Dynamic Power Management of Laptop Hard Disk

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Abstract

Optimal power management policies for laptop hard disk are obtained with a system model that can handle non-exponential interarrival times in the idle and the sleep states. The measurement results on Sony Vaio laptop show that our policy has 1.7 *times less power consumption as compared to the default Windows timeout policy with still high performance.*

Battery-operated portable systems, such as laptops, demand tight constraints on energy consumption. In this paper we focus on power management for a hard disk on a laptop. The most common policy for hard disks is a *timeout policy* implemented in most operating systems. The policy optimization technique proposed in [2] solves the policy optimization problem using discrete-time Markov decision processes (DTMDP). All state transitions are assumed to follow stationary geometric distribution. The decision evaluation is repeated periodically, even when the system is idle, thus wasting power.

Extensions to the DTMDP model are event-driven continuous-time (CTMDP) and semi-Markov (SMDP) decision process models [3, 4]. Both CTMDP and SMDP models assume exponential service request arrival times, and thus can have high energy costs and a large performance penalty. The power manager makes one decision as soon as the system is idle. If the decision is to stay awake, the system will wait until another arrival before revising the decision, possibly missing large idle times.

Measurements show that the first arrival times are better modeled with a non-exponential distribution, such as Pareto. As a result, time-indexed semi-Markov decision process model (TISMDP) is then needed to obtain optimal policy. Policy decisions are still made in event-driven manner in low-power states thus saving power by not forcing policy re-evaluations. In the idle state, policy decision are re-evaluated until the transition is made into the sleep state, thus saving power during longer breaks. The policy optimization problem based on TISMDP model can be solved *exactly* and in polynomial time (just under 1 minute on a 300MHz Pentium).

Comparison of the measurement results for different policies implemented on the Sony Vaio laptop is shown in Table 1. TISMDP policy consumes 1.7 times less power than the default Windows timeout policy of 120s and 1.4 times less power than the 30s timeout policy. From our experience with the user interaction with the hard disk, the TISMDP algorithm performs well, thus giving us low-power consumption with still good performance. The policy based on continuous-time model (CTMDP) performs worse then always-on policy, primarily due to the exponential interarrival request assumption. This policy both misses some long idle periods, and tends to shut-down too agressively, as can be seen from its very short average sleep time, T_{as}. Our policy also outperforms one based on the competitive algorithm (CA) [1] that is guaranted to yield a policy that consumes at worst twice the minimum amount of power consumed by the policy computed with perfect knowledge of the user behavior.

Table 1. Measurement Comparison

Algorithm	Pwr (W)	T_{as} (s)
oracle policy	0.33	118
TISMDP	0.40	81
CA (5.43s timeout)	0.44	79
30s timeout	0.51	157
120s timeout	0.67	255
always on	0.95	-
CTMDP	0.97	4

References

[1] L. M. A. Karlin, M. Manesse and S. Owicki. Competitive randomized algorithms for nonuniform problems. *Algorithmica*, pages 542–571, 1994.

[2] G. Paleologo, L. Benini, A. Bogliolo, and G. D. Micheli. Policy optimization for dynamic power management. *Transactions on CAD*, 1999.

[3] Q. Qiu and M. Pedram. Dynamic power management based on continuous-time markov decision processes. In *Design Automation Conference*, pages 555–561, 1999.

[4] T. Simunic, L. Benini, and G. D. Micheli. Event-driven power management. In *International Symposium on System Synthesis*, pages 18–23, 1999.