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# Predictive power conservation

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*A proposal for use of an adaptive algorithm to reduce power consumption in portable and hand-held devices with embedded disks.*

Many portable computers, such as laptop computers and hand-held calculators, have very limited battery capacities, so it is important to conserve power as much as possible. One common technique is to turn power off to portions of the system after they haven't been used for a while, in the expectation that they won't be used again in the near future.

The period before automatic shutdown takes place is either fixed by the manufacturer or set by the user—in both cases, it is a constant at any one time.

On some devices (e.g., a calculator), the restart cost is zero: there is no mechanical activity required, so selection of the right period is simply a matter of choosing a reasonable compromise between the minor inconvenience of a blank display and battery life.

In the case of a hard disk in a laptop, the restart cost is considerable: the disk has to be spun up to speed again, recalibrated, and made ready to execute commands. This takes between 2.5 and 6 seconds for typical 2.5" hard disk drives. During this time, the system is locked up waiting for the I/O to complete. The power costs are also high: on a representative Quantum 2.5" drive, spinning up the drive requires 5W for 1 second, followed by 1.5W for a 1 second calibration pass.

Under these circumstances, the selection of when to turn the disk off (and on again) is more important. Here's a proposal for a new idea: instead of fixing the turn-off period, make it a function of the previous activity.

The basic observation is that a laptop user is *likely* to use the disk in the same way that they used it last time. For example, they may be doing extensive analysis work with a spreadsheet. Once the initial data has been loaded into memory, the disk activity is likely to be limited to taking snapshots of the changes—perhaps every few minutes. Rewriting the data each time is likely to take

roughly the same number of disk I/Os—it's unlikely to increase or decrease significantly until the work is done, and a new program needs to be loaded or a new function started. And the time to do a snapshot is typically only a few seconds—much less than a 3–5 minute time-outs.

So, the algorithm for determining when to turn the disk off might be something like this:

- Calculate a (weighted) average of the last few activity durations,  $T_A$ . ("Few" may be just one.)
- Calculate a proposed delay time as  $T_d = \alpha T_A$ , for some  $\alpha > 1$ .
- If  $T_d$  is larger than a fixed threshold  $T_{max}$ , then set the delay  $T_d = T_{max}$  (this prevents very long delays after an extended active period).
- Power-down  $T_d$  seconds after the last observed activity.

A variation is to predict *power-up* time by seeing if the inactive intervals are of near-constant duration. Some applications are already programmed to take a snapshot after so many keystrokes or so much time had elapsed. Such behavior might well be quite repeatable.

Although such automatic power-ups could waste power, it may also cause a change in user behavior: knowing that the disk is spun up may provoke a save operation. Editing on a laptop, I often delay saving a snapshot of my work because I know that the disk is spun down. If I were to hear it spun up, I might well choose to make the snapshot, because the cost of doing so was now considerably less.

You could even imagine the system prodding the application: "this might be a good time for a snapshot".

In summary: I hypothesize that adaptive power conservation may provide significant savings for portable computers, thereby extending their utility.