Technical Considerations and Possible Solution Sets for EEE

IEEE 802.3 Energy Efficient Ethernet Study Group
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Switching PHYs and Start-up

- **Autonegotiation**: 802.3 defines a standard compliant mechanism to switch between copper PHY types
  - Clause 28 autonegotiation

- **PHY Control**: 802.3 defines standard control actions, timing, and sequencing necessary to establish a link between two PHYs
  - Clause 40.4.2.4 (1000BT), 50.4.2.5 (10GBT)

- **Any other means for switching between speeds and establishing a link will require a** *enhancements to the standard*
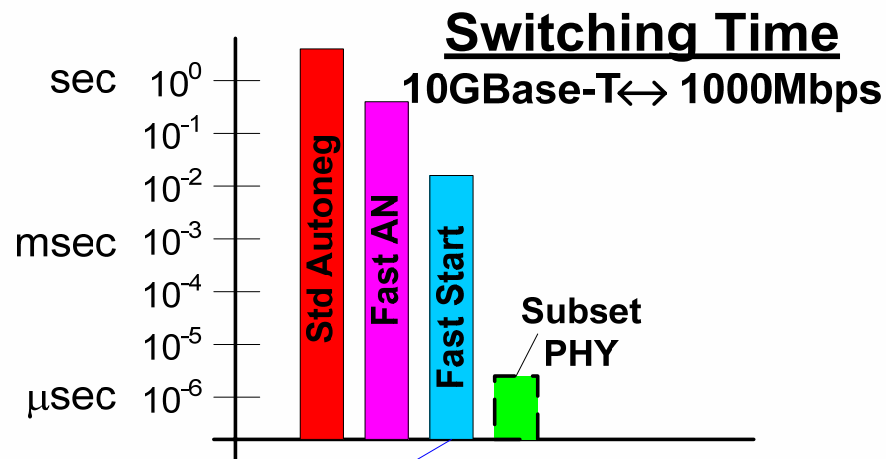
Enhancing the Standard

- **General agreement that standard autonegotiation + phy control requires too much switching time to be useful**
  - **This is the main reason for the existence of EEE**

- **To what extent is EEE willing to enhance the current standard to save power and reduce switching time ?**
  - **The answer most likely depends on "how much power" and "how much time"**
  - **Extent of modifications to the standard does not necessarily relate to extent of modifications to standard compliant PHYs**
    - **Ex: Reduce transmit voltage – simple tweak to PHY, big change to standard**
  - **The Task Force needs to solicit presentations which explore the relationship between power, switching time, and extent of enhancements to standard**
  - **The study group should not create objectives that unnecessarily limit the potential solution space**

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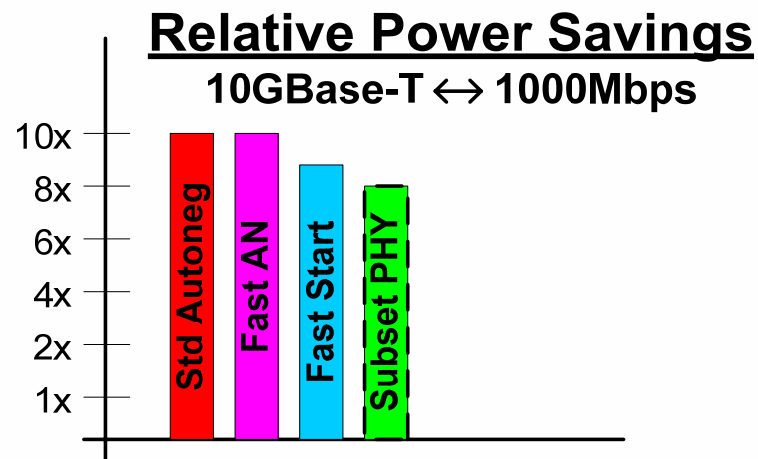
Possible Categories of Solutions

1. **Standard Autoneg + startup** **("Std Autoneg")**
   - aka, reset and re-establish at the new speed

2. **Skip unnecessary autoneg steps** **("Fast AN")**
   - Speed, duplex, M/S resolution, etc are all established on first link up
   - No need to re-negotiate after an EEE speed change

3. **Skip unnecessary start-up steps** **("Fast Start")**
   - Power backoff, precoder coefficient exchange, etc (10G)
   - Initialize filters, cancellers, control loops from last known state

4. **Switch between 802.3 PHY and subset PHY** **("Subset PHY")**
   - Define lower power PHY as a subset of the higher speed standard PHY

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Comparison of Possible Solutions

- **Assume 10GBase-T is the highest negotiated speed**
- **Speed and power of subset PHY are an early estimate of what's possible**

Switching Time
10GBase-T $\leftrightarrow$ 1000Mbps

sec 10^0			
10^{-1}			
10^{-2}			
msec 10^{-3}			
10^{-4}			
10^{-5}			
μsec 10^{-6}			

Bars: Std Autoneg, Fast AN, Fast Start, Subset PHY

20ms suggested in zimmerman_01_0307.pdf

Relative Power Savings
10GBase-T $\leftrightarrow$ 1000Mbps

10x, 8x, 6x, 4x, 2x, 1x

Bars: Std Autoneg, Fast AN, Fast Start, Subset PHY

10GBase-T ~ 10W
(www.linleygroup.com/npu/Newsletter/wire070517.html)

1GBase-T ~ 500mW
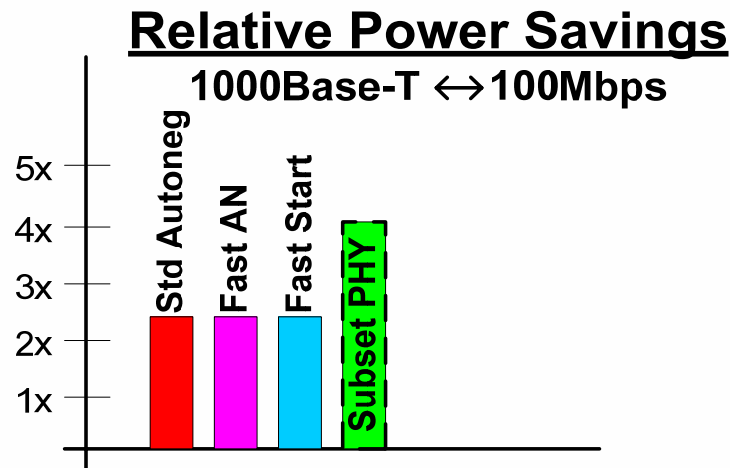(www.broadcom.com/collateral/pb/54980-PB201-R.pdf)

- **Power savings for various options is comparable**
- **Subset PHY offers potential to improve transition time by over 3 orders of magnitude**
  - μS instead of mS

Comparison of Possible Solutions

- **Assume 1000Base-T is the highest negotiated speed**
- **Speed and power of subset PHY are an early estimate of what's possible**

Switching Time
1000Base-T ↔ 100Mbps

sec, msec, µsec axis: 10^0, 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6}

Bars: Std Autoneg, Fast AN, Fast Start, Subset PHY
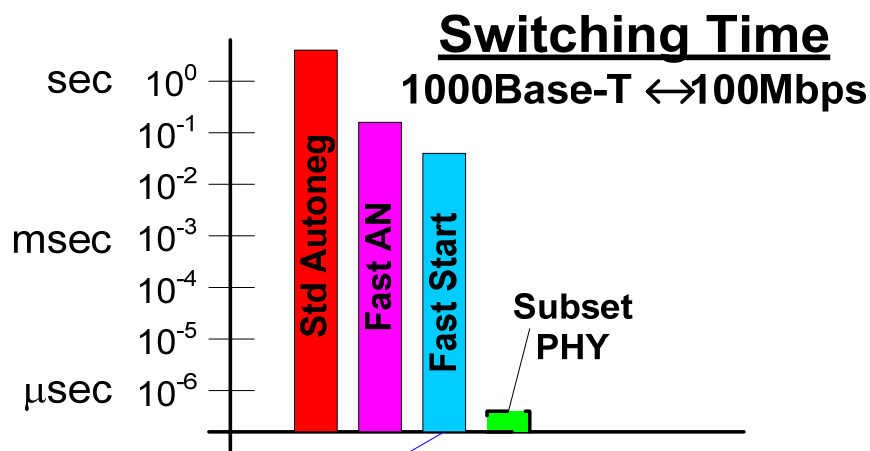
40ms suggested in chadha_1_0407[1].pdf

Relative Power Savings
1000Base-T ↔ 100Mbps

Axis: 5x, 4x, 3x, 2x, 1x

Bars: Std Autoneg, Fast AN, Fast Start, Subset PHY

100Base-TX ~ 200mW
(www.broadcom.com/collateral/pb/5241-PB01-R.pdf)

- **Subset PHY is ~2x lower power**
- **Subset PHY offers potential to improve transition time by over 4 orders of magnitude**
  - nS instead of mS

Summary

- **The currently defined standard method for changing data rates is too slow to be useful for EEE**
  - **The standard must be enhanced to allow for a more rapid change**

- **The best solution for EEE *may* be Rapid PHY Selection but …**
  - **The study group is not tasked with finding the best solution**
  - **RPS is only a subset of a larger potential solution space**
    - **At least three dimensional: speed, power, change**

- **The EEE objectives should be robust enough to encourage innovative solutions to be presented to the task force**
  - **Task force can always choose to reject proposals that are too far "out of the box"**

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