

SPC Benchmark-1™ Summary

“The First Industry-Standard Storage Benchmark”

SPC Mission

The Storage Performance Council’s strategic objectives are: to empower storage vendors to build better products, and to stimulate the IT community to more rapidly trust and deploy multi-vendor storage networking technology. In support, the SPC is a non-profit corporation that defines, standardizes and promotes storage subsystem benchmarks as well as disseminates objective, relevant and verifiable performance data and related test tools to the computer industry and its customers.

SPC Objectives

The SPC’s tactical objectives are to provide IT consumers and integrators the first accurate database of performance and price/performance results spanning manufacturers, configurations and products. Additionally, the SPC provides new, powerful tools that, for the first time, allow anyone to thoroughly analyze and tune storage networks.

SPC-1 Workload Environment

SPC Benchmark-1 (SPC-1) is the first industry-standard storage benchmark and the first benchmark for Storage Area Networks (SANs). SPC-1 is designed to accurately demonstrate the performance and price/performance of either direct attach or network storage subsystems. SPC-1 is designed around server-class system environments while performing the functions of common business applications. The I/O workload in SPC-1 is characterized by predominately random I/O operations as typified by OLTP, database and email server applications. The SPC-1 random I/O workload will ultimately be applicable to most online enterprise-class storage environments. In general, the SPC has sought an implementation for the first benchmark that:

1. Provides a level playing field for diverse system platforms across manufacturers.
2. Is embraced by virtually the entire storage industry — thus, follows rigorous standards development practices.
3. Gives manufacturers, consumers, the analyst community, and the press results that are powerful and yet simple to use.
4. Provides value throughout the life cycle of a storage subsystem, the development of product requirements, product implementation, performance tuning, market positioning and purchasing evaluations.
5. Is easy to run, easy to audit/verify, and easy to use to report official results.

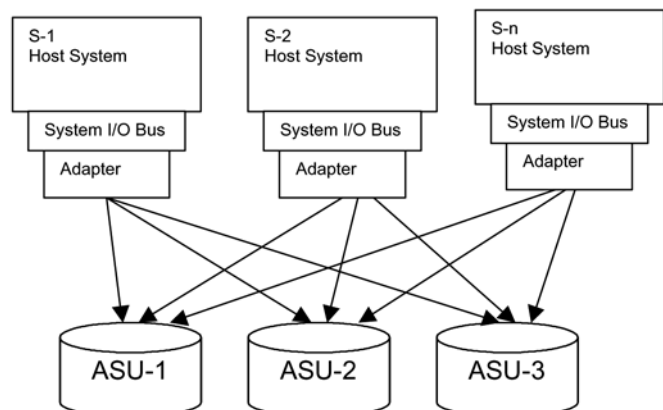
Benchmark Configuration Requirements

Virtually any storage subsystem configuration can be used to produce SPC-1 results, from a small set of JBOD disks to a large SAN composed of multiple multi-vendor array controllers, virtualization appliances and host computers. All storage configurations must provide:

- **Data Persistence:** Storage used in an SPC-1 test must demonstrate the ability to preserve data without corruption or loss. This “persistence” capability is defined as the ability to maintain data integrity across power outages as well as to ensure that the transfer of data occurs without corruption or loss. SPC-1 Test Sponsors are required to complete audited tests that demonstrate this capability.
- **Repeatability:** A benchmark configuration must demonstrate ability to reliably reproduce SPC-1 performance results across system restarts.
- **Sustainability:** A benchmark configuration must easily demonstrate that results can be consistently maintained over long periods of time as would be expected in system environments with demanding long-term I/O request throughput requirements.



Figure: Equal Access to the TSC



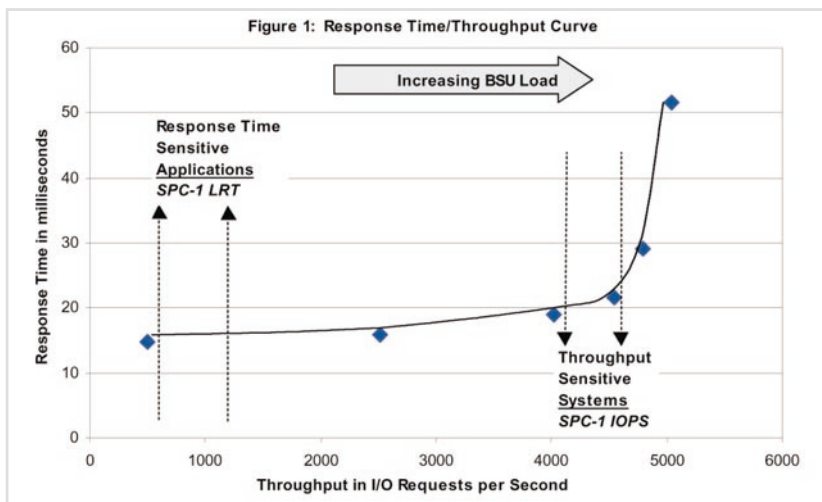
- **Equal Access to Host Systems:** All host systems used to impose benchmark related I/O load on the Tested Storage Configuration (TSC) must have equal access to all storage resources (called Application Storage Units or ASUs) as illustrated in the figure.
- **Support for General Purpose Applications:** SPC benchmarks provide objective, relevant and verifiable performance data. Specifically prohibited are benchmark systems whose primary purpose is the performance optimization of SPC benchmark results without any corresponding applicability to real-world applications and environments. In other words, all “benchmark specials” — implementations that improve benchmark results but not general, real-world applications performance — are prohibited.

Test sponsors must make a new storage subsystem broadly available for customer shipment within 60 days of reporting an SPC-1 result.

Benchmark Tests and Metrics

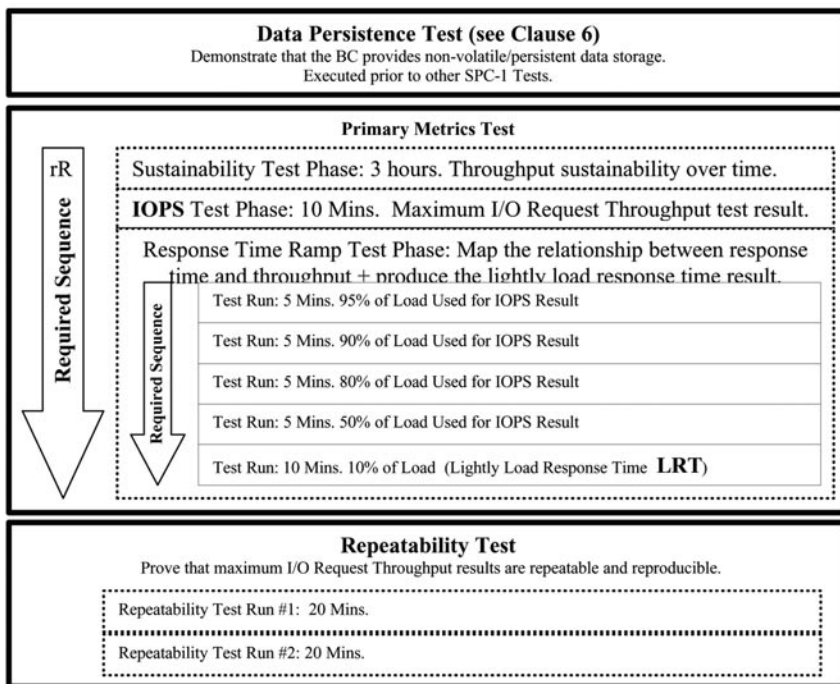
SPC-1 tests and resulting metrics are designed with an understanding that there are two classes of environments that are critically dependent on storage subsystem performance (see Figure 1).

The first environment is composed of *systems*, which have many users or many simultaneous application execution threads that can saturate the total I/O request processing potential (i.e., throughput) of a storage subsystem. An online transaction-processing system handling airline reservations is an example of such an environment. In this case, the success of the system rests on the ability of the storage subsystem to process large numbers of I/O requests while maintaining acceptable response times to the application(s) it supports. The maximum I/O request throughput capability of a storage subsystem in this environment will be documented by the SPC-1 IOPST[™] (I/Os Per Second) test and metric.



The second environment is composed of business-critical *applications* that are dependent upon minimizing wall clock completion time. These applications are sensitive to wall clock completion time as they issue thousands of serial I/O requests (one after the completion of another) in order to complete. An example of such an environment would be a large database rebuild operation. In this case, the success of the storage subsystem is dependent on its ability to minimize the response time for each I/O request and achieve significantly reduced wall clock completion time for the application. The ultimate capabilities of a storage subsystem to provide minimum I/O request response times in this environment is documented by the SPC-1 LRT[™] (Least Response Time) test and resulting metric.

A key primary metric for all benchmark runs is the capacity of the Tested Storage Configuration (TSC). This capacity is computed as storage addressable by host systems executing the benchmark and resources required to support the capacity (e.g., parity disks, hot spares, etc). Test sponsors must disclose the capacity of the tested storage configuration in conjunction with all SPC-1 IOPS and SPC-1 LRT metrics.

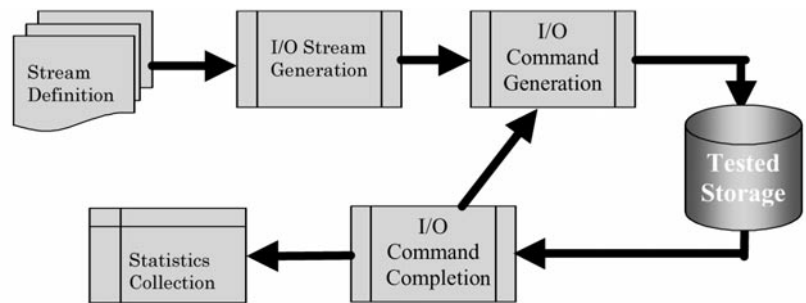


The diagram illustrates the series of tests required to complete an SPC-1 benchmark.

The reporting and promoting of SPC Benchmark-1 metrics are closely controlled. Each SPC-1 result is accompanied by a Full Disclosure Report (FDR) that details the environment and parameters used to produce the result, as well as the precise behavior of the solution tested. Published SPC-1 results must report the SPC-IOPS, SPC-1 LRT, capacity, type of data protection used for the TSC, and an audit certification identifier.

The Workload Generator

The SPC-supplied Workload Generator is run on one or more host systems that are part of the Benchmark Configuration and implements the SPC-1 Benchmark for the purpose of allowing test sponsors to produce results. As a user-space application, the Workload Generator exercises the addressable storage capacity in the TSC. The SPC licenses and supplies the Workload Generator to test sponsors in machine executable format. The implementation of the Workload Generator minimizes the number of host system instructions executed between start time and completion time stamps to increase benchmark efficiency and accuracy.

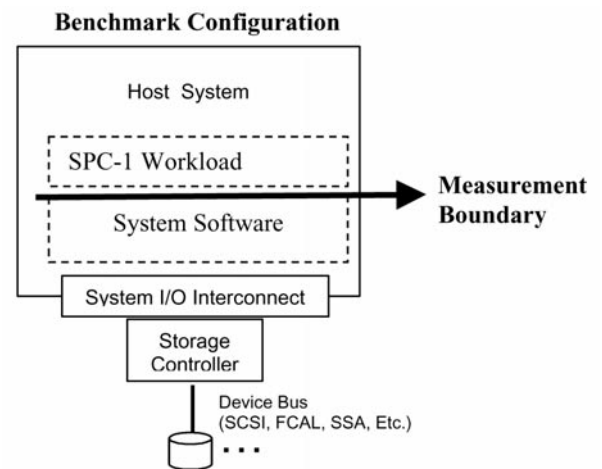


The Measurement Boundary for computing SPC-1 results within the hierarchy of software that defines a host system is outlined by the implementation of the SPC-1 Workload Generator. The Measurement Boundary occurs within specific modules of the Workload Generator where start times and completion times of I/O requests are recorded as illustrated by the figure.

Scaling the Workload

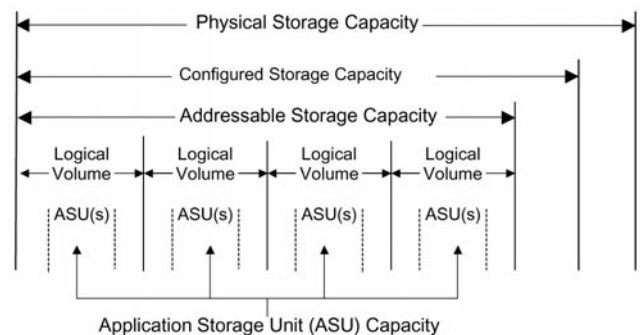
The SPC-1 benchmark synthesizes a community of users running against storage that is organized logically into the three separate ASUs as would be encountered in a real-world application. The assignment of each ASU in SPC-1 is as follows:

- **The Data Store** — ASU-1 holds system-level data and represents the area where the server initially stores, for example, incoming mail messages or transactions. As users read their mail, it may remain in the data store, be transferred to the user store or be deleted. Forty-five percent of the capacity of the Tested Storage Configuration (TSC) is contained in ASU-1.
- **The User Store** — ASU-2 holds user-level data and represents the area where, for example, users store their personal email or a transactions manager stores information persistently in a database. Forty-five percent of the capacity of the TSC is contained in ASU-2.
- **The Log** — ASU-3 contains the log files written by the server in the course of normal operations to provide durability in the event of system failure. Ten percent of the capacity of the TSC is contained in ASU-3



ASUs are distributed with a manufacturers' storage subsystem as in the diagram. A test sponsor must detail in the Full Disclosure Report for an SPC-1 results of the mapping of ASUs in Logical Volumes, Addressable Storage, Configured Storage and Physical Storage.

- **Physical Storage:** the formatted capacity of all storage devices physically present in the tested storage configuration.
- **Configured Storage:** all addressable storage capacity and any other storage devices or components of storage devices necessary to implement the addressable storage capacity described in Clause 2.4 (example: hot spares, parity disks, journal disks, log disks, etc.)
- **Addressable Storage Capacity:** the total storage that can be read and written by application programs on host systems, directly available for use by application programs that implement this benchmark, such as the Workload Generator.



Business Scaling Units (BSUs) represent the I/O load imposed by the application's user population against ASUs. Each BSU represents the aggregate I/O load created by a specified number of users. In the synthetic framework of the SPC-1 benchmark, one SPC-1 BSU corresponds to a community of users who collectively generate up to 50 I/Os per second. The throughput of 50 I/Os per second for one SPC-1 BSU represents a best case, in which no significant contention occurs for storage resources. The actual throughput obtained for any given number of SPC-1 BSUs depends on the unique characteristics of each TSC. To obtain greater I/O Request Throughput, the test sponsor will increase the number of BSUs presented by the Workload Generator to the TSC.

In SPC-1, test sponsors scale BSU load and ASU capacity independently, although a test sponsor will benefit in the market by driving both scaling factors to the highest level possible.

Results Validation

Vendors using the SPC-1 benchmark specification must successfully complete the SPC Result Validation process before results become official. Results validation is intended to certify that all the assertions made about SPC-1 results are authentic, accurate and in compliance with the benchmark specification. The SPC-1 Result Validation is composed of two required stages: Audit Certification and Peer Review. Vendors must complete both stages of result validation to become official.

1. An SPC auditor and the test sponsor attain Audit Certification through the execution of a precise audit protocol. For efficiency, Audit Certification will typically be performed remotely using automated tools but may, at the discretion of the auditor or the Test Sponsor, be performed on-site to ensure verification.
2. Peer Review occurs in a 60-day period after the public issuance of a benchmark result and related submission of a formal report, the Full Disclosure Report, that documents in detail the benchmark results. During Peer Review, benchmark results are subject to scrutiny and a compliance challenge from any member of the SPC. A result is considered validated and becomes official upon the completion of its 60-day Peer Review if no compliance challenges have been lodged against it, or if all compliance challenges have been dismissed prior to the completion of the review.



SPC Benchmark-1 Results

Official results are available at www.storageperformance.org.

Results Interpretation and Consulting

Preferred analysts of the SPC include: The Evaluator Group (www.evaluatorgroup.com) and Ideas International (www.ideasinternational.com). These firms are uniquely suited to provide a complete and timely analysis of SPC results as well as to ensure that IT consumers and integrators optimally configure storage subsystems.

SPC Benchmark-1 Test Kit

SPC-1 has been implemented in a robust and complete test kit that runs on a variety of host platforms and storage network topologies. See www.storageperformance.org for additional information.

General Purpose Testing/Analysis Tools

The SPC is constructing the most comprehensive and detailed set of stress-testing and performance-analysis tools on the market today. These tools are specifically designed to efficiently exercise and analyze large storage area networks and can also be used on smaller direct attach storage subsystems. See www.storageperformance.org to obtain a copy.

How to Produce and Publish Benchmark Results

To produce an SPC result, test sponsors should first contact the SPC to obtain the appropriate specifications, test kits, policies and procedures, and audit certification keys.

Service and Support

The SPC provides service and support to test sponsors who wish to produce results or use SPC test tools. Contact the SPC.

How to Join the SPC

A variety of membership classes exist to meet your needs. See www.storageperformance.org for a membership application and become part of the SPC revolution.

SPC Contact Information

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