

Power-efficient Server-class Performance from Arrays of Laptop Disks

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Motivation

- **Data centers are increasingly important**
 - 1995: **20 thousand** servers in the world
 - June 2001: **six million** servers
- **Disks account for 27% of total electric consumption on average**
 - High-end configurations much worse:
 - ✓ Disks can consume 15x more power than processors
- **Mobile disk power management is **not** effective for servers**
 - Server disks require **long** idle intervals to save power
 - Server workloads are characterized by **short** idle periods

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Adaptive Throughput

- **Previous work suggests multi-speed disks [DRPM'03]**
 - Take advantage of load variation in server workloads
 - **BUT:** DRPM not commercially available yet
- **Alternative design: Mirrored Arrays of Laptop Disks**
 - Keep activated subset of disks proportional to current workload.
 - Exploit latency tolerance and parallelism to
 - ✓ Achieve energy savings
 - ✓ With equal or better throughput
 - ✓ Mirrored disks → Longer idle intervals for each disk

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Disk Arrays: Why Laptop-class Disks?

Similar capacities, caches, prices

- | Server-class disks: | Laptop disks: |
|---|--|
| <ul style="list-style-type: none">➢ Lower rotational latencies (15KRPM)➢ Lower seek times (4ms)<ul style="list-style-type: none">✓ 2.5 times better➢ Larger form factor (3.5 inches)➢ Power hungry:<ul style="list-style-type: none">✓ more than 12 W even when idle.➢ No or few low-power modes | <ul style="list-style-type: none">➢ Higher Rotational Latencies (7KRPM)➢ Higher seek times (10ms)➢ Smaller form factor (2.5 inch)➢ Consume less than 3W @ Active<ul style="list-style-type: none">✓ 6 times more efficient➢ Several low power modes (5) |

Current technological design point: Replace at a ratio of **one to three**

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Advantages and Disadvantages of a Mobile Disk Array

- **Disadvantages**
 - Higher initial cost
 - Higher latency for individual requests at light workloads
- **Advantages**
 - Significantly lower operational power
 - Lower cooling needs
 - Potentially denser packaging
 - Lower noise
 - Potentially higher peak bandwidth
 - Potentially higher mean time to data loss (mirroring)
 - Faster development curve of laptop disks

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Research Challenges

- **Disk selection policy**
 - Maximize idle intervals rather than per-disk throughput
- **Handling of write activity**
 - Writes must be performed on all copies
- **Power management policy**
 - Minimize effect of high latency mode transitions
- **Two-dimensional disk arrays**
 - Interaction between mirroring and file striping

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Current Status

- **Detailed multi-disk laptop array simulator**
 - Based on DiskSim
- **Lab-bench system for high precision power measurements**
- **Preliminary results (based on simulations):**
 - Baseline savings: **50%**
 - During light workloads: Savings up to **80%**

www.cs.rochester.edu/~papathan/research/BurstyFS/

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