Server Thermal Considerations
to enable High Temperature
Ambient Data Center Operations

Improved Airflow Management Allows Servers
to Operate at 40°C Inlet Temperature While
Within Specification.

Intel Corporation

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Executive Summary

A server that can operate in a High Temperature Ambient (HTA) data center will enable data center architects and designers to consider maximizing the savings by increasing the data center operational temperature.

Thermal and airflow management is key to making servers operate in this regime.

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*High Temperature Ambient (HTA) is raising the inlet temperature of a server and staying below component specifications.*

*Therefore decreases data center chiller energy costs and increases power utilization efficiency.*

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The thermal simulation results for the server were:

- Server system thermals structure and airflow results for the following components: HDD, DDR3, VR, MCH and PCH
- System thermal performance summary

As a result of this assessment listed above Intel was able to improve mechanical design of the server design of the following areas improve the mechanical duct structure to channel air more effectively allowing HTA server operations while staying within specification.

The HTA server can stay within the specified tolerances outlined in the server specifications and warranty limits.
Executive Summary

Business Challenge

Technical Challenge

Solution: Thermal Simulation

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HTA Server System UseCase3

Business Challenge

How to save data center operational costs?

Technical Challenge

The objective was to show specification margin to thermal requirements for SuperCloud's server utilizing Computational Fluid Dynamics (CFD) software to simulate the server to look for areas of improvement. A workload was used to simulate a 100% workload on the server.

Solution: Thermal Simulation

In order to validate SuperCloud's High Temperature Operation Server, Intel built a Thermal System Model that included the following:

- CPU Heat Sink (PnP) compact Model
- VR Compact Model
- PCH, DDR3 Detailed Model
- HDD and PCI as Solid Blocks
- Inlet / Exhaust Vents with loss coefficients assigned based on mechanical structure

- Chassis Walls
- Ducting

The three dimensional System Model displayed a visual representation of the airflow and temperatures across the components. This allowed the engineers to assess the design layout to look for improvements within the design without having to physically build the server.

Maximize the operational and capital savings by increasing the Data Center operational temperature and server inlet temperature at 40°C
SuperCloud HTA Server Modeling Details:
Layout
The server was modeled independently of the rack or data center to analyze the platform level thermal characteristics.

![Server Layout with Ducting](image1)

![Server Layout without Ducting](image2)

System Modeling Details: Components
The modeled system had the following platform components:

<table>
<thead>
<tr>
<th>Component</th>
<th>Details</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU heatsink</td>
<td>Sandybridge EP</td>
<td>2</td>
</tr>
<tr>
<td>PCH</td>
<td>Patsburg</td>
<td>1</td>
</tr>
<tr>
<td>DDR3</td>
<td>DDR3 1866x4 8Gb</td>
<td>16</td>
</tr>
<tr>
<td>HDD</td>
<td>Standard</td>
<td>4</td>
</tr>
<tr>
<td>PCI Cards</td>
<td>Full height / half length</td>
<td>2</td>
</tr>
<tr>
<td>MB</td>
<td>CPU VR</td>
<td>2</td>
</tr>
</tbody>
</table>

Note: each node does not have a fan. The rack or data center fan wall should be considered to control airflow through the server.

SuperCloud HTA Server Modeling Details:
Ducting Layout
Ducting layout is a key aspect of the HTA server design. This section will highlight the improved ducting design. The original SuperCloud server had no ducting in place for the first set of tests and the design specifications and subsequent warranties would have been exceeded. Intel made the following ducting modifications in the thermal model to improve the thermal dynamics of the SuperCloud server.
Thermal Simulation: Server Results

The results of the CFD and 100% workload produced the following results.

HTA Server System UseCase1

CFD model parameters:
1. Workload: 100%
2. Airflow volume: 95 CFM (Cubic Feet per Minute)
3. Inlet temperature: 40°C

The table below shows the modeling results in relation to the specification. Red indicates the component does not meet specification whereas Orange indicates that the specification was met but was within 10%.

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
<th>Number</th>
<th>Airflow 95 CFM Status</th>
<th>Specification (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>Sandybridge EP</td>
<td>2</td>
<td>68.90 71.90 74.28 82.87</td>
<td>73</td>
</tr>
<tr>
<td>PCH</td>
<td>Patsburg</td>
<td>1</td>
<td>56.1 62.4 92.7</td>
<td></td>
</tr>
<tr>
<td>DDR3</td>
<td>1866x4 8Gb</td>
<td>16</td>
<td>77.49 96.57</td>
<td>85</td>
</tr>
<tr>
<td>HDD</td>
<td>Standard</td>
<td>4</td>
<td>57.15 60.79</td>
<td>60</td>
</tr>
<tr>
<td>PCI Cards</td>
<td>Full height / half length</td>
<td>2</td>
<td>43.24 45.28</td>
<td>55</td>
</tr>
<tr>
<td>MB/Misc</td>
<td>CPU VR:DDR3 VR</td>
<td>2 X 2</td>
<td>95.53 107.80</td>
<td>110</td>
</tr>
</tbody>
</table>

Table 2 – HTA Server System UseCase1 Results

HTA Server System UseCase2

CFD model parameters:
1. Workload: 100%
2. Airflow volume: 120 CFM
3. Inlet temperature: 40°C

Figure 7 – UseCase2 Velocity Field

Figure 8 – UseCase2 Temperature
The table below shows the modeling results in relation to the specification. Red indicates the component does not meet specification whereas Orange indicates that the specification was met but was within 10%.

### HTA Server System UseCase2 Results

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
<th>Number</th>
<th>Ducting</th>
<th>Without Ducting</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>Sandybridge EP</td>
<td>2</td>
<td>63.1</td>
<td>66.8</td>
</tr>
<tr>
<td>PCH</td>
<td>Patsburg</td>
<td>1</td>
<td>55.6</td>
<td>64.81</td>
</tr>
<tr>
<td>DDR3</td>
<td>DDR3 1866x4 8Gb</td>
<td>16</td>
<td>72.35</td>
<td>87.58</td>
</tr>
<tr>
<td>HDD</td>
<td>Standard</td>
<td>4</td>
<td>54.89</td>
<td>58.43</td>
</tr>
<tr>
<td>PCI Cards</td>
<td>Full height / half length</td>
<td>2</td>
<td>42.25</td>
<td>44.73</td>
</tr>
<tr>
<td>MB/Misc</td>
<td>CPU VR/DDR3</td>
<td>2 X 2</td>
<td>92.09</td>
<td>104.60</td>
</tr>
</tbody>
</table>

| Specification (°C) | 55.6 | 64.81 | 60.07 | 92.7 |

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
<th>Number</th>
<th>Ducting</th>
<th>Without Ducting</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>Sandybridge EP</td>
<td>2</td>
<td>61.16</td>
<td>64.09</td>
</tr>
<tr>
<td>PCH</td>
<td>Patsburg</td>
<td>1</td>
<td>53.6</td>
<td>60.07</td>
</tr>
<tr>
<td>DDR3</td>
<td>DDR3 1866x4 8Gb</td>
<td>16</td>
<td>65.51</td>
<td>76.14</td>
</tr>
<tr>
<td>HDD</td>
<td>Standard</td>
<td>4</td>
<td>52.97</td>
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</tr>
<tr>
<td>PCI Cards</td>
<td>Full height / half length</td>
<td>2</td>
<td>42.01</td>
<td>44.72</td>
</tr>
<tr>
<td>MB/Misc</td>
<td>CPU VR/DDR3</td>
<td>2 X 2</td>
<td>91.09</td>
<td>100.80</td>
</tr>
</tbody>
</table>

| Specification (°C) | 60.07 | 85    | 66.88 | 71.78 | 73    |

### Summary

By changing some system ducting, the airflow performance improved to allow all components to meet their thermal specification even with an inlet temperature of 40°C and 95CFM. This would enable data center architects and designers to look at High Temperature Operations.
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