Case Study:
Data Center Optimizes Server Capacity
with New Energy Efficiency Model

Clemens Pfeiffer, CTO, Power Assure, Inc.
About Power Assure

- **Award winning technology**
  - First ever double winner in Clean Tech Open Competition
  - $5M Depart of Energy grant
    - “Game changing energy efficiency applications”
  - Core automation software used for over 10 years at Exodus, HP & Sprint
  - Enhanced for energy Management and Optimization

- **Energy efficiency improvements 50%+**
  - Baseline monitoring of power, temperature, application utilization
  - Tracks and reports performance, capacity and savings *in real time*
  - Integrated inventory and capacity management
  - Transforms “Always On” to “Always Available”

- **Resources to expand**
  - Total capital raised $18.75M. Investors include Draper Fisher Jurvetson, Good Energies, Point Judith Capital
A Data Center Example

Data center before improvements:
- 100,000 sq ft – 700 racks
- 8,000 server (500 racks / ~3.8kW)
- Average age 3 years
- 50 racks networking (~6kW)
- 150 racks storage (~3kW)
- PUE 2.3
- Total power consumption: 6.1MW of 10MW
- Cost per year: $4.1M ($0.075/kWh)
- Average server utilization 10%

One-time improvement targets:
- Target PUE 1.3
- Cold Isle Temperature 80F
- Up to 10kW per rack
- Not to exceed 10MW at Peak Utilization
- Increase capacity 300% / leave space for more
- PAR4 Platinum Green servers
- VMware Virtualization

On-going management:
- Real-time baseline Management
- Dynamic Capacity Optimization
The Consolidation Process

1. Assess current ecosystem
   - Power
   - Metering
   - Building
   - IT Setup
   - Applications
   - Load / Utilization

2. Establish Baseline
   - Power
   - Temperature
   - PUE/DCiE
   - Load and Capacity
   - Equipment Metrics
   - Service Levels

3. One-time Improvement
   Using:
   - Variable Cooling
   - Efficient Fans
   - Increase Inlet
   - Temperature
   - Server Refresh
   - Virtualization

4. Ongoing Efficiency
   Using:
   - Vmware
   - XEN
   - Hyper-V
   - Sun
   - Citrix
   - Load balanced
   Integrated with:
   - Demand Response
   - Alerts/Outages
   - Rebates / CO2

5. Optimize capacity
   - Run-book automation
   - Align servers to meet demand
   - Manage buffer
   - Power savings
   - QoS
   - Load balancing

6. Optimize in a smart grid
   - Shed and shift load between multiple sites
   - Optimize based on:
     - energy cost
     - time of day
     - performance
     - temperature
     - incentives
   - Demand-response
   - Price shifting

Dynamic Power Management
Dynamic Power Optimization

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The Baseline

Observe and understand the opportunity
The Inventory

Interesting elements:

• Power distribution
  - Limits/redundancy/meters

• Cooling infrastructure
  - BTU/hot-cold isles/controls

• IT equipment
  - Server/network/storage
  - Age/efficiency
  - Measurements
Baseline Monitoring (Good/Better/Best)

**Good**
Building level monitoring
- PUE, kWh, Amps, kW for IT and Cooling
- Temperature

**Better**
Circuit level monitoring and IT load monitoring
- Per rack kW, Amps for what-if analysis
- Phase balancing and building details
- IT application load and capacity
- Alerts and inventory integration

**Best**
Device level monitoring
- Outlet level metering / Power supply metering
- Component utilization from devices
- Temperature of devices
NASA Ames Dashboard
One-Time Improvements

Act on information to intelligently adjust cooling and IT
Cooling – Get Your PUE Down

- Hot / cold isle isolation
- 80.6F inlet temperature, ASHRAE recommendation
- Variable cooling
- Outside air economizer
## Server Comparison

<table>
<thead>
<tr>
<th>Year</th>
<th>CPU</th>
<th>IDLE</th>
<th>LOADED</th>
<th>RACK</th>
<th>TXN/WATT</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>UltraSparc T1, 32 Threads 1GHz</td>
<td>179W</td>
<td>200W</td>
<td>4000W 20 per Rack</td>
<td>95,000</td>
</tr>
<tr>
<td>Sun T2000</td>
<td></td>
<td></td>
<td></td>
<td>380MTxn</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>Dual L5520 Quad Core, 2.27GHz, 12GB Memory</td>
<td>113W</td>
<td>197W</td>
<td>7880W 40 per Rack</td>
<td>543,000</td>
</tr>
<tr>
<td>HP DL160 G6</td>
<td></td>
<td></td>
<td></td>
<td>4,280MTxn</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>Dual L5518 Quad Core, 2.13GHz, 8GB Memory</td>
<td>132W</td>
<td>217W</td>
<td>8680W 40 per Rack</td>
<td>516,000</td>
</tr>
<tr>
<td>Supermicro 6016</td>
<td></td>
<td></td>
<td></td>
<td>4,120MTxn</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>Dual L5420 Quad Core, 2.5GHz, 8GB Memory</td>
<td>83W</td>
<td>157W</td>
<td>6280W 40 per Rack</td>
<td>700,000</td>
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<tr>
<td>Dell CS24-SC</td>
<td></td>
<td></td>
<td></td>
<td>4,400MTxn</td>
<td></td>
</tr>
</tbody>
</table>
Cisco UCS / HP 1U Examples

**10kW/Rack:**
- 3 Server (18U)
- 288 Cores
- 5,500MTxn
- 8,400W

**Cisco:**
96 Cores, 6U, 2,800 Watts

**Measurement Details**
Cisco UCS Blades with Dual Intel X5670 CPU(s)
2.66GHz 6-way Core
96GB RAM
2 x 146GB SAS / 10000RPM HDD

**PAR4®**
Estimated Cost for 3 years:
1935
$3,164.37

**Power Consumption Details**

<table>
<thead>
<tr>
<th>Mode</th>
<th>IDLE</th>
<th>LOADED</th>
<th>PEAK</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>233W</td>
<td>1218W</td>
<td>1746W</td>
</tr>
<tr>
<td>2011</td>
<td>233.7V</td>
<td>1218.0V</td>
<td>1746.0V</td>
</tr>
<tr>
<td>2012</td>
<td>327.4A</td>
<td>327.4A</td>
<td>327.4A</td>
</tr>
<tr>
<td>2013</td>
<td>0.714PF</td>
<td>0.94PF</td>
<td>0.94PF</td>
</tr>
<tr>
<td>2014</td>
<td>0.714PF</td>
<td>0.94PF</td>
<td>0.94PF</td>
</tr>
</tbody>
</table>

**PAR4® Transactions**
Average number of PAR4® Transactions on the order of: 1,843,000,000

**HP:**
8 Cores, 1U, 170 Watts

**Measurement Details**
Hewlett-Packard DL160-G8
Dual Intel L5520 CPU(s)
2.27GHz Quad Core
8GB RAM
1 x 190GB SATA / 7200RPM HDD

**PAR4®**
Estimated Cost for 3 years:
1925
$247.82

**Power Consumption Details**

<table>
<thead>
<tr>
<th>Mode</th>
<th>IDLE</th>
<th>LOADED</th>
<th>PEAK</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>267W</td>
<td>166W</td>
<td>166W</td>
</tr>
<tr>
<td>2011</td>
<td>267.7V</td>
<td>166.7V</td>
<td>166.7V</td>
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<tr>
<td>2012</td>
<td>0.40A</td>
<td>0.40A</td>
<td>0.40A</td>
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<tr>
<td>2013</td>
<td>0.143PF</td>
<td>0.143PF</td>
<td>0.143PF</td>
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<td>2014</td>
<td>0.143PF</td>
<td>0.143PF</td>
<td>0.143PF</td>
</tr>
</tbody>
</table>

**PAR4® Transactions**
Average number of PAR4® Transactions: 105,000,000

**Boot Cycle Test Cycle**

**PAR4 Test Cycle**

**Average number of PAR4® Transactions on the order of: 1,843,000,000**
What If Analysis

What if analysis:
- Required space
  - Rack U size
  - Weight
- Required power
  - A/kW
  - Outlets

After Installation:
- On-going analysis
  - Power A/kW
  - Temperature
Dynamic Capacity Optimization

Move from Always-On to Always-Available
Customer Case Study

4000 Server, 2U / 2007 Model, Dual Core AMD 2xxxHE

Idle: 269W
Loaded: 347W

Actual Circuit Cost: $2,880,000 per year ($600/20A circuit)
Available Capacity: 196,000 MTxns

16% Average utilization
Always-On vs Always-Available

Without Optimization

With Optimization
Results

1 Week – 15min average data
Compressed run – 1 Point / 3min

Cost per transaction set
- Always On ($40 - $750)
- Always Available ($21 - $192)

Always On (40 Server):
- Total Run: 31 hours
- Total kWh: 39.63

Always Available (40 Server):
- Total Run: 31 hours
- Total kWh: 17.12

Savings: 56.79%
Holistic Optimization Architecture

- **Track demand**
  - Transactions and utilization

- **Optimize / calculate**
  - # Elements to support current demand

- **Verify impact**
  - SLA, temperature, power, utilization, savings, CO2

- **Adjust capacity**
  - Real time using automated customer run books

**Reference Data**
- Equipment
  - Efficiency
  - Where/what
- Energy
  - Pricing
  - Demand response
  - Alerts
- Smart grid
Follow this Optimization Process:

To reduce capacity:
- Free up server from virtual machines
  - MigrateVMs to other hosts (DRS)
  - PowerOffVM (Optional)
  - Wait for transfer/power off to complete
  - PowerOffHost
- Server (via IPMI/iLo/ssh)
  - Shutdown server / change P state
  - Wait for no response
- Power
  - Sleep / turn off components
  - Turn off outlet
- Cooling
  - Adjust cooling

To add capacity:
- Cooling
  - Adjust cooling
- Power
  - Turn on
  - Wait for response
- Server
  - Start services
  - Wait for services
- Add virtual machines
  - AddHost
  - MigrateVMs to new hosts (Optional)
  - Add VM to cluster to Rebalance (DRS)
Example Interaction with Environment

Adjust airflow
Adjust chiller water valve

Keep temp close to ASHRAE top 80.6F / 27C

Temp Top
SNMP/IPMI

Temp Bottom
The Final Result, from Earlier Example

Original data center:
- 100,000 sqft – 700 racks
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- Average age 3 years
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- 150 racks storage (~3kW)
- PUE 2.3
- Total power consumption: 6.1MW of 10MW
- Cost per year: $4.1M ($0.075/kWh)
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One time improvements:
- 4,800 server (120 Racks / ~6.8kW)
  - Average utilization 10%
- 300 racks of UCS Blade server (16.8kW)
  - Average utilization 20%
- 70 racks networking (~6kW)
- 210 racks storage (~3kW)
- PUE 1.3
- Total peak power consumption: 9.1MW
- 25x increase in capacity
- Cost per year: $6M ($0.075/kWh)

With Dynamic Capacity Optimization:
- 100,000 sqft – 700 racks
- 4,800 server (120 Racks / ~6.8kW)
  - Average utilization 10%
- 300 racks of UCS Blade server (16.8kW)
  - Average utilization 20%
- 70 racks networking (~6kW)
- 210 racks storage (~3kW)
- PUE 1.3
- Savings 57% on virtualized blade server
- Peak power consumption: 9.1MW
- Average power consumption: 5.25MW
- Cost per year: $3.4M ($0.075/kWh)
- Average running server utilization 80%

- Power cost savings per year:
  $2.6M / 43%
Summary

- Hardware upgrades provide you the required capacity increase for consolidation

- Dynamic optimization provides you the 30% mandated power savings

- Baseline management documents the savings and improvements