

By providing a platform to maximize utilization and efficiency, virtualization has emerged as a key solution in helping to alleviate the power consumption crunch experienced by data centers of all capacities. We aim to collect detailed, online power measurements of both hardware and software. Figure 1 shows our custom hardware used to obtain these fine-grained power measurements. Our knowledge is based on:

- a. building in-depth power profiles of static & dynamic power consumption of individual HW devices (Figure 2)
- b. linking the power profiles (chronologically) to the software running on the machine

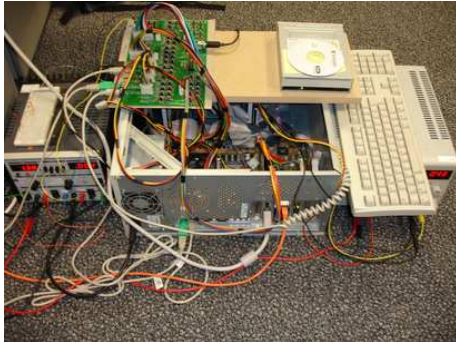


Figure 1: Hardware Measurement Setup

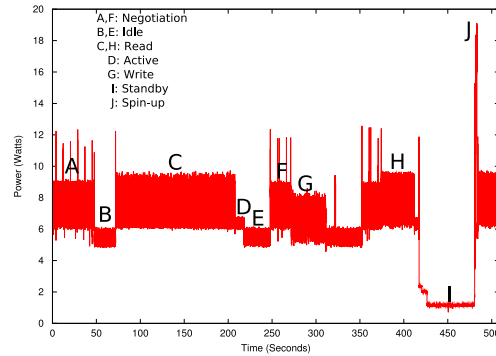


Figure 2: Hard Drive Power Consumption

Such detailed knowledge of hardware and software power consumption is essential in understanding how we can use virtualization in a variety of domain-specific manners to fight the power consumption problem's many angles. Virtualization allows us to decouple the hardware from the software and make operations power-friendly, transparently to the user, applications, and domain OSes. This power-conscious transformation is possible through (a) shutting off devices, (b) emulating devices more cheaply (in terms of power), and (c) optimizing device usage.

- a. shutting off devices (Figure 3a) includes individual cores, processors, devices, or entire machines
- b. device emulation (Figure 3b) provides a mechanism for ensuring all operations are the most power efficient
- c. detailed understanding of device power profiles makes optimized scheduling possible (Figure 4)

The VMMs constantly monitor and manage hardware power consumption and communicate utilization status between one another.

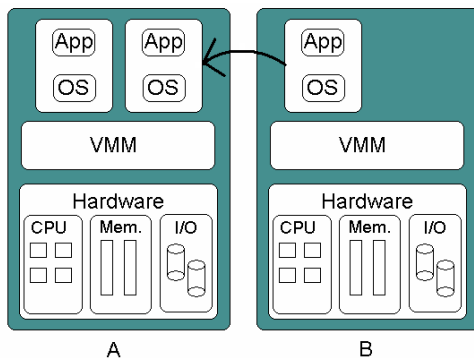


Figure 3a. Migrate jobs from under-utilized Server B to heavily-utilized Server A. Server B's VMM now can shut Server B off.

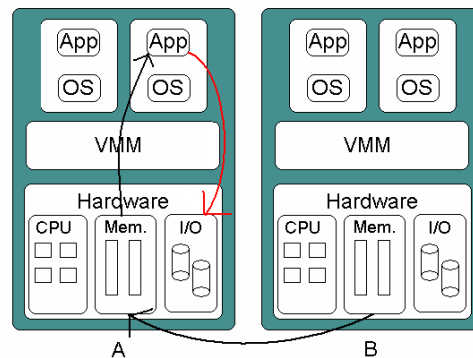


Figure 3b. Server A's VMM intercepts its virtual machine's request for hard disk I/O and satisfies the request via data obtained from RAM available on the network [1].



Figure 4: Schematic of optimized hard-drive usage