Power Scaling in Proportion to Data Processing

Author: Ecova (formerly Ecos Consulting) *Date: June 2011*

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Focus of Report	This report examines the power scaling abilities for a variety of electronic products, both network equipment (modems, routers and switches) and "edge devices" with multimedia and audio-visual capabilities e.g. game consoles, DVD Players. It discusses the energy consequences of power scaling for these products such as identifying if one device may have reduced energy consumption but increased latency and/or reduced functionality. Power scaling means a product can dynamically and proportionally change its energy consumption as its workload varies. The power scaling concept can inform the development and implementation of energy efficiency measures.
Description of Research	The research involved three primary tasks: 1. Determining a set of universal tasks that are suited to a wide variety of products (to be able to quantify and compare the extent to which each product can vary its energy consumption in relation to workload, while meeting consumer expectations for latency and functionality). 2. Measuring the power consumption over time for each function of each device. 3. Identifying and discussing the energy consequences of power scaling.
Key Findings	**General findings:** • Devices that use a small amount of absolute power do so with fundamental efficiency improvements to their hardware rather than power scaling. • Devices that use the most power have some degree of power scaling but not to the same extent as their most efficient competitors. • Only two of the devices tested demonstrated significant power scaling (one to a factor of more than four). For most devices tested, a power scaling ratio of 2:1 or less was the norm. • Game consoles and set-top boxes continue to exhibit very poor power scaling capabilities. **Findings on five of the universal tasks for edge devices:** *Standard modes (off/standby sleep and idle)* ➢ The largest observed difference between products was power draw in idle mode. ➢ Only some devices were configured to auto power down after 15 minutes. ➢ Computers were capable of the most notable power scaling, however, this ability was dependent on whether or how it had been enabled in software. ➢ Off/standby mode ranged from 0.0 to 0.9W and sleep mode from 0.03 to 1.2W. ➢ The presence of a network connection has a negligible effect on power consumption during standby and sleep modes. In idle, increases of 1 watt were observed for the iMac while the PlayStation 3 had the largest increase of 2 watts when network connectivity added. *Video play* ➢ Multi-purpose devices draw considerably more power when playing Blu-ray discs than purpose devices like Blu-ray players. Blu-ray - <10 watts, custom MultiMedia PC >70 watts. ➢ Many devices can stream Netflix movies for 10% of the power or less e.g. Apple TV consumed 98% less power to stream Netflix than the multimedia PC. ➢ The most dramatic difference in consumption was for high resolution Netflix video streaming – 1.7 watts (Apple TV) to 93.9 watts (MultiMedia PC).

	Music play ➢ The source of music being streamed did not affect power consumed. ➢ The mechanical process of spinning a CD uses more power than the electronic processes associated with playing compressed music files. ➢ Dedicated playback devices consumed far less power than other products. *Daily computing* ➢ Power scaling capability is clearly evident in the multimedia PC, more so than iMac; ➢ The iPad 2 and MacMini were both highly efficient. With its screen power included, the iPad2 consumed only 3.8 watts while internet browsing – approximately 96% less power than the custom multimedia PC consumed. ➢ Lenovo laptop exhibited wider range of power scaling capability yet consumed more when performing simple tasks such as internet browsing. *Game play* ➢ All three game consoles tested lack any meaningful power scaling; ➢ The Wii's measured power use is much lower than the other game consoles but performance is significantly lower as well. ➢ Users are shifting from multimedia desktop PCs or game consoles to mobile devices which will lead to significant energy savings; ➢ PCs sleep or hibernate in periods of inactivity, where game consoles do not. *Power Management Configuration* ➢ The desktop had a dramatic drop in power when entering sleep mode while the laptop incrementally reduced power when entering sleep mode. ➢ To fully capture energy savings consumers need to manually modify the power management settings on their laptop or desktop computers. *Latency* Latencies were investigated to determine wait times for different devices to boot up, shut down or go into sleep mode. The energy impact of latency is associated with duty cycles as users will forgo management opportunities in favour of greater convenience. ➢ Boot times – large differences noted even between computers. Pay TV STBs have much longer boot times while Game consoles had fast boot times. **Findings on the universal tasks for network equipment:** *Baseline tests* ➢ Routers and switches do scale power meaningfully with the number of connected ports but less consistently with changing network traffic speeds. ➢ The primary energy saving opportunity is in designing routers to drop into a lower power state during periods of no traffic. *Peer-to-peer file transfer testing* ➢ A modest power scaling effect as connection speeds increased. ➢ Strangely a number of devices recorded higher power consumption with no traffic. *Multiple edge devices served by network device (Ethernet & WiFi)* ➢ Only minimal power scaling was evident.
Conclusions	This report examined the power scaling abilities for a variety of electronic products and discovered that it is being underutilised for many of the products tested. The opportunities for reducing energy consumption with power scaling are evident.
Standby power policy Implications	Policy makers should consider power scaling requirements in the development and implementation of energy efficiency measures. Policy makers could use power scaling capabilities to specify standby, sleep and idle modes and also for latency and performance considerations such as how rapidly must a product return from sleep to idle mode. Further research on network power scaling is necessary to develop standard protocols backed by

	labelling programs and MEPS to promote "design approaches that meaningfully scale power consumption to network activity".