COMP 7970 Storage Systems

Power Management in Server Class Disks

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Motivations

• IBM Ultrastar 36ZX disk is rated at 22.3 W
• Intel Xeon processor clocked at 1.6 GHz is rated at 57.8 W.

• Observation?
• 4-way Intel Xeon SMP clocked at 1.6 GHz with 140 disks drawn from.
• The disks consume 13.5 times more power than the processors.
Traditional Energy Conservation Techniques

- Use a large cache; Prefetching
  - To hide disk latencies.
  - Why it sometimes does not work?
  Not all server workloads exhibit high temporal locality

- Shut down disks, i.e., completely stop disk rotation.
  - What the problem?
    (1) The disk needs to be spun up to full speed before a request can be serviced
    (2) Performance is more critical
Basic Idea

- **Dynamic Rotations Per Minute (DRPM)** - choose to dynamically operate between the two extremes: high performance and high energy efficiency.

- Dynamically **modulate the speed** at which the disk spins (RPM), thereby controlling the power expended in the spindle motor driving the platters.
A Challenge

• Are **spindle motors** major power consumers in disks?

• Can we find **real-world** multi-speed disks?

• If you **can not** find a multi-speed disk, how to develop a concept model?
IBM Server Disks

IBM Family of Server Disk Drives

Observations?
Calculating the Power Consumption at an RPM Level

- Speed -> Performance
- Speed <- Power -> Energy Efficiency

\[ V = K_E \omega \]

Voltage \( \rightarrow \) Constant

Angular velocity (rotation-speed)
Calculating the Power Consumption at an RPM Level

- Energy Consumed by a motor

\[ P = VI = \frac{V^2}{R} \]

\[ P = \frac{K_E^2 \omega^2}{R} \]
Comparison of DRPM Model to the IBM Projections

\[
P_{idle} = 1.318 \times 10^{-7} rpm^2 - 4.439 \times 10^{-4} rpm + 8.643
\]

(3)

\[
P_{idle} = 0.0013 rpm + 4.158
\]
SPM Current Profile of Multimode Harddisk Drive

Current Drawn by Sony Multimode Hard Disk

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IBM Disk Power Modes
# Disk Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Parameters Common to TPM and DRPM</strong></td>
<td></td>
</tr>
<tr>
<td>Number of Disks in the Array</td>
<td>12,24</td>
</tr>
<tr>
<td>Stripe Size</td>
<td>16 KB</td>
</tr>
<tr>
<td>RAID Level</td>
<td>5,10</td>
</tr>
<tr>
<td>Individual Disk Capacity</td>
<td>33.6 GB</td>
</tr>
<tr>
<td>Disk Cache Size</td>
<td>4 MB</td>
</tr>
<tr>
<td>Max. Disk Rotation Speed</td>
<td>12000 RPM</td>
</tr>
<tr>
<td>Idle Power @ 12000 RPM</td>
<td>22.3 W</td>
</tr>
<tr>
<td>Active (R/W) Power @ 12000 RPM</td>
<td>39 W</td>
</tr>
<tr>
<td>Seek Power @ 12000 RPM</td>
<td>39 W</td>
</tr>
<tr>
<td>Standby Power</td>
<td>4.15 W</td>
</tr>
<tr>
<td>Spinup Power</td>
<td>34.8 W</td>
</tr>
<tr>
<td>Spinup Time</td>
<td>26 secs.</td>
</tr>
<tr>
<td>Spindown Time</td>
<td>15 secs.</td>
</tr>
<tr>
<td>Disk-Arm Scheduling</td>
<td>Elevator</td>
</tr>
<tr>
<td>Bus Type</td>
<td>Ultra-3 SCSI</td>
</tr>
<tr>
<td><strong>DRPM-Specific Parameters</strong></td>
<td></td>
</tr>
<tr>
<td>Power Model Type</td>
<td>Quadratic, Linear</td>
</tr>
<tr>
<td>Minimum Disk Rotation Speed RPM Step-Size</td>
<td>3600 RPM</td>
</tr>
<tr>
<td>RPM Step-Size</td>
<td>600,2100 RPM</td>
</tr>
</tbody>
</table>

IBM Ultrastar 36ZX

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Energy Break Down

Breakdown of Energy Consumption

Observations? Implications?

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Potential Benefits

Exponential Traffic

Observations?