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GIAC-GSNA Practical assignment

Audit of Solaris 8 platform

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PART ONE: Research in Audit, Measurement Practice, and Control

1 Introduction

This audit will consist in evaluating the security of a Solaris 8 platform hosting a web server.

The purpose of this audit is to compare the initial setup/configuration of the OS against a predefined security checklist. To elaborate this checklist, I had to start with security requirements, that have been agreed by the management of our IT department. These requirements were an answer to a growing need for application web servers: we are a Telecom company, and more and more we have to make our services available to Internet users. Our standard way is to offer such services via a web application stored on a web server. This server is located on a screened subnet (i.e. subnet protected by "permissive firewall" from Internet, and separated by another firewall from our Internal backbone). Then, the application on the web server communicates with an application server (hosting the core of the application/service) located on a secure zone.

It's important to understand the scope of this audit. What will be checked, is the OS initial setup and configuration with the web server installed but before the web application is installed (by web application we mean all html pages and the binaries and/or CGI-scripts invoked through these html pages). Furthermore, the configuration of the web server will not be part of this audit. In our security processes, we have decided that before allowing the installation of the web application, the OS must comply to the security audit checklist derived from the security requirements. The web application security and the network elements of the screened subnet (switches, routers and firewall), will not be part of this study.

This audit will be done "manually" i.e. I'll review a step-by-step checklist to report on the OS compliance. As it was the first time we audited such servers against this checklist, doing it manually provides a great opportunity to really understand the inner workings of the system i.e. where and how security is configured, what to check, what else is affected, what security tools are used, etc. Sometimes, automated tools may hide the complexity and subtleties of the system and doing it by hand provides a more accurate judgement on what is secured and what is not.

2 State of practice

In the following paragraphs, I first explain, the research technique I used to find relevant information for the elaboration of my Solaris security audit checklist.

Then for each source, I show what items could be directly used and what are the points that have to be improved or modified accordingly to our specific needs.

2.1 Research technique

To find relevant information about a Solaris security audit checklist, I started to check the documentation available from known and recognized organizations dealing with IT security (e.g. CIS, SANS,

CERT, NSA, ISSA, etc.). I found two important documents: the CIS Solaris benchmark [1], and the UNIX Security Checklist from the CERT and AusCert. The former provides a clearly defined list of tasks to improve system security which can be performed without jeopardizing mission-critical applications. The latter is a comprehensive security checklists for a wide range of UNIX hosts. Both works have undergone substantial peer review and testing from many different organizations and security experts, which somehow guarantee their reliability and completeness.

Another good and reliable source is the SANS documentation. The support material I had from the SANS courses I attended in London, the free available Solaris checklist (c.f. [3]) and some of the practical works done by GCUX certified students (c.f. http://www.giac.org/GCUX.php) constituted a great contribution for the elaboration of my checklist.

Then, a logical step was to look at the vendor's available documentation. For few years, Sun Microsystems, has provided good Solaris security documents published under its famous "BluePrints" series (c.f. [4], [5] and [9]).

Since two years, I've been following the works done around the YASSP tool. The knowledge and experience I gather through the use of this tool and the available documentation about it, have been of great help for my audit (c.f. http://www.yassp.org/).

I also performed a Google search with the words "Solaris security checklist" which gave 6'840 hits. By selecting the most relevant ones (c.f. [20], [21] and [22]), I was able to find useful information. I also made more specific searches when I needed precise information on very specific topics.

Finally, I looked at different available books dealing with Unix and Internet security. I just mentioned them here for sake of completeness. However, I did not find them very helpful for my OS security audit. First, because most of the time they include generic information and principles that I already knew. Second, when there is specific information about an OS security, it's sometimes already out-of-date when the book is commercially available. Most relevant books that I found are referenced in [23] and [24].

2.2 What can be improved and how

As a primary source, I used the Solaris Benchmark v1.0.1b from the Center from Internet Security [1]. It's recognized as being a reference in Solaris security by the IT community. Moreover, I appreciated the completeness and the logical structure of the document, that help me to have a guiding line for my checklist. However, this paper is not written as an audit checklist, but more as a manual hardening checklist for Solaris. Therefore, some efforts are required to "translate" it into an audit checklist (i.e. the command used, the tests, etc.). Another point is that this document is written for generic security purposes and doesn't answer to specific security requirements. For example, for the network services they say "If you don't need this service turn it off, if you need it then configure it this way…". Our requirements, will permit to decide whether or not a service must be running. This rationale is not done in the CIS document, because they don't have requirements addressed for a specific situation. In addition, I found that some points were missing or not enough developed. For example, there is no recommendations about the Sun packages to install or de-install. Furthermore, the Kernel tuning parameters are a bit overlooked and finally there is no measures mentioned about the potential danger of SUID files.

The Unix Security Checklist has been published jointly by The Australian Computer Emergency Response Team (AusCERT) and the CERT ® Coordination Center (CERT/CC) and details steps to improve the security of Unix Operating Systems. This is also a very comprehensive security checklist on which I based my work. However, this paper mixes an auditing process (some points are listed as audit steps: *"ENSURE that…"*), with configuration process (some points are listed as: *"DO this…"*). In addition, this list is not dedicated to Solaris, and sometimes the information provided is UNIX-generic where no specific commands are mentioned. There is also a lack of information on SUID files and Solaris minimum set of required packages. The Sun's BluePrint on Solaris Operating Environment Security [4], gives good explanations and background on most of the security measures listed in the CIS and CERT documents.

The SANS Solaris checklist [3], helped me to turn the CIS benchmark security measures into a security audit checklist. However, this list doesn't provide enough detail on how to test every point (e.g. the specific command to execute).

The Sun's BluePrint on Operating Environment Network Settings for Security [5], gives details on the Kernel Parameters settings, which the other previously mentioned documents lacked for. In addition I used two relevant documents [11] and [17], obtained after sorting the results of a Google search with the words "Solaris Kernel tuning".

In the above mentioned sources, no valuable information about packages to install or de-install was present. By parsing GIAC practical works, I found some interesting advices about SUN packages to install regarding some security needs. For example, in [6] and [7] one can find what additional packages are needed to support special applications like NTP and SSH. A good source for Solaris 8 core packages used for firewall security requirements can be found at Lance Spitzner's web site [8]. In addition, the SUN BluePrint about the OS minimization for security [9] explains the role of the different packages.

I've been working with Sean Boran (www.boran.com) on system hardening (YASSP tool, manual hardening, etc.) and auditing. Thanks to this experience, I was able to make a list with the minimum set of SUID files required regarding to specific situations. An example of such list can be found at [17]. By doing a Google search, I found interesting information on SUID files at University of Waterloo, California [18].

Finally, I obtained 3 relevant security checklists with the Google web search ([20],[21] and [22]). However, most of them were out-of-date (apply to older version of Solaris), lacked information on SUID files and packages, and were installation checklists. I only used them to make a crosscheck with my own checklist.

To summarize, the main improvements were:

- Compile information from different sources (initial checklist, SUID files, packages, kernel tunings, commands, etc.)
- Turn installation checklist into audit checklist (using the right commands and tools for testing)
- Define what should be left on the machine (files, processes, services, etc.) according to our specific security requirements

3 Security requirements

For application web servers described in the introduction chapter, we have agreed in our company that the server should meet these security requirements:

Req1. The strict minimum set of services shall be available to Internet, i.e. only HTTP and/or HTTPS (SSL) to reduce the risks from Internet.

Req2. The strict minimum set of services shall be available to Intranet, i.e. only HTTP, HTTPS (SSL) and management traffic, to reduce the risks from inside our company (note that in the Intranet there are more 10'000 users!).

Req3. The management shall be made from Intranet and never from Internet. The communication between the management station(s) and the server shall be secured in terms of authentication, integrity and confidentiality.

Req4. The minimum software shall be installed on the machine.

Req5. The minimum processes and services should run on the machine hosting the web server to follow the rule: the less processes are running, the less chance we have to have a vulnerability.

Req6. Strong account and password policy shall be in place.

Req7. Good logging policy shall be in place to permit to rapidly track break-in attempts (reducing the detection time!).

Req8. The configuration shall be tightened following good practice to reduce the effectiveness of exploitable vulnerabilities.

Req9. The least privilege principal shall be applied whenever possible.

Based on these security requirements I was able to develop the audit security checklist.

4 The security audit checklist

In the following paragraphs, I will describe each item that has to be checked. Then the commands used for the tests are explained each time it's needed.

In addition, I will mention each time if the test is subjective or objective.

When the test is a UNIX command, a "#" will be added at the beginning of the command line to indicate it.

4.1 Scan

Prior to the local audit of the machine hosting the web server, a port scan and remote vulnerability scan are performed for the following reasons:

- it gives a general idea of the degree of exposure of the web server
- it shows network services reachable from outside and thus it helps prioritizing the risks

- can be used to compare the accur acy of the firewall filtering rules with the open services on the server
- it's a good "tool" to convince sysadmin and managers to take action against a potential security hole (if you show them a remote vulnerability scan they are much more impressed than if show them a hole when you're a lready logged on the machine).

4.1.1 Port scan

The port scan is done both from Internet and from the internal network (Intranet).

Since I scan only one machine, all TCP and UDP ports are scanned.

The port scan is done by the nm ap program, launched from a Linux (version 7.1) machine. The –O switch tell nmap to guess the operating system. The –p switch followed by a number is used to look for the specified port. When 1 - is specified (number one followed by minus sign), nmap will s can all 65'535 TCP ports. When in addition the switch –sU is present nmap will scan all UDP ports.

Machine that initiated the scan	Commands to test	expected results
External ma-chine (Inter-net)	# nmap –O –p 1- <IP# of server>	The only services in open sta te shall be http on tcp port 80 and https on port 443. The SSH should be in state fi ltered. OS should not be guessed
External ma-chine	# nmap –sU –p 1- <IP# of server>	No UDP services shall be opened
Internal ma-chine (Intra-net)	# nmap –O –p 1- <IP# of server>	Open services should be limited to port 80 (http), 443 (https), and 22 (ssh). OS shoud not be guessed.
Internal ma-chine	# nmap –sU –p 1- <IP# of server>	No UDP services shall be opened

Note: sometimes firewalls don't allow to ping the machines they protect. Before doing the nmap scan, I'll ping the machine to see if ping are allowed by the firewall. If ping is stopped, I'll add the –P0 switch in the nmap command. It will tell nmap not to try to ping the server, before scanning it.

The scan from Internet should show the strict minimum set of available network services i.e. only HTTP and HTTPS. No ports shall be open for remote management from Internet. All remote accesses are centralized via company wide access gateways (it can be either from di al-in connection, or from Internet). Then these connections are routed internally (Intranet).

The scan from Intranet may have other ports opened for management purposes (other than SSH). However, every additional network services used for management shall meet Req3 security requirement, his need shall be justified by the sysadmin and it shall be approved by the management.

Finally, if the system was correctly hardened nmap should not be able to guess the OS.

4.1.2 Vulnerability scan

The vulnerability scanner used is Nessus. The Nessus server is launched from the same machine as nmap i.e. the Linux 7.1. The tests are also made both from Intranet and from Internet. Note, that the latest plugins (corresponding to the latest vulnerabilities) have to be downloaded just before launching the Nessus vulnerability scan against the web server.

From the results of the nmap scan, I will reduce the number of vulnerability to test to the corresponding open ports I found.

From Internet, no vulnerability shall be found. This would imply that the latest security patches have been applied. If a vulnerability is found at this stage it should be immediately fixed without waiting for the end of the audit.

From Intranet, if a vulnerability is found it should be fixed rapidly. While, this less serious, it can be internally exploited.

4.2 Local audit

4.2.1 Installed packages

4.2.1.1 Selection of required packages

Following the Req4 requirement, only the minimum required packages shall be installed on the audited machine. What we need is the minimal set of packages to run the OS, SSH, and HTTP(S).

In addition, few other packages will be needed to run certain utilities that are vital for management.

Regarding the SUN's BluePrint [9], the minimum required packages for the OS to run are:

Solaris 8 OE running in 32 bit mode requires the following packages:

Package Name	Description
SUNWcar	Core Architecture, (Root)
SUNWcsd	Core Solaris Devices
SUNWcsl	Core Solaris, (Shared Libs)
SUNWcsr	Core Solaris, (Root)
SUNWcsu	Core Solaris, (Usr)
SUNWesu	Extended System Utilities (required for system commands like awk, last, etc.)
SUNWhmd	SunSwift SBus Adapter Drivers used at boot to configure the internal network interfaces
SUNWkvm	Core Architecture, (Kvm)

SUNWlibms	Sun WorkShop Bundled shared libm (system libraries)
SUNWloc	System Localization (used for the system installation with the JASS toolkit)
SUNWnamos	Northern America OS Support
SUNWpd	PCI Drivers for booting
SUNWlibC	Sun Workshop Compilers Bundled libC

In addition if a system is running in a 64 -bit mode the following additional packages are r equired:

Package Name	Description
SUNWcarx	Core Architecture, (Root) (64 -bit)
SUNWcslx	Core Solaris Libraries (64 -bit)
SUNWcsxu	Core Solaris (Usr) (64 -bit)
SUNWesxu	Extended System Utilities (64 -bit)
SUNWhmdx	SunSwift SBus Adapter Drivers (64 -bit)
SUNWkvmx	Core Architecture (Kvm) (64 -bit)
SUNWlmsx	Sun WorkShop Bundled 64 -bit shared libm
SUNWlocx	System Localization (64 -bit)
SUNWnamox	Northern America 64 -bit OS Support
SUNWpdx	PCI Drivers (64 -bit)
SUNWlibCx	Sun WorkShop Bundled 64 -bit libC

The following packages are required for patch management:

Package Name	Description
SUNWswmt	Install and Patch Utilities
SUNWgzip	GNU zip (gzip) compression/uncompressing utility
SUNWadmc	System administration core libraries (needed if showrev is used)

The following packages are required for OpenSSH installation:

Package Name	Description
SUNWzlib	The Zip compression li brary

Following the requirement Req7, the accurate time shall be guaranteed in order to be sure of the date and time of the logged events. For this, the NTP package should be installed. In addition, to be able to send alarm via e-mail the sendmail package should be installed.

Package Name	Description
SUNWntpr	NTP (root)
SUNWntpu	NTP (user)
SUNWsndmr	Sendmail (root)
SUNWsndmu	Sendmail (user)

The use of perl is generally useful for writing scripts. If such scripts are needed for management purposes, then the following packages should be installed:

Package Name	Description
SUNWlibm	Sun WorkShop Bundled libm
SUNWlibms	Sun WorkShop Bundled shared libm

The Man pages are also useful:

Package Name	Description
SUNWdoc SUNWman	On-line manual pages

If some software have to be compiled (e.g. Apache), then the following packages are required:

Package Name	Description
SUNWarc	Archive Libraries
SUNWarcx	Archive Libraries (64-bit)
SUNWbtoox	CCS libraries bundled with SunOS (64-bit)
SUNWbtool	CCS tools bundled with SunOS
SUNWscpux	Source Compatibility (Usr) (64-bit)
SUNWdplx	Developer Profiled Libraries (64-bit)
SUNWsprox	Sun WorkShop Bundled 64-bit make library
SUNWhea	SunOS Header Files
SUNWlibm	Sun WorkShop Bundled libm
SUNWdfbh	Dumb Frame Buffer Header Files
SUNWcg6h	GX (cg6) Header Files

4.2.1.2 How to do the test

In addition to the above mentioned packages, it's likely that other packages should be installed. First, we will have the packages for web application. Second, if we have special hardware (e.g. Ethernet card with 4 ports), then additional packages are required. However, what is important is the method adopted for package installation. At minimum, the following steps should have been observed:

Step1. installing the core packages (mentioned in the previous paragraph)

Step2. installing the additional packages for the required management tools and application (the one mentioned in previous paragraph)

Step3. if additional packages are needed for the functioning of the application, they can be installed.

Step4. if packages are needed for a one time installation (e.g. the compilation packages needed to compile apache), then after their use they should be removed.

Step5. Sysadmin have to understand what installed packages are for.

To have an idea of the number of installed packages use the following command:

Command (subjective)	expected results
`# /usr/bin/pkginfo -i | wc -l`	number of packages: quickly gives an idea if only selected packages have been installed

`pkginfo` displays information about software packages that are installed on the system or that reside on a particular device or directory. When used with the –i option, it displays information for fully installed packages only. The `wc` utility reads one or more input files and, by default, writes the number of newline characters, words and bytes contained in each input file to the standard output. When used with the –l option it counts the number of lines only.

Note, that even if this test uses a command, it's a subjective test, because we can't *say "if the number of packages is equal to…, then the test is OK"*. Rather, it gives an idea or a feeling, if a selective policy has been applied for the installation of packages.

To check if a strategy (or policy) is in place:

Test (subjective)	Expected results
Ask sysadmin for package installation strategy	Similar steps as described above (Steps1-5), shall be observed

To check for installed packages type:

Command to test (objective)	Expected results

# /usr/bin/pkginfo -i Check all installed packages and see if they are necessary	No unnecessary packages shall be installed.

4.2.2 OS Installed patches

It is very important to check that security parches are up-to-date. Different tools exist, that test if installed patches are currently up-to-date. Some free tools are provided on the net so you can quickly determine the patch level and easily apply missing patches that the vendor has recommended.

CheckPatches is a Bourne shell script for Solaris patch management developed at the University of Waterloo, California, with the help of colleagues on the net (CheckPatches was originally a Perl script posted to Usenet by Bruce Barnett). The scripts rely on the vendor's patch report to construct an incremental list of patches required. These tools have been peer reviewed by Sean Boran (www.boran.com) and other participants of the YASSP project, and can help us manage patches on Solaris system. This tool can be downloaded from http://ist.uwaterloo.ca/security/howto/2000-12-04/patches.tar.

CheckPatches makes a comparison between installed patches on the system with a Patch Report available from SUN at ftp://sunsolve.sun.com/pub/patches/Solaris8.PatchReport, updated twice a month with the latest available patches.

Sun Microsystems has a tool available at http://sunsolve.sun.com/pub-cgi/show.pl?target=patchk, that works on the same principle.

Test (objective)	Expected results
Download the tool and the latest patch report from SUN and type: # ./PatchCheck	Patches shall be up-to-date

Note: SUN's patch reports will often list patches that cannot apply to the system either because they apply to hardware drivers that are not part of the system or because they apply to packages not installed on the machine. Of course, these patches should not be taken into account.

As part of the audit the patching policy shall also be considered. This point will covered later in this document (c.f. § 4.2.15)

4.2.3 Network services, processes and deamons

4.2.3.1 Network services started by inetd

To start a service, the inetd deamon look for non-commented lines in configuration file /etc/inetd.conf.

Following the requirements Req1 and Req2, HTTP, HTTPS (SSL) and SSH are the only services allowed to run. As these 3 services are normally not running through inetd (and should not), no services shall be started through the inetd deamon. This imply that the whole /etc/inetd.conf file shall be commented, i.e. every line of this file shall start with a "#" symbol. In addition, the inetd demon should not be running.

Commands to test(objective)	Expected results
`# egrep -v "^#" /etc/inetd.conf`	nothing shall be displayed
`# ps -ef | grep inetd`	nothing shall be displayed
`# pgrep inetd`	nothing shall be displayed
Crosscheck with lsof –i and netsat –a commands that no inetd service are running (see § 4.2.3.2 for details on this test)	no inetd service shall be displayed
Crosscheck with ps –ef command that no inetd service are running (see §4.2.3.3 for details on this test)	no inetd service shall be displayed

The `egrep` command search a file for a pattern using full regular expressions. When used with the –v switch it prints all lines except those that contain the pattern. The pattern "^#" means line beginning with the "#" character.

The `ps` command is used to display information about processes. The –e switch lists information about every process running when the command is typed. The –f switch generate a full listing of information on processes (UID, PID, C, STIME, TIME, CMD).

The `pgrep` command find or signal processes by name and other attributes. When used with no switch it returns the process IDs of the active process on the system whose name matches the one specified on the command line.

4.2.3.2 Boot services

As previously mentioned only 3 network services shall be started through RC scripts: the web server deamon, the SSL deamon and SSH deamon.

Both netstat and lsof command will be used. Only the 3 above mentioned services should appear. If other services are displayed they should be discussed with sysadmins if they are necessary or not. Then the security of these services should be assessed, and based on these results, the managers should agree to let the se additional services run.

The lsof command lists information about files opened by processes. When the –i switch is used, this option selects the listing of files any of whose Internet address matches the address specified after the switch. If no address is specified, this option selects the listing of all Internet and x.25 (HP-UX) network files. In other words, we will see the binary name of the running network service (e.g. sshd) along with their connection status and port number (if any).

netstat commands shows the content of network related data structures. When used with the –a it shows the status of all sockets. When looking under the TCP and UDP socket tables, we will see the running network services.

Commands to test(objective)	Expected results
`# lsof -i`	Only SSH, SSL, and HTTP should appear, check that no inetd services are displayed
`# netstat -a`	Look under TCP and UDP tables. Only SSH, SSL, and HTTP, HTTPS (SSL) should appear, check that no inetd services are displayed
Crosscheck with ps –ef command that no only the mentioned services are running (see §4.2.3.3 for details on this test)	Only SSH, SSL, and HTTP should appear as network deamon
Reboot the system and redo the above tests	Same results shall be observed.

Note: it's important, to verify that when we reboot the machine, no new services are started. This ensure that services have not been disable manually (just killing a running process), but have been removed from the boot services i.e. removed from the rc scripts.

In addition to the above tests, two other subjective tests are important: I have to evaluate the knowledge the sysadmin has with regards to the running network services, and check the procedure (if any) for starting new services.

Test (Subjective)	Expected results
Does the sysadmin know how running service are working, starting, does he know the corresponding config files, the security implications, etc.	Detail knowledge
Check the procedure to start new network services (who gives the authorization, who checks the security implication…)	A written procedure.

4.2.3.3 Processes

With respect to the requirement Req5 , the minimum set of processes shall be running on the machine. Most of them are started through the RC scripts. They are stored under the famous /etc/rc*.d/ directories.

We should see the minimal processes for the kernel, and the processes corresponding to the network services running. Other unexpected processes shall be investigated and their presence understood and justified by the sysadmin. If they are necessary and harmless in terms of security they can be left running.

To look for current running processes I use the command ps –ef.

Commands to test(objective)	Expected results
# ps -ef	The following processes may appear: sched /etc/init - pageout fsflush /usr/lib/saf/sac -t 300 /???/???? /bin/httpd (or apache) /usr/lib/sysevent/syseventd /usr/lib/sysevent/syseventconfd /usr/sbin/syslogd -t /usr/sbin/cron /usr/sbin/vold /usr/lib/utmpd /usr/lib/sendmail -q15m /usr/local/sbin/sshd
Reboot the system and redo the above test	same processes shall be displayed

The following explanation of the processes are borrowed from [26]:
sched is the first process running. It is referred to as the swapper. This process is responsible for operating system scheduling, and swapping out light weight processes when necessary to run higher priority processes. From this process, the scheduling of and swapping of processes on the system is controlled.

init is the process that is responsible for the execution of all processes at their respective run levels. At bootstrap time, init is the first process started. From its execution, init reads the /etc/inittab and /etc/default/init and follows the instructions in those files: it starts all other processes, and brings the machine to its default run level (for Solaris, this is run level 3).

pageout is the next process in the sequence. It is used to control the paging out of memory to disk, and back in again.

fsflush is a daemon responsible for writing data back to the disks. The kernel checks superblocks on a 30 second interval, and the data in the superblock is either idle or unchanged, the kernel uses fsflush to clear the superblock and send the information back to the disks.

sac is the Service Access Controller, and is started when the system enters multiuser mode. sac is a program designed to watch ports on a Solaris system. It can provide statics on port use, poll for failure, restart port monitors that fail, a nd a variety of other functions.

devfseventd and *devfsadmd* we'll cover together, as they're dependent upon one another. These two daemons are part of the Solaris 8 device management package. devfseventd is the kernel event notification daemon. This daemon runs on the system, monitoring the kernel for things such as when device nodes are added and removed from the kernel device tree. devfsadmd is the replacement to the antiquated programs such as disks, tapes, and devlinks (all part of the old devfs tools). devfsadmd builds the links in the /dev and /devices directories. All the old devfs tools are now symbolic links to devfsadm.

syslogd is the system logging daemon. This daemon is responsible for monitoring and logging system events, or sending them to users on the system. syslogd is a critical application on every system, and is configurable with the /etc/syslog.conf file.

vold is the volume manager. This neat little daemon manages the system cdrom and floppy. When media is inserted into either the cdrom or the floppy drive, vold goes to work and mounts the media automatically. Configuration information for this utility is in /etc/vold.conf. This processes shall be left only if a good physical security is ensured for the machine.

cron is a system scheduling u tility. Cron is capable of executing events for specific users on a predetermined time schedule if entries are made into the users cro ntab.

utmpd is the utmp and utmpx monitoring daemon. utmp has been obsoleted by utmpx, but for reverse compatibility, it exists. To cut to the chase, utmpx is used to record the current users on a system. When a user terminates a process or logs out of a system, utmpd polls these files to ensure the entries for these events has been removed. Should the entries still exist in the files, utmpd removes them.

ttymon is a port monitor for terminal ports. This process is usually used in conjunction with sac. This facility controls TTY settings to users and services.

sendmail -q15m is the Mail Transport Agent used on Solaris 8. With the –q15m option specified Sendmail is left running is Queue mode: i.e. it will deliver but not accept remote emails for security reasons. We don't want to have a mail server running on this machine (because it's too dangerous). However, the machine might be able to send e -mail especially for alarms to the sysadmin official email box.

httpd is the deamon for the web server. Depending on the product, the demon might have another name (e.g. apache).

sshd is the deamon for the SSH server.

Like for network services, I have to evaluate the knowledge the sysadmin has with regards to the running processes/deamons, and check the procedure (if any) for starting new processes/deamons.

Test (Subjective)	Expected results
Does the sysadmin know to what the processes/deamon correspond to? Does he know the security implications	Detail knowledge
Check the procedure to start new processes/deamons (who gives the authorization, who checks the security implication…)	A written procedure.

4.2.4 Kernel tuning

4.2.4.1 Network parameters

Solaris includes a lot of low level network parameters, that can be adjusted according to specific situations. Amongst them, some may be tuned in order to provide greater protection against various known network attacks. According to the requirement Req8, these parameters should be set to values that guarantee a better level of protection.

Most of the explanations about these parameters have been borrowed from the SUN's BluePrint [5], because the points are clearly detailed.

Note, that I apply the test both to IP and IPv6 network parameters. Even if IPv6 is not yet used, it's safer to have everything secured also for IPv6 in case it's deployed in a near future.

The `ndd` command has to be used to read and sets these configuration parameters in the coresponding kernel drivers. Currently, `ndd` only supports the drivers that implement the TCP/IP Internet protocol family. Each driver chooses which parameters to make visible using `ndd`. When `ndd` command is used with `-set` option it sets the value to the specified value. When no option is specified, the ndd command reads the value of the parameters from the driver. I will test parameter values from three drivers: the TCP driver (`/dev/tcp`), the ARP driver (`/dev/arp`) and the IP driver (`/dev/ip`).

4.2.4.1.1 ARP defenses

Here, I check the parameter values that can be set to ensure a certain protection against known ARP attacks.

According to SUN (c.f. p.7 of [5]): "*There are two basic types of attacks possible with ARP: denial of service and spoofing. An attacker can feed a remote system incorrect address information as well. This is known as cache poisoning. Since the ARP layer always trusts the information it receives (all address information received by a system is believed to be accurate.), wrong information can be inserted and current ARP entries can be corrupted. An attacker may use the publish feature of the ARP layer to broadcast incorrect information about other systems. If two ARP replies are received, at least one will be used. It may be the correct one, or it may not. This situation can spread discord throughout*

out systems on the local network and be difficult to diagnose. ARP spoofing attacks are more serious because they are used to compromise re mote systems on the local network. By masquerading as a n- other system, it is possible for an attacker to exploit a trust relationship and gain entry to other sy s- tems. This attack involves sending false hardware address information to a target system which t he system will use to update its ARP tables. Once the false information is implanted, the attacking system changes its IP address and attempts a connection to the target."

To reduce the effectiveness of these attacks, we can set the interval time between t wo deletions of the ARP and IP tables to a low value. Thus, if false information has been stored, it will be quickly deleted. The recommended value is one minute for each (note: values are specified in mi lliseconds).

Check the values for the ARP cache and IP table cleanup interval

Commands to test(objective)	Expected results
`# /usr/sbin/ndd /dev/arp arp_cleanup_interval`	`60000`
`# /usr/sbin/ndd /dev/ip ip_ire_arp_interval`	`60000`

4.2.4.1.2 ICMP defenses

ICMP broadcasts are, at times, troublesome. A significa nt number of replies to a ICMP broadcast from all systems on a network could cause significant network performance degradation. An attacker may use ICMP broadcast requests to initiate a denial of service attack. It is best to disable the ability to respond to all type of ICMP broadcasts.

A well known ICMP broadcast is the echo request sent to a broadcast address, generated by the f a- mous `ping` command (e.g. `# ping 188.105.33.255`). If all machines of a subnet are confi g- ured to respond with an echo reply, it c an generate lots of traffic. Even worse, because echo reply will return the same data payload as in the echo request (that's how the protocol was designed), if this pa y- load is too large, the responding machine will fragment its response across several pack ets, further in- creasing the network load. Thus, I have to ensure that the machine doesn't respond to such requests:

Commands to test(objective)	Expected result
`# /usr/sbin/ndd /dev/ip ip_respond_to_echo_broadcast`	0

The equivalent of echo request broad cast in IPv6 is echo request multicast. I have to test that it's also disabled:

Commands to test(objective)	Expected result
`# /usr/sbin/ndd /dev/ip ip6_respond_to_echo_multicast`	0

Another ICMP broadcast is the timestamp request broadcast. There is no need to answer to such request, because we use the NTP protocol for all systems in our company, for the time synchronization. Ensure that these answers are disabled:

Commands to test(objective)	Expected result
`# /usr/sbin/ndd /dev/ip ip_respond_to_timest amp_broadcast`	0

Address mask broadcast are also ICMP broadcast request. They are normally used by diskless systems (e.g. printers) sent during a boot. I have to ensure that the server does send response to such requests:

Commands to test(objective)	Expected results
`# /usr/sbin/ndd /dev/ip ip_respond_to_address_mask_broadcast`	0

Another source of trouble with ICMP protocol is the redirect features.

According to SUN (c.f. p.10 of [5]): *"Redirect errors are used by a router to inform a host sending data, to forward the packets to a different router. Both routers involved in the redirection must be connected to the same subnet. The sending host will then install a new host routing entry in the routing table for the destination host. Unlike ARP entries, these will not time out and be deleted. Most systems check the redirect message for errors and potential problems prior to modifying the routing table. [...] An attacker may forge redirect errors to install bogus routes. This may initiate a denial of service attack if the newly specified router is not a router at all. There are rules governing valid redirect errors, all of which can be spoofed easily."*

I have to ensure that both sending and accepting ICMP redirect message are not allowed (both for IP and IPv6):

Commands to test(objective)	expected results
`# /usr/sbin/ndd /dev/ip ip_ignore_redirect`	1
`# /usr/sbin/ndd /dev/ip ip6_ignore_redirect`	1
`# /usr/sbin/ndd /dev/ip ip_send_redirects`	0
`# /usr/sbin/ndd /dev/ip ip6_se nd_redirects`	0

Finally, as mentioned previously, for time synchronization the NTP protocol is used so we don't need ICMP Timestamp at all. To ensure that answers to ICMP timestamp request are disabled

Commands to test(objective)	Expected results

`# /usr/sbin/ndd /dev/ip ip_respond_to_timestamp`	0

4.2.4.1.3 IP defenses

In this paragraph I will check that the routing capabilities of the Solaris are turned off, first because the role of the audited machine is hosting a web server and not being router -like machine, and second because most of these features have been exploited to generate attacks.

IP forwarding is a routing functionality that is used to transfer packets from on interface to another. Generally, when servers have two IP interfaces, one is public and the other is private (used for management purposes). This feature can be exploited by an attacker to access the network attached to the private interface.

To ensure that this feature is disabled the following parameters have to be checked:

Commands to test(objective)	expected results
`# /usr/sbin/ndd dev/ip ip_forwarding`	0
`# /usr/sbin/ndd dev/ip ip6_forwarding`	0

Another attack is still possible even when IP forwarding is disabled: if an attacker sends a packet to the public interface with a spoofed private address (i.e. the source address of the packet contains an address of the private network), the machine may send the packet to the private interface believing this packet comes from the private network. Solaris has a feature that stops such packets: the system is aware from which interface the packet arrives, and if the source address correspond to other interface it will drop it. To ensure that this feature is turned on:

Commands to test(objective)	Expected results
`# usr/sbin/ndd dev/ip ip_strict_dst_multihoming`	1
`# usr/sbin/ndd dev/ip ip6_strict_dst_multihoming`	1

Another routing functionality of the Solaris platform is the possibility to forward directed broadcast. According to SUN (c.f. p.14 of [5]): "*A directed broadcast is a unicast datagram from a system on a remote network addressed to all systems on another network. Once the datagram reaches the router connected to the intended network, the datagram is forwarded to all systems as a data -link layer broadcast. Directed broadcasts can be problematic due to the amount of network traffic generated by broadcasts and the ability to send a packet to all systems on a network.*

An attacker may take advantage of forwarded directed broadcasts to attack and probe systems. CERT Advisory CA-98.01 *describes a denial of service attack called the smurf attack after its exploit program. It involves forged ICMP echo request packets sent to broadcast addresses. The source address*

in the forged packet is set to a target. The result is that the target and intermediate routing systems forwarding the directed broadcasts suffer from network congestion ."

To ensure that this functionality is disabled:

Commands to test(objective)	Expected results
`# /usr/sbin/ndd /dev/ip ip_forward_directed_broadcasts`	0

Another routing functionality is the possibility to forward source routed packet. These packet includes the route to follow. Normally, there is no need for such packe ts, as properly configured routers take care of correct routing. However, source routed packet can be used by an attacker to bypass some fi l-tering routers and/or firewalls. Therefore, I should check that this feature is disabled:

Commands to test(objectiv e)	Expected results
`# /usr/sbin/ndd /dev/ip ip_forward_src_routed`	0
`# /usr/sbin/ndd /dev/ip ip6_forward_src_routed`	0

4.2.4.1.4 TCP defenses

The SYN flooding attack (http://www.cert.org/advisories/CA -1996-21.html) consist in opening a lot of TCP connections (SYN packet) with unreachable source IP addresses. The target machine replies with a SYN+ACK packet and waits for the ACK packet (3 -way handshake). Because of false source addresses, the target mac hine will continue resend the SYN/ACK packet, until a time limit is reached. Because of this, the backlog queue (it's the queue storing the half -open session) may fill up rapidly, and other connection requests may no longer be treated, creating a denial of service. While, it's not possible to completely stops these attacks it's possible to adjust the size of the backlog to a value that render the attack a lot more difficult to realize. The maximum value recommended by SUN is 4096:

Commands to test(objective)	Expected results
`# /usr/sbin/ndd /dev/tcp tcp_conn_req_max_q0`	4096

Likewise, it's possible to make a connection exhaustion, with established connections. An attacker can open many connections to a server and hold them open for long periods of time, ef fectively pushing the server closer to its connection limit. This attack is however less common, because the connections can be traced back, and because the attacker need great resources. Here again, to mitigate the effe c-tiveness SUN recommends a value of 1024.

Commands to test(objective)	Expected results
`# /usr/sbin/ndd /dev/tcp tcp_conn_req_max_q`	1024

The 3 next parameters are more dedicated to web server. Because the HTTP protocol uses TCP co n-nections in aspecific manner, some timers have to adjusted to strengthen the behavior of TCP.

According to SUN's reference manual for TCP/IP tunable parameters [11]: "*On a busy web server, there can be too many TCP connections in TIME -WAIT state, consuming too much memory. In this situation, we can decrease the value for performance reasons.*"

An attacker may generate an attack by improperly shutting down the sockets from the client side, thus creating a DOS.

There is an Internet draft [13] that proposes to avoid the use of this state for busy web server. A ccord-ing to them, performances can be increased up to 50%.

However, with HTTP and Solaris we can not yet bypass this state. According to SUN the minimum time we can set for this state for each connection is 60 seconds. To mitigate the effectiveness of the above mentioned attack and to increase the availability of the server, I have to check that this value has been set to minimum:

Commands to test(objective)	Expected results
`# /usr/sbin/ndd /dev/tcp tcp_t ime_wait_interval`	60000

In the same way, the timer interval which prohibits a connection to stay in the `FIN_WAIT_2` state for-ever, may be tuned. The `FIN_WAIT_2` state is reached, if a connection closes actively. The `FIN` is ac-knowledged, but the `FIN` from the passive side didn't arrive yet - and maybe never will. Usually web servers and proxies actively close connections. A crashed or misbehaving browser may cause a server to use up a precious resource for a long time. Once again, this can be used by an att acker to make a DoS attack. To mitigate, the effectiveness of such exploit, this time should be kept as low as possible.

According to SUN, they advice not to go below 67500 ms. To counter the above mentioned threat and to increase the availability of the s erver, I have to check that this value has been set to this minimum. Note, that this value has been tested and recommended by IBM [13] for their web servers, and appl i-cation servers, and by J-S Volkler[11].

Commands to test(objective)	Expected results
`# /usr/sbin/ndd /dev/tcp tcp_fin_wait_2_flush_interval`	67500

The last timer I have to look at is the TCP keep -alive interval. The *keep-alive* timer becomes signif i-cant for web servers, if after the cl ient (browser) initiates a connection (*active open*), it suddenly crashes or terminates without the server knowing about it. This condition can be forced sometimes by

quickly pressing the stop button of Netscape or the Logo of Mosaic. Thus the *keep-alive* probes do make sense for web servers and can be sent with in the HTTP header. However, I have to make sure that the probes stop after a finite time, if a peer does not answer. IBM [13] recommends that this value should be set to as low as 300'000 millise conds.

Commands to test(objective)	Expected results
`# /usr/sbin/ndd /dev/tcp tcp_keepalive_interval`	300000

TCP uses a hash table to locate TCP connection control blocks: it contains information on current state of TCP connecti ons. If the size of the table is 512 (default on Solaris8), when Solaris has more than 256 connections, the hash is bypassed and a linear search of memory is required to locate the a p-propriate TCP data structure. At this stage the performances to process T CP connections decreases. Entries remain in the hash even when the connection is closed and is in the **TIME_WAIT** and **FIN_WAIT_2** state.

To keep up the performance, Oracle [15], IBM [14] and the SYSAD MIN journal [16] recommend values from 8192 to 32768. To check this parameter:

Commands to test(objective)	Expected results
`# /usr/sbin/ndd /dev/tcp tcp_conn_hash | grep size`	`tcp_conn_hash_size=8192`
`# more /etc/system | grep tcp_conn_hash_size`	`set tcp:tcp_conn_hash_size=8192`

note: Since Solaris 2.6, the tcp_conn_hash_size parameter can no more be adjusted with the ndd command. This value can only be set in /etc/system. However, the current used value is shown at the beginning of the TCP hash table obtained with the command ndd /dev/tcp tcp_conn_hash.

Another TCP parameter that can be adjusted in Solaris is the method for generating the Initial S e-quence Number (ISN).

According to SUN (c.f. p.19 of [5]): *"Predictable ISNs make it possible for attackers to compromise some systems. The TCP three -way handshake discussed previously involves two systems synchronizing sequence numbers prior to data exchange. For each new connection most s ystems use ISNs that have fixed and predictable counter increments. An attacker uses this knowledge to create a three -way handshake by predicting the required ISN to establish a connection and execute a command."*

On Solaris, 3 different methods exist to ge nerate TCP ISNs. We have to ensure that the one used can guarantee the best randomness and uniqueness of TCP ISN, in order to prevent the above mentioned attack.

Commands to test(objective)	Expected results
`# ndd /dev/tcp tcp_strong_iss`	2

`# more /etc/default/inetinit | grep TCP_STRONG_ISS=`	`TCP_STRONG_ISS=2`

Currently, the best available method regarding the above mentioned criteria in the method number 2. The value has to be checked both with ndd command, and has also to be set in the file /etc/default/inetinit. This guarantee that the method 2 is permanently used, even after a reboot (the inetinit file is checked at each boot)

The last TCP parameter to check is the one who permits or denies reverse source routing. When TCP source routed packets arrive at the destination machine, they may include a reverse route. The destination machine copies this route to all packets to be sent back to the originating machine. Once again, this routing functionality is useless in well configured networks, and can be exploited to generate DoS attacks. To ensure, this functionality is disabled:

Commands to test(objective)	Expected results
`# ndd /dev/tcp tcp_rev_src_routes`	`0`

4.2.4.1.5 Persistency of network parameters

It's important to ensure that the values of these tested network parameters remain the same after re-booting the machine. Typically, a script has to be called at boot time that sets the desired values for the network parameters.

Test(objective)	Expected results
`Reboot the machine and re-check the value of the parameters`	Same value shall be observed
`Check that the correct values of the parameters are set within a script called at boot time (in rc directories)`	`Such file must exists`

4.2.4.2 User stack

To prevent and log stack-smashing attacks (i.e. buffer overflow), it's safe to have the users' stack non-executable. This can be done by setting to 1 the two parameters noexec_user_stack and noexec_user_stack_log.

Note the following quote taken from SUN's BluePrint (in [5] page 17):

"Some security exploitation programs take advantage of the Solaris OE kernel executable system stack to attack the system. These attack programs attempt to overwrite parts of the program stack of a privileged program in an attempt to control it. In Solaris 2.6 OE and later, some of these exploits can be avoided by making the system stack non-executable. [...] This feature does not stop all buffer overflow exploitation programs, and it does not work on Intel x86-based or older SPARC hardware. Some

overflow exploitation programs work on different principles which non-executable stacks cannot protect against."

Commands to test(objective)	expected results
`# more /etc/system | grep noexec_user_stack`	`set noexec_user_stack=1`
`# more /etc/system | grep noexec_user_stack_log`	`set noexec_user_stack_log=1`

note: the setting is only available on SunOS 5.6 and later and it's only supported on the sun4u, sun4d and sun4m hardware platforms.

4.2.4.3 File descriptor

In our case, we have a web server that communicates with an application servers. When busy, the server processes may open thousands of files or sockets. In the Solaris operating system, rlim_fd_cur sets the soft limit for the number of file descriptors per process, while rlim_fd_max is the hard limit.

Many common UNIX-based applications call the stdio fopen() library routine. If the application exceeds the rlim_fd_cur limit, the application, and possibly the operating system, will crash, often times with no error logging other than a core file.

Moreover, there is a relation between the TCP/IP stack and rlim_fd_cur and rlim_fd_max, because these protocols use sockets to make connections between the kernel and external machines. As mentioned previously in § 4.2.4.1.4, the maximum number of established connections (backlog queue) is 1024. Having a limit of 1024 for the file descriptor, guarantee that the server doesn't run out of descriptor for the accepted connections.

Likewise, SUN recommends for busy systems (e.g. iPlanet servers) to set the soft limit to 1024 and the hard limit to 2048.

To test that the file descriptor are correctly set:

Commands to test(objective)	Expected results
`# ulimit -Hn`	`2048`
`# more /etc/system | grep rlim_fd_max`	`set rlim_fd_max=2048`
`# ulimit -Sn`	`1024`
`# more /etc/system | grep rlim_fd_cur`	`set rlim_fd_cur=1024`
Reboot the system and redo the above test	Same results shall be observed

Note: a cross check between the value set in /etc/system and the value in the current kernel memory is needed, because the kernel reads the values in /etc/system only at boot time.

ulimit command sets or reads the limits of the available system resources. When ulimit is used with the –a switch it displays all the resources and their values. To specifically verify the file descriptor

limit the –n option is used. By default, the soft limit is returned. To have the hard limit, a capital H must be appended with the –n switch (-Hn).

4.2.4.4 Core file

On a production systems core files should not be needed since debugging should take pl ace only on a test system. On the other hand these files could be used by attacker to make a DoS by generating big core files and consuming the disk space. Furthermore, valuable information is sometimes stored on core files that may be helpful to attackers . To avoid the generation of core files, we can set the size of core file to 0. This is done by setting the coredumpsize system var iable to 0.

Commands to test(objective)	Expected results
# more /etc/system | grep coredumpsize=	set sys:coredumpsize = 0
# ulimit –c	0
reboot the system and redo the test	Same results shall be o b-served

Note: The value has still to be effective after a reboot.

4.2.5 File system

4.2.5.1 Partitions and mounted file systems

The partitions can be mounted with different options. The use of th ese options for dedicated partitions can enhance the security level of the Solaris system.

The nosuid option disable SUID programs. In accordance with Req9 requirement, this option shall be set for the partition where no SUID f iles are expected. The /home partition is where users have their home directories. Users shouldn't be allowed to have or install SUID programs in their home direct o-ries. Therefore, the /home partition should be mounted with the nosuid option. The /var part ition holds the log files. These files generally accessed for read and write, and there is normally no executable file stored there. Therefore we should also mount the /var partition with the nosuid option set.

The noatime option allows mounting file syste ms without updating inodes at each access to any file. This will significantly speed up services like web caches or news servers, which do a lot of I/O with small files. This option shall be set to /var because it contains the all the log files that are ac cessed fre-quently. If a special partition is created for the HTTP file of the web server, this partition can also be set with noatime option.

The logging option keeps a transaction log within the mounted partition. The advantage is an almost instantaneous file system check. The disadvantage is the additional time spent writing the transaction log. The /usr and /home part ition should have this option set

The size= shall be used on /tmp partition. The value should be set approximatively to 30% of the swap space. This setting can prevent from slowing down the system when the /tmp partition is filling up, thus preventing a potential DoS.

The ro option is the read-only option. Mounting file systems read-only provides only a limited protection against Trojans/attackers (if they get root, they can remount read-write). However, it may save time fsck'ing when booting, can improve performance (access times don't need to be updated) and can prevent the sysadmin from making mistakes or help him detecting mistakes (accidentally deleting files etc.). The /usr partition can be set to ro, but in this case it's better to have a separate partition for /usr/local.

Commands to test(objective)	Expected results
# mount -p	the /var partition has the nosuid and noatime options set the /home partition has the nosuid and logging options set the /tmp - partition has the size set to ~30% of swap space the /usr - partition has the logging option set

mount is the command used to mount or unmount file system and remote resources. When invoked with the –p option it prints the list of mounted file systems in the /etc/vfstab format.

4.2.5.2 Basic permissions

The sticky bit shall be set on /tmp and /var/tmp to prevent a user from deleting a file created by another.

Commands to test(objective)	Expected results
# ls –la / | grep tmp	drwxrwxrwxt 11 sys sys 2590 Oct 10 10:23 tmp
# ls –la /var | grep tmp	drwxrwxrwxt 11 sys sys 3400 Oct 10 10:25 tmp
create a file under an account with permission set to 777, then su to another account and try do delete the file	rm: operation not permitted

4.2.5.3 World-write files

In accordance with Req9 requirement, files should not be world-write unless it's vital for the system. At least, the minimum following rules shall be followed:

- No world-write directory that are in the root search path.
- Sticky bit in world-write directory
- No world-write files in users' home directory.

- sysadmin have to know if world -write access on files are necessary

Following the A reasonable amount of files should be world writable. If too much files are world wr i-table, then I should take closer look to see if an installation has not been made too permissively, and if it's possible to reduce the number of these files.

Commands to test(objective)	Expected results
`# find / -perm -o+w | wc -l`	Gives an idea of the number of world -write files and dir
Look in home dir if world -write files exist	No files should be found
Sticky bit set on standard world write dir	
`# find / -perm -o+w`	list of world-write files and directories should have been minimzed

Test (subjective)	Expected results
Ask sysadmin for world-write files found	They have to know whether they need it or not.

4.2.5.4 SUID and SGID files

In accordance with Req9 requirement, only the necessary files shall have the SUID bit set. We know that some past attacks have been taking advantages of SUID programs.

During execution of an SUID program, the user ID is set to the user ID of the program owner for the duration of the program. When the owner is root, the user has the superuser privileges when the pr o-gram is running. This is made to grant normal users to execute commands that require root privilege but without giving them the access to the root a ccount.

Removing, the SUID bit from files owned by root, means that the normal user won't be able to ex e-cute the command. Therefore, I should ensure that only binaries that are needed for normal users are left with SUID bit.

For the type of server I'm auditing, we hav e identify only the following files that can be left with the SUID bit set: `utmp_update, pt_chmod , login, ping, passwd, su` and `ssh`.

Note that is used to update the /var/adm/utmpx file and is needed to update information on logged user (viewed with the last command) and pt_chmod is needed when a user is logging remotely (e.g. via ssh). The others are well known commands or programs.

Commands to test(objective)	Expected results

`# find / -type f \( -perm -u+s -o -g+s \) -ls`	`/usr/lib/utmp_update`
	`/usr/lib/pt_chmod`
	`/usr/bin/login`
	`/usr/sbin/ping`

	/usr/bin/passwd /usr/bin/su /usr/local/bin/ssh

4.2.6 Account and password policy

In accordance with Req6 requirements a strong account and password policy shall be in place. To comply to such policy, some parameters have to be tested on the system and some procedures shall be verified.

The following parameters shall be checked on the Solaris operating system:

- password length of at least 8 characters
- choice of strong passwords (non-guessable, mix of numbers, capitals, and special characters)
- password expiration of 8 weeks (with a warning one week in advance)
- no duplicate accounts
- no accounts with no password
- encrypted password shall not be readable: force the use of /etc/shadow file
- minimum set of accounts
- non-users account shall be locked and have a default invalid shell.

Explanation	Commands to test(objective)	Expected results
minimum length of 8 characters	# egrep "PASSLENGTH" /etc/default/passwd	PASSLENGTH=8
	Try to change a password to a length smaller than 8 with passwd command	password can not be changed
password expiration of 8 weeks	# egrep "MAXWEEKS" /etc/default/passwd	MAXWEEKS=8
	# egrep " WARNWEEKS" /etc/default/passwd	WARNWEEKS=1
no duplicate accounts	# logins -d –x -m	no account shall be returned
no accounts with null password	# logins -p -x	no account shall be returned
Solaris' shadow password file shall be enforced	# more /etc/passwd	all accounts shall have an " x" in the password field in /etc/passwd
minimum set of accounts	# more /etc/passwd	Only root, daemon, adm, bin, sys, lp, uucp, nobody, noaccess, and one personal account for sysadmin shall figure.

non-users account shall be locked and have a default invalid shell	# more /etc/passwd	The last argument of the accounts: daemon, adm, bin, sys, lp, uucp, nobody, noaccess, shall have a shell like /sbin/noshell or /sbin/false.
	# passwd -sa	LK shall be displayed in front of the accounts: daemon, adm, bin, sys, lp, uucp, nobody, noaccess.

Then, I have to ensure that the following procedures are consistent and contribute to a strong password and account policy:

Test (Subjective)	Expected results
Ask the sysadmin and users how they choose their password (Is there a method?)	good practice, mix of numbers, characters, special characters, etc.
Can the sysadmin remember efficiently the root password (how many passwords do they have to remember)	copy of password shall be in secure places
What is the procedure when a person having a user account is leaving the company	See text below
What is the procedure when a person having access to the root account is leaving the company	See text below
What is the procedure to add a new user account	See text below
What is the procedure to give access to someone to the root account	See text below

The above mentioned procedures shall exist and must be available through a document. It's important to ask sysadmin if they are able to remember the root password without compromising the security. Often, sysadmins have several machines to manage in parallel. For each, at least one password must be remembered. Adding on top of this, that passwords are changing every 2 months, it's possible that the password be forgotten. To address this problem, sometimes, sysadmin write down somewhere their passwords, and possibly exposing them to unauthorized persons. It's thus important to know, that if there's a copy of passwords, it's stored in a secure place (e.g. in a safe), where only authorized persons have physical access (e.g. the security officer).

Another problem that is often overlooked is when a user is leaving the company. Immediate measures have to be taken to clean the user password and/or to change the root password. It's generally the task of the security officer to ensure that this procedure is enforced.

Likewise, a procedure must exist to allow access to someone to the machine. Generally, the security officer have to maintain an up-to-date list with the persons' name, the account name, and their role regarding the machine. It's also his task to grant sysadmin to create a new user account.

4.2.7 Console login

I have to ensure that root login is only permitted via the console. In addition, login with an empty password shall be prohibited, and the syslog facility shall be invoked to log security events related to login accesses. These measure have to be set in the /etc/default/login file. The parameters and the values to check are the following:

Commands to test(objective)	expected results
# more /etc/default/login | grep CONSOLE	CONSOLE=/dev/console
# more /etc/default/login | grep PASSREQ	PASSREQ=YES
# more /etc/default/login | grep SYSLOG	SYSLOG=YES

In addition the following test shall be made:

Test(objective)	expected results
Login with an empty password	login shall be refused
Check the corresponding log file	the above test shall be logged

4.2.8 Umask and Cmask

The default UMASK for users can be set in /etc/default/login file. The default user umask is used to set the initial permission when a file is created by a user. The umask value represents the complement of the permissions, i.e. a umask of 022 will set the permission to 644 to any created file. Following the least privilege principal (Req9) it is better not to have a too permissive umask. There's no reason for example to let read access to the others by default. A good policy is too have a umask of 027 or 077

Commands to test(objective)	Expected results
# more /etc/default/login | grep UMASK	UMASK=027 (or even better 077)
# umask	027 (or 077)
Login as a user and type: # touch testperm # ls –la testperm	Permission of file testperm shall be 640 or 600

The /etc/default/login file is parsed when login occurs via the console or with telnet (and "r" services). However, this file is not taken into a ccount when login is done via SSH program, except if the option UseLogin is set to "yes" in /etc/ssh/sshd_config which is not recommended (see § 4.2.12 for more detail on this)

When a user is logging in via SSH, the interactive shell specified in the /etc/passwd is invoked. D epending on the shell used, different configuration files are executed by the shell. It's in these files that the umask has to set.

If bash shell is used, the following files will be executed (in the right or der): /etc/profile, $HOME/.bash_profile, $HOME/.bash_login, $HOME/.profile, $HOME/.bashrc

If sh shell is used, the following files will be executed (in the right order): /etc/profile, $HOME/.profile

If csh is used, the following files will be executed (in the right order): /etc/.login, $HOME/.cshrc, $HOME/.login

If ksh is used, the following files will be executed (in the right order): /etc/profile, $HOME/.profile

Note that for non-root users, instead (or in addition) of invoking $HOME/.cshrc and $HOME/.pro file, sometimes $HOME/local.cshrc and $HOME/local.profile are called.

I have to check that for every used shell, the umask is appropriately set in the corresponding files by invoking umask 027 (or 077). Particular care should be taken with the root shell and umask.

Test(objective)	Expected results
Login as root using SSH and type umask	027 (or 077)
Look what are the shell used by the users in /etc/passwd. Check in the corresponding files that umask is set to 027 or 077	umask 027 (or 077)

In addition to the above test, it's important to check that if a new user account is created with a "not-yet-used" shell, then the corresponding file are setting a umask of 027 or 077

Test (Subjective)	Expected results
Ask sysadmin if they ensure a umask of 027 o r 077 when new user account is created	sysadmin shall know what files are required to set appripriately the umask for the invoked shell

There is another umask variable I have to verify. This the umask used by the init process at boot time. This is set by the CMASK variable stored in the file /etc/default/init. Note that every child process created by init inherits the CMASK value. To ensure that these processes don't create world -write files, the CMASK value shall be at least set to 022.

Test(objective)	Expected results
# grep CMASK `/etc/default/init`	022

4.2.9 Path variable

The PATH environment variable shall not contain the "." because known attacks have been taking a d-vantage of this setting.

Commands to test(objective)	Expected results
# echo $PATH	The "." shall not be included

4.2.10 Cron config files

In general the utilisation of cron job should be limited to normal users and system accounts shall not be able to schedule cron job. In accordance to Req9 requirement, all accounts except root shall pr e-vented from using cron utility.

The configuration file /etc/cron.d/cron.deny is used to list all accounts that have to be denied the a c-cess to execute cron jobs.

Commands to test(objective)	Expected results

`# more /etc/cron.d/cron.deny`	`daemon`
	`bin`
	`smtp`
	`nuucp`
	`listen`
	`nobody`
	`noaccess`
	`lp`
	`sys`
	`adm`
	`uucp`

Compare the listed accounts in /etc/cron.d/cron.deny with the one in /etc/passwd.	except the root account the lists shall be the same
log on as user account and type: `#crontab -l`	`crontab: you are not authorized to use cron. Sorry.`

In the same way the use of the at command shall be reserved to the root account only. This can be set in /etc/cron.d/at.deny.

Commands to test(objective)	Expected results
# more /etc/cron.d/at.de ny	daemon bin smtp nuucp listen nobody noaccess lp sys adm uucp
Compare the listed accounts in /etc/cron.d/cron.deny with the one in /etc/passwd.	except the root account the lists shall be the same

Note: even if the at command is not started (see the re commended list of running processes), for sake of consistency, we have to list all account names in the corresponding config uration file.

4.2.11 TCPwrapper

TCPwrapper software should be installed. As said in previous paragraphs, only HTTP, HTTPS and SSH are expec ted to run as network services. HTTP(S) can not be protected by TCPwrapper. Ho w-ever, SSH can and should.

For our exposed server the /etc/hosts.allow and /etc/hosts.deny files shall be configured to allow only ssh from remote management hosts.

Commands to test(objective)	Expected results
# which tcpd	/usr/local/bin/tcpd
# more /etc/host.deny	ALL:ALL:DENY
# more /etc/hosts.allow,	sshd: <IP# of management host>: A LLOW
Try to connect via ssh from a machine that is not specified in host.allow	The connectio n shall be refused.

The /etc/host.deny file shall only have the line mentioned above (ALL:ALL:DENY). This is the d e-fault rules that deny every connection with network services wrapped by TCPwra pper.

In /etc/hosts.allow file, rule are set for management hosts. Whenever possible, it's better to allow sp e-cific hosts rather than a whole subnet.

Even if no services are started through inetd demon, most common services contained in /etc/inet.conf should be wrapped by TCP wrapper security software.

Sometimes, sysadmins are starting inetd services for a temporary period, for troubleshooting. They uncomment the corresponding line in /etc/inetd.conf, and start the inetd demon. If these services were previously wrapped, it can guarantee that the service is only ope ned for the machines specified in /etc/hosts.allow. It also prevent from accidentally opening a service when e diting the /etc/inetd.conf.

To test if a service is wrapped by TCP wrapper, the tcpd program must be invoked at the correspon d-ing line. E.g. for F TP service wrapped by TCP wrapper we should have the following line:

ftp stream tcp nowait root /usr/sbin/**tcpd** in.ftpd

While for a non-wrapped FTP service, the ftp deamon is called directly:

ftp stream tcp nowait root /usr/sbin/**in.ftpd** in.ftpd

At least the following services should wrapped by TCP wrapper: Telnet, FTP, NNTP, r -services, pop, uucp, TFTP, Finger, Systat, Netstat.

Commands to test(objective)	Expected results
# more /etc/inetd.conf	tcpd shall be invoked for the services mentioned above

Finally, with respect to the least privilege principle (Req9 requirement), the 2 configuration files shall have their permissions set to 400 or 600.

Commands to test(objective)	Expected results
# ls –la /etc/hosts.*	-r-------- 1 root root 1584 Jul 12 17:53 etc/hosts.allow -r-------- 1 root root 1584 Jul 12 17:53 etc/hosts.deny

4.2.12 SSH security

First, the version of SSH used shall be up -to-date. This can be verified through the vulnerability sca n-ner results and by directly using the ssh command. The –V switch returns the version of the ssh sof t-ware installed.

Commands to test(objective)	Expected results
# ssh -V	latest version of OpenSSH (or SSH)
Nessus results	latest version of OpenSSH (or SSH)

To ensure that SSH security software is used in a secure way, appropriate settings have to implemented in the corresponding configuration file (/etc/sshd_config).

SSH can use two protocol version (1 and 2). Whenever possible, only the protocol 2 must be used because it's the most secure one (some weaknesses have been reported with protocol 1). If only protocol version is enabled then all parameters related to version 1 shall be disabled. This is the case of "RhostsRSAAuthentication" and "RSAAuthentication" parameters. They both have to be set to "no".

It's also important to log events related to SSH via the syslog tool. To collect enough information the log level must be at least set to info level (check § 4.2.13 for more details on this). The most appropriate facility for logging is AUTH.

The server key length must be at least 768 bit, to guarantee a minimum cryptographic strength (the shorter the key is, the easier the brute force attack is).

Direct root login via SSH can be permitted if no more than 2 sysadmin know the root password. Otherwise, login must be made from a non-root account and su shall be used. This is to be able to trace the account used in case of problems.

We don't want to allow any kind of trusts between the server and other machines. To disallow this feature a number of parameters shall be set to "no" in /etc/ssh/sshd_config.

First, the "IgnoreRhosts" has to be set to "no" to disallow the use of possible trusts specified in the .rhosts or .shosts files. however, the trusts specified in /etc/hosts.equiv and /etc/shosts.equiv are still effective.

The RhostsAuthentication shall be set to "no". It disables simple trusts specified by /etc/hosts.equiv or /etc/shosts.equiv files.

The RhostsRSAAuthentication uses the trusts specified in .rhosts or .shosts if "IgnoreRhosts" is set to yes, or the trusts specified in etc/hosts.equiv and /etc/shosts.equiv file. In addition it perform a machine authentication based on RSA, using private keys stored in the /etc/ssh/ssh_host_key. This key is normally stored in cleartext. This method is used by the protocol version 1, and therefore should be disabled, i.e. set to "no".

The HostbasedAuthentication is similar to RhostsRSAAuthentication, but uses protocol version 2. It should also be disabled as we don't allow trusts of any kind with the server. Therefore it shall be set to "no". Note that this method is the less risky method using trusts, and in some circumstances, it can be allowed. For example, if remote backups are used in conjunction with SSH, they might use trusts and host public key authentication. However, if this option is enabled it shall be justified for a special purpose.

The RSAAuthentication is used for user authentication with SSH. This method is used for protocol version 1 and therefore shall be set to "no".

For protocol version 2 there is two possible user authentication for login with SSH. The password authentication that uses the UNIX password, and the Public key authentication. While both can be enabled, it should be better to allow only one policy (it's easier to control one policy than two!)

The UseLogin option can tell SSH to use the UNIX login program. This should be avoided, because if login program has a vulnerability then SSH can inherit this vulnerability. Therefore it shall be set to "no".

Here are the recommended minimum parameters to check for this file:

Expected line in sshd_config (obje ctive)	Comments
Protocol 2	It's better to allow only SSH protocol version2 because it's more s e-cure. Default are set to Protoc ol 2,1 which means that in first priority protocol version 2 is used, and then Protocol 1 is tried. If SSH clients can handle version 2 of SSH protocol then the value shall be set to 2.
SyslogFacility AUTH	Logs the SSH events to /var/log/authlog
LogLevel INFO	The login level shall be at least set to info.
ServerKeyBits 768	The key length shall be at least 768 bit long
PermitRootLogin no	If only one or two persons have access to the root account to manage the web server, direct root login can be permitt ed. However, it's better to not allow direct root login, but to log on via a normal user account and to su to root after. In case of problems, we can better track the r e-sponsible persons.
PermitEmptyPasswords no	no comment!
StrictModes yes	Strict checks on ownership and access rights for all user files shall be enabled. This avoids attacks based on insufficient protection of such files.
IgnoreRhosts yes	Ignore the trusts between the machines using. rhosts and .shosts files.
RhostsAuthentication no	Ignore trusts using /etc/hosts.equiv and /etc/shosts.equiv
RhostsRSAAuthentication no	This is for the use of trusts between hosts with an RSA authentication. It is based on host keys only and is therefore not recommended. It is no longer supported in the versi on 2 protocol.
HostbasedAuthentication no	This is for the use of trusts between hosts using a Public key authent i-cation. It's the same as "RhostsRSAAuthentication" but for protocol version 2
RSAAuthentication no	RSAAuthentication authentication is no lon ger supported in version 2 ssh protocol (It has been replaced by DSA authentication), so it shall not be used.
PubkeyAuthentication no/yes	It's the same "RSAAuthentication" as but for protocol version 2

PasswordAuthentication yes/no	Password authentic ation shall be enabled
UseLogin no	Specify whether login program is used for interactive SSH login

The permission of the sshd_config files shall be restricted to 400 or 600 with regards to Req9 requirement.

Commands to test(objective)	Expected results
# ls –la /etc/sshd_config	-r-------- 1 root root 1584 Jul 12 17:53 /etc/sshd_config

In addition, to ensure that neither empty password nor root login are permitted the following test shall be made:

Test(objective)	Expected results
Login as root	login shall be refused
Login with an empty password	login shall be refused

4.2.13 Logging

A complete and comprehensive logging policy should be defined and then implemented in order to ensure that enough information is collected, and th at sysadmin are informed at the right time when problems occur. This policy has to be a formal document written security officer (possibly with the help of sysadmin), and approved by the manag ement.

Test (objective)	Expected results
Ask sysadmin, security officer and managers if a written policy exist	A written document

To estimate if a log policy is comprehensive and consistent might be very subjective. However, some few points are essentials. First, the policy should state when the logs have to be vie wed: it shall be a task of a dedicated person (generally the sysadmin). Then priority can be set to the different type of log events. For example, the log event related to failed access can be viewed every day, while others can be viewed every week. In add ition, for serious presumption of break -in alarm should be triggered. Finally, a procedure shall be triggered in case of emergency with the right persons i nformed

Test (subjective)
Check that the policy is comprehe nsive
Check that logs are viewed regula rly

Check that right priority are set to view the logs
Check that right priority are set for alarms
In case of alarms, the right persons must be informed, and if serious breaking has occurs an emergency procedure shall be triggered

In addition, I have to ensure that this policy is really enforced, and that right tools are used.

Test (subjective)	Expected results
Check that the policy is enforced	The document must be followed
Check that the right tools are used	At least syslog and a tool to analyze log shall be used

On Solaris system, the syslog shall be used to enforce a part of the log policy described above. This tool permits to log all types of event in a centralized way and therefore shall be used. Syslog works with facilities such as kern, mail, auth, deamon, syslog, lpr, mark, news, uucp, cron. In the configuration file (/etc/syslog.conf), we can specify to log events in a dedicated file (generally stored under /var/log/*) relative to each facility. It's also possible to specify from which priority level we want to log the events. We have 9 levels of priority (from highest to lowest): emerg, alert, crit, err, warning, notice, info, debug. To have necessary error information reported, all facilities shall be logged from the info priority, to the corresponding files. In addition, emergency errors cane be sent to all terminal.

Therefore the syslog.conf file shall be checked for

Test(objective)	Expected results
All facilities shall be logged on separate file under /var/log/	See the Figure 1
Check that the minimum priority level is info.	See the Figure 1
Generate events to trigger syslog to store the event (e.g. ssh login with wrong password)	event must be stored
Check permission for log file (/var/log/*log)	permission shall be set to 600

```
# All emergency level message are sent to all terminal
*.emerg                         *

# All facilities logged from info level to store sufficient information
```

```
kern.info               /var/log/kernlog
user.info               /var/log/userlog
mail.info               /var/log/maillog
daemon.info             /var/log/daemonlog
auth.info               /var/log/authlog
lpr.info                        /var/log/lprlog
news,uucp.info                  /var/log/newslog
cron.info               /var/log/cronlog


# Put all alerts (& higher) into a seperate log:
*.err                   /var/log/alertlog
```

Figure 1: how the syslog.conf file should look like

Note, that in accordance with Req9 requirement (least privilege), the log files have to be set with a permission of 600.

As mentioned previously, a tool to analyze the generated log files shall be used. Good tools exists such as Logcheck (available at www.psionic.com/abacus/logcheck), that helps to analyze the log files and send alert via e-mail, for error that the sysadmin has defined as serious security violation. I have to ensure that such tool enforce the security policy mentioned above about the prioritization of alarm and viewed events.

Test (Subjective)	Expected results
Check that the policy for alarm prioritization is enforced	Policy and implementation must be consistent

Test(objective)	Expected results
Generate an event that is considered as a serious security violation	Check if an e-mail is sent to the right mailbox

Finally, if administrator have several machines to administer, it might be the case that the logs from all machines are centralized on loghost (central server dedicated to collect log information from other machines). In this case the principle, for log policy is the same, but the log file differ slightly (c.f. Appendix B -§10- for an example).

4.2.14 Integrity check software

To ensure the integrity of important files, and to detect unauthorized change, integrity software such as AIDE or tripwire must be installed.

Test(objective)	Expected results
Ask sysadmin if an integrity check software is i n-stalled	AIDE or tripwire must be instaled

The minimum system files to be checked for integrity are: /kernel, /usr/bin/*, /usr/sbin/*, /usr/local/bin/*, /etc/passwd, /et c/shadows, /etc/sshd_conf, /etc/aide.conf, /etc/system, /etc/hosts.allow, /etc/hosts.deny

At least the modification of the files and the permission modification shall be checked. The database of the integrity check software must contain a cryptographic has h (e.g. MD5) of the above mentioned files. At least the modification of the files and the permission modification shall included in the hash calculation. An example of such setting with AIDE is shown below:

Commands to test (AIDE)	Expected results

`# more /etc/aide.conf`	`Rule=p+u+g+m+md5`
	`/usr/bin Rule`
	`/usr/sbin Rule`
	`/usr/local/bin Rule`
	`/kernel Rule`
	`/etc/passwd$ Rule`
	`/etc/shadows$ Rule`
	`/etc/sshd_conf$ Rule`
	`/etc/aide.conf$ Rule`
	`/etc/system$ Rule`
	`/etc/hosts.al low$ Rule`
	`/etc/hosts.deny$ Rule`

Similar rules are expected to be specified if Tripwire is installed instead.

On a regular basis, the database must be recalculated and compared to the old one. If a difference is found, then an alarm should be trigge red. As an example a shell script using AIDE is given in Appe n-dix A (§9). This script must be scheduled with the cron program. This script calculates the hash of the specified files and compares the results with the previous database. Any difference is stored in a log file.

In addition a copy of the database should be stored either on a write -once device or with a daily backup.

I should ensure that similar policy is implemented

Test (objective)	Expected results
Verify the integrity check software co nfiguration	Implementation has to be similar to the above mentioned policy.

An example of such script is given in Appendix A (§ 9).

4.2.15 Policy for security patches

A clear policy shall be in place, to decide whether a weakness is worth patching. For our web It shall include a strategy to set priority on patches to apply based on the following statements:

- If the weakness concerns a remotely exploitable weakness in an active network daemon, open to internet, the patch shall be tested and installed immediately. For our web server, it means any security patches related to the HTTP deamon, the SSL deamon, and any third party application used by the web application.
- If a weakness is remotely exploitable from the Intranet, apply it a soon as possible. For our web server, this concern the sshd deamon.
- If a weaknesses concerns a local exploit on a running deamon install it rapidly. For our web server this concern the list of deamon listed in paragraph 4.2.3.3
- for other weaknesses it may be enough to install the patch together with a bundle at regular intervals (e.g. every 2-3 months).
- Use a patch tool to help find relevant patches and install them. For patches related to Solaris some good tools such as GetApplyPatch, CheckPatches or PatchDiag can be used. More detail about these tools is given in [11], [12], and [13]
- Sysadmin shall subscribe to the vendor's mailing list for new patch announcement. In addition, being on a mailing list of an organization which produces regular summaries of weakness/patches and security news (e.g. for example SecurityFocus, SANS, etc) is recommended.

Test (Subjective)	Expected results
Ask sysadmin for their patching policy	A clear policy addressing the above mentioned points shall be in place.
Ensure that the policy is followed by sysadmin	Procedure described in policy must be followed
Ensure that sysadmin is on right mailing lists	He should subscribe to mailing for Solaris and third party applications if any (e.g. apache)
Ask sysadmin if they verify that secure state is maintained after patch installation	Check after reboot that no new services or processes are started.

In addition, to the stated policy, a kind of patch post-installation procedure should exist. This step is necessary to ensure that no new services, processes or deamons have been installed with the patches.

4.2.16 Back-up and recovery policy

A written backup policy shall be clearly defined and shall address the following points:

- the frequency of incremental backups
- the frequency of full backups
- physical storage of backups (use of safe)
- how long the backups are kept
- who has physical access of backup
- recovery procedure shall be test
- If a special tool is used the tool shall enforce the backup policy.

Test (Subjective)	Expected results
Check that a backup and recovery policy is in place and is enforced	Policy shall address the above mentioned points.

5 Audit results

5.1 Environment description

The network topology is the following:

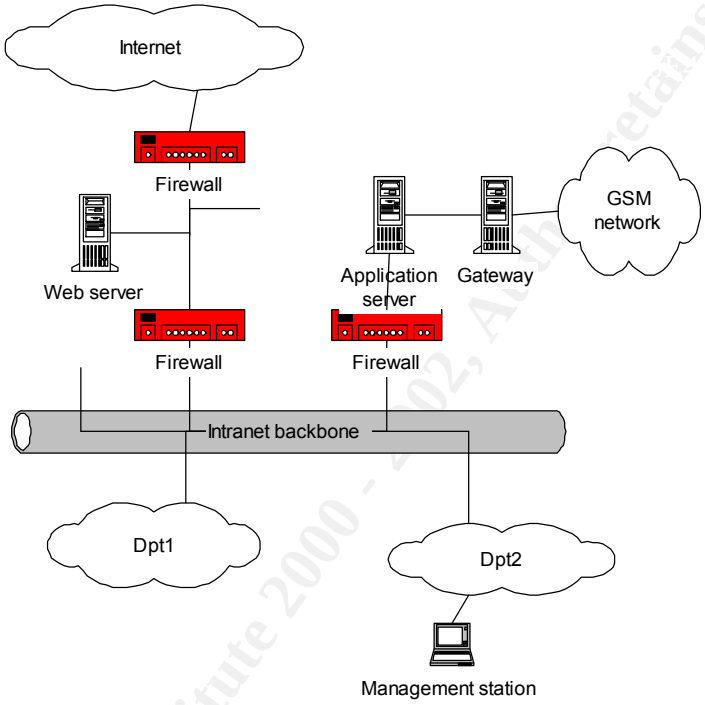

Figure 2: network environment

In the introduction chapter I mentioned that we have to make our service available to Internet users. This is a concrete example: our mobile department has deployed a service to his mobile customers to make "restricted zones of friends with chat rooms". This service was available with the mobile phones using SMS (Short Message System), and is now ported to the IP world. Internet users will be able to use this service not only with their mobile phone but also from any PC connected to Internet.

This service is offered via a web interface. The users have to log on to the application with HTTP using their mobile phone number as username and a password. Then, the web server makes a query to the application server itself connected to the GSM network through a gateway (that makes the conversion between IP and SS7 protocols).

The web server is located in a scre ened subnet zone, i.e. is protected from Internet by a "permissive Firewall" and separated from the Intranet backbone by a more restrictive firewall. Note that the fir e-wall rulebase inspection will not be part of this audit.

An important consideration is that our Intranet is considered as "moderately secure". First, this bac k-bone is shared by more than 12'000 users everyday, spread within more than 10 departments; second, we still have some connections with external networks (e.g. Internet) that are not se cured and mon i-tored in a centralized way by competent staff. Even if strong efforts have been made to suppress these "wild" connections, some are still present, especially in testing labs and env ironments.

5.2 Scope of the audit

In this audit I will evaluate the security of the operating system of the machine hosting the web server. The web application and the application that communicates with the application server is not part of this audit. Furthermore, in the project schedule, the applications will be inst alled on the machine if and only if the OS insta llation passes the security audit.

The OS that is audited here is Solaris 8 installed on a Sun SPARC station.

An important consideration is that the audit was made in mid -October 2001, and some of the results might be out-of date at the time of writing (like the ve rsion of some software).

5.3 Risk analysis

Because estimating the risks might be quite subjective, I asked two other colleagues of our security team, Stephane Grundschober(GIAC -GSNA certified) and Stepha ne Dagonnier, to participate to this task.

For each audit item or group of audit items identified in the first part of this paper, I asked them to fill two columns: one for the likelihood that a break -in succeed if the audited item doesn't conform to our requirements; and the other for potential damages caused by such a break -in. For the likelihood I d e-fined three levels, 1,2 and 3, 1 meaning low probability that a break -in succeeds, and 3 for high pro b-ability. I also defined 3 levels for the damages: 1 rep resents a non-significant loss, 2 represents an a v-erage loss (e.g. loss of image), and 3 represents critical loss (e.g. loss of the service, theft of custo m-ers' data, etc.). Then I calculated the risks by multiplying the likelihood with the damages. The re sults I obtained from each of us is given in APPENDIX C (§ 11).

Finally, I calculate the average of the risks estimated by each of us. The maximum risk is 9 (=3x3), the minimum being 1(=1x1).

The final results are given below:

Audit Item	*Risk*
Installed packages	7.33
Strategy for Installed packages	2.33
OS patches	9
Inetd service	8
Minimum boot network services running	8

Sysadmin knowledge of running network ser vices	4.67
Procedure to start a new network service	2
Minimum running processes	4
Knowlegde of running processes	3
Procedure to start a new deamon	2
ARP defenses	3
ICMP defenses	4.33
IP defenses	5
TCP defenses	4.67
Persistency after reboot	7.33
User stack protection	6
File descriptor	1.33
Core files	1.67
Partitions	3.67
/tmp sticky bit	1
World-write files and dir	3.33
SUID SGID file	6.33
Password length 8	4.67
Password expiration	6.33
no duplicate accounts	1.33
accounts with null password	9
Shadow file enforced	5.67
minimum set of accounts	2
Non-user account locked and non -valid shell	5.33
Method to choose strong passwd	6
Password storage	8
Procedure when user leaves cpny	7
procedure to add a new user and give authorization to access the machine	5.33
console login	4
Umask	5.33
CMASK	4
Path variable	5.33
cron.deny at.deny	1.33
TCP wrapper installed and configured	6.33
SSH version	9
SSH protocol	8
log of SSH events	3
SSH server key length	3.67
SSH Root login	4.33
SSH empty passwd	9
SSH No trusted hosts	6
RSA or passwd authentication	4.67
400 /etc/sshd_config	3.33
Log policy exist	7.33
log policy is comprehensive	6.33
log policy is enforced	9
log tools installed and configured	9
Integrity check software installed and well co nfigured	7.33
Patching policy exist	7.3
Patching policy enforced	9

Secure state after applying patches	6.67
Backup and recovery policy exist	4.33
Backup and recovery policy enforced	7

High risk values range from 7 to 9. Average risk values range from 4 to 6. Low risk value ranges from 1 to 3. In the above results I have written the highest risk in red.

These results will be used to prioritize the measures to apply. More details on this is given in §xxx.

5.4 Scan from Intranet (internal scan)

```
# nmap -O -p 1- xxx.xxx.xxx.xxx

Starting nmap V. 2.53 by fyodor@insecure.org ( www.insecure.org/nmap/ )
Interesting ports on www.vvv.dd (xxx.xxx.xxx.xxx):
(The 65529 ports scanned but not shown below are in state: closed)
Port       State       Service
22/tcp     open        ssh
80/tcp     open        http
443/tcp    open        https
7937/tcp   open        unknown
7938/tcp   open        unknown
32768/tcp  open        unknown

TCP Sequence Prediction: Class=truly random
                         Difficulty=9999999 (Good luck!)
No OS matches for host (If you know what OS is running on it, see http://www.insecure.org/cgi-
bin/nmap-submit.cgi).
TCP/IP fingerprint:
TSeq(Class=TR)
T1(Resp=Y%DF=Y%W=60DA%ACK=S++%Flags=AS%Ops=NNTNWM)
T1(Resp=Y%DF=Y%W=60DA%ACK=S++%Flags=A%Ops=NNT)
T2(Resp=N)
T3(Resp=N)
T4(Resp=Y%DF=Y%W=0%ACK=O%Flags=R%Ops=)
T5(Resp=Y%DF=Y%W=0%ACK=S++%Flags=AR%Ops=)
T6(Resp=Y%DF=Y%W=0%ACK=O%Flags=R%Ops=)
T7(Resp=N)
PU(Resp=Y%DF=Y%TOS=0%IPLEN=70%RIPTL=148%RID=E%RIPCK=E%UCK=E%ULEN=134%DAT=E)
```

The port scan was done with Nmap version 2.53 on a Linux platform.

The result of this TCP scan shows what services are visible to Intranet. First, 3 standard ports are actually opened: TCP port 22 for SSH, TCP port 80 for HTTP and TCP port 443 for SSL. As stated in our checklist these service are "authorized to run". However, 3 other TCP ports are opened: the port 7937, 7938 and 32768. I will have to investigate on these open ports, to see if they are really needed and they are harmless. This will be presented later in this paper when showing the results of the local audit.

Nmap rated the TCP sequence number prediction as almost impossible, which makes hijacking attacks very difficult.

Finally, nmap was not able to guess the type of OS.

```
# nmap -sU -p 1-
starting nmap V. 2.53 by fyodor@insecure.org ( www.insecure.org/nmap/ )
Interesting ports on www.vvv.dd (xxx.xxx.xxx.xxx):
(The 65533 ports scanned but not shown below are in state: closed)
Port       State       Service
123/udp    open        ntp
7938/udp   open        unknown

Nmap run completed -- 1 IP address (1 host up) scanned in 7377 seconds
```

For the UDP scan, nmap shows two ports open. The UDP port 123 for NTP service, th e a high port 7938.

If we refer to our checklist, NTP is not part of the accepted running network services. Furthermore, this service has had security vulnerabilities discovered several times. However, maintaining an acc u-rate time and date is necessary, e specially for the log analysis. I will show later in this paper how to replace this NTP network service by a simple cron job, which is a much more secure.

The UDP port 7938 is also open (note that I found the TCP port number opened). If I refer to the checklist this port is not authorized to be opened.

I should look further to what applications the non -standard ports correspond to in order to determine if they are needed and harmless. This will be covered in the next chapters dealing with the local audit.

5.5 Port scan of the web server from Internet

```
# nmap -p 1- xxx.xxx.xxx.xxx

Starting nmap V. 2.53 by fyodor@insecure.org ( www.insecure.org/nmap/ )
Interesting ports on www.vvv.dd (xxx.xxx.xxx.xxx):
(The 65529 ports scanned but not shown below are in state: closed)
Port       State       Service
22/tcp     filtered    ssh
80/tcp     open        http
443/tcp    open        https
7937/tcp   filtered    unknown
7938/tcp   filtered    unknown
32768/tcp  filtered    unknown
Nmap run completed -- 1 IP address (1 host up) scanned in 352 seconds
```

The nmap TCP scan result from Internet shows the same open ports on the server. However, the fir e-wall filters SSH, and the 3 high open ports. Even if the firewall rules are not part of this audit it's i m-portant to mention that for TCP ports only the strict minimum set of services have been opened on the Internet firewall, in accordance with Req1 requirements.

```
# nmap -sU -p 1-
starting nmap V. 2.53 by fyodor@insecure.org ( www.insecure.org/nmap/ )
Interesting ports on www.vvv.dd (xxx.xxx.xxx.xxx):
(The 65533 ports scanned but not shown below are in state: closed)
Port       State       Service
123/udp    open        ntp
7938/udp   filtered    unknown

Nmap run completed -- 1 IP address (1 host up) scanned in 8154 seconds
```

The UDP port scan from Internet shows the same ports opened on the server. The high port 7938 is filtered by the firewall. The surprise is that the nmap shows that the UDP port 123 corresponding to NTP service is opened to Internet. This means that the Firewall doesn't filter this port. Even if the audit of the firewall rules is out-of-scope, more investigation is necessary to understand why this port is opened. To our knowledge, we have two NTP reference servers that are internal machine, and time synchronization has to be made with these dedicated servers. I interviewed the sysadmin of the web server to know if he used Internet NTP servers for synchronization. He answered me that he uses our internal reference NTP servers. So I asked the Firewall administrator to immediately close this port. He was surprised and told me that as far as he knew he never opened this port. After checking his rulebase, this port was really not opened. I rescanned the NTP port from Internet, with snoop running on the web server and a sniffer placed on the external interface of the firewall. Then, I realized that no UDP packets were arriving on the server (the firewall was really blocking NTP port), but that the firewall were returning bogus UDP packets in response to our scan!

5.6 Vulnerability scan of the web server

The output of nessus is the following:

Information found on port ssh (22/tcp)
Remote SSH version : ssh-1.99-openssh_2.2.0p1

Information found on port http (80/tcp)
The remote web server type is :
IBM_HTTP_Server/1.3.12.3 Apache/1.3.12 (Unix)

We recommend that you configure your web server to return
bogus versions, so that it makes the cracker job more difficult

The scan was done using Nessus with latest available (26.10.2001) vulnerability plugins. Except the buffer overflow vulnerability that are sometimes dangerous (may cause system crash), all other existing vulnerabilities where tested. The results show that no security vulnerability where found on this server. It was only able to retrieve information about the web server type and version as well as the sshd deamon version and type.

Note that nessus shows an old version of SSH. At the time of the audit the last available version is OpenSSH_2.9.9p. An upgrade to this version shall be made.

5.7 Results of local audit

5.7.1 Installed packages

Results	Verdict
`# /usr/bin/pkginfo -i | wc -l` `649`	Fail

This results shows that 650 packages were installed on this machine! We can expect that no strategy has been adopted to limit the number of packages. This will be confirmed in the results below.

Results	Verdict
Pakage installation strategy: none	Fail

After interviewing, the sysadmin it appears that a default installation has been made, rather than a custom installation. No attention were paid to select only needed packages.

Results	Verdict
`# /usr/bin/pkginfo -i` The list is given in APPENDIX D (§ 12)	Fail

A lot of installed packages are not needed. For example all packages related a graphical interface or service are not needed and shall be removed. This includes all packages related X11, CDE, Elite3D, OpenWin, etc. Likewise, all packages related to audio devices shall be removed. The printer packages shall also be removed. Some applications packages like uucp, dhcp, ppp, power management, etc. shall also be removed. I have highlighted them in yellow, in the corresponding APPENDIX D (§ 12). They represents more 170 packages that can be immediately removed. It's important to mentioned that before removing them on the production server this should be first done on a test server. After discussion with the sysadmin, I realized that such a server already exist, and is configured exactly like the production server.

For the other packages, more scrutiny is needed. For the hardware drivers packages, we have to know exactly what hardware is present on the machine (e.g. the type of Ethernet cards), before removing packages. There are also the application packages. All packages related to IBMHTTPD server should be left as there are needed by the web server.

The measures can be applied in three steps:

- immediately remove packages highlighted in APPENDIX D (§ 12) on the test server. Reboot and observe the behavior during 2 days. If OK applied on the production server.

- Look with sysadmin what exactly hardware package are needed and which one can be removed.
- Look in IBM documentation and support, what packages are needed for their IBMHTTPD server.

5.7.2 OS installed patches

Results	Verdict
`# ./PatchCheck` See results in Appendix E (§ 13)	Fail

The system has not been patched with up-to-date patches. The results in Appendix E show that many security patches are missing. I highlighted in yellow some patches that are directly related to running processes (cron, xntp), that are part of the kernel or that apply to TCP/IP drivers. In addition many recommended patches haven't been applied.

The sysadmin agrees to quickly test these patches on the test system and then to apply them on the production server.

Note that some patches that are listed are not relevant for our server because the related packages were not installed.

5.7.3 Network services

5.7.3.1 inetd services

Results	Verdict
`# ps -ef | grep inetd` `root 243 1 0 Oct 26 ? 0:00 /usr/sbin/inetd -s -t`	Fail
`# pgrep inetd` `243`	Fail

Inetd is running. According to our checklist it should be stopped. I have to look why it's running, i.e. what services are started by inetd.

By looking at non commented lines /etc/inetd.conf we can see which services are started by inetd daemon:

Results	Verdict
`# egrep -v "^#" /etc/inetd.conf` `300326/4 tli rpc/tcp wait root /platform/SUNW,Ultra-Enterprise-10000/lib/dr_daemon dr_daemon`	Fail

The dr_daemon is a Remote Procedure Call (RPC) program that provides the interface to the Sun Enterprise 10000 Dynamic Reconfiguration (DR) driver. After discussion with the sysadmin, it appears

that this service was not needed, and therefore will be stopped. The corresponding line in inetd.conf will be commented, and inetd demon will not be started from the rc scripts.

5.7.3.2 Boot services

Results	Verdict
# lsof -i COMMAND PID USER FD TYPE DEVICE SIZE/OFF NODE NAME inetd 243 root 11u IPv4 0x300016aa1c8 0t0 TCP *:32768 (LISTEN) nsrexecd 328 root 5u IPv4 0x300018ae1d0 0t0 UDP *:7938 (Idle) nsrexecd 328 root 6u IPv4 0x300019bdd58 0t0 TCP *:7938 (LISTEN) nsrexecd 343 root 6u IPv4 0x3000114c550 0t0 TCP *:7937 (LISTEN) sshd 334 root 6u IPv4 0x300018ae6d0 0t0 TCP *:ssh (LISTEN) xntpd 345 root 19u IPv4 0x300019faf98 0t0 UDP *:ntp (Idle) httpd 4632 nobody 15u IPv4 0x300055aea40 0t0 TCP *:443 (LISTEN) httpd 4632 nobody 16u IPv4 0x300055af6c0 0t0 TCP *:80 (LISTEN) httpd 4932 nobody 15u IPv4 0x300055aea40 0t0 TCP *:443 (LISTEN) httpd 4932 nobody 16u IPv4 0x300055af6c0 0t0 TCP *:80 (LISTEN) httpd 6120 nobody 15u IPv4 0x300055aea40 0t0 TCP *:443 (LISTEN) httpd 6120 nobody 16u IPv4 0x300055af6c0 0t0 TCP *:80 (LISTEN) httpd 6873 nobody 15u IPv4 0x300055aea40 0t0 TCP *:443 (LISTEN) httpd 6873 nobody 16u IPv4 0x300055af6c0 0t0 TCP *:80 (LISTEN) httpd 8736 nobody 15u IPv4 0x300055aea40 0t0 TCP *:443 (LISTEN) httpd 8736 nobody 16u IPv4 0x300055af6c0 0t0 TCP *:80 (LISTEN) httpd 15474 nobody 15u IPv4 0x300055aea40 0t0 TCP *:443 (LISTEN) httpd 15474 nobody 16u IPv4 0x300055af6c0 0t0 TCP *:80 (LISTEN) httpd 21652 root 15u IPv4 0x300055aea40 0t0 TCP *:443 (LISTEN) httpd 21652 root 16u IPv4 0x300055af6c0 0t0 TCP *:80 (LISTEN) httpd 21670 nobody 15u IPv4 0x300055aea40 0t0 TCP *:443 (LISTEN) httpd 21670 nobody 16u IPv4 0x300055af6c0 0t0 TCP *:80 (LISTEN) httpd 23432 nobody 15u IPv4 0x300055aea40 0t0 TCP *:443 (LISTEN) httpd 23432 nobody 16u IPv4 0x300055af6c0 0t0 TCP *:80 (LISTEN) httpd 23449 nobody 15u IPv4 0x300055aea40 0t0 TCP *:443 (LISTEN) httpd 23449 nobody 16u IPv4 0x300055af6c0 0t0 TCP *:80 (LISTEN) httpd 27294 nobody 15u IPv4 0x300055aea40 0t0 TCP *:443 (LISTEN) httpd 27294 nobody 16u IPv4 0x300055af6c0 0t0 TCP *:80 (LISTEN)	Pass: only xntp shall be stopped inetd has already been discussed

The service on the port 32768 started by inetd, is the service I found in the previous paragraph (dr_deamon), and that should be stopped.

Otherwise, the lsof output shows the 3 authorized services HTTP, HTTPS and SSH. However, we have two services that were not foreseen: xntp and nsrexecd. As mentioned previously, xntp shall be replaced by a cron job. It's safer to run it as a cron job than letting this service running because of it's bad security reputation. The f ollowing line should be added in the root crontab:

```
15 * * * * /usr/sbin/ntpdate  -s <IP# ntpserver>
```

Note that here I specified to synchronize the time once per hour at quarter past.

The man pages says: " *The ntpdate utility sets the local date and time. To determine the correct time, it polls the Network Time Protocol (NTP) servers on the hosts given as arguments. This utility must be run as root on the local host. It obtains a number of samples from each of the servers and applies the standard NTP clo ck filter and selection algorithms to select the best of these.* " In addition, the –s option permit to log the related events through the syslog facility.

Running a cron job that that makes a UDP request, it much more safe than letting run a network d ea-mon because if vulnerability is discovered in NTP it can be remotely exploited.

The UDP and TCP ports 7938 are related to a backup software from Legato system (http://portal1.legato.com/). nsrexecd is the daemon that authenticates the Backup server's remote execution request and executes the save and savefs commands on the client. After discussion with the sysadmin, it appears that it their standard way of doing backup. All backups of this department are centralized to a backup server located in secure room, in the basement. As backups are vital, we d e-cided to let this service running.

The output of netstat –a gave the same results. By looking under the UDP and TCP tables I was able to confirm the above results. The ou tput of this command is not shown here as it doesn't provide a ddi-tional information.

Note: I give a passing grade to this test because only xntp will be stopped (Inetd was part of the pr e-vious test where I already gave a fail for it).

Results	Verdict
After reboot the same results were observed with lsof –I and ne tsat –a	Pass

After a reboot of the machine I did not observe additional services that started. The output of lsof –i and netstat –a showed the same results.

Results	Verdict
Sysadmin knowledge network services	Pass
Procedure to start a new service	Fail

After interviewing the sysadmin, I realize that he has in -depth knowledge of the network ser vices.

However, no procedure of control exists for the start of new network services. After discussio n with the sysadmin and his manager, it has been agreed that a small procedure will be addressed.

5.7.3.3 processes

Results	Verdict
# ps -ef UID PID PPID C STIME TTY TIME CMD root 0 0 0 Oct 21 ? 0:17 sched root 1 0 0 Oct 21 ? 4:57 /etc/init - root 2 0 0 Oct 21 ? 0:00 pageout root 3 0 1 Oct 21 ? 555:49 fsflush root 367 1 0 Oct 21 ? 0:00 /usr/lib/saf/sac -t 300 root 278 1 0 Oct 21 ? 0:01 /usr/lib/utmpd root 67 1 0 Oct 26 ? 0:00 /usr/lib/picl/picld root 56 1 0 Oct 21 ? 0:00 /usr/lib/sysevent/syseventd root 58 1 0 Oct 21 ? 0:00 /usr/lib/sysevent/syseventconfd	Pass- except picld process is not necessary and should be stopped

```
root   243     1  0   Oct 21 ?        0:00 /usr/sbin/inetd -s -t
root   254     1  0   Oct 21 ?        0:04 /usr/sbin/cron
root   343   328  0   Oct 21 ?        0:02 /usr/sbin/nsr/nsrexecd -s xxxxx
root   345     1  0   Oct 21 ?        0:01 /usr/lib/inet/xntpd
root   269     1  0   Oct 21 ?        0:23 /usr/sbin/nscd
root   288     1  0   Oct 21 ?        0:02 /usr/sbin/vold
root   253     1  0   Oct 21 ?        0:03 /usr/sbin/syslogd -t
root   328     1  0   Oct 21 ?        0:02 /usr/sbin/nsr/nsrexecd -s xxxxx
root   307     1  0   Oct 21 ?        0:00 /usr/lib/sendmail -q15m
root   334     1  0   Oct 21 ?        0:21 /usr/local/sbin/sshd
root 14439     1  0   Oct 10 console  0:00 /usr/lib/saf/ttymon -g -h -p xxxxx
console login:  -T sun -d /dev/console -
nobody  8736 21652  0   Oct 21 ?      0:49 /opt/IBMHTTPD/bin/httpd
nobody  4632 21652  0 14:18:07 ?      0:02 /opt/IBMHTTPD/bin/httpd
root   398   367    0   Oct 21 ?      0:00 /usr/lib/saf/ttymon
nobody 23432 21652  0   Oct 21 ?      0:12 /opt/IBMHTTPD/bin/httpd
root  2552   334    0   Oct 21 ?      0:17 /usr/local/sbin/sshd
nobody 21670 21652  0   Oct 21 ?      1:43 /opt/IBMHTTPD/bin/httpd
nobody  6873 21652  0 15:54:18 ?      0:01 /opt/IBMHTTPD/bin/httpd
root 21652     1    0   Oct 21 ?      0:02 /opt/IBMHTTPD/bin/httpd
nobody 27294 21652  0 09:02:18 ?      0:05 /opt/IBMHTTPD/bin/httpd
nobody  4932 21652  0   Oct 21 ?      0:28 /opt/IBMHTTPD/bin/httpd
nobody 15474 21652  0   Oct 21 ?      0:19 /opt/IBMHTTPD/bin/httpd
root  9484   334  0 17:41:00 ?        0:00 /usr/local/sbin/sshd
root  9355   334  0 17:37:48 ?        0:00 /usr/local/sbin/sshd
nobody  6120 21652  0   Oct 21 ?      1:17 /opt/IBMHTTPD/bin/httpd
nobody 23449 21652  0   Oct 21 ?      0:33 /opt/IBMHTTPD/bin/httpd
```

xntp and inetd have already been discussed.

note: the "xxxx" replace server name for security reason

The xntp, inetd deamon have already been discussed. A part from these all other deamon are necessary except one: the picld deamon. If we refer to the man pages it says: "*Platform Information and Control Library (PICL) provides a mechanism to publish platform-specific information for clients to access in a platform-independent way. picld maintains and controls access to the PICL information from clients and plug-in modules.*"
This is obviously not a necessary process and therefore in agreement with the sysadmin this it will be removed from the start-up rc script by doing the following:

```
# mv /etc/rcS.d/S95picld /etc/rcS.d/_S95picld
# mv /etc/init.d/picld /etc/init.d/.p icld
```

Results	Verdict
Sysadmin knowledge deamon/processes	Pass
Procedure to start new deamon/processes	Fail

After interviewing the sysadmin, I realize that he has in-depth knowledge of deamon/processes.

However, no procedure of control exists for the start deamon/processes. After discussion with the sysadmin and his manager, it has been agreed that a small procedure will be addressed.

5.7.4 Kernel tuning

5.7.4.1 Network parameters

For the network parameters the results are the followings:

Command	Results
# /usr/sbin /ndd /dev/arp arp_cleanup_interval	60000
# /usr/sbin/ndd /dev/ip ip_ire_arp_interval	60000
# /usr/sbin/ndd /dev/ip ip_respond_to_echo_broadcast	0
# /usr/sbin/ndd /dev/ip ip6_respond_to_echo_multicast	0
# /usr/sbin/ndd /dev/ip ip_respond_to_time stamp_broadcast	0
# /usr/sbin/ndd /dev/ip ip_respond_to_address_mask_broadcast	0
# /usr/sbin/ndd /dev/ip ip_ignore_redirect	1
# /usr/sbin/ndd /dev/ip ip6_ignore_redirect	1
# /usr/sbin/ndd /dev/ip ip_send_redirects	0
# /usr/sbin/ndd /dev/ip ip6_send_redirects	0
# /usr/sbin/ndd /dev/ip ip_respond_to_timestamp	0
# /usr/sbin/ndd /dev/ip ip_forwarding	0
# /usr/sbin/ndd /dev/ip ip6_forwarding	0
# usr/sbin/ndd /dev/ip ip_strict_dst_multihoming	1
# usr/sbin/ndd /dev/ip ip6_strict_dst_multihomi ng	1
# /usr/sbin/ndd /dev/ip ip_forward_directed_broadcasts	0
# /usr/sbin/ndd /dev/ip ip_forward_src_routed	0
# /usr/sbin/ndd /dev/ip ip6_forward_src_routed	0
# /usr/sbin/ndd /dev/tcp tcp_conn_req_max_q0	4096
# /usr/sbin/ndd /dev/tcp tcp_conn_req_max_ q	1024
# /usr/sbin/ndd /dev/tcp tcp_time_wait_interval	240000
# /usr/sbin/ndd /dev/tcp tcp_fin_wait_2_flush_interval	675000
# /usr/sbin/ndd /dev/tcp tcp_keepalive_interval	7200000
# /usr/sbin/ndd /dev/tcp tcp_conn_hash | grep size	tcp_conn_hash_size=512
# more /etc/system | grep tcp_conn_hash_size	Nothing was di s-payed
# ndd /dev/tcp tcp_strong_iss	2

# more /etc/default/inetinit | grep TCP_STRONG_ISS=	TCP_STRONG_ISS=2
# ndd /dev/tcp tcp_rev_src_routes	0

Globally the results for the network param eters conforms to the values I defined in my checklist. I can give a pass to this test. The only values that don't correspond are shown in red in the above table. Three TCP timers have not been adjusted, and the size of the hash table is under -dimensioned.

The sysadmin agrees to adjust the size of the table by entering the following line in the /etc/system file: set tcp_connect_hash_size=512

For the timer, the following line will be added in the existing script /etc/init.d/nddconfig. This script is called at boot time by /etc/rc2.d/S70nddconfig:

```
/usr/sbin/ndd -set /dev/tcp tcp_time_wait_interval 60000
/usr/sbin/ndd -set /dev/tcp tcp_fin_wait_2_flush_interval 67500
/usr/sbin/ndd -set /dev/tcp tcp_keepalive_interval 300000
```

Results	**Verdict**
After reboot the network parameters remained the same	Pass
These parameters are set in the /etc/init.d/nddconfig file called by /etc/rc2.d/S70nddconfig at boot. Other are stored in /etc/system. This file is parsed at boot time.	Pass

5.7.4.2 User stack

As shown by the results below the user stack protection is enabled.

Results	**Verdict**
# more /etc/system | grep noexec_user_stack # set noexec_user_stack=1	Pass
# more /etc/system | grep noexec_user_stack_log # set noexec_user_stack_log=1	Pass

Note: A copy of the /etc/system is given in APPENDIX F (§ 14)

5.7.4.3 File descriptor

The results of the files descriptor are shown below:

Results	**Verdict**
# ulimit -Hn	Fail (increase to 2048)

1024	
# more /etc/system | grep rlim_fd_max #	Fail (not set in /etc/system file)
# ulimit -Sn 256	Fail (increase to 1024)
# more /etc/system | grep rlim_fd_cur #	Fail (not set in /etc/system file)
Reboot the system and redo the above test	Don't apply

Both limit will be increased by entering the following line in /etc/system :

```
set rlim_fd_cur = 1024
set rlim_fd_max = 2048
```

Note: A copy of the /etc/system is given in APPENDIX F (§ 14)

5.7.4.4 Core file

Core file are disabled as shown in the results:

Results	Verdict
# more /etc/system | grep coredumpsize= # set sys:coredumpsize = 0	Pass
# ulimit -c 0	Pass
Results are the same after a reboot	Pass

Note: A copy of the /etc/system is given in APPENDIX F (§ 14)

5.7.5 File system

5.7.5.1 partitions

Results	Verdict
# df -k Filesystem kbytes used avail capacity Mounted on /dev/md/dsk/d1 4131866 2389000 1701548 59% / /proc 0 0 0 0% /proc fd 0 0 0 0% /dev/fd mnttab 0 0 0 0% /etc/mnttab /dev/md/dsk/d3 3099287 52502 2984800 2% /var swap 1804536 16 1804520 1% /var/run swap 524288 16 524272 1% /tmp /dev/md/dsk/d4 3099287 78642 1 2250881 26% /opt/valis /dev/md/dsk/d5 6047826 6017 5981331 1% /var/opt/valis	Don't apply

# mount -p /dev/md/dsk/d1 - / ufs - no rw,intr,largefiles,logging,onerror=panic,suid,dev=1540001 /proc - /proc proc - no dev=4040000 fd - /dev/fd fd - no rw,suid,dev=4100000 mnttab - /etc/mnttab mntfs - no dev=4200000 /dev/md/dsk/d3 - /var ufs - no rw,intr,largefiles,logging,onerror=panic,suid,dev=1540003 swap - /var/run tmpfs - no dev=1 swap - /tmp tmpfs - no size=512m,dev=2 /dev/md/dsk/d4 - /opt/valis ufs - no rw,intr,largefiles,logging,onerror=panic,suid,dev=1540004 /dev/md/dsk/d5 - /var/opt/valis ufs - no rw,intr,largefiles,logging,onerror=panic,suid,dev=1540005	Fail

More tightening can be applied on these partitions. The /var and /var/opt /valis should have the nosuid and noatime options set, because there is no SUID program installed on these partitions (according to the sysadmin) and it's not foreseen to install SUID programs on these partition in the future. In add i-tion the

Note that the /opt/valis and /var/opt/valis are the partition dedicated to the application that will be fu r-ther installed.

5.7.5.2 Basic permission

Results	**Verdict**
Sticky bit is set on /tmp and /var/temp	Pass
I logged on to a non-root user, then I created a file in /tmp w ith permis-sion set to 666. I su to another account and tried to delete the file. I got this message: # rm: operation not permitted	Pass

The sticky bit is set in /tmp directory, and the restrictions work.

5.7.5.3 World-write files

Results	**Verdict**
# find / -perm -o+w | wc -l # 57	Don't apply
# find / -perm -o+w See results in APPENDIX G (§ 15)	Fail

I found standard world write directory under /var partition (e.g. /var/mail, /var/preserve, /var/tmp, etc.). Most of these files are "normal", and have the sticky bit set. However, some of these are not needed and can be removed reducing the number of world-write directories. The directory /var/spool/uucppublic can be removed as uucp is not used. Likewise the /var/spool/lp/fifos/public can be removed as no printer server is installed.

Then, I found 8 world-write directories under /usr/demo/wbem/ . According to SUN " *WBEM is the Web-Based Enterprise Management initative to standardize management information across platforms. To achieve this, the Common Information Model (CIM) defines a consistent schema for information about objects (e.g. disk drives, printers, applications, operating systems) in the system. This information would be made available to management applications via an open communication standard like eXtensible Markup Language (XML) and HyperText Transport Protocol (HTTP)."* I asked the sysadmin if this tool was effectively used, and the answer was negative. It was then decided to remove these directories.

In addition, I found 17 world-write files under the directory /ctadmin. These files are in fact the results of some packages download after a "tar –xvf" has been made. In agreement with the sysadmin we removed the write access to the other for these files.

Then it lefts 3 world-write dir under /opt/WebSphere/AppServer/ and 8 world-write file. These file correspond to the WebSphere Application server from IBM. This is in relation with the application that will be further installed to communicate with the Application server located in the secure zone (c.f. Figure 2). At the time of the audit it was not possible to determine if these files and directories can have their world-write permission removed.

Results	**Verdict**
All world directories where not in Home directories, nor in the root search path.	Pass
The standard world directories have the sticky bit set	Pass
Knowledge of sysadmin regarding world-write files and directories found: it was OK except for the WebSphere files and directories	Pass/Fail

5.7.5.4 SUID files

Results	Verdict
`# find / -type f \( -perm -u+s -o -g+s \) -ls` See APPENDIX H (§ 16) for the results	Fail

I found 92 SUID/SGID files. In fact no measures has been applied to limit the number of SUID/SGID file to the minimum necessary. It has been agreed with the sysadmin to limit these files to the list I

provide in the first part of this document in § 4.2.5.4, on the test server, and it's OK to do the same on the production server.

5.7.6 Account and Password

Results	Verdict
`# egrep " PASSLENGTH" /etc/default/passwd` `# PASSLENGTH=8`	Pass
I tried to change a password account to a length smaller than 8 with passwd co mmand => not possible (see Figure 3)	

`# egrep "MAXWEEKS" /etc/default/passwd`
`# MAXWEEKS=8`
`# egrep " WARNWEEKS" /etc/default/passwd`
`# WARNWEEKS=1`
	Pass

`# logins -d -x -m`
`#`
 	
`# logins -p -x`
`#`
	Pass (nothing was returned)
	Pass(nothing was returned)

`# more /etc/passwd` All accounts have an " x" in the password field in /etc/passwd => shadow file is used `# more /etc/passwd` root, daemon, adm, bin, sys, lp, uucp, nobody, noaccess, are the only accounts	Pass Fail
`# more /etc/passwd` daemon, adm, bin, sys, lp, uucp, nobody, noaccess, have invalid shell	Pass
`# passwd -sa` LK in front of the accounts: daemon, adm, bin, sys, lp, uucp, nobody, noa ccess => all these accounts are blocked	Pass

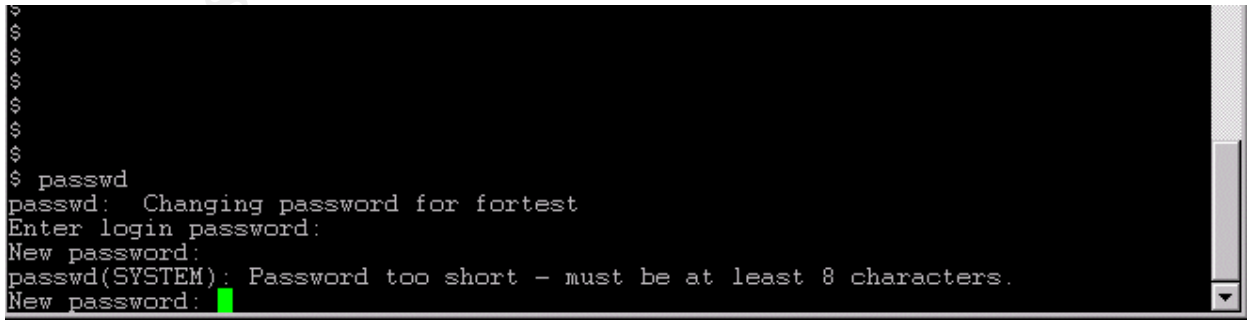

Figure 3: trying to set a password with a length < 8

All the tests passed except for the minimum number of account: the uucp and lp account can be r e-moved. Otherwise everything conforms to our requirements.

Results	**Verdict**
I approved the method chosen by the sysadmin to find strong pas s-words. It included number, capital and special characters .	Pass
The sysadmin ensured me that he was able to remember the password root account without being able to store a written copy somewhere	Pass
Procedure when person is leaving the company: doesn't exist	Fail
Procedure to give access to someone to the m achine: doesn't exist	Fail

Apparently, the sysadmin has only three passwords to remember, one being for the root account of the audited machine. It this case it's possible for him not to forget the password and therefore we can a d-mit that a copy of the password is not needed.

When interviewing the sysadmin, I realized that no written control procedure was in place for the a t-tribution of an account on this machine. Furthermore, no control procedure exist when a user is lea v-ing the company.

After discussion with the manager, it was agreed to set up a procedure for both cases, and to maintain a list of users having access to the server, and their role regarding this server.

5.7.7 Console

Results	**Verdict**
`# grep CONSOLE= /etc/default/login` `# CONSOLE=/dev/console`	Pass
`# grep PASSREQ= /etc/default/login` `# PASSREQ=YES`	Pass
`# grep SYSLOG= /etc/default/login` `# SYSLOG=YES`	Pass
`I tried to login with an empty password => the login was refused. This attempt was logged on the /var/adm/messages log file`	Pass

The direct root login is only authorized on the console. A password is required and the attempted login are logged in /var/adm/messages.

5.7.8 Umask

Results	Verdict
# umask 022	Fail Should be 027 or 077
# grep UMASK /etc/default/login # UMASK=022	

The Umask is too permissive, for this type of server. It was agreed with the sysadmin to put it to 027 in /etc/default/login file.

Results	Verdict
I logged with SSH as root and typed # umask 022	Fail Should be 027 or 077
The shell used for root is /bin/sh no umask was set in the shell configuration files	Fail

When we log in with SSH the umask taken into account is the one specified in the shell configuration files. If nothing is specified, the shell takes the system default umask which is 022. After discussion with the sysadmin, it appears that they uses only the /bin/sh shell (which is a good choice regarding security). It was then agreed to add the line " umask 027" in the file /etc/profile, and to add a .profile in all home directory with the same line (note that the $H OME/.profile shall be owned by root, and readable by all.). I also recommend to remove all other shell like bash, csh, ksh, etc.

Results	Verdict
# grep CMASK= /etc/default/init # CMASK=022	Pass

The Cmask is correctly set.

5.7.9 Path

Results	Verdict
# echo $PATH /usr/bin:/usr/sbin:/usr/ccs/bin:/usr/bin:/bin:/usr/sbin:/sbin:/usr/bin:/usr/sbin:/usr/ucb:/etc:/usr/openwin/bin:/usr/ccs/bin:/usr/local/bin:/usr/bin/nsr:.	Fail the "." shall be removed

The sysadmin agreed to remove the dangerous "." in the PATH

5.7.10 Cron

Results	Verdict
# more /etc/cron.deny daemon bin smtp nuucp listen nobody noaccess lp sys adm uucp # more /etc/at.deny daemon bin smtp nuucp listen nobody noaccess root sys adm lp uucp	Pass

The at.deny and cron.deny have account except root listed. I ch ecked these setting by trying the cro n-tab command from a non root account. The result is shown below:

Results	**Verdict**
From root I su to a non -root account and type: # crontab -l crontab: you are not authorized to use cron. Sorry.	Pass

5.7.11 TCPwrapper

Results	**Verdict**
# which tcpd no tcpd in /usr/bin /usr/sbin /usr/ccs/bin /usr/bin /bin /usr/sbin /sbin /usr/bin /usr/sbin /usr/ucb /etc /usr/openwin/bin /usr/ccs/bin /usr/local/bin /usr/bin/nsr	Fail

TCPwrapper is not installed	Fail

I did not find tcpd the binary for TCPwrapper with the "which" command. So I asked the sysadmin whether TCPwrapper was installed or not. The answer was no, but he agreed to install it and configure it very soon.

5.7.12 SSH

Results	**Verdict**
`# ssh -V` `SSH Version OpenSSH_2.2.0p1, protoco l versions 1.5/2.0.`	Fail update to OpenSSH_2.9.9p

At the time of the audit the last version was OpenSSH_2.9.9p. The version that I found installed on the server had known bugs. The sysadmin agreed to update it to the last version.

Results	**Verdict**
`# ls -la /etc/sshd_config` `-rw-r------  1 root  root  1584 Jul 12 17:53 etc/sshd_config`	Fail should be 400

The configuration file of sshd server should have more restrictive permission. The sysadmin agreed to set it to 400.

The important configuration parameter s of the `etc/sshd_config` file are shown below:

Results	**Verdict**

`Protocol 2,1`
`SyslogFacility AUTH`
`LogLevel INFO`
`ServerKeyBits  768`
`PermitRootLogin yes`
`PermitEmptyPasswords no`
`IgnoreRhosts yes`
`StrictModes yes`
`IgnoreRhosts yes`
`RhostsAuthentication no`
`RhostsRS AAuthentication no`
`HostbasedAuthentication no`
`RSAAuthentication no`
`PubkeyAuthentication  no`
`PasswordAuthentication yes`
	Pass
	(except for protocol)

`UseLogin no`	
I created an account with an empty password then I tried to log on with an empty password. The login was refused (see Figure 4). This attempt was also logged in /var/adm/messages with the following line: `Oct 28 16:26:08 xxxx sshd[813]: [ID 800047 auth.info] Failed password for fortest from xxxxxx port 1303`	Pass
I also put a trusted host in /etc/hosts.equiv. I tried to use the trust without and with the public key host based authentication (i.e. with the right pubkey set). The trust was refused.	Pass

It's better to set the protocol only to 2, to prevent a remote client to d owngrade the connection to pr o-tocol number 1, to perform an attack that exploits a weakness of protocol number 1. The sysadmin wanted to be sure that this protocol was not needed before removing it, and wanted to perform some tests on the test server. I ag reed.

Direct root login are possible. The sysadmin explained me that only two users have access to this a c-count, and that there is not so much benefit to disallow direct root login. I agreed.

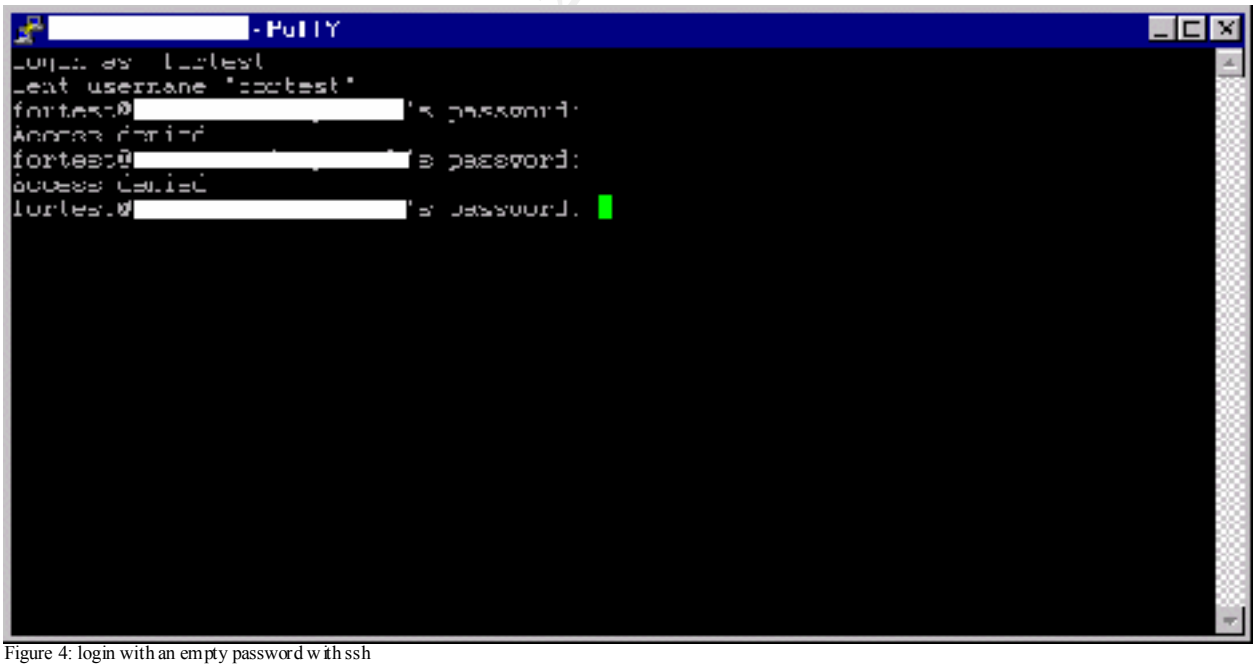

Figure 4: login with an empty password with ssh

5.7.13 Logging

Results	Verdict
No written logging policy exists.	Fail
Policy is not comprehensive	Fail
The logs are not viewed on regular basis No priority are defined form alarm	Fail/Pass Fail
No procedure exists to inform responsible persons in case of serious alarm	Fail

After interviewing the sysadmin, it happens that no written and approved logging policy existed. I then asked him, if he implicitly uses one. The answer was negative and he admitted that there was a big lack in this matter. Furthermore, I asked him if he checks the logs on a regular basis. He replied me with a hesitating "yes". So I further asked him, when exactly, and how many times per week/day. I also tried to know if it was an official task of his job (e.g. defined by the management). It appears that the log were actually monitored, but more on a random basis than as a regular task.

No procedure exists to inform responsible persons (e.g. manager) in case of serious problems detected, and no recovery plan has been foreseen.

The syslog.conf file shown below reflects the lack of clear log policy:

Results	Verdict
Syslog is used, but no tool like logcheck is installed to prioritize the alarm, and analyze the logs.	Fail

`# more /etc/syslog.conf`
`*.err;kern.notice;auth.notice  /dev/console`
`*.alert  root`
`*.emerg  *`
`*.debug  /var/adm/messages`
	Fail

Not all facilities are logged under a different log file	Fail
Event shall be logged from at least info level	Fail
/var/log/*log have a permisssion of 644 (not 600)	Fail

The configuration of the syslog.conf file doesn't include all facilities in a separate file (all facilities from debug level are sent to /var/adm/messages, all emergency messages are sent to all terminal, alert are sent to the local root mail box). This configuration doesn't permit to rapidly search an event, in case of alarm. The sysadmin agreed to change the syslog.conf configuration like it was mentioned in §4.2.13, or like the one mentioned in APPENDIX B(§ 10).

For alarm prioritization and log analysis, the sysadmin has said that he's going to investigate for tools, test and implement them. He also asked me to help him in the task of defining which event has to be considered as serious security alarm.

Results	**Verdict**
Policy for alarm prioritization not enforced	Fail

5.7.14 Integrity software

Results	**Verdict**

`# which aide`
`#`
`# which tripwire`
`#`
No integrity software is present
	Fail

After interviewing the sysadmin it appears that neither AIDE nor Tripwire (neither any other integrity check software) was installed when the machine was audited. The sysadmin assured me that he will test both software and then implement them rapidly.

5.7.15 Policy for security patches

Results	**Verdict**
No clear patching policy established	Fail
Policy followed by sysadmin Mailing list subscription	Fail Pass/Fail
Verification of secure state	Fail

When I asked the sysadmin for their patching policy the answer was: " *When we receive a notice, we check if it's worth to install the patch or if it 's necessary*...". Then I asked him what he meant by "worth to install" or "necessary". He remained silently… In fact, no written policy existed, and no r a-tionale was made regarding the priority for patch installation. Then, I proposed him to follow the rule s I have listed in § 4.2.15. He agreed saying that it was more or less what they use to do impli citly…

For the mailing list subscription, the sysadmin receives the CERT -advisory mail, and the SUN sec u-rity bulletins. For the back up software, he doesn't directly receive e -mail from Legato, but the Backup server sysadmin is responsible for this, and sends e -mail, whenever a patch is needed for the client backup software installed on the web server.

The sysadmin should also consider being on the mailing list of IBM for patches concerning, WebSphere, and IBMHTTPD web server.

For the check that the secure state was maintained after a patch installation, the sysadmin agreed, but said that if each time a new patch is installed, we have to conduct an audit like this one, it would take too much time and cost too much money. I did agree, and we decided to make a script to check important things only, or to run checking tool like the CIS benchmark.

5.7.16 Backup and recovery policy

Results	Verdict
Backup policy exists	Pass
Backup policy is enforced	Pass

There is a good backup policy in place. Incremental backups are made every night, and full backups are made every week. In addition, each month a full backup copy is stored in a safe located in the physically protected room in the basement. The backups are made with the Legato software technology. The backup server is located in the same room as the safe. To get into the room access is controlled with the contactless chip chard each employee of the company has. Only 3 persons have access to this room, and manage the backup server and tapes.

I asked if they tested the restore function of the backups. They answered that they did it with other servers and that it worked well, but for the web server we are auditing, it has not been tested yet. I the suggested them to add in their policy the steps necessary to recover this web server from system failures and other security incidents and to perform a test the restore.

The following picture explain how back ups are made with Legato backup software (this picture is taken from: http://osb.wff.nasa.gov/osbnet/man/backup/html/SOLBCKUPADMIN/appA.html)

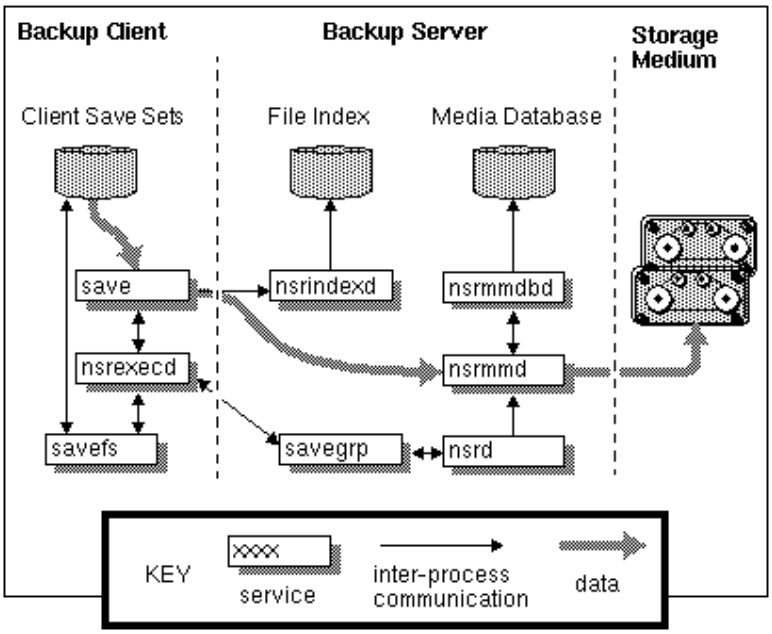

Figure 5: Backup Daemon Processes and Programs Interact During a Scheduled Save

For more detail on how it works please refer to the above mentioned URL.

6 Evaluation of the system

To make an evaluation of system I summed the "Pass" weighted with their risk and the "Fail" weighted with their risk. Then I calculated the percentage of Pass and Fail:

$\Sigma_p = \Sigma\ Pass_i \times Risk_i$

$\Sigma_f = \Sigma\ Fail_j \times Risk_j$

Percent of Pass = $[\Sigma_p / (\Sigma_f + \Sigma_p)] \times 100$

Percent of Fail = $[\Sigma_f / (\Sigma_f + \Sigma_p)] \times 100$

The results are:

$\Sigma_f = 163.67$

$\Sigma_p = 145.67$

Percent of Pass = 47,1 %

Percent of Fail = 52.9 %

The following results show that the the system comply to our securit y requirements only at 47.1%. It's obviously not enough. To analyse a bit more the results, I sorted the failed items from the riskiest to less risky item. Here's what we get:

Items that failed	*Estimated risks*
OS patches	9
SSH version	9
log policy is en forced	9
log tools installed and co nfigured	9
Patching policy enforced	9
Inetd services stopped	8
SSH protocol	8
Installed packages	7.33
Log policy exist	7.33
Integrity check software i nstalled and well configured	7.33
Patching policy exist	7.33
Procedure when user leaves cpny	7
Secure state after applying patches	6.66
SUID SGID file	6.33
TCP wrapper installed and configured	6.33
Log policy is comprehensive	6.33
procedure to add a new user and give authorization to a ccess the machine	5.33
Umask	5.33
Path variable	5.333
TCP defenses	4.66
Partitions	3.66
World-write files and dir	3.33
400 /etc/sshd_config	3.33
strategy for Installed pac kages	2.33
Procedure to start a new network service	2
Procedure to start a new d eamon	2
minimum set of accounts	2
File descriptor	1.33

A quick look at this table shows us that the immediate measures to take are (level 7, 8 and 9): patching the system; establishing a comprehensive patching policy for future patch installation; establishing a comprehensive log policy and implement it with the right tools; upgrading SSH; stopping the unne c-essary network services; minimizing the installed packages; integrity check software installed and configured; and the procedure when a user lives the company.

When I showed this table this helped me to convince the manager, to apply immediately the above mentioned measures. I also gave him an estimation of the costs for such measures.

These cost are summarized in the Table 1.

To patch the system, I estimated that, first, the sysadmin has to do it on the test system and then apply it on the production system. Taking into account that he has to observe the behavior of the system and check that the patches did install or start something we have stop ped or disabled, I counted two days of work for the sysadmin.

Measures	Cost calculation	Total
Patching the system……..……	two days sysadmin:2 x 8h x $85	$1360
Establish a patching policy…….	half a day sysadmin: 4h x $85	$340
	half a day for me: 4h x $100	$400
Minimizing the packages……	three days sysadmin:3 x 8h x $85	$2040
	half a day for me: 4h x $100	$400
Establish a log policy……	half a day sysadmin: 4h x $85	$340
	half a day for me: 4h x $100	$400
Implement log policy……	half a day for me: 4h x $100	$400
	one day sysadmin: 8h x $85	$680
Upgrade SSH and configure it…….	half a day sysadmin: 4h x $85	$340
Integrity check SW installation…..	half a day sysadmin: 4h x $85	$340
	half a day for me: 4h x $100	$400
Procedure when user leaves cp ny…	2 hours manager: 2h x $110	$220
	2 hours sysadmin: 2h x $85	$170
	2 hours me: 2h x $100	$200
Manager approval and supervision	half a day manager: 4h x $110	$440
Total		**$8'470**

Table 1: cost estimation for the immediate measures

For the log policy I proposed to the manager to do it in collaboration with the sysadmin. As we already have some good examples, this shouldn't take long as far as the sysadmin agrees with such policies. I estimated the time to half a day for the sysadmin and half a day for me. To implement this policy I estimated to half a day for me (to show the sysadmin how to use the tool and how to tune the alarm), and one day for the sysadmin (half a day with me and half a day of fine tuning). Note that the item "*log policy is comprehensive*", is also included here even if it's risk level was estimated at 6.33, because when we will establish the log policy we will make it comprehensive as well.

To install a new version of SSH and to configure it to allow only protocol 2, I estimated the time to half a day for the sysadmin.

To minimize the packages, it has first to be applied on the test server. We have to go from the minimum packages required for the OS, and then add the packages for the applications. I estimated to three days of work for the sysadmin. I also included half a day for me, to explain him how to proceed and where to find the information for the required packages.

For the integrity check software, I just counted half a day, because we already have good examples of configuration both for Tripwire and AIDE.

For the procedure when a user leaves a company, we also have some drafts that I can propose to the manager. I estimated that this task could be accomplished in two hours.

Finally, I added the time (estimated to half a day) for the manager, considering that he has to approve the policies and procedures, and that we have to present him the results when the immediate measure will be completed.

All in all for the implementation of the immediate measures it costs $ 8'470. Note that when these immediate measures will be applied to the system it will meet the requirements at 80%!

After showing these results to the manager, he decided to apply the measures immediately, in order to complete them within a time frame of two week, and to present him the status after one week. He also decided not to install the application (the web pages, and the application that communicates with the application server) before these measures are completed. He added that he wanted us to implement the rest of the measures within a time frame of one month.

7 Evaluate the audit

The audit conducted here was valuable because it permitted to discover the weaknesses of the system. Moreover, I was able to quantitatively estimate whether the system comply to the checklist, and therefore to say if the security requirements were met. It was also possible to show to the management what was the root causes why the system did no pass the audit and to give him a cost estimation.

Each items of the checklist was carefully tested except one: the backup software from Legato, was a bit overlooked. I gave a pass to this item based only on the interview I made with the sysadmin. I did not check the configuration on the backup server. More investigation on how this software works and more checks should be done (security history, patches to apply, etc.).

This audit is not sufficient to put the server in production. The scope of this study was to evaluate the system without the web application and the application that communicates with the application server. However, auditing the web server configuration and the web application is as important as the audit that we did here. Just as a reminder, CGI vulnerabilities is in "The Twenty Most Critical Internet Security Vulnerabilities". This is the reason why an audit based on similar principles (security requirements, checklists, risks evaluation) should be conducted a soon as possible.

This audit was done manually because it was the first time we applied the checklist defined in the first part of this paper. However it should have been judicious to apply tools like the CIS benchmark, TITAN, COPS, Tara, etc., and to compare the obtained results. If the checked items and the results are similar then we should consider using these tools for future audits. If these tools can not be used to automate the audit, then we can think of implementing it through scripts or a programs. While it takes time at the beginning to code them, it can be very useful if same audits have to be performed. Furthermore, the output can be formatted to an nice HTML report.

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9 Appendix A: aide.sh example file

```
#!/bin/sh
#
# Shell script to check integrity and to manage aide db files
# Written by Azim Ferchichi 17.10.2001
#
LogFile=/var/log/warn
BinFile=/usr/bin/aide
AideLogFile=/var/log/aide.log
AideDBFile=/root/AIDE/aide.db
NewAideDBFile=/root/AIDE/aide.db.new
TMPFILE=/root/TMP/aidecheck.tmp


if test -x $BinFile
then
    if test -f $AideLogFile
     then
       $BinFile --check > $TMPFILE
        if test -s $TMPFILE
             then
               echo -e "\n\n\n---------- New Entry---------------------------------- \r" >> $AideLogFile
            echo `date` >> $AideLogFile
            echo -e "\n" >> $AideLogFile
            more $TMPFILE >> $AideLo gFile
        fi
        rm -f $TMPFILE
     else
       $BinFile --check > $AideLogFile
    fi

    $BinFile --update > /dev/null
    mv $NewAideDBFile $AideDBFile
else

  echo -n `date` >> $LogFile
  echo -e " Warning: aide binary file not found. No integrity check has been done  \r" >> $LogFile
fi
#
# end of script
```

10 Appendix B: example of syslog.conf file

```
# /etc/syslog.conf      syslog configuration file.
#
# This file is processed by m4 so be careful to quote (`') names
# that match m4 reserved words.  Also, within ifdef's, arguments
# containing commas must be quot ed.
#
# Facilities:   kern            Priorities:     emerg
#               user            (highest first) alert
#               mail                            crit
#               daemon                                  err
#               auth                            warning
#               syslog                          notice
#               lpr                             info
#               mark (timestamps)               debug
#           news
#           uucp
#           cron                    none
#           local0..7           [don't send any messages]
#
# Funnies:    0. 'mail.info' logs all mail messages of priority
#                 'info' OR HIGHER (i.e. not just priority 'info')!
#             1. you can do *.priori ty but not facility.*  !!
#             2. do "m4 syslog.conf" to check preprossing
#             3. Must use tabs (not spaces) between selection and action
#             4. "kern,mail.info" logs kern & mail messages of
#                 at least priority info. The same for other com binations.
#             5. Long lines don't work.
#             6. You can have MAXIMUM 20 (non comment) lines in this file.
#                 (The rest are silently ignored..)
#
# Debugging:  . start syslogd with " -d" to enable debug output
#             . send a HUP to syslogd each time  you change this file
#             . use /usr/ucb/logger to send test messages to
#                 each facility.priority, for axample:
#           /usr/ucb/logger  -p mail.warn "test from sean"
#

# For lots of messages on the console uncomment this:
#*.err;kern.warning;a uth.err;daemon.err              /dev/console
```

```
# For minimal console messages, such as "SU":
auth.err          /dev/console

# To alert logged on root or operator user to import events:
#*.alert;kern.err;daemon.err                operator
#*.alert                                    root

# display emergencies on all termi nals (uses WALL)
*.emerg                         *

#print time on console every 20mins (not needed if you have contool)
#mark.*                         /dev/console

kern.info               ifdef(`LOGHOST', /var/log/kernlog, @loghost)
user.info               ifdef(`LOGHOST', /var/log/userlog, @loghost)
mail.info               ifdef(`LOGHOST', /var/log/maillog, @loghost)
daemon.info             ifdef(`LOGHOST', /var/log/daemonlog, @loghost)
auth.info               ifdef(`LOGHOST', /var/log/authlog, @loghost)
lpr.info                        ifdef(`LOGHOST', /var/log/lprlog, @loghost)
news,uucp.info                  ifdef(`LOGHOST', /var/log/newslog,  @loghost)
cron.info               ifdef(`LOGHOST', /var/log/cronlog, @loghost)

## other "local" messages not yet used
local0,local1.info              ifdef(`LOGHOST', /var/log/local0log, @loghost)
local2,local3,local4.info       ifdef(`LOGHOST', /var/log/local2log, @loghost)
local5,local6,local7.info       ifdef(`LOGHOST', /var/log/local5log, @loghost)

# Put all alerts (& higher) into a seperate log:
*.err                   ifdef(`LOGHOST', /var/log/alertlog, @loghost)
```

11 APPENDIX C: Matrix of risks assessments

Thomas' Matrix

Audit Item	Likelihood	consequences, damages	Risk
Installed packages	3	3	9
strategy for Installed packages	2	2	4
OS patches	3	3	9
Inetd service	3	3	9
Minimum boot network services running	3	3	9
Sysadmin knowledge of running network services	3	3	9
Procedure to start a new network service	2	2	4
Minimum running processes	2	1	2
Knowlegde of running processes	2	2	4
Procedure to start a new deamon	2	2	4
ARP defenses	1	3	3
ICMP defenses	3	3	9
IP defenses	3	3	9
TCP defenses	3	3	9
Persistency after reboot	3	3	9
User stack protection	2	3	6
File descriptor	1	1	1
Core files	1	1	1
Partitions	2	2	4
/tmp sticky bit	1	1	1
World-write files and dir	2	2	4
SUID SGID file	3	3	9
Password length 8	1	2	2
Password expiration	3	3	9
no duplicate accounts	1	1	1
accounts with null password	3	3	9
Shadow file enforced	3	3	9
minimum set of accounts	1	1	1
Non-user account locked and non-valid shell	3	3	9
Method to choose strong passwd	2	3	6
Password storage	3	3	9
Procedure when user leaves cpny	3	3	9
procedure to add a new user and give authorisation to access the machine	3	3	9
console login	1	3	3
Umask	3	2	6

CMASK	3	2	6
Path variable	1	3	3
cron.deny at.deny	1	1	1
TCP wrapper installed and configured	3	2	6
SSH version	3	3	9
SSH protocol	3	3	9
log of SSH events	3	2	6
SSH server key length	1	1	1
Root login	1	1	1
empty passwd	3	3	9
No trusted hosts	2	3	6
RSA or passwd authentication	2	2	4
400 /etc/sshd_config	2	2	4
Log policy exist	3	3	9
log policy is comprehensive	2	3	6
log policy is enforced	3	3	9
log tools installed and configured	3	3	9
Integrity check software installed and well configured	2	2	4
Patching policy exist	3	3	9
Patching policy enforced	3	3	9
Secure state after applying patches	3	3	9
Backup and recovery policy exist	2	3	6
Backup and recovery policy enforced	3	3	9

Stephane's Matrix

Audit Item	Likelihood of intrusion if audit item failed (1 - low / 2 - medium / 3 - high)	consequences, damages (1 - low / 2 - medium / 3 - high)	Risk
Installed packages	3	3	9
strategy for Installed packages	1	1	1
OS patches	3	3	9
Inetd services	2	3	6
Minimum boot network services running	2	3	6
Sysadmin knowledge of running network services	1	1	1
Procedure to start a new network service	1	1	1
Minimum running processes	2	3	6
Knowlegde of running processes	1	1	1
Procedure to start a new deamon	1	1	1
ARP defenses	2	2	4
ICMP defenses	1	2	2
IP defenses	2	2	4
TCP defenses	1	1	1
Persistency after reboot	3	3	9
User stack protection	2	3	6

File descriptor	1	2	2
Core files	1	2	2
Partitions	1	3	3
/tmp sticky bit	1	1	1
World-write files and dir	1	2	2
SUID SGID file	2	3	6
Password length 8	2	3	6
Password expiration	2	2	4
no duplicate accounts	1	1	1
accounts with null password	3	3	9
Shadow file enforced	1	2	2
minimum set of accounts	2	1	2
Non-user account locked and non-valid shell	2	2	4
Method to choose strong passwd	2	3	6
Password storage	3	3	9
Procedure when user leaves cpny	2	3	6
procedure to add a new user and give authorisation to access the machine	2	2	4
console login	1	3	3
Umask	2	2	4
CMASK	1	2	2
Path variable	3	3	9
cron.deny at.deny	1	1	1
TCP wrapper installed and configured	2	2	4
SSH version	3	3	9
SSH protocol	3	3	9
log of SSH events	1	1	1
SSH server key length	1	1	1
Root login	3	3	9
empty passwd	3	3	9
No trusted hosts	3	3	9
RSA or passwd authentication	3	3	9
400 /etc/sshd_config	2	2	4
Log policy exist	3	3	9
log policy is comprehensive	3	3	9
log policy is enforced	3	3	9
log tools installed and configured	3	3	9
Integrity check software installed and well configured	3	3	9
Patching policy exist	3	3	9
Patching policy enforced	3	3	9
Secure state after applying patches	3	3	9
Backup and recovery policy exist	1	3	3
Backup and recovery policy enforced	1	3	3

Azim's Matrix

Audit Item	Likelihood of intrusion if audit item failed (1 - low / 2 - medium / 3 - high)	consequences, damages (1 - low / 2 - medium / 3 - high)	Risks

Installed packages	2	2	4
strategy for Installed packages	2	1	2
OS patches	3	3	9
Inetd services	3	3	9
Minimum boot network services running	3	3	9
Sysadmin knowledge of running network services	2	2	4
Procedure to start a new network service	1	1	1
Minimum running processes	2	2	4
Knowlegde of running processes	2	2	4
Procedure to start a new deamon	1	1	1
ARP defenses	1	2	2
ICMP defenses	1	2	2
IP defenses	1	2	2
TCP defenses	2	2	4
Persistency after reboot	2	2	4
User stack protection	2	3	6
File descriptor	1	1	1
Core files	1	2	2
Partitions	2	2	4
/tmp sticky bit	1	1	1
World-write files and dir	2	2	4
SUID SGID file	2	2	4
Password length 8	2	3	6
Password expiration	2	3	6
no duplicate accounts	1	2	2
accounts with null password	3	3	9
Shadow file enforced	2	3	6
minimum set of accounts	1	3	3
Non-user account locked and non-valid shell	1	3	3
Method to choose strong passwd	2	3	6
Password storage	2	3	6
Procedure when user leaves cpny	2	3	6
procedure to add a new user and give authorisation to access the machine	1	3	3
console login	2	3	6
Umask	2	3	6
CMASK	2	2	4
Path variable	2	2	4
cron.deny at.deny	1	2	2
TCP wrapper installed and configured	3	3	9
SSH version	3	3	9
SSH protocol	2	3	6
log of SSH events	1	2	2
SSH server key length	3	3	9
Root login	1	3	3
empty passwd	3	3	9
No trusted hosts	1	3	3
RSA or passwd authentication	1	1	1

400 /etc/sshd_config	1	2	2
Log policy exist	2	2	4
log policy is comprehensive	2	2	4
log policy is enforced	3	3	9
log tools installed and configured	3	3	9
Integrity check software installed and well configured	3	3	9
Patching policy exist	2	2	4
Patching policy enforced	3	3	9
Secure state after applying patches	1	2	2
Backup and recovery policy exist	2	2	4
Backup and recovery policy enforced	3	3	9

12 APPENDIX D: results of # pkginfo –I

```
system      FJSVhea        SunOS Header Files
system      FJSVmdb        Fujitsu Platform Modular Debugger
system      FJSVmdbx       Fujitsu Platform Modular Debugger (64-bit)
system      FJSVvplr       Fujitsu platform links
system      FJSVvplu       Fujitsu usr/platform links
application IBMHACN        HTTP Server Admin Messages (Simplified Chinese)
application IBMHADE        HTTP Server Admin Messages (German)
application IBMHAENU       HTTP Server Admin Messages - U.S. English
application IBMHAES        HTTP Server Admin Messages (Spanish)
application IBMHAFR        HTTP Server Admin Messages (French)
application IBMHAIT        HTTP Server Admin Messages (Italian)
application IBMHAJP        HTTP Server Admin Messages (Japanese)
application IBMHAKO        HTTP Server Admin Messages (Korean)
application IBMHAPT        HTTP Server Admin Messages (Portuguese)
application IBMHATW        HTTP Server Admin Messages (Traditional Chinese)
application IBMHL128       HTTP Server LDAP Module (Domestic SSL)
application IBMHMENU       HTTP Server Manual Pages (English)
application IBMHS128       HTTP Server SSL Module (128-bit Encryption)
application IBMHSCN        HTTP Server Documentation (Simplified Chinese)
application IBMHSDE        HTTP Server Documentation (German)
application IBMHSENU       HTTP Server Documentation - U.S. English
application IBMHSES        HTTP Server Documentation (Spanish)
application IBMHSFCG       HTTP Server Fast-CGI
application IBMHSFR        HTTP Server Documentation (French)
application IBMHSIT        HTTP Server Documentation (Italian)
application IBMHSJP        HTTP Server Documentation (Japanese)
application IBMHSKO        HTTP Server Documentation (Korean)
application IBMHSLDP       HTTP Server LDAP Module (Export SSL)
application IBMHSMT        HTTP Server MT Module
application IBMHSPT        HTTP Server Documentation (Portuguese)
application IBMHSSCN       HTTP Server SSL Messages (Simplified Chinese)
application IBMHSSDE       HTTP Server SSL Messages (German)
application IBMHSSEN       HTTP Server SSL Messages - U.S. English
application IBMHSSES       HTTP Server SSL Messages (Spanish)
application IBMHSSFR       HTTP Server SSL Messages (French)
application IBMHSSIT       HTTP Server SSL Messages (Italian)
application IBMHSSJP       HTTP Server SSL Messages (Japanese)
application IBMHSSKO       HTTP Server SSL Messages (Korean)
application IBMHSSNM       HTTP Server SNMP Module
application IBMHSSPT       HTTP Server SSL Messages (Portuguese)
application IBMHSSRC       HTTP Server Source Code
application IBMHSSSB       HTTP Server SSL Module Common
```

```
application IBMHSSTW       HTTP Server SSL Messages (Traditional Chinese)
application IBMHSTW        HTTP Server Documentation (Traditional Chinese)
application IBMHTTPA       HTTP Server Administration (Run-time)
application IBMHTTPD       HTTP Server Base Run-Time
application NSCPcom        Netscape Communicator
application RTCdoc         RTC Hard und Software Dokumentationsscripts
application SMCgcc         gcc
application SMCgzip        gzip
application SMClsof        lsof
application SMCmd5         md5
application SMCperl        perl
application SMCsudo        sudo
application SMCtop         top
system      SMEvplr        SME platform links
system      SMEvplu        SME usr/platform links
system      SUNW1251f      Russian 1251 fonts
system      SUNW1394h      Sun IEEE1394 Framework Header Files
system      SUNW1394x      Sun IEEE1394 Framework (64-bit)
ALE         SUNW5ttf       Traditional Chinese BIG5 True Type Fonts Package
ALE         SUNW5xmft      Chinese/Taiwan BIG5 X Windows Platform minimum required Fonts Package
system      SUNWaccr       System Accounting, (Root)
system      SUNWaccu       System Accounting, (Usr)
system      SUNWadmap      System administration applications
system      SUNWadmc       System administration core libraries
system      SUNWadmfw      System & Network Administration Framework
system      SUNWadmj       Admin/Install Java Extension Libraries
system      SUNWadmr       System & Network Administration Root
system      SUNWafb        Elite3D Graphics System Software/Device Driver
system      SUNWafbcf      Elite3D Graphics Configuration Software
system      SUNWafbr       Elite3D Graphics System Software (Root)
application SUNWafbw       Elite3D Graphics Window System Support
system      SUNWafbx       Elite3D Graphics System Software/Device Driver (64-bit)
system      SUNWami        Authentication Management Infrastructure
system      SUNWamir       Configuration files for Authentication Management Infrastructure
system      SUNWamix       Authentication Management Infrastructure (64 bit)
system      SUNWapchd      Apache Web Server Documentation
system      SUNWapchr      Apache Web Server (root)
system      SUNWapchu      Apache Web Server (usr)
system      SUNWapct       ABI Application Certification Tools
system      SUNWapppr      PPP/IP Asynchronous PPP daemon configuration files
system      SUNWapppu      PPP/IP Asynchronous PPP daemon and PPP login service
system      SUNWarc        Archive Libraries
system      SUNWarcx       Archive Libraries (64-bit)
system      SUNWarrf       X11 Arabic required fonts
system      SUNWast        Automated Security Enhancement Tools
system      SUNWatfsr      AutoFS, (Root)
system      SUNWatfsu      AutoFS, (Usr)
system      SUNWauda       Audio Applications
system      SUNWaudd       Audio Drivers
system      SUNWauddx      Audio Drivers (64-bit)
system      SUNWaudh       Audio Header Files
system      SUNWaudio      Audio applications
system      SUNWaudmo      Audio demo programs
system      SUNWbash       GNU Bourne-Again shell (bash)
system      SUNWbcp        SunOS 4.x Binary Compatibility
system      SUNWbnur       Networking UUCP Utilities, (Root)
system      SUNWbnuu       Networking UUCP Utilities, (Usr)
system      SUNWbtool      CCS tools bundled with SunOS
system      SUNWbtoox      CCS libraries bundled with SunOS (64-bit)
system      SUNWbzip       The bzip compression utility
system      SUNWbzipx      The bzip compression library (64-bit)
system      SUNWcar        Core Architecture, (Root)
system      SUNWcarx       Core Architecture, (Root) (64-bit)
system      SUNWcea        Sun GigaSwift Ethernet Adapter Driver 32 bit adb Macros
system      SUNWceax       Sun GigaSwift Ethernet Adapter Driver 64 bit adb Macros
system      SUNWced        Sun GigaSwift Ethernet Adapter (32-bit Driver)
```

```
system      SUNWcedu      Sun GigaSwift Ethernet Adapter Driver Headers
system      SUNWcedx      Sun GigaSwift Ethernet Adapter (64-bit Driver)
system      SUNWcg6       GX (cg6) Device Driver
system      SUNWcg6h      GX (cg6) Header Files
system      SUNWcg6x      GX (cg6) Device Driver (64-bit)
ALE         SUNWciu8      Simplified Chinese (EUC) iconv modules for UTF-8
ALE         SUNWciu8x     Simplified Chinese (EUC) iconv modules for UTF-8 (64-bit)
system      SUNWcpc       CPU Performance Counter driver
system      SUNWcpcu      CPU Performance Counter libraries and utilities
system      SUNWcpcux     CPU Performance Counter libraries and utilities (64-bit)
system      SUNWcpcx      CPU Performance Counter driver (64-bit)
system      SUNWcpr       Suspend, Resume package
system      SUNWcprx      Suspend, Resume package (64-bit)
system      SUNWcsd       Core Solaris Devices
system      SUNWcsl       Core Solaris, (Shared Libs)
system      SUNWcslx      Core Solaris Libraries (64-bit)
system      SUNWcsr       Core Solaris, (Root)
system      SUNWcstl      Apptrace Utility
system      SUNWcstlx     Apptrace Utility (64 bit)
system      SUNWcsu       Core Solaris, (Usr)
system      SUNWcsxu      Core Solaris (Usr) (64-bit)
system      SUNWcti2x     Netra ct I2C and System Drivers (64-bit)
system      SUNWctlu      Print utilities for CTL locales
CTL         SUNWctpls     Portable layout services for Complex Text Layout support
CTL         SUNWctplx     Portable layout services for CTL (64-bit)
ALE         SUNWcttf      Simplified Chinese (EUC) True Type Fonts
system      SUNWctu       Netra ct usr/platform links (64-bit)
system      SUNWcvc       Network Console
system      SUNWcvcr      Network Console daemon and rc script
system      SUNWcvcx      Network Console (64-bit)
ALE         SUNWcxmft     Simplified Chinese (EUC) X Windows Platform minimum Required Fonts
system      SUNWdclnt     Solaris Diskless Client Management Application
system      SUNWdcsr      Domain Configuration Server, (Root)
system      SUNWdcsu      Domain Configuration Server
system      SUNWdfb       Dumb Frame Buffer Device Drivers
system      SUNWdfbh      Dumb Frame Buffer Header Files
system      SUNWdhcm      DHCP Manager
system      SUNWdhcsb     Binary File Format Data Module for BOOTP/DHCP Services
system      SUNWdhcsr     BOOTP/DHCP Server Services, (Root)
system      SUNWdhcsu     BOOTP/DHCP Server Services, (Usr)
system      SUNWdial      Buttons/Dials Streams Module
application SUNWdialh     Buttons/Dials Header Files
system      SUNWdialx     Buttons/Dials Streams Module (64-bit)
system      SUNWdoc       Documentation Tools
system      SUNWdpl       Developer Profiled Libraries
system      SUNWdplx      Developer Profiled Libraries (64-bit)
system      SUNWdrcrx     Dynamic Reconfiguration Modules for Sun Fire 15000 (64-bit)
system      SUNWdrr       Dynamic Reconfiguration Modules for Sun Enterprise 10000
system      SUNWdrrx      Dynamic Reconfiguration Modules for Sun Enterprise 10000 (64-bit)
application SUNWdsab      Solstice DiskSuite 4.2.1 Collection
system      SUNWdtab      CDE DTBUILDER
system      SUNWdtbas     CDE application basic runtime environment
system      SUNWdtbax     CDE application basic runtime environment (64-bit)
system      SUNWdtcor     Solaris Desktop /usr/dt filesystem anchor
system      SUNWdtct      UTF-8 Code Conversion Tool
system      SUNWdtdem     CDE DEMOS
system      SUNWdtdmn     CDE daemons
system      SUNWdtdst     CDE Desktop Applications
system      SUNWdtdte     Solaris Desktop Login Environment
system      SUNWdtezt     Solaris Desktop Extensions Applications
system      SUNWdthe      CDE HELP RUNTIME
system      SUNWdthed     CDE HELP DEVELOPER ENVIRONMENT
system      SUNWdthev     CDE HELP VOLUMES
system      SUNWdthez     Desktop Power Pack Help Volumes
system      SUNWdticn     CDE icons
system      SUNWdtim      Solaris CDE Image Viewer
```

```
system      SUNWdtinc     CDE Includes
system      SUNWdtjxt     Java Extensions
system      SUNWdtlog     System boot for Desktop Login
system      SUNWdtma      CDE man pages
system      SUNWdtmad     CDE developer man pages
system      SUNWdtmaz     Desktop Power Pack man pages
system      SUNWdtnsc     Netscape Componentization Support for CDE
system      SUNWdtrme     CDE Release Documentation
system      SUNWdtscm     CDE Dtpower Schemes (Root)
system      SUNWdtwm      CDE DESKTOP WINDOW MANAGER
system      SUNWebnfs     WebNFS
system      SUNWefclx     Embedded FCode Libraries (64-bit)
system      SUNWefcr      Embedded FCode Interpreter (Root)
system      SUNWefcux     Embedded FCode Interpreter (64-bit)
system      SUNWefcx      Embedded FCode Interpreter Drivers (64-bit)
system      SUNWensqr     Ensoniq ES1370/1371/1373 Audio Device Driver (32-bit), (Root)
system      SUNWensqx     Ensoniq ES1370/1371/1373 Audio Device Driver (64-bit), (Root)
system      SUNWerego     Solaris User Registration Installation ID file
system      SUNWeridx     Sun RIO 10/100 Mb Ethernet Drivers (64-bit)
system      SUNWesu       Extended System Utilities
system      SUNWesxu      Extended System Utilities (64-bit)
system      SUNWeudba     UTF-8 L10N for CDE Base
system      SUNWeudbd     UTF-8 L10N for CDE Dtbuilder
system      SUNWeudda     UTF-8 L10N For CDE Desktop Applications
system      SUNWeudhr     UTF-8 L10N For CDE Help Runtime
system      SUNWeudhs     UTF-8 L10N For CDE Help Runtime
system      SUNWeudis     UTF-8 L10N For CDE Icons
system      SUNWeudiv     UTF-8 L10N For Desktop Imagetool
system      SUNWeudlg     UTF-8 L10N For CDE Desktop Login
system      SUNWeudmg     UTF-8 L10N For Desktop Window Manager
system      SUNWeuezt     English UTF-8 L10N For Desktop Power Pack Applications
system      SUNWeugrf     X11 sun_eu_greek fonts
system      SUNWeuluf     UTF-8 L10N For Language Environment User Files
system      SUNWeulux     UTF-8 L10N For Language Environment User Files (64-bit)
system      SUNWeuodf     UTF-8 Core OPENLOOK Desktop Files
system      SUNWeusru     English UTF-8 L10N For Solaris User Registration
system      SUNWeuxwe     UTF-8 X Window Environment
system      SUNWfac       Framed Access Command Environment
application SUNWfbc       Frame Buffer Configuration Utility
system      SUNWfcip      Sun FCIP IP/ARP over FibreChannel Device Driver
system      SUNWfcipx     Sun FCIP IP/ARP over FibreChannel Device Driver (64 bit)
system      SUNWfcp       Sun FCP SCSI Device Driver
system      SUNWfcpx      Sun FCP SCSI Device Driver (64-bit)
system      SUNWfctl      Sun Fibre Channel Transport layer
system      SUNWfctlx     Sun Fibre Channel Transport layer (64-bit)
system      SUNWfdl       Font Downloader
system      SUNWffb       Creator Graphics System Software/Device Driver
application SUNWffbcf     Creator Graphics Configuration Software
application SUNWffbw      Creator Graphics Window System Support
system      SUNWffbx      Creator Graphics System Software/Device Driver (64-bit)
system      SUNWfns       Federated Naming System
system      SUNWfnsx      Federated Naming System (64-bit)
system      SUNWfnsx5     FNS Support For X.500 Directory Context
system      SUNWfnx5x     FNS Support For X.500 Directory Context (64-bit)
system      SUNWfruid     FRU ID Utility and Library (Usr)
system      SUNWfruip     FRU ID Platform Modules (Usr)
system      SUNWfruix     FRU ID Library (64-bit)
system      SUNWftdur     ftSafe developer utilities package (Root)
system      SUNWftduu     ftSafe developer utilities package (Usr)
system      SUNWftdux     ftSafe developer utilities package (Root) (64-bit)
system      SUNWftpr      FTP Server, (Root)
system      SUNWftpu      FTP Server, (Usr)
system      SUNWfwdcd     IEEE 1394 Video Conferencing Demo (64-bit)
system      SUNWfwdcu     IEEE 1394 Video Conferencing Support, (Usr) (64-bit)
system      SUNWfwdcx     IEEE 1394 Video Conferencing Class Driver (64-bit)
system      SUNWged       Sun Gigabit Ethernet Adapter Driver
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system      SUNWgedm      Sun Gigabit Ethernet Adapter Driver Man Pages
system      SUNWgedu      Sun Gigabit Ethernet Adapter Driver Headers
system      SUNWglmr      rasctrl environment monitoring driver for i2c, (Root) (32-bit)
system      SUNWglmx      rasctrl environment monitoring driver for i2c (Root) (64-bit)
system      SUNWglt       Layout Table Generation Utility
system      SUNWgpch      The GNU Patch utility
system      SUNWgsdhx     GSS Diffie-Hellman (64-bit)
system      SUNWgss       GSSAPI V2
system      SUNWgssc      GSSAPI CONFIG V2
system      SUNWgssdh     GSS Diffie-Hellman
system      SUNWgssk      kernel GSSAPI V2
system      SUNWgsskx     kernel GSSAPI V2 (64-bit)
system      SUNWgssx      GSSAPI V2 (64-bit)
system      SUNWgzip      The GNU Zip (gzip) compression utility
system      SUNWhea       SunOS Header Files
ALE         SUNWhiu8      Traditional Chinese iconv modules for UTF-8
ALE         SUNWhiu8x     Traditional Chinese (EUC) iconv modules for UTF-8 (64-bit)
system      SUNWhmd       SunSwift SBus Adapter Drivers
system      SUNWhmdu      SunSwift SBus Adapter Headers
system      SUNWhmdx      SunSwift SBus Adapter Drivers (64-bit)
system      SUNWi13rf     X11 ISO-8859-13 required fonts
system      SUNWi15cs     X11 ISO8859-15 Codeset Support
system      SUNWi15rf     X11 ISO-8859-15 required fonts
system      SUNWi1cs      X11 ISO8859-1 Codeset Support
system      SUNWi1of      ISO-8859-1 (Latin-1) Optional Fonts
system      SUNWi2cr      Device drivers for I2C devices, (Root, 32-bit)
system      SUNWi2cx      Device drivers for I2C devices, (Root, 64-bit)
system      SUNWi2rf      X11 ISO-8859-2 required fonts
system      SUNWi4rf      X11 ISO-8859-4 required fonts
system      SUNWi5rf      X11 ISO-8859-5 required fonts
system      SUNWi7rf      X11 ISO-8859-7 required fonts
system      SUNWi8rf      X11 iso8859-8 required fonts
system      SUNWi9rf      X11 ISO-8859-9 required fonts
system      SUNWidecr     IDE device drivers
system      SUNWidecx     IDE device drivers- 64bit
system      SUNWider      IDE Device Driver, (Root)
system      SUNWidn       Inter-Domain Network Modules for Sun Enterprise 10000
system      SUNWidnx      Inter-Domain Network Modules for Sun Enterprise 10000 (64-bit)
system      SUNWifb       Sun Expert3D (IFB) Graphics System Software/Device Driver
application SUNWifbcf     Sun Expert3D (IFB) Graphics Configuration Software
system      SUNWifbr      Sun Expert3D (IFB) Graphics System Software (Root)
application SUNWifbw      Sun Expert3D (IFB) Graphics Window System Support
system      SUNWifbx      Sun Expert3D (IFB) Graphics System Software/Device Driver (64-bit)
system      SUNWifp       Sun Fibre Channel Arbitrated Loop Device Driver
system      SUNWifph      Sun Fibre Channel Arbirated Loop Driver Header Files
system      SUNWifpx      Sun Fibre Channel Arbitrated Loop Device Driver (64-bit)
system      SUNWigsr      IGS CyberPro2010 Device Driver (ROOT)
application SUNWigsu      IGS CyberPro2010 DDX (OW) Driver and Utilities
system      SUNWigsx      IGS CyberPro2010 64-bit Device Driver (ROOT)
system      SUNWinst      Install Software
system      SUNWipc       Interprocess Communications
system      SUNWipcx      Interprocess Communications (64-bit)
system      SUNWiscr      Sun ISCRI OCF CT Driver
system      SUNWiscrx     Sun ISCRI OCF CT Driver (64-bit)
system      SUNWislcc     XSH4 conversion for Eastern European locales
system      SUNWislcx     64-bit iconv conversion for Eastern European locales
system      SUNWisolc     XSH4 conversion for ISO Latin character sets
system      SUNWisolx     64-bit iconv conversion for ISO Latin character sets
system      SUNWj2dem     JDK 1.2 demo programs
system      SUNWj2dev     JDK 1.2 development tools
system      SUNWj2man     JDK 1.2 man pages
application SUNWj2pi      Java Plug-in
system      SUNWj2rt      JDK 1.2 run time environment
system      SUNWj3dev     JDK 1.3 development tools
system      SUNWj3dmo     JDK 1.3 demo programs
system      SUNWj3man     JDK 1.3 man pages
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system      SUNWj3rt       JDK 1.3 run time environment
Application SUNWjass       JASS Toolkit 0.3.1
system      SUNWjcom       Java Communications API
system      SUNWjcomx      Java Communications API (64-bit)
system      SUNWjib        iButton OCF CT Driver
system      SUNWjiu8       Japanese iconv modules for UTF-8
system      SUNWjiu8x      Japanese iconv modules for UTF-8 (64-bit)
system      SUNWjmfp       Java Media Framework Player
system      SUNWjsnmp      Java SNMP API
system      SUNWjvdem      JavaVM demo programs
system      SUNWjvdev      JavaVM developers package, includes javac, javah, and javap
system      SUNWjvjit      Java JIT compiler
system      SUNWjvman      JavaVM man pages
system      SUNWjvrt       JavaVM run time environment
system      SUNWjxcft      Japanese X Window System common fonts
system      SUNWjxmft      Japanese X Window System Minimum Required Fonts
application SUNWkcspf      KCMS Optional Profiles
application SUNWkcspg      KCMS Programmers Environment
application SUNWkcspx      KCMS Programmers Environment (64-bit)
application SUNWkcsrt      KCMS Runtime Environment
application SUNWkcsrx      KCMS 64 bit Runtime Environment
system      SUNWkey        Keyboard configuration tables
ALE         SUNWkiu8       Korean UTF-8 iconv modules for UTF-8
ALE         SUNWkiu8x      Korean (UTF-8) iconv modules for UTF-8 (64-bit)
system      SUNWkmp2r      PS/2 Keyboard and Mouse Device Drivers, (Root, 32-bit)
system      SUNWkmp2x      PS/2 Keyboard and Mouse Device Drivers, (Root, 64-bit)
ALE         SUNWkttf       Korean True Type Fonts
system      SUNWkvm        Core Architecture, (Kvm)
system      SUNWkvmx       Core Architecture (Kvm) (64-bit)
ALE         SUNWkxmft      Korean UTF-8 X Windows Platform minimum Required Fonts
system      SUNWlccom      Localization common files
system      SUNWlcl        Locale Conversion Library
system      SUNWlclx       Locale Conversion Library (64-bit)
system      SUNWless       The GNU pager (less)
system      SUNWlibC       Sun Workshop Compilers Bundled libC
system      SUNWlibCf      SunSoft WorkShop Bundled libC (cfront version)
system      SUNWlibCx      Sun WorkShop Bundled 64-bit libC
system      SUNWlibm       Sun WorkShop Bundled libm
system      SUNWlibms      Sun WorkShop Bundled shared libm
system      SUNWllc        LLC2 driver and its initialization programs
system      SUNWllcr       LLC2 driver configuration and startup files
system      SUNWllcx       LLC2 64bit driver
system      SUNWlldap      LDAP Libraries
system      SUNWlmsx       Sun WorkShop Bundled 64-bit shared libm
system      SUNWlmx        Sun WorkShop Bundled misc. 64-bit libm files
system      SUNWloc        System Localization
system      SUNWlocx       System Localization (64-bit)
system      SUNWlpmsg      LP Alerts
system      SUNWluxd       Sun Enterprise Network Array sf Device Driver
system      SUNWluxdx      Sun Enterprise Network Array sf Device Driver (64-bit)
system      SUNWluxl       Sun Enterprise Network Array socal Device Driver
system      SUNWluxlx      Sun Enterprise Network Array socal Device Driver (64-bit)
system      SUNWluxop      Sun Enterprise Network Array firmware and utilities
system      SUNWluxox      Sun Enterprise Network Array libraries (64-bit)
system      SUNWlvma       Solaris Volume Management API's
system      SUNWlvmg       Solaris Volume Management Application
system      SUNWlvmr       Solaris Volume Management (root)
system      SUNWm64        M64 Graphics System Software/Device Driver
application SUNWm64cf      M64 Graphics Configuration Software
application SUNWm64w       M64 Graphics Window System Support
system      SUNWm64x       M64 Graphics System Software/Device Driver (64-bit)
system      SUNWm64xr      M64XR System Software (Device Driver Config.)
system      SUNWman        On-Line Manual Pages
application SUNWmc         Solaris Management Console 2.0 (Server Components)
application SUNWmcc        Solaris Management Console 2.0 (Client Components)
application SUNWmccom      Solaris Management Console 2.0 (Common Components)
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application SUNWmcdev      Solaris Management Console 2.0 (Development Kit)
application SUNWmcex       Solaris Management Console 2.0 (Examples)
system      SUNWmdb        Modular Debugger
system      SUNWmdbdm      Modular Debugger Demo Source
system      SUNWmdbx       Modular Debugger (64-bit)
system      SUNWmdg        Solstice DiskSuite Tool
system      SUNWmdi        Sun Multipath I/O Drivers
system      SUNWmdix       Sun Multipath I/O Drivers (64-bit)
system      SUNWmdnr       Solstice DiskSuite Log Daemon Configuration Files
system      SUNWmdnu       Solstice DiskSuite Log Daemon
system      SUNWmdr        Solstice DiskSuite Drivers
system      SUNWmdu        Solstice DiskSuite Commands
system      SUNWmdx        Solstice DiskSuite Drivers(64-bit)
system      SUNWmfdev      Motif UIL Compiler
system      SUNWmfman      CDE Motif Manuals
system      SUNWmfrun      Motif RunTime Kit
system      SUNWmga        Solaris Management Applications
system      SUNWmgapp      Solaris Management Applications
system      SUNWmibii      Solstice Enterprise Agents 1.0.3 SNMP daemon
system      SUNWmipr       Mobile-IP (Root)
system      SUNWmipu       Mobile-IP (Usr)
system      SUNWmkcd       CD creation utilities
system      SUNWmp         MP Print Filter
system      SUNWnamdt      Northern America CDE Support
system      SUNWnamos      Northern America OS Support
system      SUNWnamow      Northern America OW Support
system      SUNWnamox      Northern America 64-bit OS Support
system      SUNWncar       Solaris Network Cache and Accelerator (Root)
system      SUNWncarx      Solaris Network Cache and Accelerator (Root) (64-bit)
system      SUNWncau       Solaris Network Cache and Accelerator (Usr)
system      SUNWncaux      Solaris Network Cache and Accelerator (Usr) (64-bit)
system      SUNWnisr       Network Information System, (Root)
system      SUNWnisu       Network Information System, (Usr)
system      SUNWntpr       NTP, (Root)
system      SUNWntpu       NTP, (Usr)
system      SUNWocf        Open Card Framework
system      SUNWocfh       Open Card Framework header files
system      SUNWocfr       Configuration files for Open Card Framework
system      SUNWocfx       Open Card Framework (64 bit)
system      SUNWoladd      OPEN LOOK Alternate Desktop Demos
system      SUNWolaud      OPEN LOOK Audio applications
system      SUNWolbk       OpenWindows online handbooks
system      SUNWoldcv      OPEN LOOK document and help viewer applications
system      SUNWoldem      OPEN LOOK demo programs
system      SUNWoldim      OPEN LOOK demo images
system      SUNWoldst      OPEN LOOK deskset tools
system      SUNWoldte      OPEN LOOK Desktop Environment
system      SUNWolimt      OPEN LOOK imagetool
system      SUNWolinc      OPEN LOOK include files
system      SUNWolman      OPEN LOOK toolkit/desktop users man pages
system      SUNWolrte      OPEN LOOK toolkits runtime environment
system      SUNWolslb      OPEN LOOK toolkit/desktop static/lint libraries
system      SUNWolsrc      OPEN LOOK sample source
system      SUNWosdem      OS demo source
system      SUNWowbcp      OpenWindows binary compatibility
system      SUNWpamsc      PAM Smart Card module
system      SUNWpamsx      PAM Smart Card module (64-bit)
system      SUNWpcelx      3COM EtherLink III PCMCIA Ethernet Driver
system      SUNWpcmci      PCMCIA Card Services, (Root)
system      SUNWpcmcu      PCMCIA Card Services, (Usr)
system      SUNWpcmcx      PCMCIA Card Services (64-bit)
system      SUNWpcmem      PCMCIA memory card driver
system      SUNWpcr        SunSoft Print - Client, (root)
system      SUNWpcser      PCMCIA serial card driver
system      SUNWpcu        SunSoft Print - Client, (usr)
system      SUNWpd         PCI Drivers
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system      SUNWpdas       PDA Synchronization for Solaris
system      SUNWpdu        PCI Drivers Headers
system      SUNWpdx        PCI Drivers (64-bit)
system      SUNWpiclh      PICL Header Files (Usr)
system      SUNWpiclr      PICL Framework (Root)
system      SUNWpiclu      PICL Libraries, and Plugin Modules (Usr)
system      SUNWpiclx      PICL Libraries (64-bit)
system      SUNWpl5m       Perl5 On-Line Manual Pages
system      SUNWpl5p       Perl 5.005_03 (POD Documentation)
system      SUNWpl5u       Perl 5.005_03
system      SUNWplow       OpenWindows enabling for Partial Locales
system      SUNWplow1      OpenWindows enabling for Supplementary Partial Locales
system      SUNWpmowm      Power Management OW Utilities Man Pages
system      SUNWpmowr      Power Management OW Utilities, (Root)
system      SUNWpmowu      Power Management OW Utilities, (Usr)
system      SUNWpmr        Power Management config file and rc script
system      SUNWpmu        Power Management binaries
system      SUNWpmux       Power Management binaries (64-bit)
system      SUNWppm        Solaris Print Manager
system      SUNWpppd       Solaris PPP Device Drivers
system      SUNWpppdr      Solaris PPP configuration files
system      SUNWpppdu      Solaris PPP daemon and utilities
system      SUNWpppdx      Solaris PPP Device Drivers (64-bit)
system      SUNWpppg       GNU utilities for PPP
system      SUNWpppk       PPP/IP and IPdialup Device Drivers
system      SUNWpppkx      PPP/IP and IPdialup Device Drivers (64-bit)
system      SUNWpsdpr      PCMCIA ATA card driver
system      SUNWpsf        PostScript filters - (Usr)
system      SUNWpsr        SunSoft Print - LP Server, (root)
system      SUNWpstl       Apptrace Utility
system      SUNWpstlx      Apptrace Utility (64 bit)
system      SUNWpsu        SunSoft Print - LP Server, (usr)
system      SUNWqfed       Sun Quad FastEthernet Adapter Driver
system      SUNWqfedu      Sun Quad FastEthernet Adapter Driver Headers
system      SUNWqfedx      Sun Quad FastEthernet Adapter Driver (64-bit)
system      SUNWqlc        Qlogic ISP 2200/2202 Fibre Channel Device Driver
system      SUNWqlcx       Qlogic ISP 2200/2202 Fibre Channel Device Driver (64 bit)
system      SUNWrdm        On-Line Open Issues ReadMe
system      SUNWrmodu      Realmode Modules, (Usr)
system      SUNWrpm        Utilities for processing RPM archives
system      SUNWrsg        RPCSEC_GSS
system      SUNWrsgk       kernel RPCSEC_GSS
system      SUNWrsgx       RPCSEC_GSS (64-bit)
system      SUNWrtvc       SunVideo Device Driver
application SUNWrtvcl      SunVideo XIL library support
application SUNWrtvcu      SunVideo Runtime Support Software
system      SUNWrtvcx      SunVideo Device Driver (64-bit)
system      SUNWsacom      Solstice Enterprise Agents 1.0.3 files for root file system
system      SUNWsadmi      Solstice Enterprise Agents 1.0.3 Desktop Management Interface
system      SUNWsadml      Solstice Launcher.
system      SUNWsadmx      Solstice Enterprise Agents 1.0.3 Desktop Management Interface Libraries
(64-bit)
system      SUNWsasnm      Solstice Enterprise Agents 1.0.3 Simple Network Management Protocol
system      SUNWsasnx      Solstice Enterprise Agents 1.0.3 Simple Network Management Protocol
Libraries (64-bit)
application SUNWsbuc       Solstice Backup (Backup/Recover) Client
application SUNWsbum       Solstice Backup (Backup/Recover) Man
system      SUNWscbcp      SPARCompilers Binary Compatibility Libraries
system      SUNWscgui      Solaris Smart Card Administration GUI
system      SUNWsckmr      Init script & links for Sun Fire 15000 Key Management daemon
system      SUNWsckmu      Key Management daemon for Sun Fire 15000
system      SUNWsckmx      Key Management Modules for Sun Fire 15000 (64-Bit)
system      SUNWscmos      SCM Microsystems SmartOS
system      SUNWscmsc      Sun SCRI OCF CT Driver
system      SUNWscplp      SunSoft Print - Source Compatibility, (Usr)
system      SUNWscpr       Source Compatibility, (Root)
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system      SUNWscpu       Source Compatibility, (Usr)
system      SUNWscpux      Source Compatibility (Usr) (64-bit)
system      SUNWses        SCSI Enclosure Services Device Driver
system      SUNWsesx       SCSI Enclosure Services Device Driver (64-bit)
system      SUNWsfdr       Sun Fire 880 DR Daemon
system      SUNWsfdrr      Sun Fire 880 DR Daemon init script
system      SUNWsior       SuperIO 307 (plug-n-play) device drivers, (Root) (32-bit)
system      SUNWsiox       SuperIO 307 (plug-n-play) device drivers, (Root) (64-bit)
system      SUNWslpr       SLP, (Root)
system      SUNWslpu       SLP, (Usr)
system      SUNWslpx       SLP (64-bit)
system      SUNWsndmr      Sendmail root
system      SUNWsndmu      Sendmail user
system      SUNWsolnm      Solaris Naming Enabler
system      SUNWspl        Spell Checking Engine - Base Release (English)
system      SUNWsprot      Solaris Bundled tools
system      SUNWsprox      Sun WorkShop Bundled 64-bit make library
system      SUNWsra        Source Compatibility Archive Libraries
system      SUNWsregu      Solaris User Registration
system      SUNWsrh        Source Compatibility Header Files
system      SUNWssad       SPARCstorage Array Drivers
system      SUNWssadx      SPARCstorage Array Drivers (64-bit)
system      SUNWssaop      SPARCstorage Array Utility
system      SUNWstcx       SUN ISCRI Kernel Driver - (64-bit)
system      SUNWsutl       Static Utilities
system      SUNWswmt       Install and Patch Utilities
application SUNWsx         SX/CG14 Shareable Library
application SUNWsxow       SX/CG14 Window System Support
system      SUNWtcsh       Tenex C-shell (tcsh)
application SUNWtcxow      TCX Window System Support
system      SUNWter        Terminal Information
system      SUNWtiu8       Thai UTF-8 iconv modules for UTF-8
system      SUNWtiu8x      Thai UTF-8 iconv modules for UTF-8 (64-bit)
system      SUNWtleu       Thai Locale Environment User Files
system      SUNWtleux      Thai Language Environment user files (64-bit)
system      SUNWtltk       ToolTalk runtime
system      SUNWtltkd      ToolTalk developer support
system      SUNWtltkm      ToolTalk manual pages
system      SUNWtltkx      ToolTalk library (64-bit)
system      SUNWtnfc       TNF Core Components
system      SUNWtnfcx      TNF Core Components (64-bit)
system      SUNWtnfd       TNF Developer Components
system      SUNWtoo        Programming Tools
system      SUNWtoox       Programming Tools (64-bit)
system      SUNWtxfnt      Thai X Windows Platform required Fonts Package
system      SUNWucbt       Apptrace support objects for ucblib
system      SUNWucbtx      Apptrace support objects for ucblib (64 bit)
system      SUNWudf        Universal Disk Format 1.50, (Usr)
system      SUNWudfr       Universal Disk Format 1.50
system      SUNWudfrx      Universal Disk Format 1.50 (64-bit)
system      SUNWuiu8       Iconv modules for UTF-8 Locale
system      SUNWuiu8x      Iconv Modules for UTF-8 Locale (64-bit)
system      SUNWuium       Iconv Man Pages for UTF-8 Locale
system      SUNWulcf       UTF-8 Locale Environment Common Files
system      SUNWulcfx      UTF-8 Locale Environment Common Files (64-bit)
system      SUNWulocf      UTF-8 Locale Environment OpenWindows Common Files
system      SUNWusb        USB Device Drivers
system      SUNWusbu       USB  Headers
system      SUNWusbx       USB Device Drivers (64-bit)
system      SUNWusoc       Sun Universal SOC+ Device Driver
system      SUNWusocx      Sun Universal SOC+ Device Driver (64-bit)
system      SUNWusx        UltraSPARC CPU Device Driver (64-bit)
system      SUNWuxfl1      SUNW,Ultra-1 FLASH PROM Update
system      SUNWuxfl2      SUNW,Ultra-2 FLASH PROM Update
system      SUNWuxfl4      SUNW,Ultra-4 FLASH PROM Update
system      SUNWuxfle      SUNW,Ultra-Enterprise FLASH PROM Update
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system      SUNWuxflr     Sun4u FLASH PROM update generic components, (Root)
system      SUNWuxflu     Sun4u FLASH PROM Update generic components, (Usr)
system      SUNWuxlcf     UTF-8 X Locale Environment Common Files
system      SUNWuxlcx     UTF-8 X Locale Environment Common Files (64-bit)
system      SUNWvld       Sun Ethernet Vlan Utility Routines
system      SUNWvldu      Sun Ethernet Vlan Utility Headers
system      SUNWvldx      Sun Ethernet Vlan Utility Routines (64-bit)
system      SUNWvolg      Volume Management Graphical User Interface
system      SUNWvolr      Volume Management, (Root)
system      SUNWvolu      Volume Management, (Usr)
system      SUNWvolux     Volume Management (Usr) (64-bit)
system      SUNWwbapi     WBEM API
system      SUNWwbcor     WBEM Services (root)
system      SUNWwbcou     WBEM Services (usr)
application SUNWwbdev     Sun WBEM SDK
application SUNWwbdoc     Sun WBEM SDK - Documentation
application SUNWwbmc      Solaris Management Console 2.0 (WBEM Components)
system      SUNWwsr2      Solaris Product Registry & Web Start runtime support
system      SUNWwsrv      Solaris Product Registry Viewer
system      SUNWxcu4      XCU4 Utilities
system      SUNWxcu4t     XCU4 make and sccs utilities
system      SUNWxcu4x     XCU4 Utilities (64-bit)
system      SUNWxi18n     X Window System Internationalization Common Package
system      SUNWxi18x     X Window System Internationalization Common Package (64-bit)
application SUNWxilcg     SX/CG14 XIL Support
application SUNWxildh     XIL Loadable Pipeline Libraries
application SUNWxilh      XIL API Header Files
application SUNWxilow     XIL Deskset Loadable Pipeline Libraries
application SUNWxilrl     XIL Runtime Environment
application SUNWxilvl     VIS/XIL Support
system      SUNWxim       X Window System X Input Method Server Package
system      SUNWximx      X Window System X Input Method Server Package (64-bit)
system      SUNWxwacx     AccessX client program
system      SUNWxwcft     X Window System common (not required) fonts
system      SUNWxwcsl     X Window System Display Postscript CID support library
system      SUNWxwdem     X Window System demo programs
system      SUNWxwdim     X Window System demo images
system      SUNWxwdv      X Windows System Window Drivers
system      SUNWxwdvx     X Windows System Window Drivers (64-bit)
system      SUNWxwdxm     DPS motif library
system      SUNWxwfa      X Window System Font Administrator
system      SUNWxwfnt     X Window System platform required fonts
system      SUNWxwfs      Font server
system      SUNWxwhl      X Window System & Graphics Header links in /usr/include
system      SUNWxwice     ICE components
system      SUNWxwicx     X Window System ICE library (64-bit)
system      SUNWxwinc     X Window System include files
system      SUNWxwkey     X Windows software, PC keytables
system      SUNWxwman     X Window System online user man pages
system      SUNWxwmod     OpenWindows kernel modules
system      SUNWxwmox     X Window System kernel modules (64-bit)
system      SUNWxwoft     X Window System optional fonts
system      SUNWxwopt     nonessential MIT core clients and server extensions
system      SUNWxwplt     X Window System platform software
system      SUNWxwplx     X Window System library software (64-bit)
system      SUNWxwpmn     X Window System online programmers man pages
system      SUNWxwpsr     Sun4u-platform specific X server auxiliary filter modules
system      SUNWxwrtl     X Window System & Graphics Runtime Library Links in /usr/lib
system      SUNWxwrtx     X Window System Runtime Compatibility Package (64-bit)
system      SUNWxwslb     X Window System static/lint libraries
system      SUNWxwslx     X Window System lint libraries (64-bit)
system      SUNWxwsrc     X Window System sample source
system      SUNWypr       NIS Server for Solaris (root)
system      SUNWypu       NIS Server for Solaris (usr)
system      SUNWzip       The Info-Zip (zip) compression utility
system      SUNWzlib      The Zip compression library
```

```
system      SUNWzlibx      The Info-Zip compression library (64-bit)
system      SUNWzsh        Z shell (zsh)
system      TSBWvplr       Toshiba platform links
system      TSBWvplu       Toshiba usr/platform links
system      TSIpgx         PGX32 (Raptor GFX) System Software/Device Driver
application TSIpgxw        PGX32 (Raptor GFX) X Window System Support
system      TSIpgxx        PGX32 (Raptor GFX) System Software/Device Driver (64-bit)
system      TWSvplr        TWS platform links
system      TWSvplu        TWS usr/platform links
application gsk4bas        gsk4bas
application itj000001      IBMWebAS.base - WASicon
application itj000002      IBMWebAS.base - server
application itj000003      IBMWebAS.base - tivoli
application itj000004      IBMWebAS.base - IBMApache
application itj000005      IBMWebAS.base - ITJ Info
```

13 APPENDIX E: results of # ./PatchCheck

Missing Security Patches for Solaris8

```
108528-12   SunOS 5.8: kernel update patch
108773-13 * SunOS 5.8: IIIM and X Input & Output Method patch
108869-12   SunOS 5.8: snmpdx/mibiisa/libssasnmp/snmplib patch
108875-10   SunOS 5.8: c2audit patch
108909-12 * CDE 1.4: Smart Card Administration GUI patch
108949-07   CDE 1.4: libDtHelp/libDtSvc patch
108975-05   SunOS 5.8: /usr/bin/rmformat and /usr/sbin/format patch
108987-07   SunOS 5.8: Patch for patchadd and patchrm
108991-18   SunOS 5.8: /usr/lib/libc.so.1 patch
108993-05   SunOS 5.8: nss and ldap patch
109005-03 * SunOS 5.8: /sbin/su.static and /usr/bin/su patch
109134-24 * SunOS 5.8: WBEM patch
109149-02 * SunOS 5.8:: /usr/sbin/mkdevmaps and /usr/sbin/mkdevalloc patch
109154-10 * SunOS 5.8: PGX32 Graphics
109202-03 * SunOS 5.8: /kernel/misc/gld and /kernel/misc  /sparcv9/gld patch
109234-07 * SunOS 5.8: Apache and NCA patch
109238-02   SunOS 5.8: /usr/bin/sparcv7/ipcs and /usr/bin/sparcv9/ipcs patch
109279-18   SunOS 5.8: /kernel/drv/ip patch
109320-04   SunOS 5.8: LP patch
109322-09   SunOS 5.8: libnsl patch
109324-04   SunOS 5.8: sh/jsh/rsh/pfsh patch
109326-06   SunOS 5.8: libresolv.so.2 and in.named patch
109354-13 * CDE 1.4: dtsession patch
109667-04   SunOS 5.8: /usr/lib/inet/xntpd and /usr/sbin/ntpdate patch
109695-03 * SunOS 5.8: /etc/smartcard/opencard.pro  perties patch
109805-04   SunOS 5.8: /usr/lib/security/pam_krb5.so.1 patch
109887-10 * SunOS 5.8: smartcard patch
109888-13   SunOS 5.8: platform drivers patch
109896-07 * SunOS 5.8: USB and Audio Framework patch
109898-05   SunOS 5.8: /kernel/drv/arp patc h
109951-01   SunOS 5.8: jserver buffer overflow
110286-04   OpenWindows 3.6.2: Tooltalk patch
110416-03 * SunOS 5.8: ATOK12 patch
110668-02   SunOS 5.8: /usr/sbin/in.telnetd patch
110898-03   SunOS 5.8: csh/pfcsh patch
```

```
110903-02   SunOS 5.8: edit, ex, ved it, vi and view patch
110957-02   SunOS 5.8: /usr/bin/mailx patch
111085-02   SunOS 5.8: /usr/bin/login patch
111332-04 * SunOS 5.8: /usr/lib/dcs patch
111504-01   SunOS 5.8: /usr/bin/tip patch
111596-02   SunOS 5.8: /usr/lib/netsvc/yp/rpc.yppasswdd patch
111606-02   SunOS 5.8: /usr/sbin/in.ftpd patch
111626-01   OpenWindows 3.6.2: Xview Patch
111647-01 * BCP libmle buffer overflow
111659-03   SunOS 5.8: passwd and pam_unix.so.1 patch
111826-01   SunOS 5.8: /usr/sbin/sparcv7/whodo & /usr/sbin/sparcv9/whodo    patch
111874-02   SunOS 5.8: usr/bin/mail patch
111881-01   SunOS 5.8: /usr/kernel/strmod/telmod patch
112039-01 * SunOS 5.8: usr/bin/ckitem patch
112218-01   SunOS 5.8:: pam_ldap.so.1 patch

Missing Recommended Patches for Solaris8

108434-04   32-Bit Sha red library patch for C++
108435-04   64-Bit Shared library patch for C++
108528-12   SunOS 5.8: kernel update patch
108652-46   X11 6.4.1 Xsun patch
108725-06   SunOS 5.8: st driver patch
108727-09   SunOS 5.8: /kernel/fs/nfs and /kernel/fs/sparcv9/nfs pa  tch
108827-12   SunOS 5.8: /usr/lib/libthread.so.1 patch
108869-12   SunOS 5.8: snmpdx/mibiisa/libssasnmp/snmplib patch
108875-10   SunOS 5.8: c2audit patch
108949-07   CDE 1.4: libDtHelp/libDtSvc patch
108974-17   SunOS 5.8: dada, uata, dad, sd and scsi d  rivers patch
108975-05   SunOS 5.8: /usr/bin/rmformat and /usr/sbin/format patch
108981-07   SunOS 5.8: /kernel/drv/hme and /kernel/drv/sparcv9/hme patch
108987-07   SunOS 5.8: Patch for patchadd and patchrm
108991-18   SunOS 5.8: /usr/lib/libc.so.1 patch
108993-05   SunOS 5.8: nss and ldap patch
109007-06   SunOS 5.8: at/atrm/batch/cron patch
109147-12   SunOS 5.8: Linker patch
109238-02   SunOS 5.8: /usr/bin/sparcv7/ipcs and /usr/bin/sparcv9/ipcs patch
109277-02   SunOS 5.8: /usr/bin/iostat patch
109279-18   SunOS 5.8: /kernel/drv/ip patch
109318-21   SunOS 5.8: suninstall patch
109320-04   SunOS 5.8: LP patch
109322-09   SunOS 5.8: libnsl patch
109324-04   SunOS 5.8: sh/jsh/rsh/pfsh patch
109326-06   SunOS 5.8: libresolv.so.2 and in.named patch
109657-06   SunOS 5.8: isp driver patch
109667-04   SunOS 5.8: /usr/lib/inet/xntpd and /usr/sbin/ntpdate patch
109805-04   SunOS 5.8: /usr/lib/security/pam_krb5.so.1 patch
109882-05   SunOS 5.8: eri header files patch
109888-13   SunOS 5.8: platform drivers patch
109898-05   SunOS 5.8: /kernel/drv/arp patch
109904-05   SunOS 5.8: /etc/default/mpathd and /sbin/in.mpathd patch
109951-01   SunOS 5.8: jserver buffer overflow
```

```
110283-05   SunOS 5.8: mkfs and newfs patch
110286-04   OpenWindows 3.6.2: Tooltalk patch
110380-04   SunOS 5.8: ufssnapshots support, libadm patch
110460-13   SunOS 5.8: fruid/PICL plug -ins patch
110662-06   SunOS 5.8: ksh patch
110668-02   SunOS 5.8: /usr/sbin/in.telnetd patch
110723-04   SunOS 5.8: /kernel/drv/sparcv9/eri patch
110898-03   SunOS 5. 8: csh/pfcsh patch
110903-02   SunOS 5.8: edit, ex, vedit, vi and view patch
110934-05   SunOS 5.8: pkgtrans, pkgadd, pkgchk and libpkg.a patch
110945-04   SunOS 5.8: /usr/sbin/syslogd patch
110951-02   SunOS 5.8: /usr/sbin/tar and /usr/sbin/static/tar pat  ch
110957-02   SunOS 5.8: /usr/bin/mailx patch
111085-02   SunOS 5.8: /usr/bin/login patch
111177-06   SunOS 5.8: /usr/lib/lwp/libthread.so.1 patch
111293-04   SunOS 5.8: /usr/lib/libdevinfo.so.1 patch
111327-05   SunOS 5.8: libsocket patch
111504-01   SunOS 5.8: /usr/bin/tip patch
111596-02   SunOS 5.8: /usr/lib/netsvc/yp/rpc.yppasswdd patch
111606-02   SunOS 5.8: /usr/sbin/in.ftpd patch
111626-01   OpenWindows 3.6.2: Xview Patch
111659-03   SunOS 5.8: passwd and pam_unix.so.1 patch
111826-01   SunOS 5.8:  /usr/sbin/sparcv7/whodo & /usr/sbin/sparcv9/whodo patch
111874-02   SunOS 5.8: usr/bin/mail patch
111881-01   SunOS 5.8: /usr/kernel/strmod/telmod patch
112138-01   SunOS 5.8:: usr/bin/domainname patch
112218-01   SunOS 5.8:: pam_ldap.so.1 patch

For more information see 'Solaris8.PatchReport'
```

14 APPENDIX F: /etc/system file

```
forceload: misc/md_stripe
forceload: misc/md_mirror
forceload: drv/pcipsy
forceload: drv/simba
forceload: drv/glm
forceload: drv/sd
rootdev:/pseudo/md@0:0,1,blk
set md:mddb_bootlist1="sd: 6:16 sd:6:1050 sd:7:16 sd:7:1050 sd:14:16"
set md:mddb_bootlist2="sd:14:1050 sd:15:16 sd:15:1050"
set sys:coredumpsize=0
set nfssrv:nfs_portmon=1
set noexec_user_stack_log=1
set noexec_user_stack=1
```

15 Appendix G: World-write files

```
>>>> 57 World writeable files....
-rw-rw-rw-   1 root     root           0 Oct 16 16:10 /var/sadm/install/.pkg.lock
-rw-rw-rw-   1 root     bin            0 Oct 16 16:13 /var/adm/spellhist
drwxrwxrwt   3 root     mail         512 Oct 25 17:48 /var/mail
drwxrwxrwt   2 root     bin          512 Oct 16 16:13 /var/preserve
```

```
drwxrwxrwt   7 root     bin          512 Oct 25 17:09 /var/spool/pkg
drwxrwx-wx   2 lp       lp           512 Oct 16 16:20 /var/spool/lp/fifos/public
-rw-rw-rw-   1 lp       lp             0 Oct 17 07:25 /var/spool/lp/fifos/FIFO
drwxrwxrwt   2 uucp     uucp         512 Oct 16 16:44 /var/spool/uucppublic
drwxrwxrwt   2 root     sys          512 Oct 26 14:55 /var/tmp
drwxrwxrwt   2 root     root         512 Oct 16 16:22 /var/dt/dtpower/schemes
-rw-rw-rw-   1 root     root           8 Sep 24  1999 /var/dt/dtpower/_current_scheme
drwxrwxrwt   2 root     root         512 Oct 17 07:25 /var/dt/tmp
-rw-rw-rw-   1 root     other          0 Oct 17 07:43 /var/nsr/tmp/product.res.lck
-rw-rw-rw-   1 root     other          0 Oct 17 07:43 /var/nsr/tmp/nsrla.res.lck
drwxrwxrwx   2 root     other        512 Oct 17 07:43 /var/nsr/applogs
drwxrwxrwx   3 root     other       1024 Oct 26 14:45 /opt/WebSphere/AppServer/properties
drwxrwxrwx   2 root     other        512 Oct 25 17:09 /opt/WebSphere/AppServer/deployableEJBs
-rwxrwxrwx   1 root     other       6715 Oct 25 17:49
/opt/WebSphere/AppServer/deployableEJBs/Access.jar
-rwxrwxrwx   1 root     other       6641 Oct 25 17:49
/opt/WebSphere/AppServer/deployableEJBs/Account.jar
-rwxrwxrwx   1 root     other       4265 Oct 25 17:49
/opt/WebSphere/AppServer/deployableEJBs/Audit.jar
-rwxrwxrwx   1 root     other       3942 Oct 25 17:49
/opt/WebSphere/AppServer/deployableEJBs/Hello.jar
-rwxrwxrwx   1 root     other       4781 Oct 25 17:49
/opt/WebSphere/AppServer/deployableEJBs/History.jar
-rwxrwxrwx   1 root     other       3953 Oct 25 17:49
/opt/WebSphere/AppServer/deployableEJBs/Increment.jar
-rwxrwxrwx   1 root     other       5129 Oct 25 17:49
/opt/WebSphere/AppServer/deployableEJBs/Leave.jar
-rwxrwxrwx   1 root     other       5995 Oct 25 17:49
/opt/WebSphere/AppServer/deployableEJBs/Transfer.jar
drwxrwxrwx   2 root     other        512 Oct 26 15:23 /opt/WebSphere/AppServer/logs
----rw-rw-   1 root     sys        42849 May 24 18:26 /usr/sadm/lib/wbem/prodregapi.jar
-rw-rw-rw-   1 bin      bin          137 Jun  2  1999 /usr/dt/appconfig/jmf/jmf.properties
drwxrwxrwx   2 root     sys          512 Oct 16 16:52 /usr/demo/wbem/applet
drwxrwxrwx   7 root     sys          512 Oct 16 16:52 /usr/demo/wbem/client
drwxrwxrwx   2 root     sys          512 Oct 16 16:52 /usr/demo/wbem/client/enumeration
drwxrwxrwx   2 root     sys          512 Oct 16 16:52 /usr/demo/wbem/client/logging
drwxrwxrwx   2 root     sys          512 Oct 16 16:52 /usr/demo/wbem/client/misc
drwxrwxrwx   2 root     sys          512 Oct 16 16:52 /usr/demo/wbem/client/namespace
drwxrwxrwx   2 root     sys          512 Oct 16 16:52 /usr/demo/wbem/client/systeminfo
drwxrwxrwx   6 root     sys          512 Oct 16 16:52 /usr/demo/wbem/provider
drwxrwxrwx   2 root     sys          512 Oct 16 16:52 /usr/demo/wbem/provider/jni
drwxrwxrwx   2 root     sys          512 Oct 16 16:52 /usr/demo/wbem/provider/sfl
drwxrwxrwx   2 root     sys          512 Oct 16 16:52 /usr/demo/wbem/provider/sip
-rw--w--w-   1 bin      bin            0 Jan  6  2000 /usr/oasys/tmp/TERRLOG
-rw-rw-rw-   1 root     other   12673730 Mar  5  2001 /ctadmin/2001-10-
25/3.5_fixpack_3/was35_adv_ptf_3.jar
-rw-rw-rw-   1 root     other    3891825 Mar  5  2001 /ctadmin/2001-10-
25/3.5_fixpack_3/was35_adv_ptf_3.log
-rwxrwxrwx   1 25226    24641       5843 Feb 28  2001 /ctadmin/2001-10-
25/3.5 fixpack 3/was35 adv ptf 3.readme
-rw-rw-rw-   1 root     other    13080295 Mar  5  2001 /ctadmin/2001-10-25/3.5_fixpack_3/ihs_ptf_3.jar
-rw-rw-rw-   1 root     other      113848 Mar  5  2001 /ctadmin/2001-10-25/3.5_fixpack_3/ihs_ptf_3.log
-rw-rw-rw-   1 root     other      896078 Mar  5  2001 /ctadmin/2001-10-25/3.5_fixpack_3/jdk_ptf_3.jar
-rw-rw-rw-   1 root     other        9311 Mar  5  2001 /ctadmin/2001-10-25/3.5_fixpack_3/jdk_ptf_3.log
-rwxrwxrwx   1 25226    24641        7174 Mar  5  2001 /ctadmin/2001-10-25/3.5_fixpack_3/install.sh
-rw-rw-rw-   1 root     other    14304535 May 16 07:55 /ctadmin/2001-10-
25/3.5_fixpack_4/was35_adv_ptf_4.jar
-rw-rw-rw-   1 root     other    4157558 May 16 07:55 /ctadmin/2001-10-
25/3.5_fixpack_4/was35_adv_ptf_4.log
-rwxrwxrwx   1 25226    24641       5846 May 15 19:12 /ctadmin/2001-10-
25/3.5_fixpack_4/was35_adv_ptf_4.readme
-rw-rw-rw-   1 root     other    11177446 May 16 07:57 /ctadmin/2001-10-25/3.5_fixpack_4/ihs_ptf_4.jar
-rw-rw-rw-   1 root     other      30563 May 16 07:57 /ctadmin/2001-10-25/3.5_fixpack_4/ihs_ptf_4.log
-rw-rw-rw-   1 root     other    21393039 May 16 08:00 /ctadmin/2001-10-25/3.5_fixpack_4/jdk_ptf_4.jar
-rw-rw-rw-   1 root     other      109435 May 16 08:00 /ctadmin/2001-10-25/3.5_fixpack_4/jdk_ptf_4.log
-rwxrwxrwx   1 25226    24641       7789 May 16 08:00 /ctadmin/2001-10-25/3.5_fixpack_4/install.sh
```

```
-rwxrwxrwx   1 25226    24641         19 May 15 19:12 /ctadmin/2001-10-25/3.5_fixpack_4/admin
```

16 APPENDIX H: SUID/SGID files

```
-r-s--x--x   1 root     bin        19620 Feb 26  2001 /usr/lib/lp/bin/netpr
-r-sr-xr-x   1 root     bin        13840 Jan  6  2000 /usr/lib/fs/ufs/quota
-r-sr-xr-x   1 root     bin         83008 Jan 24  2001 /usr/lib/fs/ufs/ufsdump
-r-sr-xr-x   1 root     bin       907796 Dec 21  2000 /usr/lib/fs/ufs/ufsrestore
---s--x--x   1 root     bin         4104 Jan  6  2000 /usr/lib/pt_chmod
-r-sr-xr-x   1 root     bin         7068 Jan  6  2000 /us  r/lib/utmp_update
-r-sr-xr-x   1 root     bin       107408 Apr  6  2001
/usr/lib/fbconfig/SUNWifb_config
-r-sr-xr-x   1 root     bin       752512 Nov 10  2000 /usr/lib/sendmail
-rwsr-xr-x   1 root     adm         5040 Jan  6  2000 /usr/lib/acct/accton
---s--x--x   1 uucp     uucp        5964 Jan  6  2000 /usr/lib/uucp/remote.unknown
---s--x--x   1 uucp     uucp      166448 Jul 12 04:53 /usr/lib/uucp/uucico
---s--x--x   1 uucp     uucp       33620 Jul 12 04:53 /usr/lib/uucp/uusched
---s--x--x   1 uucp     uu cp       82932 Jul 12 04:53 /usr/lib/uucp/uuxqt
-rwsr-xr-x   1 root     bin        68856 Jul 12 04:51 /usr/openwin/bin/xlock
-r-sr-sr-x   1 root     bin        18144 Dec  9  1999 /usr/openwin/bin/ff.core
-rwsr-xr-x   1 root     bin        44096 Sep 28  200  0 /usr/openwin/bin/sys -suspend
-rwsr-sr-x   1 root     bin        24292 Nov 11  1999
/usr/openwin/bin/kcms_configure
-rwsr-sr-x   1 root     bin        89792 Nov 11  1999
/usr/openwin/bin/kcms_calibrate
-rwsr-sr-x   1 root     bin        31952 Nov 10  1999
/usr/openwin/bin/sparcv9/kcms_configure
-rwsr-xr-x   1 root     bin        27620 Dec 16  1999 /usr/openwin/lib/mkcookie
-r-sr-sr-x   1 root     sys        22808 Dec  2  1999 /usr/dt/bin/dtaction
-r-sr-xr-x   1 root     bin        34036 Dec  2  1999 /usr/d  t/bin/dtappgather
-r-sr-sr-x   1 root     daemon    304176 Dec  2  1999 /usr/dt/bin/sdtcm_convert
-r-sr-xr-x   1 root     bin       358340 Nov  8  2000 /usr/dt/bin/dtprintinfo
-r-sr-xr-x   1 root     bin       166336 May 17 15:35 /usr/dt/bin/dtsession
-r-sr-xr-x   1 root     sys        28196 Mar 16  2000 /usr/bin/sparcv7/ps
-r-sr-xr-x   2 root     bin        11368 Jan  6  2000 /usr/bin/sparcv7/uptime
-r-sr-xr-x   2 root     bin        11368 Jan  6  2000 /usr/bin/sparcv7/w
-rwsr-xr-x   1 root     sys         37780 Jan 24  2001 /usr/bin/at
-rwsr-xr-x   1 root     sys        13732 Jan 24  2001 /usr/bin/atq
-rwsr-xr-x   1 root     sys        12692 Jan 24  2001 /usr/bin/atrm
-r-sr-xr-x   1 root     bin        17072 Jan 24  2001 /usr/bin/crontab
-r-sr-xr-x   1 root      bin        13808 Jan  6  2000 /usr/bin/eject
-r-sr-xr-x   1 root     bin        26372 Jan  6  2000 /usr/bin/fdformat
-r-sr-xr-x   1 root     bin        29312 Feb 26  2001 /usr/bin/login
-rwsr-xr-x   1 root     sys         7328 Jan  6  2000 /usr/bin/ne  wgrp
-rwsr-xr-x   1 root     sys         7764 Mar 16  2000 /usr/bin/newtask
-r-sr-sr-x   3 root     sys       101744 Jan  6  2000 /usr/bin/passwd
-r-sr-xr-x   1 root     bin         6508 Jan  6  2000 /usr/bin/pfexec
-r-sr-xr-x   1 root     bin        21008  Jan  6  2000 /usr/bin/rcp
-r-sr-xr-x   1 root     bin        55480 Jan  6  2000 /usr/bin/rdist
-r-sr-xr-x   1 root     bin        16012 Jan  6  2000 /usr/bin/rlogin
-r-sr-xr-x   1 root     bin         8964 Jan  6  2000 /usr/bin/rsh
-r-sr-xr-x   1 root      sys        17564 May  2  2001 /usr/bin/su
```

```
-r-s--x--x   1 uucp     bin        55228 Jan  6  2000 /usr/bin/tip
-r-sr-sr-x   3 root     sys       101744 Jan  6  2000 /usr/bin/yppasswd
-r-s--x--x   1 root     sys       340260 Nov  2  2000 /usr/bin/admintool
-r-s--x--x   1 root     lp         22460 Feb 26  2001 /usr/bin/lp
-r-s--x--x   1 root     lp          9736 Jan  6  2000 /usr/bin/cancel
-r-s--x--x   1 root     lp          7116 Jan  6  2000 /usr/bin/lpset
-r-s--x--x   1 root     lp         21704 Feb 26  200  1 /usr/bin/lpstat
-r-sr-xr-x   1 root     sys        37096 Mar 16  2000 /usr/bin/sparcv9/ps
-r-sr-xr-x   2 root     bin        15392 Jan  6  2000 /usr/bin/sparcv9/uptime
-r-sr-xr-x   2 root     bin        15392 Jan  6  2000 /usr/bin/sparcv9/w
-r-sr-xr-x   1 root     sys        41708 Jan  6  2000 /usr/bin/chkey
-r-sr-sr-x   3 root     sys       101744 Jan  6  2000 /usr/bin/nispasswd
-r-sr-xr-x   1 root     bin        38740 Jan 24  2001 /usr/bin/rmformat
-r-sr-xr-x   1 root     bin         5980 Jan  6  2000 /  usr/bin/volcheck
-r-sr-xr-x   1 root     bin        12580 Feb 26  2001 /usr/bin/volrmmount
---s--x--x   1 root     uucp       69784 Jan  6  2000 /usr/bin/ct
---s--x--x   1 uucp     uucp       83808 Feb 26  2001 /usr/bin/cu
---s--x--x   1 uucp     uucp        67176 Jul 12 04:53 /usr/bin/uucp
---s--x--x   1 uucp     uucp       22588 Jul 12 04:53 /usr/bin/uuglist
---s--x--x   1 uucp     uucp       19568 Jan  6  2000 /usr/bin/uuname
---s--x--x   1 uucp     uucp       62012 Jul 12 04:53 /usr/bin/uustat
---s--x--x   1 uucp     uucp       71032 Jul 12 04:53 /usr/bin/uux
-r-sr-xr-x   1 root     bin       229416 Feb 21  2001 /usr/bin/pppd
-r-sr-xr-x   1 root     bin        12916 Jan  6  2000 /usr/sbin/sparcv7/whodo
-rwsr-xr-x   3 root     bin        17616 Jan  6  2000   /usr/sbin/allocate
-rwsr-xr-x   1 root     bin         9800 Jan  6  2000 /usr/sbin/mkdevalloc
-rwsr-xr-x   1 root     bin        10032 Apr 13  2000 /usr/sbin/mkdevmaps
-r-sr-xr-x   1 root     bin        48028 Jan  6  2000 /usr/sbin/ping
-rwsr-xr-x   1 roo t     sys        22640 Jan  6  2000 /usr/sbin/sacadm
-r-sr-xr-x   1 root     bin        35652 Jan  6  2000 /usr/sbin/traceroute
-rwsr-xr-x   3 root     bin        17616 Jan  6  2000 /usr/sbin/deallocate
-rwsr-xr-x   3 root     bin        17616 Jan  6  2000   /usr/sbin/list_devices
-r-sr-xr-x   1 root     bin        61508 Dec  9  1999 /usr/sbin/afbconfig
-r-s--x--x   1 root     lp          6856 Feb 26  2001 /usr/sbin/lpmove
-r-sr-xr-x   1 root     bin        17408 Jan  6  2000 /usr/sbin/sparcv9/whodo
-r-sr-xr-x   1 root     bin        58980 Dec  9  1999 /usr/sbin/ffbconfig
-r-sr-xr-x   1 root     bin        37260 Nov  1  1999 /usr/sbin/igsconfig
-r-sr-xr-x   1 root     bin        28784 Apr 23  2001 /usr/sbin/m64config
-r-sr-xr-x   1 root     bin        29640 Ju n  5 15:24 /usr/sbin/pmconfig
-r-sr-xr-x   1 root     bin         5584 Jan  6  2000 /usr/sbin/aspppls
-r-sr-xr-x   1 root     bin       767844 Nov 30  2000 /usr/sbin/static/rcp
-r-sr-xr-x   1 root     sys        22988 Jan  6  2000 /usr/ucb/sparcv7/ps
-r-sr-xr-x   1 root     sys        31544 Jan  6  2000 /usr/ucb/sparcv9/ps
-r-sr-sr-x   1 bin      bin         9836 Jan  9  2000 /usr/vmsys/bin/chkperm
---s--x--x   1 root     root       60004 Sep 26  1999 /usr/local/bin/sudo
-rwsr-xr-x   1 root     other     85 0552 Oct 17 08:02 /usr/local/bin/ssh
-r-sr-xr-x   1 lp       lp            203 Dec 16  1999 /etc/lp/alerts/printer
-rwsr-sr-x   1 root     other         408 Jun  8  2000
/etc/tivready/monitorslfs/IBM_HTTP_Server_1.3.6_for_Solaris.slf
```