Asymmetrical Link Operation using EEE

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Asymmetrical Operation

- Several OEMs and Tier1s have expressed a desire for “asymmetrical” operation of .3ch PHYs and are concerned about not having an explicit objective for this.

- Adopted objectives state the following –
  3. Support full duplex operation only
  7. Support optional Auto-Negotiation
  8. Support optional Energy Efficient Ethernet

- This presentation discusses two methods of combining #3 and #8 to achieve efficient Asymmetrical operation

EEE background (Clause 97.1.2.3)

1000BASE-T1 PHY may **optionally** support the EEE capability, as described in 78.3.

The EEE capability is a mechanism by which 1000BASE-T1 PHYs are able to reduce power consumption during periods of low link utilization. PHYs can enter the LPI mode of operation after completing training.

Each direction of the full duplex link is able to enter and exit the LPI mode independently, **supporting symmetric and asymmetric LPI operation**. This allows power savings when only one side of the full duplex link is in a period of low utilization.

The transition to or from LPI mode shall not cause any MAC frames to be lost or corrupted.

In the transmit direction the transition to the LPI transmit mode begins when the PCS transmit function detects an “Assert Low Power Idle” condition on the GMII in the last 80B/81B block of a PHY frame. At the next PHY frame aligned to the wake window the PCS transmits a sleep signal composed of an entire PHY frame containing only LP_IDLE. The sleep signal indicates to the link partner that the transmit function of the PHY is entering the LPI transmit mode. Immediately after the transmission of the sleep frame, the transmit function of the local PHY enters the LPI transmit mode. While the transmit function is in the LPI mode the PHY may disable data path and control logic to save additional power. Periodically the transmit function of the local PHY transmits refresh frames that may be used by the link partner to update adaptive filters and timing circuits. LPI mode may begin with quiet signaling, a full refresh period, or a wake frame. The quiet-refresh cycle continues until the PCS function detects a condition that is not Assert Low Power Idle on the GMII. This condition signals to the PHY that the LPI transmit mode should end. At the next PHY frame the PCS transmits a wake frame composed of an entire PHY frame containing only Idle. On the next PHY frame normal power mode shall resume.

Support for EEE capability is advertised during Training. See 97.4.2.4.5 for details. Transitions to and from the LPI transmit mode are controlled via GMII signaling. Transitions to and from the LPI receive mode are controlled by the link partner using sleep and wake signaling. When the 1000BASE-T1 OAM SNR settings indicate that LPI is insufficient to maintain PHY SNR, the PHY may temporarily be forced to exit LPI mode and send idles. The PCS 80B/81B Transmit state diagram in Figure 97–14 includes additional states for EEE. The PCS80B/81B Receive state diagram in Figure 97–12 includes additional states for EEE.

Asymmetrical Transmission - Method 1

- Achieve Asymmetrical link operation using “normal” EEE
  - One direction of the link is put in a pre-determined PERIODIC SLEEP & WAKE sequence

  QUIET > REFRESH > WAKE > DATA > REPEAT

- Throughput of the the low-bandwidth side of the link is flexible and can be adjusted by the MAC by changing the Duration of LPI state

- For systems requiring only an initial burst of data in one direction (for example - reading camera or display attributes), the mechanism allows MAC to send a burst and then put that direction of the PHY in perpetual sleep state

- For systems requiring ongoing data transfer in the low-bandwidth direction, the method allows for flexible or fixed data rate

Asymmetrical Transmission - Method 2

- Achieve Asymmetrical link operation by putting one direction of the link in PERMANENT EEE state

QUIET > REFRESH > ~~WAKE~~ > ~~DATA~~ > REPEAT

Send DATA within REFRESH signal (if DATA is available from MAC)

Else send normal REFRESH signal

- Periodicity of REFRESH (containing DATA) determines peak bandwidth of the low-bandwidth side of the link
- For systems requiring only an initial burst of data (for example - reading camera or display attributes), the mechanism allows MAC to send a burst of DATA and then allows PHY to send Normal Refresh
- For systems requiring ongoing data transfer in the low-bandwidth direction, the method allows for flexible or fixed data rate by adjusting the period of Refresh signal

Summary

- Method 1 does not require any change to the existing EEE framework
- 1000BASE-T1 and future -T1 PHYs can “optionally” implement and utilize EEE to achieve Asymmetrical Link
- Do we want to consider making EEE – “required” ?
- Method 2 requires modification of existing EEE framework but could result in following benefits
  - Overall lower power operation
  - Reduced latency due to removal of time needed for WAKE state