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Oracle Solaris 11 Express: What's New for Application Developers

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Introduction

Streamlining the development process for enterprise applications is key to business success. To be as productive as possible, enterprise developers need an integrated environment that lets them work on tasks concurrently, collaborate with other developers, and create optimized and parallelized applications in less time. Yet no application is perfect. Studies show that the earlier a software defect is found in the development cycle, the less time consuming and expensive it is to fix. As a result, sophisticated debugging and analysis tools that enable the construction of quality solutions are a must for enterprise developers.

For over two decades, Oracle Solaris has been the platform of choice for enterprise developers. Providing a rich environment for the creation and deployment of strategic enterprise applications, Oracle Solaris combines key computing elements—operating system, networking, storage management, and user environment—into a stable, high-quality foundation that developers can depend on when creating solutions. Many innovations, including built-in virtualization technology, broad hardware applicability, massive scalability, rich security capabilities, debugging and analysis tools and more, made Oracle Solaris 10 the mission-critical operating system.

Now Oracle Solaris 11 raises the bar on the innovation introduced in Oracle Solaris 10. A wide range of built-in features and unbundled tools are designed to help developers create higher performing applications in less time and with less risk. Providing the first fully virtualized operating system and including over 2,700 projects, 400 inventions, and support for over 11,000 applications, Oracle Solaris 11 provides the foundation of Oracle's complete applications-to-disk technology stack and a strategic platform for application developers.

To allow developers to transition smoothly to Oracle Solaris 11, Oracle is releasing Oracle Solaris 11 Express—a production-quality, fully supported release that allows developers to create applications with confidence while learning specific advantages behind its new features. With these tools, developers can optimize the application development process, simplify testing and deployment, create optimized virtual environments, and secure applications, services, and systems.

Note: A newer version of this article for Oracle Solaris 11 is available at www.oracle.com/technetwork/server-storage/solarisstudio/documentation/o11-156-s11-app-dev-new-1414087.pdf.

What's New in Oracle Solaris 11 Express

A key design goal of Oracle Solaris 11 Express is to incorporate technology enhancements and ensure binary compatibility so that developers can create and deploy reliable application stacks with greater efficiency. These advancements come together in a single, integrated platform that developers can use to create and test applications, as well as model production environments. This release adds new functionality and streamlines common software management tasks, with specific enhancements in the following areas (Figure 1).



Figure 1. Oracle Solaris 11 Express builds on the four pillars underpinning Oracle Solaris 10: scalability, efficiency, security, and availability.

- **Scalability.** Oracle Solaris 11 Express continues to keep pace with hardware advancements. Support for thousands of threads, terabytes of memory, and hundreds of Gbps of network bandwidth is seamless through APIs that remain consistent from one version of the operating system to the next. In addition, virtualized storage and networking enhancements make it possible for enterprise developers to create and deploy applications that can take advantage of massive scalability to support growing data sets and deliver application throughput.
- **Efficiency.** Oracle Solaris 11 Express is a completely virtualized operating environment, with technologies that span network, storage, and server virtualization to support consolidation initiatives effectively. A gradual migration path to Oracle Solaris 11 Express exists by running applications within Oracle Solaris Containers to help developers move to Oracle Solaris 11 without disrupting existing tools and environments. In addition, a new software packaging model takes the guesswork out of figuring out which operating system patches need to be bundled with applications, easing the move to production environments and creating more reliable application stacks.
- **Security.** Providing a fully secure-by-default environment, Oracle Solaris 11 Express advances data and system security with on-disk Oracle Solaris ZFS encryption, delegated zone administration, and certification of the operating system at boot time. In addition, Oracle Solaris 11 Express includes enhancements to the Oracle Solaris Cryptographic Framework—a unified interface for encryption services that supports built-in software encryption algorithms as well as the automatic offloading of operations to hardware-based cryptographic accelerators.
- **Availability.** Oracle continues to expand the Service Management Facility and Fault Management Architecture to increase the availability of services. Oracle Solaris 11 Express incorporates significant enhancements to these technologies. In addition, tools are included to clone and roll back to a previous snapshot of a boot environment, enabling safe upgrade.

By releasing Oracle Solaris 11 Express, Oracle paves the way for developers to transition to Oracle Solaris 11. Combined with Oracle Solaris Studio, Oracle Solaris 11 Express gives developers access to the latest innovations while delivering the advanced and integrated environment they have come to depend on from the leader in enterprise applications. This white paper provides a survey of the new features in Oracle Solaris 11 Express that can help developers optimize the application development process, as well as references to more detailed information.

Streamline the Application Development Process

Coding and testing applications is a time-consuming and often complex process. While individual point products can help with certain tasks, building applications with an integrated platform designed for all of the pieces to work together streamlines workflow and results in more robust applications. Oracle Solaris 11 Express supports a rich set of tools for optimizing the development process.

Oracle Solaris Studio

Oracle Solaris Studio provides developers with everything needed to create high-quality, cross-platform desktop, enterprise, and Web applications. An integrated development environment optimizes the application development process, from creating and building C, C++, Java™, or Fortran applications, to debugging problems and tuning for optimal performance. By integrating all the steps programmers take—from GUI design and code generation, to edit-compile-debug-tune cycles—the Oracle Solaris Studio integrated development environment (IDE) makes it easy to rapidly build applications.

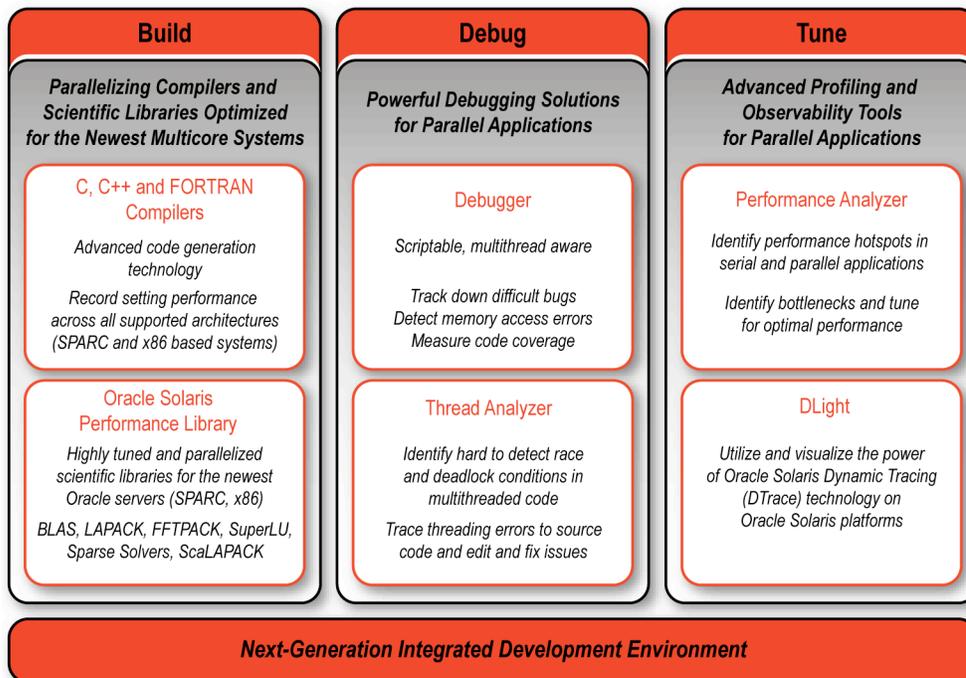


Figure 2. The Oracle Solaris Studio IDE integrates advanced tools and helps streamline the development process.

Build Applications

Oracle Solaris Studio provides the tools needed to build enterprise applications faster.

- **Gain efficiency with an integrated environment.** All tools in the Oracle Solaris Studio suite—compilers, debuggers, code coverage tools and more—come together in the IDE to provide an optimized development platform for the end-to-end process of building, debugging, analyzing, and tuning single-threaded and multithreaded applications. Developers can exploit platform functionality while accelerating and simplifying the process of application development.
- **Build better and faster applications with sophisticated C, C++, and Fortran compilers.** Currently a leader among IDEs in multithreading development, Oracle Solaris Studio offers high-performance parallelizing compilers that are tuned for Oracle Solaris 11 Express and underlying hardware, resulting in the best overall development platform for Oracle systems. Indeed, the record-setting application performance of Oracle Solaris Studio C, C++, and Fortran compilers consistently exceeds the performance of open-source alternatives.
- **Take advantage of the best platform for developing Java applications.** Oracle Solaris 11 Express helps Java developers create applications with superior performance, scalability, and security. By combining Java and Oracle Solaris, enterprise developers can take advantage of superior out-of-the-box performance, high-quality virtual machine implementations, and innovative tools designed to simplify Java code debugging and performance tuning tasks. More information can be found in *Oracle Solaris: The Platform of Choice for Java Application Development and Deployment*, located at <http://www.oracle.com/technetwork/articles/servers-storage-dev/solarisforjavadevelop-168642.pdf>.
- **Create cross-platform applications.** Oracle Solaris Studio compilers provide a solid foundation for building robust, high-performance, parallel code for Oracle systems with single or multicore SPARC®, x64, and x86 processors. Utilizing the extensive set of 32- and 64-bit options available in the Oracle Solaris Studio compilers, applications can be built to meet a broad range of needs. For instance, an application can be compiled to provide reasonable performance on any SPARC processor, resulting in a single application binary for all Oracle systems with SPARC processors.

Alternatively, developers can compile the same application to run with maximum performance by using different compiler options to take advantage of features found in the latest 64-bit UltraSPARC® processor. This is accomplished by specifying the type of processor to be used so that the compilers can generate code optimized for different processor instruction sets. As a result, the same application source code can be used to create optimized application binaries for each SPARC architecture, maximizing performance across the entire SPARC product line.

Debug Applications

Oracle Solaris Studio provides powerful debugging solutions for single-threaded and multithreaded application development.

- **Find problems faster.** Multithreaded programs running on multicore servers can turn debugging into a labor-intensive and time-consuming endeavor. Oracle Solaris Studio tools address some of the most difficult aspects of application development. The Sun Memory Error Discovery Tool (Discover) is an advanced development tool for detecting memory access errors during program execution. Two powerful debugging options, `dbx` and `dbxtool`, provide time-tested, interactive debugging facilities that let developers run programs in a controlled fashion and inspect the state of stopped programs. In addition, a Thread Analyzer helps identify common—yet notoriously difficult to debug—issues in multithreaded code, including deadlock and data race conditions.
- **Measure code coverage.** The Code Coverage Tool (Uncover) helps developers measure the code coverage of applications. Developers can determine which areas of source code are being exercised during testing. Armed with that knowledge, programmers can make improvements in test suites to test greater portions of code more effectively.

Tune Applications

Built-in advanced profiling and observability tools make it easier to identify performance hotspots in serial and parallel applications, and visualize application behavior.

- **Understand application behavior.** Developers meet with many different challenges when attempting to determine why an application is performing in a certain way. Oracle Solaris Studio contains tools for analyzing applications at the thread level to full-scale performance analysis. The Oracle Solaris Studio Performance Analyzer contains tools to assess the performance of application code, identify potential performance problems, and locate the part of the code where the problems occur. The Performance Analyzer offers support for MPI applications as well as zooming and filtering capabilities. A Collector tool gathers performance data by tracing function calls and collecting profiling data for applications written in the Java™ programming language, including clock-based profiling data, hardware counter overflow profiling data, synchronization wait tracing data, heap tracing data, and more. The Oracle Solaris Studio Performance Analyzer displays the data recorded by the Collector, processes the data, and displays various metrics of performance at the program, function, source line, and instruction level.
- **Unify application and system profiling.** System profiling tools allow developers to explore systems to understand how they work, identify performance problems across many software layers, and pinpoint the source of aberrant system or application behavior. DLight is a new GUI tool with a simple drag-and-drop interface that unifies application and system profiling using Oracle Solaris Dynamic Tracing (DTrace) technology on Oracle Solaris platforms. With Dlight, developers gain a new and unique level of visibility into the behavior of user programs and the operating system.

More information on Oracle Solaris Studio can be found in the Oracle Solaris Studio 12.2 collection located at <http://docs.sun.com/app/docs/prod/stud.12~771.10-bic>.

Other Built-in Tools

Oracle Solaris 11 Express includes a wide range of other tools that facilitate application development, including open-source scripting languages and shells.

- **Other programming languages.** Oracle Solaris 11 Express now includes Python and Ruby for high-level application development. These tools are integrated with DTrace, Oracle Solaris analysis tools, and the new Image Packaging System to ease the debug process and simplify the task of finding the right versions of software.
- **Powerful scripting.** Oracle Solaris 11 Express includes the popular Perl language, providing developers with powerful scripting capabilities and text processing facilities.
- **A new default system shell.** For years, the Korn shell (**ksh**) was the default shell environment in Oracle Solaris. With Oracle Solaris 11 Express, **ksh** is superseded by **ksh93**, an updated and improved version of the popular system shell. Note that the *.kshrc* file is read in addition to the *.profile* file when the **ENV** environment variable is not set.
- **A new default interactive shell.** To ease familiarity with other operating systems, Oracle Solaris 11 Express uses the Bourne-again shell (**bash**) as the default interactive shell for users. When used as a login shell, **bash** finds the first instance of a *.bash_profile*, *.bash_login*, or *.profile* file that exists and uses that configuration information. When a non-login interactive shell is used, the *.bashrc* file is read instead. When a non-interactive shell is used, **bash** uses the **\$BASH_ENV** environment variable setting. More information on **bash** can be found in the **bash(1)** man page.
- **Environment variable and path enhancements.** The default path now lists */usr/gnu/bin* before */usr/bin*, giving developers a GNU-like environment by default. In addition, the **MANPATH** environment variable no longer is required. The **man(1)** command determines the appropriate **MANPATH** based on the **\$PATH** environment variable setting. Note that **MANPATH** can be set, however it usually is not necessary to override automatic handling. Finally, files previous located in the */usr/sfw* directory now are located in the */usr/bin* directory. Links exist so that either path is valid, however developers can simplify path settings to use the new location.

More information can be found on the Oracle Solaris 11 Express Web page located at <http://www.oracle.com/technetwork/server-storage/solaris11/overview/index.html>

Multimedia Application Support

Working in a multimedia environment enhances the development process. Oracle Solaris 11 Express includes a new sound system and framework for supporting current and future generation multimedia audio applications and devices. Key components include:

- Expanded device and platform support for audio, including Via 82C686, Creative Sound Blaster Audigy LS, Creative SBP16X, ESS Technology Solo-1 AudioDrive PCI, and Creative EMU10K audio devices
- Inclusion of the popular Open Sound System API
- Introduction of a new interface for audio device drivers that makes the creation of new, and porting of existing, device drivers a modest effort

Simplify Application Testing

Testing applications is a critical step in the development process. Oracle Solaris 11 Express includes several features that help developers validate that applications work in multiple operating environments, and find and fix problems faster.

Replicate Development, Test, and Production Environments

Creating identical instances for development, test, and production environments is a time-consuming process that is prone to error. Applications need to be able to move throughout the build, test, and deploy chain in a timely manner. With Oracle Solaris Containers and Oracle Solaris ZFS, applications can be developed in an isolated environment, cloned, and packaged for movement to testing systems (Figure 3). Pre-built, pre-configured, pre-patched virtual environments and their application stacks are replicated on new machines. Shared storage makes it possible for the transition to happen quickly, and applications do not need to be duplicated. Once tested, applications can be moved quickly to production systems. With these capabilities, organizations can experience rapid roll out of applications, little downtime, and automatic roll back to development and testing systems when needed.

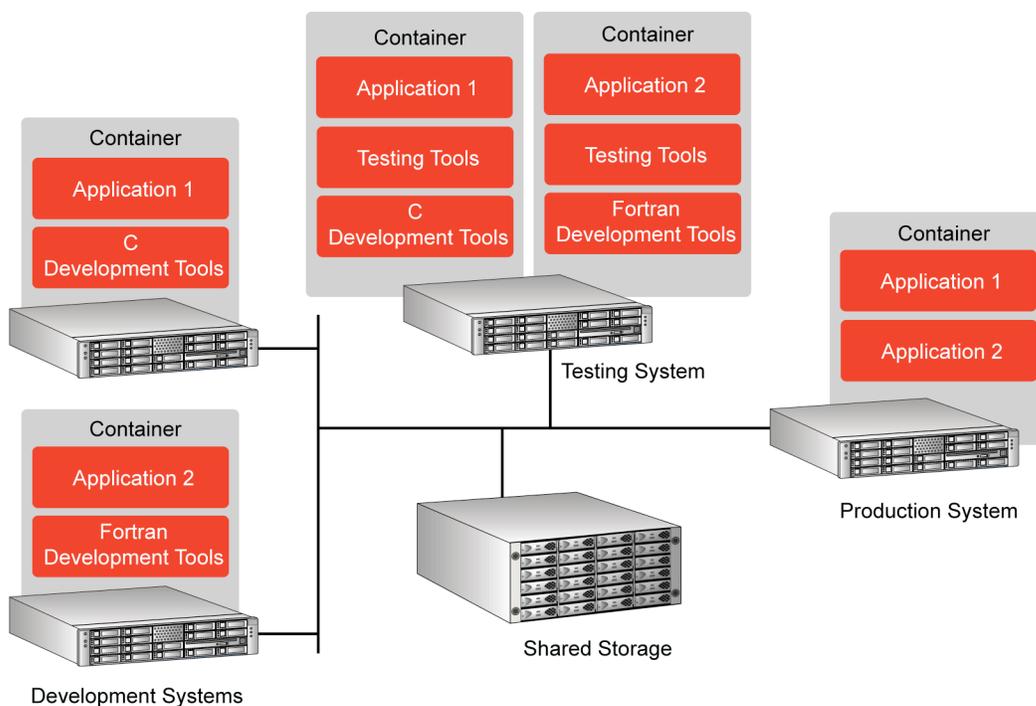


Figure 3. Oracle Solaris Containers facilitate the movement of entire application stacks between systems

More information on Oracle Solaris Containers can be found in the *Resource Management and Oracle Solaris Zones Developer's Guide* located at <http://docs.sun.com/app/docs/doc/821-1499>.

Validate Application Behavior on Multiple Environments

Developers and quality assurance teams need to test applications on multiple systems, each running a different operating system or patch level. Using Oracle Solaris Containers, developers can run multiple environments on a single server running Oracle Solaris 11 Express (Figure 4). In this solution, the server is divided into distinct areas that each run an operating system in an isolated application execution environment at the same time on the same system. Each container provides the functionality of previous-generation operating systems, as well as any application software, and can take advantage of the resources and services provided by the underlying hardware in order to complete tasks. As a result, the specific configuration needs of applications under test can be addressed individually. In fact, different versions or patch levels of an operating system can be hosted on the system, giving each application access to the specific operating system features needed.

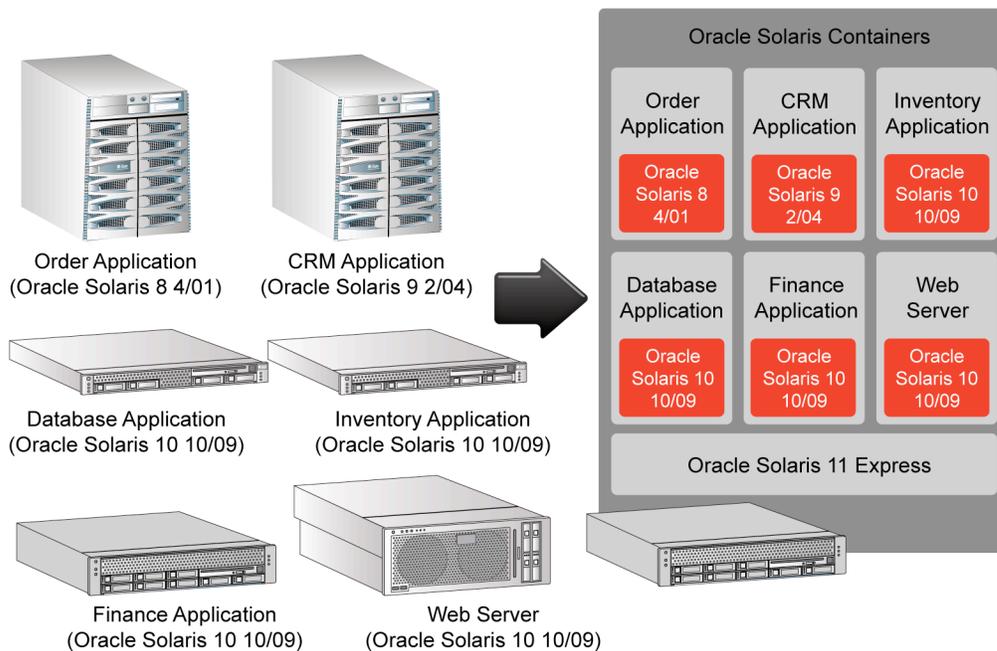


Figure 4. Developers can run multiple operating systems versions on Oracle Solaris 11 Express.

More information on Oracle Solaris Containers can be found in the *System Administration Guide: Oracle Solaris Zones, Oracle Solaris 10 Containers, and Resource Management*.

Migrate Oracle Solaris 10 Applications to Oracle Solaris 11 Express with Ease

While the binary compatibility of Oracle Solaris helps ensure applications simply run from one release to another, there may be times when having a complete runtime environment for Oracle Solaris 10 applications is needed. Oracle Solaris 10 Containers can host Oracle Solaris 10 10/09 and later environments on SPARC, x86, or x64 servers running Oracle Solaris 11 Express. Built-in tools enable the migration of an existing physical Oracle Solaris 10 system into a virtual environment on the target system, or the migration of a virtualized Oracle Solaris 10 environment, facilitating the immediate adoption of Oracle Solaris 11 Express.

Information on Oracle Solaris Containers can be found in the *System Administration Guide: Oracle Solaris Zones, Oracle Solaris 10 Containers, and Resource Management* at <http://docs.sun.com/app/docs/doc/821-1460>.

Observe Application Behavior and Diagnose Faults

Enterprise applications are sophisticated and complex, often consisting of multiple pieces of software that interact with one another to deliver needed functionality. With software components spread across multiple systems, isolating problems can be difficult. In addition, traditional tools make it impossible for developers to debug live production environments without affecting performance, and entire production environments cannot be replicated due to their size and complexity. The Dynamic Tracing (DTrace) facility in Oracle Solaris 11 Express lets enterprise developers turn a production deployment environment into a debug environment—without impacting user access or application performance.

DTrace is a dynamic tracing framework that provides top-to-bottom system observability for troubleshooting systemic problems in real time. Designed to quickly identify the root cause of system performance problems, DTrace combines over a hundred thousand trace points with a powerful scripting language and a simple, interactive command-line interface. It works by safely and dynamically instrumenting the running operating system kernel and applications with trace points that are completely passive until enabled. These trace points can be enabled quickly for data collection, and then disabled again to minimize performance impacts on the system being examined. With this information, developers can rapidly observe production environments, identify performance bottlenecks, and troubleshoot issues in a secure and safe manner.

- **Ease application observation.** Observing applications in production environments often is disruptive. Indeed, many tools that are typically used to observe applications cannot be used on production systems. Unlike traditional debug flags that must be turned on when applications are started, the dynamic nature of DTrace makes it possible to turn debug flags on and off at runtime. With DTrace, developers can turn on select probes or scripts only when needed, eliminating diagnostic overhead when disabled.
- **Support QA testing efforts.** Error induction and code coverage testing is expensive to conduct. DTrace scripts can help QA engineers evaluate code coverage rates. In addition, DTrace provides mechanisms for introducing errors to see how systems behave under adverse conditions. For example, the `chill` action can be used to introduce race conditions, and the `copyout` action can be used to modify variables at runtime.

- **Observe all levels of the technology stack.** Unlike tools that focus on specific debugging tasks or application layers, DTrace provides a single tool for observing all levels of the technology stack. For example, device driver developers can use the anonymous tracing feature in DTrace to observe the boot phase, and telemetry can be collected for system management applications. In addition, DTrace includes pre-built instrumentation for I/O scheduling, signals, networks, iSCSI communication, and applications written in C, C++, Java, Ruby, PHP, Perl, and more.
- **Instrument Java code.** While DTrace includes embedded probes for C and C++ applications, scripts must be used for Java applications. Alternatively, an additional tool can be used to dynamically trace running Java programs. BTrace dynamically instruments target application classes to inject tracing code. Now BTrace and DTrace can be used together to embed DTrace probes in Java applications. The framework creates and compiles a BTrace script and embeds it in Java code.
- **Take advantage of new providers and probes.** A number of new DTrace providers and probes are included in Oracle Solaris 11 Express.
 - A `cpc` provider, for connecting CPU events, such as TLB or L2 cache misses, to the cause of the event on a system-wide basis
 - New `tcp`, `udp`, and `ip` providers, for tracing the TCP, UDP, and IPv4/IPv6 network protocols
 - An `iscsi` provider, for tracing iSCSI activity
 - PHP and MySQL probes

More information on DTrace can be found in the following documents.

- *How to Use Oracle Solaris DTrace* located at <http://www.oracle.com/technetwork/server-storage/solaris/solaris-dtrace-mp-167895.pdf>
- *Using DTrace with Sun Studio Tools to Understand, Analyze, Debug, and Enhance Complex Applications*, located at <http://dlc.sun.com/pdf/820-4221/820-4221.pdf>

Find and Understand Faults Faster

As applications gain in complexity, analyzing error conditions becomes increasingly complicated. Developers understand that finding and fixing faults quickly can alleviate resulting side effects. Oracle Solaris 11 Express includes a framework for a decision system that can analyze, report, and if possible, work around faults automatically. The Service Management Facility (SMF) provides the ability to view system-wide service status, manage services and their dependencies, and automatically restore services when a failure occurs. The Fault Management Architecture (FMA) enables systems to automatically monitor, report, and recover from hardware errors to maintain data integrity and keep mission-critical applications and services online. Together, these tools can help developers to find and fix faults faster.

Significant improvements have been made to the Service Management Facility and Fault Management Architecture in Oracle Solaris 11 Express.

- Developers can be notified of service state transitions and fault management events via SNMP traps or email messages.
- With the introduction of new installation and packaging technologies, SMF enhanced profiles have been leveraged as the primary system configuration mechanism in Oracle Solaris 11 Express as a way of configuring the system post installation.
- FMA reports errors in a standard format that can be analyzed. Root cause can be determined in an automatic way and reported in readable and actionable formats. In addition, Oracle continues to integrate FMA with new hardware features as they are released.

Several best practices can help developers move applications to the SMF and FMA framework.

- Eliminate custom scripts that analyze application health and restart applications. SMF provides a simple way to encapsulate and standardize the methods for starting, stopping, and restarting applications.
- Make applications SMF aware during initial development, if possible. Identify fault states and create a fault tree. Review error messages and determine if they can become FMA events.
- Convert *.rc* scripts to SMF profiles.
- Convert custom scripts to SMF profiles. Look for instances of start method, stop method, and check status method. Once these areas are converted, migrating the remainder of the script typically is straightforward.
- Use privileges with SMF to minimize security exposure. Be sure to release the privileges after the SUID process starts.

Detailed information on SMF and FMA can be found in the following documents.

- *Using the Service Management Facility*, a worked example, located at <http://www.oracle.com/technetwork/systems/articles/smf-example-jsp-136458.html>
- *How to Create an Oracle Solaris Service Management Facility Manifest*, located at <http://www.oracle.com/technetwork/server-storage/solaris/solaris-smf-manifest-wp-167902.pdf>

Improve System and Application Deployment

Oracle Solaris 11 Express introduces a completely new software installation and deployment architecture that makes it easier for developers to create deployment environments and manage the software lifecycle.

Updated Installation and Configuration Programs

Oracle Solaris 11 Express provides updated installation and configuration programs—from interactive interfaces to full automation—to give developers the right amount of control when preparing systems.

- **Automated installer.** The automated installer makes it possible to apply an Oracle Solaris 11 Express installation to multiple systems. Developers can quickly create an installation service that lets systems look for, locate, and install a manifest that matches specifications. The automated install images are bootable, providing an easy way of installing Oracle Solaris 11 Express on SPARC and x86 systems without the need to set up a server with an active install service. Simply boot off a CD, point the system at an install manifest (or default to the one included in the media) and watch while the system automatically installs over the network. With this tool, developers can replicate operating environments on systems to speed the application testing and deployment process. See the *Oracle Solaris 11 Express Automated Installer Guide* located at <http://docs.sun.com/app/docs/doc/820-6566> for more details.
- **Distribution Constructor.** The distribution constructor is a new command-line tool for building pre-configured, bootable Oracle Solaris 11 Express images that contain a collection of software. The tool takes an install manifest file as input, and outputs an ISO image or virtual machine image, allowing developers to create completely customizable golden images for use in development, testing, and deployment environments. See the *Oracle Solaris 11 Express Distribution Constructor Guide* located at <http://docs.sun.com/app/docs/doc/820-6564> for more details.

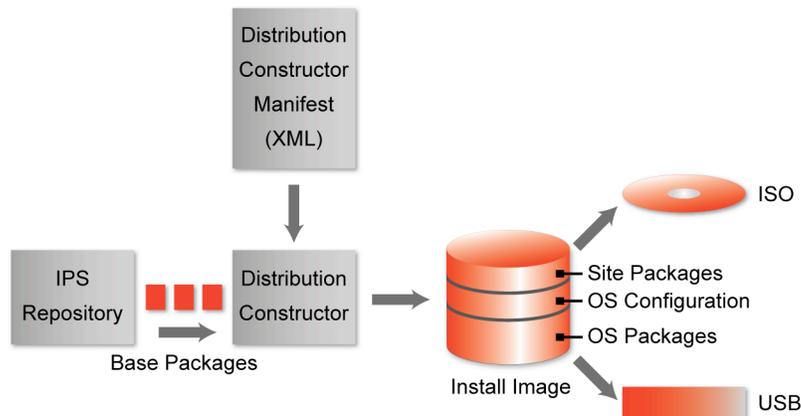


Figure 5. Distribution Constructor makes it easy for developers to create software, configuration, and target media.

- **Graphical LiveCD.** The Oracle Solaris 11 Express LiveCD for x86 gives developers the ability to boot directly off CD and evaluate the operating system in a complete graphical desktop environment prior to installing it on the system. The LiveCD installs a pre-determined selection of software with a full desktop environment.
- **Text-based interactive installer.** A new text-based interactive installer lets developers install systems using a console. It installs a selection of software considered suitable for server deployments. For example, graphical desktop environments, and audio and wireless networking drivers are not installed. However, several configuration options are available, including IPv4 and IPv6 network interfaces, a DNS resolver, LDAP clients and a name service switch.

TABLE 1. COMPARISON OF ORACLE SOLARIS 10 AND ORACLE SOLARIS 11 EXPRESS INSTALL FEATURES

FEATURE	ORACLE SOLARIS 10		ORACLE SOLARIS 11 EXPRESS	
Interactive Install	Yes		Yes	LiveCD, text-based user interface, updated look and feel, live desktop
Live Upgrade	Yes	Oracle Solaris Live Upgrade	Yes	pkg image update, full backup
Network Install	Yes		Yes	
Hands-free Install	Yes	Oracle Solaris JumpStart	Yes	Automated Installer
User Specified Install Parameters	Yes	Oracle Solaris JumpStart, text file, not easily updated	Yes	Automated Installer manifests, XML-based, easily extended, default provided
Begin, Finish Scripts	Yes		Yes	Derived manifests (Begin), device driver utility (Begin), first boot SMF services (Finish)
Heterogeneous Environment Support	Limited	Non-standard protocols	Yes	
Software Customization	Limited	User-defined HTTP package repository	Yes	Integration with Image Packaging System, multiple repositories available
System Configuration	Yes	Sysidtool, sysidcfg	Yes	Enhanced SMF profiles, stable system interfaces more extensible, SMF profile, text-based utility
WAN-based Installation	Yes	SPARC only	Yes	SPARC and x86 Image Packaging System repository-based installs
Fully Integrated Install Server Utilities	No		Yes	
Derived Profiles	Yes		Yes	Automated Installer derived manifests
Packaging Independent of Media	No	SVR4 packages included with media	Yes	Image Packaging System packages are separated from delivered media, reduces the need for image storage and the burden on developers, provides better performance, WAN based
Easy to Customize Distribution	No		Yes	Distribution Constructor

A New, Modern Software Packaging Model

Oracle Solaris 11 Express modernizes the software packaging model. The Image Packaging System (IPS) is a new network-based package management system that provides a framework for complete software lifecycle management, including the installation, upgrade, and removal of software packages. IPS takes the guesswork out of configuring systems. Enterprise developers can easily determine what software is installed, learn whether needed patches are installed, and rest assured that dependent patches are identified and installed automatically. In addition, developers can use IPS to get their enterprise applications ready for distribution.

- **A new software publishing model.** IPS provides an easy method for publishing software packages. Package content, metadata, and dependent system services are added to a repository upon installation. Software repositories can be created and managed for local software delivery, and multi-repository support lets developers pull software and fixes from different sources. While IPS packaging is the default for Oracle Solaris 11 Express, compatibility with previous System V software packages is preserved with continued access to `pkgadd` and related commands.
- **A new set of repositories.** Oracle Solaris 11 Express defines a new set of new repositories that contain additional software packages (Table 2). The repositories can be added in the Package Manager, or by using the `pkg set-publisher` command.
- **More reliable application install, version control and locking, and minimization.** Package refactoring simplifies minimization efforts and supports version control measures. In addition, developers can use IPS to validate installed packages and make any needed changes.
- **Eliminated patching.** IPS eliminates lengthy and complicated patching procedures. Preflight checking and automated downloads ensure only the differences needed are obtained and installed.
- **Safer system upgrades.** IPS and Oracle Solaris ZFS work together to deliver safe system upgrades. Developers can install software from a series of network-based package repositories with full automatic dependency checking for additional libraries that might be required during software package installation.
- **A choice of interfaces.** IPS provides two different interfaces for interacting with the packaging system. A command-line interface, and graphical Package Manager and Update Manager give developers flexibility. In addition, MIME associations allow for single click package installs while browsing the Web and on-disk archive formats.

TABLE 2. IMAGE PACKAGING SYSTEM REPOSITORIES

REPOSITORY	DESCRIPTION
http://pkg.oracle.com/solaris/release	The default repository for new Oracle Solaris 11 Express users. This repository receives updates for each new release of Oracle Solaris. Significant bug fixes, security updates, and new software may be provided at any time for users to install at Oracle's discretion.
https://pkg.oracle.com/solaris/support	Provides bug fixes and updates. Accessible with a current support contract from Oracle.
https://pkg.oracle.com/solaris/dev	Provides the latest development updates. Accessible to users enrolled in the Oracle Solaris 11 Platinum Customer Program and approved Oracle Partners.

More information on the Image Packaging System can be found in the *Oracle Solaris 11 Express Image Packaging System Guide* located at <http://docs.sun.com/app/docs/doc/820-6572> and the *Application Packaging Developer's Guide* located at <http://docs.sun.com/app/docs/doc/821-1672>.

Take Advantage of a Fully Integrated and Virtualized Environment

Oracle Solaris 11 Express is a completely virtualized operating environment, with technologies that span server, network, and storage virtualization to let enterprise developers make the most out of available resources. With these tools, enterprise developers can create minimized environments targeted to development, testing, and deployment processes, yet add in additional functionality whenever needed.

Create a Lightweight Development Environment

Keeping environments small and focused makes it simpler and safer to build applications and move them throughout the build, test, debug, and deploy process. Using IPS, enterprise developers can create a minimized operating environment inside an Oracle Solaris Container. This lightweight development environment includes only essential operating system components and services. Tools and source code can be installed in the container to create an application development stack that is compact and complete. The container can be moved in its entirety to testing and production environments—that may or may not be located on the same server—with ease. Other Oracle Solaris technologies can be layered on top of the minimized environment as needed, giving developers access to greater functionality and larger amounts of resources in a safe and controlled manner.

Manage Resources

Developers often have limited access to systems during application and development and testing phases. Finding ways to share systems and ensure developers, tools, and applications have sufficient resources can be challenging. Oracle Solaris Containers provide fine-grained resource management controls to ensure applications do not starve one another when running on the same system. Developers can create collections of resources, such as CPUs, physical memory, or network bandwidth, which are reserved for exclusive use by an application or set of applications. Virtual environments provide fixed boundaries between workloads, ensuring each has access to a consistent set of resources regardless of resource usage on the rest of the machine. As a result, programmers can create separate environments for development and testing efforts to eliminate competition for resources, helping achieve predictable application and system performance.

Virtualize the Network

Oracle Solaris 11 Express brings network virtualization and resource control into the operating system architecture, instead of adding on layered functionality with heavy overhead and undue complexity. Within the operating system, Network Virtualization virtualizes the network stack and allows fine-grained monitoring and control to let applications take advantage of improved network performance. With parallelization of network workloads across multiple processor threads and cores, and the ability to provide dedicated bandwidth and resources to separate services and protocols without a performance penalty, developers can create high-performance multitiered applications on a single kernel.

- **Virtualize NICs.** A physical network card can be presented to applications as multiple virtual network cards (VNICs). Each VNIC acts like any networking device on which an IP interface can be plumbed.
- **Gain flexibility without sacrificing performance.** Network Virtualization virtualizes the network stack and network interface card (NIC) around any service protocol, such as HTTP, HTTPS, FTP and NFS, or virtual environments created with Oracle Solaris Containers or Oracle VM Server for SPARC. Each virtual stack can be assigned its own priority and bandwidth on a shared NIC without degrading performance.
- **Consolidate workloads.** Built-in network virtualization promotes more effective sharing of network resources and enhances the ability to consolidate server workloads. Using the basic building block of Virtual Network Interface Controllers (VNICs), virtual switches and interconnects, virtual LANs (VLANs), and built-in routing and firewall functionality, developers can consolidate an entire distributed computing environment on a single system for prototyping, testing, and deployment.
- **Control network usage.** Each VNIC can be assigned its own priority and bandwidth on a shared NIC. Traffic for one VNIC can be isolated from other traffic and assigned limits or guarantees on amount of bandwidth it can use. Placing limits on bandwidth consumption improves network utilization and performance rates and supports operating system virtualization, utility computing, and server consolidation efforts.
- **Model networking environments.** Network Virtualization gives developers the ability to model a complete data center networking topology in a virtual network, reducing limitations created by the availability of physical NICs.
- **Secure applications from attacks.** The architecture dynamically manages priority and bandwidth resources, and can provide a better defense against denial of service attacks directed at a particular service or virtual machine by isolating the impact to that entity.

Expand the Storage Infrastructure

Enterprise applications often need to be tested with extremely large datasets to ensure information can be handled and throughput is sufficient. However, managing a large storage infrastructure can take time away from application development efforts. Now the default (root) file system in Oracle Solaris 11 Express, Oracle Solaris ZFS is an enterprise-class, general-purpose file system designed to ease data and storage management complexity. Unlike traditional file systems that require a separate volume manager, Oracle Solaris ZFS integrates traditional file system functionality with built-in volume management techniques and data services. Several important changes result from Oracle Solaris ZFS becoming the default file system.

- Oracle Solaris 11 Express now installs only on an Oracle Solaris ZFS root file system.
- Oracle Solaris ZFS eliminates the need for Solaris Volume Manager (SVM).
- Oracle Solaris ZFS is now the root file system. While the Unix File System (UFS) now is a legacy file system, it is still available for use. Note that the `mkfs` and `newfs` commands remain available.

Integrated Volume Management

Breaking free of the typical one-to-one mapping between the file system and its associated storage, Oracle Solaris ZFS decouples the file system from physical storage in the same way that virtual memory abstracts the address space from physical memory, allowing for more efficient use of storage devices. Space is shared dynamically between multiple file systems from a single storage pool. Thousands of file systems can draw from a common storage pool, with each file system consuming only the disk space it needs. Physical storage can be added to storage pools dynamically—without interrupting applications and services—providing new levels of flexibility, availability, and performance. When capacity is freed by one file system in the pool, it becomes available to other file systems. As a result, developers no longer need to deal with the problems associated with partitioning, provisioning, wasted bandwidth, and stranded storage.

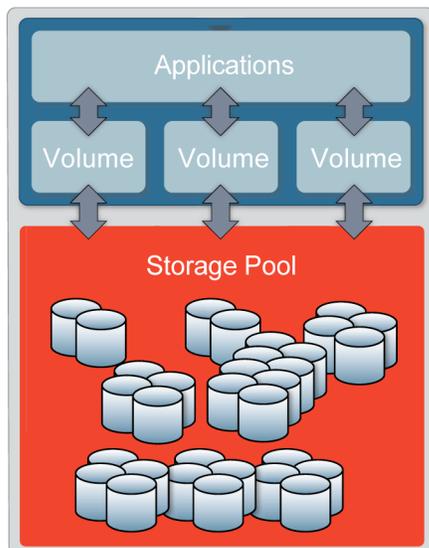


Figure 6. Virtual storage pools let multiple file systems share storage space

Built-in Scalability and Data Integrity

Providing virtually unlimited storage (up to 21 billion YottaBytes of capacity), Oracle Solaris ZFS scales to support large datasets. Several techniques, such as copy-on-write and end-to-end checksumming, keep on-disk data self-consistent and eliminate silent data corruption. Data is written to a new block on the media before changing the pointers to the data and committing the write. Because the file system is always consistent, time-consuming recovery procedures like `fsck` are not required if the system is shut down in an unclean manner. In addition, data is checked when read to help ensure correctness, and any errors detected in a mirrored pool are automatically repaired to protect against costly and time-consuming data loss and (previously undetectable) silent data corruption. Corrections are made possible by a RAID-Z implementation that uses parity, striping, and atomic operations to help reconstruct corrupted data and reduce planned and unplanned downtime.

New Data Services

Oracle Solaris ZFS incorporates new data services in the Oracle Solaris 11 Express release.

- **Save space with de-duplication.** Modern storage platforms use de-duplication technology to reduce the amount of total data stored by eliminating and sharing common components. In Oracle Solaris 11 Express, Oracle Solaris ZFS uses a checksum-based comparison of blocks with optional verification. When common blocks are found in the storage pool, only one copy is maintained, freeing the space associated with duplicate data. While de-duplication is optional, it provides benefit in environments containing highly duplicated data, such as virtualized images, tools, home directories, email folders, and more.
- **Protect data with encryption.** Oracle Solaris ZFS now includes encrypted dataset support to provide dataset level secured deletion and protection against physical storage theft and man-in-the-middle attacks on the SAN. Because data is encrypted at the dataset level, users can mix encrypted and unencrypted data in the same Oracle Solaris ZFS storage pool for maximum flexibility.

I/O Performance Improvements with Flash Device Support

Flash technology is gaining in popularity. Oracle Solaris 11 Express includes support for solid-state disks (SSDs) to give developers the opportunity to put the right information on faster Flash devices to speed application performance. For example, developers can use SSDs to hold frequently accessed data to minimize the impact of disk latencies and improve application performance. By creating Hybrid Storage Pools—storage infrastructure that uses enterprise Flash devices to handle certain types of I/O with dramatically reduced latency and hard disk drives for high capacity—applications can store and access massive data sets with high performance and at lower cost.

Greater Storage Device Support

Developers can take advantage of the wide range of storage devices now available to meet capacity and performance demands for development and deployment systems—from smaller, low-cost systems to high-performance, high-capacity devices, and everything in between. Oracle Solaris 11 Express supports a variety of protocols and interface technologies and provides key host bus adapter drivers with the software distribution.

- **Internet SCSI (iSCSI) target support.** Many storage deployments rely on the iSCSI protocol to move data across intranets and manage devices remotely. With iSCSI target support, the operating system can make SCSI storage devices available to clients over the network.
- **Fibre Channel.** Oracle Solaris 10 includes a number of Fibre Channel packages, including libraries based on the T11 FC-HBA specification, Emulex and QLogic device drivers, debugging aids, a FCIP IP/ARP over Fibre Channel device driver, a Fibre Channel transport layer, and much more.
- **Host bus adapter drivers.** A wide range of drivers are included in the operating system, including the Adaptec AdvanceRaid Controller SCSI HBA, Adaptec Ultra320, Advanced Host Controller Interface SATA, LSI MegaRAID SCSI HBA, LSI Hardware RAID HBA, LSI MegaSAS RAID Controller HBA, and Marvell 88SX SATA device drivers.

- **Multiple protocol support.** Several protocols are supported by the operating system, including the Serial Management Protocol for Serial Attached SCSI (SAS) that provides a way to communicate with SAS expanders through the Serial Management Protocol (SMP). A SMP target driver lets developers issue SMP requests and receive SMP responses through an interface, giving privileged users the ability to configure and manage SAS domains.

Integrate Storage Management into Enterprise Applications

Many enterprise applications have unique requirements that make it necessary to integrate storage management into the application. However, connecting software components in the datacenter requires intelligent storage interconnectivity. Developers can take advantage of Oracle Solaris ZFS and the Common Multiprotocol SCSI Target (COMSTAR) framework included in Oracle Solaris 11 Express to create in-house solutions that are tailored to enterprise storage needs.

Block-based devices are prevalent in storage infrastructures, and many enterprise applications are designed specifically to work with these systems. However, a trend is on to move toward object- and file-based access and utilize virtualization and abstraction techniques for better utilization and simplified management and access as data volumes grow. Yet traditional block-based storage continues to serve these new data access methods.

Supporting both block-based and file-based access, the COMSTAR framework lets developers transform any server that is running Oracle Solaris 11 Express into a target storage device that can be accessed by initiator hosts over the network (Figure 7). What makes the COMSTAR framework revolutionary is its ability to employ an Oracle Solaris ZFS file system on a target storage device and combine it with off-the-shelf components to create a storage server. All SCSI devices types, including disk and tape, can connect to a transport with concurrent access to all logical unit numbers (LUNs) and a single point of management.

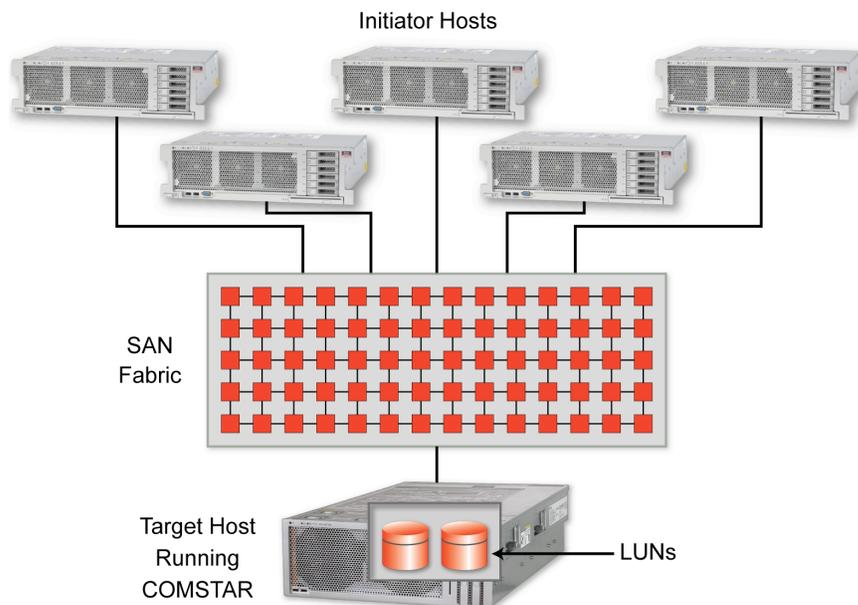


Figure 7. A target host running the COMSTAR framework can be accessed by initiator hosts over a SAN fabric.

COMSTAR provides a single framework for all target storage devices, so enhancements can be made in one place. Developers do not need to update each architecture independently whenever problems arise or new features are implemented, and any port can access any LUN. Each COMSTAR target device contains several components.

- Logical unit (LU) providers implement the functions associated with a SCSI LUN.
- Port providers provide local ports or connection points, such as host bus adapters (HBAs) and network interface cards (NICs), for transports.
- A SCSI target mode framework (STMF) manages common block storage functionality, including contexts and resources for SCSI command execution, LUN mappings, management of logical unit and port providers, abnormal command termination, and more.
- A management library (`libstmf`) communicates with, and configures, the COMSTAR framework.

Oracle Solaris 11 Express adds support for several protocols.

- Internet SCSI (iSCSI) protocol, and iSCSI Extensions for RDMA (iSER) protocol
- SCSI RDMA Protocol (SRP), for hosts that include an InfiniBand host channel adapter
- Fibre Channel over Ethernet (FCoE) protocol

In addition, DTrace probes have been added to COMSTAR in the SCSI Target Mode Framework (STMF) and SCSI Block Device (SBD) code.

Work in Heterogeneous Environments

Developers often need to work in, or create applications for, heterogeneous environments. Whether data is located on storage systems connected directly to a server, across a local or remote enterprise network, or on an external Web site, one or more protocols likely is needed to make the data available to applications. Oracle Solaris 11 Express supports a number of block- and file-level protocols, such as iSCSI, Network File System (NFS), SAMBA, and Common Internet File System (CIFS).

Native CIFS support simplifies data access by Windows virtual machines. Incorporating an in-kernel CIFS/SMB implementation, the operating system provides a rich set of permission and identity mapping capabilities that allows transparent file access—even to files on the same share—from Windows or UNIX virtual machines. By simplifying Windows and UNIX interoperability and seamlessly mapping file system credentials, applications, storage servers, and appliances can integrate more easily into existing heterogeneous environments.

The Oracle Solaris 11 Express CIFS service includes several new features, including:

- Host-based access control, allowing CIFS servers to restrict access to specific clients by IP address
- Access control lists (ACLs) on shares
- Client-side caching of offline files and synchronization when reconnected
- Complete Windows file sharing interoperability that pairs with Active Directory integration

Secure Applications, Services, and Systems

Oracle Solaris 11 Express integrates key security features that enterprise developers can leverage to create more secure production environments and applications. More information can be found in the *Developer's Guide to Oracle Solaris Security* located at <http://docs.sun.com/app/docs/doc/819-2145>.

- **Secure the environment.** Oracle Solaris ZFS allows the creation of a read-only copy of a file system, including the root file system. Developers can deploy a read-only root file system in an Oracle Solaris Zone to lock down the environment for added security.
- **Encrypt information.** The ubiquity of networked computing and growing demand for multimedia and rich Internet applications and Web services are pushing developers to implement data encryption capabilities into applications to protect valuable information as it flows across the network. Oracle Solaris 11 Express includes a cryptographic framework that provides application-level and kernel-level cryptographic operations. Based on the PKCS#11 public key cryptography standard, the framework brings the power of advanced, streamlined encryption algorithms and hardware acceleration to user-level C and Java programming language-based applications. New cryptographic enhancements in Oracle Solaris 11 Express include support for FIPS 140-2 of the Federal Information Processing Standard, and the implementation of ECC and other NSA Suite B protocols to meet stringent government standards.
- **Secure data.** Oracle Solaris ZFS now uses the cryptographic framework built into the operating system to enable cryptographic protection of data on a per-dataset basis.
- **Create secure by default environments.** Oracle Solaris 11 Express network services are disabled by default, or set to listen only for local system communications, to limit opportunities for unauthorized access.
- **Audit access.** The Oracle Solaris audit feature provides the ability to log system activity for any auditable Oracle Solaris event—such as system calls on the server machine, packets sent over the network, or a sequence of bits written to disk—at a granular level. As of Oracle Solaris 11 Express, auditing is a service and auditing records are stored in binary files on an Oracle Solaris ZFS file system. Developers do not need to reboot systems to enable auditing. The `/etc/security/audit_user` and `/etc/security/audit_control` files, and the `bsmconv/unconv` script, no longer are used.
- **Set sensitivity levels.** Oracle Solaris includes support for Trusted Extensions, an advanced security feature that implements labels to protect data and applications based on their sensitivity level, not just who owns or runs them. Labeled objects have an explicit relationship with each other, and an application usually cannot see or access data with a different security label. Oracle Solaris 11 Express includes two significant enhancements to Trusted Extensions. Security labels now can be created on Oracle Solaris ZFS data sets for explicit mandatory access control (MAC) policies. In addition, the existing trusted networking protocol assumes the underlying network is secure and that packet headers cannot be manipulated or observed in transit. Oracle Solaris 11 Express introduces labeled IPsec, enabling sensitivity labels to be associated with network traffic. Traffic with different sensitivity levels can be isolated and contained, and labeled networking can take place over untrusted networks.

- Protect Web-facing applications.** With pressure on to create and deploy more network services faster, developers sometimes are forced to skip or shorten the testing process, making these applications targets for hackers looking to deface Web sites or steal information. Developers can use the access control mechanisms built into Oracle Solaris 11 Express to protect Web-facing applications. These features—such as Oracle Solaris Containers, User and Process Rights Management, and the Oracle Solaris Service Manager—can be used to separate data and Web servers and limit access (Figure 8). Data is hosted in a container and connected to the corporate intranet or LAN. Another container holds the Web server and is configured with a reduced set of privileges. While the Web container is accessible to the public internet through a firewall, it has read-only access to the files contained in the data container to help protect HTML and data files. As a result, intruders that hack into the system are unable to modify the IP address or corrupt other system data.

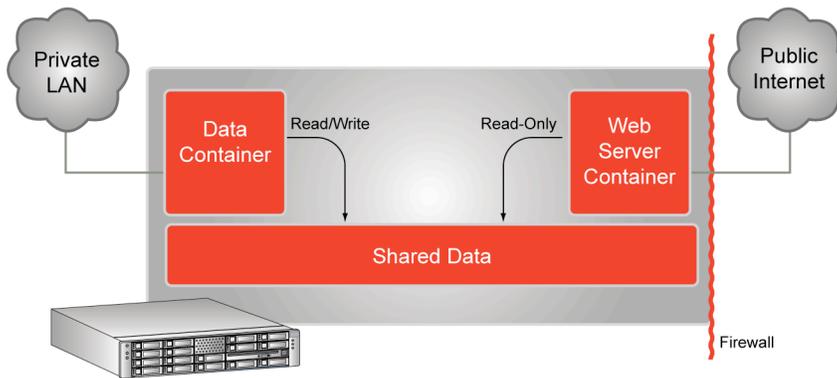


Figure 8. Oracle Solaris 11 Express technologies can be used to prevent Web-based hijacking.

Porting Applications to Oracle Solaris 11 Express

Porting applications from one environment to another can be a lengthy and expensive task. Continuing over a decade of tradition, Oracle preserves the long-standing guarantee of binary compatibility—applications that run on previous Oracle Solaris releases can run unchanged on Oracle Solaris 11 Express within the same processor architecture: x86 or SPARC. In addition, the Oracle Solaris Source Code Guarantee provides assurance that C and C++ applications developed and compiled to run on SPARC or x86 platforms will compile and run on either of these platforms. Together, these compatibility guarantees help ensure applications run from one Oracle Solaris platform to the next, lower development and testing costs, and speed time to deployment.

Developers porting applications from other UNIX environments, such as Linux, should consider the following.

- Placing tools in similar locations in the new environment can help minimize changes to source files.
- Source files should be modified to use Oracle Solaris tools, utilities, and libraries, and care should be taken to ensure the options used provide the intended functionality.

- Keep in mind that some compiler options may have the same name but behave differently in the old and new environments. Similarly, some options may have the same functionality but different names in the two environments.
- Determine whether any APIs used by the application are incompatible with Oracle Solaris 11 Express. While in-line source code changes can be made, Oracle recommends creating a compatibility library that implements the changes needed to resolve issues. Modifications to the source code can be limited to conditional compile directives, ensuring backward compatibility.
- A number of new routines are included in the Oracle Solaris C library to improve familiarity with Linux and BSD operating systems and help reduce the time and cost associated with porting applications to Oracle Solaris 11 Express. Examples of new routines include `asprintf()`, `vsprintf()`, `getline()`, `strdupa()` and `strndup()`.
- Changes to source code may be required as a result of the semantic and syntactic differences in how Oracle and other vendors implement the C, C++, and Fortran languages. Oracle's compilers conform to the American National Standard for Programming Language C, ANSI/ISO 9899-1990, and also support traditional K&R C.

Table 3 summarizes a few of the key differences between the Oracle Solaris 10 and Oracle Solaris 11 environments.

TABLE 3. ORACLE SOLARIS 10 AND ORACLE SOLARIS 11 DIFFERENCES SUMMARY

COMPONENT	ORACLE SOLARIS 10	ORACLE SOLARIS 11
Hardware	SPARC and x86	SPARC and x86
Distribution Media	6 CDs or 1 DVD	1 Live CD (Installs as a minimal OS. Use the package repository to add additional components.
Default User Shell	<code>/usr/bin/sh</code>	<code>/usr/bin/bash</code>
Default User Path	<code>/usr/bin</code> before GNU	GNU before <code>/usr/bin</code>
Default Desktop	JDS	GNOME
Default X Server	Xsun	Xorg
Default File System	UFS	ZFS
Additional Software	Companion CD	Image Packaging System
CD Path	<code>/cdrom</code>	<code>/media</code>
Upgrade Mechanism	Oracle Solaris Live Upgrade	Image update
Binary Compatibility	Guarantee	Guarantee
Root Login	Allowed	Role-based access control (RBAC)

Conclusion

Long considered the mission-critical operating system, Oracle Solaris is the platform of choice for enterprise developers. Oracle Solaris 11 Express builds on this foundation to deliver an integrated and virtualized environment that facilitates the enterprise application development process. With a wide range of scalability, efficiency, security, and availability enhancements, Oracle Solaris 11 Express makes it easier than ever before to create and deploy reliable application stacks with greater efficiency.

For More Information

For more information on Oracle Solaris 11 Express, see the references listed in Table 4.

TABLE 4. REFERENCES FOR MORE INFORMATION

Oracle Solaris 11 Express	http://www.oracle.com/technetwork/server-storage/solaris11/overview/index.html
Oracle Solaris 11 Express Documentation	http://www.oracle.com/technetwork/server-storage/solaris11/documentation/productdocumentation-178191.html
Oracle Solaris Studio	http://www.oracle.com/us/products/tools/050872.html
Oracle Solaris Developer Documentation	http://docs.sun.com/app/docs/doc/820-0696
Memory and Thread Placement Optimization Developer's Guide	http://docs.sun.com/app/docs/doc/820-1691
Multithreaded Programming Guide	http://docs.sun.com/app/docs/doc/821-1601
Linker and Libraries Guide	http://docs.sun.com/app/docs/doc/819-0690
Programming Interfaces Guide	http://docs.sun.com/app/docs/doc/821-1602
Device Driver Tutorial	http://docs.sun.com/app/docs/doc/819-3159
ONC+ Developer's Guide	http://docs.sun.com/app/docs/doc/821-1671
Oracle Solaris DHCP Service Developer's Guide	http://docs.sun.com/app/docs/doc/821-1604
Oracle Solaris WBEM Developer's Guide	http://docs.sun.com/app/docs/doc/821-1605
SIP API Developer's Guide	http://docs.sun.com/app/docs/doc/820-0643
Resource Management and Oracle Solaris Zones Developer's Guide	http://docs.sun.com/app/docs/doc/821-1499
Oracle Solaris Modular Debugger Guide	http://docs.sun.com/app/docs/doc/817-2543
Developer's Guide to Oracle Solaris Security	http://docs.sun.com/app/docs/doc/819-2145
Writing Device Drivers	http://docs.sun.com/app/docs/doc/819-3196
Oracle Technology Network	http://www.oracle.com/technetwork/index.html
Oracle Solaris 11 Express Support	http://www.oracle.com/us/support/software/premier/index.html



Oracle Solaris 11: What's New for Application
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