Optimizing Intel® Xeon® Processor 5500 Series (Nehalem-EP Processor) Based Workstation and Server Platforms for the ENERGY STAR* Program

Whitepaper

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<th>Document</th>
<th>Document Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workstation and Server Platform Readiness Checks for the ENERGY STAR* Program</td>
<td>Intel IBL website, DocID 411729.</td>
</tr>
</tbody>
</table>
1 Preface

This document contains techniques that allow an Intel® Xeon® Processor 5500 Series (Nehalem-EP Processor) based platform to be tuned to obtain the optimum idle and maximum power measurements. These optimized idle and maximum power measurements are used to verify that a Workstation, Small-Scale Server or Server based platform has all of the capabilities required to pass the ENERGY STAR® Specification (version 5.0 for Workstations/1.0 for Servers, Draft 4) for Computers. Included in this document are detailed sections on platform and memory configuration, CPU SKUs to be tested, BIOS settings guidelines, suggested operating systems and patches, validation tools and usage, and other considerations that allow an end user to verify that the platform under test will pass the requirements of the appropriate ENERGY STAR Specification for Computers. Finally, this document should be used in conjunction with the whitepaper titled “Workstation and Server Platform Readiness Checks for the ENERGYSTAR® Program”, Intel’s IBL number 411729.
2 Suggested Platform and Memory Configuration

Suggested Intel Chipset: Table 2-1 below shows the suggested Intel® 5520 and 5500 chipset for an Intel® Xeon® Processor 5500 Series-based platform.

Table 2-1. Tylersburg Chipset

<table>
<thead>
<tr>
<th>Description</th>
<th>Part Number</th>
<th>Silicon Stepping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tylersburg IOH- 36D</td>
<td>Intel® 5520 Chipset</td>
<td>B3</td>
</tr>
<tr>
<td>Tylersburg IOH- 24D</td>
<td>Intel® 5500 Chipset</td>
<td>B3</td>
</tr>
</tbody>
</table>

Suggested South Bridge Configuration: Table 2-2 below shows the suggested south bridge configurations for an Intel Xeon Processor 5500 Series-based platform.

Table 2-2. South Bridge Selection

<table>
<thead>
<tr>
<th>South Bridge Configuration</th>
<th>Description</th>
<th>Part Number</th>
<th>Silicon Stepping</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intel® I/O Controller Hub 9</td>
<td>Intel® 82801Ix I/O Controller Hub (ICH9)</td>
<td>A0</td>
</tr>
<tr>
<td></td>
<td>(Intel ICH9/ICH9R)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intel® I/O Controller Hub 10</td>
<td>Intel® 82801Jx I/O Controller Hub (ICH10)</td>
<td>A2</td>
</tr>
<tr>
<td></td>
<td>(ICH9) (ICH10/ICH10R)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Suggested Memory Configuration: In order to obtain optimum performance and power savings, it is suggested that memory is populated with at least 1 GB per core and at least one DIMM per channel. Furthermore, Intel suggests using x8 memory to minimize power draw. On a 2-socket platform for example, populate one 2 GB dual-rank x8 DIMM per channel, with three channels per socket. In this configuration, each processor socket has 6 GB of memory attached.
3 **CPU SKUs to be Tested**

The following table contains a list of possible silicon SKUs that could be shipped with a platform. Each selection will affect maximum power draw as well as performance level. It is highly recommended that the lowest TDP CPU, as well as the highest TDP CPU, that could be shipped be tested. This testing will ensure that the platform under test will pass the requirements of the appropriate ENERGY STAR Specification (version 5.0 for Workstations/1.0 for Servers, Draft 4) for Computers, no matter which CPU type is shipped.

**Table 3-1. List of Available CPU SKUs**

<table>
<thead>
<tr>
<th>Processor TDP</th>
<th>Part Number and Frequency</th>
<th>Silicon Stepping</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 W</td>
<td>Intel® Xeon® L5520 LV processor 2.13GHz with 4-core 8MB L3 Cache (Nehalem-EP LV),</td>
<td>D0</td>
</tr>
<tr>
<td>60 W</td>
<td>Intel® Xeon® L5520 LV processor 2.26GHz with 4-core 8MB L3 Cache (Nehalem-EP LV)</td>
<td>D0</td>
</tr>
<tr>
<td>80 W</td>
<td>Intel® Xeon® E5502 processor 1.86GHz with 2-core 4 MB L3 Cache (Nehalem-EP)</td>
<td>D0</td>
</tr>
<tr>
<td>80 W</td>
<td>Intel® Xeon® E5504 processor 2.00GHz with 4-core 4 MB L3 Cache (Nehalem-EP)</td>
<td>D0</td>
</tr>
<tr>
<td>80 W</td>
<td>Intel® Xeon® E5506 processor 2.13GHz with 4-core 4 MB L3 Cache (Nehalem-EP)</td>
<td>D0</td>
</tr>
<tr>
<td>80 W</td>
<td>Intel® Xeon® E5520 processor 2.26GHz with 4-core 8 MB L3 Cache (Nehalem-EP)</td>
<td>D0</td>
</tr>
<tr>
<td>80 W</td>
<td>Intel® Xeon® E5530 processor 2.40GHz with 4-core 8 MB L3 Cache (Nehalem-EP)</td>
<td>D0</td>
</tr>
<tr>
<td>80 W</td>
<td>Intel® Xeon® E5540 processor 2.53GHz with 4-core 8 MB L3 Cache (Nehalem-EP)</td>
<td>D0</td>
</tr>
<tr>
<td>95 W</td>
<td>Intel® Xeon® X5550 processor 2.66GHz with 4-core 8 MB L3 Cache (Nehalem-EP)</td>
<td>D0</td>
</tr>
<tr>
<td>95 W</td>
<td>Intel® Xeon® X5560 processor 2.80GHz with 4-core 8 MB L3 Cache (Nehalem-EP)</td>
<td>D0</td>
</tr>
<tr>
<td>95 W</td>
<td>Intel® Xeon® X5570 processor 2.93GHz with 4-core 8 MB L3 Cache (Nehalem-EP)</td>
<td>D0</td>
</tr>
<tr>
<td>130 W</td>
<td>Intel® Xeon® W5580 processor 3.20GHz with 4-core 8 MB L3 Cache (Nehalem-EP)</td>
<td>D0</td>
</tr>
<tr>
<td>130 W</td>
<td>Intel® Xeon® W3520 processor 2.66 GHz with 4-core 8 MB L3 Cache (Nehalem 1 socket only)</td>
<td>D0</td>
</tr>
</tbody>
</table>
## CPU SKUs Continued

<table>
<thead>
<tr>
<th>Processor TDP</th>
<th>Part Number and Frequency</th>
<th>Silicon Stepping</th>
</tr>
</thead>
<tbody>
<tr>
<td>130 W</td>
<td>Intel® Xeon® W3540 processor 2.93 GHz with 4-core 8 MB L3 Cache (Nehalem 1 socket only)</td>
<td>D0</td>
</tr>
<tr>
<td>130 W</td>
<td>Intel® Xeon® W5570 processor 3.20GHz with 4-core 8 MB L3 Cache (Nehalem 1 socket only)</td>
<td>D0</td>
</tr>
</tbody>
</table>
4 BIOS Settings Guidelines

The following guidelines should be used when configuring the BIOS for ENERGY STAR Readiness Testing. These guidelines are applicable to both Workstation and Server class platforms, and are tailored to give the optimum power performance on Intel’s Nehalem-EP Processor based products.

First, ensure you have the latest BIOS installed. Next, verify that all capabilities to support processor deep sleep states (C6) and closed loop thermal throttling (CLTT) if applicable are enabled. Finally, use the guidelines below to ensure that all power management functionality is properly enabled.

Note: These suggested settings are only guidelines; the BIOS you are working with may have different or missing settings. Several iterations of BIOS settings may be necessary to obtain optimum performance and power efficiency.

Table 4-1. BIOS Settings Guidelines

<table>
<thead>
<tr>
<th>BIOS Setting Section</th>
<th>Description</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU Settings</td>
<td>Turbo Mode</td>
<td>Enabled</td>
</tr>
<tr>
<td></td>
<td>Intel® Hyper-Threading Technology (Intel® HT Technology) (SMT)</td>
<td>Enabled</td>
</tr>
<tr>
<td></td>
<td>Enhanced Intel SpeedStep® Technology or Demand Based Switching (DBS)</td>
<td>Enabled</td>
</tr>
<tr>
<td></td>
<td>Hardware Prefetcher</td>
<td>Enabled</td>
</tr>
<tr>
<td></td>
<td>Processor C1E</td>
<td>Enabled</td>
</tr>
<tr>
<td></td>
<td>Processor C3</td>
<td>Disabled</td>
</tr>
<tr>
<td></td>
<td>Processor C6</td>
<td>Enabled</td>
</tr>
<tr>
<td>Intel® QuickPath Interconnect Settings</td>
<td>L1</td>
<td>Enabled</td>
</tr>
<tr>
<td>PCI Express* Settings</td>
<td>ASPM (Active State Power Management)</td>
<td>Auto</td>
</tr>
<tr>
<td>Miscellaneous Settings</td>
<td>CLTT (Closed Loop Thermal Throttling)</td>
<td>Enabled</td>
</tr>
</tbody>
</table>
5 **Operating Systems and Patches**

For the operating system chosen, use the sections below to verify that all required software is installed, and use the whitepaper “Workstation and Server Platform Readiness Checks for the ENERGY STAR* Program” to set and enable all operating system directed power management functions that are applicable.

5.1 **Workstations**

For workstations, the operating systems of choice are Windows* XP, and Windows Vista both 32 and 64 bit versions.

5.1.1 **Windows* XP (32- and 64-bit)**

Required Software:
- Windows XP Professional (32- or 64-bit version)
- Service Pack 2
- All applicable software patches
- Microsoft .NET framework 2.0
- KB941838 (http://support.microsoft.com/kb/941838)
- KB918005 (http://support.microsoft.com/kb/918005)

Known Problems:
- None

Power Policy:
- Home/Office Desk

5.1.2 **Windows Vista (32- and 64-bit)**

Required Software:
- Windows Vista (any edition, 32- or 64-bit version)
- Service Pack 1
- All applicable software patches
- Microsoft .NET framework 2.0
- KB955302 (http://support.microsoft.com/kb/955302)

Known Problems:
- Screen Saver “3D-text” causes high power consumption.

Power Policy:
- Balanced Power
5.2 **Servers**

For servers, the operating systems of choice are Windows 2003, and Windows Server 2008, and certain versions of Linux (RHEL 5.3 and SuSE SLES 10.2+) both 32 and 64 bit versions.

5.2.1 **Windows Server 2003 (32- and 64-bit)**

Required Software:
- Windows Server 2003 (32- or 64-bit version)
- Service Pack 2
- All applicable software patches
- Microsoft .NET framework 2.0
- KB941838 [http://support.microsoft.com/kb/941838](http://support.microsoft.com/kb/941838)
- KB918005 [http://support.microsoft.com/kb/918005](http://support.microsoft.com/kb/918005)

Known Problems:
- Server 2003 doesn't fully support C6

Power Policy:
- Home/Office Desk

5.2.2 **Windows Server 2008 (32- and 64-bit)**

Required Software:
- Windows Server 2008 Enterprise (32- or 64-bit version)
- Service Pack 2
- All applicable software patches
- Microsoft .NET framework 2.0
- KB955302 [http://support.microsoft.com/kb/955302](http://support.microsoft.com/kb/955302)

Known Problems:
- None

Power Policy:
- Balanced Power

5.2.3 **Linux Based OS (32- and 64-bit)**

5.2.3.1 **RHEL 5.3 (32- and 64-bit)**

Required Software:
- RedHat* Enterprise Linux Update 3
- All applicable software patches
Known Problems:
Low package C-state residency on some platforms (processors do not enter low power states as often, resulting in higher platform power consumption). A fix for this is expected in future kernel updates.
Workaround – ACPI C3 exit latency in BIOS ACPI CST table > 200 us.

Power Policy:
Ondemand Governor

5.2.3.2 SuSE SLES 10.2+ (32 and 64 bit)

Required Software:
SuSE Linux Enterprise Server 10
Service Pack 2 + update kernel > 2.6.26.60 or Service Pack 3
All applicable software patches

Known Problems:
Low package C-state residency on some platforms (processors do not enter low power states as often, resulting in higher platform power consumption). A fix for this is expected in future kernel updates.
Workaround – ACPI C3 exit latency in BIOS ACPI CST table > 200 us.

Power Policy:
Ondemand Governor
6 Validation Tools and Usage

Use the tools outlined in this section (or equivalent tools depending on operating system type) to validate that the platform under test is properly configured before running the ENERGY STAR Readiness Test procedure.

6.1 CPU-Z

Use this application (or an equivalent) to verify that the hardware installed in your platform matches all recommendations in sections 2 and 3. This software can be downloaded using the following URL: http://www.cpuid.com/cpuz.php.

Figure 6-1. CPU-Z
6.1.1 Hwmonitor

Use this application (or an equivalent) to monitor platform hardware including power supplies, fan speeds, CPU temperatures and power draws as well as hard drive temperatures. This software can be downloaded at the following URL: http://hwmonitor.en.softonic.com/.

Figure 6-2. Hwmonitor
6.2 **CoreTemp**

Use this application (or an equivalent) to monitor all CPU core temperatures, and can be downloaded at the following URL: [http://www.alcpu.com/CoreTemp/](http://www.alcpu.com/CoreTemp/).

**Figure 6-1. CoreTemp**

![CoreTemp screenshot](image)
6.3 PerfMon

Use this application to verify that all BIOS settings and operating system patches required to place processors in deep sleep states are enabled and functioning correctly. Open PerfMon (included with the Windows operating system) and add processor C2 and C3 transitions/sec counters for each processor core. When the platform is in an idle state, you should see C2/C3 state transitions similar to the ones shown below.

Figure 6-2. PerfMon
6.4 Max Power Tools

This section contains brief descriptions, as well as screen shots, of applications used to place a platform under test in a state that will draw as close to maximum power as possible.

6.4.1 Linpack

This application is specified by the EPA as one of the benchmarks to be used when testing a platform for ENERGY STAR compliance. All details of how to obtain, setup and use this application are in section 4.10 of the whitepaper “Workstation and Server Platform Readiness Checks for the ENERGY STAR* Program”, Intel’s IBL number 411729.

Figure 6-3. Linpack
6.4.2 Prime95

This application (or an equivalent) is used to place all CPU cores in their maximum power draw state. The tool and its documentation can be downloaded from the Internet using the following URL: http://files.extremeoverclocking.com/file.php?f=103.

Use this application in conjunction with an external power meter to gauge the effectiveness of your Linpack configuration to obtain maximum power draw at the platform level.

Figure 6-4. Prime95
6.4.3 Nehalem-EP Processor Power and Thermal Utility

This application (or an equivalent) is used to place all CPU cores in their maximum power draw state. The tool and its documentation can be obtained from the Intel IBL website, Doc ID 414105, or 387761. Use this application in conjunction with an external power meter to gauge the effectiveness of your Linpack configuration to obtain maximum power draw at the platform level.

Figure 6-5. Nehalem-EP Processor Power and Thermal Utility
6.4.4 Task Manager

This application (included with the Windows operating system) is used to determine if all CPU cores are at either minimum or maximum utilization, or somewhere in between. Use this application with Linpack, Prime95 or the Nehalem-EP Processor Thermal and Power Utility and an external power meter to verify that the platform under test is utilizing all CPU cores to their maximum extent.

Figure 6-6. Task Manager
6.4.5 **RW - Everything**

This application is used to interrogate/change memory, registers, I/O space, PCI configuration space, ACPI tables, MSRs (Model Specific Registers), and many other hardware related data objects. This application is helpful for checking that ACPI tables are correct, and that MSRs defined in the Intel BIOS Writers Guide are correctly populated. The tool and its documentation can be downloaded from the internet using the following URL: http://jacky5488.myweb.hinet.net/.

*Figure 6-7. RW-Everything*
7 Other Considerations

7.1 Power Supply Selection

The power supply selection should be in accordance with section 3.1 of the whitepaper “Workstation and Server Platform Readiness Checks for the ENERGY STAR® Program”, and in accordance with the appropriate section of the ENERGY STAR Specification (version 5.0 for Workstations/1.0 for Servers, Draft 4) for Computers.

7.2 Fan and Thermal Control

For maximum power efficiency, enable all closed loop thermal throttling parameters in both BIOS and by the operating system. All CPU and platform fans should have multispeed capability. Low power acoustic settings are generally labeled “Quiet” or “Silent” in BIOS or OS options; “Performance” and “Max Speed” settings should be avoided.

At the hardware level, care must be taken to select fans that will provide adequate air flow velocities and are efficient both in design and power utilization. Improper setup of fan speed control and poor choices in either fan design, or sizing, can result in 20+ watts of excess platform idle power.

7.3 USB Device Interactions

The following text is from Microsoft KB article 918005 where hotfix downloads are available: http://support.microsoft.com/default.aspx/kb/918005.

On Windows XP and Server 2003 operating systems, you may experience one of the following issues:

A desktop computer or a server that is running Windows XP or Windows Server 2003 may consume more power than you expect. When you unplug the AC power on a portable computer, the battery may drain more quickly than you expect. Then, the operating system may shut down prematurely.

This problem may occur if one of the following conditions is true:

The portable computer cannot enter the deeper Advanced Configuration and Power Interface (ACPI) processor idle sleep states.

This occurs when the USB 2.0 driver leaves the asynchronous scheduler component running continuously. This prevents the processor from entering the deeper ACPI processor idle sleep states (C-states). C-states save power when the processor is not busy. These states range from C0 to C3 or C4. Typically, an idle portable computer uses the C3 and C4 states to reduce power consumption. If an idle
portable computer cannot enter or maintain the C3 or C4 states, the power consumption is increased. This problem is fixed by installing the download that is available in this article.

The USB host controller cannot turn off.

This typically occurs when devices are removed from a nested USB hub that is attached to the host controller. The host controller does not recognize the device removal. Therefore, the controller is never turned off. This prevents the processor from entering the ACPI processor idle sleep states. This problem is not fixed by installing the download that is available in this article.

The USB host controller uses the periodic scheduler for USB 2.0 devices.

This typically occurs when devices that rely on the periodic scheduler are attached to the host controller. These may be isochronous (Isoch) devices such as audio devices. Or, they may be interrupt devices such as mouse or keyboard. This problem is not fixed by installing the download that is available in this article.

7.4 ACPI Tables and MSRs

In order to maximize energy efficiency under operating system control, follow all ACPI table entries delineated in the BIOS Writers Guide. In addition, for optimum energy efficiency and performance, the Intel BIOS Writers Guide recommends certain MSR (Model Specific Register) entries be set to Intel suggested settings. The application ReadWrite Everything may be used in conjunction with the BIOS Writers Guide to verify that ACPI tables and MSRs are correctly populated.

Suggested ACPI Table/MSR entries: Table 7-1 below shows the suggested ACPI Table/MSR entries that should be verified; see the Intel BIOS Writers Guide for more information.

Table 7-1. ACPI/MSR Entries

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSR 1A0h</td>
<td>Turbo Mode Disable</td>
</tr>
<tr>
<td>MSR 1AAh</td>
<td>Enhanced Intel SpeedStep Technology Hardware Coordination Disable</td>
</tr>
<tr>
<td>MSR 0E2h</td>
<td>Package C State Limit</td>
</tr>
<tr>
<td>MSR 1FCh</td>
<td>Power Control</td>
</tr>
<tr>
<td>MSR 1A4h</td>
<td>Miscellaneous Feature Control</td>
</tr>
<tr>
<td>MSR 0E4h</td>
<td>CST Range</td>
</tr>
<tr>
<td>ACPI Entries</td>
<td>_CST, _PSD</td>
</tr>
</tbody>
</table>

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