Models and Metrics to Enable Energy-Efficiency Optimizations

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What?
- Power consumption from data centers have been increasing dramatically, and will double during the next five years (2007)
- Much research on power management, but few models for energy efficiency
- Propose a benchmark power consumption in all systems: JouleSort
Why?
Why

- Previously, benchmarks have been for specific domains
- Need metrics that can drive energy efficient design
  - For large systems, costs for power exceeds hardware costs by a large margin
  - Benchmarks can help guide design processes and other decisions that may increase efficiency
How
- JouleSort
- Use external sort as workload
  - sort a file consisting of randomly permuted 100-byte records with 10 byte key
  - input file read from, and output file written to, nonvolatile storage
  - newly created file
- Measures peak performance
How to measure?

- Fixed energy budget
- Fixed time budget
- Fixed workload size
Results
### Table 4. Systems for which the JouleSort rating was experimentally measured.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laptop</td>
<td>A modern laptop with an Intel Core 2 Duo processor and 3 Gbytes of RAM</td>
</tr>
<tr>
<td>Blade-wall</td>
<td>A single low-power blade plus the full wall power of its enclosure (designed for 16 blades)</td>
</tr>
<tr>
<td>Blade-amortized</td>
<td>A single low-power blade plus its proportionate share of the enclosure power</td>
</tr>
<tr>
<td>Standard server</td>
<td>A standard server with Intel Xeon processor, 2 Gbytes of RAM, and 2 hard disks</td>
</tr>
<tr>
<td>Fileserver</td>
<td>A fileserver with 2 disk trays containing 6 disks per tray</td>
</tr>
<tr>
<td>CoolSort</td>
<td>A desktop with a high-end mobile processor, 2 Gbytes of RAM, and 13 SATA laptop disks</td>
</tr>
<tr>
<td>Gumstix</td>
<td>An ultra-low-power system used in embedded devices</td>
</tr>
<tr>
<td>Soekris</td>
<td>A board typically used for networking applications</td>
</tr>
<tr>
<td>VIA-laptop</td>
<td>A VIA picoITX multimedia machine with laptop hard disks</td>
</tr>
<tr>
<td>VIA-flash</td>
<td>A VIA picoITX multimedia machine with flash drives</td>
</tr>
</tbody>
</table>
Results
Results
- Demonstrated that improvements in energy efficiency can be driven by benchmarks
- Continues on sort benchmark tradition of identifying promising new technology

- Parallelism might be even better (2007)
- Scaledown of unused parts might be bigger/better (2007)