



Standard Performance Evaluation Corporation (SPEC)

Server Efficiency Rating Tool (SERT) Run and Reporting Rules 2.0.0

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1. Introduction

1.1. Overview

The Server Efficiency Rating Tool (SERT)[™] was created by the Standard Performance Evaluation Corporation (SPEC), the world's leading organization for benchmarking expertise. The SPECpower Committee designed, implemented, and delivered the SERT suite, a next-generation tool set for measuring and evaluating the energy efficiency of servers. The SERT suite was created with the input of various global energy-efficiency programs in order to incorporate their regional program requirements. Designed to be simple to configure and use via a comprehensive graphical user interface. The SERT suite uses a set of synthetic worklets to test discrete system components such as CPU, memory, and storage, providing detailed power consumption data at different load levels. Results are provided in both machine- and human-readable forms, enabling automatic submission to government-sponsored certification programs as well as both summary and detail reports for use by potential customers.

These rules abide by the norms laid down by SPEC in order to ensure that results generated with this tool are meaningful, comparable to other generated results, and repeatable, with documentation covering factors pertinent to reproducing the results. Per the SPEC license agreement, all results must adhere to these Run and Reporting Rules in order to be considered valid. Only valid results may be submitted for regulatory programs.

1.1.1. Applicability

SPEC intends that this tool measures the AC power and performance of computer servers for use by various energy efficiency programs.

The AC power consumption measured by this tool should not be assumed to represent the AC power consumption of other applications on the same hardware.

While this tool was designed to be a measure of computer servers, SPEC acknowledges that it may also be used to measure other classes of computing devices. Given the speed of technology advances in the industry, SPEC does not arbitrarily restrict the type of system on which the SERT suite is used. However, the SERT workload is not representative of workstation and client workloads.

1.2. Trademark and Copyright Notice

SPEC and the names SERT, SPECpower, and SPEC PTDaemon are trademarks of the Standard Performance Evaluation Corporation. Additional product and service names mentioned herein may be the trademarks of their respective owners. Copyright © 1988-2017 Standard Performance Evaluation Corporation (SPEC). All rights reserved.

2. Run Rules

2.1. Manual Intervention

No manual intervention or optimization of the Controller, SUT, or its internal and external environment is allowed during the measurement run.

2.2. SUT Configuration Information

The configuration information used to generate the final report must be populated accurately by the tester.

2.3. Client Configuration

JVMs are capable of modifying their behavior based on flags. Only Client Configurations (JVM options and JVM count) that are documented for the measurement environment https://www.spec.org/sert2/SERT-JVM_Options-2.0.html are allowed for valid measurements. Configuring the JVM through other means is strictly forbidden.

2.4. Testbed Configuration

The SERT suite is developed for out-of-the-box configurations. Limited tuning has been implemented to ensure consistency across architectures.

- Any deviations from the standard default configuration for the testbed components must be documented so an independent party would be able to reproduce the configuration and the result without any further assistance.
- The JVM director and all instances of the SPEC PTDaemon must run on system(s) other than the SUT.

2.4.1. General Availability

Availability requirements are defined by the regulatory agency in charge of the specific energy-efficiency program that is using data from the SERT suite.

The entire SUT must be comprised of components that are generally available on or before the date of publication, or must be generally available within three months of the first publication of these results.

World-wide availability is not a requirement. However, the entire SUT must be available in a region that supports the current and voltage sources used in the measurement of the SERT suite.

Products are considered generally available if they are orderable by ordinary customers and ship within a reasonable time frame. This time frame is a function of the product size and classification and common practice. Some limited quantity of the product must have shipped on or before the close of the stated availability window. Shipped products do not have to match the tested configuration in terms of CPU count, memory size, and disk count or size, but the tested configuration must be available to ordinary customers. The availability of support and documentation of the products coincide with the release of the products. Documentation must be provided in a language that is appropriate for the region where the SUT is claimed to be available.

Hardware products that are still supported by their original or primary vendor may be used if their original general availability date was within the last five years. The five-year limit is waived for hardware used in controller systems.

Software products that are still supported by their original or primary vendor may be used if their original general availability date was within the last three years.

2.4.2. System(s) Under Test (SUT)

Each SERT result submitted or made public must be for an actual run of the tool on the SUT named in the result.

2.4.3. Memory

Memory must be evenly distributed between processors (e.g. sockets or physical packages) and at least one DIMM must be populated per available memory channel for best performance. In the case of a multi socket/processor system, the memory must be equally distributed between the sockets.

2.4.4. Network Interfaces

At least one port of the SUT's fastest network interface controller must be connected to the Controller

2.4.5. Storage

If available, write caches in the storage subsystems (e.g., disk and RAID controllers) must be disabled or set to write-through mode. For systems where disabling either of the caches is not supported, a statement must be added to the SUT notes in the FDR.

2.4.6. Software

Required software components per server (host) are:

- Exactly one operating system instance (with one user space), including all modules that are installed during the default installation process.
- If the system uses a hypervisor by default, the SERT suite may run in a guest instance (virtual machine) of that hypervisor. Only one guest may run on each host. The guest must be configured to use all hardware resources that are not reserved by the hypervisor.
- A 64-bit Java run time environment including one or more instances of a Java Virtual Machine (JVM).

Optional power management software, when installed by default, must be reported. The operating system must be in a state sufficient to execute a class of server applications larger than the tool alone. Disabling operating system services is forbidden.

2.5. Java Specifications

The SERT 2.0 suite requires Java 7 or later and its implementation must follow the following specification:

- Java Virtual Machine Specification (ISBN-13: 978-0133260441)

2.5.1. Tool Binaries and Recomilation

The SERT suite binaries are provided in jar files containing the Java classes. Valid runs must use the SPEC provided jar files and these files must not be updated or modified in any way.

2.6. Validity Checks

At the end of the run, the results file is checked for conformance to the SERT run rules. The run will be marked invalid if the configuration or results do not adhere to these requirements. "Invalid" messages will appear in the report to explain the reasons why the result was marked invalid. In addition, warning messages may be included in the report to alert the reader to possible issues.

The following are required for a valid run and are automatically checked:

ResultModificationValidator	Verifies that the results.xml file was not modified after the run, aside from in the section of the file that is explicitly marked where editorial changes are allowed
CompleteRunValidator	Ensures that all of the configured measurement intervals were actually included in the result
TransactionFailuresValidator	Confirms that all transactions completed successfully

TargetThroughputValidator	Verifies that the target throughput for each load level was achieved (within acceptable thresholds)
ThroughputVariationValidator	Ensures that each host in multi-node runs has similar performance
VoltageValidator	Verifies that the measured voltage is within 5% of the line standard.
PowerAnalyzerDeviceValidator	Confirms that power analyzer are configured properly and on the accepted device list
PowerErrorReadingsValidator	Validates that there are no more than 1% error readings of power data and no more than 2% error readings for power-factor, voltage, and current
PowerUncertaintyReadingsValidator	Confirms that power analyzers report no more than 5% of readings with uncertainty greater than 1%, and no more than 1% of readings that have unknown uncertainty
TemperatureSensorDeviceValidator	Confirms that temperature sensors are configured properly and on the accepted device list
MinimumTemperatureValidator	Verifies that the minimum reported temperature is at least 20.0 degrees C throughout the run

2.7. Line Voltage Source

The preferred line voltage source used for measurements is the main AC power as provided by local utility companies. Power generated from other sources often has unwanted harmonics which are incapable of being measured correctly by many power analyzers, and thus, would generate inaccurate results.

The AC Line Voltage Source needs to meet the following characteristics:

- Frequency: (50Hz or 60Hz) \pm 1%
- Voltage in rms: (100V, 110V, 120V, 200V, 208V, 220V, 230V, 240V or 400V) \pm 5%

The usage of an uninterruptible power source (UPS) as the line voltage source is allowed, but the voltage output must be a pure sine-wave. For placement of the UPS, see 2.9.2. This usage must be specified in the Notes section of the FDR.

Systems that are designed to be able to run normal operations without an external source of power cannot be used to produce valid results. Some examples of disallowed systems are notebook computers, hand-held computers/communication devices, and servers that are designed to frequently operate on integrated batteries without external power.

Systems with batteries intended to preserve operations during a temporary lapse of external power, or to maintain data integrity during an orderly shutdown when power is lost, can be used to produce valid tool results. For SUT components that have an integrated battery, the battery must be fully charged at the end of each of the measurement intervals, and proof must be provided that it is charged at least to the level of charge at the beginning of the interval.

Note that integrated batteries that are intended to maintain such things as durable cache in a storage controller can be assumed to remain fully charged. The above paragraph is intended to address “system” batteries that can provide primary power for the SUT.

If an unlisted AC line voltage source is used, a reference to the standard must be provided to SPEC. DC line voltage sources are currently not supported.

For situations in which the appropriate voltages are not provided by local utility companies (e.g., measuring a server in the United States which is configured for European markets, or measuring a server in a location where the local utility line voltage does not meet the required characteristics), an AC power source may be used, and the power source must be specified in the Notes section of the disclosure report. In such situations, the following

requirements must be met, and the relevant measurements or power source specifications disclosed in the general notes section of the disclosure report:

- Total Harmonic Distortion of source voltage (loaded), based on IEC standards: < 5%
- The AC power source needs to meet the frequency and voltage characteristics previously listed in this section.
- The AC power source must not manipulate its output in a way that would alter the power measurements compared to a measurement made using a compliant line voltage source without the power source.

The intent is that the AC power source does not interfere with measurements such as power factor by trying to adjust its output power to improve the power factor of the load.

2.8. Environmental Conditions

The following environmental conditions need to be met:

- Ambient temperature lower limit: 20°C
- Ambient temperature upper limit: within documented operating specification of the SUT
- Elevation: within documented operating specification of the SUT
- Humidity: within documented operating specification of the SUT
- Overtly directing air flow in the vicinity of the measured equipment in a way that would be inconsistent with normal data center practices is not allowed.

The intent is to discourage extreme environments that may artificially impact power consumption or performance of the server, before and during the SERT run.

2.9. Power and Temperature Measurements

2.9.1. Supported and Compliant Devices

The SERT suite will utilize SPEC's accepted measurement devices list and SPEC PTDaemon update process. See Device List at https://www.spec.org/power/docs/SPECpower-Device_List.html for a list of currently supported (by the SPEC PTDaemon) and compliant (in specifications) power analyzers and temperature sensors.

The process to add software support for a power analyzer or temperature sensor to the infrastructure can be found on the Power Analyzer Acceptance Process page at https://www.spec.org/power/docs/SPEC-Power_Analyzer_Acceptance_Process.pdf.

2.9.2. Power Analyzer Setup

The power analyzer must be located between the AC line voltage source (or UPS) and the SUT. No other active components are allowed between the AC line voltage source and the SUT. Power analyzer configuration settings that are set by the SPEC PTDaemon must not be manually overridden.

2.9.3. DC Line Voltage

The SERT suite is neither supported nor tested with DC loads today.

2.9.4. Power Measurement Exclusion

Switches (network or KVM) need not be included in the power measurement of the SUT for a multi-node configuration.

3. Reporting Rules

In order to publicly disclose the SERT results, the tester must adhere to these reporting rules in addition to having followed the Run Rules above. The goal of the reporting rules is to ensure the system under test is sufficiently documented so that someone could reproduce the test and its results and to ensure that the tester has complied with the Run Rules.

3.1. Publication and Disclosure Requirement

Any entity choosing to make statements using the SERT suite must follow the SPEC Fair Use Rule. Fair Use: Consistency and fairness are guiding principles for SPEC. To help assure that these principles are met, any organization or individual who makes public use of SPEC tool results must do so in accordance with the SPEC Fair Use Rule, posted at <https://www.spec.org/fairuse.html>.

Any entity publically disclosing information associated with a SERT result must be willing to share the results.xml file with SPEC for evaluation purposes. Any SPEC member may request that a full disclosure of the result be forwarded to SPEC. The disclosure is expected to be complete, including the configuration description. The full disclosure must be made available to the relevant subcommittee no later than 10 working days after the request.

SPEC may take action: When public claims are made about SPEC results, by any party (including but not limited to members, licensees, the press, academic researchers), SPEC reserves the right to take action if the full disclosure is not made available, or shows different results than the tester's claim, has other rule violations, or violates SPEC policies (such as the Fair Use policy).

3.1.1. Research and Academic Usage

SPEC encourages the use of the SERT suite by the Research and Academic Community; please consult the SPEC Fair Use Rule for Research and Academic Usage at <https://www.spec.org/fairuse.html#Academic>.

3.2. Reproducibility

By submitting or publishing a tool disclosure (report), the test sponsor implicitly states that the system performance and power measured is representative of such systems.

3.3. Testbed Configuration Disclosure

The system configuration information that is required to reproduce published power and performance results must be reported. The principle is that if anything affects power or performance or is required to duplicate the results, it must be described. Any deviations from the standard, default configuration for the SUT must be documented so an independent party would be able to reproduce the result without any further assistance.

3.4. General Availability Dates

The dates of general customer availability must be listed for the major hardware components (including system firmware) and server software, by month and year.

3.5. Disclosure Notes

The Notes section is used to document additional important information required to reproduce the results from other reporting sections that require a larger text area.

4. Platform Support

The SERT suite has two levels of platform support:

Enablement: Enablement indicates that a processor architecture, operating system, or JVM has the necessary functional support implemented in the SERT suite, and has passed functional testing to ensure that SERT runs correctly.

Acceptance: Accepted “client configurations” are required to produce compliant results. A client configuration applies to a specific combination of processor family, operating system, and JVM, and specifies the runtime parameters that will be used with this configuration.

The sections below define the process for extending enablement and acceptance to new platforms.

4.1. Platform Enablement

Platform enablement primarily relates to functional support for a processor architecture, operating system, or JVM. Enablement is not sufficient for producing compliant runs, but is a prerequisite for accepting new platform configurations. The list of currently enabled processor architectures, operating systems, and JVMs is in section 5.

Enabling support for a new processor architecture, operating system, or JVM involves implementing any platform-specific code that is necessary for the SERT suite to run properly in that environment, and then producing test results to confirm that the SERT suite functions properly.

Specific aspects of the SERT suite that may require platform-specific code include:

- Affinity
- Discovery
- Storage worklet implementation
- Run scripts (serthost.sh / serthost.bat)
- Documentation updates (particularly the User's Guide); this includes any necessary steps for configuring large pages (if supported) and for deactivating write cache for storage devices

Implementing these functions requires SERT source code access; therefore, this work must be done by a SPEC member or supporting contributor. For further information please contact info@spec.org.

The SERT suite testing must be completed to confirm that the changes are working properly. The extent of testing required depends on the extent of code changes required. For example, if the only necessary changes are to the Discovery code, testing would focus on the accuracy of the discovery data for the new platform as well as regression tests on existing systems that share the same discovery scripts.

Testing should also demonstrate that the new platform is capable of achieving compliant SERT results on one or more typical system configurations using the new platform support.

In some cases, adding enablement for a new platform may not require code changes, but just updates to documentation and testing.

Finally, in order for SPEC to officially add enablement support for a new platform, the submitting party must provide a commitment for future support and testing. Support for a particular platform may be withdrawn in a future update of the SERT suite if no party is able to provide adequate testing to ensure that the new update still runs properly on that platform.

4.2. Client Configuration Acceptance

Compliant SERT runs require the use of an accepted client configuration. Each client configuration applies to specific combinations of processor, operating system version, and JVM version. The client configuration specifies

the runtime configuration that must be used for that combination, including the number of client JVMs and the JVM command-line options to be used when running each worklet.

The “platform owner”, which is the CPU silicon vendor, is responsible for proposing new client configurations that are appropriate for their platform(s). By request to the SPECpower subcommittee, a third party can become a platform owner unless the CPU vendor raises an objection. New client configurations are reviewed by SPEC to ensure the configuration meets the requirements of the run rules. Once the client configuration is reviewed and accepted by SPEC, the new configuration will be published on the Internet. The SERT suite licensees can download the latest copy of the client-configurations-2.0.xml file to get support for the most recent accepted client configurations.

In order for a client configuration to be accepted by SPEC, it must meet the following requirements:

1. The processor, operating system version, and JVM version must have completed the SERT enablement process described in the previous section.
2. The processor, operating system version, and JVM version must meet the General Availability requirements defined in section 2.4.1.
3. JVM tuning parameters must meet the requirements listed in section 4.2.1 below.
4. SERT test results must be produced to demonstrate that the client configuration produces valid and repeatable results. Specific test requirements are listed in section 4.2.2 below.

4.2.1. Tuning Parameter Requirements

The JVM options used in the configuration must be:

1. Described in publicly available documentation from the JVM vendor
2. Supported for use in production environments

The JVM options must NOT:

1. Disable Reliability, Availability, or Serviceability (RAS) features that are enabled by default in the JVM
2. Cause applications to behave in ways contrary to the Java Virtual Machine specification. For example, this requirement would preclude options that relax the level of precision required by mathematical operations.
3. Enable optimizations that target the specific code sequences executed by the SERT suite and would not be expected to improve performance or power consumption of a wider class of applications

4.2.2. Test Requirements

Before a client configuration can be accepted, test data must be produced to demonstrate that the configuration produces valid and repeatable results for the environments it applies to. The amount of testing required depends on the similarity of the new configuration to previously-accepted configurations. In the simplest case, an existing configuration can be applied to a new environment without modification; this would require only minimal test data for acceptance. At the other extreme is a new configuration with substantial differences compared to existing configurations, being applied to a previously-unsupported architecture; in this case, a more comprehensive set of test data would be required.

The subsections below list specific requirements for these two extremes as well as a typical “in between” scenario. For situations that do not match with any of these cases, the platform owner should work with SPEC to determine an appropriate test plan which fits somewhere between these extremes.

At a minimum, the acceptance test data must include a series of 5 consecutive SERT runs on a typical server configuration. At least 4 of the 5 runs must be valid (i.e. the SERT suite does not mark the run invalid). The coefficient of variation (CV) of the worklet performance scores for each worklet must be less than 10%.

Applying an Existing Client Configuration

In many cases, an existing client configuration can be applied to a new configuration (combination of processor, operating system version, and JVM version) that has minor differences from the existing combination. Common examples of this situation would be to extend an existing configuration to a new processor generation from the same processor architecture, or to extend support to a different Linux distribution using an existing configuration from another distribution based on the same kernel.

In these cases, only the minimum set of tests defined above (5 consecutive SERT runs on a typical configuration) is normally required.

New Client Configurations for New Architectures

Extending the SERT suite support to entirely new architectures requires a comprehensive set of test data to ensure that the proposed client configuration is appropriate across the entire class of servers that will be supported.

In addition to the minimum set of tests defined above (5 consecutive SERT runs on a typical configuration), the test data should include SERT runs:

- On 1-socket, 2-socket, 4-socket, and 8-socket configurations (as supported by the platform).
- On at least 4GB, 8GB, 32GB, 128GB, and 1024GB of memory (as supported by the platform).
- With a single disk, 2 disks, 4 disks, and 8 disks (as supported by the platform).
- With varying processor core counts and/or core frequencies.
- With at least two different memory frequencies.
- With at least two different storage technologies (if supported) or rotational speeds (if only HDDs are supported).

Only one run per configuration is needed for these tests.

If the environment is expected to participate in multi-node measurements, it is highly recommended that a set of measurements be made in a multi-node environment, to ensure that measurements complete correctly and that cross-node CVs are satisfactory.

SPEC will review the data to determine whether the server is behaving appropriately. For example, running with a faster processor frequency would normally be expected to improve the performance of CPU worklets, while having little or no impact on the performance of the storage worklets.

Minor Updates to an Existing Client Configuration

In some cases, a new proposed client configuration will be very similar to one or more existing configurations. Different levels of testing may be required depending on the nature of the change.

For example, if the new client configuration makes a change only to the configuration of cryptography support, it would be reasonable to expect that it would only impact the results of the SERT CryptoAES worklet. Acceptance of this configuration would require the minimum 5 consecutive runs of the entire SERT suite, and may also require additional runs of the CryptoAES worklet to show that the new settings work effectively with varying numbers of processor cores.

In another example, a change to the configuration of the Storage workload (leaving the configuration for other workloads unchanged) may require test data of the Storage worklets with a variety of storage configurations, including different numbers of disks as well as different disk technologies (e.g. HDD and SSD). The minimum requirement for 5 full SERT runs would also be required.

Use of Normalized Test Data

In some cases a platform owner may not wish to share their absolute test results with SPEC. It is acceptable to normalize all performance results to a single baseline configuration. In this way, SPEC can review the relative change in results, but would not be able to make comparisons to data produced by other parties.

For client configuration acceptance, it is not necessary to submit the full results.xml or generated reports to SPEC. Instead, the submitter provides a document that summarizes the results from their test runs. It is not normally necessary to report power consumption or efficiency metrics as part of the acceptance data.

4.3. Client Configuration Applicability to New Updates

When a client configuration is accepted for a particular version of software, it remains valid for future minor updates to that software. For example, a client configuration that applies to IBM J9 8.0 SR1 would also be used (without further acceptance by SPEC) for IBM J9 8.0 SR2 and SR3.

This applies only to new minor versions of the software, and not to new major versions. Since different software vendors use different nomenclature for version numbers, it may not always be obvious what constitutes a major or minor version. In general, a major version has an independent service stream, and new updates (minor versions) are periodically released for that service stream. Minor versions generally do not have an independent service stream, though they may have interim fixes available.

4.4. Acceptance of Unreleased Platforms

In some cases a platform owner may want to get acceptance for a platform (processor, operating system, or JVM version) which has not yet been released. This is possible as long as the appropriate data can be shared with SPEC under the normal SPEC Confidentiality rules. It is acceptable for the data to be “blinded”, by obscuring details such as the processor model number or operating system name. It should be noted, however, that details such as processor speed or core count are generally a necessary part of the acceptance data.

If necessary, once the client configuration is accepted SPEC can update the client-configurations-2.0.xml file with the new client configuration but without the matching criteria that would identify the details of the new environment. This is sufficient to allow testers to get valid SERT runs. The matching criteria can then be added in a later update to the client-configurations-2.0.xml file once the platform has been publicly announced.

4.5. Retirement of Client Configurations

Client configuration acceptance is effective for the life of the major version of the SERT suite, as long as the major components (CPU, Operating System, and JVM) remain supported by their vendor. If a vendor ends support, the corresponding client configuration entry shall be removed. Once removed, new results cannot be obtained with that configuration, but existing results remain valid.

Client configurations may be superseded by new configurations, but only in conjunction with new minor versions of the operating system or JVM. An existing client configuration for a specific processor, operating system version, and JVM version will remain valid, and new results can be obtained with that client configuration as long as those specific versions remain supported by the vendor.

In rare cases, SPEC may modify an existing client configuration for reasons such as, compatibility with a new minor SERT version or extension of the client configuration for broader platform applicability. In such a case, it will be verified that in at least one configuration (approved by the SPECpower Committee), the new SERT efficiency result is not changed by more than the SERT run to run variance versus the original efficiency result.

5. Enabled Platforms

The following processor architectures, operating systems, and JVM implementations are currently enabled in the SERT suite. These platforms have completed the necessary functional testing to be supported by the SERT suite. In order to produce compliant results, the specific combination of processor, operating system, and JVM must have completed the platform acceptance process described in section 4.1 and added to the client configurations file.

Processor Architectures

- ARM64
- Power
- SPARC
- x86-64

Operating Systems

- IBM AIX 7.1
- openSUSE Leap 42.x
- Oracle Linux 6
- Red Hat Enterprise Linux Server 6
- Red Hat Enterprise Linux Server 7
- Oracle Solaris 11
- SUSE Linux Enterprise Server 11
- SUSE Linux Enterprise Server 12
- Ubuntu 14.04.x
- Ubuntu 16.04.x
- Microsoft Windows Server 2008 R2 SP1
- Microsoft Windows Server 2012
- Microsoft Windows Server 2012 R2

Java Virtual Machines

- IBM SDK, Java Technology Edition, Version 7 (J9)
- IBM SDK, Java Technology Edition, Version 8 (J9)
- OpenJDK 8
- Oracle Java Platform, Standard Edition 7 (HotSpot)
- Oracle Java Platform, Standard Edition 8 (HotSpot)