Sun's Quality, Engineering, and Deployment (QED) Test Train Model

Testing Software Building Blocks to Drive Increased System Reliability

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As a trusted advisor, Sun wants to ensure that its products are fully tested not only as individual components, but also on a full range of hardware and with other software packages, including key third party packages.

Sun has long conducted a software testing program, known internally as the Solaris™ OE Train, to support each Solaris operating environment (Solaris OE) release and to drive higher software quality. This testing program has been recently expanded to include rigorous integration and interoperability testing of key third party software from VERITAS Software and Oracle Corporation, as well as Sun™ ONE software.

This white paper explains the why and how of Sun's integration and interoperability testing process known internally as the Solaris OE Train, which runs quarterly to test all new hardware and software product releases.

Background

Software integration and interoperability testing is an evolution of testing that validated the integrated image of VERITAS, Oracle, and Sun on a database configuration. That software stack is now configured to run on clusters, and includes the addition of the Sun ONE products. Clustering is accomplished using Sun Cluster software. The software test plan follows IEEE Standard 829 for test documentation.

Objectives

The primary purpose of the integration and interoperability testing is to test the co-existence and interaction of various software products in a single integrated system environment.

Scope of Testing

Validating that the integration and interoperability of various software applications can function and coexist in one environment. No functional or unit level testing is performed on individual software, hardware, or components. Testing ends when all test cases have been executed and the exit criteria are met.

Integration testing is the coexistence of two or more software applications working side by side in one system environment. The applications must not interfere with each others functions.

Interoperability testing is two or more software applications working together in one system environment. The applications are dependent upon one another to function properly.

The objectives of this testing are:

- Perform integration and interoperability testing in the combined VERITAS, Oracle, Sun Cluster, Sun ONE and Solaris operating environment.
- Run a set of system level test suites on specific configurations of machines.
- Validate multiple application availability in a clustered system environment.
- Validate Sun's Sun Cluster HA agent for Oracle with two different file management systems, VERITAS Volume Manager and the Solaris Volume Manager software. Validate the interoperability of the Oracle9*i* RAC software.
- Validate the Sun ONE products—Sun ONE Directory Server (Sun ONE DS), Sun ONE Application Server (Sun ONE AS), Sun ONE Calender Server (Sun ONE CS), Sun ONE Enterprise Server (Sun ONE ES), and Sun ONE Portal Server (Sun ONE PS), and look for any integration problems.

The integration and interoperability testing of a software stack includes, but is not limited to, the following software building blocks: Solaris, Sun Cluster, Oracle, VERITAS, and the Sun ONE suite of products, which include the Application Server (Sun ONE AS), Calendar Server (Sun ONE CS), Directory Server (Sun ONE DS), Messaging Server (Sun ONE MS), Portal Server (Sun ONE PS), and Enterprise Server (Sun ONE ES).

Functional Testing

New products are introduced to the Solaris OE Train for interoperability testing only after functional testing of the individual products is completed by the developers. As the Solaris OE Train moves along, new hardware and software components are introduced into the test process by the various business unit and development groups—Enterprise Server Product Group (ESPG), Work Group Server (WGS), Desktop Products (DT), Network Systems (NWS), Data Center High Performance Group (DHPG), VERITAS, Oracle, Sun ONE, Sun Clusters, and Network Appliance and Security Group ((NAS)–third party products).

The Test Process

FIGURE 1 shows a high level view of the Solaris OE Train test process used by Sun's Central Systems Test Quality Assurance (QA) group. TABLE 1 lists the test areas.

TABLE 1   Test Areas

Configuration	Tests hardware and software configurations.
Networking	Tests network components and software.
Operating Environment Regression	Performs regression testing on the Solaris operating environment.
Storage	Tests storage components and software.
Sun Clusters	Tests Sun Cluster software.

Integration and Interoperability Versus Functional Testing

The goal of integration and interoperability testing is to discover the incompatibilities described previously. Although it is not clear how much of a given application must be exercised to ensure complete integration coverage, the focus of this testing is to not duplicate any prior functional testing. Ideally, QA knows which functions result in communications external to the application and focuses testing on

those functions. Without this detailed knowledge, QA performs basic integration and interoperability tests by ensuring that the fundamental functions of an application execute properly.
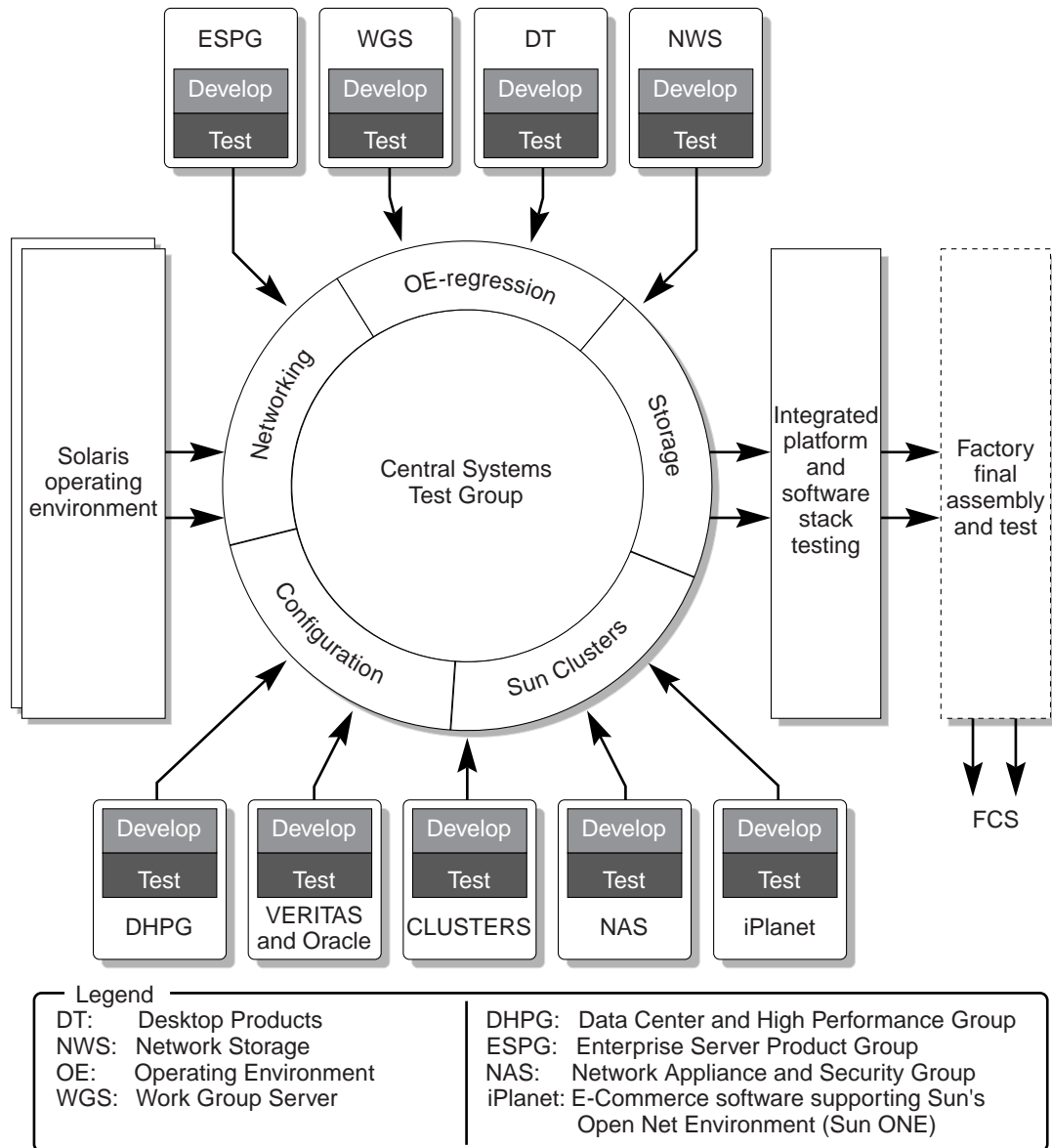
FIGURE 1   Solaris OE Train Testing Flow Diagram

Defect Management

All defects are entered into Sun's BugTraq+ tool. Weekly "bug court" reviews are held to assess the assigned defects priority and severity level, and to determine if a given defect must be fixed prior to the next release or by General Availability (GA). Any necessary corrections are integrated into a new build of the software stack for the next test cycle. After all planned tests are executed at least once on the current build, the integration and interoperability tests on the entire stack can begin. Tests are then run to verify each correction (defect correction verification) and appropriate regression testing is run, according to QA Engineering's discretion.

This cycle of test, bug fix, and build continues until the exit criteria have been met. the new build is turned over to the Software Stack Test Group by IPG Release Engineering.

Typical Solaris OE Train Build Schedule

FIGURE 2 shows a typical Solaris OE Train build schedule for Sun Cluster and software stack testing.
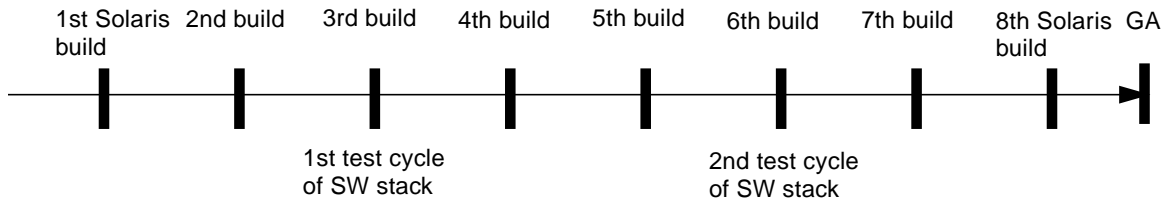
FIGURE 2   Typical Solaris OE Build Schedule

Testing Tasks

Most test procedures were created for previous releases of the software image included with fixed configuration platforms. Some were obtained from other groups. See each individual test procedure document for details. The following tests are run:

1. Hardware version audits and health check (SunVTS™)

2. Operation's installation tests (verify operation's procedure for installing the system)

3. System installation and configuration tests (per the platform installation guide)

4. Hardware and software acceptance tests (audits)

5. Basic Solaris operating environment test procedure

6. VERITAS Test Suite

7. Basic Oracle test procedure on HA

8. Basic Oracle test procedure on Oracle9*i* RAC

9. TPC test procedure

10. I/O fault tolerance tests

11. File system stress tests

12. VeritasTS test suite

13. Defect correction verification

14. Cluster tests, including failover scenarios for Oracle HA and Oracle9*i* RAC

15. Shutdown and resumption tests

TPC-C Testing

TPC-C validation is used for two reasons. First, this benchmark test performs both read/write operations. Second, this benchmark puts a good load on the system. This load is used as a background process while faults are injected in the foreground to ensure that the system remains operational and no date is lost or corrupted.

The TPC-C web page is `www.tpc.org/tpcc`.

VERITAS Test Suite

The VERITAS Test Suite performs the most common functions of the VERITAS file system and volume manager applications by exercising as much of the code as possible on different versions of the Solaris operating environment.

The main goal is to ensure that bug fixes or new features added to the kernel in new versions of the Solaris operating environment do not break the VERITAS products. The extent of the testing depends directly on the hardware provided in the test machine. Some tests are only performed if the required hardware is present.

Also, the test suite is self-contained. It can detect and configure the hardware present in the test machine and, with this information, configure the tests to run. Some of the tests are not started if the required hardware is missing. For example, a mirror across disk controllers can only be tested if the test machine has two controllers.

The VERITAS Test Suite provides the necessary functionality to test most of the common functions performed by a system administrator in charge of a Sun system running VERITAS software. This functionality includes:

- Creating and removing striped and concatenated volumes
- Creating and removing mirrors, RAID5 configurations
- Performing re-layouts on a live system
- Removing and replacing disks in a running system
- Growing and shrinking file systems
- Adding and removing disk quotas
- Mounting and unmounting the VERITAS File System (VxFS)
- Defragmenting file systems
- Taking snapshots of the file system
- Encapsulating root disk
- Creating a second boot disk.

During the test execution, simulations of disk usage and system load are run in parallel, thus adding extra reality to the tests. These simulations include:

- File system 80 percent full with one single large file.
- Multiple small files and directories.
- Number of files growing and shrinking during the test execution.
- Simulation of users accessing, reading, and writing files. This functionality of the test suite is not yet incorporated. It will be part of the planned second phase of Sun's work on the VERITAS Test Suite.

Sun ONE Software Testing

This testing validates the Sun ONE products (Sun ONE DS, Sun ONE AS, Sun ONE CS, Sun ONE ES and Sun ONE PS), and looks for any integration problems.

Sun ONE Directory Server (Sun ONE DS)

QA tests the Directory Server (Sun ONE DS) by testing other Sun ONE products that depend on it. These Sun ONE products are: Sun ONE AS and Sun ONE PS.

The Sun ONE DS tests are:

- Automatic functional tests (for example, schema creation, update, deletion, connectivity standards, SSL communication, and so forth)
- Automatic stress tests
- Testing Directory Server by testing other Sun ONE products that depend on it (Sun ONE AS. Sun ONE MS and Sun ONE PS).

Sun ONE Application Server (Sun ONE AS)

The Sun ONE AS uses:

- Sun ONE ES 6.0 SP1 as a front end
- Sun ONE Directory Server
- Oracle9*i* RAC (currently Oracle9*i*)

Currently QA performs the following tests on the Sun ONE AS:

- Automatic product installation and Solaris kernel tuning
- Sample application using Oracle9*i*
- Automatic functional test using a Java™ Technology Bookstore sample application
- Automatic stress test with load increase, monitoring system behavior and measuring time until system overloads

Future test software development:

- Functional tests
- Additional sample applications

Sun ONE Calendar Server (Sun ONE CS)

The currently tested version is 5.1. The Sun ONE CS uses the Sun ONE Directory Server.

Currently QA performs the following tests on the Sun ONE CS:

- Automatic installation of the Sun ONE DS and creation of the `calsrv` Lightweight Directory Application Protocol (LDAP) database via the `ldif` file
- Automatic functional tests as defined within the Sun ONE `calsrv` test plan

Future test software development:

- Administration tests
- Automatic user interface tests
- Stress tests (48 hour runs)

Sun ONE Enterprise Server (Sun ONE ES)

The currently tested version is 6.0 with Service Pack 2. The Sun ONE ES uses the Sun ONE DS.

Currently QA performs the following tests on the Sun ONE ES:

- Automatic product installation and configuration
- Automatic stress tests, monitoring system behavior and measuring time until the system overloads

Future test software development:

- Automatic functional tests

Sun ONE Portal Server (Sun ONE PS)

The currently tested version is Sun ONE PS 3.0 with Service Pack 4. The Sun ONE PS uses the Sun ONE ES and Sun ONE DS.

Currently QA performs the following tests on the Sun ONE PS:

- Automatic product installation
- Automatic functional testing of the `ipsadmin` command line interface, specifically:
  - Usage string
  - Domain creation, modification, and deletion using several right and wrong examples
  - Role creation, modification, and deletion using several right and wrong examples
  - User creation, modification, and deletion using several right and wrong examples

Future test software development:

- Test software for alternative configurations, for example, Open Portal, gateway on a separate machine and so forth.
- Automatic stress test

Future Development Plans Across All Test Suites

- Integration in a test harness so that tests can be run automatically as part of a test suite covering large software stacks
- Failure recovery tests on clusters as appropriate and needed; guided by Sun ONE and customer requirements

Hardware

As Sun hardware belongs to platform families, actual testing can be completed on a subset of hardware and extrapolated to the larger population of hardware in that platform. For example, QA tests a Sun Enterprise™ 6500 server; then these tests can be extrapolated to the Sun Enterprise 4500 server and the Sun Enterprise 3500 server. Different architectures (Sun Enterprise 6500 server versus Sun Fire™ 6800 server) cannot be extrapolated from one another. Using extrapolation, QA tries to cover all Sun platforms of hardware and storage by testing on a subset of products.

Once the QA group qualifies a particular product and it is released, the system is moved into the Solaris OE Train test area for compatibility testing of new Solaris operating environment and third party software releases.

Software

The integrated products of the Solaris 9 update 2 operating environment, Oracle9*i* RAC 9.0.1.2, VERITAS Volume Manager 3.1.1, Sun Cluster 3.0 update 1 software and Sun ONE products (Sun ONE DS, Sun ONE AS, Sun ONE CS, Sun ONE ES, and Sun ONE PS) running on various platforms.

Solaris 9 Update 2 Operating Environment

The Solaris 9 update 2 operating environment is acknowledged by the industry to be the premier UNIX® environment for SPARC® and Intel Architecture systems. This operating environment minimizes planned and unplanned downtime, reduces administration errors, and simplifies troubleshooting, which keeps mission-critical applications available and ensures high-speed, reliable access to data. Based on a smaller, more stable kernel, the Solaris platform delivers industry-leading load balancing across multiple processors.

To maximize uptime, the Solaris operating environment provides built-in features such as live upgrade, automatic dynamic reconfiguration, hot-swapping, hot diagnostics, dynamic system domains, IP network failover and balancing, UNIX file system logging, and remote console. These features enable maximization of uptime and increase availability of services.

As with previous versions, the modular construction of the Solaris 9 update 2 operating environment allows installation of new feature updates as they become available—while applications continue to run. Updates can be installed on a separate partition from the currently running environment. When installation is complete, a simple reboot enables the new version to take control. This reduces the amount of planned downtime needed and significantly decreases risk—because the older version is just a reboot away.

Oracle9*i* Real Application Clusters

The Oracle9*i* Real Application Clusters (Oracle9*i* RAC) database system allows two or more cluster nodes to simultaneously perform transactions against a single database. These nodes can operate in two modes—*active-active* and *active-passive*.

Active-active is a type of architecture in which multiple nodes synchronize their accesses to database objects.

Active-passive or primary-secondary is a type of architecture in which one node performs work against the database while a second node stands by, ready to take over processing if the first node fails.

The Oracle9*i* RAC uses a shared disk architecture so each node in the cluster has direct access to the shared disks. All database instances access the data files and control files.

VERITAS Volume Manager

VERITAS Volume Manager (VxVM) is an enterprise-level, online storage management tool that provides flexible storage configuration and powerful, reliable performance. Volume Manager removes the physical limitations of disk storage, so you can configure, share, and manage storage without interrupting data availability.

Sun Cluster 3.0

The Sun Cluster 3.0 update 1 software increases the availability and capacity of the Solaris operating environment by enabling core services, such as devices, file systems, and networks, to operate seamlessly across a cluster. Sun Cluster 3.0 is integral to the SunPlex™ framework, which is an end-to-end, fully integrated application service delivery solution for tightly-coupled environments that also includes servers, storage, interconnects, the Solaris operating environment, applications, and support. Within the Sun Cluster environment, both failover and scalable services help manage and maintain service levels.

Nodes in a cluster can be used to automatically recover failed services, or dynamically add scalable services anywhere in the cluster to increase capacity. These capabilities are key to increasing delivered service levels, while decreasing costs and reducing administrative risk.

VERITAS File System

VxFS is a powerful, quick-recovery, journaling file system that provides the high performance and easy management required by mission critical applications. It delivers scalable performance and provides continuous availability, increased I/O, and up-to-date structural integrity. VxFS also provides extremely fast recovery following a system crash or reboot, reducing unplanned downtime. Compatible with any disk storage hardware platform, VxFS supports online backup, resizing, and defragmentation without interrupting data access.

Sun ONE

The Sun ONE™ products are the Sun ONE AS, Sun ONE CS, Sun ONE DS, Sun ONE MS, Sun ONE PS, and Sun ONE ES.

Application Server

The Sun ONE AS provides a robust Java™ 2 Platform, Enterprise Edition (J2EE™) e-commerce platform for delivering innovative and leading-edge application services to a broad range of servers, clients and devices.

Calender Server

The Sun ONE CS enables customers to deploy customized calendar and planning solutions to share up-to-date, real-time information.

Directory Server (Sun Cluster 3.0 Support)

The Sun ONE DS delivers a user-management infrastructure for enterprises that manage high volumes of information for partners, customers, suppliers, and others. It integrates with existing systems and acts as a central repository for the consolidation of user profiles.

Enterprise Server

A key component of the Sun ONE Intelligent Communications Platform, the Sun ONE MS provides a highly scalable, reliable Web-based solution for communications and messaging.

Portal Server

The Sun ONE PS provides all of the membership management, personalization, aggregation, security, and integration services needed to quickly deploy e-commerce portals.

Messaging Server (Sun Cluster 3.0 Support)

The Sun ONE MS combines industrial strength reliability, performance, and security with the ability to deliver dynamic, personalized content, in an easy-to-manage environment enabling worry-free deployment of e-commerce sites.

Sun's Sun Cluster HA Agent for Oracle Versus Oracle9*i* RAC

The Sun Cluster HA agent for Oracle is configured specifically for Oracle. This agent monitors the health of its target application. If the active application fails, the agent starts the application on the surviving node. This provides a hot backup capability rather than parallel operation.

The HA configuration can use Solstice DiskSuite™ software or the VERITAS Volume Manager.

Oracle9*i* RAC runs concurrently on both cluster nodes. A failure on one node causes sessions to be transferred to the surviving node. The Oracle9*i* RAC software only supports the use of the VERITAS Volume Manager (VxVM).

This results in three configuration options for Oracle:

1. HA with VxVM

2. HA with Solstice DiskSuite software

3. Oracle9*i* RAC with VxVM only

Software Testing

Software Stack

The following tests are performed on the software stack:

■ Basic database tests

■ Database-centric software fault injection tests

■ Database and cluster-centric hardware fault injection tests

■ VERITAS VxVM/Sun Cluster software fault injection test cases

Basic Database Test Cases

The basic database test cases are:

1. Create and layout storage volumes

2. Install and configure Oracle9*i* RAC software

3. Create TPC-C database. [size will vary]

4. Tune TPC-C database for optimal performance

Database-Centric Software Fault Injection Test Cases

The database-centric test cases are:

1. Kill Oracle DLM process (`dlmd`) on one cluster node

2. Kill Oracle `ucmmd` process on one cluster node

3. Kill Oracle DLM monitor process (`dlmmon`) on one node

4. Halt node while Oracle instance is running by using the `send brk` command

5. Kill `rgmd` on one node

6. Kill Oracle `idlm` (`lmon`, `lmd0`, or `lck0`) process on one node.

The test software automatically verifies that the system reacts to each of these six steps as expected.

Database and Cluster-Centric Hardware Fault Injection Test Cases

The database and cluster-centric hardware fault injection test cases are:

1. Single private interconnect failure

2. Split brain; failure of all private interconnects

VERITAS VxVM/Sun Cluster Fault Injection Test Cases

The VERITAS VxVM/Sun Cluster fault injection test cases are:

1. Failure of single disk drive in RAID 1+0 volume

2. Root mirror disk drive pull of one node

3. Grow and shrink VERITAS volumes without disrupting TPC-C benchmark

4. Detach and re-attach plex(es)

Sun ONE Load and Stress Test Case

The Sun ONE loader test case is:

Sun ONE AS loader test suite

Configurations

The standard configurations are:

Single Node
- Sun Enterprise 420R Server with Sun StorEdge™ T3 array
- Sun Enterprise 4500 Server with Sun StorEdge T3 array
- Sun Enterprise 6500 Server with Sun StorEdge A5200 array

Cluster Nodes

Sun Fire 280R Server with Sun StorEdge T3 array

Future Plans

In the future, QA will expand its testing to include more clustered systems, including four-node cluster platforms. Testing will be expanded to include Sun's newly released hardware and software shortly after it becomes available. Manufacturing will also implement a test process to test the final assembly on the manufacturing floor before shipment to the customer for customization of the cluster at the customer's site. Customers will be offered more flexibility in selecting and having Sun test and integrate the exact hardware and software they need to meet their business needs as Sun's Customer Ready Systems program continues to grow its capabilities.

The testing process will also be automated, with QA moving from running the Solaris operating environment, Oracle, VERITAS and Sun ONE software in separate batches as a single integrated system to testing all packages in one batch process, driven by a common test harness, encompassing Sun ONE and failure recovery test suites and interoperability testing.

QA plans to use a test suite developed around a "real life" application later this year. It will be based on Sun's translation database, which contains translations of Solaris software and documentation in various languages, and is used to minimize localization cost and turnaround time. It will exercise several Sun ONE components of the stack, as well as Oracle, VERITAS, Sun Cluster and the Solaris operating environment.

Updated versions of this white paper will be developed after major improvements become available.