Dynamic Power Management at HP

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Hewlett-Packard products span many different types of computing devices, ranging from subPDAs such as calculators, through PDAs, laptops, desktops, servers and their networks, home appliances and home networks, just to name a few. Energy consumption has become one of the primary concerns due to the need for longer battery lifetime in portable devices and environmental concerns related to desktops and servers. Dynamic power management decreases the energy consumption by selectively placing idle components into lower power states. System resources can be modeled using state-based abstraction where each state trades off performance for power. The transitions between states are controlled by commands issued by a power manager that observes the workload of the system and decides when and how to force power state transitions according to the power management policy.

The most common power management policy is a timeout policy. Predictive policies force the transition to a low power state as soon as a component becomes idle if the predictor estimates that the idle period will last long enough. Both timeout and predictive policies are heuristic in nature, and thus do not guarantee optimal results. In contrast, policies derived from stochastic models can guarantee optimal results. Stochastic models use distributions to describe the times between arrivals of service requests, the length of time it takes for a device to service a request, and the time it takes for the device to transition between its power states. The system model for stochastic optimization can be described either with memoryless distributions (exponential or geometric) or with general distributions. Policies derived from stochastic models based on general distributions have shown the largest power savings as compared to the other power management policies [4]. The savings for such policies range from a factor of 1.7 to a factor of 5 when implemented on the SmartBadge portable device [2], a laptop hard disk and a wireless LAN (WLAN) card [3].

Dynamic power management implementation in real systems has several issues that still need to be resolved. A critical problem is the lack of operating system (OS) support for power management. ACPI [1] has enabled a standard interface for power management in systems running Windows 2000. For devices such as sub-PDAs which deploy small footprint embedded operating systems, there is little or no OS support for dynamic power management. An additional problem is that not all hardware components in a device support controllable power states. For example, a WLAN card interface typically has none. A typical consequence of this is that the PDA has an 8 hour battery life without the WLAN, but with WLAN the battery life drops down to little more than 2 hours. Even with systems that have full OS and hardware support for power management, it would help to have *smart applications* that inform the power manager of their energy needs. In this way the power manager together with the OS can schedule processes to maximize idle times and thus enable larger energy savings.

The last area where power management has large potential savings is at the level of networked home appliances and servers. In such systems, the gateway should actively participate in appliance power management. The electricity cost for just one PC class processor with storage elements can be as much as $140/year when operating 24 hours per day. Since homes may have many such appliances, the yearly cost to operate them could become significant. Allowing remote power activation control using a networked mechanism such as a gateway or advanced network interface can save significant energy while maintaining 24 hour connected functionality.

In conclusion, the dynamic power management algorithms have already shown large power savings. The implementation of optimal stochastic algorithms to a laptop hard disk, WLAN card and the SmartBadge device exhibit savings raging from a factor of 1.7 through a factor of 5. Much larger savings can be obtained when issues such as better operating system support, fully controllable hardware component power states, application and gateway support for power management become available.

1. REFERENCES

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