The Effect of Data Centre Environment on IT Reliability & Energy Consumption

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IBM
Agenda

- History of IT environmental operating ranges
  - Increasing data centre efficiency
  - Concerns with operating at higher temperatures
- IT reliability and temperature
- Using the ASHRAE classes
  - Exploiting the allowable range
  - IT Reliability in the allowable range
- Higher operating ranges
  - ASHRAE 2011 classes
  - Effect on chiller hours
- Implications
  - IT hardware design
  - Data Centre design
- Further information
History of IT Operating Ranges

• 20°C considered optimal operational temperature
  ▪ Intended for punched cards?

• ASHRAE
  ▪ TC 9.9 - Mission Critical Facilities, Technology Spaces, and Electronic Equipment
  ▪ 2004, 2008 guidance
    – Recommended range
    – Allowable range

<table>
<thead>
<tr>
<th>Year</th>
<th>Recommended</th>
<th>Allowable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature range</td>
<td>20°C - 25°C</td>
<td>18°C - 27°C</td>
</tr>
<tr>
<td>Moisture range</td>
<td>40% - 55% RH</td>
<td>5.5°C DP – 60% RH</td>
</tr>
</tbody>
</table>

Source: ASHRAE Whitepaper – 2011 Thermal Guidelines for Data Processing Environments
Increasing Data Centre Efficiency

- Increasing usage of economizers
  - Reduce costs by increasing number of hours that economizers can be used
    - Direct air cooled, indirect air cooled, indirect water cooled.
  - Reduce size of chiller plant or remove all together

- Higher return temperatures to increase cooling efficiency
  - Contained aisle solutions
    - Stop air mixing and recirculation
    - Elimination of hot spots

- Little change in operating temperatures for most data centres
  - Poor communication between facilities and IT
  - Concern about business impact
    - The effect of temperature and humidity on reliability
    - Industry support and warranties
Industry Change

• Rise of cloud computing as a new IT delivery model
  ▪ Early adopters demonstrated viability of higher temperatures
  ▪ Different approach to systems availability
    – Reliability at the software and application layer
    – Enterprise IT model assumes high infrastructure reliability

• Intel study
  ▪ Traditional DC with supply temperatures of approximately 20°C resulted in a failure rate of 2.5% to 3.8% over twelve months
  ▪ Similar data centre using an air-side economizer with temperatures occasionally ranging to 35°C the failure rate was 4.5%
    – Note no classification of the hardware failures was performed
Concerns With Higher Operating Temps

- Lack of data on change of reliability with temperature
- Increasing server energy consumption with temperature
  - Server fan power
  - Silicon leakage current
- Older equipment
  - Rapid change in environmental support in last 4 years
- Current models support higher ranges
  - Blades
    - Cisco UCS: 10-35°C, 10%-90%
    - IBM BladeCenter HS22: 10-35°C, 8%-80%
    - HP BL490c G6: 10-35°C, 10%-90%
  - Switches
    - Cisco Nexus 5000: 0-40°C, 5%-90%
  - Storage
    - EMC Symmetrix V-MAX: 10-32°C, 20%-80%
    - NetApp 10-40°C, 20%-80%

Source: Information from vendors websites
IT Reliability and Temperature

Relative server failure rate with temperature

- Manufacturer's data in ASHRAE 2011 guidance shows moderate increasing failure rate with temperature
  - Limited duration operation above 20°C has marginal impact on overall failure rate
  - Operation below 20°C reduces failure rate

Source: ASHRAE Whitepaper – 2011 Thermal Guidelines for Data Processing Environments
Power Consumption With Temperature

- Fan power consumption increases as a cube of the airflow rate
- Large fans consume less energy and create less noise for the same airflow
Higher Inlet Temperatures

• Power
  ▪ Increase by up to 20%

• Airflow
  ▪ Can double by 35°C
  ▪ Requires improved air flow design
  ▪ Increased failure rate if starved

• Noise
  ▪ Increases as 5th power of rotational speed
  ▪ Exceed health and safety guidelines

• Exhaust temperature
  ▪ Can be 20°C more than inlet
  ▪ Exceed health and safety guidelines

Source: ASHRAE Whitepaper – 2011 Thermal Guidelines for Data Processing Environments
Using The ASHRAE Classes

The Green Grid has identified that much of Europe can benefit from air side economizers while remaining within ASHRAE Class 2 Recommended upper guideline of 27°C

Hours per year when dry bulb temperature less than or equal 27°C
Exploiting the Allowable Range

- **ASHRAE Class 2**
  - **Recommended range**
    - 15°C to 27°C
  - **Allowable range**
    - 10°C to 35°C
Reliability within Allowable Range

Relative failure rate by temperature

Economised air temperature by percentage of time for major cities

Relative failure rate for major cities within ASHRAE allowable range
Higher Operating Ranges

- **ETSI EN 300 019 Class 3.1 (NEBS)**
  - Operation up to 45°C
  - Small number of server models available
  - Usually limited performance compared to volume models
  - Higher cost

- **ASHRAE 2011 guidelines**

<table>
<thead>
<tr>
<th>2011 classes</th>
<th>2008 classes</th>
<th>Applications</th>
<th>IT Equipment</th>
<th>Environmental Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>1</td>
<td>Datacenter</td>
<td>Enterprise servers, storage products</td>
<td>Tightly controlled</td>
</tr>
<tr>
<td>A2</td>
<td>2</td>
<td></td>
<td>Volume servers, storage products, personal computers, workstations</td>
<td>Some control</td>
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<tr>
<td>A3</td>
<td>NA</td>
<td></td>
<td>Volume servers, storage products, personal computers, workstations</td>
<td>Some control</td>
</tr>
<tr>
<td>A4</td>
<td>NA</td>
<td></td>
<td>Volume servers, storage products, personal computers, workstations</td>
<td>Some control</td>
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<tr>
<td>B</td>
<td>3</td>
<td>Office, home, transportable environment, etc.</td>
<td>Personal computers, workstations, laptops, and printers</td>
<td>Minimal control</td>
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<tr>
<td>C</td>
<td>4</td>
<td>Point-of-sale, industrial, factory, etc.</td>
<td>Point-of-sale equipment, ruggedized controllers, or computers and PDAs</td>
<td>No control</td>
</tr>
</tbody>
</table>

Source: ASHRAE Whitepaper – 2011 Thermal Guidelines for Data Processing Environments
## Equipment Environmental Specifications

<table>
<thead>
<tr>
<th>Classes</th>
<th>Product Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dry-Bulb Temperature (°C)</strong></td>
<td><strong>Humidity Range non-Condensing</strong></td>
</tr>
<tr>
<td><strong>Recommended</strong></td>
<td></td>
</tr>
<tr>
<td>A1 to A4</td>
<td>18 to 27</td>
</tr>
<tr>
<td><strong>Allowable</strong></td>
<td></td>
</tr>
<tr>
<td>A1</td>
<td>15 to 32</td>
</tr>
<tr>
<td>A2</td>
<td>10 to 35</td>
</tr>
<tr>
<td>A3</td>
<td>5 to 40</td>
</tr>
<tr>
<td>A4</td>
<td>5 to 45</td>
</tr>
<tr>
<td>B</td>
<td>5 to 35</td>
</tr>
<tr>
<td>C</td>
<td>5 to 40</td>
</tr>
</tbody>
</table>

Source: ASHRAE Whitepaper – 2011 Thermal Guidelines for Data Processing Environments (Reformatted)
Chiller Hours When Using Economizers

Number of hours per year of chiller operation required for air-side and waterside economizer for ASHRAE classes

Source: ASHRAE Whitepaper – 2011 Thermal Guidelines for Data Processing Environments

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Chiller Hours Using Closed Loop Cooling

Number of hours per year of chiller operation required for a water-side economizer with a dry-cooler type tower for ASHRAE classes.

Source: ASHRAE Whitepaper – 2011 Thermal Guidelines for Data Processing Environments
Implications for Design of IT Equipment

- Lower temperature differential across hot components (Delta T)
  - Intel processors typically run at 60°C
- Greater airflow required
- Larger heat sinks

- New server form factors
  - Heat dissipation of 1U servers is limited by fan and headsink size
  - Reduced fan power consumption and noise

- Expectations of warranty and reliability
- Costs of classes A3/A4 compared to A1/A2
- Future fan-less servers and water cooling
Implications For Design of Data Centres

• Higher data centre airflow
• Temperature and noise in hot aisle
• Humidity and corrosion effects
• Are chillers required?
• Ride through time on cooling plant failure
• PUE anomalies due to server fan power at high temperatures

• Redundant IT service design and workload migration
  ▪ Requires holistic approach to IT and DC
• Water cooling

• Server replacement costs are lower than investment costs in plant and electricity
• IT service level requirements
Further Information

• 2011 Thermal Guidelines for Data Processing Environments – Expanded Data Centre Classes and Usage Guidance

• Deutsche Bank - Banking on Fresh AirEco Data Centre New York

• British Computer Society
  “IT environmental range and data centre cooling analysis”
Thank you for attending!

Questions?