Small Networking Equipment: Making the Connection to Energy Efficiency

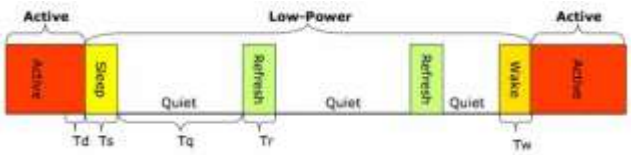
Networking equipment is used to connect two or more edge devices, such as computers, IP phones, and printers. In a residential setting, network equipment has about 5% utilization, characterized by short bursts of downloading and long periods of low or no data traffic. Today, these devices draw almost as much power whether idle or fully utilized, leaving room for large energy savings. Energy Efficient Ethernet (a new standard, IEEE 802.3az) solves this problem by powering down Ethernet connections when not in use.

Additionally, users commonly leave networked edge devices in on-mode to maintain network presence. When a computer is sleeping, it loses functionality, such as file sharing, the ability to receive incoming instant messages, or voice over IP phone calls. A so-called network proxy can interface between the edge device and the network, allowing the edge device to sleep while maintaining a low level network presence for some of these monitoring functions.

Energy Efficient Ethernet

The IEEE completed standard 802.3az, Energy Efficient Ethernet (EEE), in September 2010. It functions by putting the Ethernet interface of a device to sleep during small periods of inactivity. The interface can wake up in under 3 microseconds, which maintains a high quality of service and allows the interface to check in so the device does not fall off the network. The protocol requires compliant devices on both ends of the Ethernet cable to achieve savings, making it only available for new equipment.

Sleep Schedule for Devices with EEE[1]



Varying reports claim approximately 80% power reduction between full and no capacity for EEE-capable Ethernet ports. For example, ASUS claims their new motherboard network interfaces scale power from 476.8 to 89.1 mW when idle. Similarly, the interface for an Innovaphone IP phone scales from 380 to 105mW. Although measured in milliwatts, when compounded by the number of Ethernet ports per device and devices in use today, the total savings can be quite dramatic. IEEE estimated that once fully

implemented, EEE could save 5 TWh per year in the U.S., enough to offset the need for almost 2 typical coal-fired power plants. Ecos estimates this could save over 23 TWh worldwide.

Component vendors including Broadcom, Realtek, and Intel have begun producing compliant interfaces. To date, a limited number of small networking devices have incorporated EEE, probably because the final protocol has existed for less than a year.

Ecos found one company, Sapido, that currently sells 802.3az routers for residential use. Commercial applications are much more prevalent, such as enterprise network switches, where the savings potential is far greater. ASUS has begun to incorporate 802.3az in LAN-on-motherboard solutions. As for IP phones, two manufacturers have advertised including the technology for upcoming products.

In the future, any device with an Ethernet port could employ EEE, including all networking devices, Internet-enabled TVs, and set-top boxes. Currently, network interfaces most commonly feature maximum speeds of 100 or 1,000 Mb/s. As 1,000 Mb/s becomes the norm and 10Gb/s interfaces penetrate the market, EEE will become increasingly important to save energy as higher speeds require more power. Many of these products do not require higher throughputs; however, the market is trending towards faster Ethernet ports regardless. For example, an IP phone does not need a 1,000 Mb/s interface to transmit voice, but commonly the phone connects a computer to the network, and lower link rates could cause a bottleneck. The next generation of Ethernet devices are expected to consume an

[1] Source: Lawrence Berkeley National Laboratory

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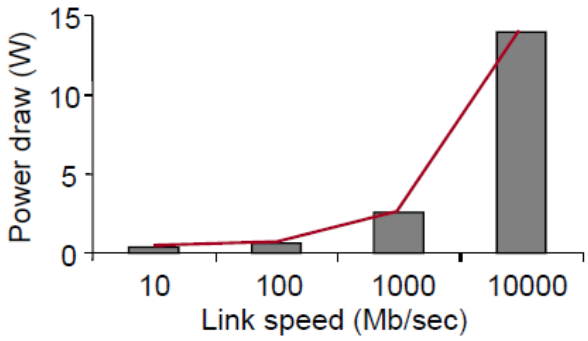
order of magnitude greater power than those used today (see below) without the power management offered by EEE.

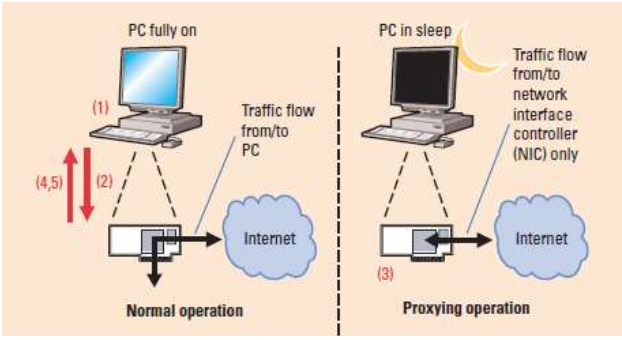
Port Capacity and Port Power[2]



Network Connection Proxy

Putting a computer to sleep can reduce power draw by up to 95%. For example, consider a new, Apple iMac released in May 2011. It idles at 36 W with the screen off, uses 1.2 W while in sleep mode, and can wake from sleep mode in about 2 seconds. The savings are even greater for older PCs, which typically idle around 70 W. However, when computers are in sleep mode, they become invisible to the network. This is especially problematic in a business setting, where IT personnel need to send software updates to all the computers on the network. Computers with Wake-on-LAN (WOL) mitigated this problem by telling the network that they were sleeping so the network could send a "magic packet" to wake the devices. However, WOL only works within a local region of the network (subnet) and requires other devices to know WOL is active and then send a "magic packet" to wake the sleeping computer. As a result, WOL technology never achieved its intended market penetration and savings.

A promising alternative to WOL is a network connection proxy, which works by maintaining a minimal network presence while its host sleeps. To the network, the computer appears to be on and ready to receive information. When a packet is sent to the computer, it goes through the proxy, which decides to reply, ignore, or wake up the computer to respond, depending on the content. The proxy is, in effect, a gatekeeper that decides whether network traffic is important enough to warrant powering up the host device.



A Sample of a Proxy Installed in a Computer's Network Interface Card[3]

Several flavors of this technology currently exist. Under the ECMA-393 ProxZzzy standard, which will likely be included in ENERGY STAR's computer specification, the proxy is typically located on an Ethernet card inside the computer. Under Apple's Wake-on-Demand technology, the proxy exists in an Apple wireless router and further requires that client devices run a special sleep proxy application, making the technology ideal for small networks using Apple products. A proxy for enterprise solutions could mitigate the need for new hardware by existing as a physical server that functions as a proxy to hundreds of client computers, such as the Sleep Server developed at University of California San Diego.

Calculating energy savings in absolute values is difficult because individual computer power draw, duty cycle, and network traffic varies so dramatically. Some users may already forgo network connectivity and schedule their computer to sleep after one hour, whereas there may be entire companies that disable sleep settings. Regardless, getting a 60 W desktop computer to sleep even 3 hours more per day, every day, results in annual savings of over 60 kWh – about the same amount of energy saved by changing out a 60 W incandescent lamp for a CFL. When multiplied by the over 1 billion PCs in use globally, even small improvements in sleep enabling can translate into tens of TWh in energy savings and billions of AUD in utility bill savings.

To date, voluntary programs in Europe and the U.S. have adopted ECMA-393 ProxZzzy as the network connection proxy standard. While not found in the commercial market, proxies for other edge devices, such as IP phones, have also appeared in academic studies. The same concept has also

[2] Source: K.Christensen, University of Southern Florida

[3] Source: B. Nordman, LBNL

been adopted by Broadcom, which created a proxy for IPTV set-top boxes in the form of a microprocessor that allows the set-top box to sleep.

Toward a Greener Internet

Currently, more research is needed to validate savings from both Energy Efficient Ethernet and proxying. ENERGY STAR's upcoming Small Network Equipment specification will include a standardized test procedure, enabling more uniform comparisons of savings potential from EEE. ENERGY STAR's current computer specification provides power reduction incentives for proxying by adjusting the assumed duty cycle to account for the greater number of hours in sleep mode. Both technologies can effectively reduce the energy consumption of network devices without degrading quality of service. Due to the bilateral nature of EEE, it is imperative that any policy work incent EEE in networking equipment as well as edge devices to realize energy savings. Therefore, it is important to pursue both technologies and increase the rate of adoption in new equipment moving forward.