The Greening of PoE

Power over Ethernet (PoE) has emerged as an important deployment tool for IP telephony and wireless networking

There are few issues more prominent than the growing energy crisis in today's enterprise computing and IP-telephony infrastructure. The topic continues to draw attention, especially in the wake of the 2007 EPA study reporting that energy usage in the data center doubled between 2000 and 2005 and will grow to 3 percent of all U.S. energy consumption by 2010. The EPA report did not include the power consumed in the telecommunications and LAN closets.

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Power over Ethernet (PoE) has emerged as an important deployment tool for IP telephony and wireless networking thanks to its ability to provide a new, universal power/data jack. And now, thanks to new advances, PoE is also becoming a weapon in the war against energy inefficiency throughout the enterprise and even in the data center – from small server closets to large enterprise-class data centers -- where the energy efficiency of large switches is of particular concern.

PoE is very rapidly evolving in support of ever-more-rigorous power mandates including those imposed by the Energy Efficient Ethernet (EEE) standard and other "green" initiatives. Several PoE technologies are addressing this challenge and turning PoE from a liability to a solution in the quest for improved energy efficiency. Increasingly, PoE energy-delivery efficiency is surpassing that of traditional wall-adapter solutions in a wide variety of applications, and new techniques and technologies such as dynamic power management and emergency power management are poised to make new "smart" PoE solutions even more power-efficient than prior PoE solutions and traditional wall adapters.

PoE's Cost and Deployment Benefits

Beginning with the first Bell telephone installations in the late 19th century, power and data co-existed on the same electrical cable. In contrast, the first IEEE802.3 and other data communications systems in the 1970s did not deliver power. By the late 20th century, data transmission rates were high enough to ensure the transmission of data packets. With the evolution of VoIP Protocols, it was necessary for Ethernet to evolve such that VoIP could become as simple and reliable as traditional and digital telephony. At the same time, sophisticated new high-bandwidth wireless LAN protocols were enabling wireless LAN access points to replace wired Ethernet in many applications, which made it even more important that Ethernet provide power-delivery capabilities where A/C power outlets were not available. The twin developments of VoIP and WLAN led the IEEE802.3 work group to create the IEEE802.3af task force in 1999. The task force's mission was to enable the transmission of data and packets on the same CAT3 (or above) Ethernet cable. Four years later, the IEEE802.3af task force created the first PoE standard, which supported the delivery of 12.95W to powered devices.

The Goal: More Power, More Efficiently

IEEE802.3af provided enough power for the majority of intended VoIP and WLAN applications, as well as network cameras, embedded thin clients, barcode RFID readers, access control applications and others. More power was required, however, if the RJ45 connector were to truly become a universal power socket for virtually any terminal, including video phones, multi-channel Access Points, outdoor applications such as Fiber to the Home Optical Network Terminators, IEEE802.16 subscriber stations and notebook computers. In 2004, the IEEE802.3 working group created the PoEPlus study group, which in 2005 became the IEEE802.3at, with the goal of delivering at least 30W for devices powered over Ethernet cables.

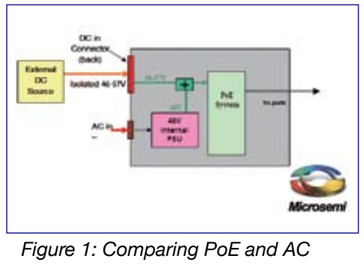

Figure 1: Comparing PoE and AC Adapter Efficiency.

Today, IEEE802.3at is poised to usher in a new generation of easy-to-deploy, easy-to-power wireless applications. In addition to delivering more power, the technology is also capable of more carefully managing power delivery and ensuring it's most efficient use.

Comparing PoE and AC Adapter Efficiency

The most important gauge of energy efficiency is overall PoE system efficiency at maximum load. Power is converted from 100-240VAC to 44-57VDC at the output of the PoE power sourcing equipment (PSE), than delivered over an up-to-300-foot cable to the powered device at a voltage of 37-57VDC, after which it is again converted to the several voltages at which the different circuits work (5V, 3.3V, 2.5V, 1.2V, 0.9V, etc…). See Figure 1.

To calculate the overall efficiency of a PoE system, the following formula is used:

PoE System Efficiency = PSE (Power supply efficiency) x PoE PSE circuit efficiency x channel (cable, patch panel and connectors) efficiency x PoE PD circuit efficiency x PD DC/DC efficiency

Clearly, system losses occur, and one initially might believe there is little that can be done about it. However, there is a major difference between the PSE and the PD. In the case of the PD, designers must assume a worst case power conversion of 57VDC down to its lowest voltage (e.g.3.3V) for power dissipation purposes. But the PSE designer has the freedom to determine the voltage it outputs. As an example, consider an IEEE802.3at-powered device that requires exactly 29.52W to operate and is placed at the end of a 300ft CAT5 channel (resistance is 12.5Ω). In this scenario, the PSE circuit resistance is 0.65Ω, and the PD circuit resistance is 0.58Ω plus a diode bridge and the source is 110VAC. The PSE designer can either use a power supply with a 56V minimum voltage or a power supply with an output voltage of 51V. In the 56V system, current will be 616mA, while in the 51V system, current will be 720mA. The following formulae apply:

56V System Efficiency = Eff 110→56V x 99.3% x 86.1% x 97.2% x Eff 46.54→3.3V = 83.1% x DC/DC efficiency

51V System Efficiency = Eff 110→51V x 99.1% x 82% x 96.5% x Eff 39.58→3.3V = 78.4% x DC/DC efficiency

The choice of a 56V minimum voltage yields 5% higher system efficiency than the choice of a 51V minimum voltage. Additionally, this choice results in a low overall resistance of only 0.65Ω inside the PSE circuitry.

In this example, the assumed efficiency of the DC/DC stage in the PD and the AC/DC stage in the PSE power supply is 90%, making the overall efficiency of this PoE system, at full IEEE802.3at load, 90% x 90% x 83.1%= 67.3%. This compares with a typical standalone AC adapter, such as that used in a laptop, which normally has an efficiency of approximately 50% to 70% at maximum load.

Additional Power-Saving Opportunities

Besides improving overall system efficiency as compared to traditional A/C wall adapters, PoE has the opportunity to squeeze even more power efficiency out of today's multi-user systems through smart power deployment and management.

Clearly, a very significant energy factor is how much power is being dissipated by large PoE power supplies when those are not being used. For instance, an IT manager might purchase a 48-port switch with full power per port (800W), but only use it to power 20 ports. In this scenario, the power supply may be operating well below its optimal efficiency state, wasting as much as 80W of quiescent power. At below maximum power loads, the quiescent power can be typically 10% of the power supply level. By choosing a non-full power supply, the IT manager may be reducing wasted power by half.

The utilization of available power will be maximized only when there is an accurate measurement of power consumption and the proper algorithm is used to dynamically allocate power to many diverse ports, according to priority. Additionally, smaller power supplies are also more economical and, in situations where users do want to have full power per port, the switch vendor can offer incremental additional power via an external power supply. This requires a smart management of the power supplies available on the system.

Cost implications

Having established that system efficiency is optimized when voltage is as high as possible at the PSE power supply, the next consideration is cost. In general, the cost of a PSE power supply is typically directly proportional to the difference between the input and output voltages. In other words, a PSE power supply supporting 110→56V will be less expensive than a power supply supporting 110→51V. On the PD side, the power supply needs to be designed for the worst case (57V), which means the voltage on the PSE will not affect its cost.

Additionally, because overall system efficiency is improved at higher voltages, it is possible to support a given PD load with a smaller power supply. And, because of the resulting lower heat dissipation of the system, smaller and/or lower-speed fans can be used, further reducing costs.

From both a system efficiency and cost perspective, PoE is emerging as a highly viable solution for significantly improving energy efficiency in the enterprise.

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