Information Technology and Data Centers (Webinar 1)

Emerging Technologies Showcase
IT Equipment & Power Management

November 20, 2013

Welcome. Today’s webinar is being recorded and will be posted at:

• www.E3Tnw.org
• www.ConduitNW.org
Information Technology and Data Centers (Webinar 1)

Mike Bailey – Ecova
- Server Virtualization
- High-Efficiency UPS Equipment
- Power Management for IT Equipment

Brian Fortenbery & Micah Sweeney – EPRI
- Solid State Drives (Flash Memory)

John Seger – CABLEexpress
- Storage Area Network (SAN) & Network Core Consolidation
Server Virtualization

Mike Bailey – Director, Facility Engineering

November 20, 2013
Virtualization Overview

- VMware decouples software from hardware:

![Diagram of Virtualization]

Source: VMware Overview Presentation to PG&E
Challenge: Server Proliferation

- Consolidate servers
- Increase utilization
- Reduce hardware, power, cooling

Server Sprawl

Low Utilization

High Power Consumption

Higher Utilization

Lower Consumption

Source: VMware Overview Presentation to PG&E
Server, Storage and Network Consolidation

<table>
<thead>
<tr>
<th></th>
<th>BEFORE VMware</th>
<th>AFTER VMware</th>
</tr>
</thead>
<tbody>
<tr>
<td>Servers</td>
<td>1,000</td>
<td>80</td>
</tr>
<tr>
<td>Storage</td>
<td>Direct attach</td>
<td>Tiered SAN and NAS</td>
</tr>
<tr>
<td>Network</td>
<td>3,000 cables/ports</td>
<td>300 cables/ports</td>
</tr>
<tr>
<td>Facilities</td>
<td>200 racks</td>
<td>10 racks</td>
</tr>
<tr>
<td></td>
<td>400 power whips</td>
<td>20 power whips</td>
</tr>
</tbody>
</table>

Source: VMware Overview Presentation to PG&E March 2008
## Power Savings from Consolidation

### BEFORE

<table>
<thead>
<tr>
<th>Max Power Capacity Rating</th>
<th>% of Max</th>
<th>kW / Yr</th>
<th>Cost / kWh</th>
<th>Cost / Yr</th>
<th>Savings / Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 CPU</td>
<td>300</td>
<td>475 W</td>
<td>x 67%</td>
<td>407 kW/hr x 24 x 365</td>
<td>= Power: $356,554</td>
</tr>
<tr>
<td>2 CPU</td>
<td>500</td>
<td>550 W</td>
<td>x 67%</td>
<td>53 kW/hr x 24 x 365</td>
<td>= Cooling: $445,693</td>
</tr>
<tr>
<td>4 CPU</td>
<td>200</td>
<td>950 W</td>
<td>x 67%</td>
<td>53 kW/hr x 24 x 365</td>
<td>= Power: $46,513</td>
</tr>
<tr>
<td>8 CPU</td>
<td>--</td>
<td>1600 W</td>
<td>x 67%</td>
<td>53 kW/hr x 24 x 365</td>
<td>= Cooling: $58,141</td>
</tr>
</tbody>
</table>

### AFTER

<table>
<thead>
<tr>
<th>Max Power Capacity Rating</th>
<th>% of Max</th>
<th>kW / Yr</th>
<th>Cost / kWh</th>
<th>Cost / Yr</th>
<th>Savings / Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 CPU</td>
<td>--</td>
<td>594 W</td>
<td>x 67%</td>
<td>53 kW/hr x 24 x 365</td>
<td>= Power: $697,593 (86%)</td>
</tr>
<tr>
<td>2 CPU</td>
<td>38</td>
<td>688 W</td>
<td>x 67%</td>
<td>53 kW/hr x 24 x 365</td>
<td>= Cooling: $58,141</td>
</tr>
<tr>
<td>4 CPU</td>
<td>38</td>
<td>1188 W</td>
<td>x 67%</td>
<td>53 kW/hr x 24 x 365</td>
<td>= Power: $697,593 (86%)</td>
</tr>
<tr>
<td>8 CPU</td>
<td>4</td>
<td>2000 W</td>
<td>x 67%</td>
<td>53 kW/hr x 24 x 365</td>
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</table>

### Rule of thumb:

~$700 and 7,000 kWh saved per year per workload virtualized
Data Centers are often under utilized

- Up to 30% servers are dead

- Savings from removing “dead” or decommissioned servers often included in virtualization benefits – but can be done without virtualization

Source: Uptime Institute, McKinsey Data Center Report

* Sample size – 45 data centres
# Replace Old Servers (Refresh!)

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2009</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product</strong></td>
<td>Intel Xeon Single Core (3.8GHz w/ 2M cache)</td>
<td>Intel Xeon 5680 (6 cores, 3.33GHz)</td>
<td>Intel Xeon E5-4650 (4-socket, 8 cores)</td>
</tr>
<tr>
<td><strong>Performance per Server</strong></td>
<td>50,970bops SPECjbb2005</td>
<td>765,000bops SPECjbb2005</td>
<td>2,818,988 SPECjbb2005</td>
</tr>
<tr>
<td><strong>KWh per server per day</strong></td>
<td>6.704 (382 W active / 228 W idle)</td>
<td>4.936 (383 W active / 117 W idle)</td>
<td>3.216 (402 W active / 98 W idle)</td>
</tr>
<tr>
<td><strong>Desired Performance</strong></td>
<td>9.4 million business operations per second</td>
<td>9.4 million business operations per second</td>
<td>9.4 million business operations per second</td>
</tr>
<tr>
<td><strong>Servers Needed</strong></td>
<td>315 in 15 racks</td>
<td>21 in 1 rack</td>
<td>6 Servers</td>
</tr>
<tr>
<td><strong>Estimated Annual Energy Cost (2.0 PUE)</strong></td>
<td>$154,581</td>
<td>$7,588</td>
<td>$1,410</td>
</tr>
</tbody>
</table>

- Savings from server refresh often included in virtualization benefits – but can be done without virtualization

Source: Intel Xeon 5600 Refresh Brief, Xeon Performance
High Efficiency UPS Equipment

Mike Bailey – Director, Facility Engineering

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Components of a data center

- Air Conditioning (AC)
  - HVAC, Chillers
  - ACU, CRAC

- Uninterruptable Power Supply (UPS)
  - batteries

- AC – Alternating Current
- DC - Direct Current

- Emergency Generator
  - “Gen-set”

- Computer (Server) Racks

Source: Graphic from SUN Microsystems, server photos from Intel
Increase Component Efficiency

Assume rack mount Dual Processor server and centralized UPS

PDU includes cable losses

Heavy load efficiencies

High efficiency components: reduce input power by 30%

For PSU, can recoup higher cost of high efficiency unit in < 1 year

Source: Intel Public Presentation on benefits of DC Data Centers

Typical 89% x 93% x 75% x 81% = 52%
Better 94% x 94% x 88% x 87% = 68%
Best? 96% x 95% x 94% x 91% = 78%

89% 93% 75% 81% = 52%
94% 94% 88% 87% = 68%
96% 95% 94% 91% = 78%
Purchase High Efficiency Power Equipment

Factory Measurements of UPS Efficiency
(tested using linear loads)

Source: US Department of Energy
Where is the Savings?

Technical Savings Potential Pacific NW

- PC Power Management, 24.0%
- Efficient Servers, 29.6%
- Virtualization, 19.1%
- HVAC and Air Handling, 26.6%
- Efficient UPS, 0.7%

Source: Integrated Data Centers Opportunity Assessment – Final Report, 2013, PECI report to NEEA
Power Management for IT Equipment

Mike Bailey – Director, Facility Engineering

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Server Power Demand vs. Utilization

- Idle or Low Utilized Servers & PC still use 60-70% of power of servers at fully capacity

CPU power use varies with utilization

Memory, Disk Drives, Cooling Fans, & I/O are fairly constant

Source: US DOE Energy Matters
Enable CPU Power Management

Source: AMD Whitepaper: Power and Cooling in the Data Center
Computers left on overnight & Weekend

Power meter data of a desktop computer at the small office

Small amount of time in active mode
Lots of time in idle mode at night and on weekends

62% of desktop computers at the small office and 40% of staff (non-public) computers at the library were often left operating in active or idle mode overnight and on weekends.

Source: Ecova PEIR Plug Load Study
Power Management: Desktop Computer

Base case: 356 kWh/year
Improved case: 153 kWh/year
Energy reduction = 202 kWh/year

No Power Mgmt.

With Power Mgmt.

-57%
ENERGY STAR maintains a list of two dozen enterprise software packages for power management.
Timer Plug Strip: Workstation at the Small Office

Base case: 375 kWh/year
Improved case: 214 kWh/year
Energy reduction = 161 kWh/year (43%)
Smart Plug Strips 2.0

Wirelessly networked
Centrally managed
Dashboards
BEMS integration

BUT...

Pricey
What’s the right form factor?
Is this overkill?
Solid State Drives (SSDs)

Brian Fortenbery – Program Manager
Micah Sweeney – Project Engineer/Scientist

November 20, 2013
Conventional Hard Disk Drives (HDDs)

• Invented in 1956
• Data stored magnetically on solid disk
• Disk spinning
• Latency of moving arm
• Prone to random mechanical failure
• Typically 12-15 W for servers
• Common speeds: 5400, 7200, 10k, 15k rpm
Solid State Drives (SSDs)

- Flash-based data storage
- No moving parts
- Faster Response (low access latency)
- Low power
- High cost / GB
- Little impact to shock, vibration
- Lifetime based on write-endurance

10x faster at 50% power of 15k rpm HDDs
## SSD vs. HDD

<table>
<thead>
<tr>
<th></th>
<th>HDD (15k)</th>
<th>Enterprise SSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Power</td>
<td>8-15 W</td>
<td>1-4 W</td>
</tr>
<tr>
<td>Response time (latency)</td>
<td>4-7 ms</td>
<td>&lt;0.1 ms</td>
</tr>
<tr>
<td>Bandwidth (sequential)</td>
<td>100-150 MB/s</td>
<td>100-150 MB/s</td>
</tr>
<tr>
<td>Throughput (random)</td>
<td>200-500 IOPS</td>
<td>3,000-60,000 IOPS</td>
</tr>
<tr>
<td>Capacity</td>
<td>HUGE!</td>
<td>Price coming down...</td>
</tr>
</tbody>
</table>

- IOPS – input / output operations per second
- About half the power of HDD per drive
## SSD Technology Merits

<table>
<thead>
<tr>
<th></th>
<th>GB/$</th>
<th>MB/s/$</th>
<th>IOPS/$</th>
<th>GB/W</th>
<th>MB/s/W</th>
<th>IOPS/W</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SSD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Worst**: IOPS – Random read/write
- **Average**: MB/s – Sequential read/write
- **Better**: GB – Capacity
- **Best**: SSD

- Comparable capacity per watt
- Superior performance per watt
- Up to 100x IOPS/W over HDD
Tiered Storage

- Virtualization of storage
- Storage Area Network (SAN) or storage array
- Utilize SSD for high I/O applications
- Tier 0 – between memory (RAM) and storage (drives)
Tiered Storage

- Virtualization of storage
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Killer App: Short-Stroked HDDs

- High-performance application demanding 100k IOPS
- **Baseline:** 200 “short-stroked” HDDs
- Replaced with 2 SSDs
- 100:1 reduction
- 50% energy savings per drive
- **99.5% energy savings**
- Lower cost
- 100x lower latency
Short-Stormed Savings Potential

• Storage accounts for about 24% of IT power (9% of total data center)\(^1\)
• Short-stroked HDDs account for 5% of market – iSuppli 2009
• 99.5% savings through 100:1 drive reduction
• Roughly 300-400 GWh savings annually

\(^1\)Source: J Koomey. *Growth in data center electricity use 2005 to 2010.* (2011)
SAN/IP Convergence

Impacts to network design and power consumption

John Seger – Data Center Infrastructure Architect

November 20, 2013
Acronym Breakdown

- **SAN** – Storage Area Network
- **FC** – Fibre Channel
- **IP** – Internet Protocol – Ethernet – “Network”
- **FCoE** – Fibre Channel over Ethernet
- **NIC** – Network Interface Card (IP)
- **HBA** – Host Bus Adapter (FC)
- **CNA** – Converged Network Adapter

All links lead to Wikipedia entries
Background

• Typical DC Network designs included two distinct and separate systems – SAN and Network (IP)
• SAN – Storage Area Network: Low Latency access from servers to block storage equipment that appears to be internal to the server operating system. FC dominates
• IP – Ubiquitous across all networks, but has design characteristics that limit scalability in a SAN arrangement
Typical Topography

- IP Network (Enet LAN) and SAN connectivity to each server
- Top level units are large chassis based core or director class switches
- SAN typically fiber optic while LAN typically copper at access layer with a copper or fiber core
- “Access Layer” switches are smaller in-row or Top Of Rack
Typical Connectivity

- IP connections in small to mid-tier DC’s are largely copper – 1Gbps moving to 10Gbps quickly
  - Approx. 1W at 1G and 2 to 4W+ at 10G up to 100Meters

- SAN connections are fiber based – 2 to 4Gbps (FC) moving to 8Gbps now.
  - Less than 1W at any speed, .7W typical
Model Power Consumption at 10G

- Enet LAN fiber = 8 ports – 8W
- Enet LAN Copper = 8 ports – 24W (3Wpp)
- SAN = 16P – 16W
- Total power (Ports only) – 48W
Model Power Consumption

- Enet LAN fiber = 8 ports – 8W
- FCoE = 4 ports – 4W
- SAN = 4P – 4W
- CNA = 8 ports – 8W

- Total power (Ports only) – 24W
- Many options and paths to network convergence exist

- Simplified view of end goal results in a reduction in deployed switch equipment

- Reduced footprint, power and cost
Questions?

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Next Webinar

Tuesday, November 26, 2013 at noon PST

IT Emerging Technologies – focus on HVAC

Register at www.e3tnw.org/webinars

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