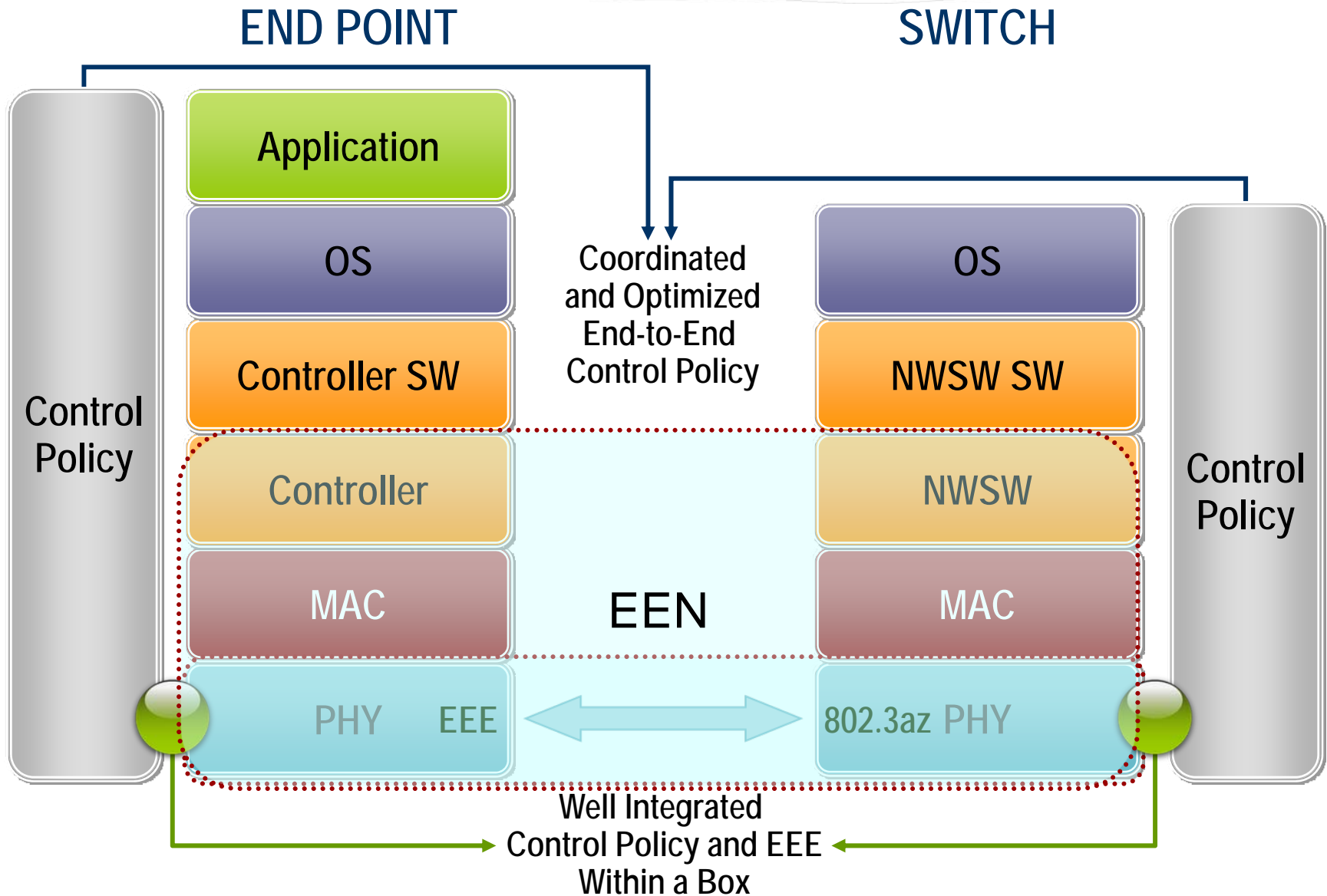   - 10GBASE-T: $Tw\_PHY < \sim8$ usec (2 modes)

Broadcom Enabling Energy Efficient Ethernet

Comprehensive Energy-Efficient Ethernet portfolio includes

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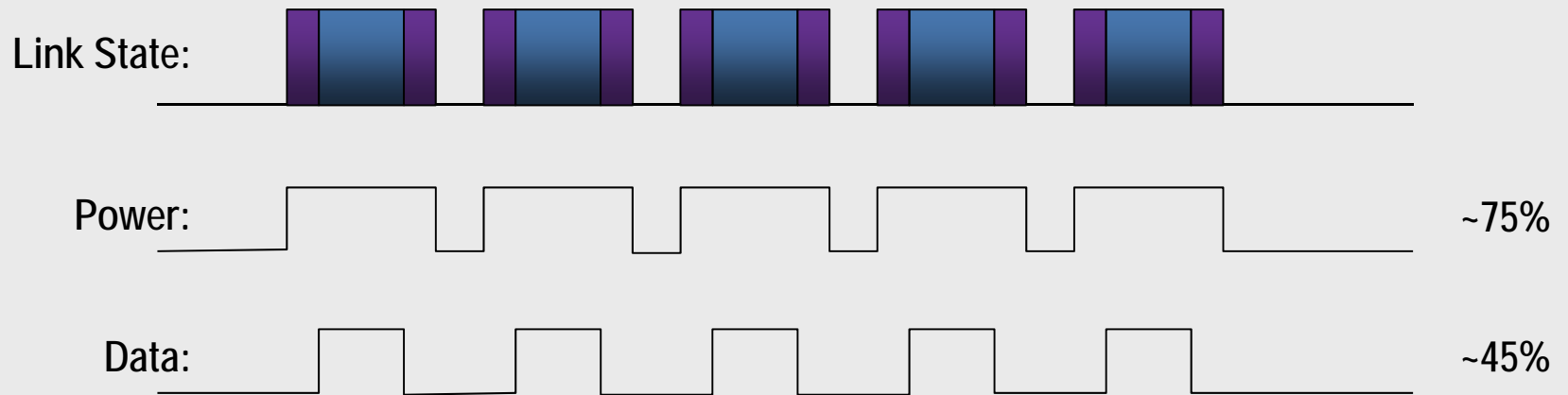Switches • SMB switches

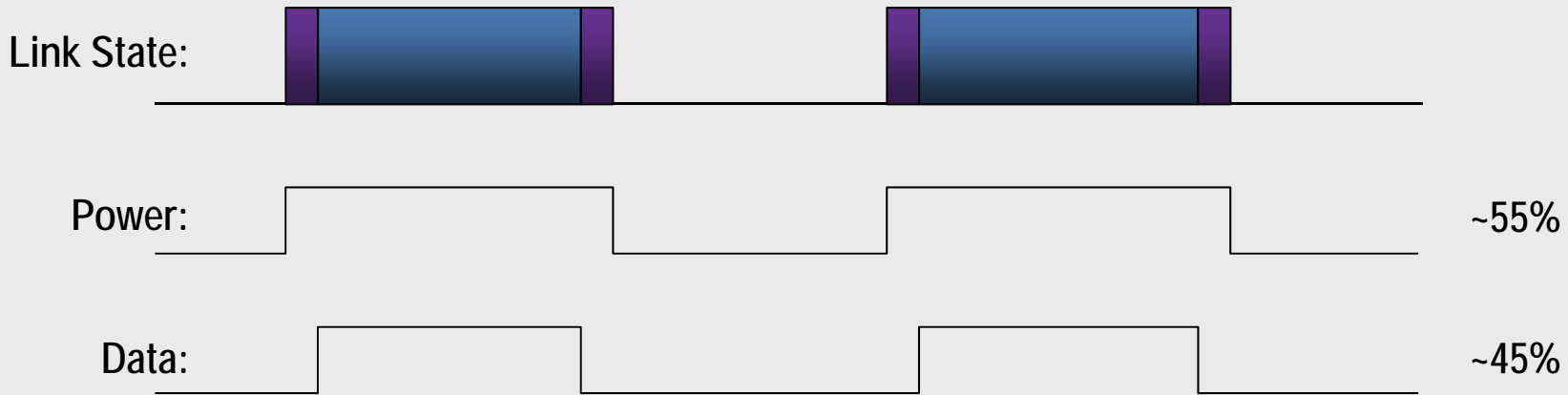# Broadcom's EEN: End-to-End Savings

END POINT

SWITCH

Control Policy

Application

OS

Controller SW

Controller

MAC

PHY   EEE

Coordinated and Optimized End-to-End Control Policy

EEN

OS

NWSW SW

NWSW

MAC

802.3az PHY

Control Policy

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

SWITCH

Broadcom Customizable and Optimized Control Policy

End Point stack (top to bottom): Application, OS, Controller SW, Controller, MAC, PHY — labeled "Broadcom Enabled"
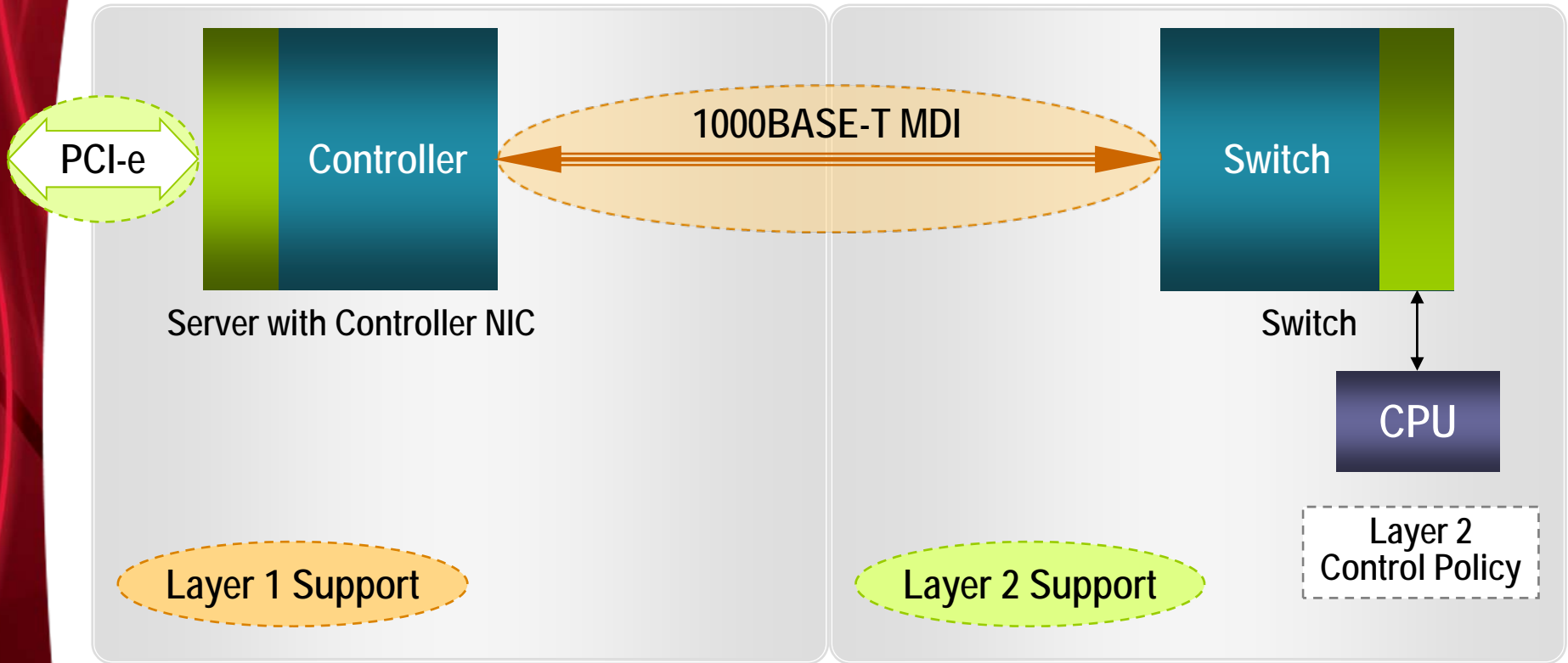
Switch stack (top to bottom): OS, NWSW SW, NWSW, MAC, PHY — labeled "Broadcom Enabled"
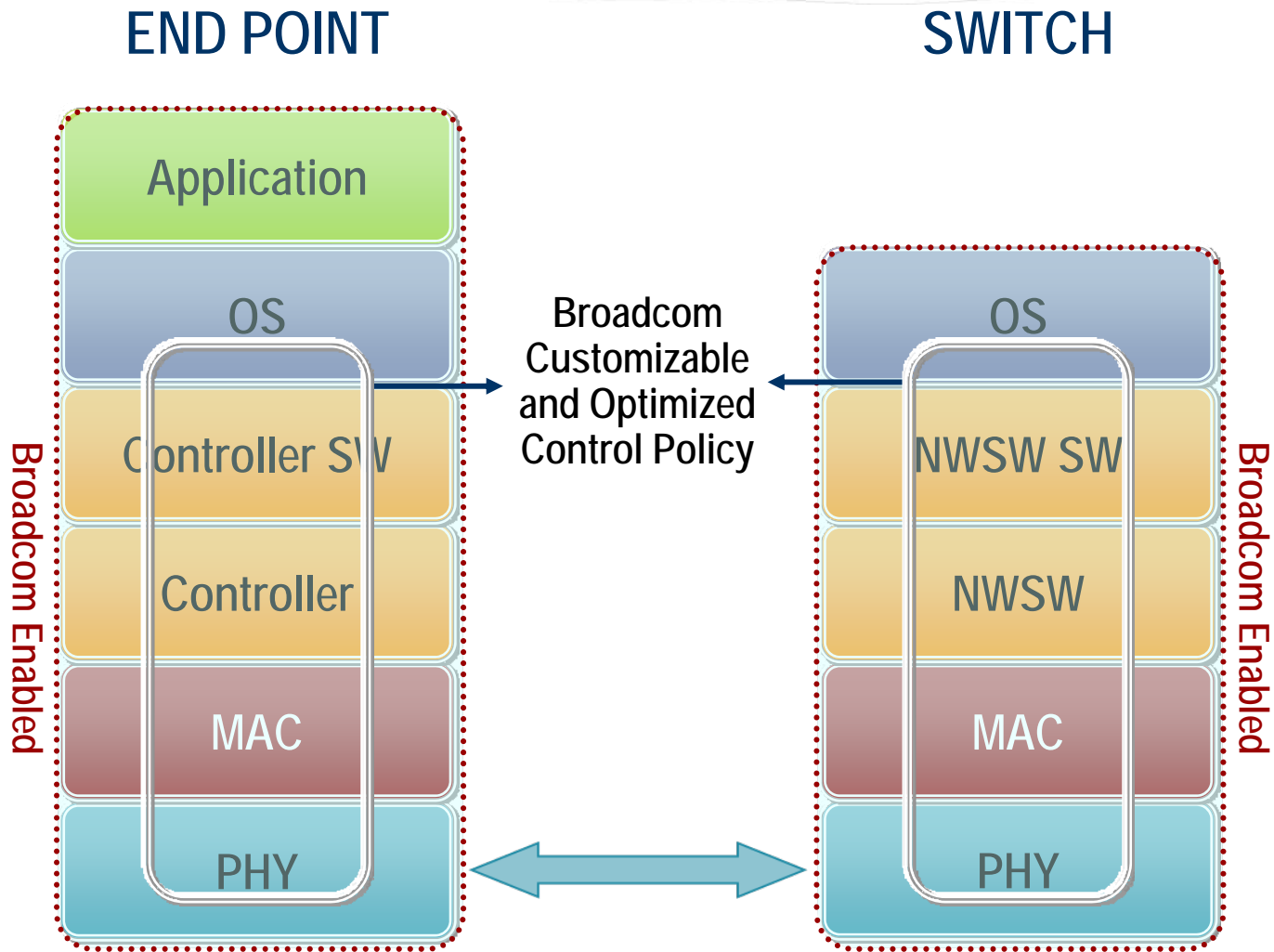
- Maximize energy efficiency by maximizing operation in saving states
- Minimize performance, latency impact by avoiding unnecessary transitions
- Customizable via FastPATH/SmartPATH Software

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*
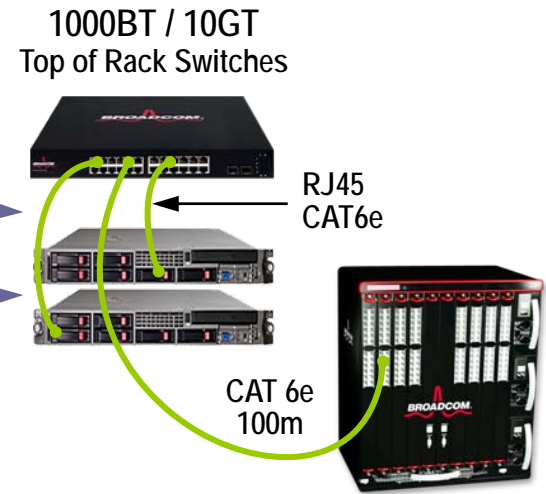
10GBASE-T Efficiency Trend

Dedicated Racks for 10G SFP+ & 1000BT

1000BT
Top of Rack Switches

10G SFP+
Top of Rack Switches

RJ45
CAT5/6e

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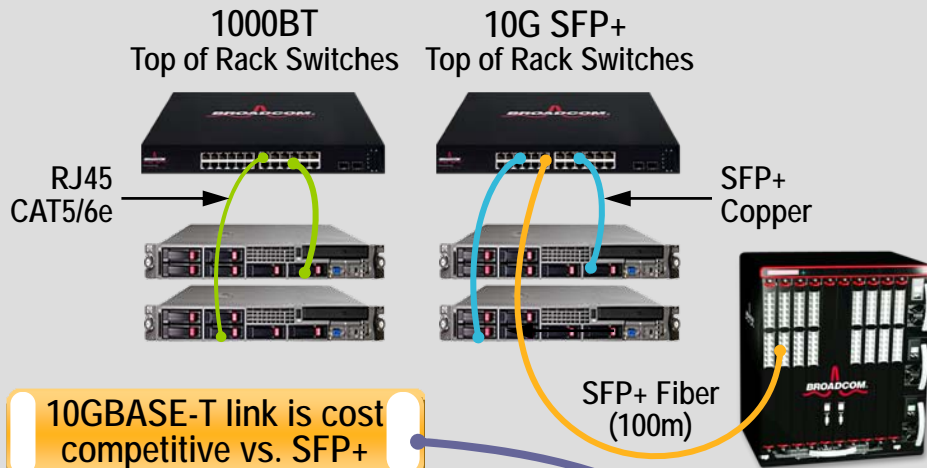
10GBASE-T link is cost competitive vs. SFP+

SFP+ Fiber
(100m)

6 port 1000Base-T installation

1G
Top of Rack Switches

Better cable management
More efficient bandwidth

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
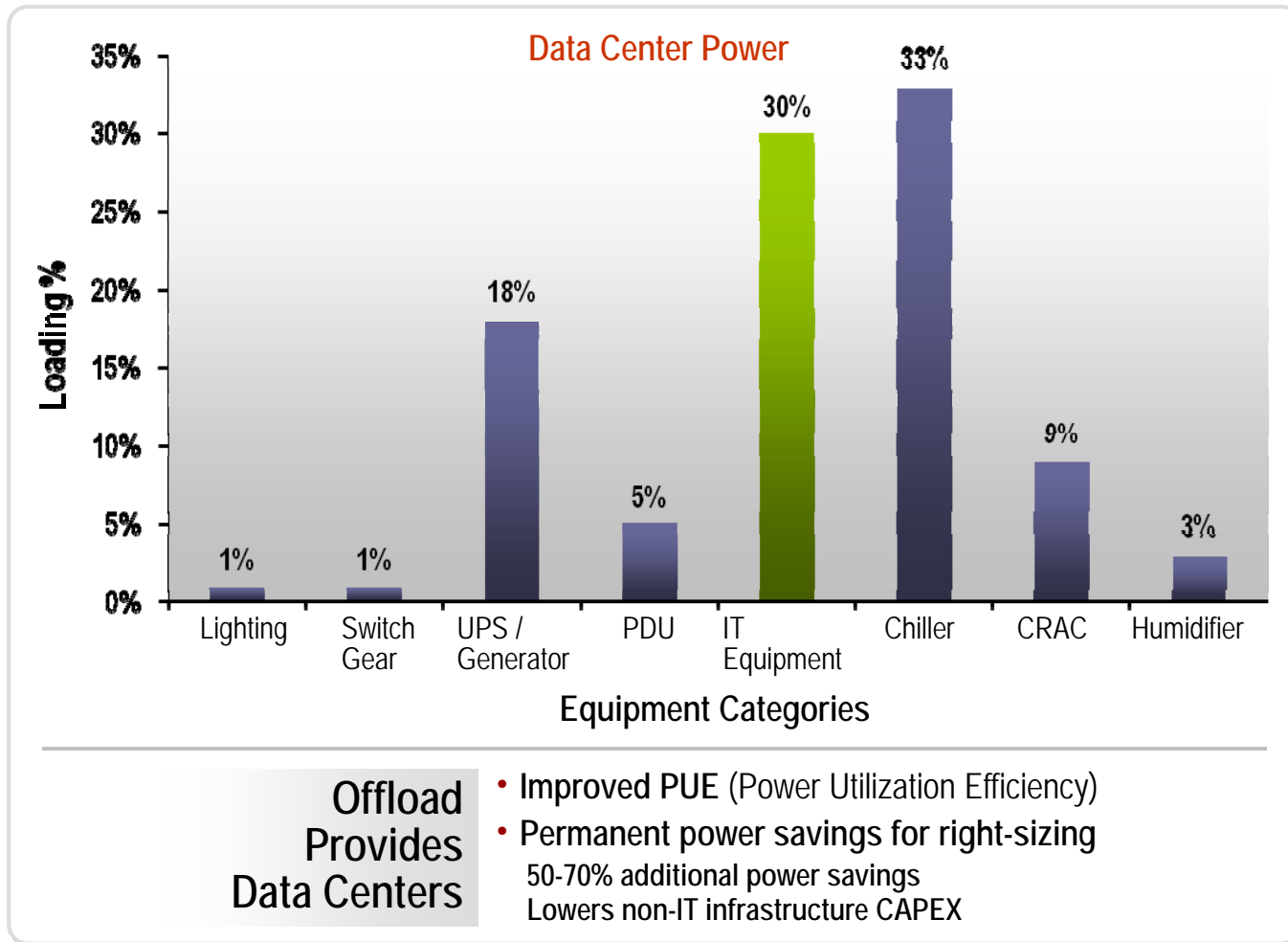
RJ45
CAT6e

CAT 6e
100m

400mW/Gbit

10GBase-T double power efficiency of 1000BT

200mW/Gbit

Improve Data Center Power Efficiency
Offload Significantly Improves Performance / Watt

Data Center Power

Offload
Provides
Data Centers

- **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 C-NIC Improves Power Utilization

Reduced power across full spectrum of data traffic patterns

BROADCOM.
Connecting
everything®

Heavy traffic

120W per server

~4000W per Rack

Stateful Offloads
~60W per port!

NetX II
NetXtreme II™

Power and performance optimization for <u>Maximum Link Utilization</u>

Broadcom EEE PHY

Switch

Energy Efficient Networking
Control Policy Driven (L2-L4)

Broadcom EEE PHY

Server

100%

25%

Without EEE — With EEE

PHY Level – 802.3az
Server, Storage, Switch

Broadcom EEE PHY

Power optimization for <u>Low Link Utilization</u> including Tunable Latency

Low traffic

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

Thank You