Securing Systems and Attached Devices in Oracle® Solaris 11.2

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Contents

Using This Documentation

Securing Systems and Attached Devices in Oracle® Solaris 11.2 explains how to protect and monitor your Oracle Solaris system from unauthorized access.

- **Overview** – Describes different methods of securing systems and devices from unauthorized access.
- **Audience** –System administrators responsible for implementing security on the corporate network.
- **Required knowledge** – Familiarity with security concepts and features that are supported in Oracle Solaris.

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♦ ♦ ♦ CHAPTER 1

Managing Machine Security

Keeping a machine's information secure is an important system administration responsibility. This chapter provides overview information about managing machine security.

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- "Controlling Access to Devices" on page 16
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What's New in Securing Systems and Devices in Oracle Solaris 11.2

This section highlights information for existing customers about important new features in this release that secure systems and devices from unauthorized access.

- Boot verification support protects the operating system's kernels. For details, see "Using Verified Boot" on page 31.
- Support for Trusted Platform Modules (TPM). For details, see "Initializing TPM on Oracle Solaris Systems" on page 38.

Controlling Access to a Computer System

In the workplace, all computers that are connected to a server can be thought of as one large multifaceted system. You are responsible for the security of this larger system. You need to defend the network from outsiders who are trying to gain access. You also need to ensure the integrity of the data on the computers within the network.

At the file level, Oracle Solaris provides standard security features that you can use to protect files, directories, and devices. At the system and network levels, the security issues are mostly the same. The first line of security defense is to control access to your system, as described in the following sections.

Maintaining Physical Security

To control access to your system, you must maintain the physical security of your computing environment. For instance, a system that is logged in and left unattended is vulnerable to unauthorized access. An intruder can gain access to the operating system and to the network. The computer's surroundings and the computer hardware must be physically protected from unauthorized access.

You can protect a SPARC system from unauthorized access to the hardware settings. Use the `eeprom` command to require a password to access the PROM. For more information, see "How to Require a Password for SPARC Hardware Access" on page 56. To protect x86 hardware, consult the vendor documentation.

Maintaining Login Control

You can prevent unauthorized logins to a system or the network through password assignment and login control. A password is a simple authentication mechanism. All accounts on a system must have a password. An account without a password makes your entire network accessible to an intruder who guesses a user name. A strong password algorithm protects against brute force attacks.

When a user logs in to a system, the `login` command checks the appropriate naming service or directory service database according to the information in the name switch service, `svc:/system/name-service/switch`. To change values in a naming service database, you use the SMF commands. The naming services indicate the location of the databases that affect login:

- `files` – Designates the `/etc` files on the local system
- `ldap` – Designates the LDAP directory service on the LDAP server
- `nis` – Designates the NIS database on the NIS master server
- `dns` – Designates the domain name service on the network

For a description of the naming service, see the `nscd`(1M) man page. For information about naming services and directory services, see "Working With Oracle Solaris 11.2 Directory and Naming Services: DNS and NIS " and "Working With Oracle Solaris 11.2 Directory and Naming Services: LDAP ".

The `login` command verifies the user name and password that were supplied by the user. If the user name is not in the password database, the `login` command denies access to the system. If the password is not correct for the user name that was specified, the login command denies access to the system. When the user supplies a valid user name and its corresponding password, the system grants the user access to the system.

PAM modules can streamline logging in to applications after a successful system login. For more information, see Chapter 1, “Using Pluggable Authentication Modules,” in “Managing Kerberos and Other Authentication Services in Oracle Solaris 11.2 ”.

Sophisticated authentication and authorization mechanisms are available on Oracle Solaris systems. For a discussion of authentication and authorization mechanisms at the network level, see “Authentication and Authorization for Remote Access” on page 26.

Managing Password Information

When users log in to a system, they must supply both a user name and a password. Although logins are publicly known, passwords must be kept secret. Passwords should be known only to each user. Users must choose their passwords carefully and change them often.

Passwords are initially created when you set up a user account. To maintain security on user accounts, you can set up password aging to force users to routinely change their passwords. You can also disable a user account by locking the password. For detailed information about administering passwords, see Chapter 1, “About User Accounts and User Environments,” in “Managing User Accounts and User Environments in Oracle Solaris 11.2 ” and the passwd(1) man page.

Local Passwords

If your network uses local files to authenticate users, the password information is kept in the system's /etc/passwd and /etc/shadow files. The user names and other information are kept in the /etc/passwd file. The encrypted passwords themselves are kept in a separate *shadow* file, /etc/shadow. This security measure prevents a user from gaining access to the encrypted passwords. While the /etc/passwd file is available to anyone who can log in to a system, only the root account can read the /etc/shadow file. You can use the passwd command to change a user's password on a local system.

NIS Passwords

If your network uses NIS to authenticate users, password information is kept in the NIS password map. NIS does not support password aging. You can use the command passwd -r nis to change a user's password that is stored in an NIS password map.

LDAP Passwords

The Oracle Solaris LDAP naming service stores password information and shadow information in the `ou=people` container of the LDAP directory tree. On the Oracle Solaris LDAP naming service client, you can use the `passwd -r ldap` command to change a user's password. The LDAP naming service stores the password in the LDAP repository.

Password policy is enforced on the Oracle Directory Server Enterprise Edition. Specifically, the client's `pam_ldap` module follows the password policy controls that are enforced on Oracle Directory Server Enterprise Edition. For more information, see "LDAP Naming Services Security Model" in "Working With Oracle Solaris 11.2 Directory and Naming Services: LDAP ".

Password Encryption

Strong password encryption provides an early barrier against attack. Oracle Solaris software provides six password encryption algorithms. The Blowfish and SHA algorithms provide robust password encryption.

Note - To be FIPS 140-approved, use the SHA algorigthms. For information, see "passwd Command as a FIPS 140 Consumer" in "Using a FIPS 140 Enabled System in Oracle Solaris 11.2 ".

Password Algorithm Identifiers

You specify the algorithms configuration for your site in the `/etc/security/policy.conf` file. In the `policy.conf` file, the algorithms are named by their identifier, as shown in the following table. For the identifier-algorithm mapping, see the `/etc/security/crypt.conf` file.

Note - Use FIPS-approved algorithms when possible. For lists of FIPS-approved algorithms, see "FIPS 140 Algorithm Lists and Certificate References for Oracle Solaris Systems" in "Using a FIPS 140 Enabled System in Oracle Solaris 11.2 " .

TABLE 1-1 Password Encryption Algorithms

Identifier	Description	Algorithm Man Page
1	The MD5 algorithm that is compatible with MD5 algorithms on BSD and Linux systems.	`crypt_bsdmd5`(5)

Identifier	Description	Algorithm Man Page
2a	The Blowfish algorithm that is compatible with the Blowfish algorithm on BSD systems. **Note -** To promote FIPS 140 security, remove the Blowfish algorithm (2a) from the CRYPT_ALGORITHMS_ALLOW=2a,5,6 entry in the /etc/security/policy.conf file.	crypt_bsdbf(5)
md5	The Sun MD5 algorithm, which is considered stronger than the BSD and Linux version of MD5.	crypt_sunmd5(5)
5	The SHA256 algorithm. SHA stands for Secure Hash Algorithm. This algorithm is a member of the SHA-2 family. SHA256 supports 255-character passwords. This algorithm is the default, (CRYPT_DEFAULT).	crypt_sha256(5)
6	The SHA512 algorithm.	crypt_sha512(5)
__unix__	Deprecated. The traditional UNIX encryption algorithm. This algorithm can be of use when connecting to old systems.	crypt_unix(5)

Note - The algorithm that is used for a user's initial password continues to be used for new password generation for that user even though a different default algorithm might have been selected prior to generating a new password for that user. This mechanism applies under the following conditions:

- The algorithm is included in the list of allowed algorithms to be used for password encryption.
- The identifier is not _unix_.

For procedures describing how to switch algorithms for password encryption, see "Changing the Default Algorithm for Password Encryption" on page 50.

Algorithms Configuration in the policy.conf File

The default algorithms configuration in the policy.conf file is as follows:

```
#
…
# crypt(3c) Algorithms Configuration
#
# CRYPT_ALGORITHMS_ALLOW specifies the algorithms that are allowed
to
# be used for new passwords.  This is enforced only in crypt_gensalt(3c).
```

```
#
CRYPT_ALGORITHMS_ALLOW=1,2a,md5,5,6

# To deprecate use of the traditional unix algorithm, uncomment below
# and change CRYPT_DEFAULT= to another algorithm.  For example,
# CRYPT_DEFAULT=1 for BSD/Linux MD5.
#
#CRYPT_ALGORITHMS_DEPRECATE=__unix__

# The Oracle Solaris default is a SHA256 based algorithm.  To revert to
# the policy present in Solaris releases set CRYPT_DEFAULT=__unix__,
# which is not listed in crypt.conf(4) since it is internal to libc.
#
CRYPT_DEFAULT=5
…
```

When you change the value for CRYPT_DEFAULT, the passwords of new users are encrypted with the algorithm that is associated with the new value.

When existing users change their passwords, the way their old password was encrypted affects which algorithm is used to encrypt the new password. For example, assume that CRYPT_ALGORITHMS_ALLOW=1,2a,md5,5,6, and CRYPT_DEFAULT=6. The following table shows which algorithm would be used to generate the encrypted password. The password consists of identifier=algorithm.

Initial Password	Changed Password	Explanation
1 = crypt_bsdmd5	Uses same algorithm	The 1 identifier is in the CRYPT_ALGORITHMS_ALLOW list. The user's password continues to be encrypted with the crypt_bsdmd5 algorithm.
2a = crypt_bsdbf	Uses same algorithm	The 2a identifier is in the CRYPT_ALGORITHMS_ALLOW list. Therefore, the new password is encrypted with the crypt_bsbdf algorithm.
md5 = crypt_md5	Uses same algorithm	The md5 identifier is in the CRYPT_ALGORITHMS_ALLOW list. Therefore, the new password is encrypted with the crypt_md5 algorithm.
5 = crypt_sha256	Uses same algorithm	The 5 identifier is in the CRYPT_ALGORITHMS_ALLOW list. Therefore, the new password continues to be encrypted with the crypt_sha256 algorithm.
6 = crypt_sha512	Uses same algorithm	The 6 identifier is s the value of CRYPT_DEFAULT. Therefore, the new password continues to be encrypted with the crypt_sha512 algorithm.
__unix__ = crypt_unix	Uses crypt_sha512 algorithm	The __unix__ identifier is not in the CRYPT_ALGORITHMS_ALLOW list. Therefore, the crypt_unix algorithm cannot be used. The new password is encrypted with the CRYPT_DEFAULT algorithm.

For more information about configuring the algorithm choices, see the policy.conf(4) man page. To specify password encryption algorithms, see "Changing the Default Algorithm for Password Encryption" on page 50.

Special System Accounts

The `root` account is one of several special *system* accounts. Of these accounts, only the `root` account is assigned a password and can log in. The `nuucp` account can log in for file transfers. The other system accounts either protect files or run administrative processes without using the full powers of `root`.

Caution - Never change the password setting of a system account. System accounts from Oracle Solaris are delivered in a safe and secure state. Do not revise or create system files with a UID that is 101 or less.

The following table lists some system accounts and their uses. The system accounts perform special functions. Each account on this list has a UID that is less than 100. For a full listing of system files, use the command `logins -s`.

TABLE 1-2 Selected System Accounts and Their Uses

System Account	UID	Use
`root`	`0`	Has almost no restrictions. Can override other protections and permissions. The `root` account has access to the entire system. The password for the `root` account should be very carefully protected. The `root` account owns most of the Oracle Solaris commands.
`daemon`	`1`	Controls background processing.
`bin`	`2`	Owns some Oracle Solaris commands.
`sys`	`3`	Owns many system files.
`adm`	`4`	Owns some administrative files.
`lp`	`71`	Owns the object data files and spooled data files for the printer.
`uucp`	`5`	Owns the object data files and spooled data files for UUCP, the UNIX-to-UNIX copy program.
`nuucp`	`9`	Used by remote systems to log in to the system and start file transfers.

Remote Logins

Remote logins offer a tempting avenue for intruders. Oracle Solaris provides several commands to monitor, limit, and disable remote logins. For procedures, see Table 3-1.

By default, remote logins cannot gain control or read certain system devices, such as the system mouse, keyboard, frame buffer, or audio device. For more information, see the `logindevperm(4)` man page.

Controlling Access to Devices

Peripheral devices that are attached to a computer system pose a security risk. Microphones can pick up conversations and transmit them to remote systems. CD-ROMs can leave their information behind for reading by the next user of the CD-ROM device. Printers can be accessed remotely. Devices that are integral to the system, for example, network interfaces such as `bge0`, can also present security issues.

Oracle Solaris software provides several methods of controlling access to devices.

- **Set device policy –** You can require that the process that is accessing a particular device be run with a set of privileges. Processes without those privileges cannot use the device. At boot time, Oracle Solaris software configures device policy. Third-party drivers can be configured with device policy during installation. After installation, you as the administrator can add device policy to a device.
- **Make devices allocatable –** You can require that a user must allocate a device before use. Allocation restricts the use of a device to one user at a time. You can further require that the user be authorized to use the device.
- **Prevent devices from being used –** You can prevent the use of a device, such as a microphone, by any user on a computer system. For example, a computer kiosk might be a good candidate for making certain devices unavailable for use.
- **Confine a device to a particular zone –** You can assign the use of a device to a non-global zone. For more information, see "Device Use in Non-Global Zones" in "Creating and Using Oracle Solaris Zones ". For a more general discussion of devices and zones, see "/dev File System in Non-Global Zones" in "Introduction to Oracle Solaris Zones ".

Device Policy

The device policy mechanism enables you to specify that processes that open a device require certain privileges. Devices that are protected by device policy can only be accessed by processes that are running with the privileges that the device policy specifies. Oracle Solaris provides default device policy. For example, network interfaces such as `bge0` require that the processes that access the interface be running with the `net_rawaccess` privilege. The requirement is enforced in the kernel. For more information about privileges, see "Process Rights Management" in "Securing Users and Processes in Oracle Solaris 11.2 ".

In Oracle Solaris, devices are protected with file permissions *and* with device policy. For example, the /dev/ip file has 666 permissions. However, the device can only be opened by a process with the appropriate privileges.

The configuration of device policy can be audited. The AUE_MODDEVPLCY audit event records changes in device policy.

For more information about device policy, see the following:

- Table 4-1
- "Device Policy Commands" on page 70
- "Privileges and Devices" in "Securing Users and Processes in Oracle Solaris 11.2 "

Device Allocation

The device allocation mechanism enables you to restrict access to a peripheral device, such as a CD-ROM. If device allocation is not enabled, peripheral devices are protected only by file permissions. For example, by default, peripheral devices are available for the following uses:

- Any user can read and write to a CD-ROM drive or disc.
- Any user can attach a microphone.
- Any user can access an attached printer.

Device allocation can restrict a device to authorized users. Device allocation can also prevent a device from being accessed at all. A user who allocates a device has exclusive use of that device until the user deallocates the device. When a device is deallocated, device-clean scripts erase any leftover data. You can write a device-clean script to purge information from devices that do not have a script. For an example, see "Writing New Device-Clean Scripts" on page 77.

Attempts to allocate a device, deallocate a device, and list allocatable devices can be audited. The audit events are part of the other audit class.

For more information about device allocation, see the following:

- Table 4-2
- "Device Allocation" on page 71
- "Device Allocation Commands" on page 72

Controlling Access to Machine Resources

Some system resources are protected by default. Additionally, as system administrator, you can control and monitor system activity. You can set limits on who can use what resources. You can log resource use, and you can monitor who is using the resources. You can also set up your systems to minimize improper use of resources.

Address Space Layout Randomization

Oracle Solaris tags many of its userland binaries to enable address space layout randomization (ASLR). ASLR randomizes the starting address of key parts of an address space. This security defense mechanism can cause Return Oriented Programming (ROP) attacks to fail when they try to exploit software vulnerabilities.

Zones inherit this randomized layout for their processes. Because the use of ASLR might not be optimal for all binaries, the use of ASLR is configurable at the zone level and at the binary level.

The three ASLR configurations are:

- **Disabled –** ASLR is disabled for all binaries.
- **Tagged binaries –** ASLR is controlled by the tag that is coded in the binaries.

  The default Oracle Solaris value for ASLR is `tagged-binaries`. Many binaries in the Oracle Solaris release are tagged to use ASLR.
- **Enabled –** ASLR is enabled for all binaries, except for those that are explicitly tagged to disable it.

The `sxadm` command is used to configure ASLR. You must assume the `root` role to run this command. For examples and information, see the `sxadm`(1M) man page. For developer information, see "Developer's Guide to Oracle Solaris 11 Security ".

Limiting and Monitoring Superuser Access

Your system requires a `root` password for superuser access. In the default configuration, a user cannot remotely log in to a system as `root`. When logging in remotely, users must log in with their user name and then use the `su` command to become `root`. You can monitor who has been using the `su` command, especially those users who are trying to gain superuser access. For procedures that monitor superuser and limit access to superuser, see "Monitoring and Restricting `root` Access" on page 54.

Configuring Role-Based Access Control to Replace Superuser

Role-based access control (RBAC), a feature of Oracle Solaris, is designed to distribute the capabilities of superuser to administrative roles. Superuser, the `root` user, has access to every resource in the system. With RBAC, you can replace many of `root`'s responsibilities with a set of roles with discrete powers. For example, you can set up one role to handle user account creation and another role to handle system file modification. Although you might not modify the root account, you can leave the account as a role, then not assign the role. This strategy effectively removes root access to the system.

Each role requires that a known user log in with her or his user name and password. After logging in, the user then assumes the role with a specific role password. For more information about RBAC, see "User Rights Management" in "Securing Users and Processes in Oracle Solaris 11.2 ".

Preventing Unintentional Misuse of System Resources

You can prevent you and your users from making unintentional errors in the following ways:

- You can keep from running a Trojan horse by correctly setting the PATH variable.
- You can assign a restricted shell to users. A restricted shell prevents user error by steering users to those parts of the system that the users need for their jobs. In fact, through careful setup, you can ensure that users access only those parts of the system that help the users work efficiently.
- You can set restrictive permissions on files that users do not need to access.

Setting the PATH Variable

Take care to correctly set the PATH variable. Otherwise, you can accidentally run a program that was introduced by someone else that creates a security hazard. The intruding program can corrupt your data or harm your system. This kind of program is referred to as a *Trojan horse*. For example, a substitute su program could be placed in a public directory where you, as system administrator, might run the substitute program. Such a script would look just like the regular su command. Because the script removes itself after execution, you would have little evidence to show that you have actually run a Trojan horse.

The PATH variable is automatically set at login time. The path is set through your initialization files, such as .bashrc and /etc/profile. When you set up the user search path so that the current directory (.) comes last, you are protected from running this type of Trojan horse. The PATH variable for the root account should not include the current directory at all.

Assigning a Restricted Shell to Users

The standard shell allows a user to open files, execute commands, and so on. The restricted shell limits the ability of a user to change directories and to execute commands. The restricted shell is invoked with the `/usr/lib/rsh` command. Note that the restricted shell is not the remote shell, which is `/usr/sbin/rsh`.

The restricted shell differs from a standard shell in the following ways:

- User access is limited to the user's home directory, so the user cannot use the `cd` command to change directories. Therefore, the user cannot browse system files.
- The user cannot change the `PATH` variable, so the user can use commands only in the path that is set by the system administrator. The user also cannot execute commands or scripts by using a complete path name.
- The user cannot redirect output with > or >>.

The restricted shell enables you to limit a user's ability to stray into system files. The shell creates a limited environment for a user who needs to perform specific tasks. The restricted shell is not completely secure, however, and is intended only to keep unskilled users from inadvertently doing damage.

For information about the restricted shell, use the `man -s1m rsh` command to see the `rsh`(1M) man page.

Restricting Access to Data in Files

Because Oracle Solaris is a multiuser environment, file system security is the most basic security risk on a system. You can use traditional UNIX file protections to protect your files. You can also use the more secure access control lists (ACLs).

You might want to allow some users to read some files, and give other users permission to change or delete some files. You might have some data that you do not want anyone else to see. Chapter 1, “Controlling Access to Files,” in “Securing Files and Verifying File Integrity in Oracle Solaris 11.2 ” discusses how to set file permissions.

Restricting `setuid` Executable Files

Executable files can be security risks. A few executable programs still have to be run as `root` to work properly. These `setuid` programs run with the user ID set to `0`. Anyone who is running these programs runs the programs with the `root` ID. A program that runs with the `root` ID creates a potential security problem if the program was not written with security in mind.

Except for the executables that Oracle Solaris provides with the `setuid` bit set to `root`, you should disallow the use of `setuid` programs. If you cannot disallow the use of `setuid` programs, then you must restrict their use. Secure administration requires few `setuid` programs.

For more information, see “Protecting Executable Files From Compromising Security” in “Securing Files and Verifying File Integrity in Oracle Solaris 11.2 ”. For procedures, see

"Protecting Against Programs With Security Risk" in "Securing Files and Verifying File Integrity in Oracle Solaris 11.2 ".

Using the Secure by Default Configuration

By default, when Oracle Solaris is installed, a large set of network services are disabled. This configuration is called "Secure by Default" (SBD). With SBD, the only network service that accepts network requests is the `sshd` daemon. All other network services are disabled or handle local requests only. To enable individual network services, such as `ftp`, you use the Service Management Facility (SMF) feature of Oracle Solaris. For more information, see the `netservices`(1M) and `smf`(5) man pages.

Using Resource Management Features

Oracle Solaris software provides sophisticated resource management features. Using these features, you can allocate, schedule, monitor, and cap resource use by applications in a server consolidation environment. The resource controls framework enables you to set constraints on system resources that are consumed by processes. Such constraints help to prevent denial-of-service attacks by a script that attempts to flood a system's resources.

With these resource management features, you can designate resources for particular projects. You can also dynamically adjust the resources that are available. For more information, see "Administering Resource Management in Oracle Solaris 11.2 ".

Using Oracle Solaris Zones

Oracle Solaris zones provide an application execution environment in which processes are isolated from the rest of the system within a single instance of the Oracle Solaris OS. This isolation prevents processes that are running in one zone from monitoring or affecting processes that are running in other zones. Even a process running with superuser capabilities cannot view or affect activity in other zones.

Oracle Solaris zones are ideal for environments that place several applications on a single server. For more information, see "Introduction to Oracle Solaris Zones ".

Monitoring Use of Machine Resources

As a system administrator, you need to monitor system activity. You need to be aware of all aspects of your machines, including the following:

- What is the normal load?
- Who has access to the system?
- When do individuals access the system?
- What programs normally run on the system?

With this kind of knowledge, you can use the available tools to audit system use and monitor the activities of individual users. Monitoring is very useful when a breach in security is suspected. For more information about the audit service, see Chapter 1, "About Auditing in Oracle Solaris," in "Managing Auditing in Oracle Solaris 11.2 ".

Monitoring File Integrity

As a system administrator, you need assurance that the files that were installed on the systems that you administer have not changed in unexpected ways. In large installations, a comparison and reporting tool about the software stack on each of your systems enables you to track your systems. The Basic Audit Reporting Tool (BART) enables you to comprehensively validate systems by performing file-level checks of one or more systems over time. Changes in a BART manifest across systems, or for one system over time, can validate the integrity of your systems. BART provides manifest creation, manifest comparison, and rules for scripting reports. For more information, see Chapter 2, "Verifying File Integrity by Using BART," in "Securing Files and Verifying File Integrity in Oracle Solaris 11.2 ".

Controlling Access to Files

Oracle Solaris is a multiuser environment in which all the users who are logged in to a system can read files that belong to other users. With the appropriate file permissions, users can also use files that belong to other users. For more discussion, see Chapter 1, "Controlling Access to Files," in "Securing Files and Verifying File Integrity in Oracle Solaris 11.2 ". For step-by-step instructions on setting appropriate permissions on files, see "Protecting Files" in "Securing Files and Verifying File Integrity in Oracle Solaris 11.2 ".

Encrypting Files on Disk

You can keep a file secure by making the file inaccessible to other users. For example, a file with permissions of `600` cannot be read except by its owner and by the `root` account. A directory with permissions of `700` is similarly inaccessible. However, someone who guesses your password or who discovers the `root` password can access that file. Also, the otherwise inaccessible file is preserved on a backup tape every time that the system files are backed up to offline media. For additional protection, you can use on-disk encryption or use Cryptographic Framework commands.

For more information about ZFS file systems, see "Encrypting ZFS File Systems" in "Managing ZFS File Systems in Oracle Solaris 11.2 ".

The Cryptographic Framework provides `digest`, `mac`, and `encrypt` commands. Regular users can use these commands to protect files and directories. For more information, see Chapter 1, "Cryptographic Framework," in "Managing Encryption and Certificates in Oracle Solaris 11.2 ".

Using Access Control Lists

ACLs, pronounced "ackkls," can provide greater control over file permissions. You add ACLs when traditional UNIX file protections are not sufficient. Traditional UNIX file protections provide read, write, and execute permissions for the three user classes: owner, group, and other. An ACL provides finer-grained file security.

ACLs enable you to define fine-grained file permissions, including the following:

- Owner file permissions
- File permissions for the owner's group
- File permissions for other users who are outside the owner's group
- File permissions for specific users
- File permissions for specific groups
- Default permissions for each of the previous categories

To protect ZFS files with access control lists (ACLs), see Chapter 7, "Using ACLs and Attributes to Protect Oracle Solaris ZFS Files," in "Managing ZFS File Systems in Oracle Solaris 11.2 ". For information about using ACLs on legacy file systems, see "Using Access Control Lists to Protect UFS Files" in "Securing Files and Verifying File Integrity in Oracle Solaris 11.2 ".

Sharing Files Across Machines

A network file server can control which files are available for sharing. A network file server can also control which clients have access to the files, and what type of access is permitted for those clients. The file server can grant read-write access or read-only access either to all clients or to specific clients. Access control is specified when resources are made available with the `share` command.

When you create an NFS share of a ZFS file system, the file system is permanently shared until you remove the share. SMF automatically manages the share when the system is rebooted. For more information, see "Oracle Solaris ZFS and Traditional File System Differences" in "Managing ZFS File Systems in Oracle Solaris 11.2 ".

Restricting root Access to Shared Files

Usually, superuser is not allowed root access to file systems that are shared across the network. The NFS system prevents root access to mounted file systems by changing the user of the requester to the user nobody with the user ID 60001. The access rights of user nobody are the same as those access rights that are given to the public. The user nobody has the access rights of a user without credentials. For example, if the public has only execute permission for a file, then user nobody can only execute that file.

An NFS server can grant root access to a shared file system on a per-host basis. To grant these privileges, use the root=*hostname* option to the share command. You should use this option with care. For a discussion of security options with NFS, see Chapter 5, "Commands for Managing Network File Systems," in "Managing Network File Systems in Oracle Solaris 11.2 ".

Controlling Network Access

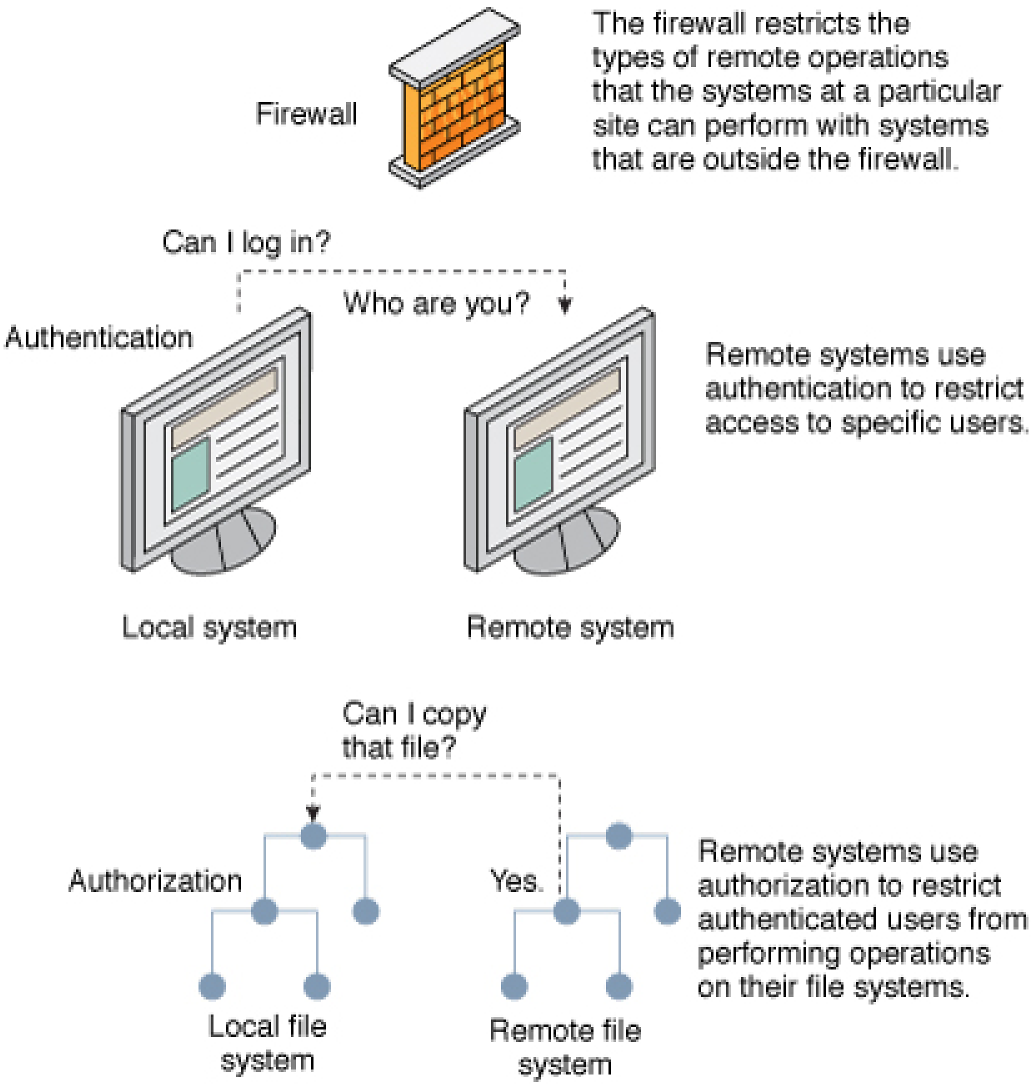
Computers are often part of a network of computers that allows connected computers to exchange information. Networked computers can access data and other resources from other computers on the network. Although computer networks create a powerful and sophisticated computing environment, networks also complicate computer security.

For example, within a network of computers, individual systems allow the sharing of information. Unauthorized access is a security risk. Because many people have access to a network, unauthorized access is more likely, especially through user error. A poor use of passwords can also allow unauthorized access.

Network Security Mechanisms

Network security is usually based on limiting or blocking operations from remote systems. The following figure describes the security restrictions that you can impose on remote operations.

FIGURE 1-1 Security Restrictions for Remote Operations


Firewall
The firewall restricts the types of remote operations that the systems at a particular site can perform with systems that are outside the firewall.
Can I log in?
Who are you?
Authentication
Remote systems use authentication to restrict access to specific users.
Local system
Remote system
Can I copy that file?
Authorization
Yes.
Remote systems use authorization to restrict authenticated users from performing operations on their file systems.
Local file system
Remote file system

Authentication and Authorization for Remote Access

Authentication is a way to control access when users try to access a remote system. Authentication can be set up at both the system level and the network level. After a user has gained access to a remote system, *authorization* is a way to restrict operations that the user can perform. The following table lists the services that provide authentication and authorization.

TABLE 1-3 Authentication Services for Remote Access

Service	Description	For More Information
IPsec	IPsec provides host-based and certificate-based authentication and network traffic encryption.	Chapter 6, "About IP Security Architecture," in "Securing the Network in Oracle Solaris 11.2 "
Kerberos	Kerberos uses encryption to authenticate and authorize a user who is logging in to the system.	For an example, see "How the Kerberos Service Works" in "Managing Kerberos and Other Authentication Services in Oracle Solaris 11.2 ".
LDAP	The LDAP directory service can provide both authentication and authorization at the network level.	"Working With Oracle Solaris 11.2 Directory and Naming Services: DNS and NIS "
Remote login commands	The remote login commands enable users to log in to a remote system over the network and use its resources. Some of the remote login commands are `rlogin`, `rcp`, and `ftp`. If you are a trusted host, authentication is automatic. Otherwise, you are asked to authenticate yourself.	Chapter 3, "Accessing Remote Systems," in "Managing Remote Systems in Oracle Solaris 11.2 "
SASL	The Simple Authentication and Security Layer (SASL) is a framework that provides authentication and optional security services to network protocols. Plugins enable you to choose an appropriate authentication protocol.	"About SASL" in "Managing Kerberos and Other Authentication Services in Oracle Solaris 11.2 "
Secure RPC	Secure RPC improves the security of network environments by authenticating users who make requests on remote machines. You can use either a UNIX, DES, or Kerberos authentication mechanism for Secure RPC.	"About Secure RPC" in "Managing Kerberos and Other Authentication Services in Oracle Solaris 11.2 "
	Secure RPC can also be used to provide additional security in an NFS environment. An NFS environment with secure RPC is called Secure NFS.	"NFS Services and Secure RPC" in "Managing Kerberos and Other Authentication Services in Oracle Solaris 11. 2 "
Secure Shell	Secure Shell encrypts network traffic over an unsecured network. Secure Shell provides	"Secure Shell (Overview)" in "Managing Secure Shell Access in Oracle Solaris 11.2 "

Service	Description	For More Information
	authentication by the use of passwords, public keys, or both.	

A possible substitute for Secure RPC is the Oracle Solaris *privileged port* mechanism. A privileged port is assigned a port number less than `1024`. After a client system has authenticated the client's credential, the client builds a connection to the server by using the privileged port. The server then verifies the client credential by examining the connection's port number.

Clients that are not running Oracle Solaris software might be unable to communicate by using the privileged port. If the clients cannot communicate over the port, you see an error message that appears similar to the following:

```
“Weak Authentication
NFS request from unprivileged port”
```

Firewall Systems

You can set up a firewall system to protect the resources in your network from outside access. A *firewall system* is a secure host that acts as a barrier between your internal network and outside networks. The internal network treats every other network as untrusted. You should consider this setup as mandatory between your internal network and any external networks, such as the Internet, with which you communicate.

A firewall acts as a gateway and as a barrier. As a gateway, it passes data between the networks. As a barrier, it blocks the free passage of data to and from the network. A user on the internal network must log in to the firewall system to access hosts on remote networks. Similarly, a user on an outside network must first log in to the firewall system before being granted access to a host on the internal network.

A firewall can also be useful between some internal networks. For example, you can set up a firewall or a secure gateway computer to restrict the transfer of packets by address or by protocol. You could then allow packets for transferring mail but not allow packets for the `ftp` command.

In addition, all electronic mail that is sent from the internal network is first sent to the firewall system. The firewall then transfers the mail to a host on an external network. The firewall system also receives all incoming electronic mail, and distributes the mail to the hosts on the internal network.

Caution - Even if you maintain strict and rigidly enforced security on the firewall, if you relax security on other hosts on the network, an intruder who can break into your firewall system can then gain access to all the other hosts on the internal network.

A firewall system should not have any trusted hosts. A *trusted host* is a host from which a user can log in without being required to supply a password. A firewall system should not share any of its file systems, or mount any file systems from other servers.

IPsec and the IP Filter feature of Oracle Solaris can provide firewall protection. For more information about protecting network traffic, see "Securing the Network in Oracle Solaris 11.2 ".

Encryption and Firewall Systems

Unauthorized users from outside a network can corrupt or destroy the data in packets by capturing the packets before they reach their destination and injecting arbitrary data into the contents before sending the packets back on their original course. This procedure is called *packet smashing*.

On a local area network, packet smashing is impossible because packets reach all systems, including the server, at the same time. Packet smashing is possible on a gateway, however, so make sure that all gateways on the network are protected.

The most dangerous attacks affect the integrity of the data. Such attacks involve changing the contents of the packets or impersonating a user.

Other attacks might involve eavesdropping but do not compromise data integrity or impersonate a user. An eavesdropper records conversations for later replay. Although eavesdropping attacks do not attack data integrity, the attacks do affect privacy. You can protect the privacy of sensitive information by encrypting data that goes over the network.

- To encrypt remote operations over an insecure network, see Chapter 1, "Using Secure Shell (Tasks)," in "Managing Secure Shell Access in Oracle Solaris 11.2 ".
- To encrypt and authenticate data across a network, see Chapter 2, "About the Kerberos Service," in "Managing Kerberos and Other Authentication Services in Oracle Solaris 11.2 ".
- To encrypt IP datagrams, see Chapter 6, "About IP Security Architecture," in "Securing the Network in Oracle Solaris 11.2 ".

Reporting Security Problems

If you experience a suspected major enterprise security breach, you can contact the Computer Emergency Response Team/Coordination Center (CERT/CC). CERT/CC is a Defense Advanced Research Projects Agency (DARPA) funded project that is located at the Software Engineering Institute at Carnegie Mellon University. This agency can assist you with any security problems you are having. This agency can also direct you to other Computer Emergency Response Teams that might be more appropriate for your particular needs. For current contact information, consult the CERT/CC (http://www.cert.org/contact_cert/) web site.

♦ ♦ ♦ CHAPTER 2

Protecting Oracle Solaris Systems Integrity

Oracle Solaris systems can be protected from unauthorized kernel modules, Trojan applications, and other threats being loaded on the system. This chapter describes security features in Oracle Solaris that provide protection from such threats and maintain system integrity as a whole. The chapter covers the following topics:

- "Using Verified Boot" on page 31
- "Enabling Verified Boot" on page 34
- "About Trusted Platform Module" on page 37
- "Initializing TPM on Oracle Solaris Systems" on page 38
- "Troubleshooting TPM" on page 44

Using Verified Boot

Verified boot in Oracle Solaris secures a system's boot process. The feature protects the system from threats such as the following:

- Corruption of kernel modules
- Insertion or substitution of malicious programs that masquerade as legitimate kernel modules, such as Trojan viruses, spyware, and rootkits
- Installation of unauthorized third-party kernel modules

Malicious programs can pass information to third parties as well as alter the behavior of Oracle Solaris. Although third-party modules are typically non-malicious, they might violate policies that control site changes. Therefore, the system also needs protection from unauthorized installation of these modules.

Verified Boot and ELF Signatures

In Oracle Solaris, boot verification is performed by means of `elfsign` signatures or keys. At the factory, Oracle Solaris kernel modules are signed with these keys. Because of their file format, these modules are also called ELF objects. The signature is created by using the SHA-1 or SHA-256 checksums of selected ELF records in an object file. The SHA-1 or SHA-256 checksums are signed with a RSA-2048 private and public key pair. The public key is distributed in `/etc/certs` while the private key is not distributed.

All keys are stored in the system's **pre-boot environment**, which is the software or firmware that runs prior to the booting of Oracle Solaris. The firmware loads and boots `platform/.../unix`.

The pre-boot environment differs for each category of systems. The supported pre-boot environment for each category is as follows:

- Legacy SPARC systems and x86 systems - These systems have no storage capabilities outside the filesystem so configuration settings for boot verification are stored in the filesystem itself. Specifically, the configuration information is stored in `/etc/system`. The keys are stored in `/etc/certs/*SE` in the root filesystem and boot archive.
- SPARC systems with verified-boot support in their Oracle Integrated Lights Out Manager (ILOM) - Keys and configuration settings are stored in Oracle ILOM.

  Because Oracle ILOM is outside the operating system's filesystem, verified boot configuration is protected from tampering by users of the operating system, including those with administrator (root) privileges. Thus, verified boot in this category of systems is more secure.

  You must ensure that access to Oracle ILOM is secure to prevent unauthorized changes to the verified boot configuration. For more information about securing Oracle ILOM, refer to the documentation at http://www.oracle.com/goto/ILOM/docs.
- SPARC M5 Series, SPARC M6 series, and SPARC T5 series - Configuration settings are stored in the system's Oracle ILOM. The SPARC firmware sends the configuration information to Oracle Solaris.

Verification Sequence During System Boot

Verified boot automates the verification of the `elfsign` signatures of Oracle Solaris kernel modules. With verified boot, the administrator can create a verifiable chain of trust in the boot process beginning from system reset up to the completion of the boot process.

During a system boot, each block of code that is started in the boot process verifies the next block that needs to be loaded. The sequence of verification and loading continues until the last kernel module is loaded.

When a power cycle is subsequently performed on the system, a new sequence of verification begins. The administrator can also configure verified boot to take the appropriate action in the event of verification failure.

Consider the boot flow of Oracle Solaris on a SPARC system:

```
Firmware -> Bootblock -> /platform/.../unix -> genunix -> other kernel modules
```

SPARC firmware is installed at the factory. The firmware's digital signature can also be updated by using the `fwupdate` utility. The firmware verifies, and then loads, the Oracle Solaris `/platform/.../unix` module, which is the initial Oracle Solaris module. In turn, the Oracle Solaris kernel runtime loader `krtld`, which is part of the module, verifies and loads the generic UNIX (`genunix`) module and subsequent modules.

Policies for Verified Boot

Two policies manage verified boot:

- The boot policy regulates the verification of the UNIX and `genunix` modules. These modules are the first to be loaded during the boot process.
- The module policy regulates the verification of other kernel modules that need to be loaded after the `genunix` module.

On legacy SPARC systems and x86 systems, the policies are defined in the `boot_policy` and `module_policy` variables of the `/etc/system` file. On SPARC systems with Oracle ILOM verified-boot support, `boot_policy` and `module_policy` are properties of Oracle ILOM in `/HOST`*x*`/verified_boot`, where *x* is the physical domain (PDomain) number.

Both variables or properties can be configured with one of the following values:

- `none` - No boot verification is performed. By default, both `boot_policy` and `module_policy` are not configured and therefore verified boot is disabled.
- `warning` - The `elfsign` signature of each kernel module is verified before the module is loaded. If verification fails on a module, the module is still loaded. The discrepancies are recorded on the system console or, if available, in the system log. By default, the log is `/var/adm/messages`.
- `enforce` - The `elfsign` signature of each kernel module is verified before the module is loaded. If verification fails on a module, the module is not loaded. The discrepancies are recorded on the system console or, if available, in the system log. By default, the log is `/var/adm/messages`.

In addition to configuring the policies, you also specify `elfsign` X.509 public key certificates on the system. Similar to the modules, you specify the certificates by either using a variable or defining an Oracle ILOM property.

On systems with Oracle ILOM that supports verified boot, a preinstalled verified boot certificate file, `/etc/certs/ORCLS11SE`, is provided as part of Oracle ILOM. On legacy SPARC systems and x86 systems, the certificate is available as the Oracle Solaris file `/etc/certs/ORCLS11SE`.

The certificate contains the RSA public key that is used to verify the `elfsign` signatures in ELF objects. However, you can install a company-provided certificate to replace `/etc/certs/ORCLS11SE`. All certificates are loaded and managed on each individual PDomain.

Enabling Verified Boot

By default, verified boot is disabled on systems. The procedures to enable the feature differ depending on your system. To enable the feature, use one the procedure in this section that applies to your system.

▼ SPARC: How to Enable Verified Boot on SPARC Systems With Oracle ILOM Verified-Boot Support

For SPARC systems with Oracle ILOM verified-boot support, the verified boot properties are in `/HOST`*x*`/verified_boot`, where *x* is the PDomain number, such as `HOST0`, `HOST1`, and so on.

Note - Some SPARC systems only have one physical domain, `/HOST`, while others have multiple physical domains. This procedure assumes that you are using a system with multiple physical domains and refers to a physical domain as `/HOST`*x*. For security features that are specific to your system, refer to your system's security manual.

---

1. **(Optional) Determine whether your system supports verified boot.**

```
# show /HOSTx/verified_boot
show: Invalid target /HOST/verified_boot
```

You can use the `fwupdate` to update the system's Oracle ILOM firmware.

2. **As an administrator, log in to the Oracle ILOM user interface.**

```
% ssh root@ilom
```

where *ilom* can be either the Oracle ILOM service processor IP address or the chassis-monitoring module IP address.

3. **Configure the verified boot properties.**

```
--> set /HOSTx/verified_boot/boot_policy=warning
--> set /HOSTx/verified_boot/module_policy=warning
```

Note - Specify either `warning` or `enforce` for each property. The properties can have differing configurations. For an explanation of these policy configurations, see "Policies for Verified Boot" on page 33.

If the boot policy is configured with `enforce` and discrepancies in the UNIX or `genunix` modules are detected, the system does not boot. Instead, the system reverts to OpenBoot PROM (OBP).

4. **Specify the certificate that you want to use in place of the certificate that is provided with the system.**

```
--> load /HOSTx/verified_boot/cert -source ftp-location
```

where *ftp-location* refers to the FTP server and file name that stores the certificate. *ftp-location* must be in the URL format `ftp://`*server*`/`*filename*.

5. **(Optional) Display the verified boot configuration.**

```
--> show /HOSTx/verified_boot
/HOST0
Properties:
boot_policy = warning
module_policy = warning
cert = ftp://server/filename
```

How to Enable Verified Boot on Legacy SPARC Systems and x86 Systems

Use this procedure if your system does not have the means to store boot verification configuration outside of the system's local filesystem.

When you enable boot verification on this type of system, note the following security considerations:

- Configuration information is stored in the local file system and is therefore accessible.
- Any privileged user can modify the configuration.
- Policy settings can be changed, and boot verification itself can be disabled.
- Extra keys can be added that might allow any arbitrary `elfsign` signer to sign object modules.

1. **Edit the `/etc/system` file.**

a. **Add and configure the `boot_policy` and `module_policy` variables.**

For example, in `/etc/system`, you might type the following (shown in bold):

```
* Verified Boot settings: 1=none (default), 2=warning, 3=enforce
set boot_policy=2
set module_policy=2
```

Specify the number that corresponds to the configuration that you want for each variable. The variables can have differing configurations. For an explanation of these policy configurations, see "Policies for Verified Boot" on page 33.

If the boot policy is configured with `enforce` and discrepancies in the UNIX or `genunix` modules are detected, the system does not boot. Instead, the system reverts to OpenBoot PROM (OBP).

b. **Specify one or more `elfsign` X.509 key certificates for the `verified_boot_certs` variable.**

```
set verified_boot_certs="/etc/certs/THIRDPARTYSE"
```

where *THIRDPARTY* is the name of the certificate file provided by the user.

2. **Update the `/etc/system` file in the boot archive.**

```
# bootadm update-archive
```

3. **(Optional) View the verified boot configuration.**

a. **Mount the archive.**

- For SPARC systems:

```
# mount -r -F hsfs /platform/sun4v/boot_archive /mnt
```

- For x86 systems:

```
# mount -r -F hsfs /platform/x86-type/boot_archive /mnt
```

where *x86-type* is either `i86pc` or `amd64`.

b. **Display the verified boot configuration and `elfsign` keys.**

```
# gzcat /mnt/etc/system | egrep 'verified|policy'
# ls -l /etc/certs
```

▼ How to Manage Certificates on Systems With Oracle ILOM Verified-Boot Support

This procedure describes how to manage the system's verified boot certificates.

1. **To replace the preinstalled certificate with a certificate provided by the user, type the following:**

   ```
   --> load /HOSTx/verified_boot/cert -source ftp://server/filename
   ```

2. **To save a copy of the current certificate to the source that is provided by the user, type the following:**

   ```
   --> dump /HOSTx/verified_boot/cert -dest ftp://server/filename
   ```

3. **To remove any user-installed certificate and revert to the system's preinstalled certificate, type the following:**

   ```
   --> reset /HOSTx/verified_boot/cert
   ```

▼ How to Manually Verify the `elfsign` Signature

Verified boot is an automatic mechanism that provides a quick and efficient way to ensure the integrity of the boot process. However, you can still verify a kernel module's signature manually.

- **Use the `elfsign` command syntax as follows:**

  ```
  $ elfsign verify -v kernel_module
  ```

  For example:

  ```
  $ elfsign verify -v /kernel/misc/sparcv9/cardbus
  elfsign: verification of /kernel/misc/sparcv9/cardbus passed.
  format: rsa_sha1.
  signer: O=Oracle Corporation, OU=Corporate Object Signing, \
                OU=Solaris Signed Execution, CN=Solaris 11
  ```

About Trusted Platform Module

Trusted Platform Module (TPM) refers to the device as well as the implementation by which encrypted configuration information specific to the system is stored. The information serves as metrics against which processes are measured during system boot. Oracle Solaris uses TPM to securely store encryption keys.

The following components implement TPM in Oracle Solaris:

- The TPM device driver communicates with the TPM device.
- The Trusted Computing Group (TCG) Software Stack, or TSS, functions as the communication channel with the TPM device by means of the `tcsd` daemon.
- The PKCS #11 libraries implement a hardware token or provider that uses the TPM to generate keys and perform sensitive operations. The provider protects all private data objects by encrypting them with keys that can be used only inside the TPM device. The PKCS #11 libraries adhere to the following standard: RSA Security Inc. PKCS #11 Cryptographic Token Interface (Cryptoki).
- The `tpmadm` command is used to administer the TPM-related aspects for verification of the boot process.

  For more details, see the `tpmadm`(1M) man page.

The platform owner must initialize TPM by setting an owner password which is used to authorize privileged operations. The platform owner, also called the TPM owner, differs from the traditional superuser in two ways:

- To access TPM functions, process privilege is irrelevant. Privileged operations require knowledge of the owner password regardless of the privilege level of the calling process.
- The TPM owner cannot override access controls for data protected by TPM keys. The owner can effectively destroy data by reinitializing the TPM. However, the owner cannot access data that has been encrypted with TPM keys which are owned by other users.

Trusted Platform Module, together with the other measures described in this guide, secures the system from unauthorized access by users or applications.

Initializing TPM on Oracle Solaris Systems

This section contains procedures for initializing TPM on Oracle Solaris systems. The procedures differ between SPARC and x86 systems. However, to initialize TPM, certain prerequisites are common for both platforms.

- The TPM device `/dev/tpm` must be installed on the system.
- TPM must be using TCG Trusted Platform Module specification Version 1.2, otherwise known as ISO/IEC 11889-1:2009. Refer to the specification published in http://www.trustedcomputinggroup.org/resources/tpm_main_specification.
- The following Oracle Solaris TPM packages must be installed:
  - Trusted Platform Module driver (`driver/crypto/TPM`)
  - TrouSerS TCG software (`library/security/trousers`)

To install these packages, use the following commands:

```
# pkg install driver/crypto/tpm
# pkg install library/security/trousers
```

How to Check Whether the TPM Device Is Recognized by the Operating System

Use this procedure to determine whether Oracle Solaris recognizes the installed TPM device. This procedure applies to both SPARC and x86 systems.

- **On a terminal window, issue the following command:**

```
# prtconf -v |grep tpm
```

If the TPM device is recognized, the command generates output similar to the following:

```
# prtconf -v |grep tpm
tpm, instance #0
dev_path=/pci@0,0/isa@lf/tpm@0,fed40000:tpm
dev_link=/dev/tpm
```

If no output is generated, then the device might be disabled. For information about how to enable the device, see either "How to Initialize TPM Using the Oracle ILOM Interface" on page 39 or "How to Initialize TPM Using BIOS" on page 41 depending on your system's platform.

Note - As an alternative, you can also use the `ls` command to obtain the same information. However, the output would contain less information than what is provided by the `prtconf` syntax.

```
# ls -l /dev/tpm
lrwxrwxrwx  1 root root  44 May 22 2012 /dev/tpm ->
../devices/pci@0,0/isa@lf/tpm@0,fed40000:tpm
```

SPARC: How to Initialize TPM Using the Oracle ILOM Interface

On SPARC systems, you use both the system's Oracle ILOM and Oracle Solaris interfaces to initialize TPM.

1. **At the Oracle ILOM prompt, turn the system power off.**

   ```
   -> stop -f/SYS
   ```

2. **Activate TPM.**

   Activate TPM with one of the following sets of commands depending on the SPARC system.

   - On SPARC M5 series servers and SPARC T5 series servers, use the following command:

     ```
     -> set /HOST/tpm mode=activated
     ```

   - On SPARC M5-32 series servers, use the following command:

     ```
     -> set /HOST#/tpm mode=activated
     ```

     where # is an instance number, for example, `HOST0/tpm`.

   - On SPARC T4 servers, use the following commands:

     ```
     -> set /HOST/tpm enable=true activate=true
     -> show /HOST/tpm
     ```

3. **At the Oracle Solaris prompt, initialize TPM.**

   Initializing TPM causes you to become a TPM owner and requires you to assign an owner password, also called the Owner PIN.

   ```
    # tpmadm init
   TPM Owner PIN:
   Confirm TPM Owner PIN
   ```

4. **Verify the status of TPM.**

   ```
    # tpmadm status
   TPM Version: 1.2 (ATML Rev: 13.9, SpecLevel: 2, ErrataRev: 1)
   TPM resources
   Contexts: 16/16 available
   Sessions: 2/3 available
   Auth Sessions: 2/3 available
   Loaded Keys: 18/21 available
   Platform Configuration Registers (24)
   PCR 0: E1 EE 40 D8 66 28 A9 08 B6 22 8E AF DC 3C BC 23 71 15 49 31
   PCR 1: 5B 93 BB A0 A6 64 A7 10 52 59 4A 70 95 B2 07 75 77 03 45 0B
   PCR 2: 5B 93 BB A0 A6 64 A7 10 52 59 4A 70 95 B2 07 75 77 03 45 0B
   PCR 3: 5B 93 BB A0 A6 64 A7 10 52 59 4A 70 95 B2 07 75 77 03 45 0B
   PCR 4: AF 98 77 B8 72 82 94 7D BE 09 25 10 2E 60 F9 60 80 1E E6 7C
   PCR 5: E1 AA 8C DF 53 A4 23 BF DB 2F 4F 0F F2 90 A5 45 21 D8 BF 27
   PCR 6: 5B 93 BB A0 A6 64 A7 10 52 59 4A 70 95 B2 07 75 77 03 45 0B
   PCR 7: 5B 93 BB A0 A6 64 A7 10 52 59 4A 70 95 B2 07 75 77 03 45 0B
   PCR 8: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
   PCR 9: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
   PCR 10: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
   PCR 11: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
   PCR 12: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
   PCR 13: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
   ```

```
PCR 14: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
PCR 15: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
PCR 16: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
PCR 17: FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
PCR 18: FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
PCR 19: FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
PCR 20: FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
PCR 21: FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
PCR 22: FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
PCR 23: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
```

5. **(Optional) Enable the TPM crypto provider.**

Note - The TPM crypto provider is slower than Oracle Solaris. Perform this step only if you want TPM to perform cryptographic operations.

```
# cryptoadm install provider='/usr/lib/security/$ISA/pkcs11_tpm.so'
# cryptoadm list -mv provider='/usr/lib/security/$ISA/pkcs11_tpm.so'
```

x86: How to Initialize TPM Using BIOS

On x86 systems, you perform steps on the system's BIOS before initializing the service using Oracle Solaris.

1. **At the Oracle Solaris prompt, reboot the system.**

```
# reboot -p
```

2. **While the system is booting, press F2 to access the BIOS menu.**

3. **Using BIOS menu options, configure TPM.**

a. **Navigate to Advanced → Trusted Computing.**

b. **Set TPM by specifying values for the following menu items.**

```
TCG/TPM Support [Yes]
Execute TPM Command [Enabled]
```

c. **Press the Esc key to exit the BIOS menu.**

d. **Choose Save Changes and Exit.**

e. **To proceed with the boot process, choose Ok.**

4. **After the boot process is completed, enable the `tcsd` daemon.**

```
# svcadm enable -s svc:/application/security/tcsd
```

5. **Initialize TPM.**

   Initializing TPM causes you to become a TPM owner and requires you to assign an owner password.

```
# tpmadm init
TPM Owner PIN:
Confirm TPM Owner PIN
```

6. **Verify the status of TPM.**

```
 # tpmadm status
TPM Version: 1.2 (ATML Rev: 13.9, SpecLevel: 2, ErrataRev: 1)
TPM resources
Contexts: 16/16 available
Sessions: 2/3 available
Auth Sessions: 2/3 available
Loaded Keys: 18/21 available
Platform Configuration Registers (24)
PCR 0: E1 EE 40 D8 66 28 A9 08 B6 22 8E AF DC 3C BC 23 71 15 49 31
PCR 1: 5B 93 BB A0 A6 64 A7 10 52 59 4A 70 95 B2 07 75 77 03 45 0B
PCR 2: 5B 93 BB A0 A6 64 A7 10 52 59 4A 70 95 B2 07 75 77 03 45 0B
PCR 3: 5B 93 BB A0 A6 64 A7 10 52 59 4A 70 95 B2 07 75 77 03 45 0B
PCR 4: AF 98 77 B8 72 82 94 7D BE 09 25 10 2E 60 F9 60 80 1E E6 7C
PCR 5: E1 AA 8C DF 53 A4 23 BF DB 2F 4F 0F F2 90 A5 45 21 D8 BF 27
PCR 6: 5B 93 BB A0 A6 64 A7 10 52 59 4A 70 95 B2 07 75 77 03 45 0B
PCR 7: 5B 93 BB A0 A6 64 A7 10 52 59 4A 70 95 B2 07 75 77 03 45 0B
PCR 8: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
PCR 9: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
PCR 10: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
PCR 11: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
PCR 12: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
PCR 13: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
PCR 14: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
PCR 15: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
PCR 16: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
PCR 17: FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
PCR 18: FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
PCR 19: FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
PCR 20: FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
PCR 21: FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
PCR 22: FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
PCR 23: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
```

7. **(Optional) Enable the TPM crypto provider.**

   Note - The TPM crypto provider is slower than Oracle Solaris. Therefore, perform this step only if you want TPM to perform cryptographic operations.

```
# cryptoadm install provider='/usr/lib/security/$ISA/pkcs11_tpm.so'
# cryptoadm list -mv provider='/usr/lib/security/$ISA/pkcs11_tpm.so'
```

How to Enable PKCS #11 Consumers to Use TPM as a Secure Keystore

Before You Begin To perform this procedure, you must install and enable TPM on the system. Ensure that the `tcsd` daemon is also running.

1. **Verify that the TPM device is installed.**

```
# ls -alF /dev/tpm
lrwxrwxrwx 1 root 39 Dec 27 2011 /dev/tpm -> ../devices/pci@0,0/isa@1/tpm@1,1670:tpm
```

2. **Enable the `tcsd` daemon.**

```
# svcadm enable tcsd
```

3. **Initialize the personal TPM-protected token storage area.**

```
$ pktool inittoken currlabel=TPM
```

Note - All individual users must perform this step.

4. **Set the token PIN for the security officer.**

```
$ pktool setpin token=tmp/TPM so
```

5. **Set the user's PIN.**

```
$ pktool setpin token=tmp/TPM
```

6. **Generate keys and certificates that use the TPM device by specifying the token name that was used when the token was initialized.**

```
$ pktool gencert token=tpm/TPM -i
$ pktool list token=tpm/TPM
```

Any existing applications that already use the Cryptographic Framework in `libpkcs11` can use the TPM token for their operations by making the applications select the TPM token device for the sessions.

Example 2-1 Enabling PKCS #11 Consumers to Use TPM

In this example, the TPM token is first assigned a new name. Thereafter, all subsequent actions on the token refer to the new name.

```
$ pktool inittoken currlable=TPM newlabel=JohnDoeTPM
$ pktool setpin token=tmp/JohnDoeTPM so
$ pktool gencert token=tpm/JohnDoeTPM -i
$ pktool list token=tpm/JohnDoeTPM
```

Troubleshooting TPM

Use the commands described in this section to monitor different operating components that enable you to successfully use TPM and troubleshoot TPM problems.

- To verify that the `tcsd` daemon is running:

  ```
  # svcs tcsd
  STATE      STIME      FMRI
  online     Nov_07     svc:/application/security/tcsd:default
  ```
- To ensure that the TPM device is installed:

  ```
  # ls -alF /dev/tpm
  lrwxrwxrwx 1 root 39 Dec 27 2011 /dev/tpm -> ../devices/pci@0,0/isa@1/tpm@1,1670:tpm
  ```
- To verify that the TSS software package is installed:

  ```
  # pkg info trousers
  Name: library/security/trousers
  Summary: TrouSerS TCG software to access a TPM device
  Description: The TrouSerS library provides a software stack from the
  Trusted Computer Group (TCG) that accesses a Trusted Platform Module
  (TPM) hardware device.
  Category: System/Security
  State: Installed
  Publisher: solaris
  Version: 0.3.6
  Build Release: 5.11
  Branch: 0.175.1.0.0.24.0
  Packaging Date: September 4, 2012 05:28:21 PM
  Size: 3.65 MB
  FMRI: pkg://solaris/library/security/
  trousers@0.3.6,5.11-0.175.1.0.0.24.0:20120904T1728212
  ```
- To clear TPM as a requirement after TPM was previously reinitialized.
  - At the Oracle Solaris prompt:

```
# tpmadm clear owner
```

- At the Oracle ILOM prompt:

  ```
  -> stop /SYS
  -> set /HOST/tpm forceclear=true
  -> start /SYS
  ```

♦ ♦ ♦ CHAPTER 3

Controlling Access to Systems

This chapter describes the procedures for controlling who can access Oracle Solaris systems.

The chapter covers the following topics:

- "Securing Logins and Passwords" on page 47
- "Changing the Default Algorithm for Password Encryption" on page 50
- "Monitoring and Restricting root Access" on page 54
- "Controlling Access to System Hardware" on page 56

For overview information about system security, see Chapter 1, "Managing Machine Security".

Securing Logins and Passwords

To guard access to your systems, you can limit remote logins, require users to have passwords, and require the root account to have a complex password. To manage user access, you can display a security message to users, monitor failed access attempts, and disable logins temporarily.

The following task map points to procedures that monitor user logins and that disable user logins.

TABLE 3-1 Securing Logins and Passwords Task Map

Task	Description	For Instructions
Inform users of site security at login.	Displays a text message on the login screen with site security information.	"How to Place a Security Message in Banner Files" in "Oracle Solaris 11 Security Guidelines " "How to Place a Security Message on the Desktop Login Screen" in "Oracle Solaris 11 Security Guidelines "

Task	Description	For Instructions
Display the user's login status.	Lists extensive information about the user's login account, such as full name and password aging information.	"How to Display the User's Login Status" on page 48
Find users who do not have passwords.	Finds only those users whose accounts do not require a password.	"How to Display Users Without Passwords" on page 49
Disable logins temporarily.	Denies user logins to a machine as part of system shutdown or routine maintenance.	"How to Temporarily Disable User Logins" on page 49

▼ How to Display the User's Login Status

Before You Begin To use the `logins` command, you must become an administrator who is assigned either the User Management or the User Security rights profile. By default, the `root` role has this authorization. For more information, see "Using Your Assigned Administrative Rights" in "Securing Users and Processes in Oracle Solaris 11.2 ".

● **Display a user's login status by using the `logins` command.**

```
# logins -x -l username
```

`-x` Displays an extended set of login status information.

`-l` *username* Displays the login status for the specified user. The variable *username* is a user's login name. Multiple login names are separated by commas.

The `logins` command uses the appropriate password database to obtain a user's login status. The database can be the local `/etc/passwd` file, or a password database for the naming service. For more information, see the `logins`(1M) man page.

Example 3-1 Displaying a User's Login Status

In the following example, the login status for the user `jdoe` is displayed.

```
# logins -x -l jdoe
jdoe       500     staff          10   Jaylee Jaye Doe
/home/jdoe
/bin/bash
PS 010103 10 7 -1
```

`jdoe` Identifies the user's login name.

`500` Identifies the user ID (UID).

`staff` Identifies the user's primary group.

`10` Identifies the group ID (GID).

Jaylee Jaye Doe Identifies the comment.

`/home/jdoe` Identifies the user's home directory.

`/bin/bash` Identifies the login shell.

`PS 010170 10 7 -1` Specifies the password aging information:

- Last date that the password was changed
- Number of days that are required between changes
- Number of days before a change is required
- Warning period

▼ How to Display Users Without Passwords

Before You Begin To use the `logins` command, you must become an administrator who is assigned either the User Management or the User Security rights profile. By default, the `root` role has this authorization. For more information, see "Using Your Assigned Administrative Rights" in "Securing Users and Processes in Oracle Solaris 11.2 ".

● **Display all users who have no passwords by using the `logins` command.**

```
# logins -p
```

The `-p` option displays a list of users with no passwords. The `logins` command uses the `passwd` database from the local system unless a distributed naming service is specified in the `password` property of the `system/name-service/switch` service.

Example 3-2 Displaying Accounts Without Passwords

In the following example, the user `pmorph` and the role `roletop` do not have passwords.

```
# logins -p
pmorph          501     other           1       Polly Morph
roletop         211     admin           1       Role Top
#
```

▼ How to Temporarily Disable User Logins

Temporarily disable user logins during system shutdown or routine maintenance.

Note - This procedure does not affect all users. The following can continue to log in to the system despite the presence of the /etc/nologin file created by this procedure.

- Superuser
- Users who are assigned the root role
- Users who are assigned the solaris.system.maintenance authorization

---

For more information, see the nologin(4) man page.

Before You Begin You must become an administrator who is assigned the solaris.admin.edit/etc/nologin authorization. By default, the root role has this authorization. For more information, see "Using Your Assigned Administrative Rights" in "Securing Users and Processes in Oracle Solaris 11.2 ".

1. **Create the /etc/nologin file in a text editor.**

```
# pfedit /etc/nologin
```

For an example of using the solaris.admin.edit/etc/nologin authorization, see Example 3-3.

2. **Include a message about system availability.**

3. **Close and save the file.**

Example 3-3 Disabling User Logins

In this example, a user is authorized to write the notification of system unavailability.

```
% pfedit /etc/nologin
***No logins permitted.***

***The system will be unavailable until 12 noon.***
```

Changing the Default Algorithm for Password Encryption

To use a different algorithm for password encryption, edit the /etc/security/policy.conf file. By default, user passwords are encrypted with the crypt_sha256 algorithm. The algorithm is represented by the identifier 5 assigned to the CRYPT_DEFAULT parameter in the file. To switch to another algorithm, assign a different identifier. For a list of password encryption algorithms and their corresponding identifiers, see Table 1-1.

Note - Whenever possible, use FIPS-approved algorithms. See "FIPS 140 Algorithm Lists and Certificate References for Oracle Solaris Systems" in "Using a FIPS 140 Enabled System in Oracle Solaris 11.2 " for lists of FIPS-approved algorithms and non-approved algorithms.

Note that the new algorithm applies only to password encryption for new users. For existing users, the previous algorithm remains operative if it remains defined in the `CRYPT_ALGORITHMS_ALLOW` parameter and is not `unix`. To see how encryption is implemented in this case, see "Algorithms Configuration in the `policy.conf` File" on page 13. To include existing users under the new password encryption algorithm, remove the previous algorithm from the `CRYPT_ALGORITHMS_ALLOW` parameter as well.

For more information about configuring the algorithm choices, see the `policy.conf(4)` man page.

▼ How to Specify an Algorithm for Password Encryption

Before You Begin You must assume the `root` role. For more information, see "Using Your Assigned Administrative Rights" in "Securing Users and Processes in Oracle Solaris 11.2 ".

1. **In the `/etc/security/polic.conf` file, specify the identifier for your chosen encryption algorithm as the value for the `CRYPT_DEFAULT` variable.**

2. **(Optional) Comment the file to explain your choice.**

   For example:

```
# cat  /etc/security/policy.conf
…
# Sets the SHA256 (5) algorithm as default.
# SHA256 supports 255-character passwords.
# Passwords previously encrypted with MD5 (1) will be encrypted
# with SHA256 (5) when users change their passwords.
#CRYPT_DEFAULT=1
CRYPT_DEFAULT=5
```

   In this example, the new value of `CRYPT_DEFAULT` is `5`, which is `SHA256`, the SHA256 algorithm. SHA stands for Secure Hash Algorithm. This algorithm is a member of the SHA-2 family. SHA256 supports 255-character passwords.

3. **(Optional) Remove the previous algorithm from the `CRYPT_ALGORITHM_ALLOWED` to make the new algorithm apply to existing users.**

For example, to ensure that the SHA256 algorithm also applies to existing users, the CRYPT_ALGORITHM_ALLOWED should exclude the prior identifier for MD5, 1.

Note - In addition, to promote FIPS 140 security, exclude the Blowfish algorithm (2a) from the entry.

```
CRYPT_ALGORITHMS_ALLOW=5,6
```

Example 3-4 Constraining Password Encryption Algorithms in a Heterogeneous Environment

In this example, the administrator on a network that includes BSD and Linux systems configures passwords to be usable on all systems. Because some network applications cannot handle SHA512 encryption, the administrator does not include its identifier in the list of allowed algorithms. The administrator retains the SHA256 algorithm, 5, as the value for the CRYPT_DEFAULT variable. The CRYPT_ALGORITHMS_ALLOW variable contains the MD5 identifier, which is compatible with BSD and Linux systems, and the Blowfish identifier, which is compatible with BSD systems. Because 5 is the CRYPT_DEFAULT algorithm, it does not need to be listed in the CRYPT_ALGORITHMS_ALLOW list. However, for maintenance purposes, the administrator places 5 in the CRYPT_ALGORITHMS_ALLOW list and the unused identifiers in the CRYPT_ALGORITHMS_DEPRECATE list.

```
CRYPT_ALGORITHMS_ALLOW=1,2a,5
#CRYPT_ALGORITHMS_DEPRECATE=__unix__,md5,6
CRYPT_DEFAULT=5
```

▼ How to Specify a New Password Algorithm for an NIS Domain

When users in an NIS domain change their passwords, the NIS client consults its local algorithms configuration in the /etc/security/policy.conf file. The NIS client system encrypts the password.

Before You Begin You must assume the root role. For more information, see "Using Your Assigned Administrative Rights" in "Securing Users and Processes in Oracle Solaris 11.2 ".

1. **Specify the password encryption algorithm in the /etc/security/policy.conf file on the NIS client.**

2. **Copy the modified /etc/security/policy.conf file to every client system in the NIS domain.**

3. **To minimize confusion, copy the modified `/etc/security/policy.conf` file to the NIS root server and to the slave servers.**

▼ How to Specify a New Password Algorithm for an LDAP Domain

When the LDAP client is properly configured, the LDAP client can use the new password algorithms. The LDAP client behaves just as an NIS client behaves.

Before You Begin You must assume the `root` role. For more information, see "Using Your Assigned Administrative Rights" in "Securing Users and Processes in Oracle Solaris 11.2 ".

1. **Specify a password encryption algorithm in the `/etc/security/policy.conf` file on the LDAP client.**

2. **Copy the modified `policy.conf` file to every client system in the LDAP domain.**

3. **Ensure that the client's `/etc/pam.conf` file does not use a `pam_ldap` module.**

   Ensure that a comment sign (`#`) precedes entries that include `pam_ldap.so.1`. Also, do not use the `server_policy` option with the `pam_authtok_store.so.1` module.

   The PAM entries in the client's `pam.conf` file enable the password to be encrypted according to the local algorithms configuration. The PAM entries also enable the password to be authenticated.

   When users in the LDAP domain change their passwords, the LDAP client consults its local algorithms configuration in the `/etc/security/policy.conf` file. The LDAP client system encrypts the password. Then, the client sends the encrypted password, with a `{crypt}` tag, to the server. The tag tells the server that the password is already encrypted. The password is then stored, as is, on the server. For authentication, the client retrieves the stored password from the server. The client then compares the stored password with the encrypted version that the client has just generated from the user's typed password.

   Note - To take advantage of password policy controls on the LDAP server, use the `server_policy` option with the `pam_authtok_store` entries in the `pam.conf` file. Passwords are then encrypted on the LDAP server. For the procedure, see Chapter 4, "Setting Up Oracle Directory Server Enterprise Edition With LDAP Clients," in "Working With Oracle Solaris 11.2 Directory and Naming Services: LDAP ".

Monitoring and Restricting root Access

By default, the root role is assigned to the initial user, and cannot directly log in to the local system or remotely log in to any Oracle Solaris system.

▼ How to Monitor Who Is Using the su Command

The sulog file lists every use of the switch user (su) command, not only the su attempts that are used to switch from user to root.

The su logging in this file is enabled by default through the following entry in the /etc/default/su file:

```
SULOG=/var/adm/sulog
```

Before You Begin You must assume the root role. For more information, see "Using Your Assigned Administrative Rights" in "Securing Users and Processes in Oracle Solaris 11.2 ".

- **Monitor the contents of the /var/adm/sulog file on a regular basis.**

```
# more /var/adm/sulog
SU 12/20 16:26 + pts/0 stacey-root
SU 12/21 10:59 + pts/0 stacey-root
SU 01/12 11:11 + pts/0 root-rimmer
SU 01/12 14:56 + pts/0 jdoe-root
SU 01/12 14:57 + pts/0 jdoe-root
```

The entries display the following information:

- The date and time that the command was entered.
- If the attempt was successful. A plus sign (+) indicates a successful attempt. A minus sign (-) indicates an unsuccessful attempt.
- The port from which the command was issued.
- The name of the user and the name of the switched identity.

Troubleshooting Entries that include ??? indicate that the controlling terminal for the su command cannot be identified. Typically, system invocations of the su command before the desktop appears include ???, as in SU 10/10 08:08 + ??? root-root. After the user starts a desktop session, the ttynam command returns the value of the controlling terminal to the sulog: SU 10/10 10:10 + pts/3 jdoe-root.

Entries similar to the following can indicate that the su command was not invoked on the command line: `SU 10/10 10:20 + ??? root-oracle`. A Trusted Extensions user might have switched to the oracle role by using a GUI.

▼ How to Restrict and Monitor root Logins

This method immediately detects root attempts to access the local system.

Before You Begin You must assume the root role. For more information, see "Using Your Assigned Administrative Rights" in "Securing Users and Processes in Oracle Solaris 11.2 ".

1. **View the CONSOLE entry in the /etc/default/login file.**

```
CONSOLE=/dev/console
```

By default, the console device is set to /dev/console. With this setting, root can log in to the console. root cannot log in remotely.

2. **Verify that root cannot log in remotely.**

From a remote system, try to log in as root.

```
mach2 % ssh -l root mach1
Password:        <Type root password of mach1>
Password:
Password:
Permission denied (gssapi-keyex,gssapi-with-mic,publickey,keyboard-interactive).
```

In the default configuration, root is a role, and roles cannot log in. Also, in the default configuration the ssh protocol prevents root user login.

3. **Monitor attempts to become root.**

By default, attempts to become root are printed to the console by the SYSLOG utility.

   a. **Open a terminal console on your desktop.**

   b. **In another window, use the su command to become root.**

```
% su -
Password:        <Type root password>
#
```

A message is printed on the terminal console.

```
Sep 7 13:22:57 mach1 su: 'su root' succeeded for jdoe on /dev/pts/6
```

Example 3-5 Logging root Access Attempts

In this example, root attempts are not being logged by SYSLOG. Therefore, the administrator is logging those attempts by removing the comment from the #CONSOLE=/dev/console entry in the /etc/default/su file.

```
# CONSOLE determines whether attempts to su to root should be logged
# to the named device
#
CONSOLE=/dev/console
```

When a user attempts to become root, the attempt is printed on the terminal console.

```
SU 09/07 16:38 + pts/8 jdoe-root
```

Troubleshooting To become root from a remote system when the /etc/default/login file contains the default CONSOLE entry, users must first log in with their user name. After logging in with their user name, users then can use the su command to become root.

If the console displays an entry similar to Last login: Wed Sep 7 15:13:11 2011 from mach2, then the system is configured to permit remote root logins. To prevent remote root access, change the #CONSOLE=/dev/console entry to CONSOLE=/dev/console in the /etc/default/login file. To find out how to return the ssh protocol to the default, see the sshd_config(4) man page.

Controlling Access to System Hardware

You can protect the physical system by requiring a password to gain access to the hardware settings. You can also protect the system by preventing a user from using the abort sequence to leave the windowing system.

To protect the BIOS, consult the vendor documentation.

▼ How to Require a Password for SPARC Hardware Access

Before You Begin You must become an administrator who is assigned the Device Security, Maintenance and Repair, or System Administrator rights profile. For more information, see “Using Your Assigned Administrative Rights” in “Securing Users and Processes in Oracle Solaris 11.2 ”.

1. **In a terminal window, enable the PROM security mode.**

```
# eeprom security-mode=command

Changing PROM password:
New password:        <Type password>
Retype new password:        <Retype password>
```

Choose the value `command` or `full`. For more details, see the `eeprom`(1M) man page.

If, when you type the preceding command, you are not prompted for a PROM password, the system already has a PROM password.

2. **(Optional) Change the PROM password.**

Caution - Do not forget the PROM password. The hardware is unusable without this password.

```
# eeprom security-password=        Press Return
Changing PROM password:
New password:        <Type password>
Retype new password:        <Retype password>
```

The new PROM security mode and password are in effect immediately. However, they are most likely to be noticed at the next boot.

▼ How to Disable a System's Abort Sequence

Note - Some server systems have a key switch. When the key switch is set in the secure position, the switch overrides the software keyboard abort settings. So, any changes that you make with the following procedure might not be implemented.

Before You Begin You must become an administrator who is assigned the `solaris.admin.edit/etc/default/kbd` authorization. By default, the `root` role has this authorization. For more information, see "Using Your Assigned Administrative Rights" in "Securing Users and Processes in Oracle Solaris 11.2 ".

1. **Change the value of `KEYBOARD_ABORT` to `disable`.**

   Comment out the `enable` line in the `/etc/default/kbd` file. Then, add a `disable` line:

```
# cat /etc/default/kbd
…
# KEYBOARD_ABORT affects the default behavior of the keyboard abort
# sequence, see kbd(1) for details.  The default value is "enable".
# The optional value is "disable".  Any other value is ignored.
```

```
…
#KEYBOARD_ABORT=enable
KEYBOARD_ABORT=disable
```

2. **Update the keyboard defaults.**

   ```
   # kbd -i
   ```

♦ ♦ ♦ CHAPTER 4

Controlling Access to Devices

This chapter provides step-by-step instructions for protecting devices, in addition to a reference section. The chapter covers the following topics:

- "Configuring Device Policy" on page 59
- "Managing Device Allocation" on page 61
- "Allocating Devices" on page 66
- "Device Protection Reference" on page 70

For overview information about device protection, see "Controlling Access to Devices" on page 16.

Configuring Device Policy

Device policy restricts or prevents access to devices that are integral to the system. The policy is enforced in the kernel.

The following task map points to device configuration procedures that are related to device policy.

TABLE 4-1 Configuring Device Policy Task Map

Task	Description	For Instructions
View the device policy for the devices on your system.	Lists the devices and their device policy.	"How to View Device Policy" on page 60
Audit changes in device policy.	Records changes in device policy in the audit trail.	"How to Audit Changes in Device Policy" on page 60
Access `/dev/arp`.	Gets Oracle Solaris IP MIB-II information.	"How to Retrieve IP MIB-II Information From a `/dev/*` Device" on page 61

▼ How to View Device Policy

- **Display the device policy for all devices on your system.**

```
% getdevpolicy | more
DEFAULT
read_priv_set=none
write_priv_set=none
ip:*
read_priv_set=net_rawaccess
write_priv_set=net_rawaccess
…
```

Example 4-1 Viewing the Device Policy for a Specific Device

In this example, the device policy for three devices is displayed.

```
% getdevpolicy /dev/allkmem /dev/ipsecesp /dev/bge
/dev/allkmem
read_priv_set=all
write_priv_set=all
/dev/ipsecesp
read_priv_set=sys_net_config
write_priv_set=sys_net_config
/dev/bge
read_priv_set=net_rawaccess
write_priv_set=net_rawaccess
```

▼ How to Audit Changes in Device Policy

By default, the `as` audit class includes the `AUE_MODDEVPLCY` audit event.

Before You Begin You must become an administrator who is assigned the Audit Configuration rights profile. For more information, see "Using Your Assigned Administrative Rights" in "Securing Users and Processes in Oracle Solaris 11.2 ".

- **Preselect the audit class that includes the `AUE_MODDEVPLCY` audit event.**

```
# auditconfig -getflags
current-flags
# auditconfig -setflags current-flags,as
```

For detailed instructions, see "How to Preselect Audit Classes" in "Managing Auditing in Oracle Solaris 11.2 ".

How to Retrieve IP MIB-II Information From a `/dev/*` Device

Applications that retrieve Oracle Solaris IP MIB-II information should open `/dev/arp`, not `/dev/ip`.

1. **Determine the device policy on `/dev/ip` and `/dev/arp`.**

```
% getdevpolicy /dev/ip /dev/arp
/dev/ip
read_priv_set=net_rawaccess
write_priv_set=net_rawaccess
/dev/arp
read_priv_set=none
write_priv_set=none
```

Note that the `net_rawaccess` privilege is required for reading and writing to `/dev/ip`. No privileges are required for `/dev/arp`.

2. **Open `/dev/arp` and push the `tcp` and `udp` modules.**

No privileges are required. This method is equivalent to opening `/dev/ip` and pushing the `arp`, `tcp`, and `udp` modules. Because opening `/dev/ip` now requires a privilege, the `/dev/arp` method is preferred.

Managing Device Allocation

Device allocation is commonly implemented at sites that require an additional layer of device security. Typically, users must have authorization to access allocatable devices.

The following task map points to procedures that enable, configure, and troubleshoot device allocation. Device allocation is not enabled by default. After device allocation is enabled, see “Allocating Devices” on page 66 for instructions on allocating devices.

TABLE 4-2 Managing Device Allocation Task Map

Task	Description	For Instructions
Make a device allocatable.	Enables a device to be allocated to one user at a time.	“How to Enable Device Allocation” on page 62
Disable device allocation.	Removes allocation restrictions from all devices.	

Task	Description	For Instructions
Authorize users to allocate a device.	Assigns device allocation authorizations to users.	"How to Authorize Users to Allocate a Device" on page 63
View the allocatable devices on your system.	Lists the devices that are allocatable, and the state of the device.	"How to View Allocation Information About a Device" on page 63
Forcibly allocate a device.	Allocates a device to a user who has an immediate need.	"How to Forcibly Allocate a Device" on page 64
Forcibly deallocate a device.	Deallocates a device that is currently allocated to a user.	"How to Forcibly Deallocate a Device" on page 65
Change the allocation properties of a device.	Changes the requirements for allocating a device.	"How to Change Which Devices Can Be Allocated" on page 65
Audit device allocation.	Records device allocation in the audit trail	"How to Audit Device Allocation" on page 66
Create a device-clean script.	Purges data from a physical device.	"Writing New Device-Clean Scripts" on page 77

▼ How to Enable Device Allocation

Before You Begin You must become an administrator who is assigned the Device Security rights profile. For more information, see "Using Your Assigned Administrative Rights" in "Securing Users and Processes in Oracle Solaris 11.2 ".

1. **Enable the device allocation service and verify that the service is enabled.**

```
# svcadm enable svc:/system/device/allocate
# svcs -x allocate
svc:/system/device/allocate:default (device allocation)
State: online since September 10, 2011 01:10:11 PM PDT
See: allocate(1)
See: deallocate(1)
See: list_devices(1)
See: device_allocate(1M)
See: mkdevalloc(1M)
See: mkdevmaps(1M)
See: dminfo(1M)
See: device_maps(4)
See: /var/svc/log/system-device-allocate:default.log
Impact: None.
```

2. **To disable the device allocation service, use the `disable` subcommand.**

```
# svcadm disable device/allocate
```

▼ How to Authorize Users to Allocate a Device

Before You Begin You must become an administrator who is assigned the User Security rights profile. Your rights profiles must include the `solaris.auth.delegate` authorization. For more information, see "Using Your Assigned Administrative Rights" in "Securing Users and Processes in Oracle Solaris 11.2 ".

1. **Create a rights profile that contains the appropriate authorization and commands.**

   Typically, you would create a rights profile that includes the `solaris.device.allocate` authorization. Follow the instructions in "How to Create a Rights Profile" in "Securing Users and Processes in Oracle Solaris 11.2 ". Give the rights profile appropriate properties, such as the following:

   - Rights profile name: `Device Allocation`
   - Granted authorizations: `solaris.device.allocate`
   - Commands with privileges: `mount` with the `sys_mount` privilege, and `umount` with the `sys_mount` privilege

2. **(Optional) Create a role for the rights profile.**

   Follow the instructions in "Assigning Rights to Users" in "Securing Users and Processes in Oracle Solaris 11.2 ". Use the following role properties as a guide:

   - Role name: `devicealloc`
   - Role full name: `Device Allocator`
   - Role description: `Allocates and mounts allocated devices`
   - Rights profile: `Device Allocation`

     This rights profile must be the first in the list of profiles that are included in the role.

3. **Assign the rights profile to authorized users or authorized roles.**

4. **Teach the users how to use device allocation.**

   For examples of allocating removable media, see "How to Allocate a Device" on page 67.

▼ How to View Allocation Information About a Device

Before You Begin Complete "How to Enable Device Allocation" on page 62.

You must become an administrator who is assigned the Device Security rights profile. For more information, see "Using Your Assigned Administrative Rights" in "Securing Users and Processes in Oracle Solaris 11.2 ".

● **Display information about allocatable devices on your system.**

```
# list_devices device-name
```

where *device-name* is one of the following:

- `audio`[*n*] – Microphone and speaker.
- `rmdisk`[*n*] – Removable media device, such as a USB flash drive.
- `sr`[*n*] – CD-ROM drive.
- `st`[*n*] – Tape drive.

Troubleshooting If the `list_devices` command returns an error message similar to the following, then either device allocation is not enabled, or you do not have sufficient permissions to retrieve the information.

```
list_devices: No device maps file entry for specified device.
```

For the command to succeed, enable device allocation and assume a role with the `solaris.device.revoke` authorization.

▼ How to Forcibly Allocate a Device

Forcible allocation is used when someone has forgotten to deallocate a device. Forcible allocation can also be used when a user has an immediate need for a device.

Before You Begin You must become an administrator who is assigned the `solaris.device.revoke` authorization. For more information, see "Using Your Assigned Administrative Rights" in "Securing Users and Processes in Oracle Solaris 11.2 ".

1. **Determine whether you have the appropriate authorizations in your role.**

```
$ auths
solaris.device.allocate solaris.device.revoke
```

2. **Forcibly allocate the device to the user who needs the device.**

In this example, a USB flash drive is forcibly allocated to the user `jdoe`.

```
$ allocate -U jdoe
```

▼ How to Forcibly Deallocate a Device

Devices that a user has allocated are not automatically deallocated when the process terminates or when the user logs out. Forcible deallocation is used when a user has forgotten to deallocate a device.

Before You Begin You must become an administrator who is assigned the `solaris.device.revoke` authorization. For more information, see "Using Your Assigned Administrative Rights" in "Securing Users and Processes in Oracle Solaris 11.2 ".

1. **Determine whether you have the appropriate authorizations in your role.**

```
$ auths
solaris.device.allocate solaris.device.revoke
```

2. **Forcibly deallocate the device.**

   In this example, a printer is forcibly deallocated so it is available for allocation by another user.

```
$ deallocate -f /dev/lp/printer-1
```

▼ How to Change Which Devices Can Be Allocated

Before You Begin Device allocation must be enabled for this procedure to succeed. To enable device allocation, see "How to Enable Device Allocation" on page 62. You must assume the `root` role.

- **Change the fifth field in the device entry in the `device_allocate` file to specify whether authorization is required, or specify the `solaris.device.allocate` authorization.**

```
audio;audio;reserved;reserved;solaris.device.allocate;/etc/security/lib/audio_clean
fd0;fd;reserved;reserved;solaris.device.allocate;/etc/security/lib/fd_clean
sr0;sr;reserved;reserved;solaris.device.allocate;/etc/security/lib/sr_clean
```

where `solaris.device.allocate` indicates that a user must have the `solaris.device.allocate` authorization to use the device.

Example 4-2 Permitting Any User to Allocate a Device

In the following example, any user on the system can allocate any device. The fifth field in every device entry in the `device_allocate` file has been changed to an at sign (`@`).

```
# pfedit /etc/security/device_allocate
audio;audio;reserved;reserved;@;/etc/security/lib/audio_clean
fd0;fd;reserved;reserved;@;/etc/security/lib/fd_clean
sr0;sr;reserved;reserved;@;/etc/security/lib/sr_clean
```

```
…
```

Example 4-3 Preventing Some Peripheral Devices From Being Used

In the following example, the audio device cannot be used. The fifth field in the audio device entry in the `device_allocate` file has been changed to an asterisk (`*`).

```
# pfedit /etc/security/device_allocate
audio;audio;reserved;reserved;*;/etc/security/lib/audio_clean
fd0;fd;reserved;reserved;solaris device.allocate;/etc/security/lib/fd_clean
sr0;sr;reserved;reserved;solaris device.allocate;/etc/security/lib/sr_clean
…
```

Example 4-4 Preventing All Peripheral Devices From Being Used

In the following example, no peripheral device can be used. The fifth field in every device entry in the `device_allocate` file has been changed to an asterisk (`*`).

```
# pfedit /etc/security/device_allocate
audio;audio;reserved;reserved;*;/etc/security/lib/audio_clean
fd0;fd;reserved;reserved;*;/etc/security/lib/fd_clean
sr0;sr;reserved;reserved;*;/etc/security/lib/sr_clean
…
```

▼ How to Audit Device Allocation

By default, the device allocation commands are in the `other` audit class.

Before You Begin You must become an administrator who is assigned the Audit Configuration rights profile. For more information, see "Using Your Assigned Administrative Rights" in "Securing Users and Processes in Oracle Solaris 11.2 ".

- **Preselect the `ot` audit class.**

```
$ auditconfig -getflags
current-flags
$ auditconfig -setflags current-flags,ot
```

For detailed instructions, see "How to Preselect Audit Classes" in "Managing Auditing in Oracle Solaris 11.2 ".

Allocating Devices

Device allocation reserves the use of a device to one user at a time. Devices that require a mount point must be mounted. The following procedures show users how to allocate devices.

▼ How to Allocate a Device

Before You Begin Device allocation must be enabled, as described in "How to Enable Device Allocation" on page 62. If authorization is required, the user must have the authorization.

1. **Allocate the device.**

   Specify the device by device name.

   ```
   % allocate device-name
   ```

2. **Verify that the device is allocated by repeating the command.**

   ```
   % allocate device-name
   allocate. Device already allocated.
   ```

Example 4-5 Allocating a Microphone

In this example, the user `jdoe` allocates a microphone, `audio0`.

```
% whoami
jdoe
% allocate audio0
```

Example 4-6 Allocating a Printer

In this example, a user allocates a printer. No one else can print to `printer-1` until the user deallocates it, or until the printer is forcibly allocated to another user.

```
% allocate /dev/lp/printer-1
```

For an example of forcible deallocation, see "How to Forcibly Deallocate a Device" on page 65.

Example 4-7 Allocating a USB Flash Drive

In this example, a user allocates a USB flash drive, `rmdisk1`.

```
% allocate rmdisk1
```

Troubleshooting If the `allocate` command cannot allocate the device, an error message is displayed in the console window. For a list of allocation error messages, see the `allocate`(1) man page.

▼ How to Mount an Allocated Device

Devices mount automatically if you are granted the appropriate privileges. Follow this procedure if the device fails to mount.

Before You Begin You have allocated the device. You are assigned the privileges that are required for mounting the device, as described in "How to Authorize Users to Allocate a Device" on page 63.

1. **Assume a role that can allocate and mount a device.**

```
% su - role-name
Password:       <Type role-name password>
$
```

2. **Create and protect a mount point in the role's home directory.**

   You only need to do this step the first time that you need a mount point.

```
$ mkdir mount-point ; chmod 700 mount-point
```

3. **List the allocatable devices.**

```
$ list_devices -l
List of allocatable devices
```

4. **Allocate the device.**

   Specify the device by device name.

```
$ allocate device-name
```

5. **Mount the device.**

```
$ mount -o ro -F filesystem-type device-path mount-point
```

`-o ro` Indicates that the device is to be mounted read-only. Use`-o rw` to make the device writable.

`-F` *filesystem-type* Indicates the file system format of the device. Typically, a CD-ROM is formatted with an HSFS file system. A diskette is typically formatted with a PCFS file system.

device-path Indicates the path to the device. The output of the `list_devices -l` command includes the *device-path*.

mount-point Indicates the mount point that you created in Step 2.

Example 4-8 Allocating a CD-ROM Drive

In this example, a user assumes a role that can allocate and mount a CD-ROM drive, `sr0`. The drive is formatted as an HSFS file system.

```
% roles
devicealloc
% su - devicealloc
Password:       <Type devicealloc password>
$ mkdir /home/devicealloc/mymnt
$ chmod 700 /home/devicealloc/mymnt
$ list_devices -l
...
device: sr0 type: sr files: /dev/sr0 /dev/rsr0 /dev/dsk/c0t2d0s0 ...
...
$ allocate sr0
$ mount -o ro -F hsfs /dev/sr0 /home/devicealloc/mymnt
$ cd /home/devicealloc/mymnt ; ls
List of the contents of CD-ROM
```

Troubleshooting If the `mount` command cannot mount the device, the `mount: insufficient privileges` error message is displayed: Check the following:

- Verify that you are executing the `mount` command in a profile shell. If you have assumed a role, the role has a profile shell. If you are a user who has been assigned a profile with the `mount` command, you must create a profile shell. For the list of available profile shells, see the `pfexec`(1) man page.
- Verify that you own the specified mount point. You must have read, write, and execute access to the mount point.

Contact your administrator if you still cannot mount the allocated device. See "How to Troubleshoot Rights Assignments" in "Securing Users and Processes in Oracle Solaris 11.2 " is a starting point.

▼ How to Deallocate a Device

Deallocation enables other users to allocate and use the device when you are finished.

Before You Begin You must have allocated the device. For information, see "How to Allocate a Device" on page 67.

1. **If the device is mounted, unmount the device.**

```
$ cd $HOME
$ umount mount-point
```

2. **Deallocate the device.**

```
$ deallocate device-name
```

Example 4-9 Deallocating a Microphone

In this example, the user `jdoe` deallocates the microphone, `audio`.

```
% whoami
jdoe
% deallocate audio0
```

Example 4-10 Deallocating a CD-ROM Drive

In this example, the Device Allocator role deallocates a CD-ROM drive. After the message is printed, the CD-ROM is ejected.

```
$ whoami
devicealloc
$ cd /home/devicealloc
$ umount /home/devicealloc/mymnt
$ ls /home/devicealloc/mymnt
$
$ deallocate sr0
/dev/sr0:      326o
/dev/rsr0:     326o
…
sr_clean: Media in sr0 is ready.  Please, label and store safely.
```

Device Protection Reference

Devices in Oracle Solaris are protected by kernel device policy. Peripheral devices can be protected by device allocation. Device allocation is optionally enabled, and is enforced at the user level.

Device Policy Commands

Device management commands administer the device policy on local files. Device policy can include privilege requirements. Users who are assigned the Device Management and Device Security rights profiles can manage devices.

The following table lists the device management commands.

TABLE 4-3 Device Management Commands

Command	Purpose
add_drv(1M)	Adds a new device driver to a running system. Contains options to add device policy to the new device. Typically, this command is called in a script when a device driver is being installed.
devfsadm(1M)	Administers devices and device drivers on a running system. Also loads device policy. The devfsadm command enables the cleanup of dangling /dev links to disk, tape, port, audio, and pseudo devices. Devices for a named driver can also be reconfigured.
getdevpolicy(1M)	Displays the policy associated with one or more devices. This command can be run by any user.
rem_drv(1M)	Removes a device or device driver.
update_drv(1M)	Updates the attributes of an existing device driver. Contains options to update the device policy for the device. Typically, this command is called in a script when a device driver is being installed.

Device Allocation

Device allocation can protect your site from loss of data, computer viruses, and other security breaches. Unlike device policy, device allocation is optional. Device allocation uses authorizations to limit access to allocatable devices.

Components of Device Allocation

The components of the device allocation mechanism are as follows:

- The svc:/system/device/allocate service. For more information, see the smf(5) man page and the man pages for the device allocation commands.
- The allocate, deallocate, dminfo, and list_devices commands. For more information, see "Device Allocation Commands" on page 72.
- The Device Management and Device Security rights profiles. For more information, see "Device Allocation Rights Profiles" on page 72.
- Device-clean scripts for each allocatable device.

These commands and scripts use the following local files to implement device allocation:

- The /etc/security/device_allocate file. For more information, see the device_allocate(4) man page.
- The /etc/security/device_maps file. For more information, see the device_maps(4) man page.

- A lock file, in the `/etc/security/dev` directory, for each allocatable device.
- The changed attributes of the lock files that are associated with each allocatable device.

Device Allocation Service

The `svc:/system/device/allocate` service controls device allocation. This service is disabled by default.

Device Allocation Rights Profiles

The Device Management and Device Security rights profiles are required to manage devices and device allocation.

These rights profiles include the following authorizations:

- `solaris.device.allocate` – Required to allocate a device
- `solaris.device.cdrw` – Required to read and write a CD-ROM
- `solaris.device.config` – Required to configure the attributes of a device
- `solaris.device.mount.alloptions.fixed` – Required to specify mount options when mounting a fixed device
- `solaris.device.mount.alloptions.removable` – Required to specify mount options when mounting a removable device
- `solaris.device.mount.fixed` – Required to mount a fixed device
- `solaris.device.mount.removable` – Required to mount a removable device
- `solaris.device.revoke` – Required to revoke or reclaim a device

Device Allocation Commands

With uppercase options, the `allocate`, `deallocate`, and `list_devices` commands are administrative commands. Otherwise, these commands are user commands. The following table lists the device allocation commands.

TABLE 4-4 Device Allocation Commands

Man Page for Command	Purpose
`allocate`(1)	Reserves an allocatable device for use by one user. By default, a user must have the `solaris.device.allocate` authorization to allocate a device. You can modify the `device_allocate` file to not require user authorization. Then, any user on the system can request the device to be allocated for use.

Man Page for Command	Purpose
deallocate(1)	Removes the allocation reservation from a device.
dminfo(1M)	Searches for an allocatable device by device type, by device name, and by full path name.
list_devices(1)	Lists the status of allocatable devices. Lists all the device-special files that are associated with any device that is listed in the device_maps file. With the -U option, lists the devices that are allocatable or allocated to the specified user ID. This option allows you to check which devices are allocatable or allocated to another user. You must have the solaris.device.revoke authorization.

Authorizations for the Allocation Commands

By default, users must have the solaris.device.allocate authorization to reserve an allocatable device. To create a rights profile to include the solaris.device.allocate authorization, see "How to Authorize Users to Allocate a Device" on page 63.

Administrators must have the solaris.device.revoke authorization to change the allocation state of any device. For example, the -U option of the allocate and list_devices commands, and the -F option of the deallocate command require the solaris.device.revoke authorization.

For more information, see "Selected Commands That Require Authorizations" in "Securing Users and Processes in Oracle Solaris 11.2 ".

Allocate Error State

A device is put in an *allocate error state* when the deallocate command fails to deallocate, or when the allocate command fails to allocate. When an allocatable device is in an allocate error state, then the device must be forcibly deallocated. Only a user or role with the Device Management rights profile or the Device Security rights profile can handle an allocate error state.

The deallocate command with the -F option forces deallocation. Or, you can use allocate -U to assign the device to a user. Once the device is allocated, you can investigate any error messages that appear. After any problems with the device are corrected, you can forcibly deallocate it.

device_maps File

Device maps are created when you set up device allocation. The /etc/security/device_maps file includes the device names, device types, and device-special files that are associated with each allocatable device.

The device_maps file defines the device-special file mappings for each device, which in many cases is not intuitive. This file allows programs to discover which device-special files map to which devices. You can use the dminfo command, for example, to retrieve the device name, the device type, and the device-special files to specify when you set up an allocatable device. The dminfo command uses the device_maps file to report this information.

Each device is represented by a one-line entry in the following format:

device-name:*device-type*:*device-list*

EXAMPLE 4-11 Sample device_maps Entry

The following example shows an entry in a device_maps file.

```
audio0:\
audio:\
/dev/audio /dev/audioctl /dev/dsp /dev/dsp0 /dev/mixer0 /dev/sound/0
/dev/sound/0ctl /dev/sound/audio810\:0mixer /dev/sound/audio810\:0dsp
/dev/sound/audio810\:0 /dev/sound/audio810\:0ctl
```

Lines in the device_maps file can end with a backslash (\) to continue an entry on the next line. Comments can also be included. A pound sign (#) comments all subsequent text until the next newline that is not immediately preceded by a backslash. Leading and trailing blanks are allowed in any field. The fields are defined as follows:

device-name
Specifies the name of the device. For a list of current device names, see "How to View Allocation Information About a Device" on page 63.

device-type
Specifies the generic device type. The generic name is the name for the class of devices, such as st, fd, rmdisk, or audio. The *device-type* field logically groups related devices.

device-list
Lists the device-special files that are associated with the physical device. The *device-list* must contain all of the special files that allow access to a particular device. If the list is incomplete, a malevolent user can still obtain or modify private information. Valid entries for the *device-list* field reflect the device files that are located in the /dev directory.

`device_allocate` File

You can modify the `/etc/security/device_allocate` file to change devices from allocatable to nonallocatable, or to add new devices.

An entry in the `device_allocate` file does not mean that the device is allocatable, unless the entry specifically states that the device is allocatable.

In the `device_allocate` file, each device is represented by a one-line entry in the following format:

device-name`;`*device-type*`;reserved;reserved;`*auths*`;`*device-exec*

The following example shows a sample `device_allocate` file.

```
st0;st;;;;/etc/security/lib/st_clean
fd0;fd;;;;/etc/security/lib/fd_clean
sr0;sr;;;;/etc/security/lib/sr_clean
audio;audio;;;*;/etc/security/lib/audio_clean
```

Note the asterisk (`*`) in the fifth field of the `audio` device entry.

Lines in the `device_allocate` file can end with a backslash (`\`) to continue an entry on the next line. Comments can also be included. A pound sign (`#`) comments all subsequent text until the next newline that is not immediately preceded by a backslash. Leading and trailing blanks are allowed in any field. The fields are defined as follows:

device-name
: Specifies the name of the device. For a list of current device names, see "How to View Allocation Information About a Device" on page 63.

device-type
: Specifies the generic device type. The generic name is the name for the class of devices, such as `st`, `fd`, and `sr`. The *device-type* field logically groups related devices. When you make a device allocatable, retrieve the device name from the *device-type* field in the `device_maps` file.

`reserved`
: Oracle reserves the two fields that are marked `reserved` for future use.

auths
: Specifies whether the device is allocatable. An asterisk (`*`) in this field indicates that the device is not allocatable. An authorization string, or an empty field, indicates that the device is allocatable. For example, the string `solaris.device.allocate` in the *auths* field indicates that the `solaris.device.allocate` authorization is required to allocate the device. An at sign (`@`) in this file indicates that the device is allocatable by any user.

device-exec
: Supplies the path name of a script to be invoked for special handling, such as cleanup and object reuse protection during the allocation process.

The *device-exec* script is run any time that the device is acted on by the `deallocate` command.

For example, the following entry for the `sr0` device indicates that the CD-ROM drive is allocatable by a user with the `solaris.device.allocate` authorization:

```
sr0;sr;reserved;reserved;solaris.device.allocate;/etc/security/lib/sr_clean
```

You can decide to accept the default devices and their defined characteristics. After you install a new device, you can modify the entries. Any device that needs to be allocated before use must be defined in the `device_allocate` and `device_maps` files for that device's system. Currently, cartridge tape drives, diskette drives, CD-ROM drives, removable media devices, and audio chips are considered allocatable. These device types have device-clean scripts.

Note - Xylogics and Archive tape drives also use the `st_clean` script that is supplied for SCSI devices. You need to create your own device-clean scripts for other devices, such as terminals, graphics tablets, and other allocatable devices. The script must fulfill object reuse requirements for that type of device.

Device-Clean Scripts

Device allocation satisfies part of what security auditors call the *object reuse* requirement. The device-clean scripts address the security requirement that all usable data be purged from a physical device before reuse. The data is cleared before the device is allocatable by another user. By default, cartridge tape drives, diskette drives, CD-ROM drives, and audio devices require device-clean scripts, which Oracle Solaris provides. This section describes what device-clean scripts do.

Device-Clean Script for Tapes

The `st_clean` device-clean script supports three tape devices:

- SCSI ¼-inch tape
- Archive ¼-inch tape
- Open-reel ½-inch tape

The `st_clean` script uses the `rewoffl` option to the `mt` command to clean up the device. For more information, see the `mt`(1) man page. If the script runs during system boot, the script queries the device to determine whether the device is online. If the device is online, the script determines whether the device has media in it. The ¼-inch tape devices that have media in them are placed in the allocate error state. The allocate error state forces the administrator to manually clean up the device.

During normal system operation, when the `deallocate` command is executed in interactive mode, the user is prompted to remove the media. Deallocation is delayed until the media is removed from the device.

Device-Clean Scripts for Diskettes and CD-ROM Drives

The following device-clean scripts are provided for diskettes and CD-ROM drives:

- **`fd_clean`** script – Device-clean script for diskettes.
- **`sr_clean`** script – Device-clean script for CD-ROM drives.

The scripts use the `eject` command to remove the media from the drive. If the `eject` command fails, the device is placed in the allocate error state. For more information, see the `eject`(1) man page.

Device-Clean Script for Audio

Audio devices are cleaned up with an `audio_clean` script. The script performs an `AUDIO_GETINFO` ioctl system call to read the device. The script then performs an `AUDIO_SETINFO` ioctl system call to reset the device configuration to the default.

Writing New Device-Clean Scripts

If you add more allocatable devices to the system, you might need to create your own device-clean scripts. The `deallocate` command passes a parameter to the device-clean scripts. The parameter, which is shown here, is a string that contains the device name. For more information, see the `device_allocate`(4) man page.

clean-script `-[I|i|f|S]` *device-name*

Device-clean scripts must return “`0`” for success and greater than “`0`” for failure. The options `-I`, `-f`, and `-S` determine the running mode of the script:

`-I` Needed during system boot only. All output must go to the system console. Failure or inability to forcibly eject the media must put the device in the allocate error state.

`-i` Similar to the `-I` option, except that output is suppressed.

`-f` For forced cleanup. The option is interactive and assumes that the user is available to respond to prompts. A script with this option must attempt to complete the cleanup if one part of the cleanup fails.

`-S` Standard cleanup. The option is interactive and assumes that the user is available to respond to prompts.

♦ ♦ ♦ CHAPTER 5

Virus Scanning Service

This chapter provides information about using antivirus software, and covers the following topics:

- "About Virus Scanning" on page 79
- "About the vscan Service" on page 80
- "Using the vscan Service" on page 80

About Virus Scanning

Data is protected from viruses by a scanning service, vscan, that uses various *scan engines*. A scan engine is a third-party application, residing on an external host, that examines a file for known viruses. A file is a candidate for virus scanning if the file system supports the vscan service, the service has been enabled, and the type of file has not been exempted. The virus scan is then performed on a file during open and close operations if the file has not been scanned with the current virus definitions previously or if the file has been modified since it was last scanned.

The vscan service can be configured to use multiple scan engines. Best practice is to use a minimum of two scan engines. The requests for virus scans are distributed among all available scan engines.

The vscanadm show command lists scan engines configured on the system.

```
# vscanadm show
max-size=1GB max-size-action=allow
types=+*
no scan engines configured
```

About the vscan Service

The benefit of the real-time scan method is that a file is scanned with the latest virus definitions *before* it is used. By using this approach, viruses can be detected before they compromise data.

When a user opens a file from the client, the virus scanning process operates as follows:

1. The vscan service determines whether the file needs to be scanned, based on whether the file has been scanned with the current virus definitions previously and if the file has been modified since it was last scanned.

   If scanning is not necessary, then the process ends and the user is permitted to access the file
2. If scanning is necessary, the file is transferred to the scan engine.

   If the transfer is successful, then the engine scans the file using the current virus definitions to determine whether the file is infected.

   If the transfer fails, the process continues as follows:

   - The file is transferred to the next available scan engine that can perform the file scanning.
   - If no alternative engines exist or are available, virus scanning is considered failed and access to the file might be denied.
3. If no virus is detected, the file is tagged with a scan stamp and the client is permitted to access the file.

   If a virus is detected, the file is marked as quarantined. A quarantined file cannot be read, executed, or renamed but it can be deleted. The system log records the name of the quarantined file and the name of the virus and, if auditing has been enabled, an audit record with the same information is created.

Using the vscan Service

Scanning files for viruses is available when the following requirements are met:

- At least one scan engine is installed and configured.
- The files reside on a file system that supports virus scanning.
- Virus scanning is enabled on the file system.
- The vscan service is enabled.
- The vscan service is configured to scan files of the specified file type.

The following table points to the tasks you perform to set up the vscan service.

Task	Description	For Instructions
Install a scan engine.	Installs and configures one or more of the supported third-party antivirus products in Oracle Solaris.	See the product documentation.
Enable the file system to allow virus scans.	Enables virus scans on a ZFS file system. By default, scans are disabled.	"How to Enable Virus Scanning on a File System" on page 81
Enable the `vscan` service.	Starts the scan service.	"How to Enable the `vscan` Service" on page 82
Add a scan engine to the `vscan` service.	Includes specific scan engines in the `vscan` service.	"How to Add a Scan Engine" on page 82
Configure the `vscan` service.	Views and changes `vscan` properties.	"How to View Vscan Properties" on page 82 "How to Limit the Size of Scanned Files" on page 83
Configure the `vscan` service for specific file types.	Specifies the file types to include and exclude in a scan.	"How to Exclude Files From Virus Scans" on page 83

▼ How to Enable Virus Scanning on a File System

Use the file system command to allow virus scans of files. For example, to include a ZFS file system in a virus scan, use the `zfs`(1M) command.

The ZFS file system allows some administrative tasks to be delegated to specific users. For more information about delegated administration, see Chapter 8, "Oracle Solaris ZFS Delegated Administration," in "Managing ZFS File Systems in Oracle Solaris 11.2 ".

Before You Begin You must become an administrator who is assigned the ZFS File System Management or the ZFS Storage Management rights profile. For more information, see "Using Your Assigned Administrative Rights" in "Securing Users and Processes in Oracle Solaris 11.2 ".

● Enable virus scanning on a ZFS file system.

```
# zfs set vscan=on zfs-file-system
```

For example, if the ZFS file system is *path*`/pool/volumes/vol1`, then type the following command:

```
# zfs set vscan=on path/pool/volumes/vol1
```

How to Enable the vscan Service

Before You Begin You must become an administrator who is assigned the VSCAN Management rights profile. For more information, see "Using Your Assigned Administrative Rights" in "Securing Users and Processes in Oracle Solaris 11.2 ".

- **Enable the virus scanning service.**

  ```
  # svcadm enable vscan
  ```

How to Add a Scan Engine

Before You Begin You must become an administrator who is assigned the VSCAN Management rights profile. For more information, see "Using Your Assigned Administrative Rights" in "Securing Users and Processes in Oracle Solaris 11.2 ".

- **To add a scan engine to the vscan service with default properties, type:**

  ```
  # vscanadm add-engine engineID
  ```

  For more information, see the vscanadm(1M) man page.

How to View Vscan Properties

Before You Begin You must become an administrator who is assigned the VSCAN Management rights profile. For more information, see "Using Your Assigned Administrative Rights" in "Securing Users and Processes in Oracle Solaris 11.2 ".

- **View the properties of the vscan service, of all scan engines, or of a specific scan engine.**
  - **To view the properties of a particular scan engine, type:**

    ```
    # vscanadm get-engine engineID
    ```

  - **To view the properties of all scan engines, type:**

    ```
    # vscanadm get-engine
    ```

  - **To view one of the properties of the vscan service, type:**

    ```
    # vscanadm get -p property
    ```

where *property* is one of the parameters described in the man page for the vscanadm(1M) command.

For example, if you want to see the maximum size of a file that can be scanned, type:

```
# vscanadm get max-size
```

▼ How to Limit the Size of Scanned Files

Many scan engines limit the size of the files they scan, so the vscan service's max-size property must be set to a value less than or equal to the scan engine's maximum allowed size. You then define whether files that are larger than the maximum size, and therefore not scanned, are accessible.

Before You Begin You must become an administrator who is assigned the VSCAN Management rights profile. For more information, see "Using Your Assigned Administrative Rights" in "Securing Users and Processes in Oracle Solaris 11.2 ".

1. **View the current properties.**

```
# vscanadm show
```

2. **Set the maximum size for virus scans.**

   For example, to set a limit of 128 megabytes:

```
# vscanadm set -p max-size=128M
```

3. **Specify that access is denied to any file that is not scanned due to its size.**

```
# vscanadm set -p max-size-action=deny
```

   For more information, see the vscanadm(1M) man page.

▼ How to Exclude Files From Virus Scans

When you enable antivirus protection, you can specify that all files of specific types are excluded from the virus scan. Because the vscan service affects the performance of the system, you can conserve system resources by targeting specific file types for virus scans.

Before You Begin You must become an administrator who is assigned the VSCAN Management rights profile. For more information, see "Using Your Assigned Administrative Rights" in "Securing Users and Processes in Oracle Solaris 11.2 ".

1. **View the list of all file types that are included in the virus scan.**

   ```
   # vscanadm get -p types
   ```

2. **Specify the types of files to be scanned for virus.**

   For example:

   - **To exclude a specific file type, for example the JPEG type, from the virus scan.**

     ```
     # vscanadm set -p types=-jpg,+*
     ```

   - **To include a specific file type, for example executable files, in the virus scan.**

     ```
     # vscanadm set -p types=+exe,-*
     ```

   For more information, see the `vscanadm`(1M) man page.

Security Glossary

Access Control List (ACL) An access control list (ACL) provides finer-grained file security than traditional UNIX file protection provides. For example, an ACL enables you to allow group read access to a file, while allowing only one member of that group to write to the file.

admin principal A user principal with a name of the form *username*`/admin` (as in `jdoe/admin`). An admin principal can have more privileges (for example, to change policies) than a regular user principal. See also principal name, user principal.

AES Advanced Encryption Standard. A symmetric 128-bit block data encryption technique. The U.S. government adopted the Rijndael variant of the algorithm as its encryption standard in October 2000. AES replaces user principal encryption as the government standard.

algorithm A cryptographic algorithm. This is an established, recursive computational procedure that encrypts or hashes input.

application server See network application server.

asynchronous audit event Asynchronous events are the minority of system events. These events are not associated with any process, so no process is available to be blocked and later woken up. Initial system boot and PROM enter and exit events are examples of asynchronous events.

audit files Binary audit logs. Audit files are stored separately in an audit file system.

audit policy The global and per-user settings that determine which audit events are recorded. The global settings that apply to the audit service typically affect which pieces of optional information are included in the audit trail. Two settings, `cnt` and `ahlt`, affect the operation of the system when the audit queue fills. For example, audit policy might require that a sequence number be part of every audit record.

audit trail The collection of all audit files from all hosts.

authenticated rights profile A rights profile that requires the assigned user or role to type a password before executing an operation from the profile. This behavior is similar to `sudo` behavior. The length of time that the password is valid is configurable.

authentication The process of verifying the claimed identity of a principal.

authenticator Authenticators are passed by clients when requesting tickets (from a KDC) and services (from a server). They contain information that is generated by using a session key known only by the client and server, that can be verified as of recent origin, thus indicating that the transaction is secure. When used with a ticket, an authenticator can be used to authenticate a user principal. An authenticator includes the principal name of the user, the IP address of the user's host, and a time stamp. Unlike a ticket, an authenticator can be used only once, usually when access to a service is requested. An authenticator is encrypted by using the session key for that client and that server.

authorization 1. In Kerberos, the process of determining if a principal can use a service, which objects the principal is allowed to access, and the type of access that is allowed for each object.

2. In user rights management, a right that can be assigned to a role or user (or embedded in a rights profile) for performing a class of operations that are otherwise prohibited by security policy. Authorizations are enforced at the user application level, not in the kernel.

basic set The set of privileges that are assigned to a user's process at login. On an unmodified system, each user's initial inheritable set equals the basic set at login.

Blowfish A symmetric block cipher algorithm that takes a variable-length key from 32 bits to 448 bits. Its author, Bruce Schneier, claims that Blowfish is optimized for applications where the key does not change often.

client Narrowly, a process that makes use of a network service on behalf of a user; for example, an application that uses `rlogin`. In some cases, a server can itself be a client of some other server or service.

More broadly, a host that a) receives a Kerberos credential, and b) makes use of a service that is provided by a server.

Informally, a principal that makes use of a service.

client principal (RPCSEC_GSS API) A client (a user or an application) that uses RPCSEC_GSS-secured network services. Client principal names are stored in the form of `rpc_gss_principal_t` structures.

clock skew The maximum amount of time that the internal system clocks on all hosts that are participating in the Kerberos authentication system can differ. If the clock skew is exceeded between any of the participating hosts, requests are rejected. Clock skew can be specified in the `krb5.conf` file.

confidentiality See privacy.

consumer In the Cryptographic Framework feature of Oracle Solaris, a consumer is a user of the cryptographic services that come from providers. Consumers can be applications, end users, or kernel operations. Kerberos, IKE, and IPsec are examples of consumers. For examples of providers, see provider.

credential An information package that includes a ticket and a matching session key. Used to authenticate the identity of a principal. See also ticket, session key.

credential cache A storage space (usually a file) that contains credentials that are received from the KDC.

cryptographic algorithm See algorithm.

DES Data Encryption Standard. A symmetric-key encryption method developed in 1975 and standardized by ANSI in 1981 as ANSI X.3.92. DES uses a 56-bit key.

device allocation Device protection at the user level. Device allocation enforces the exclusive use of a device by one user at a time. Device data is purged before device reuse. Authorizations can be used to limit who is permitted to allocate a device.

device policy Device protection at the kernel level. Device policy is implemented as two sets of privileges on a device. One set of privileges controls read access to the device. The second set of privileges controls write access to the device. See also policy.

Diffie-Hellman protocol Also known as public key cryptography. An asymmetric cryptographic key agreement protocol that was developed by Diffie and Hellman in 1976. The protocol enables two users to exchange a secret key over an insecure medium without any prior secrets. Diffie-Hellman is used by Kerberos.

digest See message digest.

DSA Digital Signature Algorithm. A public key algorithm with a variable key size from 512 to 4096 bits. The U.S. Government standard, DSS, goes up to 1024 bits. DSA relies on SHA1 for input.

ECDSA Elliptic Curve Digital Signature Algorithm. A public key algorithm that is based on elliptic curve mathematics. An ECDSA key size is significantly smaller than the size of a DSA public key needed to generate a signature of the same length.

effective set The set of privileges that are currently in effect on a process.

flavor Historically, *security flavor* and *authentication flavor* had the same meaning, as a flavor that indicated a type of authentication (AUTH_UNIX, AUTH_DES, AUTH_KERB). RPCSEC_GSS is also a security flavor, even though it provides integrity and privacy services in addition to authentication.

forwardable ticket A ticket that a client can use to request a ticket on a remote host without requiring the client to go through the full authentication process on that host. For example, if the user `david` obtains a forwardable ticket while on user `jennifer`'s machine, `david` can log in to his own machine without being required to get a new ticket (and thus authenticate himself again). See also proxiable ticket.

FQDN Fully qualified domain name. For example, `central.example.com` (as opposed to simply `denver`).

GSS-API The Generic Security Service Application Programming Interface. A network layer that provides support for various modular security services, including the Kerberos service.

GSS-API provides for security authentication, integrity, and privacy services. See also authentication, integrity, privacy.

hardening The modification of the default configuration of the operating system to remove security vulnerabilities that are inherent in the host.

hardware provider In the Cryptographic Framework feature of Oracle Solaris, a device driver and its hardware accelerator. Hardware providers offload expensive cryptographic operations from the computer system, thus freeing CPU resources for other uses. See also provider.

host A system that is accessible over a network.

host principal A particular instance of a service principal in which the principal (signified by the primary name `host`) is set up to provide a range of network services, such as `ftp`, `rcp`, or `rlogin`. An example of a host principal is `host/central.example.com@EXAMPLE.COM`. See also server principal.

inheritable set The set of privileges that a process can inherit across a call to `exec`.

initial ticket A ticket that is issued directly (that is, not based on an existing ticket-granting ticket). Some services, such as applications that change passwords, might require tickets to be marked `initial` so as to assure themselves that the client can demonstrate a knowledge of its secret key. This assurance is important because an initial ticket indicates that the client has recently authenticated itself (instead of relying on a ticket-granting ticket, which might existed for a long time).

instance The second part of a principal name, an instance qualifies the principal's primary. In the case of a service principal, the instance is required. The instance is the host's fully qualified domain name, as in `host/central.example.com`. For user principals, an instance is optional. Note, however, that `jdoe` and `jdoe/admin` are unique principals. See also primary, principal name, service principal, user principal.

integrity A security service that, in addition to user authentication, provides for the validity of transmitted data through cryptographic checksumming. See also authentication, privacy.

invalid ticket A postdated ticket that has not yet become usable. An invalid ticket is rejected by an application server until it becomes validated. To be validated, an invalid ticket must be presented to the KDC by the client in a TGS request, with the `VALIDATE` flag set, after its start time has passed. See also postdated ticket.

KDC Key Distribution Center. A machine that has three Kerberos V5 components:

- Principal and key database
- Authentication service
- Ticket-granting service

Each realm has a master KDC and should have one or more slave KDCs.

Kerberos

An authentication service, the protocol that is used by that service, or the code that is used to implement that service.

The Kerberos implementation in Oracle Solaris that is closely based on Kerberos V5 implementation.

While technically different, “Kerberos” and “Kerberos V5” are often used interchangeably in the Kerberos documentation.

Kerberos (also spelled Cerberus) was a fierce, three-headed mastiff who guarded the gates of Hades in Greek mythology.

Kerberos policy

A set of rules that governs password usage in the Kerberos service. Policies can regulate principals' accesses, or ticket parameters, such as lifetime.

key

1. Generally, one of two main types of keys:

- A *symmetric key* – An encryption key that is identical to the decryption key. Symmetric keys are used to encrypt files.
- An *asymmetric key* or *public key* – A key that is used in public key algorithms, such as Diffie-Hellman or RSA. Public keys include a private key that is known only by one user, a public key that is used by the server or general resource, and a private-public key pair that combines the two. A private key is also called a *secret* key. The public key is also called a *shared* key or *common* key.

2. An entry (principal name) in a keytab file. See also keytab file.

3. In Kerberos, an encryption key, of which there are three types:

- A *private key* – An encryption key that is shared by a principal and the KDC, and distributed outside the bounds of the system. See also private key.
- A *service key* – This key serves the same purpose as the private key, but is used by servers and services. See also service key.
- A *session key* – A temporary encryption key that is used between two principals, with a lifetime limited to the duration of a single login session. See also session key.

keystore

A keystore holds passwords, passphrases, certificates, and other authentication objects for retrieval by applications. A keystore can be specific to a technology, or a location that several applications use.

keytab file

A key table file that contains one or more keys (principals). A host or service uses a keytab file in the much the same way that a user uses a password.

kvno

Key version number. A sequence number that tracks a particular key in order of generation. The highest kvno is the latest and most current key.

least privilege

A security model which gives a specified process only a subset of superuser powers. The least privilege model assigns enough privilege to regular users that they can perform personal administrative tasks, such as mount file systems and change the ownership of files. On the other hand, processes run with just those privileges that they need to complete the task, rather than with the full power of superuser, that is, all privileges. Damage due to programming errors like buffer overflows can be contained to a non-root user, which has no access to critical abilities like reading or writing protected system files or halting the machine.

limit set The outside limit of what privileges are available to a process and its children.

MAC 1. See message authentication code (MAC).

2. Also called labeling. In government security terminology, MAC is Mandatory Access Control. Labels such as Top Secret and Confidential are examples of MAC. MAC contrasts with DAC, which is Discretionary Access Control. UNIX permissions are an example of DAC.

3. In hardware, the unique system address on a LAN. If the system is on an Ethernet, the MAC is the Ethernet address.

master KDC The main KDC in each realm, which includes a Kerberos administration server, `kadmind`, and an authentication and ticket-granting daemon, `krb5kdc`. Each realm must have at least one master KDC, and can have many duplicate, or slave, KDCs that provide authentication services to clients.

MD5 An iterative cryptographic hash function that is used for message authentication, including digital signatures. The function was developed in 1991 by Rivest. Its use is deprecated.

mechanism 1. A software package that specifies cryptographic techniques to achieve data authentication or confidentiality. Examples: Kerberos V5, Diffie-Hellman public key.

2. In the Cryptographic Framework feature of Oracle Solaris, an implementation of an algorithm for a particular purpose. For example, a DES mechanism that is applied to authentication, such as CKM_DES_MAC, is a separate mechanism from a DES mechanism that is applied to encryption, CKM_DES_CBC_PAD.

message authentication code (MAC) MAC provides assurance of data integrity and authenticates data origin. MAC does not protect against eavesdropping.

message digest A message digest is a hash value that is computed from a message. The hash value almost uniquely identifies the message. A digest is useful for verifying the integrity of a file.

minimization The installation of the minimal operating system that is necessary to run the server. Any software that does not directly relate to the operation of the server is either not installed, or deleted after the installation.

name service scope The scope in which a role is permitted to operate, that is, an individual host or all hosts that are served by a specified naming service such as NIS LDAP.

network application server A server that provides a network application, such as `ftp`. A realm can contain several network application servers.

network policies The settings that network utilities configure to protect network traffic. For information about network security, see “Securing the Network in Oracle Solaris 11.2 ”.

nonattributable audit event An audit event whose initiator cannot be determined, such as the AUE_BOOT event.

NTP Network Time Protocol. Software from the University of Delaware that enables you to manage precise time or network clock synchronization, or both, in a network environment. You can use NTP to maintain clock skew in a Kerberos environment. See also clock skew.

PAM Pluggable Authentication Module. A framework that allows for multiple authentication mechanisms to be used without having to recompile the services that use them. PAM enables Kerberos session initialization at login.

passphrase A phrase that is used to verify that a private key was created by the passphrase user. A good passphrase is 10-30 characters long, mixes alphabetic and numeric characters, and avoids simple prose and simple names. You are prompted for the passphrase to authenticate use of the private key to encrypt and decrypt communications.

password policy The encryption algorithms that can be used to generate passwords. Can also refer to more general issues around passwords, such as how often the passwords must be changed, how many password attempts are permitted, and other security considerations. Security policy requires passwords. Password policy might require passwords to be encrypted with the AES algorithm, and might make further requirements related to password strength.

permitted set The set of privileges that are available for use by a process.

policy Generally, a plan or course of action that influences or determines decisions and actions. For computer systems, policy typically means security policy. Your site's security policy is the set of rules that define the sensitivity of the information that is being processed and the measures that are used to protect the information from unauthorized access. For example, security policy might require that systems be audited, that devices must be allocated for use, and that passwords be changed every six weeks.

For the implementation of policy in specific areas of the Oracle Solaris OS, see audit policy, policy in the Cryptographic Framework, device policy, Kerberos policy, password policy, and rights policy.

policy for public key technologies In the Key Management Framework (KMF), policy is the management of certificate usage. The KMF policy database can put constraints on the use of the keys and certificates that are managed by the KMF library.

policy in the Cryptographic Framework In the Cryptographic Framework feature of Oracle Solaris, policy is the disabling of existing cryptographic mechanisms. The mechanisms then cannot be used. Policy in the Cryptographic Framework might prevent the use of a particular mechanism, such as `CKM_DES_CBC`, from a provider, such as DES.

postdated ticket A postdated ticket does not become valid until some specified time after its creation. Such a ticket is useful, for example, for batch jobs that are intended to run late at night, since the ticket, if stolen, cannot be used until the batch job is run. When a postdated ticket is issued, it is issued as `invalid` and remains that way until a) its start time has passed, and b) the client requests validation by the KDC. A postdated ticket is normally valid until the expiration time of the ticket-granting ticket. However, if the postdated ticket is marked `renewable`, its lifetime is normally set to be equal to the duration of the full life time of the ticket-granting ticket. See also invalid ticket, renewable ticket.

primary The first part of a principal name. See also instance, principal name, realm.

principal 1. A uniquely named client/user or server/service instance that participates in a network communication. Kerberos transactions involve interactions between principals (service principals and user principals) or between principals and KDCs. In other words, a principal is a unique entity to which Kerberos can assign tickets. See also principal name, service principal, user principal.

2. (RPCSEC_GSS API) See client principal, server principal.

principal name 1. The name of a principal, in the format *primary/instance@REALM*. See also instance, primary, realm.

2. (RPCSEC_GSS API) See client principal, server principal.

principle of least privilege See least privilege.

privacy A security service, in which transmitted data is encrypted before being sent. Privacy also includes data integrity and user authentication. See also authentication, integrity, service.

private key A key that is given to each user principal, and known only to the user of the principal and to the KDC. For user principals, the key is based on the user's password. See also key.

private-key encryption In private-key encryption, the sender and receiver use the same key for encryption. See also public-key encryption.

privilege 1. In general, a power or capability to perform an operation on a computer system that is beyond the powers of a regular user. Superuser privileges are all the rights that superuser is granted. A privileged user or privileged application is a user or application that has been granted additional rights.

2. A discrete right on a process in an Oracle Solaris system. Privileges offer a finer-grained control of processes than does `root`. Privileges are defined and enforced in the kernel. Privileges are also called *process privileges* or *kernel privileges*. For a full description of privileges, see the `privileges(5)` man page.

privilege escalation Gaining access to resources that are outside the range of resources that your assigned rights, including rights that override the defaults, permit. The result is that a process can perform unauthorized operations.

privilege model A stricter model of security on a computer system than the superuser model. In the privilege model, processes require privilege to run. Administration of the system can be divided into discrete parts that are based on the privileges that administrators have in their processes. Privileges can be assigned to an administrator's login process. Or, privileges can be assigned to be in effect for certain commands only.

privilege set A collection of privileges. Every process has four sets of privileges that determine whether a process can use a particular privilege. See limit set, effective set set, permitted set set, and inheritable set set.

Also, the basic set set of privileges is the collection of privileges that are assigned to a user's process at login.

privilege-aware Programs, scripts, and commands that turn on and off the use of privilege in their code. In a production environment, the privileges that are turned on must be supplied to the process, for example, by requiring users of the program to use a rights profile that adds the privileges to the program. For a full description of privileges, see the `privileges`(5) man page.

privileged application An application that can override system controls. The application checks for security attributes, such as specific UIDs, GIDs, authorizations, or privileges.

privileged user A user who is assigned rights beyond the rights of regular user on a computer system. See also trusted users.

profile shell In rights management, a shell that enables a role (or user) to run from the command line any privileged applications that are assigned to the role's rights profiles. The profile shell versions correspond to the available shells on the system, such as the `pfbash` version of `bash`.

provider In the Cryptographic Framework feature of Oracle Solaris, a cryptographic service that is provided to consumers. PKCS #11 libraries, kernel cryptographic modules, and hardware accelerators are examples of providers. Providers plug in to the Cryptographic Framework, so are also called *plugins*. For examples of consumers, see consumer.

proxiable ticket A ticket that can be used by a service on behalf of a client to perform an operation for the client. Thus, the service is said to act as the client's proxy. With the ticket, the service can take on the identity of the client. The service can use a proxiable ticket to obtain a service ticket to another service, but it cannot obtain a ticket-granting ticket. The difference between a proxiable ticket and a forwardable ticket is that a proxiable ticket is only valid for a single operation. See also forwardable ticket.

public object A file that is owned by the `root` user and readable by the world, such as any file in the `/etc` directory.

public-key encryption An encryption scheme in which each user has two keys, one public key and one private key. In public-key encryption, the sender uses the receiver's public key to encrypt the message, and the receiver uses a private key to decrypt it. The Kerberos service is a private-key system. See also private-key encryption.

QOP Quality of Protection. A parameter that is used to select the cryptographic algorithms that are used in conjunction with the integrity service or privacy service.

RBAC Role-based access control, the user rights management feature of Oracle Solaris. See rights.

RBAC policy See rights policy.

realm 1. The logical network that is served by a single Kerberos database and a set of Key Distribution Centers (KDCs).

2. The third part of a principal name. For the principal name `jdoe/admin@CORP.EXAMPLE.COM`, the realm is `CORP.EXAMPLE.COM`. See also principal name.

reauthentication The requirement to provide a password to perform a computer operation. Typically, `sudo` operations require reauthentication. Authenticated rights profiles can contain commands that require reauthentication. See authenticated rights profile.

relation A configuration variable or relationship that is defined in the `kdc.conf` or `krb5.conf` files.

renewable ticket Because having tickets with very long lives is a security risk, tickets can be designated as `renewable`. A renewable ticket has two expiration times: a) the time at which the current instance of the ticket expires, and b) maximum lifetime for any ticket. If a client wants to continue to use a ticket, the client renews the ticket before the first expiration occurs. For example, a ticket can be valid for one hour, with all tickets having a maximum lifetime of ten hours. If the client that holds the ticket wants to keep it for more than an hour, the client must renew the ticket. When a ticket reaches the maximum ticket lifetime, it automatically expires and cannot be renewed.

rights An alternative to the all-or-nothing superuser model. User rights management and process rights management enable an organization to divide up superuser's privileges and assign them to users or roles. Rights in Oracle Solaris are implemented as kernel privileges, authorizations, and the ability to run a process as a specific UID or GID. Rights can be collected in a rights profile and a role.

rights policy The security policy that is associated with a command. Currently, `solaris` is the valid policy for Oracle Solaris. The `solaris` policy recognizes privileges and extended privilege policy, authorizations, and `setuid` security attributes.

rights profile Also referred to as a profile. A collection of security overrides that can be assigned to a role or user. A rights profile can include authorizations, privileges, commands with security attributes, and other rights profiles that are called supplementary profiles.

role A special identity for running privileged applications that only assigned users can assume.

RSA A method for obtaining digital signatures and public key cryptosystems. The method was first described in 1978 by its developers, Rivest, Shamir, and Adleman.

scan engine A third-party application, residing on an external host, that examines a file for known viruses.

SEAM The product name for the initial version of Kerberos on Solaris systems. This product is based on the Kerberos V5 technology that was developed at the Massachusetts Institute of Technology. SEAM is now called the Kerberos service. It continues to differ slightly from the MIT version.

secret key See private key.

Secure Shell A special protocol for secure remote login and other secure network services over an insecure network.

security attributes Overrides to security policy that enable an administrative command to succeed when the command is run by a user other than superuser. In the superuser model, the `setuid root` and `setgid` programs are security attributes. When these attributes are applied to a command, the command succeeds no matter who runs the command. In the privilege model, kernel privileges and other rights replace `setuid root` programs as security attributes. The privilege model is compatible with the superuser model, in that the privilege model also recognizes the `setuid` and `setgid` programs as security attributes.

security flavor See flavor.

security mechanism See mechanism.

security policy See policy.

security service See service.

seed A numeric starter for generating random numbers. When the starter originates from a random source, the seed is called a *random seed*.

separation of duty Part of the notion of least privilege. Separation of duty prevents one user from performing or approving all operations that complete a transaction. For example, in RBAC, you can separate the creation of a login user from the assignment of security overrides. One role creates the user. A separate role can assign security attributes, such as rights profiles, roles, and privileges to existing users.

server A principal that provides a resource to network clients. For example, if you `ssh` to the system `central.example.com`, then that system is the server that provides the `ssh` service. See also service principal.

server principal (RPCSEC_GSS API) A principal that provides a service. The server principal is stored as an ASCII string in the form *service@host*. See also client principal.

service 1. A resource that is provided to network clients, often by more than one server. For example, if you `rlogin` to the machine `central.example.com`, then that machine is the server that provides the `rlogin` service.

2. A security service (either integrity or privacy) that provides a level of protection beyond authentication. See also integrity and privacy.

service key An encryption key that is shared by a service principal and the KDC, and is distributed outside the bounds of the system. See also key.

service principal A principal that provides Kerberos authentication for a service or services. For service principals, the primary name is a name of a service, such as `ftp`, and its instance is the fully qualified host name of the system that provides the service. See also host principal, user principal.

session key A key that is generated by the authentication service or the ticket-granting service. A session key is generated to provide secure transactions between a client and a service. The lifetime of a session key is limited to a single login session. See also key.

SHA1 Secure Hashing Algorithm. The algorithm operates on any input length less than 2^{64} to produce a message digest. The SHA1 algorithm is input to DSA.

single-system image A single-system image is used in Oracle Solaris auditing to describe a group of audited systems that use the same naming service. These systems send their audit records to a central audit server, where the records can be compared as if the records came from one system.

slave KDC A copy of a master KDC, which is capable of performing most functions of the master. Each realm usually has several slave KDCs (and only one master KDC). See also KDC, master KDC.

software provider In the Cryptographic Framework feature of Oracle Solaris, a kernel software module or a PKCS #11 library that provides cryptographic services. See also provider.

stash file A stash file contains an encrypted copy of the master key for the KDC. This master key is used when a server is rebooted to automatically authenticate the KDC before it starts the `kadmind` and `krb5kdc` processes. Because the stash file includes the master key, the stash file and any backups of it should be kept secure. If the encryption is compromised, then the key could be used to access or modify the KDC database.

superuser model The typical UNIX model of security on a computer system. In the superuser model, an administrator has all-or-nothing control of the system. Typically, to administer the machine, a user becomes superuser (`root`) and can do all administrative activities.

synchronous audit event The majority of audit events. These events are associated with a process in the system. A non-attributable event that is associated with a process is a synchronous event, such as a failed login.

TGS Ticket-Granting Service. That portion of the KDC that is responsible for issuing tickets.

TGT Ticket-Granting Ticket. A ticket that is issued by the KDC that enables a client to request tickets for other services.

ticket An information packet that is used to securely pass the identity of a user to a server or service. A ticket is valid for only a single client and a particular service on a specific server. A ticket contains the principal name of the service, the principal name of the user, the IP address of the user's host, a time stamp, and a value that defines the lifetime of the ticket. A ticket is created with a random session key to be used by the client and the service. Once a ticket has been created, it can be reused until the ticket expires. A ticket only serves to authenticate a client when it is presented along with a fresh authenticator. See also authenticator, credential, service, session key.

ticket file See credential cache.

trusted users Users whom you have decided can perform administrative tasks at some level of trust. Typically, administrators create logins for trusted users first and assign administrative rights that match the users' level of trust and ability. These users then help configure and maintain the system. Also called *privileged users*.

user principal A principal that is attributed to a particular user. A user principal's primary name is a user name, and its optional instance is a name that is used to described the intended use of the corresponding credentials (for example, `jdoe` or `jdoe/admin`). Also known as a user instance. See also service principal.

virtual private network (VPN) A network that provides secure communication by using encryption and tunneling to connect users over a public network.

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