Configuring and tuning HP ProLiant Servers for low-latency applications

Contents

Introduction ......................................................................................................................................................... 2
What’s new .......................................................................................................................................................... 2
Recommended hardware configurations ........................................................................................................ 3
Preparing for low-latency configuration ...................................................................................................... 4
  Taking inventories or snapshots ......................................................................................................................... 4
  Upgrading BIOS and firmware .......................................................................................................................... 4
  Obtaining the Scripting Utilities ......................................................................................................................... 5
Recommended platform tuning ....................................................................................................................... 7
  System requirements .......................................................................................................................................... 7
  Tuning recommendations and explanations ....................................................................................................... 7
    OPI Snoop Configuration information and considerations (Gen9 only) ......................................................... 9
    Core frequencies for AVX vs non-AVX applications information and considerations (Gen9 only) .......... 10
    Turbo mode information and considerations ................................................................................................. 10
    Disabling processor power and utilization monitoring and memory pre-failure notification SMIs .......... 11
    Disabling Dynamic Power Capping Functionality ............................................................................................ 11
    Disabling Patrol Scrubbing ............................................................................................................................... 12
    Setting the Memory Refresh Rate ..................................................................................................................... 12
    Tuning with the ROM-based Setup Utility (RBSU) ......................................................................................... 12
    Tuning with HP RESTful Interface Tool (Gen 9) ............................................................................................. 12
    Tuning with conrep (Gen 8 and older) ............................................................................................................... 13
Recommended operating system tuning ......................................................................................................... 16
  Linux ................................................................................................................................................................. 16
    Preparing Linux-based servers for low-latency tuning ..................................................................................... 16
    Red Hat MRG Realtime ................................................................................................................................... 17
    Recommended Linux boot-time settings .......................................................................................................... 17
    Verifying the configuration ............................................................................................................................... 18
  Windows ............................................................................................................................................................ 18
  HP-TimeTest ...................................................................................................................................................... 19
Frequently asked questions ............................................................................................................................... 20
Support and other resources ............................................................................................................................ 21
  Resources and documentation .......................................................................................................................... 21
  Before you contact HP ....................................................................................................................................... 21
  HP contact information .................................................................................................................................... 22
Acronyms and abbreviations ............................................................................................................................ 22
Documentation feedback .................................................................................................................................... 23

Part Number: 581608-008
October 2015
Edition: B
Introduction

Low-latency, deterministic system performance is a required system characteristic in the financial services market, where it enables high frequency trading, market data distribution, and exchange data processing. It is also required in other industries such as real-time signal and image processing.

These systems must respond rapidly to external events in a predictable manner. They must do so under heavy workloads, sometimes reaching millions of transactions per second. To achieve this level of performance, system designers must consider the following factors during system design and configuration:

- **Hardware**—System design, processor type and speed; memory latency, speed, and capacity; network components; and storage subsystem, including SSDs
- **OS selection**—Operating system kernels specifically designed and tuned for minimum latency and, in some cases, real-time preemption
- **BIOS configuration**—BIOS support configured for minimum latency and maximum performance
- **Networking fabric**—Network technology (1/10/40 Gigabit Ethernet, InfiniBand, Fibre Channel)
- **Middleware**—Messaging and database services on the network designed for minimum latency and maximum throughput with reliability
- **End-user applications**—Designed to perform multicast messaging accelerated via kernel bypass and RDMA techniques
- **Physical distances**—Physical separation between the information sources and clients affects overall system performance.

This document presents suggestions and best practice recommendations on BIOS configuration and on OS tuning to obtain the lowest-latency performance from HP ProLiant BL c-Class server blades and HP ProLiant DL, ML, SL, and XL servers. While this document contains information pertaining to G7 and earlier ProLiant servers, the primary focus is Gen8 servers and later.

The recommendations to disable System Management Interrupts (SMIs) are intended only for extreme latency-sensitive use cases. Most customers benefit from the power savings, monitoring, and notifications that the SMIs enable. These SMIs consume less than 0.1% of the server’s processing capability, and HP continues to reduce their impact with each new generation of ProLiant server.

Important. The information in this document is accurate as of the document’s release date but is subject to change based on updates made by HP.

What’s new

The current edition of the Configuring and Tuning HP ProLiant Servers for Low-Latency Applications White Paper, 581608-008, includes the following additions and updates:

- “Recommended hardware configurations” on page 3
  - Updated information to new E5-2600 v3 versions of processors
  - Updated recommended memory speed to 2133 MHz
  - Added information for Smart Array P440 and P840 SAS controllers
- Updated the following tuning procedures:
  - “Tuning with HP RESTful Interface Tool (Gen 9)” on page 12
  - “Tuning with conrep (Gen 8 and older)” on page 13
  - “Recommended operating system tuning” on page 16
Recommended hardware configurations

HP recommends the following HP ProLiant Gen9 hardware configuration when low-latency is required. This information is subject to change and is valid as of the date of publication. For the latest information, see the server QuickSpecs on the HP website (http://www.hp.com/go/support).

- **Processor**
  - E5-2637 v3 (4c 3.5 GHz), E5-2643 v3 (6c 3.4 GHz), E5-2667 v3 (8c 3.2 GHz) and E5-2687 v3 (10c 2.7 GHz) in HP ProLiant DL, ML, and BL servers, and select Apollo System servers
  - E5-2690 v3 (12c 2.6GHz) in select Apollo System servers that do not support the higher-wattage processors

- **Memory**
  - 8 GB Single Rank DDR4-2133MT/s CAS-15 RDIMMs
  - If installing only one DIMM per channel, consider using 8 Dual-Rank 2133MT/s 16 GB RDIMMs for improved memory interleaving.
  - Each channel should be populated with at least one DIMM.

- **PCIe Gen3 architecture**
  - The HP ProLiant DL380 Gen9 Server offers three x8 slots that communicate with processor 1 and three x8 or higher slots that communicate with processor 2. Two additional option slots communicate with processor 1, one x8 FlexibleLOM slot for network options and an x8 Flexible SA slot for storage controller options.
  - The HP ProLiant DL360 Gen9 Server offers two x8 or higher slots that communicate with processor 1 and one x16 slot that communicates with processor 2. Two additional option slots communicate with processor 1, one x8 FlexibleLOM slot for network options and an x8 Flexible SA slot for storage controller options.

Consider a single processor configuration if your workload does not benefit from a second processor. The benefits are as follows:
- Yields automatic PCI-to-core affinity (no application rewrite).
- DDIO performs optimally.
- Cache snooping is eliminated.
- No QPI latency is experienced.
- Simplified CPU core mapping is achieved.
- Even with one processor, there are still three x8 PCIe slots for NICs, timing cards, Fusion-io, and so forth.

- The HP ProLiant BL460c Gen 9 Server Blade has one x16 mezzanine slot that communicates with processor 1 and one x16 mezzanine that communicates with processor 2, plus a FlexibleLOM off processor 1.
- The HP ProLiant XL230a Gen9 offers an optional x16 Riser Kit (Part #788126-B21) that provides a low-profile PCIe slot with direct connectivity to the second processor. Additionally, an optional HP Apollo 6000 Dual FlexibleLOM Riser kit (Part # 757401-B21) is available to provide a second x8 FlexibleLOM slot.

- **PCIe NIC**
  - Mellanox ConnectX-3 based adapters offer ultra-low latency and are designed specifically for HP servers in three form factors: PCIe card, FlexibleLOM, and server blade mezzanine. They are sold, integrated, and directly supported by HP. The Mellanox ConnectX-3 NIC offers native Gen3 x8 performance (40GbE and FDR InfiniBand). Mellanox Connect-IB based adapters offer even greater throughput by offering native Gen3 x16 performance.
  - Additional popular third-party PCIe Ethernet cards for ultra-low latency are available from Solarflare and Myricom and can be installed in HP industry-standard ProLiant DL, ML, and SL servers.

- **Storage**
  - New HP Smart Array P44x and P840 storage controllers offer 12 Gb/s SAS performance when used in Gen 9 servers with 12 Gb/s devices (SSDs or HDDs), which can deliver as much as 60% more IOPS vs. 6Gb/s devices.
  - The B140i is the base storage controller on the HP ProLiant DL360 Gen9 and HP ProLiant DL380 Gen9. It utilizes a special OS driver to provide RAID functionality to provide a low cost solution. However the driver-based RAID solution may introduce slight OS overhead which could affect latency. For latency-sensitive applications, it is recommended that the B140i be run in AHCI mode and for RAID based configurations a hardware-based RAID controller such as the HP Smart Array P44x be used.
  - HP I/O Accelerator now supports up to 1.2 TB MLC in server blade mezzanine cards.

For more information, see the HP IO Accelerator for HP BladeSystem c-Class QuickSpecs on the HP website (http://h18004.www1.hp.com/products/quickspecs/13220_div/13220_div.pdf).

- **Tuning**

  See “Tuning recommendations and explanations” on page 7.
Preparing for low-latency configuration

Taking inventories or snapshots

Before you configure servers for low-latency applications, HP recommends that you take an inventory or snapshot of the following items. This will enable you to track changes during the optimization process.

- `dmidecode`
  For RHEL before 6.2 and SLES before 12, obtain v. 2.11 from the nongnu website (http://www.nongnu.org/dmidecode).
- `lspci -vv`
- `conrep` (for ProLiant Gen9 and earlier servers)
- `hpdiscovery`
  To obtain the latest versions of `conrep` or `hpdiscovery`, see "Obtaining the Scripting Toolkit" on page 5.
- `sysctl -a`
- `HP-timetest7.2`
  HP-TimeTest is a utility distributed by HP that enables customers to test for jitter in a server. To obtain the HP-TimeTest utility, contact HP by emailing to: (low.latency@hp.com). Please include the name of your HP contact.
- Capture kernel boot settings
  - For non-UEFI systems (Gen8 and earlier)
    - `cat /boot/grub/grub.conf` (for RHEL)
    - `cat /boot/grub/menu.lst` (for SLES)
  - For UEFI systems (DL580 Gen8 and Gen 9)
    - `cat /boot/efi/EFI/redhat/grub.conf` (for RHEL)
    - `cat /boot/efi/efi/SuSE/elilo.conf` (for SLES)

Upgrading BIOS and firmware

Before making changes for low-latency operation, be sure that all platform firmware is up-to-date. For low latency, it is especially important to upgrade the BIOS, iLO 4 and network card firmware to the latest versions. HP offers the Service Pack for ProLiant (SPP) as a comprehensive solution to maintain all of the firmware and software for a server in a single ISO image. Use of the HP SPP is the recommended method of upgrading the platform firmware. Refer to the "HP Service Pack for ProLiant Contents Report" for the selected HP SPP on www.hp.com to verify latest versions of BIOS, iLO 4, and network card firmware are included.

**Important.** The HP SPP and BIOS images both require an active warranty or support agreement covering HP ProLiant servers to be linked to the HP Support Center profile used to download the components. Please refer to: [http://h20564.www2.hp.com/hpsc/doc/public/display?docId=c040444353](http://h20564.www2.hp.com/hpsc/doc/public/display?docId=c040444353) for more information.

To obtain the most recent HP Service Pack for ProLiant (HP SPP) upgrade for HP ProLiant servers:

1. Go to the HP website (http://www.hp.com/go/support).
2. Select **Drivers & Software**.
3. Enter the server model number, and then click **Search**.
4. Select the appropriate product link.
5. Select your operating system.
6. Select the **Application – System Management** category.
7. To obtain the HP SPP upgrade, do the following:
   - Download the latest HP SPP ISO image, and then upgrade the firmware using the instructions included with the ISO. The HP SPP can be used in online mode from either a Windows- or Linux-hosted operating system, or in offline mode by booting to the ISO.
To obtain the most recent BIOS upgrade for HP ProLiant servers, if not in HP SPP:

1. Go to the HP website (http://www.hp.com/go/support).
2. Select Drivers & Software.
3. Enter the server model number, and then click Search.
4. Select the appropriate product link.
5. Select your operating system.
6. Select the BIOS - System ROM category.
7. To obtain the BIOS upgrade, do one of the following:
   - Download the latest ROMPaq firmware, and then upgrade the firmware using the instructions included with the ROMPaq.
   - Select Online ROM Flash Component, click the Installation Instructions tab, and then follow the instructions on the Online ROM Flash Component page.

To obtain the latest network card firmware, if not in HP SPP:

1. Go to the HP website (http://www.hp.com/go/support).
2. Select Drivers & Software.
3. Enter the server model number, and then click Search.
4. Select the appropriate product link.
5. Select your operating system.
7. Download the appropriate NIC firmware.

**Important.** Version 1.40 of the iLO 4 firmware has been found to experience an increased number of periodic SMIs that cause some latency jitter on Gen8 systems. It is therefore strongly recommended to update the iLO 4 firmware to the v1.50 or greater release to address the problem.

Version 2.20 of the iLO 4 firmware has been found to experience periodic SMIs every 15 seconds that cause some latency jitter. It is therefore recommended to use the iLO 4 v2.10 firmware to address the problem. The issue will be resolved in the v2.30 release of the firmware.

To obtain the latest iLO 4 firmware, if not in HP SPP:

1. Go to the HP website (http://www.hp.com/go/support).
2. Select Drivers & Software.
3. Enter the server model number, and then click Search.
5. Click Obtain software, and then click the executable file to download it.

**Obtaining the Scripting Utilities**

For Gen 9 servers:
The HP RESTful Interface Tool can be used to configure BIOS options on Gen9 servers and is the preferred tool for future systems.

To install the HP RESTful Interface Tool:

1. Go to the HP website (http://www.hp.com/go/support).
2. Select Drivers & Software.
3. Enter the server model number, and then click Search.
4. Select the appropriate product link.
5. Select your operating system.
6. Select **Utility - Tools**.
7. Click **Download**, next to the appropriate executable file to save it.

For Gen 8 and older servers:

The conrep utility can be used to configure Processor Power and Utilization Monitoring or Memory Pre-Failure Notification for minimum latency, and are included in Smart Start Scripting Toolkit (SSSTK) 9.10 or later. For Gen8 servers, SSSTK is now called STK.

conrep is the only method available for configuring these options on HP ProLiant G5 servers and HP ProLiant G6 servers that utilize AMD Opteron processors. The utility is one method available for configuring HP ProLiant G6, G7, and Gen 8 servers that utilize Intel Xeon processors.

To install the STK:

1. Go to the HP website (http://www.hp.com/go/support).
2. Select **Drivers & Software**.
3. Enter the server model number, and then click **Search**.
4. Select the appropriate product link.
5. Select your operating system.
6. Select **Utility - Tools**.
7. Click **Download**, next to the appropriate executable file to save it.
**Recommended platform tuning**

**System requirements**

The HP BIOS configuration options described in this document include options in HP ProLiant servers to disable the generation of periodic System Management Interrupts (SMIs) used for Power Monitoring and for Memory PreFailure Notification, with their attendant latency impact. BIOS options are generally independent of the OS, and a properly tuned low-latency operating system is also required to achieve deterministic performance.

The tuning recommendations described in this document are based on testing and customer interactions. But no single “recipe” can be prescribed. Customers needing a low-latency environment often perform exhaustive testing of the latency impact of various tuning parameters with their application and systems to determine the optimum settings for their environment.

**Tuning recommendations and explanations**

Consider the following options as part of any deployment in low-latency OS kernel environments:

- Take an inventory or snapshot. See "Taking inventories or snapshots" on page 4.
- Upgrade the BIOS. See "Upgrading BIOS and firmware" on page 4.
- If using a Linux-based server, prepare the server for low-latency tuning. See "Preparing Linux-based servers for low-latency tuning" on page 16.
- Make the recommended changes to the BIOS.
- For tuning recommendations and instructions, see the following sections:
  - "Tuning with the ROM-based Setup Utility (RBSU)" on page 12.
  - "Tuning with HP RESTful Interface Tool (Gen 9)" on page 12.
  - "Tuning with conrep (Gen 8 and older)" on page 13.

HP servers are configured by default to provide the best balance between performance and power consumption. These default settings may not provide the lowest latency. The first step in tuning for low latency is to examine these additional settings that may assist in obtaining optimal low-latency performance. These settings are accessible through RBSU and with the conrep and hprcu utilities, configuration tools that are provided by HP.

All HP ProLiant G6 and later Intel-based servers, regardless of the ROM version, support setting Intel Turbo Boost and C-States. For G7 and earlier servers, HP ProLiant 100 Series servers do not support advanced features for iLO Performance Monitoring and Memory Pre-Failure notification.
The following table provides descriptions of the recommended low-latency settings for Linux environments. For recommended Windows settings, see "Windows" on page 18.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intel Virtualization Technology (pre-UEFI menu)</td>
<td>Disabled</td>
<td>Allows Virtual Machine Managers to utilize virtualization hardware capabilities</td>
</tr>
<tr>
<td>Virtualization Technology (UEFI menu)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intel Hyperthreading Options</td>
<td>Disabled</td>
<td>Allows Hyperthreading, which adds logical cores but increases computational jitter</td>
</tr>
<tr>
<td>Intel Turbo Boost Technology</td>
<td>Enabled</td>
<td>Allows processors to make a transition to a frequency that is higher than its rated speed. For more information, see “Turbo mode information and considerations” on page 10.</td>
</tr>
<tr>
<td>Intel VT-d</td>
<td>Disabled</td>
<td>Enables virtualized Directed I/O</td>
</tr>
<tr>
<td>Thermal Configuration</td>
<td>First try Optimal Cooling, then repeat with Increased Cooling and then Max Cooling (if available)*</td>
<td>Steps through the different available cooling settings available in RBSU. Use the one that provides the desired performance for the lowest power consumption. For more information, see “Thermal considerations” on page 11.</td>
</tr>
<tr>
<td>HP Power Profile</td>
<td>Maximum Performance</td>
<td>Disables all power management options that may negatively affect performance</td>
</tr>
<tr>
<td>HP Power Regulator</td>
<td>HP Static High Performance Mode</td>
<td>Keeps processors in their maximum power/performance state (automatically set by HP Power Profile for Gen 8 and Gen 9 servers)</td>
</tr>
<tr>
<td>Intel QPI Link Power Management</td>
<td>Disabled</td>
<td>Precludes placing unutilized QPI links into low power state</td>
</tr>
<tr>
<td>Minimum Processor Idle Power Core State</td>
<td>No C-States</td>
<td>Precludes processor transitions into low-power core C-States (automatically set by HP Power Profile for Gen 8 and Gen 9 servers)</td>
</tr>
<tr>
<td>Minimum Processor Idle Power Package State</td>
<td>No Package State</td>
<td>Precludes processor transitions into low-power package C-States (automatically set by HP Power Profile for Gen 8 and Gen 9 servers)</td>
</tr>
<tr>
<td>Energy/Performance Bias</td>
<td>Maximum Performance</td>
<td>Configures processor subsystems for high-performance/low-latency (automatically set by HP Power Profile for Gen 8 and Gen 9 servers)</td>
</tr>
<tr>
<td>Collaborative Power Control</td>
<td>Disabled</td>
<td>Precludes the OS from changing clock frequency (automatically set by HP Power Profile for Gen 8 and Gen 9 servers)</td>
</tr>
<tr>
<td>DIMM Voltage Preference</td>
<td>Optimized for Performance</td>
<td>Runs DIMMs at a higher voltage if it increases performance. (Gen 8 only)</td>
</tr>
<tr>
<td>Dynamic Power Capping Functionality</td>
<td>Disabled</td>
<td>This option allows for disabling System ROM Power Calibration during the boot process. Doing so accelerates boot times but precludes enabling of a Dynamic Power Cap. (Gen 8 and Gen 9 only)</td>
</tr>
</tbody>
</table>

*Steps through the different available cooling settings available in RBSU. Use the one that provides the desired performance for the lowest power consumption. For more information, see “Thermal considerations” on page 11.
Table 1. Recommended low-latency settings for Linux environments, continued.

<table>
<thead>
<tr>
<th>Memory Power Savings Mode</th>
<th>Maximum Performance</th>
<th>This option configures several memory parameters to optimize the memory subsystems performance and is configured to Balanced by default. (Gen 8 only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>QPI Snoop Configuration</td>
<td>Early Snoop or Cluster on Die**</td>
<td>This option allows for the configurations of different snoop modes that impact the QPI interconnect. Changing this option may improve performance in certain workloads. Home Snoop provides high-memory bandwidth in an average NUMA environment (default setting). Cluster on Die may provide increased memory bandwidth in highly optimized NUMA workloads. Early Snoop may decrease memory latency but may also result in lower overall bandwidth as compared to other modes. (Gen 9 only)</td>
</tr>
<tr>
<td>ACPI SLIT Preferences</td>
<td>Enabled</td>
<td>This ACPI SLIT describes the relative access times between processors, memory subsystems, and I/O subsystems. Operating systems that support the SLIT can use this information to improve performance by allocating resources and workloads more efficiently. This option is disabled by default on most ProLiant Gen 8 and Gen 9 servers.</td>
</tr>
<tr>
<td>Processor Power and Utilization Monitoring</td>
<td>Disabled***</td>
<td>Disables iLO Processor State Mode Switching and Insight Power Manager Processor Utilization Monitoring, and its associated SMI</td>
</tr>
<tr>
<td>Memory Pre-Failure Notification</td>
<td>Disabled***</td>
<td>Disables Memory Pre-Failure Notification and its associated SMI</td>
</tr>
<tr>
<td>Memory Patrol Scrubbing</td>
<td>Disabled***</td>
<td>Memory Periodic Patrol Scrubber corrects memory soft errors so that, over the length of the system runtime, the risk of producing multi-bit and uncorrectable errors is reduced.</td>
</tr>
<tr>
<td>Memory Refresh Rate</td>
<td>1x Refresh***</td>
<td>This option controls the refresh rate of the memory controller. The default value for this parameter is 2x.</td>
</tr>
</tbody>
</table>

*If Turbo mode is enabled, then step through the available cooling settings described in “Thermal considerations” on page 11. Otherwise, the default Optimal Cooling setting is adequate.

**QPI Snoop Configuration selection depends on the processor and workload used. See “QPI Snoop Configuration information and considerations (Gen9 only)” on page 9.

***These options are under the Service Options menu. See “Tuning with ROM Based Setup Utility (RBSU)” on page 12, “Tuning with conrep” on page 13, or “Tuning with HP RESTful Interface Tool” on page 12 for details on how to set these options.

QPI Snoop Configuration information and considerations (Gen9 only)

The QPI Snoop Configuration setting will control how cache snoops are handled. When using the “Early Snoop” option the snoops will be sent by the caching agents; this will provide better cache latency for processors when the snoop traffic is low. The “Home Snoop” option will cause the snoops to be sent from the home agent; this provides optimal memory bandwidth balanced across local and remote memory access. The “Cluster on Die” option will snoop the directory cache first and then the home agent. Using this option will also cause the processor to appear as two NUMA nodes within operating systems, one for each MC. This option provides optimal performance for highly NUMA-aware workloads. Note that the “Cluster on Die” option is available only on processors with 10 or more cores. See the table below for a summary of the QPI Snoop options.
Table 2. QPI Snoop modes supported in 2-socket configurations

<table>
<thead>
<tr>
<th></th>
<th>Early Snoop</th>
<th>Home Snoop (Default RBSU option)</th>
<th>Cluster on Die</th>
</tr>
</thead>
<tbody>
<tr>
<td>Previously available on</td>
<td>E5-2600 (SNB)</td>
<td>E5-2600 v2 (IVB)</td>
<td>E5-2600 v3 (HSW)</td>
</tr>
<tr>
<td>Snoop sent by</td>
<td>Caching Agent</td>
<td>Home Agent</td>
<td>Directory Cache, then Home Agent</td>
</tr>
<tr>
<td>Best used for</td>
<td>Memory latency-sensitive workloads</td>
<td>NUMA workloads that need maximum local and remote bandwidth</td>
<td>Highly NUMA-optimized workloads</td>
</tr>
</tbody>
</table>

Core frequencies for AVX vs. non-AVX applications information and considerations (Gen9 only)

With the new Intel Xeon E5-2600 v3 series processors, Advanced Vector Extensions version 2.0 (AVX2) allow applications to perform 256-bit wide operations for integer and floating-point operations, providing an opportunity for increased performance. However, the power requirements for running AVX instructions are higher than for non-AVX instructions. Therefore the CPU's core frequency range will change depending upon whether AVX instructions are executing or not. Cores that are executing AVX instructions will be constrained to a lower frequency range (AVX base and AVX Turbo) while running the instructions. The CPU's core frequency will return to the non-AVX frequency range ~1m-sec after the AVX instructions have completed. The table below shows both the AVX and non-AVX frequency ranges for two segment-optimized E5-2600 v3 processors. Note that the processor is still also governed by the power/thermal characteristics of the system, so the actual frequency will be determined by both the type of instructions used and the power/thermal conditions.

Table 3. Turbo frequency ranges for certain E5-2600 v3 Series processors

<table>
<thead>
<tr>
<th>Processor</th>
<th>Power</th>
<th>Base frequency</th>
<th>Number of active cores</th>
<th>Turbo-enabled frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>AVX</td>
<td>Non-AVX</td>
<td></td>
</tr>
<tr>
<td>E5-2687W v3</td>
<td>150 W</td>
<td>2.7 GHz</td>
<td>3.1 GHz</td>
<td>4-10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>3.3 GHz</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-2</td>
<td>3.5 GHz</td>
<td></td>
</tr>
<tr>
<td>E5-2667 v3</td>
<td>135 W</td>
<td>2.7 GHz</td>
<td>3.2 GHz</td>
<td>3-8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-2</td>
<td>3.5 GHz</td>
<td></td>
</tr>
<tr>
<td>E5-2637 v3</td>
<td>135 W</td>
<td>3.2 GHz</td>
<td>3.5 GHz</td>
<td>3-4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-2</td>
<td>3.6 GHz</td>
<td></td>
</tr>
</tbody>
</table>

If the penalty of computational jitter is too severe and you are unable to control temperature and TDP, you should disable Turbo Mode.

Power consumption
Pushing the processor’s TDP limit will result in the processor changing its turbo frequency if the processor consumes too much power. Because of the risk of processor failure, Intel offers no method to lock a processor into Turbo Mode. Most applications will not consume enough power to exceed the processor's TDP. If you are concerned that yours might, then you can disable a core per processor from within the BIOS, reducing power consumption and providing TDP headroom.
Tests have shown that the E5-2690 v3 processor under heavy computational load is able to stay at the maximum Turbo frequency indefinitely when the system is properly configured, as outlined in this document. However, this is not guaranteed behavior and you should verify this with your workload.

Thermal considerations
The processor’s thermal limits are another consideration in maintaining consistent turbo operation. Ensure that the server’s inlet temperature meets the specification in the associated QuickSpecs. Beyond that, there is a BIOS parameter that can be used to regulate the amount of cooling delivered by the fans, but before changing it, note that most configurations will maintain the preferred operating state with the default Optimal Cooling setting. If the system requires more cooling, the server will respond by increasing the fan speed to deliver the necessary cooling.

However, some demanding environments may require a greater base level of cooling. If testing shows that your server’s turbo frequency varies in response to exceeding temperature limits due to varying system load, evaluate the Increased Cooling option, which carries a penalty of increased system power consumption, acoustics, and airflow demand.

The third setting for this parameter is Maximum Cooling, which causes the fans to operate always at their highest speed. Use this setting only if your environment requires it, as it has significantly higher power consumption, acoustic noise, and facility airflow demand.

Keep in mind that different processors have different requirements. The E5-2687W v3 has a notably higher TDP than the E5-2690 v3, but the TCase for the E5-2687W v3 is 15°C (27° F) lower than for the E5-2690 v3, making proper cooling especially important.

Active cores
In addition to TDP and thermals, the amount of frequency boost obtained is a function of the number of active cores, which is never more than the number of operational cores as specified by a BIOS setting. Active cores are cores in C0, C1, or C1E State, and HP recommends disabling C-States in order to keep the number of active cores constant and avoid the attendant latency jitter of changing turbo frequencies.

Other considerations for Turbo Mode
As noted in “Active cores” page 11, C-States must be disabled in the BIOS. However, some versions of Linux ignore the BIOS setting and must be configured to disable C-States. For more information, see “Recommended Linux boot-time settings” on page 17.

Disabling processor power and utilization monitoring and memory pre-failure notification SMIs
Disabling System Management Interrupts to the processor provides one of the greatest benefits to low-latency environments. Disabling the Processor Power and Utilization Monitoring SMI has the greatest effect because it generates a processor interrupt eight times a second in G6 and later servers. Disabling the Memory Pre-Failure Notification SMI has a much smaller effect because it generates an interrupt at a low frequency: once per hour on G6 and G7 servers, once every five minutes on Gen8 servers, and once every minute on the DL580 Gen8 and all Gen9 servers.

Disabling each option causes some server features to become unavailable. Before reconfiguring BIOS, be sure that none of the features described below are required.

Disabling Processor Power and Utilization Monitoring disables the following features:

- iLO Processor State Monitoring
- Insight Power Manager CPU Utilization Reporting
- HP Dynamic Power-Savings Mode

Disabling Memory Pre-Failure Notification has the following effects:

- Disables Memory Pre-Failure Warranty Support
- Disables notification when correctable memory errors occur above a pre-defined threshold
- Forces the system to run in Advanced ECC Mode, regardless of the mode configured in RBSU

**Important.** Online Spare Mode, Mirroring Mode, and Lock-step Mode are not supported when Memory Pre-Failure Notification support is disabled. Supported AMP modes depend on the generation and model of the ProLiant server.

Disabling Memory Pre-Failure Notification does not disable the Advanced ECC mode or correction of errors. Uncorrectable errors are still flagged, logged, and bring the system down. The only difference when this SMI is disabled is that there is no early notification if the correctable error threshold is exceeded.

Disabling Dynamic Power Capping Functionality
Disabling Dynamic Power Capping Functionality prevents the ability to enable a Power Cap via iLO. When this parameter is disabled, the option to enable a Power Cap via iLO is no longer available. Since low-latency installations are unlikely to set power caps, the Dynamic
Power Capping Functionality option may be safely disabled in the BIOS. This option accelerates the boot process but does not have any impact on latency when the platform is operating.

**Disabling Patrol Scrubbing**

Patrol Scrubbing is a feature that scans memory to correct soft memory errors. On the HP ProLiant Gen9 Server, the Patrol Scrubber re-arm itself through an SMI. The frequency of this event is roughly once per day, but varies based on the amount of installed memory. Low-latency installations can avoid this SMI by disabling Patrol Scrubbing, which is an option in the Service Options menu. On other platforms, Patrol Scrubbing does not require SMI functionality and does not need to be disabled.

**Setting the Memory Refresh Rate**

An extremely rare potential for memory errors is eliminated by the default memory refresh rate of 2x. Decreasing the rate to 1x will improve memory performance, but with a vanishingly small potential for memory errors. This affects G6 and later servers. This option is available in the Service Options menu.

**Tuning with the ROM-based Setup Utility (RBSU)**

For new system testing or in environments with a small number of systems where script-based maintenance is not used, the RBSU in the UEFI Systems utilities is the recommended method to configure the BIOS.

To configure BIOS low-latency options using RBSU:
1. Power the server.
2. When prompted during POST, press F9 to enter RBSU (Gen 8 and earlier) or System Utilities (Gen 9).
3. For Gen 9 servers, select **System Configuration → BIOS/Platform Configuration (RBSU)**.
4. Browse through the menus to change the parameters. For more information, see “Tuning recommendations and explanations” on page 7.

**Important.** Do not change the other options in the Services Options menu.

5. For the parameters marked with “*****” in the “Tuning recommendations and explanations” table on page 7, go into the Service Options menu:
   a. For Gen 8 and earlier, while in the top level of the RBSU menu, press CTRL-A to display the option for the Service Options menu. Select Service Options.
   b. For Gen 9 and DL580 Gen 8, press CTRL-A. You will be immediately redirected to the Service Options menu.
6. Verify that the parameters are set as indicated in “Tuning recommendations and explanations” on page 7.

**Tuning with HP RESTful Interface Tool (Gen 9)**

The HP RESTful Interface tool is useful for scripting the deployment of BIOS options across multiple servers from a common profile file. For complete details on how to utilize the HP RESTful Interface tool for scripting, please refer to the HP RESTful Interface Tool 1.10 User Guide on the HP website (See. “Resources and documentation” on page 21 for links).

This section will provide details on how to download the service menu options to a json profile file and modify those setting via hprest. To configure BIOS low-latency options using the HP RESTful Interface Tool:
1. Edit the /etc/hprest/hprest.conf file and update the following fields:
   
   ```
   url = https://[iLO IP address]
   username = [iLO user account name]
   password = [iLO user password]
   ```

   **Note.** Instead of editing the /etc/hprest/hprest.conf file to pass the iLO’s settings to hprest, you can append “--url https://[iLO IP Address] -u [iLO user account name] -p [iLO user password]” to the “hprest rawget” and “hprest rawpatch” commands described below.

2. Change the current directory to a convenient working directory:
   
   ```
   cd /home/user/hprest
   ```

3. Capture a snapshot of your current Service menu settings:
   
   ```
   hprest rawget /rest/v1/systems/1/bios/service/settings > service.opts.txt
   ```
4. To disable Processor Power and Utilization Monitoring, disable Memory Pre-Failure Notification, and set Memory Refresh Rate to 1x, and create a patch file, service.patch, with the following format:

```json
{
   "path": "/rest/v1/systems/1/bios/Service/Settings",
   "body": {
      "ProcPwrUtilMonitor": "Disabled",
      "MemPreFailureNotification": "Disabled",
      "MemRefreshRate": "1xRefresh"
   }
}
```

5. To disable Patrol Scrubbing, add to the service.patch patch file the following markup in the "body" stanza:

```
"MemPatrolScrubbing": "Disabled",
```

**Important.** The "body" stanza in the service.patch file can contain multiple BIOS settings. Each setting should be separated by a comma; the final setting should not have a comma following it. Also, you cannot include settings from the Service RBSU menu and the other menus in the same patch file.

6. Update the BIOS with the modified settings:

   `hprest rawpatch service.patch`

7. Log out of hprest’s iLO session:

   `hprest logout`

8. Reboot the server:

   `Reboot`

**Tuning with conrep (Gen 8 and older)**

conrep is useful for scripting the deployment of BIOS options across multiple servers from a common profile file. For complete details in how to utilize conrep for scripting, please refer to the HP Scripting Toolkit for Linux User Guide on the HP website. (See "Resources and documentation" on page 21 for links).

**Important.** Using conrep to modify BIOS settings may result in different behavior than using RBSU or the HP RESTful interface tool. In particular, caution must be made when changing the HP Power Profile with conrep as it will not propagate changes to other BIOS settings like RBSU and the HP RESTful interface tool will. When changing the HP Power Profile using conrep, you will also need to change the settings shown in Table 1 on page 8 that are linked to the HP Power Profile.

This section will provide details on how to add the service menu options to the default profile file, conrep.xml and modify those setting via conrep. To configure low-latency Service Menu BIOS options using the conrep utility in STK:

1. Change the current directory to the STK/utilities directory:

   `cd STK/utilities`

2. Edit the conrep.xml file to include the following stanzas before `</Conrep>` at the end of the file:

   ```xml
   <Section name="PowerMonitoring">
   <helptext>
   <![CDATA[This setting determines if Pstate logging and utilization is supported.]]>
   </helptext>
   <ev>CQHGV3</ev>
   <length>1</length>
   <value id="0x00">Enabled</value>
   <value id="0x10">Disabled</value>
   <mask>0x10</mask>
   <byte>0</byte>
   ```
3. Capture a snapshot of your current settings:

```bash
./conrep -s -x conrep.xml -f conrep_settings.xml
```

4. To disable Intel Turbo Boost Technology, verify that the `conrep_settings.xml` file contains the following markup (G7 servers):

```xml
<Section name="Intel_Processor_Turbo_Mode" helptext="Allows Intel processors to transition to a higher frequency than its rated speed if the processor has available headroom and is within temperature specification.">Disabled</Section>
```

5. To disable Intel Turbo Boost Technology, verify that the `conrep_settings.xml` file contains the following markup (Gen 8 and Gen 9 servers):

```xml
<Section name="Intel_Turbo_Boost_Optimization_Gen8" helptext="Optimize Turbo Boost heuristics for different situations. For Gen8 or later servers only.">Disabled</Section>
```

6. To disable Processor Power and Utilization Monitoring, verify that the `conrep_settings.xml` file contains the following markup:
7. To disable Memory Pre-Failure Notification, verify that the conrep_settings.xml file contains the following markup:

```
<Section name="DisableMemoryPrefailureNotification" helptext="This setting allows the user to disable Memory Pre-Failure Notification support, which will remove the periodic SMI associated with this support. Not recommended for anyone except for those who absolutely need every periodic SMI removed.">Yes</Section>
```

8. To disable Memory Patrol Scrubbing (Gen 9 servers), verify that the conrep_settings.xml file contains the following markup:

```
<Section name="Memory_Patrol_Scrubbing" helptext="This setting allows the user to enable or disable the Memory Patrol Scrubbing setting on Gen9 servers.">Disabled</Section>
```

9. Update the BIOS with the modified settings:

```
./conrep -l -x conrep.xml -f conrep_settings.xml
```

10. Reboot the server:

```
reboot
```
**Recommended operating system tuning**

**Linux**

**Preparing Linux-based servers for low-latency tuning**
Before configuring a ProLiant Gen8 server for low latency, do the following:

1. Make the following edits:
   - For non-UEFI configurations (Gen8 and earlier):
     - Red Hat (EL 6.x): Edit `/boot/grub/grub.conf` and add "nosoftlockup intel_idle.max_cstate=0 mce=ignore_ce" to the kernel line
     - SLES: Edit `/boot/grub/menu.lst` and add " nosoftlockup intel_idle.max_cstate=0 mce=ignore_ce" to the kernel line
   - For UEFI configurations (Gen9 and DL580 Gen8):
     - Red Hat (EL 6.x): Edit `/boot/efi/EFI/redhat/grub.conf` and add "nosoftlockup intel_idle.max_cstate=0 mce=ignore_ce" to the kernel line
     - SLES: Edit `/boot/efi/efi/SuSE/elilo.conf` and add " nosoftlockup intel_idle.max_cstate=0 mce=ignore_ce" to the kernel line
   - For Red Hat Enterprise Linux Server 7.0 or greater:
     - Edit `/etc/default/grub` file and add "nosoftlockup intel_idle.max_cstate=0 mce=ignore_ce" to the "GRUB_CMDLINE_LINUX" value.
     - Run command:
       ```bash
       # grub2-mkconfig -o /boot/grub2/grub.cfg (non-UEFI configurations) or
       # grub2-mkconfig -o /boot/efi/EFI/redhat/grub.cfg (UEFI configurations)
       ```
   nosoftlockup prevents the kernel from logging an event when a high-priority thread executes continuously on a core for longer than the soft lockup threshold.
   intel_idle.max_cstate=0 prevents the kernel from overriding the BIOS C-State setting.
   mce=ignore_ce prevents Linux from initiating a poll every five minutes of the Machine Check Banks for correctable errors, which can cause latency spikes. For more information, see the Linux Kernel Archives website [http://www.kernel.org/doc/Documentation/x86/x86_64/boot-options.txt](http://www.kernel.org/doc/Documentation/x86/x86_64/boot-options.txt).

2. Set tuned profile (RHEL only). Tuned is a utility introduced in RHEL 6 that allows the user to implement a set of OS optimizations as part of a profile. Red Hat provides a set of pre-defined profiles that can be used. For RHEL 6, it is recommended that the "latency-performance" profile is used for latency-sensitive applications. For RHEL 7, "network-latency" is recommended for low latency environments. For details on the performance options being set, please see the /usr/lib/tuned/[performance profile]/tuned.conf file for the desired performance profile. To set the desired profile, run the command:
   ```bash
   # tuned-adm profile latency-performance (RHEL 6) or
   # tuned-adm profile network-latency (RHEL 7)
   ```

3. Reboot the server.

4. After reboot, run the `stop-services.sh` script to stop extraneous services. The following example stops the services shown and prevents them from starting on subsequent boots:
   ```bash
   for SERVICE in acpid conman dhcddb ip6tables lvm2-monitor multipathd oddjobd pacct
   do
       # add the service name here
   done
   ```
   For a complete list of services, refer to the `/etc/services` file.
**Recommended operating system tuning**

- rhnsd
- rpcgssd
- rpcidmapd
- rpcsvgssd
- saslauthd
- sendmail
- slpd
- smartd
- smbs
- suseRegister
- sysstat
- wpa_supplicant
- xfs
- vpbind
- yum
- updatesd
- novell-zmd

```bash
do
  chkconfig --level 2345 $SERVICE off
  service $SERVICE stop
done
```

- Note: for RHEL 7 systems, use the following script to disable services:

```bash
for SERVICE in 
  avahi-daemon.service
cordon.service
dnsmasq.service
  firewalld.service
  lvm2-monitor.service
  postfix.service
  rpcgssd.service
  rpcidmapd.service
  rpcsvgssd.service
  wpa_supplicant.service
do
  systemctl disable $SERVICE
  systemctl stop $SERVICE
done
```

5. Use the irqbalancer to preclude some cores from servicing software IRQs:

- a) Enter the following command:
  ```bash
  # service irqbalance stop
  ```
- b) Do a one-time run of the irq balancer:
  ```bash
  # IRQBALANCE_ONESHOT=1 IRQBALANCE_BANNED_CPUS=${CoreMask} irqbalance
  ```
- c) Wait until the command `service irqbalance status` returns "irqbalance is stopped."
- d) On SLES, the name of the IRQ balancer service is `irq_balancer`.
- e) On RHEL 7, use systemctl instead of service command to stop irqbalance.

**Red Hat MRG Realtime**

Red Hat resolved scaling issues for the MRG 2.3 operating system for ProLiant servers with large core counts, such as the DL580 G7 server with four 10-core E7-4870 processors. If you are using MRG 2.3 on servers with a large number of cores, be sure to use a release with a kernel version equal to or greater than the following:

```makefile
kernel-rt-3.6.11-rt30.25.el6rt
```

In addition to having a large number of cores, if your server is running the MRG 2.3 (or later) Realtime kernel, it is using the SLUB memory allocator. The SLUB memory allocator requires additional tuning for real-time performance. The SLUB allocator has pseudo-files named "cpu_partial" in the `/sys/kernel/slab` file system. To get the best real-time performance from the allocator, these files should be set to "0", disabling the cpu_partial logic. This can be done with the following command:

```bash
# find /sys/kernel/slab -name 'cpu_partial' -exec echo 0 > {}`

**Recommended Linux boot-time settings**

The Linux boot parameter "idle=poll" keeps the processing cores in C0 state when used in conjunction with "intel_idle.max_cstate=0." Without it, the processor will enter C1 state.

- For RHEL systems:
  - For RHEL 6, edit `/boot/grub/grub.conf` (or `/boot/efi/EFI/redhat/grub.conf` for UEFI systems) and add "idle=poll" to the kernel line. This is in addition to the "nosoftlockup intel_idle.max_cstate=0 mce=ignore_ce" parameters that should have been added previously.

  ```bash
  grub2-mkconfig -o /boot/grub2/grub.cfg (non-UEFI configurations) or
  grub2-mkconfig -o /boot/efi/EFI/redhat/grub.cfg (UEFI configurations)
  ```
For SLES systems:

Edit /boot/grub/menu.lst (or /boot/efi/efi/SuSE/elilo.conf for UEFI systems) and add "idle=poll" to the kernel line. This is in addition to the "nosoftlockup intel_idle.max_cstate=0 mce=ignore_ce" parameters that should have been added previously.

**Verifying the configuration**

To verify your ProLiant server is properly configured for low-latency operation, clear one core (selected at random) of the operating system IRQs, and then run the HP-TimeTest utility on the randomly selected core:

```bash
Core=5
CoreMask=`echo "16 o 2 $Core ^ p" | dc`

service irqbalance stop
until [ "$service irqbalance status" = "irqbalance is stopped" ] ; do sleep 1 ; done
IRQBALANCE_ONESHOT=1 IRQBALANCE_BANNED_CPUS=${CoreMask} irqbalance
sleep 1
until [ "$service irqbalance status" = "irqbalance is stopped" ] ; do sleep 1 ; done
numactl --physcpubind=${Core} --localalloc nice -n -20 ./HP-timetest7.2 -v -f csv -o smi_count
```

On SLES, the name of the IRQ balancer service is `irq_balancer`.

On RHEL 7, use `systemctl` to disable and monitor the status of the "irqbalance.service" process.

Consider the following:

- Consider changing the smp_affinity for the IRQs. For example, on a server on which you want to leave core 0 for the OS, the following masks off the other processors for all IRQs:

  ```bash
  for MF in `/find /proc/irq -name *smp_affinity` ; do awk -F, \
  '{for(i=1;i<NF;i++)printf("00000000,",);printf("%8.8x\n",and(0x00000001, \nstrtonum("0x"$NF)))}' \
  $MF > $MF ; done
  ```

- Consider using cset (http://code.google.com/p/cpuset/) to shield cores from the OS. For example, on a server on which you want to keep the OS from all cores except for 0, use the following command:

  ```bash
  # cset shield --cpu 1-15 --kthread=on
  ```

- If running as root, the following command can then be used to move the current PID to the "user" set of cores:

  ```bash
  # cset proc --move --pid=$$ --threads --toset=user
  ```

**Windows**

HP BIOS low-latency options are supported in Windows Server 2008 and 2012 environments.

To apply the low-latency options in a Microsoft Windows environment:

1. Obtain the STK. See "Obtaining the Scripting Toolkit" on page 5.

2. Run the SmartComponent for the most recent version of the STK, note the directory it is in, and then change to it in Windows Explorer or a command window.


For other low-latency tuning recommendations in a Windows environment, do the following:


For more information or assistance, contact Microsoft to be put in touch with one of their low-latency experts.
The original behavior of HP-TimeTest has been maintained through its many edits, but this behavior is not optimal. For example, it runs at real-time priority 99, but should be run at no higher than 80. On an otherwise idle system, a real-time priority of "1" is adequate for HP-TimeTest to run properly.

The following provides an example of running HP-TimeTest with an explanation of each component of the command:

```
HP-TimeTest
```

```
time numactl --physcpubind=3      \ Bind to core 3 and use local memory
--localalloc
nice -n -20                  \ nice; probably not necessary
/HP-TimeTest/HP-TimeTest7.2    \ HP-TimeTest7.2 executable
-f csv                       \ output in Comma Separated Variable (csv) format
-o smi                       \ print SMI_count at the beginning and end
-o date                      \ print a timestamp at the beginning and end
-m cycles                    \ latency is determined by cycles (instead of time)
-t `echo '.000005 2900000000 * 0 k \ threshold is 5 μsec on 2.90 GHz processor
1 / p' | dc`                  \ run for ~30 minutes on 2.90 GHz processor
44`                           \ ("44" is # of cycles per loop iteration I get)
-p FIFO,80,-20                \ Use FIFO scheduling at priority 80; use "nice"
Generating the output in CSV format allows for easy import into a spreadsheet for plotting.
To provide additional suggestions, contact the HP low-latency team.
Frequently asked questions

Q. Does disabling Memory Pre-Failure Notification disable memory error correction?
A. Memory errors are still corrected, but notification that the error rate has exceeded a pre-set threshold is disabled. The latency impact of this feature is very small. HP recommends disabling Memory Pre-Failure Notification only if absolutely necessary.

Q. What memory features are lost if Memory Pre-Failure Notification is disabled?
A. If Memory Pre-Failure Notification is disabled, Online Spare and Mirroring memory modes become unavailable. The system is forced to run in Advanced ECC mode, regardless of the mode set in BIOS. Memory Pre-Failure Warranty Support also becomes unavailable because there is no notification of errors exceeding the programmed threshold.

Q. How does disabling iLO Processor State Monitoring in the HP ProLiant c-Class enclosure affect power management?
A. Disabling state monitoring does not affect power management.

Q. How can I verify that a server has the low-latency option set?
A. Use one of the following options to verify that the low-latency option is set:
   • See the information in “Tuning recommendations and explanations” on page 7.
   • Run HP-TimeTest to see if you are getting spikes. For more information, contact HP by emailing to: low.latency@hp.com.

Q. Can I interrogate or confirm the memory operating speed?
A. To interrogate or confirm the memory operating speed, ensure your SMBIOS is 2.7 or later and use dmidecode 2.11 or later with the following command:
   ```
   dmidecode -t 17
   ```

Q. How do I verify what turbo frequency my cores are running at?
A. There are a number of utilities that track the real time frequency of each CPU core. For example, for Linux:
   1. i7z is an open source utility that provides information on the Intel Core i3, i5, i7, and corresponding Xeon processors. Pre-compiled versions of this utility can be found for most Linux distributions, including Red Hat and SLES.
   2. Red Hat Enterprise Linux 6.4 and later provides the utility turbostat as part of its cpupowerutils package.
      Both of these utilities will provide real-time information about each cores’ frequency and percent time in each C-state.
Support and other resources

Resources and documentation

The following resources are available:

- **HP ROM-Based Setup Utility User Guide** on the HP website (http://www.hp.com/support/rbsu)
- **iLO documentation:**
  - **HP iLO 4 Scripting and Command Line Guide** (for Gen8 servers) on the HP website (http://h20565.www2.hp.com/portal/site/hpsc/guide)
- **STK** on the HP website (http://www.hp.com/go/support)

The conrep, hcrpu, and hpdiscovery utilities are available through STK. For more information on downloading STK, see "Obtaining the Scripting Toolkit" on page 5.

- **HP-TimeTest 7.2 utility.** To obtain the utility, contact HP by emailing: low.latency@hp.com.

Before you contact HP

Be sure to have the following information available before you call HP:

- **Active Health System log**
  
  Download and have available an Active Health System log for three days before the failure was detected. For more information, see the **HP ILO 4 User Guide** or **HP Intelligent Provisioning User Guide** on the HP website (http://www.hp.com/go/ilo/docs).

- **Onboard Administrator SHOW ALL report** (for HP BladeSystem products only)
  
  For more information on obtaining the Onboard Administrator SHOW ALL report, see the HP website (http://h20000.www2.hp.com/bizsupport/TechSupport/Document.jsp?lang=en&cc=us&objectID=c02843807).

- **Technical support registration number** (if applicable)

- **Product serial number**

- **Product model name and number**

- **Product identification number**

- **Applicable error messages**

- **Add-on boards or hardware**

- **Third-party hardware or software**

- **Operating system type and revision level**
**HP contact information**

For United States and worldwide contact information, see the Contact HP website [http://www.hp.com/go/assistance](http://www.hp.com/go/assistance).

In the United States:

- To contact HP by phone, call 1-800-334-5144. For continuous quality improvement, calls may be recorded or monitored.


On a best-effort basis only, HP offers technical assistance on low-latency tuning to customers who have followed this guide and still have questions. For more information, contact HP by emailing: low.latency@hp.com. Please provide the name of your local HP representative and region of origin so that we can better serve your request.

**Acronyms and abbreviations**

- **ACPI**
  Advanced Configuration and Power Interface specification
- **AMP**
  Advanced Memory Protection
- **AVX**
  Intel Advanced Vector Extension
- **BIOS**
  Basic Input/Output System
- **DDIO**
  Distributed Discrete Input/Output
- **HPRCU**
  HP ROM Configuration Utility
- **iLO**
  Integrated Lights-Out
- **LOM**
  LAN on Motherboard
- **MRG**
  Red Hat Enterprise Messaging Realtime Grid platform
- **POST**
  Power-On Self Test
- **QPI**
  Intel QuickPath Interconnect
- **RBSU**
  ROM-Based Setup Utility
- **SLES**
  SUSE Linux Enterprise Server
- **SLIT**
  System Locality Information Table
- **SLUB**
  Unqueued slab memory allocator
- **SMI**
  System Management Interrupt
- **STK**
  Scripting Toolkit
- **TDP**
  Thermal Design Power
- **UEFI**
  Unified Extensible Firmware Interface
Documentation feedback

HP is committed to providing documentation that meets your needs. To help us improve the documentation, send any errors, suggestions, or comments to Documentation Feedback (docsfeedback@hp.com). Include the document title and part number, version number, or the URL when submitting your feedback.