CHAPTER

1

The Basics of Oracle Solaris 11
Welcome to Oracle Solaris 11

For those who have worked with Sun Microsystems’ flagship operating system for many years, the pairing of the Solaris and Oracle trademarks may seem a bit odd and unfamiliar. And although many mourned the acquisition of Sun by Oracle—and some even questioned its wisdom—the result of the merger has produced an OS that is true to the tradition and original vision of Solaris and yet is modernized to meet the scalability and feature requirements of both traditional enterprise IT and new cloud computing infrastructures.

As you will see, Solaris 11’s advanced features help system administrators quickly and easily install, configure, update, and manage the OS and its applications. They provide for secure administration of users, data, and system access, and include unique technologies for virtualization, resource management, and system stability.

In this complete reference we explain Solaris 11’s key capabilities for those new to this modern implementation of UNIX as well as for those with prior Solaris experience. We show you how to install Solaris 11 on your desktop PC or laptop for learning, experimentation, and development, and how to deploy it on production servers in your data centers.

Linux users and developers will find in Solaris 11 a familiar and quickly productive working environment; we point out similarities and differences between the Linux and Solaris kernels and system administration tools, and describe how typical open source Web development tasks are accomplished in this OS.

We think you will like what you learn here about what Oracle calls “the #1 enterprise operating system.”

So, Why Should You Use Oracle Solaris 11?

If you are a longtime Solaris end user, developer, or administrator, you already know many of the features and benefits provided by this operating system as well as its generally excellent reputation for performance, security, stability, and scalability. Even still, every OS has its faults and annoyances, and Solaris is no exception. Historically, patching and updating the Solaris kernel has been a difficult and time-consuming process, with a bothersome lack of user-friendly tools to help with these tasks. Users of GNU/Linux environments might have found the open source utilities delivered with later Solaris versions buried in some subdirectory, but the default behavior of Solaris’ common UNIX tools did not match their user experience on modern Linux systems. And even new and potentially useful technologies such as containers were often incompletely implemented and supported until late in the Solaris 10 release cycle. Oracle Solaris 11 addresses these deficiencies and improves upon the solid OS kernel capabilities that make Solaris a powerful application deployment platform.

But if you consider yourself primarily a “Linux developer,” what’s in it for you? Well, first we must remind you that virtually all of your familiar development tools—from Apache, MySQL, and PHP, to Java, Perl, Python, gcc, and Ruby—are easily available. Some even come preinstalled on Solaris 11. You’ll also find typical open source user utilities such as the Firefox web browser, the Thunderbird e-mail client, OpenOffice, GIMP, and many others. In fact, referring to all these as “Linux applications” is inaccurate because they were long ago ported to Solaris and run equally well or even better on this OS. True, there is no longer a comparable community development approach for Solaris 11 as there is for Linux, but that does not negate the value of its innovative features.

Solaris 11 runs on SPARC servers and on a wide variety of Intel- and AMD-based x86 systems, including servers, workstations, and laptops, as you will see in the next chapter. Moreover, Solaris 11
has been optimized to produce superior performance on SPARC and Intel hardware from Oracle, as well as optimized for Oracle's application software such as Weblogic, Oracle Database, and other products.

For developers needing extreme scalability, virtualization, security, and elasticity features required for safe web-based and cloud computing solutions, Solaris 11 provides these capabilities, along with management tools that help administrators install, configure, monitor, and maintain their systems and ensure the integrity and availability of their data.

So, if you're ready to try Solaris 11, read on, and we'll tell you how to obtain, install, license, and use this newest version of the venerable Solaris OS.

A New Name, a New Owner, a Familiar Operating System

Oracle Solaris 11 inherits its features from three major sources: from Solaris 10 (introduced by Sun Microsystems in 2005), from the earlier work by Sun and the OpenSolaris community, and from the ongoing work of the combined Oracle and Sun OS engineering teams.

Solaris 10 introduced innovative and valuable OS capabilities, including the following:

- **Hardware and software fault and service management**  Solaris 10’s Fault Management Architecture, consisting of hardware fault monitoring and software service management, reduces system downtime by proactively reporting and correcting problems without the need to shut down the operating system or interrupt applications. It automatically diagnoses hardware failures, taking faulty components out of service and alerting the system administrator; it replaces the manually created and maintained individual software service configuration files with a common framework and execution environment that reacts to and corrects software faults, and provides a better understanding of the interrelationships and dependencies among the services.

- **Extreme multiprocessor/multicore performance and scalability**  Solaris has been designed to take advantage of multiple CPUs, managing and scheduling thousands of processes and execution threads, hundreds of terabytes of system memory, and hundreds of gigabits per second of I/O. Solaris 10 continued to enhance its performance and scalability with the introduction of multicore SPARC and x86 processors, allowing multichip systems to efficiently serve very demanding application workloads, large numbers of users, and complex distributed system architectures.

- **The ZFS filesystem**  ZFS, first introduced with Solaris 10, was designed to eliminate file and directory size limitations, to reduce the burden of storage management, and to guarantee data integrity. It enhanced and extended the capabilities of system management, patching, and upgrading, and has become an essential technology component of Solaris virtualization. ZFS includes features such as file system snapshotting and rollback, fast file system cloning, and root/boot file system support.

- **Built-in virtualized workload containment**  Solaris 10 introduced an efficient form of OS virtualization that does not require a hypervisor—containers (also called zones). This feature provides for the secure and safe hosting of multiple application environments on a single instance of Solaris, supporting separate security and performance domains for development, testing, and production. Solaris containers—because they are not full virtual machine guest operating system kernels—have negligible system impact and can scale to many hundreds of efficiently isolated execution environments. Additionally, Solaris 10 includes workload and resource management capabilities that allow allocation...
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of memory, CPU, storage, and bandwidth limits and guarantees for applications, users, and virtualized environments.

- **Integrated observability**  The ability to observe and quickly diagnose production system problems is essential to business operations. Solaris 10 is fully instrumented with nonintrusive observation points that include the entire execution path from application function calls through hardware interrupts, enabling performance analysts using the DTrace tools to rapidly identify application design defects and bugs, system performance bottlenecks, and configuration errors.

- **Enhanced security**  Solaris is already very well known for its high level of OS security. Solaris 10 introduced significant enhancements and new technologies for secure operation, including Role-Based Access Control (RBAC), management of root privileges, safe initial configuration and installation, support for processor-based encryption technologies, and labeled security domains using Trusted Extensions. Solaris 10 also introduced support for key security features such as digitally signed files, installation packages, and executables.

- **Hypervisor-based virtualization for SPARC processors**  Along with the multicore SPARC processors introduced earlier by Sun, Solaris 10 added support for a SPARC-based hypervisor that enables a single processor chip to be partitioned into multiple Solaris 10 domains (originally called LDoms, or Logical Domains, and now called Oracle VM for SPARC). This provides virtualization features for SPARC servers comparable to those based on Intel processors such as VMware and Microsoft Hyper-V.

- **A familiar user and developer environment**  Solaris 10 standardized on the GNOME user interface, and included popular open source applications such as the Firefox browser and the Thunderbird e-mail client, along with available GNU utilities, the gcc compiler, web development tools, Java support, NetBeans, and the StarOffice desktop suite. This approach was introduced in part to attract the growing number of Linux users and web developers by providing a working environment nearly identical to their open source workspaces. Additionally, Sun emphasized that popular open source application and developer tools such as Apache, Perl, and MySQL had long been available on Solaris and in fact ran equally well or even better on the Solaris 10 alternative to the Linux kernel.

**Solaris Now “Goes to 11”**

In November 2010, Oracle released Solaris 11 Express, which gave a preview of the new Oracle Solaris 11 operating system. This gave end users, administrators, and developers an opportunity to learn about new OS features. This preview was fully tested and quality reviewed, and even offered subscription software support for use in production environments, although not all of the planned OS features were fully implemented. Also, several recently introduced Oracle products, such as the Sun ZFS Storage Appliances and the Exalogic Elastic Cloud system, include Solaris 11 among their foundation operating systems.

The complete/production version of Oracle Solaris 11 (Figure 1-1), released in November 2011, is supported by both legacy Sun OS engineers and Oracle software developers; it runs on SPARC, Intel, and AMD processors, as well as on servers, workstations, and even laptops manufactured
by Oracle, IBM, HP, Dell, and others. It enhances and adds to the impressive Solaris 10 features listed previously, and we’ll be covering many of these new Solaris 11 features in more detail in subsequent chapters:

- **A new patching and updating facility, the Image Packaging System (IPS)**  Adding OS kernel and application patches are essential administrative tasks, which have historically been difficult and error prone on earlier versions of Solaris. IPS is a network repository–based service that enables easy updates to new kernel versions and patches, as well as application installation, updating, and removal, including installation of any needed dependencies. These updates can be accomplished using Oracle and third-party repositories over the Internet, or using locally installed and managed repositories. IPS can be accessed through command-line utilities, enabling inclusion in your custom scripts, or through an easy-to-use graphical interface. It also retains compatibility with the legacy SVR4 package utilities.

![FIGURE 1-1. Welcome to Oracle Solaris 11](image-url)
Automated installation  The new Automated Installer (AI) for Solaris 11 helps server administrators easily deploy multiple customized OS kernel environments over their local networks. AI interfaces with IPS image repositories to allow for software installation without manual intervention, automatically recognizing and locating installation profiles for each type of hardware client, either SPARC or x86.

Network virtualization  Solaris 11 supports the flexible creation and configuration of virtual network interface controllers (VNICs) and virtual LANs (VLANs), along with virtual switches and routing protocols. This enables modeling and testing of network environments within a single Solaris server in preparation for wider deployment. Additionally, both VNICs and NICs can be configured to control both bandwidth limits and CPU resources assigned to network traffic, allowing administrators to enforce quality of service (QoS) policies and to minimize the effects of network-based denial of service (DoS) attacks. Solaris 11’s full network virtualization capabilities now permit administrators of individual containers to configure complete, exclusive, IP stacks for each container instead of allocating a full hardware NIC from the server.

Built-in CIFS support  Solaris 11 includes kernel-based support for the Common Internet File System (CIFS) to provide file-sharing services for Microsoft Windows client systems. This service includes the ability to manage network connection and file access restrictions.

Security enhancements  Solaris 11 adds many security features to the already well-known earlier capabilities of Solaris. For example, the root user is no longer a default super-privileged account; root is now simply a role whose privileges are managed through the Role-Based Access Control (RBAC) service. This eliminates the traditional approach of giving full root privileges to applications; now they can be granted only what they need in order to run. Additionally, direct root logins are disabled, requiring users to log in without special privileges and then explicitly asking for the root role. This permits control and monitoring of privileged actions. And Solaris 11 initial installations are “secure by default,” meaning that no network-based services are activated automatically during the first system setup; only local console access is active. This prevents accidental exposure of the system to network-based intrusions during installation.

Enhanced GNOME and GNU user and developer environments  The default GUI environment for Solaris 11 is the well-known GNOME interface, and includes by default common user applications such as Thunderbird, Firefox, and many utilities familiar to Linux users. For developers, the command-line PATH defaults to include /usr/gnu/bin, containing familiar GNU utilities rather than pointing to the System V binaries traditionally provided by Solaris. This creates a user and developer experience matching that of Linux environments because it is paired with the bash shell for standard users and ksh for the root user.

New ZFS features  The ZFS file system is an integral technology of Solaris 11, supporting data integrity, easy storage management, patching and updating services, and virtualized environment configuration. New ZFS features in Solaris 11 include file system encryption, compression, and deduplication for security and for conserving disk space. The new zfsdiff command assists in identifying changes between file system snapshots, and the new TimeSlider utility allows users to manage their own home directory snapshots with an easy-to-use GUI that can recover deleted files or earlier file versions.
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- **CUPS printing system**  The legacy LP printing services used in earlier Solaris versions have been replaced with the widely used Common UNIX Printing System (CUPS). This service uses a web interface to discover, install, configure, and manage both local and remote printers and queues.

- **Distribution Constructor**  System administrators who need to configure and deploy customized Solaris 11 OS server environments can now use the new Distribution Constructor to create “golden images” of operating systems and guest virtual machines and then install them over their local networks. These images can include customizations of OS parameters, application configurations, and policy implementations, as well as support the creation of bootable media on files, USB memory devices, or other media that can be used with the Automated Installer service (described earlier).

- **New boot features**  Enabled by ZFS snapshots, Solaris 11 supports the instant creation of multiple boot environments. Administrators who make changes to the configurations or patches of an OS installation can first take a snapshot of that instance and then proceed with any needed updates or changes. A simple reboot to the snapshotted previous boot environment leaves everything unchanged in the event that there were problems with the changes made. This feature is what enables the Solaris 11 Live Upgrade service to easily install revisions to the OS. And to reduce the impact of OS restarts, Solaris 11 enables fast reboots that bypass previously successful hardware tests and initializations from earlier system startups.

- **New container features**  Although containers have been in Solaris 10 from its introduction, new container features and services continue to be added to the OS. Solaris 11 now supports Solaris 10 branded containers that can run applications in a Solaris 10 environment, assisting developers and administrators with updating their applications to the next OS level. Additionally, new container administration tools have been introduced, including the `zonestat` program, which allows full observation of container resource utilization. The creation of new boot environments, mentioned previously, clones nonglobal containers along with the global container.

- **Observability enhancements**  Solaris 11 now includes improved network observation utilities such as `dlstat`, `wireshark`, and `snoop` that can monitor traffic on both real and virtual network interfaces, including those assigned to containers. Moreover, the well-known DTrace utility has been enhanced to provide better observability of caches, network protocols, and `iscsi` I/O traffic, as well as general system latencies.

- **Network auto-magic**  Wired and wireless network connection availability is now automatically detected and connected by default upon system startup. This is particularly useful for Solaris 11 installations on laptops dependent on wireless networks, and for newly installed servers within a DHCP environment.

- **Multicore processor support**  On both x86 and SPARC systems that implement multiple-CPU cores and execution threads, Solaris 11 recognizes each hardware thread as a separately schedulable CPU. For example, on the new SPARC T4 processor, which has eight cores and eight threads per core, Solaris 11 sees 64 CPUs, and automatically recognizes and uses each core’s crypto stream processors for applications requiring high-performance encryption services.
These are just a few of the innovative technologies introduced or enhanced in Solaris 11. In subsequent chapters, we explain many of these features, how to use them, and why they are important to end users, developers, and system administrators.

A Short Review of Solaris’ Long History
The early history and evolution of UNIX is well known; it originated in the late 1960s at AT&T’s Bell Laboratories, developed by researchers Ken Thompson and Dennis Ritchie. Later, at the University of California at Berkeley, Bill Joy, eventual Sun Microsystems cofounder, extended UNIX virtual memory management on the DEC VAX systems and contributed important development tools such as the vi editor and the csh command shell. By the early 1990s Sun had licensed the distribution rights to the UNIX SVR4 source code, derivatives, and kernel binaries. Eventually, in response to growing interest in community-developed open source solutions on the x86 architecture, Sun announced plans to release Solaris under an open source license and to reverse its decision to end-product development of Solaris on the x86 platform. Finally, in 2005, Sun introduced Solaris 10 for both SPARC and x86 systems, including release of the Solaris 10 kernel source code under an OSI-approved open source license, and founded the OpenSolaris.org developer community. An OpenSolaris binary distribution was released in 2008 with an update in 2009, but by that time Sun was starting to feel the effects of competition and the general downturn in IT spending and evolved into an acquisition target.

Initially, IBM showed interest in acquiring Sun Microsystems but ultimately declined, at which point Oracle announced its intention in early 2009 to purchase Sun, declaring its interest in Sun’s key intellectual properties and technologies—SPARC, Java, and Solaris. Then, following nearly a year of wrangling with the European Union (EU) over concerns about Oracle’s plans for the popular open source database MySQL that Sun had acquired earlier, Oracle basically completed its purchase of Sun in early 2010 (with the exception of some non-U.S. assets that followed later).

Because Sun was well known for strongly supporting open source software and Oracle was definitely not known for such support, users of Sun’s open source products such as MySQL, OpenOffice, NetBeans, Lustre, Java, and of course Solaris, along with open source competitors and supporters such as Red Hat, were worried and critical of Oracle’s ownership of these technologies. Oracle eventually met the EU’s concerns about MySQL, but then discontinued its support of the OpenSolaris community development model and decided to focus on internal Solaris development and to take a more traditional, monetized approach to its newly acquired operating system. The general open source community and Oracle’s competitors widely criticized the apparent abandonment of the Solaris community’s development process, even claiming “Solaris is dead.” Oracle insisted, however, that Solaris’ value was worth the price it was now charging for development and support of a world-class operating system. Nevertheless, Oracle does provide source code to limited, GPL-licensed components of Solaris, and much of the original CDDL-licensed OpenSolaris source is still available for study at http://src.opensolaris.org/source, with helpful OS design discussions at www.solarisinternals.com.

The Future of Solaris
In spite of what may have been said by those concerned and critical about Oracle’s acquisition of Sun Microsystems, Solaris, along with other legacy Sun technologies such as Java software and SPARC hardware, indeed has a future. Oracle is generally not very open and detailed about future product plans, but the company has publicly revealed its general operating systems strategy and direction, and has backed it up by incorporating Solaris 11 into key products such as Exadata, Exalogic, the SPARC SuperCluster, and the ZFS-based storage appliances.
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Oracle’s current public roadmap for Solaris includes additional updates for Solaris 10 (the most recently released version is the Solaris 10 8/11 update, sometimes referred to as “Update 10” in the series) and future updates for Solaris 11 that track the evolution of Intel chips and especially new SPARC processors through at least 2015, as these chips increase their number of cores, core clock speeds, and multichip capabilities. Oracle’s general OS strategy, having acquired Solaris after initially competing against it with significant Linux development and support, now encompasses two major operating systems—Linux and Solaris. Oracle is expected to continue to develop and evolve both of these operating systems and the application products and systems based on each of them, positioning each OS as appropriate to specific markets and solutions.

Solaris 11 Licensing

Prior to Oracle’s acquisition of the company, Sun Microsystems provided unlimited free downloads and use of its software, including Solaris. The intent behind this approach was to encourage use and distribution of Solaris in order to increase its user base and market share. And although Oracle still provides free software downloads at www.oracle.com/technetwork/indexes/downloads/index.html, the company only permits “use of full versions of the products at no charge while developing and prototyping your applications, or for strictly self-educational purposes.” All other uses require a software support license, including any use of applications and operating systems in production environments. Additionally, whereas Sun provided certain Solaris OS patches for free, Oracle now requires a software support subscription to download any Solaris patches, including those addressing security issues. Sun/Oracle servers, both SPARC and x86, include a Solaris 11 usage license and subscription with the cost of the server support contract; a separate Solaris 11 subscription is not needed for Sun/Oracle hardware because it is included at the point of sale when the customer purchases Premier Support. However, support for Solaris 11 on non-Oracle hardware, such as that manufactured by Dell, IBM, or HP, requires a separate OS support contract that can be purchased through Oracle’s online store at http://shop.oracle.com. The cost of such subscriptions depends on the number of processor chips, or “sockets,” in the system to be supported, and includes 24/7 problem reporting and resolution services, access to the Oracle Solaris knowledge base and patches, and upgrades to future Oracle Solaris releases and enhancements. And although distribution of Solaris is intended primarily through downloads from Oracle’s website at www.oracle.com/technetwork/server-storage/solaris11/downloads/index.html, media packs with installation DVDs will also be available for extra cost.

Solaris Communities

Numerous technical user and developer communities can be found on the Web for Oracle and legacy Sun technologies, including many that address Solaris tutorials, hints and tricks, and best practice recommendations. The largest such community originated with Sun Microsystems’ BigAdmin site, now subsumed by the Oracle Technology Network (OTN) at www.oracle.com/technetwork/systems/index.html (see Figure 1-2). This site is an excellent resource of solutions and advice for system administrators working not only with Solaris but with Linux as well.

At the time of this publication, parts of the OpenSolaris.org community website are still active, with ongoing contributions around the earlier OpenSolaris release and derivatives. It still hosts active discussions and solutions related to ZFS, containers, DTrace, and other technologies directly relevant to those in Oracle Solaris 11, so it is worth a visit, especially for the best practice FAQs on zones and ZFS (see Figure 1-3).
As a response to Oracle’s changes to its involvement with OpenSolaris, several derivative efforts were initiated by contributors to that community, including Illumos (www.illumos.org), a fork of the original OpenSolaris kernel intended to replace any proprietary components with open source equivalents, and the OpenIndiana project (www.openindiana.org), based on the Illumos kernel. Oracle has no involvement in these efforts, although some corporations such as Nexenta and Joyent have provided some support and use of these derivatives in their products.

Another spinoff of the original Solaris and OpenSolaris technologies is DTrace.org (www.dtrace.org), formed by DTrace developer Adam Leventhal and other former Sun engineers. Although independent of Oracle, contributors to this website include Sun DTrace experts such as
Brendan Gregg, developer of the DTrace Toolkit, and ZFS developers Brian Cantrill and Erick Schrock. As such, it hosts much valuable information about how to use the powerful DTrace tools for performance diagnostics.

There are, however, several Solaris 11 community web resources worth highlighting. Brian Leonard, one of Oracle’s Solaris Product Managers, blogs regularly at The Observatory (http://blogs.oracle.com/observatory/), where he posts valuable instructions on how to use various features of Solaris 11 (see Figure 1-4). Readers of this book and any Solaris administrator will gain valuable knowledge about the operating system by frequently checking Leonard’s website.
No modern technology would be complete without a presence in popular social media, and Solaris 11 is no exception. Readers should check out Oracle’s Solaris 11 group on Facebook (www.facebook.com/oraclesolaris), where product managers and others post announcements and technical product discussions with group members (see Figure 1-5).

And for immediate, live updates from Solaris engineers and users, you can even follow the action on Twitter at @ORCL_Solaris, currently with more than 1,100 followers.
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FIGURE 1-5. The Oracle Solaris group on Facebook
Solaris 11 Documentation

Sun users were long accustomed to using http://docs.sun.com for all documentation related to Sun hardware and software. That link now redirects to the Oracle Technology Network (OTN), which includes not only Oracle’s collection of software references but also the legacy and current Sun hardware and software documentation. Downloadable Solaris 11 references in English and other major languages are available at www.oracle.com/technetwork/documentation/solaris-11-192991.html, including the all-important Release Notes, What’s New announcements, and End-of-Feature notices, along with documentation on installation, administration, security, and developer tools. Here, you will also find pointers to related Solaris resources such as articles and whitepapers, training videos, podcasts and webcasts, feature demos, and links to Solaris 11 training offerings (see Figure 1-6).

FIGURE 1-6. The Oracle Solaris 11 Express Information Library (formerly at docs.sun.com)
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For Those Moving from Solaris 10 to Solaris 11
Any time a vendor makes major changes to operating systems, administrators and developers need to learn how to use the new features and to relearn how to do routine tasks differently. Solaris 11 is no exception—there are significant changes (assuming most are for the better!) to how you install, configure, maintain, patch, monitor, and upgrade the OS. We detail these changes in the following chapters, but be forewarned—there are many things you will do much differently in Solaris 11, such as the following, to name but a few:

- Update and patch the OS and applications using IPS instead of patch tools
- Boot by default from a ZFS filesystem instead of UFS
- Boot over the Net with Automated Installer instead of JumpStart
- Use Distro Constructor instead of Flash Archive
- Manage printers with CUPS instead of LP services
- Create and manage alternate boot environments with ZFS and beadm
- Configure real and virtual network interfaces with ipadmin instead of ifconfig

Additionally, some familiar tools and procedures will change or go away, including these:

- Basic security module auditing
- Cryptographic services and tools
- rdist distributed file management

Summary
Oracle Solaris 11 continues to evolve as the leading implementation of UNIX on multiple hardware platforms from laptops to enterprise servers, exploiting modern multicore processors and a range of virtualization technologies. It has a long and rich history, a well-defined future supported by Oracle, and a large and active community of end users, system administrators, and application developers. We encourage Linux users and developers to complement their UNIX skills by learning more about Solaris 11 in the following chapters, not to replace Linux but to enhance their skills and to expand their repertoire of technical solutions. And current users of Solaris 10 will find both new capabilities and significant enhancements to existing features. So, let's get started!

NOTE
Unfortunately, as of this publication, no administrator tools are available to automate your upgrade from Solaris 10 to 11—you must perform a new installation and then manage movement of your data files separately. There are, however, some utilities to help you convert Solaris 10 procedures to those used in Solaris 11, such as the JumpStart to Automated Installer utility.

Reference
Information on licensing Oracle Solaris 11 can be found at www.oracle.com/technetwork/licenses/solaris-cluster-express-license-167852.html.