Energy Management
The key to successful storage optimization

Joe Polastre
chief technology officer and co-founder
Sentilla Corporation
35% of facility electricity consumption
Data Center Trends

Data Center Electricity Use in the United States

Avg Annual Use (billion kWh)


Actual Estimated
### Data Center Energy Density by Company

<table>
<thead>
<tr>
<th>ft² (CRE)</th>
<th>IBM</th>
<th>AT&amp;T</th>
<th>JPMorgan Chase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Bill</td>
<td>6%</td>
<td>3%</td>
<td>2%</td>
</tr>
<tr>
<td>Energy Bill</td>
<td>30%</td>
<td>16%</td>
<td>20%</td>
</tr>
</tbody>
</table>
Impact of Storage

- IT Load consumes 46% of D.C.
  - Server 25%
  - Networks 8%
  - Storage 13%

Installed # of Petabytes (57% 2006-2011 CAGR)

Cost to Power and Cool (19% 2006-2011 CAGR)

Capacity (PBs)

SM
The role storage plays

- Amount of data being stored increases 56% per year
- High density racks and server virtualization put more pressure on storage requirements
- Consolidate to:
  - Simplify tiering
  - Manage less equipment
  - Save power and cooling
  - Utilize more of what you already have
Intelligent Data Center Energy Management
A complete view of energy as a key data center asset
The IT-Facilities Gap

Facilities
- Cooling
- Air Flow
- Energy Suppliers
- Power Bill

Infrastructure

IT
- SLAs
- Servers/Storage
- Delivery/Network
- Cloud

Applications
- EMS
- SNMP
- IMPI/iLO

Data Center
Applications!
Power Usage Effectiveness

- As developed by The Green Grid

$\text{PUE} = \frac{\text{Total Power Consumed}}{\text{IT Power Consumed}}$

$\text{DCiE} = \frac{1}{\text{PUE}}$
Exploring PUE

- For every W of IT power consumed, up to 2.2W of total power consumed
A Look at Server Consolidation

2.248 MW
$1.57m/year
PUE = 2.059

1.795 MW
$1.25m/year
PUE = 2.326

Cost
Capacity
PUE = 6.384
PUE is not a measure of EFFICIENCY

Efficiency = \frac{\text{Useful Work}}{\text{Quantity of Energy}}

100W, 1500 lumens
25W, 1700 lumens

Energy

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Washing machine</th>
</tr>
</thead>
<tbody>
<tr>
<td>More efficient</td>
<td>B</td>
</tr>
<tr>
<td>Less efficient</td>
<td>G</td>
</tr>
</tbody>
</table>

Energy consumption kWh/cycle
(based on standard test results for 60°C cotton cycle)
Actual energy consumption will depend on how the appliance is used

Washing performance
A: higher, G: lower

Spin drying performance
A: higher, G: lower
Spin speed (rpm)

Capacity (cotton) kg
Water consumption

Noise (dB(A) re 1 pW) Washing Spinning
5.2 7.0

Further information contained in product brochure
What about Google?
A Tale of Three Companies

Revenue generated per advertisement

Cost of content for each ad served

Financial Transactions

Cost per Transaction

Supply chain throughput

Supply chain & Asset Mgmt IT overhead
Steps to Energy Sustainability

1. Measure
   • Arm yourself with as much information as is practical
   • Set a baseline of your consumption

2. Analyze
   • Identify offenders, waste, unknowns
   • Uncover trends

3. Act
   • Adjust operations, schedules, cooling, load
   • Replace, repair, turn off offending equipment,
   • Adopt automation solutions
Inventory & Turning off Equipment

- Typical data center utilization: 8-10%
- Equipment added, but old equipment not removed/replaced
- 15% unused
  - Costing $24.7b/year
  - Only $4b is energy
- 83% of data center managers “don’t have a grasp on utilization”  
  [source: IDC]
MIPS/Watt

- Used to measure supercomputers for decades
  - But really only applies to compute-intensive workloads
  - FLOPS or MIPS per Watt
  - (Relatively) easy to measure

- Variants normalize MIPS using SPEC_int
  - Petacycles/Watt
- Useful work is proportional to network volume

- \( \text{Bits/kWh} = \frac{\text{Total Outbound Volume}}{\text{Total Data Center Consumption}} \)

- Easy to set up, easy to measure
- Not necessarily representative of the work (i.e., backups)
Storage Consolidation

Watts/TB = 33
Watts/Usable TB = 111

Watts/TB = 33
Watts/Usable TB = 55
Understand storage needs

- What are the workloads?
- What are the existing storage capabilities?
- What are the performance characteristics of the existing storage and workloads?
- What are the data protection and business continuity requirements?
- What is the current SAN Architecture?
Define storage performance requirements

- What is needed now and in the future?
  - IOPS / MBPS
  - Fan-out Ratios
  - Masked Device limits
  - Risk domains

- Define success metrics
  - IO/sec
  - MBPS
  - % cache hits

- Incorporate power metrics
  - W/IO
  - W/TB
Baseline today’s storage

- **Perform a storage audit**
  - Storage array vendor and model
  - Microcode
  - Disks (size, speeds, etc)
  - Cache
  - LUN size
  - Power consumed
  - Allocated storage
  - Utilized storage

- **Unlikely that your storage arrays have power metering**
  - Compute power consumed per disk
  - Sum with the power consumed by the array chassis

- **Most companies are near 100% allocation but only 30% utilized!**
Rank existing storage

- **Compute energy performance metrics for existing storage:**
  - Watts per sq ft
    - Impact of storage on the space that you own/lease
  - Watts per TB
    - How much does it cost to power a single TB (capacity)
  - Watts per used TB
    - How much is the overhead costing
  - Watts per IOPS (or kilo-IOPS)
    - How much are you getting out of a specific array
  - Watts per MBPS (or kBPS)
    - How efficient is the cache/data transport

- **Compare existing and new arrays to perform ROI analysis**
  - Compare each tier of storage
  - Identify where existing storage can be used for new data
Tactics: Higher Density Disks

1 TB on 7200RPM drive is 94% more efficient than 15000 RPM 73GB Fibre Channel drives

Source: ITPMG
Tactics: MAID

- **Level 0:**
  - Normal operation at 7,200 rpm with heads loaded (un-parked)

- **Level 1:**
  - Heads Unloaded (parked, reduces wind resistance on heads)
  - 15% to 20% power savings
  - Sub-second recovery time

- **Level 2:**
  - Heads Unloaded
  - Slows to 4000 rpm
  - 35% to 45% power savings
  - 15 second recovery time

- **Level 3:**
  - Stops spinning (sleep mode; powered on)
  - 60% to 70% savings
  - 30 to 45 second recovery time
Compute the TCO of new Storage Operating Budget & Capital Expense

<table>
<thead>
<tr>
<th>Capex 1</th>
<th>Capex 2</th>
<th>Cost of Fuel 1</th>
<th>Cost of Fuel 2</th>
<th>TCO 1</th>
<th>TCO 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>$150,000</td>
<td>$200,000</td>
<td>$202,500</td>
<td>$135,000</td>
<td>$352,500</td>
<td>$335,000</td>
</tr>
</tbody>
</table>
Operating Budget & Capital Expense

Factors:
- CapEx of Server
- Useful Work it Performs
- Energy Operating Cost
- Operational Management

<table>
<thead>
<tr>
<th>IU servers</th>
<th>Blade server</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 servers</td>
<td>8 blades</td>
</tr>
<tr>
<td>25.2mops/sec</td>
<td>25.8mops/sec</td>
</tr>
<tr>
<td>$72,000 capex</td>
<td>$94,000 capex</td>
</tr>
<tr>
<td>8.4kW load</td>
<td>3.9kW load</td>
</tr>
<tr>
<td>$17.6k/3yr IT</td>
<td>$8.2k/3yr IT</td>
</tr>
<tr>
<td>$38.7k/3yr Total</td>
<td>$14.7k/3yr Total</td>
</tr>
<tr>
<td>$111k TCO</td>
<td>$109k TCO</td>
</tr>
</tbody>
</table>
SNIA Green Storage Initiative

- Benchmark the **Idle** power consumption over a 24 hour period
- Only a measurement proposal
- Measures *Storage Capacity per Watt* – eg 1 GB / 200 W
- No user IO during test period

**Equation 7-1 SNIA Idle Power Metric**

\[ P = \frac{C}{P_i} \]

Where:
- \( P \) is the SNIA Idle Power Metric
- \( C \) is the total capacity of the SUT
- \( P_i \) is the average idle power
- Benchmark the system, not the components
- Record & Report:
  - tps for an OLTP workload
  - Idle power consumption
  - Full load power consumption
  - Watts/tps
  - System cost
  - Cost/tps
Report in the context of Applications
Correlate the business cost back to terms that each Line of Business can understand

Key Performance Indicators
Time Range: July 2010
Filter: (ApplicationFamily = "SAP ERP") AND (PUECategory = IT)

Data Center Summary
Data Center: NYM03

![Graphs showing kW Demand, PUE, Watts, and Watts/TB]

Application Summary
For all known applications, normalized using SPEC_int benchmark.

<table>
<thead>
<tr>
<th>Application</th>
<th>Cost</th>
<th>kWh</th>
<th>MFlop/s</th>
<th>W/MFlop</th>
<th>W/TB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microsoft Exchange Server</td>
<td>$17</td>
<td>2,166</td>
<td>41</td>
<td>73</td>
<td>3104</td>
</tr>
<tr>
<td>Oracle 11g</td>
<td>$1,71</td>
<td>21,657</td>
<td>422</td>
<td>71</td>
<td>2730</td>
</tr>
<tr>
<td>PeopleSoft</td>
<td>$684</td>
<td>8,663</td>
<td>150</td>
<td>80</td>
<td>3162</td>
</tr>
<tr>
<td>Exadata</td>
<td>$114</td>
<td>1,444</td>
<td>27</td>
<td>74</td>
<td>2460</td>
</tr>
<tr>
<td>SAP CRM 6.0</td>
<td>$513</td>
<td>6,497</td>
<td>116</td>
<td>78</td>
<td>2218</td>
</tr>
<tr>
<td>SAP ERP 6.0</td>
<td>$1,14</td>
<td>14,438</td>
<td>262</td>
<td>76</td>
<td>2498</td>
</tr>
</tbody>
</table>
Available Redundant Capacity

- What happens if P1 fails?
  - P2 must provide full load

- P1+P2 capacity: 10kW (kVA)
- Server actual consumption: 4kW

- Redundant Capacity = 10kW / 2 = 5kW
- Actual Consumption = 4kW
- ARC = 5 - 4 = 1kW

1kW redundant capacity available for expansion

(assuming the circuits have equal capacity)
And your UPS is now really underutilized and running inefficiently
Loading circuits to Active Consumption

![Bar Chart]

- **Capacity**
- **Allocated**
- **Active Load**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Capacity</th>
<th>Allocated</th>
<th>Active Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical</td>
<td>1800</td>
<td>600</td>
<td>1200</td>
</tr>
<tr>
<td>Derating</td>
<td>1800</td>
<td>600</td>
<td>1200</td>
</tr>
<tr>
<td>Dynamic</td>
<td>2000</td>
<td>400</td>
<td>1600</td>
</tr>
</tbody>
</table>
Storage is a Black Hole!

- Few data center operators have visibility into storage use
  - Leads to excessive purchase of new inefficient storage for their workloads
- Need visibility into:
  - Real time power consumption
  - Performance (IOPS, MBPS)
  - Allocation and Utilization
  - Configuration, Redundancy, and Tiering
- Manage using metrics
  - Watts per TB (usable and allocated)
  - Watts per IOPS
- Evaluate changes with TCO analysis incorporating power performance over 3 years
Additional Resources

- ITPMG Achieving Green Storage

- SNIA Green Storage Initiative
  - http://www.snia.org/forums/green/

- TPC-E Benchmark
  - http://www.tpc.org/tpce/

- The Green Grid (PUE, free cooling calculator, etc)
  - http://www.thegreengrid.org

- The Green and Virtual Data Center (book)
Thank You

joe@sentilla.com

Blog: http://blog.sentilla.com
Twitter: http://twitter.com/sentilla