

Networks: Tomorrow's Big Challenge for IT Energy Use

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In 1999, the spectre of “The Internet” already consuming large amounts (8-13%) of electricity and rising to 50% of all U.S. electric use was given much publicity, then painstakingly debunked, most prominently by Jon Koomey of LBNL. The true figure was closer to 3%, for all office, telecommunications, and network equipment. This episode — combined with the success of the Energy Star program in causing power management capability to be pervasive in office equipment markets — has led to the impression that energy consumption of Information Technology (IT) equipment need not be an area of large or active concern. We believe that while much progress has been made, this progress is likely to be undone by trends in the IT market, principally due to factors related to networks. Addressing this challenge will require both research, technical solutions and outreach to put the results into practice. Unfortunately, there seems to be no entity in the federal government with this important research problem on its agenda. This needs to be changed.

Networks will increase future energy consumption in a variety of ways. In this discussion we consider three major topics: induced consumption, rising network speeds, and displays.

Induced Consumption

“Induced” consumption is the increased energy used by electronic devices solely by the fact of their being networked. When devices are being actively used, the network connection has modest or no impact. However, for the great majority of time a product is not in active use, the network connection can increase consumption dramatically.

In some cases, PCs and other devices are left on when they would otherwise be off so that they are accessible over the network. In other cases, they are fully on when they might otherwise be asleep because in general, sleeping PCs “fall off” the network². The introduction of applications and services that rely on network connections increases the demand for “on-time” of electronics, and the existence of the “network problem” in PCs means that network presence defeats the use of PC sleep modes (although display power management is not affected). In the near future we will see many more networked devices, many of which will in practice require continuous network presence to provide acceptable functionality to end users. This is already the case for many office PCs for remote user access, data backups, and IT administrator access. It is increasingly true for home PCs, particularly in home network contexts that include more than one PC (even by 2001, most home PCs were in homes with more than one PC). The “network problem” that prevents PCs from sleeping while they retain network connectivity is technically solvable. While there are many uncertainties, we estimate that the potential annual electricity bill savings from solving this problem range from \$0.8 to \$2.7 billion.

Unfortunately, there are an increasing number of barriers to devices going to sleep and saving energy. Perhaps the largest looming manifestation of this is UPnP (Universal Plug and Play) for which the current version lacks any implementation of power management and seems likely to require devices to be on continuously. The next version of the UPnP specification could define power states and allow devices to power manage, but this has yet to receive significant development attention.

Other forces also conspire to defeat power management. For example, some consumer electronics need to remain awake and active, even when performing no function, to monitor network links passing through them to protect copyrighted content. Security is also likely to defeat power management in many circumstances.

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² Many PCs incorporate a technology called “magic packet” that allows them to sleep through most network traffic but wake up when a special data packet is received. This works in a limited set of commercial applications, but is not a solution that allows PCs to respond to general network traffic while asleep.

We are also seeing a rapid rise in the number of digitally-connected devices particularly those not traditionally considered information technology, such as consumer electronics. Many of these new devices have, or will have, increased consumption induced by this connectivity.

Network Speed

A second major trend is the increasing speed of network links. Present-day PCs usually have 10/100 Mbit/s network interfaces, but 1 Gbit/s interfaces are increasingly common, with 10 Gbit/second ones ready to become prevalent. Higher speeds require more power-consumptive interfaces, and the 10 Gbit/s models may consume 10-15 W at each end of the link (usually a PC and a network switch). If this power level is maintained during times of little activity, this is a substantial source of increasing energy consumption. An increasing number of devices have network interfaces so the problem will only multiply in coming years.

Displays

The third source of large increases in IT energy consumption that we should expect is displays (also called monitors). The transition from CRT-based to flat panel displays makes them much easier to deploy widely in homes, offices, and public spaces. In addition, more flexible wired and wireless network technologies make it easier to provide content for such displays. These are already being used to replace previous unpowered applications such as bulletin boards and photograph display frames, and are likely to also make communications (e.g. email and instant messaging) and recorded digital content more widely available throughout homes (particularly with the larger average size of homes). While recent advances in display technology are also partly responsible for this, the driving of displays over network links rather than solely as single slaves of a PC is also a key technology. The opportunity in this area is to embed principles of power management in the communications protocols, user interfaces, and use conventions by end users so that most displays will be asleep — not on — most of the time.

What to do

There is a public interest in reducing energy use of IT equipment, but relatively little publicly-funded activity to address these problems. A key problem for this issue is the apparent vacuum of responsibility for the topic within the federal government. Network-related consumption is new as a large consumer of electricity, which helps explain the lack of attention to it. While Energy Star does a good job in its labeling activities for electronics, it lacks the resources to address these other types of energy consumption issues. Because industry has many other issues to grapple with and because end users rarely make purchase decisions with energy consumption in mind, industry has not paid sufficient attention to energy issues inherent in networked devices. For these reasons, progress will only be made if an outside entity prods industry to take energy issues seriously.

As to what should be done in the near term, there is a need to confirm, document, and possibly uncover other significant energy problems related to networks. In addition, we need people whose prime interest is energy efficiency to work with industry to fix existing problems to the degree possible, and be part of the development of new products and protocols to ensure that they are “friendly” to energy efficiency. It is simply not realistic to expect industry to make this a sufficient priority on its own, but it can be expected to cooperate with efficiency researchers who do their share of the work in technology development. They can also help with end-user education on how to efficiently use networked equipment.

Some specific near-term needs are:

- Review major network protocols and standards (current and in development) to determine how power management might be incorporated.
- Develop cost-effective smart network interfaces that allow PCs and other devices to sleep but retain network connectivity.
- Develop methods to modulate network link speeds with traffic levels to scale energy consumption with actual service demand.
- Develop standards for evolving display usage models with sophisticated interfaces among devices and for users that facilitate robust power management.

The evolution of network hardware, software, and applications shows no sign of slowing down so that public-interest attention to their energy impacts needs to be an ongoing activity.