

Powersaving with Universal Plug and Play

A narration of a Master's thesis by Martin Olsson and Jakob Klamra

Universal Plug and Play (UPnP) is an emerging standard for automatic configuration of network connected devices. All UPnP devices connected to the network must be fully powered up at all times. Using UPnP therefore means increased power consumption. In this article a design, implementation and evaluation of two different solutions to enable power management in UPnP are discussed.

As the cost of advanced electronic devices for consumer use continues to decrease, the number of network enabled devices in a household is increasing. The increased number of devices also increases the consumption of electricity, whether the devices are connected to a power line or run on batteries. Lawrence Berkeley National Laboratory estimates that home IT equipment, such as office equipment and closely related communications devices, were responsible for consuming 280 kWh/year per American household in 2004. The prognosis for 2005 is even higher. Reducing this consumption will bring significant economic savings and environmental benefits. It will also extend the lifetime of battery driven devices. To achieve this we need devices that are *power management* enabled. This means that the devices can enter a state where they consume less energy, a so called sleep mode. In a sleep mode the devices will shut down parts that are not in use, e.g. the screen or the hard drive.

A cornerstone in power management is the *protocols* that computers use to communicate with each other. A protocol is a set of rules of how communication between two devices should be made. Different protocols are used for different tasks and different kind of communication. One of these protocols is *Universal Plug and Play (UPnP)*. UPnP is designed for automatic configuration of networks. UPnP will automatically make any device that connects to the network instantly accessible to all other devices on that network. UPnP is completely platform and media independent which means that your coffee pot could be able to communicate with your computer using a power line.

However there is a problem with the current version of UPnP. For the protocol to work all devices must be fully powered up at all times. This means that no device using UPnP can be allowed to enter power sleep mode. This is due to the fact that a device in power sleep mode cannot communicate with other devices. This means that when a device enters power sleep mode it cannot be found by other devices and information about the sleeping device can be lost. This goes against the whole idea of UPnP where each device should be instantly accessible and ready to use. There are various ways to solve the power management problem in UPnP. We have chosen to use two solutions, both containing a power management *proxy*. A proxy can handle the communication for a device that has entered power sleep mode. If the sleeping device is required to be fully

powered up the proxy can force it to exit the power sleep mode. A proxy can be implemented as software in standalone devices dedicated to running proxy tasks, or integrated in other devices in the network.

The two solutions that we have designed are called the *invisible* and the *cooperating* proxy. They are very similar as they both use a power management proxy, however there are some important differences. The invisible proxy is, just as the name suggests, invisible to other devices in the network. The invisible proxy does not communicate directly with any devices in the network. Although there is no direct communication with the proxy it will listen to all traffic on the network. This means that the proxy will know how much time has passed since the last message from a device in the network. Without direct communication the proxy has to guess when a device has entered power sleep mode and when to start handling the communication for the sleeping device.

The cooperating proxy does not have to guess when a device enters power sleep mode since the proxy communicates directly with all devices in the network. Whenever a device enters power sleep mode it will notify the proxy so that the proxy can start handling the communication. Without guesses the solution is more accurate and eliminates the risk of incorrect assumptions. However, UPnP devices on the market today are not prepared for direct communication with a proxy and therefore each device that communicates with the cooperating proxy needs additions to its software. These additions are not required for the invisible proxy

since there is no direct communication between devices in the network and the invisible proxy.

To prove the functionality of our solutions they were both implemented and tested. Both proxies were tested with various UPnP devices and all software could be run on regular PCs. We tested the software and concluded that it did solve the power management problem of UPnP. Both proxies allowed devices connected to the network to enter power sleep mode without breaking any existing UPnP functionality.

To show how much energy and money that can be saved we estimated the possible benefits of our solutions by 2008 if they would be widely deployed. These estimates were only made for PCs and printers in American households, even though there are many other devices that would benefit from using UPnP and our power management solution. To make accurate estimations of the power savings in 2008 we had to estimate the number of PCs and printers in American households by 2008, and how these devices will be used in this near future. Our estimates were based on figures from the Energy Analysis Program at Lawrence Berkley National Laboratory as represented by Bruce Nordman. Our conclusions were that by 2008 the stocks of PCs and printers will increase significantly and more devices will be network connected. Our estimates of the stocks are presented in table 1.

Since UPnP is a relatively new protocol it is hard to predict its impact on the market. Therefore we estimated that between 10% and 25% of all network connected devices will use UPnP.

Table 1. Number of devices in American households 2001, 2008 and connected to a network in 2008 (all figures are in million)

Device	Devices 2001	Devices 2008	Network connected devices 2008
PC	85.2	134	127.3
Printer	61.2	118.9	113.3

The estimated total amount of energy and money (counting at 8 cents/ kWh) that can be saved by 2008 is presented in table 2.

Table 2, Savings achieved by using a power management proxy in all UPnP networks 2008

	Savings in TWh/year	Savings in million \$/year
Low estimation	1.6	128
High estimation	4	320

These figures show that a considerable amount of energy and money can be saved if our power management solution for UPnP would be widely deployed.

We are to our knowledge the first to design and implement a solution to the power management problem for UPnP. Our estimates of power savings show that this work is highly motivated. Introducing power management to UPnP does not only mean environmental and economic benefits. All battery powered devices that use UPnP will have an extended battery lifetime because they use less power. With this extended battery lifetime a lot of devices that before had to be connected to a power line now can be made mobile and run on batteries. Extended battery life and reduced power consumption also allows many new applications to use the UPnP

protocol. One example of such an application is battery powered, wireless security cameras. Today most security cameras have to use an external power source and be connected to a wired network to send its images to the user. If a camera can enter power sleep mode when it is not sending images it can save enough energy to be mobile, battery powered and using a wireless network. This opens the possibility for a low cost, battery driven camera that never has to be recharged. When the battery is empty the camera is replaced by a new one. The camera can be activated by a motion sensor or an external wake up mechanism. All cameras can then be controlled by a single user interface from a laptop over the same wireless network or even remotely over the Internet. These cameras might replace the intrusion alarms that many doors and windows are equipped with today.

Even though our solutions are proved to solve the power management problem there is still some work left to be done. Our software contains several minor bugs and our solution could be improved for performance issues. There are also parts of the design yet to be implemented. These parts were left out of the implementation due to lack of time and equipment, but they have no bigger impact on the results of this project. Our solutions can be extended and improved as we have only designed and implemented a first version to prove its functionality and to show how the power management problem can be solved in UPnP.

More information about the project that led to this article can be found at <http://www.csee.usf.edu/~christen/upnp/>.