The Efficient Datacenter

Improving Datacenter Efficiency Through Intel Technologies and High Ambient Temperature Operation

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Agenda

• Datacenters Today
• The High Ambient Temperature (HTA) Datacenter
• HTA Examples
• What Else Do You Need to Build a More Efficient Datacenter?
  – Intel solutions to achieve high temp operation
• Near-Future Technologies
• Summary
Today

- Datacenters are estimated to consume 1.5% of total world power and rising rapidly
  - Equivalent to 50 power stations
  - Generating 210 M metric tons of CO₂
    - Equivalent to 41 M cars
  - Using ~300 B Litres of Water
    - Equivalent to nearly 250,000 Olympic sized swimming pools
- Many datacenters still use CFC’s in their chillers
- $27 B annual server energy cost

*See slide in backup for substantiation
2014

*See slide in backup for substantiation
Why are datacenters cooled to 18-21°C?

• Because they always have been
• Non-homogeneous environment
• SLA’s and Warranties
• Legacy Systems Engineered to 21°C
• Over-engineered hot spot avoidance
THE HIGH AMBIENT TEMPERATURE (HTA) DATACENTER
High Temperature Operation

- Datacenter operating at a raised operating temperature designed to decrease cooling costs and increase power efficiency
- 4% operational savings from cooling for every 1 °C increase in operating temperature

<table>
<thead>
<tr>
<th>Class and Upper Temperature Limit Recommended by ASHRAE</th>
<th>New / Modular Datacenters</th>
<th>Existing Datacenters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Recommended</strong></td>
<td><strong>Allowable</strong></td>
<td></td>
</tr>
<tr>
<td>All 'A' Classes</td>
<td>A1</td>
<td>A2</td>
</tr>
<tr>
<td>27°C (81°F)</td>
<td>32 °C (90°F)</td>
<td>35 °C (95°F)</td>
</tr>
<tr>
<td><strong>Allowable</strong></td>
<td>A3</td>
<td>A4</td>
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</table>

2) http://www.datacenterknowledge.com/archives/2008/10/14/google-raise-your-data-center-temperature

*Intel Internal Estimate with conceptual feedback from IDC and Gartner*
Leading adoption of datacenter efficiency standards

- Code of Conduct on Data Centres Energy Efficiency
- Aligned with ASHRAE working towards DC operating at 40°C by 2012
- 2011 Thermal Guidelines for Data Processing Environments
- Expanded the HTA recommended operating range
- Green Grid Metrics: Describing Datacenter Power Efficiency
- Aligned with ASHRAE
- Working towards enabling additional classes DC operating at 40°C by 2015

IDA (Singapore)  CITR (China)
The Effect of Increased PUE

PUE 3
- Un-optimized datacenter
- Typical design used in emerging economies

PUE 2
- Retrofitted datacenter
- Hot and cold air aisle separation
- Blanking panels

PUE 1.25
- Hot aisle containment
- Higher efficiency & reduced UPS
- Higher temperature operation
- Economizers instead of chillers
- Intel Node Manager

PUE = \frac{\text{Total Datacenter Power}}{\text{Actual IT Power}}

*Intel Internal Data based on whitepaper on High Temperature Server Datacenter POC, June 2010
Impact of Free Air & HTA - Intel Analysis

- Option 1 - Increase compute capacity by 35%, add ~12K servers with current power
- Option 2 - Decrease cooling operational costs up to 85% or ~$6 M/yr based on exiting computing
- Option 3 - For new datacenters, decrease capital costs up to 39% or ~$50 M in power infrastructure investment

Note - Intel Internal estimate, based on HTA optimized system using 60W Romley CPU vs 95W Romley CPU and assume 70% SpecPower workload and 24/7/365 ambient temperature in New Mexico. And for a 15 MW data center, 10 KW rack and 50 – 100% utilization. Assumed 10c/kw as cost of power.
Industry Examples...

Leading Internet Portal datacenters operating at higher operating temperature – > 80 °F

2) http://www.datacenterknowledge.com/archives/2008/10/14/google-raise-your-data-center-temperature/
4) Intel internal estimate and based on market data analysis
• 900 production servers
• 100% air exchange at up to 92°F/33°C
  - No humidity control
  - Minimal air filtration
• 67% estimated power savings
• Estimated annual savings of $2.87 million in a 10MW DC

WHAT ELSE DO YOU NEED TO BUILD A MORE EFFICIENT DATACENTER?

- Choose from a choice of Intel products for high temp operation
- Build HTA capable systems based on Intel Platform design guide
- Achieve optimal Data center temperature set point using Intel Data center prescriptive guide
Intel - Gate to Grid

Achieve efficiency by increasing users, compute and performance

Significant platform features that accelerates data center efficiency
Platform Innovation - Choice of Intel products

Range of Best In Class products for high temperature operation

Optimal Performance & Power Efficiency

- Up to 25% more performance/watt with Intel Xeon 5600 series based processors over prior generation processor

Platform of Choice For High Ambient Operation

- Broad offering – 130W, 95W, 80W, 60 W, 45W & 20W
- Well defined, robust reliability verification
- Processor and memory power/thermal management
- Chipset, with Intel Node Manager for power capping
- SSDs for higher temperature

Intel products support ASHRAE temperature limits of up to 45°C

1 Source: Internal Intel estimates comparing OLTP Warehouse performance of Xeon® X7560 vs. Xeon-EX (top bin) systems with same memory capacity and system configurations. See Relative Top Bin Performance projections for more system configurations. Excludes possible additional system power savings with Xeon-EX due to power gating, LV DIMM support and standard or LV memory buffers (Millbrook2) usage. See Xeon-EX power management summary table for more details.
System Design With Intel Platform Guide

- **Platform Design Guide – Power reduction Recommendations**
  - Spread core layout
  - Processors with 80 – 95 W
  - Efficient copper heat sink

- **Datacenter Optimization Guide**
  - Predictive modeling to identify optimal set point
  - Recommend 30 – 35 C for existing datacenters and > 35 C for modular/new datacenters

- **Components**
  - 80 – 95 W CPU’s are optimal
  - SSD
  - Memory - Larger DIMM

- **Board/Chassis**
  - 2 U optimal
  - Spread core
  - Thermal features enabled

- **Design**
  - Cu Heatsink
  - Fan speed control algorithm
  - Power management features

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*Systems optimized on Intel Platform could result in >10% in power savings*

*Note - Intel Internal estimate, based on HTA optimized system using 60W Romley CPU vs 95W Romley CPU and assume 70% SpecPower workload and 24/7/365 ambient temperature in New Mexico*
Example Optimizing Server Layout – Thermal Shadowing

Non-Shadowed layout enables lower fan power and wider temperature Range

• Note - Intel Internal estimate, based on HTA optimized system using 60W Romley CPU vs 95W Romley CPU and assume 70% SpecPower workload and 24/7/365 ambient temperature in New Mexico
Intel® Intelligent Power Node Manager and Intel® Data Center Manager

- Limit total RACK power draw
- More productivity per rack
- Report system level energy use
- Limit individual SERVER power consumption
- Limit aggregated ROW power draw

Aggregated, policy-based power management for the data center
Intel® Node Manager & Data Center Manager Results

- **Power and Thermal Monitoring**: Replace IP power strips and serial concentrators, saving ~$400 per rack
- **Increased Rack Density**: Up to 40% more servers and performance per rack
- **Workload Power Optimization**: Up to 30% power optimization without performance impact
- **Business Continuity**: Continued compute availability through power or thermal event

*Other brands and names may be claimed as the property of others.*
Solution Choices For Directed Power Management

Node Manager Servers
- ASUS
- DELL
- GIGABYTE
- Inspur
- Lenovo
- Matrixtial
- PowerEdge C
- Quanta Computer
- sgi
- Supermicro
- TYAN
- IESk
- ZT Systems
- Wistron

DCM Enabled Consoles
- ASG
- PowerLeader
- Power Assure
- SiteView
- Supermicro
- Joulex
- Solution Labs

Growing Choices For Solutions Using Intel® Directed Power Management

*Other brands and names may be claimed as the property of others.

List represents OEMs, ODMs and ISVs that have supported Node Manager and/or Data Center Manager in Intel® Xeon® 5500, E5 and E7 generation servers and console products. Contact the OEM, ODM or ISV for up-to-date information on products that are supported.
NEAR FUTURE TECHNOLOGIES
Power & Thermal Aware Scheduling (PTAS)

Platform with Power, Thermal & Workload intelligence to enable dynamic management of resources

Integrate IT and Facilities Management

- Builds upon Intel Node Manager and Data Center Manager
- Lower operational costs
  ~20%\(^1\)
- Recovery up to 50% of unused cooling capacity\(^1\)
- Reduce DC monitoring instrumentation costs

Maximize operational efficiency thru dynamic resource management

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Intel® Battery Backup Solution

Build servers or racks with battery backup unit enhanced thru integration with Intel Power Node Manager

Reduce Data Center Capital Costs

- Reduce UPS related capital expenditure costs \(~ 5\times^1\)
- Recover UPS related power efficiency loss \(~30-40\%^2\)
- Easy deployment and time to market solution

Integrate with Intel Node Manager to increase battery life, reduce battery size ..or for graceful shutdown

1 Intel internal estimate  
2 APC whitepaper # 108
What if -
The world used HTA for a 5°C Datacenter Rise?
World HTA 5°C Datacenter Rise

- $2.16 B in annual power savings
- 8% Decrease in world-wide datacenter power consumption
- 24.3 B kWh saved
  - More than month of total energy consumption by Spain, South Africa, Australia or Taiwan.
- 1.7 M metric tons of CO₂

*See slide in backup for substantiation*
Call to Action

✓ Increasing data center efficiency could significantly reduce spending and have a positive impact on the environment

✓ Leverage Intel Solutions to achieve data center efficiency
  - Range of Intel products - Intel Xeon, Intel power node manager, Intel Datacenter manager...
  - System design guide - Optimize for spread core layout, copper heatsink and usage/workload
  - Data center prescriptive guide – Achieve optimal set point up to 35 °C of higher for data centers
Further Reading


• Reducing Data Center Cost with an Air Economizer

• Intel IT Data Center Solutions: Strategies to Improve Efficiency


BACKUP
Environmental Benefits Claims Details

- Datacenters consume 1.5% of total world power and rising rapidly
  - Equivalent to 50 power stations
- Generating 210 Million Metric tons of CO2
  - Equivalent to 41 million cars
- Using ~300 Billion Litres of Water
  - Equivalent to nearly 250,000 Olympic sized swimming pools
- $27 billion annual server energy cost

- $2.16 Billion in immediate annual power savings
- 5C Worldwide Raise – What would it mean?
  - 8% Decrease in WW datacenter power consumption
  - 24.3 Billion Kwh saved
    - More than month of total energy consumption by Spain, South Africa, Australia or Taiwan.
  - Equivalent to 1.7 Million metric tons of CO2
    - Same as carbon sequestered by 43 Million tree seedlings grown for 10 years

- Total World Power Generation:
  - http://www.iea.org/stats/electricitydata.asp?COUNTRY_CODE=29 20,260,838,000,000 kWh Total World Electricity Generation /1.5= 303,912,570,000 kWh is total power used by Datacenters
  - CO2 Calculator http://www.epa.gov/cleanenergy/energy-resources/calculator.html
  - 1.5% of World Power – Koomey 2011 http://www.analyticspress.com/datacenters.html

- Water:
  - 1KWh of DC uses ~2L of water = 303,912,570,000 x 2 = 607,825,140,000 L of water used by WtW DCs.
  - 1 Olympic Swimming pool uses 2.5M Litres.

- $2.16 Billion annual server energy cost savings (IDC 2009)
- Data will grow 44 times to 35ZB between 2009 – 2020…IDC 2011
- X2 Claim
  - Assumption based on linear extrapolation of data in EPA Report to Congress on Server and Data Center Energy Efficiency; August 2, 2007
  - Total power consumed by datacenters could be .2-3% of all electricity generated by 2014
  - 2011 - ~110 B Kwh/year 1% decrease = 1.1 Bkwh/hr
  - 5C Worldwide Raise
    - http://www.iea.org/stats/electricitydata.asp?COUNTRY_CODE=29 20,260,838,000,000 kWh Total World Electricity Generation in 2008 /1.5= 303,912,570,000 kWh is total power used by Datacenters
    - 1.5% of World Power – Koomey 2011 http://www.analyticspress.com/datacenters.html
  - 20% decrease in cooling energy costs. (4% savings for 1 C increase in temp) http://www.datacenterknowledge.com/archives/2007/06/05/googles newIndexcenter-temperature/
  - Carbon Calculator: http://www.epa.gov/cleaneenergy/energy-resources/calculator.html
Data center Savings Claims Backup – Intel Analysis

15 MW Facility, Temperature range of 21 - 35 C
10 KW rack, Utilization - 50% and 100%

<table>
<thead>
<tr>
<th>Option 1- Server Capacity</th>
<th>Option 2 - Opex ($K)/yr</th>
<th>Option 3 - Capex ($k)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PUE 3.0 (21 C)</td>
<td>543</td>
<td>$216,000k</td>
</tr>
<tr>
<td>PUE 2.0 (27 C)</td>
<td>856</td>
<td>$178,000k</td>
</tr>
<tr>
<td>PUE 2.0 (35 C)</td>
<td>848</td>
<td>$149,500k</td>
</tr>
<tr>
<td>PUE 2.0 (35 C)</td>
<td>845</td>
<td>$153,500k</td>
</tr>
<tr>
<td>Advanced</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Increase capacity (Server count)</th>
<th>% change</th>
<th>Cooling Opex Savings ($K)/yr</th>
<th>% Savings</th>
<th>Cooling Capex ($k)</th>
<th>% Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>12507</td>
<td>37%</td>
<td>3018.0</td>
<td>43%</td>
<td>23461.0</td>
<td>20%</td>
</tr>
<tr>
<td>12198</td>
<td>36%</td>
<td>4003.0</td>
<td>56%</td>
<td>49192.5</td>
<td>42%</td>
</tr>
<tr>
<td>12045</td>
<td>36%</td>
<td>6065.4</td>
<td>85%</td>
<td>45738.8</td>
<td>39%</td>
</tr>
</tbody>
</table>

- Data center populated with 50000 1U servers
- Assumed $0.10/kwh power cost and no chiller power required at 35C ambient, will vary based on location
- 60W Romley CPU used in all servers, except for “wrong” CPU design choice which used 95W Romley CPU
- Assume 70% SpecPower workload and 24/7/365 ambient temperature

Key system layout considerations – layout, heatsink, fan speed
Node Manager Claims Back Up

Extreme Efficiency: Power Management


Increasing Rack Density Proof Points

• Baidu statement based on proof of concept results documented in Intel legally approved whitepaper posted at http://communities.intel.com/docs/DOC-4212.


• Intel IT and FSI results based on Intel internal testing of Intel Xeon Processor 5500 series whiteboxes in an NDA environment.

Increasing Rack Density Model Baidu Proof Point


Power Optimization Model Oracle Proof Point
