METHOD AND SYSTEM FOR MANAGING ENERGY EFFICIENCY OF A NETWORK LINK VIA PLUGGABLE TRANSCIEVER MODULES IN AN ENERGY EFFICIENT NETWORK DEVICE

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ABSTRACT

An Ethernet network may comprise link partners that may be coupled via an Ethernet link. The link partners may comprise pluggable PHY devices. The pluggable PHY devices and/or other link partner devices may determine energy efficient network (EEN) control policies, may select a power level mode and may configure the link partners to operate in the power level mode. Some components may be reconfigured prior to sending an energy efficient network control signal to a link partner and configuring remaining components. Hardware, software and/or firmware may execute the pluggable PHY energy efficient network control policies. Packet data pending delivery may be buffered in the pluggable PHY. The pluggable PHY devices may comprise a MAC and/or a SERDES device. Exemplary form factors for the pluggable PHYs may comprise a SFP, a SFP+, a XENPAK, a X2, a XFP and/or a XPAK. Low power idle mode and/or sub-rate mode may be utilized.

Pluggable Transceiver Module (SFP, SFP+, GBIC, SFP, XENPAK, X2, XFP, XPAK)
Establish physical layer communications within a pluggable PHY device

Detect condition(s) for a power mode state transition

Trigger a state transition in at least the pluggable PHY device

Implement a different mode of operation in the pluggable PHY device

Transmit a physical layer, energy efficient networking control signal to link partner

Completion of transition

FIG. 5
METHOD AND SYSTEM FOR MANAGING ENERGY EFFICIENCY OF A NETWORK LINK VIA PLUGGABLE TRANSCEIVER MODULES IN AN ENERGY EFFICIENT NETWORK DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS/INCORPORATION BY REFERENCE

[0001] This application makes reference to, claims priority to, and claims the benefit of U.S. Provisional Application Ser. No. 61/111,653, filed on Nov. 5, 2008.

[0002] This application makes reference to:


[0008] Each of the above stated applications is hereby incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

[0009] Certain embodiments of the invention relate to networking. More specifically, certain embodiments of the invention relate to a method and system for managing energy efficiency of a network link via pluggable transceiver modules in an energy efficient network device.

BACKGROUND OF THE INVENTION

[0010] Communications networks and in particular Ethernet networks, are becoming an increasingly popular means of exchanging data of various types and sizes for a variety of applications. In this regard, Ethernet networks are increasingly being utilized to carry voice, data, and multimedia traffic. Accordingly, more and more devices are being equipped to interface to Ethernet networks. Broadband connectivity including internet, cable, phone and VoIP offered by service providers has led to increased traffic and more recently, migration to Ethernet networking. Much of the demand for Ethernet connectivity is driven by a shift to electronic lifestyles involving desktop computers, laptop computers, and various handheld devices such as smart phones and PDAs. Applications such as search engines, reservation systems and video on demand that may be offered at all hours of a day and seven days a week, have become increasingly popular.

[0011] These recent developments have led to increased demand on datacenters, aggregation, high performance computing (HPC) and core networking. As the number of devices connected to data networks increases and higher data rates are required, there is a growing need for new transmission technologies which enable higher data rates. Conventionally, however, increased data rates often result in significant increases in power consumption. In this regard, as an increasing number of portable and/or handheld devices are enabled for Ethernet communications, battery life may be a concern when communicating over Ethernet networks. Accordingly, ways of reducing power consumption when communicating over Ethernet networks may be needed.

[0012] Further limitations and disadvantages of conventional and traditional approaches will become apparent to one of skill in the art, through comparison of such systems with the present invention as set forth in the remainder of the present application with reference to the drawings.

BRIEF SUMMARY OF THE INVENTION

[0013] A system and/or method for managing energy efficiency of a network link via pluggable transceiver modules in an energy efficient network device, substantially as shown in and/or described in connection with at least one of the figures, as set forth more completely in the claims.

[0014] Various advantages, aspects and novel features of the present invention, as well as details of an illustrated embodiment thereof, will be more fully understood from the following description and drawings.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

[0015] FIG. 1 is a block diagram illustrating an exemplary Ethernet connection between two network devices, in accordance with an embodiment of the invention.

[0016] FIG. 2 is a block diagram illustrating an exemplary Ethernet over twisted pair PHY device architecture comprising a multi-rate capable physical module, in accordance with an embodiment of the invention.

[0017] FIG. 3 is a block diagram illustrating an exemplary pluggable PHY device operable to implement an energy efficient network control policy.

[0018] FIG. 4A is a block diagram illustrating an exemplary copper based pluggable PHY device, in accordance with an embodiment of the invention.

[0019] FIG. 4B is a block diagram illustrating an exemplary pluggable optical PHY device, in accordance with an embodiment of the invention.

[0020] FIG. 5 is a flow chart illustrating exemplary steps implementing an energy efficient network control policy in a pluggable physical layer device, in accordance with an embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0021] Certain embodiments of the invention can be found in a method and system for managing energy efficiency of a network link via pluggable transceiver modules in an energy efficient network device. An Ethernet network may comprise one or more link partners that may be coupled via an Ethernet link. The one or more link partners may comprise one or more pluggable PHY devices. The pluggable PHY devices and/or higher layer devices may be operable to determine one or more energy efficient network control policies that may specify a power level mode for the one or more link partners, and the one or more link partners may be configured to operate in the specified power level mode. In various embodiments of the invention, a power level mode of operation may be selected based on the energy efficient network control policies. Accordingly, one or more components of the pluggable PHY devices may be reconfigured based on the selected power level mode of operation. A first portion of the one or more components may be reconfigured prior to sending an energy efficient network control signal to one or more of the link partners and reconfiguring a remaining portion of the one...
or more components. Hardware, software and/or firmware within the one or more pluggable PHY devices may be utilized to execute the one or more energy efficient network control policies. In some instances, while transitioning to an active power mode, packet data that may be pending delivery in the one or more pluggable PHY devices may be buffered. The one or more pluggable PHY devices may comprise one or both of a media access controller and/or a serializer de-serializer device. Exemplary form factors for the one or more pluggable PHY devices may comprise one or more of a SFP, a XFP+, a XENPAK, a X2, a XFP and a XPAK form factor. The power level mode may comprise low power idle mode and/or sub-rate mode.

[0022] FIG. 1 is a block diagram illustrating an exemplary Ethernet connection between a two network devices, in accordance with an embodiment of the invention. Referring to FIG. 1, there is shown a system 100 that comprises a network device 102 and a network device 104. In addition, there is shown two hosts 106a and 106b, two MAC controllers 108a and 108b, a pluggable PHY device 110a and a PHY device 110b, interfaces 114a and 114b, bus controller interfaces 116a and 116b and a link 112.

[0023] The network devices 102 and 104 may be link partners that may communicate via the link 112. The Ethernet link 112 is not limited to any specific medium and may utilize any suitable medium. Exemplary Ethernet link 112 media may comprise copper, optical and/or backplane technologies. For example, copper medium such as STP, Cat5, Cat5, Cat5e, Cat6, Cat7 and/or Cat7a as well as ISO nomenclature variants may be utilized. Additionally, copper media technologies such as InfiniBand, Ribbon and backplane may be utilized. With regard to optical media for the Ethernet link 112, single mode fiber as well as multi-mode fiber may be utilized. In various embodiments of the invention, one or both of the network devices 102 and 104 may be operable to comply with one or more standards based on IEEE 802.3, for example, 802.3az.

[0024] In an exemplary embodiment of the invention, the link 112 may comprise up to four or more physical channels, each of which may, for example, comprise an unshielded twisted pair (UTP). The network device 102 and the network device 104 may communicate via two or more physical channels comprising the link 112. For example, Ethernet over twisted pair standards 10 BASE-T and 100 BASE-TX may utilize two pairs of UTP while Ethernet over twisted pair standards 1000 BASE-T and 10 GBASE-T may utilize four pairs of UTP. In this regard, however, aspects of the invention may enable varying the number of physical channels via which data is communicated.

[0025] The network device 102 may comprise a host 106a, a medium access control (MAC) controller 108a and a pluggable PHY device 110a. The network device 104 may comprise a host 106b, a MAC controller 108b, and a PHY device 110b. The PHY device(s) 110a and/or 110b may be pluggable transceiver modules or may be an integrated PHY device. Notwithstanding, the invention is not limited in this regard. In various embodiments of the invention, the network device 102 and/or 104 may comprise, for example, a network switch, a router, computer systems or audio/video (A/V) enabled equipment. In this regard, A/V equipment may, for example, comprise a microphone, an instrument, a sound board, a sound card, a video camera, a media player, a graphics card, or other audio and/or video device. Additionally, the network devices 102 and 104 may be enabled to utilize Audio/Video Bridging and/or Audio/video bridging extensions (collectively referred to herein as audio video bridging or AVB) for the exchange of multimedia content and associated control and/or auxiliary data.

[0026] The pluggable PHY device 110a and the PHY device 110b may each comprise suitable logic, circuitry, interfaces and/or code that may enable communication, for example, transmission and reception of data, between the network device 102 and the network device 104. One or both of the PHY device 110a and 110b may comprise pluggable modules. In this regard, the pluggable device(s) may be a removable or replaceable component within a network communication device. The pluggable PHY device(s) 110a and/or 110b may comprise suitable logic, circuitry, interfaces and/or code that may provide an interface between the network device(s) 102 and/or 104 to an optical and/or copper cable. In some instances, the pluggable device(s) 110a and/or 110b may enable interfacing host and/or MAC that are designed to communicate over a copper link to an optical link or vice versa. Exemplary form factors for the pluggable device(s) 110a and/or 110b comprise SFP, SFP+, XENPAK, X2, XFP and XPAK modules. In various embodiments of the invention, the pluggable PHY device(s) 110a and/or 110b may be enabled to be replaced without shutting down the entire network device.

[0027] The pluggable PHY device 110a and/or the PHY device 110b may be operable to support, for example, Ethernet over copper, Ethernet over fiber, and/or backplane Ethernet operations. The pluggable PHY device 110a and/or the PHY device 110b may enable multi-rate communications, such as 10 Mbps, 100 Mbps, 1000 Mbps (or 1 Gbps), 2.5 Gbps, 4 Gbps, 10 Gbps, 40 Gbps or 100 Gbps for example. In this regard, the pluggable PHY device 110a and/or the PHY device 110b may support standard-based data rate limits and/or non-standard data rate limits. Moreover, the pluggable PHY device 110a and/or the PHY device 110b may support standard Ethernet link lengths or ranges of operation and/or extended ranges of operation. The pluggable PHY device 110a and/or the PHY device 110b may enable communication between the network device 102 and the network device 104 by utilizing a link discovery signaling (LDS) operation that enables detection of active operations in the other network device. In this regard, the LDS operation may be configured to support a standard Ethernet operation and/or an extended range Ethernet operation. The pluggable PHY device 110a and/or the PHY device 110b may also support autonegotiation for identifying and selecting communication parameters such as speed and duplex mode.

[0028] The pluggable PHY device 110a and/or the PHY device 110b may comprise a pluggable twisted pair PHY capable of operating at one or more standard rates such as 10 Mbps, 100 Mbps, 1 Gbps, and 10 Gbps (10 BASE-T, 100 BASE-TX, 1 GBASE-T, and/or 10 GBASE-T); potentially standardized rates such as 40 Gbps and 100 Gbps; and/or non-standard rates such as 2.5 Gbps and 5 Gbps. The pluggable PHY device 110a and/or the PHY device 110b may comprise a pluggable backplane PHY capable of operating at one or more standard rates such as 2.5 Gbps and 5 Gbps. The pluggable PHY device 110a and/or the PHY device 110b may comprise a pluggable optical PHY capable of operating at one or more standard ranges such as 10 Mbps, 100 Mbps, 1 Gbps, and 10 Gbps; potentially standardized ranges such as 40 Gbps and 100 Gbps; and/or non-stan-
dardized rates such as 2.5 Gbps and 5 Gbps. In this regard, the optical PHY may be a passive optical network (PON) PHY.

[0029] The pluggable PHY device 110a and/or the PHY device 110b may support multi-stand network topologies such as 40 Gbps CR4, ER4, KR4; 100 Gbps CR10, SR10 and/or 10 Gbps LX4 and CX4. Also, serial electrical and copper single channel technologies such as XX, KR, SR, LR, LRM, SX, LX, CX, BX10, LX10 may be supported. Non standard speeds and non-standard technologies, for example, single channel, two channel or four channels may also be supported. More over, TDM technologies such as PON at various speeds may be supported by the network devices 102 and/or 104.

[0030] In various embodiments of the invention, the pluggable PHY device 110a and/or the PHY device 110b may comprise suitable logic, circuitry, and/or code that may enable transmission and/or reception at a high(er) rate in one direction and transmission and/or reception at a low(er) data rate in the other direction. For example, the network device 102 may comprise a multimedia server and the network device 104 may comprise a multimedia client. In this regard, the network device 102 may transmit multimedia data, for example, to the network device 104 at high(er) data rates while the network device 104 may transmit control or auxiliary data associated with the multimedia content at low(er) data rates.

[0031] The data transmitted and/or received by the pluggable PHY device 110a and/or the PHY device 110b may be formatted in accordance with the well-known OSI protocol standard. The OSI model partitions operability and functionality into seven distinct and hierarchical layers. Generally, each layer in the OSI model is structured so that it may provide a service to the immediately higher interfacing layer. For example, layer 1, or physical layer, may provide services to layer 2 and layer 2 may provide services to layer 3. The hosts 106a and 106b may implement layer 3 and above, the MAC controllers 108a and 108b may implement layer 2 and above and the pluggable PHY device 110a and/or the PHY device 110b may implement the operability and/or functionality of layer 1 or the physical layer. In this regard, the pluggable PHY device 110a and/or the PHY device 110b may refer to one or more interface transmitters and/or receivers, physical layer transceivers, PHY transceivers, and PHY devices, for example. The hosts 106a and 106b may comprise suitable logic, circuitry, and/or code that may enable operability and functionality of the five highest functional layers for packets that are to be transmitted over the link 112. Since each layer in the OSI model provides a service to the immediately higher interfacing layer, the MAC controllers 108a and 108b may provide the necessary services to the hosts 106a and 106b to ensure that packets are suitably formatted and communicated to the pluggable PHY device 110a and/or the PHY device 110b. During transmission, a device implementing a layer function may add its own header to the packet and then pass it to the next layer. However, during reception, a compatible device having a similar OSI stack may strip off the headers as the message passes from the lower layers up to the higher layers.

[0032] The pluggable PHY device 110a and/or the PHY device 110b may be configured to handle physical layer requirements, which include, but are not limited to, packetization, data transfer and serialization/deserialization (SERDES), in instances where such an operation is required. Data packets received by the pluggable PHY device 110a and/or the PHY device 110b from MAC controllers 108a and 108b, respectively, may include data and header information for each of the six functional layers above the PHY layer. The pluggable PHY device 110a and/or the PHY device 110b may be configured to encode data packets that are to be transmitted over the link 112 and/or to decode data packets received from the link 112.

[0033] In various embodiments of the invention, one or both of the pluggable PHY device 110a and the PHY device 110b may comprise suitable logic, circuitry, interfaces, and/or code that may be operable to implement one or more energy efficient Ethernet (EEE) techniques in accordance with IEEE 802.3az as well as other energy efficient network techniques. For example, the pluggable PHY device 110a and/or the PHY device 110b may be operable to support low power idle (LPI) and/or sub-rating, also referred to as set PHY, techniques. LPI may generally refer to a family of techniques where, instead of transmitting conventional IDLE symbols during periods of inactivity, the pluggable PHY device 110a and/or the PHY device 110b may remain silent and/or communicate signals other than conventional IDLE symbols. Sub-rating, or sub-set PHY, may generally refer to a family of techniques where the PHY's are re-configurable, in real-time or near real-time, to communicate at different data rates.

[0034] In various embodiments of the invention, the host 106a and/or 106b may be operable to communicate LPI control information with the pluggable PHY devices 110a and/or 110b via an alternate path. For example, the host 106a and/or the host 106b may be operable to communicate via a general purpose input output (GPIO) and/or a peripheral component interconnect express (PCI-E).

[0035] The MAC controller 108a may comprise suitable logic, circuitry, and/or code that may enable handling of data link layer, layer 2, operability and/or functionality in the network device 102. Similarly, the MAC controller 108b may comprise suitable logic, circuitry, and/or code that may enable handling of layer 2 operability and/or functionality in the network device 104. The MAC controllers 108a and 108b may be configured to implement Ethernet protocols, such as those based on the IEEE 802.3 standards, for example. Notwithstanding, the invention is not limited in this regard.

[0036] The MAC controller 108a may communicate with the pluggable PHY device 110a via an interface 114a and with the host 106a via a bus controller interface 116a. The MAC controller 108b may communicate with the PHY device 110b via an interface 114b and with the host 106b via a bus controller interface 116b. The interfaces 114a and 114b correspond to Ethernet interfaces that comprise protocol and/or link management control signals. The interfaces 114a and 114b may be multi-rate capable interfaces and/or media independent interfaces (MII). The bus controller interfaces 116a and 116b may correspond to PCI or PCI-X interfaces. Notwithstanding, the invention is not limited in this regard.

[0037] In operation, one or both of the pluggable PHY device 110a and/or the PHY device 110b may comprise a pluggable module that may support one or more energy efficient network (EEN) techniques. Accordingly, an energy efficient network (EEN) control policy may be implemented in firmware, hardware, and/or software within the pluggable module(s). The EEN control policy may determine how and/or when to configure and/or reconfigure the pluggable PHY device 110a and/or the PHY device 110b to optimize a tradeoff between energy efficiency and performance. For LPI, the control policy may determine, for example, what variant
of LPI to utilize, when to go into a LPI mode and when to come out of a LPI mode. For subset PHY, the pluggable PHY device 110a may be operable to determine, for example, how to achieve a desired data rate and/or when to transition between data rates. Although various aspects of the invention are described with regard to LPI and subset PHY, the invention is not so limited and other EEN techniques may be implemented via a pluggable PHY based control policy. In various embodiments of the invention, the pluggable PHY device 10 may be operable to communicate EEN control policy information with the host 106a via a GPIO and/or a PCI-E, for example.

[0038] In instances when the energy efficient network (EEN) control policy may be implemented at the physical layer (PHY), it may be transparent to open systems interconnect (OSI) Layer 2 and above. A pluggable PHY device that implements such an EEN control policy may thus be a drop-in replacement for a conventional PHY device.

[0039] Accordingly, such a pluggable PHY device, and the energy efficient network control policy implemented by the PHY device, may be compatible with a legacy MAC and/or a legacy host. In this manner, implementing an energy efficient network control policy in a pluggable PHY device 110a and/or 110b may enable reapuring the benefits of a more energy efficient network while avoiding the need to redesign or “respin” a MAC 108 or a host 106.

[0040] FIG. 2 is a block diagram illustrating an exemplary Ethernet over twisted pair PHY device architecture comprising a multi-rate capable physical module, in accordance with an embodiment of the invention. Referring to FIG. 2, there is shown a network device 200 which may comprises an Ethernet over twisted pair pluggable PHY device 202, a MAC controller 204, a host 206 and interfaces 116 and 114. The pluggable PHY device 202 may be a pluggable transceiver device which may comprise a multi-rate capable physical layer module 212, one or more transmitters 214, one or more receivers 220, a memory 216, a memory interface 218, and one or more input/output interfaces 222.

[0041] The pluggable PHY device 202 may be a pluggable transceiver module that may comprise a multi-rate capable physical layer module 212, one or more transmitters 214, one or more receivers 220, a memory 216, a memory interface 218, and one or more input/output interfaces 222. The operation of the pluggable PHY device 202 may be the same as or substantially similar to that of the pluggable PHY device 110a disclosed in FIG. 1. In this regard, the pluggable PHY device 202 may provide OSI layer 1 (physical layer) operability and/or functionality that enables communication with a remote PHY device. Similarly, the operation of the MAC controller 204, the host 206 and the interfaces 114 and/or 116 may be the same as or substantially similar to the respective MAC controllers 108a and 108b, hosts 106a and 106b and interfaces 116a, 116b, 114a and 114b described with respect to FIG. 1. The MAC controller 204 may comprise a multi-rate capable interface 204a that may comprise suitable logic, circuitry, interfaces and/or code to enable communication with the pluggable PHY device 202 at a plurality of data rates via the interface 208.

[0042] The interface 114 may be the same as or substantially similar to the interfaces 114a and 114b described with respect to FIG. 1. The interface 114 may comprise, for example, a media independent interface such as XGMII, GMII, or RGMII for communicating data to and from the pluggable PHY device 202. In this regard, the interface 114 may comprise a signal to indicate that data from the MAC 204 to the pluggable PHY 202 is imminent on the interface 114. Such a signal is referred to herein as a transmit enable (TX_EN) signal. Similarly, the interface 114 may utilize a signal to indicate that data from the PHY 202 to the MAC 204 is imminent on the interface 114. Such a signal is referred to herein as a receive data valid (RX_DV) signal. The interface 114 may also comprise a control interface such as a management data input/output (MDIO) interface.

[0043] The multi-rate capable physical layer module 212 in the pluggable PHY device 202 may comprise suitable logic, circuitry, and/or code that may enable operability and/or functionality of physical layer requirements. In this regard, the multi-rate capable physical layer module 212 may enable generating the appropriate link discovery signaling utilized for establishing communication with a remote PHY device in a remote network device. The multi-rate capable physical layer module 212 may communicate with the MAC controller 204 via the interface 114. In various embodiments of the invention, the interface 114 may be a media independent interface (MII) and may be configured to utilize a plurality of serial data lanes for receiving data from the multi-rate capable physical layer module 212 and/or for transmitting data to the multi-rate capable physical layer module 212. The multi-rate capable physical layer module 212 may be configured to operate in one or more of a plurality of communication modes, where each communication mode may implement a different communication protocol. These communication modes may include, but are not limited to, Ethernet over twisted pair standards 10 BASE-T, 100 BASE-TX, 1000 BASE-T, 10 GBASE-T, and other similar protocols that utilize multiple physical channels between network devices. The multi-rate capable physical layer module 212 may be configured to operate in a particular mode of operation upon initialization or during operation. In this regard, the pluggable PHY device 202 may operate in a normal mode or in one of a plurality of an energy saving modes. Exemplary energy saving modes may comprise a low power idle (LPI) mode and one or more sub-rate modes where the pluggable PHY device 202 may communicate at less than a maximum supported or initially negotiated data rate.

[0044] In various embodiments of the invention, the multi-rate capable physical layer module 212 may comprise suitable logic, circuitry, interfaces, and/or code for implementing an energy efficient networking (EEN) control policy. Accordingly, the multi-rate capable physical layer module 212 may be operable to monitor one or more conditions and/or signals in the pluggable PHY device 202 and control mode of operation based on the monitoring. In this regard, the multi-rate capable physical layer module 212 may generate one or more control signals to configure and/or reconfigure the various components of the pluggable PHY device 202.

[0045] The multi-rate capable physical layer module 212 may comprise memory 216a and/or be coupled to memory 216b through a memory interface 218. The memories 216a and 216b, referred collectively herein as memory 216, may comprise suitable logic, circuitry, and/or code that may enable storage or programming of information that includes parameters and/or code that may effectuate the operation of the multi-rate capable physical layer module 212. In this regard, the memory 216 may, for example, comprise one or more registers which may be accessed and/or controlled via a MDIO portion of the interface 114. Additionally, the memory 216 may buffer data received via the inter-
face 114 prior to converting the data to physical symbols and transmitting it via one or more of the interfaces 222. For example, data from the interface 114 may be buffered while the PHY transitions from an energy saving mode to a higher performance mode (transitioning out of LPI mode) or from a higher data rate to a sub-rate, for example. Also, the memory 216 may buffer data received via one or more of the interfaces 222 prior to converting the data to physical symbols and transmitting it via the interface 114. For example, data received via the link 112 may be buffered in the memory block 216 while higher layer functions and/or circuitry, such as a MAC or PCI bus, come out of an energy saving mode.

Each of the transmitters 214a, 214b, 214c, 214d, collectively referred to herein as transmitters 214 may comprise suitable logic, circuitry, and/or code that may enable transmission of data from the network device 200 to a remote network device via, for example, the link 112 shown in FIG. 1. The receivers 220a, 220b, 220c, 220d may comprise suitable logic, circuitry, and/or code that may enable receiving data from a remote network device. Each of the transmitters 214a, 214b, 214c, 214d and receivers 220a, 220b, 220c, 220d in the pluggable PHY device 202 may correspond to a physical channel that may comprise the link 112. In this manner, a transmitter/receiver pair may interface with each of the physical channels 224a, 224b, 224c, and 224d. In this regard, the transmitter/receiver pairs may be enabled to support various communication rates, modulation schemes, and signal levels for each physical channel. In this manner, the transmitters 214a, 214b, 214c, 214d and/or receivers 220a, 220b, 220c, 220d may support various modes of operation that enable management of energy consumption of the PHY device 202 and energy consumption on the link 112. Accordingly, one or more of the transmitters 214a, 214b, 214c, 214d and/or receivers 220a, 220b, 220c, 220d may be powered down and/or otherwise configured based on a mode of operation of the pluggable PHY device 202.

The input/output interfaces 222 may comprise suitable logic circuitry, and/or code that may enable the pluggable PHY device 202 to impress signal information onto a physical channel, for example a twisted pair of the link 112 disclosed in FIG. 1. Consequently, the input/output interfaces 222 may, for example, provide conversion between differential and single-ended, balanced and unbalanced, signaling methods. In this regard, the conversion may depend on the signaling method utilized by the transmitter 214, the receiver 220, and the type of medium of the physical channel. Accordingly, the input/output interfaces 222 may comprise one or more baluns and/or transformers and may, for example, enable transmission over a twisted pair. Additionally, the input/output interfaces 222 may be internal or external to the pluggable PHY device 202. In this regard, if the pluggable PHY device 202 comprises an integrated circuit, then “internal” may, for example, refer to being “on-chip” and/or sharing the same substrate. Similarly, if the pluggable PHY device 202 comprises one or more discrete components, then “internal” may, for example, refer to being on the same printed circuit board or being within a common physical package.

The pluggable PHY device 202 may be enabled to transmit and receive simultaneously over up to four or more physical links. Accordingly, the pluggable PHY device 202 may comprise a number of hybrids 226 corresponding to the number of physical links. Each hybrid 226 may comprise suitable logic, circuitry, and/or code that may enable separating transmitted and received signals from a physical link. For example, the hybrids may comprise echo cancellers, far-end crosstalk (FEXT) cancellers, and/or near-end crosstalk (NEXT) cancellers. Each hybrid 226 in the network device 200 may be communicatively coupled to an input/output interface 222. One or more of the hybrids 226 may be enabled to support various modes of operation that enable managing energy consumption of the pluggable PHY device 202 and energy consumption on the link 112. Accordingly, portions of the hybrids 226 may be powered down and/or otherwise configured based on a mode of operation of the pluggable PHY device 202.

In operation, the network device 200 may communicate with a remote partner via the link 112. For example, for 10 Gbps Ethernet, the network device 200 may transmit data to and receive data from a remote partner via the physical channels 224a, 224b, 224c, and 224d. In this regard, when there is no data for the network device 200 to transmit, then it may transmit idle symbols to keep itself and/or the remote partner “trained”. In this manner, power consumption of a network may be largely independent of the amount of actual data being transmitted over the network. Accordingly, controlling the data rate limit on the link 112 may enable the network devices 200 to transmit fewer idle symbols and thus communicate in a more energy efficient manner. In this regard, the pluggable PHY device 202 may implement an energy efficient network control policy to decide when to transition between various modes of operation. The control policy may affect a tradeoff between performance and energy consumption. Performance may be measured by a variety of metrics such as jitter, latency, bandwidth and error rates, for example.

In one exemplary embodiment of the invention, the control policy may determine when and how to utilize subruting to improve energy efficiency. Accordingly, the control policy may determine what data rate to utilize, how to configure the various components of the pluggable PHY device 202 to realize a selected data rate, and when to transition between data rates. In this regard, the pluggable PHY device 202 may be operable to generate one or more control signals, based on the control policy, to configure or reconfigure the transmitters 214, receivers 220, hybrids 226, the memory 216, and/or one or more portions of the multi-rate capable PHY module 212. The pluggable PHY device 202 may also be operable to generate signals for communicating energy efficient network (EEN) states and/or decisions to a link partner based on the control policy.

In another exemplary embodiment of the invention, the control policy implemented by the pluggable PHY device may make determinations as to when and how to utilize low power idle (LPI) to improve energy efficiency. Accordingly, the control policy may determine when to go into an LPI mode, how to configure the various components of the PHY device 202 when in LPI mode, and when to come out of a LPI mode. The PHY device 202 may also be operable to, based on the control policy, generate signals for communicating EEN states and/or decisions to a link partner.

The pluggable PHY device 202 and/or devices implementing higher OSI layer functions may be placed in a low power idle mode (LPI) wherein the pluggable PHY device and/or the devices implementing high layers may be powered down during idle periods. In some instances, LPI control information regarding when to power down, may be communicated via a GPIO and/or PCI-E. During power down, the pluggable PHY device 202 may maintain various coefficients, for example, adaptive filter and/or block coefficients and may maintain synchronization to allow for a more
rapid return to an active state. In addition, during LPI mode, a portion of the receiver circuitry may be turned off. In asymmetric systems, devices that handle one direction of communication may be in a quiet state independent of devices that handle communication in an opposite direction. In synchronous systems, both directions of a PHY device may enter and/or leave a quiet state together. Although a PHY device 202 may operate in a synchronous mode, devices that may handle OSI layers above the PHY layer may operate in an asymmetric mode.

[0053] FIG. 3 is a block diagram illustrating an exemplary pluggable PHY device operable to implement an energy efficient network control policy, in accordance with an embodiment of the invention. Referring to FIG. 3, there is shown a pluggable PHY device 302, a MAC 304, a host 306, an interface 350, the interface 114 and the link 112. The PHY device 302 may comprise a PHY and logic module 308 for implementing the physical coding sublayer (PCS), the physical media attachment (PMA) sublayer and/or the physical media dependent (PMD) sublayer; and an optional control policy assist module 314. The PHY and logic module 308 may comprise one or more transmit buffers 310a, one or more receive buffers 310b.

[0054] The pluggable PHY device 302 and the MAC 304 may be similar or substantially the same as the pluggable PHY device 202 and the MAC 204 respectively, which are described with respect to, for example, FIG. 2. The host 306 may be similar and/or substantially the same as the host 106 and/or the host 206 described with respect to FIG. 1 and FIG. 2 respectively. The interface 114 and the link 112 are described with respect to, for example, FIG. 1.

[0055] In various embodiments of the invention, the host 306 may be operable to communicate LPI control information with the control policy assist module 314 GPIO and/or a PCI-E bus, for example, via the interface 350. In this regard, the host 306 may indicate when the control policy assist may go into and/or out of an LPI mode.

[0056] The pluggable PHY device 302 may comprise suitable logic, circuitry, interfaces and/or code that may be operable to implement physical layer functionality. In this regard, the physical coding sublayer (PCS), physical medium attachment (PMA) sublayer, and physical medium dependent (PMD) sublayer may be implemented via hardware, firmware, and/or software represented as the PHY and logic module 308. The PHY and logic module 308 may be operable to perform one or more of physical encoding and/or decoding, PMA framing, and transmitter and/or receiver operations. The PHY and logic module 308 may comprise one or more transmit buffers 310a that may be operable to store data received via the interface 114 and destined for transmission on the link 112. The PHY and logic module 308 may comprise one or more receive buffers 310b that may be operable to store data received via the link 112 and destined for the MAC 304 via the interface 114.

[0057] The pluggable PHY device 302 may also comprise an optional control policy assist module 314 which may comprise suitable logic, circuitry, interfaces and/or code that may be operable to implement an energy efficient network control policy. In various exemplary embodiments of the invention, the pluggable PHY device 302 may comprise memory 316 and/or one or more counters 318. In various embodiments of the invention, the optional control policy assist module 314 may be operable to generate energy efficient network control information to be communicated to a link partner and/or process energy efficient network control information received from a link partner.

[0058] The memory 316 may comprise one or more state registers and/or configuration registers. The registers may comprise content that may be read to control transitioning of the pluggable PHY device 302 into and/or out of low(er) power level modes of operation. Additionally, the memory 316 may be allocated and reallocated to supplement the Tx buffer 310a and/or the Rx buffer 310b.

[0059] In various embodiments of the invention, the pluggable PHY device 302 may comprise suitable logic, circuitry, interfaces and/or code that may be operable to communicate via a link comprising an extended range. In this regard, the PHY layer architecture in the pluggable PHY device 302 may support signal-processing operations, such as echo cancellation and/or equalization, which may be applied to a reduced communication rate to enable range extension. Range extension is described in greater detail in U.S. patent application Ser. No. 11/473,205 (Attorney Docket No. 17396-US02) filed Jun. 22, 2006 titled “Method and System for Extended Reach Copper Transceiver,” which is hereby incorporated herein by reference in its entirety.

[0060] The pluggable PHY device 302 may comprise suitable logic, circuitry, interfaces and/or code that may be operable to support MACSEC communication. For example, the pluggable PHY device 302 may support controlled network access wherein network device identities may be validated and network security policies may be enforced. MACSEC is described in greater detail in U.S. patent application Ser. No. 11/685,554 (Attorney Docket No. 1803-US01) filed Mar. 13, 2007 titled “Method and System for Tunneling MACSEC Packets Through Non-MACSEC Nodes,” which is hereby incorporated herein by reference in its entirety.

[0061] In operation, the energy efficient network (EEN) control policy may make decisions such as when to enter and/or exit a low(er) power mode. EEN control policy decisions and the resulting actions, such as reconfiguring the pluggable PHY device 302, may be determined based on one or more signals and/or conditions monitored within the pluggable PHY device 302. Several examples of factors which may be considered by the control policy follow. Many of the examples are simplified and various embodiments of the invention may utilize a combination of two or more of them. Nevertheless, the invention is not limited to the examples provided.

[0062] Management of the energy efficient network (EEN) protocols and/or techniques may be based, for example, on an amount of data buffered in the buffers 310a and/or the memory 316. For example, in instances that the Tx buffer 310a [Rx buffer 310b] is empty, or is empty for a certain amount of time, portions of the PHY device 302 associated with data transmission [reception] may be reconfigured into a low(er) power state.

[0063] Management of the energy efficient network protocols and/or techniques may be based, for example, on one or more counters and/or registers in the optional control policy assist module 314. For example, in instances that the TX_EN of the interface 114 has not been asserted for a determined period of time, portions of the pluggable PHY device 302 associated with data transmission [reception] may be reconfigured into a low(er) power state. Additionally, values of the counter may be stored and historical values of the counter may be utilized to predict when the pluggable PHY device
302 may transition to a low(er) power mode without having a significant negative impact on performance. [0064] Management of the energy efficient network protocols and/or techniques may be based, for example, on management signals of an MDIO bus to the MAC. For example, the MDIO may configure thresholds such as how long the pluggable PHY device 302 should stay in a low(er) power mode after entering the low(er) power mode, how long a buffer should be empty before going into a low(er) power mode, and how full a buffer should be before waking up from a low(er) power mode. The MDIO may also be utilized to configure parameters pertaining to a link partner. Exemplary parameters comprise how long the link partner takes to wake up and how much buffering is available in the link partner’s buffers. The MDIO may enable configuration of the control policy by a system designer or administrator. [0065] Management of the energy efficient network protocols and/or techniques may be based, for example, on signals received from a device implementing layers above the MAC layer, such as signals generated by a PCI bus controller and/or the host 306. For example, a signal indicating whether the PCI bus is active may be utilized to predict whether data will be arriving at the pluggable PHY device 302 and/or to determine whether the devices implementing higher layers are ready to receive data from the pluggable PHY device 302. For another example, signals from the host 306, or other data processing components, may indicate a type of traffic communicated to the pluggable PHY device 302 and the control policy may determine an appropriate mode of operation of the pluggable PHY device 302 and/or an appropriate allocation of buffering, or other resources, in the PHY device 302 based on the data type. In this regard, management of the energy efficient network protocols and/or techniques may be based, for example, on latency constraints of the traffic to be transmitted via the link 112 or communicated up to the MAC 304. In instances when latency is not tolerable, a series of traffic bursts may be buffered for an acceptable amount of time before waking the pluggable PHY device 302, the MAC 304, and/or devices implementing higher layer functions for delivery of the accumulated traffic bursts. [0066] Management of the energy efficient network protocols and/or techniques may be based, for example, on signals received from a link partner to which the pluggable PHY device 302 is communicatively coupled. In this regard, going into and coming out of low(er) power modes may require agreement by the link partner, or at least awareness of what the link partner is doing. For example, in instances that the link partner takes longer to wake up then the pluggable PHY device 302, the pluggable PHY device 302 may need to plan accordingly and allocate sufficient memory to the Tx buffer 310a. Conversely, in instances that the link partner wakes up faster than the pluggable PHY device 302, the pluggable PHY device 302 may need to plan accordingly and allocate sufficient memory to the Rx buffer 310b and/or instruct the link partner to increase its Tx buffer to hold off transmissions. A similar situation may occur when a link partner has less buffering available than the pluggable PHY device 302. Accordingly, in some embodiments of the invention, the control policy may be operable to dynamically allocate and reallocate as the memory 316, for example, to supplement the Tx buffer 310a or the Rx buffer 310b. [0067] FIG. 4A is a block diagram illustrating an exemplary, copper based pluggable PHY device, in accordance with an embodiment of the invention. Referring to FIG. 4A, there is shown a MAC 404, a host 406, an interface 450, a serial link 414, a pluggable PHY device 402, the PHY and logic module 308, the control policy assist module 314 and the link 112. [0068] The MAC 404, the host 406, the interface 450 and pluggable PHY device 402 may be similar and/or substantially the same as the MAC 304, the host 306, the interface 350 and pluggable PHY device 302 described with respect to, for example, FIG. 3. The PHY and logic module 308 and the control policy assist module 314 are described with respect to FIG. 3. The link 112 is described with respect to, for example FIG. 1. [0069] The pluggable PHY device 402 may comprise suitable logic, circuitry, interfaces and/or code that may be operable to implement an energy efficient network (EEN) control policy. The pluggable PHY device 402 may be a removable or replaceable component within a network communication device. In various embodiments of the invention, the pluggable PHY device 402 may be enabled so that it may be replaced without shutting down the entire network device. In this regard, the pluggable PHY device 402 may comprise a hot swappable PHY device. The pluggable PHY device 402 may comprise the PHY and logic module 308, the control policy assist module 314. In this regard, the pluggable PHY device 402 may be operable to determine when to enter and/or exit a low(er) power mode and may be operable to communicate EEN control policy instructions to one or more link partners. [0070] In operation, the MAC 404 may be integrated within a network device such as a switch, for example. [0071] In an exemplary embodiment of the invention, the pluggable PHY device 402 may support 10 GBASE-T. The pluggable PHY device 402 may be coupled to the MAC 404 via the serial link 414. The pluggable PHY device 402 may monitor the serial link 414 and/or the link 112 and may determine when data may and/or may not be available for transmission and/or reception. The pluggable PHY device 402 may determine when to enter and/or exit an energy efficient network (EEN) low(er) power mode and may configure the various components of the pluggable PHY device 402 accordingly. The pluggable PHY device 402 may also be operable to generate signals for communicating energy efficient network (EEN) states and/or decisions to a link partner. [0072] FIG. 4B is a block diagram illustrating an exemplary pluggable optical PHY device, in accordance with an embodiment of the invention. Referring to FIG. 4B, there is shown a MAC 424, a host 456, an interface 458, a pluggable PHY device 422, the serializer-deserializer (SerDes) 426, a SerDes 428, a MAC and logic module 420, the PHY and logic module 308, the control policy assist module 314 and the link 112. [0073] The MAC 424, the host 456, the interface 458 and the pluggable PHY device 422 may be similar and/or substantially the same as the MAC 304, the host 306, the interface 350 and pluggable PHY device 302 described with respect to FIG. 3. The PHY and logic module 308 and the control policy assist module 314 are described with respect to FIG. 3. The link 112 is described with respect to FIG. 1. [0074] The SerDes 426 and SerDes 428 may comprise suitable logic, circuitry, interfaces and/or code that may be operable to convert data between serial data and parallel data in forward and/or reverse directions. In various embodiments of the invention, the SerDes 426 and/or 428 may be operable to perform line coding and/or framing functions.
The MAC and logic module 420 may comprise suitable logic circuitry interfaces and/or code that may be operable to implement Ethernet protocols, such as those based on the IEEE 802.3 standards, for example 802.3az. In various embodiments of the invention, the MAC 420 may be operable to handle MACSEC for secure communication. For example, the MAC and logic module 420 may support network access wherein network device identities may be validated and network security policies may be enforced.

The pluggable PHY device 422 may comprise suitable logic, circuitry, interfaces and/or code that may be operable to implement an energy efficient network control policy. The pluggable PHY device 422 may be a removable or replaceable component within a network communication device. In various embodiments of the invention, the pluggable PHY device 422 may be enabled to be replaced without shutting down the entire network device. The pluggable PHY device 422 may comprise the PHY and logic module 308, the control policy assist module 314. In this regard, the pluggable PHY device 422 may be operable to determine when to enter and/or exit a low(er) power mode and may be operable to communicate the energy efficient network control policy instructions to one or more link partners.

In operation, the MAC 424 may be integrated within a network device comprising, for example, a switching device. The pluggable PHY device 422 may provide an interface between the MAC 424 and the link 112 which may comprise a fiber optic medium. In various embodiments of the invention, the pluggable PHY device 422 may be operable to interface a MAC that may be designed to communicate via a fiber optic link, to a copper link such as a twisted pair. The pluggable PHY device 422 may comprise a form factor similar to, for example, a small form-factor pluggable (SFP), an SFP+, a GHIC, a XENpak, a X2, a XFP and/or a XPAK.

The SerDes 426 may convert parallel data received from the MAC 424, to serial data and may convert serial data received from the pluggable PHY device 422 to parallel data. In this regard, the pluggable PHY device 422 may be coupled to the SerDes 426 via the serial link 444. In order to make MAC functionality compatible with the energy efficient network control policy, the MAC and Logic module 420 may be integrated within the pluggable PHY device 422. The SerDes 426 receives serial data from the SerDes 426 and converts the data to a parallel format for the MAC and logic module 420. The parallel data may be sent to the MAC and logic module 420 for processing which may then forward data to the pluggable PHY device 422.

The pluggable PHY device 422 may determine when to enter and/or exit an energy efficient network low(er) power mode and may configure the various components of the pluggable PHY device 422 accordingly. The pluggable PHY device 422 may also be operable to generate signals for communicating energy efficient network states and/or decisions to a link partner.

FIG. 5 is a flow chart illustrating exemplary steps implementing an energy efficient network (EEN) control policy in a pluggable physical layer device, in accordance with an embodiment of the invention. Referring to FIG. 5, the exemplary steps may begin with step 502 when communications may be established between a pluggable PHY device 302 described with respect to FIG. 3 (pluggable PHY device 1) of a first link partner and a PHY device (PHY 2) of a second link partner. PHY 2 may be a pluggable device or may be an integrated device. Subsequent to step 502, the exemplary steps may advance to step 504. In step 504, conditions may be detected for a power mode state transition of at least the pluggable PHY device 1. It may be determined that pluggable PHY device 1 should transition to a different mode of operation. Configuration of the pluggable PHY device 1 for the different mode and/or when to perform the transition may be determined. In various embodiments of the invention, an energy efficient network control policy may determine how to configure the pluggable PHY device 1 for the different mode and when to perform the transition. The energy efficient network control policy may be implemented in the pluggable PHY device 1 or in a device that implements a higher layer protocol. Subsequent to step 504 the exemplary steps may advance to step 506.

In step 506, a status transition in at least the pluggable PHY device 1 may be triggered. For example, an energy efficient network control policy may trigger the state transition. In this regard, one or more control signals may be generated in the pluggable PHY device 1 and/or a higher layer device. For example, the optional energy efficient network control policy assist module 314 described with respect to FIG. 3, may reconfigure one or more components of the pluggable PHY device 1 to implement the different mode of operation. Subsequent to step 506, the exemplary steps may advance to step 508.

In step 508, a different mode of operation may be implemented. In this regard a portion of the pluggable PHY device 1 may be powered up and/or reconfigured to implement the different mode of operation. Subsequent to step 508, the exemplary steps may advance to step 510.

In step 510, pluggable PHY device 1 may transmit a control signal to PHY 2 to indicate that it desires, and/or has decided, to transition to a different state of operation. In this regard, the control signal may cause an energy efficient network control policy on the PHY 2 to trigger a transition to a new mode of operation and/or to reallocate resources such as buffers. Subsequent to step 510, the exemplary steps may advance to step 512.

In step 512, PHY 2 may complete the transition to the different mode of operation. In this regard, one or more control signals may be generated in the pluggable PHY device 1, by the energy efficient network control policy module 314 in FIG. 3, for example, to reconfigure one or more components of the pluggable PHY device 1 to implement the different mode of operation. In some embodiments of the invention, the transition may comprise training of one or more components such as, NEXT, PEXT, and echo cancellers. Subsequent to step 512, the pluggable PHY device 1 may operate in the different mode of operation and until the control policy determines to transition again.

In an embodiment of the invention, an Ethernet network 100 may comprise one or more link partners 102 and/or 104 that may be coupled via an Ethernet link 112. The one or more link partners 102 and/or 104 may comprise one or more pluggable PHY devices 402 and/or 422 for example. The pluggable PHY devices 402 and/or 422 may be operable to determine one or more energy efficient network control policies that may specify a power level mode for the one or more link partners 102 and/or 104 and the one or more link partners may be configured to operate in the specified power level mode. In various embodiments of the invention, a power level mode of operation may be selected based on the energy efficient network control policies. Accordingly one or more components of the pluggable PHY devices 402 and/or 422 may be
reconfigured based on the selected power level mode of operation. A first portion of the one or more components may be reconfigured prior to sending an energy efficient network control signal to one or more of the link partners 102 and/or 104 and reconfiguring a remaining portion of the one or more components.

[0086] Hardware, software and/or firmware 314 within the one or more pluggable PHY devices 402 and/or 422 may be utilized to execute the one or more energy efficient network control policies. In some instances, while transitioning to an active power mode, packet data that may be pending delivery in the one or more pluggable PHY devices may be buffered in the TX FIFOs 310a. The one or more pluggable PHY devices 402 and/or 422 may comprise one or both of a media access controller 414 and/or a serializer-de-serializer device 428. Exemplary form factors of the one or more pluggable PHY devices 402 and/or 422 may comprise one or more of a SFP, a SFP+, a XENPAK, a X2, a XFP and a XPAK form factor. The power level mode may comprise low power idle mode and/or sub-rate mode.

[0087] Another embodiment of the invention may provide a machine and/or computer readable storage and/or medium, having stored thereon, a machine code and/or a computer program having at least one code section executable by a machine and/or a computer, thereby causing the machine and/or computer to perform the steps as described herein for a method and system for managing energy efficiency of a network link via pluggable transceiver modules in an energy efficient network device.

[0088] Accordingly, the present invention may be realized in hardware, software, or a combination of hardware and software. The present invention may be realized in a centralized fashion in at least one computer system or in a distributed fashion where different elements are spread across several interconnected computer systems. Any kind of computer system or other apparatus adapted for carrying out the methods described herein is suited. A typical combination of hardware and software may be a general-purpose computer system with a computer program that, when being loaded and executed, controls the computer system such that it carries out the methods described herein.

[0089] The present invention may also be embodied in a computer program product, which comprises all the features enabling the implementation of the methods described herein, and which when loaded in a computer system is able to carry out these methods. Computer programs in the present context means any expression, in any language, code or notation, of a set of instructions intended to cause a system having an information processing capability to perform a particular function either directly or after either or both of the following: a) conversion to another language, code or notation; b) reproduction in a different material form.

[0090] While the present invention has been described with reference to certain embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted without departing from the scope of the present invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present invention without departing from its scope. Therefore, it is intended that the present invention not be limited to the particular embodiment disclosed, but that the present invention will include all embodiments falling within the scope of the appended claims.

What is claimed is:

1. A method for communication, the method comprising: in an Ethernet network comprising one or more link partners that are coupled via an Ethernet link, said one or more link partners comprising one or more pluggable PHY devices: determining one or more energy efficient network control policies that specifies a power level mode for one or more said link partners and/or said one or more pluggable PHY devices; and configuring said one or more link partners and/or said one or more pluggable PHY devices to operate in said specified power level mode based on said determined one or more energy efficient network control policies.

2. The method according to claim 1, comprising determining by said pluggable PHY device said one or more energy efficient network control policies.

3. The method according to claim 1, comprising selecting a power level mode of operation for said one or more pluggable PHY devices based on said one or more energy efficient network control policies.

4. The method according to claim 3, comprising reconfiguring one or more components of said one or more pluggable PHY devices based on said selected power level mode of operation.

5. The method according to claim 4, comprising reconfiguring a first portion of said one or more components prior to sending an energy efficient network control signal to said one or more of said link partners.

6. The method according to claim 5, comprising reconfiguring a remaining portion of said one or more components after sending said energy efficient network control signal.

7. The method according to claim 1, comprising executing said one or more energy efficient network control policies from within said one or more pluggable PHY devices utilizing hardware, software, and/or firmware within said one or more PHY devices.

8. The method according to claim 1, comprising buffering packet data that is pending delivery in said one or more pluggable PHY devices while transitioning to an active power mode.

9. The method according to claim 1, wherein said one or more pluggable PHY devices comprises one or both of a media access controller and/or a serializer-de-serializer device.

10. The method according to claim 1, wherein said one or more pluggable PHY devices comprises one or more of a SFP, a SFP+, a XENPAK, a X2, a XFP and a XPAK form factor.

11. The method according to claim 1, wherein said power level mode comprises low power idle mode and/or sub-rate mode.

12. A system for communication, the system comprising: one or more circuits for use in an Ethernet network comprising link partners that are coupled via an Ethernet link, said one or more circuits comprising one or more pluggable PHY devices, wherein said one or more circuits are operable to: determine one or more energy efficient network control policies that specifies a power level mode for one or more said link partners, and/or said one or more pluggable PHY devices, and configure said one or more link partners and/or said one or more pluggable PHY devices to operate in said
specified power level mode based on said determined one or more energy efficient network control policies.

13. The system according to claim 12, wherein said one or more pluggable PHY devices determines said one or more energy efficient network control policies.

14. The system according to claim 12, wherein said one or more circuits are operable to select a power level mode of operation for said one or more pluggable PHY devices based on said one or more energy efficient network control policies.

15. The system according to claim 14, wherein said one or more circuits are operable to reconfigure one or more components of said one or more pluggable PHY devices based on said selected power level mode of operation.

16. The system according to claim 15, wherein said one or more circuits are operable to reconfigure a first portion of said one or more components prior to sending an energy efficient network control signal to said one or more of said link partners.

17. The system according to claim 16, wherein said one or more circuits are operable to reconfigure a remaining portion of said one or more components after sending said energy efficient network control signal.

18. The system according to claim 12, wherein said one or more circuits are operable to execute said one or more energy efficient network control policies from within said one or more pluggable PHY devices utilizing hardware, software, and/or firmware within said one or more PHY devices.

19. The system according to claim 12, wherein said one or more circuits are operable to buffer packet data that is pending delivery in said one or more pluggable PHY devices while transitioning to an active power mode.

20. The system according to claim 12, wherein said one or more pluggable PHY devices comprises one or both of a media access controller and/or a serializer de-serializer device.

21. The system according to claim 12, wherein said one or more pluggable PHY devices comprises one or more of a SFP, a SFP+, a XENPAK, a X2, a XFP and a XPAK form factor.

22. The system according to claim 12, wherein said power level mode comprises low power idle mode and/or sub-rate mode.

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