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SANS GCUX Practical Assignment:
Securing Unix Step by Step

Installation of a Secure User-Chrooted SSH Jumphost

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1 Abstract

This paper describes the setup of a secure SSH jumphost. Besides the usual hardening tasks two additional layers of security are put in place. After a successful authentication the non-privileged users are locked up in a chrooted environment, also called jail, where the users are only allowed to jump via SSH, Telnet or FTP to other servers. They can change their password that required the setup of a daemon (Monit) which monitors the chrooted password files and updates the system files accordingly. In addition the destination servers and ports a user can jump to are restricted with the Owner-socketlookup patch for Iptables.

All user names and sensitive IP addresses have been changed.

2 System specification and risk mitigation plan

2.1 Jumphost definition

The term "jumphost" describes the logical location and the purpose of the server. Its purpose is to let co-workers and contractors log in and "jump" via SSH, Telnet or FTP to another device in the same network. It is used to do maintenance work on servers in a demilitarized zone. Authorized personnel has to have the possibility to maintain servers from anywhere in the world. Without a middle server like a jumphost the maintenance ports had to be opened on each production server. From a security perspective this can not be tolerated. An additional layer of security had to be put into place to mitigate the risk of a break-in on a production server.

Source	Destination	Port
Internet	Production Server	TCP/80 (HTTP)
Internet	Jumphost	TCP/22 (SSH)
Jumphost	Production Server	TCP/22 (SSH)

Advantages of a jumphost:

- Dedication to one task only which allows stricter hardening.
- Centralization of user database. Only one place to disable a user.
- Just a few daemons have to run which mitigates privilege escalation.
- In case of a compromise of the jumphost the production servers still work.

2.2 Users

There are two groups of users allowed to log into the jumphost.

The first group are the system administrators. They access the jumphost to do maintenance tasks like adding and removing users and keeping the system up-to-date. More details about these tasks are described in section 8. As there are only a few system administrators and they all need to do the same tasks they are allowed to become root.

The second group are the jailed users. As soon as they were successfully authorized by the jumphost they find themselves in a restricted environment. In this environment only a few commands are available and other restrictions like disk space limits are set.

2.3 Hardware

The hardware used for the server is a Sun Netra Ultrasparc T1 105:

- 440 Mhz CPU
- 500 MB RAM
- 2 hard disks with 4 GB each

This hardware was obviously not chosen for its high performance. We had some servers left from former mail servers that had been replaced with faster machines. To run the SSH daemon these machines are sufficient.

There is probably a little security related advantage of using a Sparc/Linux platform because there are fewer pre-compiled binaries available which could prevent automated worms from causing further damage after a successful break-in. As soon as a worm or attacker is equipped with runnable binaries or shell scripts this does not matter any longer.

In general the installation of Linux on the Sparc hardware was not any different once the installation media had been booted. There are differences in the boot loader configuration which will be discussed later.

To keep the list of installed packages as small as possible an identical Netra T1 has been setup to serve as building host.

2.4 Software

Some of the important software components are briefly introduced in this section. A list of all installed packages will follow later in this paper.

2.4.1 Kernel, Grsecurity and Iptables

At the time of installation the newest Kernel from the 2.4 tree was 2.4.26. In addition to only enable the necessary Kernel features the Kernel was patched with the Owner-socketlookup patch from the extra repository of Netfilter/Iptables. This feature allows filtering on a per-user basis. Also the Kernel has been patched with the Grsecurity to add Kernel level security. In the case of the jumphost the Grsecurity patches suits very well, because it protects from known Chroot breakouts.

2.4.2 Distribution

The choice of the operating system was Debian/Linux. It is the standard Linux distribution used in the enterprise. It has proven to install and run nicely on the Sparcs. The text mode installation can be done via serial connection. The main reason to go for Debian is its package management which makes it really easy to keep the system up-to-date. In general a Debian installation has a very small footprint in comparison with other big distributions. This simplifies the removal of unneeded packages. There could have been other choices, but Debian did the task.

2.4.3 Openssh

Openssh was the natural choice to provide the users with a familiar syntax and to comply with our standards. Its wide spread use has the advantage that security updates are made available quickly. The downside of Openssh's popularity is that vulnerabilities are sought upon and found fairly often. To enhance security Openssh has been patched with the Openssh-chroot patch, which locks the user into a restricted area after he successfully logged in. From within that restricted area only a few commands can be run and permissions are strict.

2.4.4 Quota

The jumphost is required to provide disk space for file transfers. The jailed users' home directories are put on a separate partition and to ensure availability to all users, available disk space for each of them has been restricted. This regulation is done by Quota-tools.

2.4.5 Software summary

Description	Version	URL
Debian Linux	3.0r2	http://www.debian.org
Linux Kernel	2.4.26	http://www.kernel.org/pub/linux/kernel/v2.4
Grsecurity	2.0- 2.4.26	http://www.grsecurity.net
Iptables/Netfilter	1.2.11	http://www.netfilter.org
Owner- socketlookup patch		http://www.netfilter.org/patch-o-matic/ pom-extra.html
Openssh	3.8.1p1	http://www.openssh.org
Openssh chroot patch	3.8.1p1	http://chrootssh.sourceforge.net/index.php
Quota-tools	3.12	http://sourceforge.net/projects/linuxquota

2.5 Risk mitigation plan

The following table identifies the main risks involved in running the jumphost:

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Risk description	Risk mitigation
A remote attacker breaks into the jumphost.	Only SSH is available from outside. Iptables have been installed and configured.
A non-privileged user becomes root.	Administrators have root permission already. They have to be trusted. Other users are jailed as soon as SSH authentication was successful. Unneeded packages have been removed. Jumphost has been hardened.
A successful attacker is not discovered.	Logging has been configured. Logcheck informs administrator about unusual system events. Integrity keeps track of the file checksums and informs accordingly.
A non-privileged user guesses or brute-forces passwords.	Password are MD5 hashed and the obscure option has been used to forbid simple passwords.
A non-privileged user loads malicious modules into the Kernel.	Kernel has been minimized and module support has been disabled.
A jailed user breaks out of the jail.	The Kernel has been patched with Grsecurity which counter-measures well-known break-outs.
A jailed user jumps to a server he is not supposed to.	This concerns especially external users (contractors etc). In a user agreement it is defined which servers a user is allowed to jump to. On the jumphost the destination servers and ports a user is allowed to initiate connections to have been enforced with the help of the Iptables Owner-socketlookup.
A jailed user fills up the hard disk and prevents other jailed users from storing data.	The disks have been partitioned accordingly and quotas restrict available disk space per user.
A jailed user carelessly adds keys to <code>~/.ssh/authorized_keys</code> .	Keys can only be added by the system administrator.
Password changing and synchronization mechanisms could be abused by jailed users.	Restrictive PAM configuration in the jail environment.

3 Base installation

3.1 Preparation and boot

This section describes how the Debian GNU/Linux 3.0r2 distribution has been installed on the Sun Netra Ultrasparc T1 105. More detailed information can be found on <http://www.debian.org/releases/stable/sparc/install>.

- The Debian GNU/Linux 3.0r2 distribution has been downloaded from <http://www.debian.org/CD/http-ftp/> and burned on a CD-ROM.
- The SCSI CD-ROM has been attached to the Netra.

Because there was no screen or keyboard to the Netra attached, a serial connection had to be setup. This was done from a physically close by Linux machine. A roll-over cable connected the serial DB-9 (ttyS1) of this other machine with the Serial A LOM of the jumphost. Once this was setup, a connection from the Linux machine with the Ckermite package (a serial communication software) was established:

```
linux# kermite
C-Kermite 7.0.196, 1 Jan 2000, for Linux
  Copyright (C) 1985, 2000,
  Trustees of Columbia University in the City of New York.
Type ? or HELPE for help.
(/root/) C-Kermite>set line /dev/ttyS1
(/root/) C-Kermite>set carrier-watch off
(/root/) C-Kermite>connect
Connecting to /dev/ttyS1, speed 9600.
The escape character is Ctrl-\ (ASCII 28, FS)
Type the escape character followed by C to get back,
or followed by ? to see other options.
-----
ok
```

If the `ok`-prompt (openboot prompt) would not appear a `break` signal had to be sent. With Ckermite this can be accomplished with `[Ctrl]+[\]+[b]`. To see all the available escape characters `[Ctrl]+[\]+[?]` can be issued. If the Netra is not configured to automatically boot up, the `lom>` (Lights Out Management) will appear. Entering `power-on` and sending a `break` will get you to the `ok`-prompt.

Now the the device alias of the connected SCSI-CDROM can be figured out. It usually is `cdrom1`. To boot the Debian installation disk boot `cdrom1` was issued.

```
ok
ok probe-scsi
Primary UltraSCSI bus:
Target 0
  Unit 0  Disk      FUJITSU MAB3045S SUN4.2G1705
Target 1
  Unit 0  Disk      IBM      DDRS34560SUN4.2GS98E
Target 6
  Unit 0  Removable Read Only device  TOSHIBA XM5701TASUN12XCD0997
ok
ok devalias
cdrom1          /pci@1f,0/pci@1,1/scsi@2/disk@6,0:f
cdrom           /pci@1f,0/pci@1/pci@1/ide@e/cdrom@2:f
..
ok
ok boot cdrom1
```

3.2 Installation of the Debian base system

Not all the installation steps will be described here. The focus will be on security relevant steps.

3.2.1 Disk partitioning

The table below lists the size and file system types chosen for this installation. Mark that the second hard disk is not partitioned yet. It will be partitioned later (see section 6.1).

The `/boot` partition has to be `ext2` in order to let `openboot` read the Kernel image. For the other partitions the choice was the `ext3` file system because of its journaling capabilities which enables to boot up without manual interaction in case of a system crash. The `sda3` contains traditionally the entire disk (see <http://www.debian.org/releases/stable/sparc/ch-partitioning.en.html#s-partition-programs>).

The partitioning of the disk has been done with security in mind. Each partition can be mounted with different mount options. For example it will be possible to mount `/tmp` with the options `rw,noexec,nodev` while `/` will be mounted with `rw` only because it contains executables and devices.

Partition	Mount point	Size	File system
sda1	/boot	50 MBytes	ext2
sda2	/	200 MBytes	ext3
sda3	/	Whole disk	Whole disk
sda4	/usr	500 MBytes	ext3
sda5	/var	800 MBytes	ext3
sda6	/tmp	200 MBytes	ext3
sda7	swap	500 MBytes	Linux swap
sda8	/home	Rest sda	ext3

This results are shown in the following partition table. The u-flag marks a swap partition for Solaris, but GNU/Linux chooses to ignore it.

Disk /dev/sda (Sun disk label): 16 heads, 135 sectors, 3880 cylinders
Units = cylinders of 2160 * 512 bytes

Device	Flag	Start	End	Blocks	Id	System
/dev/sda1		0	47	50760	83	GNU/Linux native
/dev/sda2	u	47	236	204120	83	GNU/Linux native
/dev/sda3	u	0	3880	4190400	5	Whole disk
/dev/sda4		236	710	511920	83	GNU/Linux native
/dev/sda5		710	1468	818640	83	GNU/Linux native
/dev/sda6		1468	1657	204120	83	GNU/Linux native
/dev/sda7	u	1657	2131	511920	82	GNU/Linux swap
/dev/sda8		2131	3880	1888920	83	GNU/Linux native

3.2.2 Finishing base installation and booting the system

- There is no need to install any additional Kernel modules and packages.
- Enable MD5 passwords.
- IP address should be configured statically.
- APT (Debian package handling utility) has to be configured to access a close Debian mirror and the Debian security update server.
- At the end the system is made bootable. Silo will take care of the boot process. The configuration of Silo will be explained in section [4.3.3](#).
- After the system reboot the freshly installed GNU/Linux system starts up.

4 Build Kernel and special packages

The following packages and the Kernel have been built from source for the reasons stated in each section.

In order to keep the jumphost clean from packages not needed for productive environment a build host had been setup. The build host is identical with the jumphost (same hardware, same operating system) but additionally is equipped with development tools in order to compile source code and create Debian packages (e.g. gcc, make, wget, gpg, bunzip2, fakeroot).

The setup of a build host is not explained in this paper. It is important to harden and protect the build host with the same care as the jumphost. If an attacker can get hold of the build host he would be able to fiddle with the build environment and indirectly bring malicious code to the jumphost.

- It is recommended not to build the packages as user `root`. This is a precaution to not mess around with the standard installation of the build host.
- The resulting binaries, man pages etc. are bundled in Debian packages before being transferred to the jumphost. The original package names were complemented with the string `-cc` to avoid accidental updates via `apt-get upgrade`. It also is a good way to get an overview of the packages that had been built from source (`dpkg -l |grep -- -cc`).

4.1 Getting Kernel source

Before building `iptables` the Kernel sources need to be downloaded and unpacked, because the `iptables owner-socketlookup` patch will change the Kernel sources. The steps for configuring, building and installing the new Kernel will be explained in section 4.3.

```
buildhost# wget http://www.kernel.org/pub/linux/kernel/v2.4/linux-2.4.26.tar.bz2
buildhost# wget http://www.kernel.org/pub/linux/kernel/v2.4/linux-2.4.26.tar.bz2.sign
buildhost# gpg linux-2.4.26.tar.bz2.sign
```

4.2 Iptables

After a jailed users has successfully logged into the jumphost he will want to connect to another server within the same network to do maintenance work. The connection will be established via SSH, FTP or Telnet.

Every jailed user is allowed to connect to a specific set of servers and ports. This policy is enforced by Iptables patched with the Owner-socketlookup feature which allows to set rules on a connection-per-user basis.

Clearly this strategy could be challenged because it can be bypassed. If for example a user is allowed to connect to host A, but not host B, he could first connect to host A and from there connect to host B. This way he would have circumvented the security policy.

Still it adds a layer of security especially together with the user agreement wherein the relevant parties agreed on what servers will be accessed. It also defines misuse of the jumphost clearer because users have to actively find a way “jumping” around the jumphost regulations.

4.2.1 Getting and verifying source

The sources for Iptables and the extra repository have to be downloaded and verified with GnuPG.

```
buildhost# wget http://www.netfilter.org/files/iptables-1.2.11.tar.bz2
buildhost# wget http://www.netfilter.org/files/iptables-1.2.11.tar.bz2.sig
buildhost# gpg iptables-1.2.11.tar.bz2.sig
buildhost# wget http://www.netfilter.org/files/patch-o-matic-ng-20040621.tar.bz2
buildhost# wget http://www.netfilter.org/files/patch-o-matic-ng-20040621.tar.bz2.sig
buildhost# gpg patch-o-matic-ng-20040621.tar.bz2.sig
```

4.2.2 Unpacking and patching

After unpacking Iptables and patch-o-matic (includes the extra repository) `runme extra` starts an interactive shell program that lets you choose the patches. For the jumphost installation only the Owner-socketlookup patch was applied. The environment variables `KERNEL_DIR` and `IPTABLES_DIR` have to be set according to their location.

```
buildhost# tar xjf iptables-1.2.11.tar.bz2
buildhost# tar xjf patch-o-matic-ng-20040621.tar.bz2
buildhost# cd patch-o-matic-ng-20040621
buildhost# KERNEL_DIR=../linux-2.4.26 IPTABLES_DIR=../iptables-1.2.11/ ./runme extra
..
Testing owner-socketlookup... not applied
..
Do you want to apply this patch [N/y/t/f/a/r/b/w/q/?] y
..
```

4.2.3 Making and packaging

Now that the Iptables source has been patched, it can be built. I chose to statically build it (`NO_SHARED_LIBS=1`) to not minimize the amount of libraries on the system. Because the standard installation on the build host should be left alone the installation directory was set to `tmp/`.

```
buildhost# cd iptables-1.2.11
buildhost# make KERNEL_DIR=../linux-2.4.26 NO_SHARED_LIBS=1
buildhost# mkdir -p tmp/DEBIAN
buildhost# make KERNEL_DIR=../linux-2.4.26 PREFIX=tmp/usr NO_SHARED_LIBS=1 install
```

The minimum requirement to build a Debian package is the `DEBIAN/control` file. `fakeroot` runs `dpkg-deb` in its own environment. It simulates root file privileges. The package is then being transferred to the jumphost where it is installed.

```
buildhost# vi tmp/DEBIAN/control
# ----- DEBIAN/control -----
Package: iptables-cc
Priority: standard
Section: net
Architecture: sparc
Maintainer: intern
Version: 1.2.11
Description: IP packet filter administration tools
# -----
buildhost# fakeroot dpkg-deb --build tmp iptables-cc_1.2.11_sparc.deb
```

Strangely enough the dependencies of `net-base` require `ipchains` | `iptables` | `ipfwadm` while on other GNU/Linux machines this is not a requirement anymore. This was probably changed in newer versions of `net-base`. With the package named `iptables-cc` this dependency was not fulfilled anymore.

Instead of messing around with `net-base` it seemed easier to just install a dummy `iptables` package with no contents except a `README` and version number high enough to prevent `apt-get upgrade` from installing the full-blown `iptables` package.

```
buildhost# mkdir -p iptables-dummy-package/DEBIAN
buildhost# cd iptables-dummy-package
buildhost# vi DEBIAN/control
# ----- DEBIAN/control -----
Package: iptables
Priority: standard
Section: net
```

```
Architecture: sparc
Maintainer: intern
Version: 99.9
Description: This package does not contain any files except this one. I created
this package to meet the netbase dependency. The real iptables package is named
iptables-cc to meet naming conventions (all packages built by cc are to be named
<package>-cc).
# -----
buildhost# mkdir -p usr/share/doc/iptables
buildhost# vi usr/share/doc/iptables/README
# ----- README -----
This package does not contain any files except this one. I created
this package to meet the netbase dependency. The real iptables package
is named iptables-cc to meet naming conventions (all packages built
by cc are to be named <package>-cc).
# -----
buildhost# fakeroot dpkg-deb --build iptables-dummy-package \
iptables-dummy-package_99.9_sparc.deb
```

4.2.4 Installing and configuring

Both packages had to be installed with `dpkg -i <package-name>` on the jumphost. Because of the dependency issue discussed above the old Iptables package had to be removed with `dpkg --purge --ignore-deps=netbase iptables` command.

The following startup file was put into `/etc/init.d/iptables`. It installs (start) or uninstalls (stop) the rule base. The rule set is enabled during system start-up. This can be done by linking `/etc/init.d/iptables` to the `/etc/rc?.d` run-levels or on the jumphost this was done with the Debian specific command `update-rc.d iptables defaults`.

Running `/etc/init.d/iptables stop` flushes the active rule set and sets the policies of the INPUT and OUTPUT chain to ACCEPT. This has proven to be useful when troubleshooting connection problems.

The entire `/etc/init.d/iptables` is attached in [Appendix A](#).

Installing the rule set with the command `/etc/init.d/iptables start` respectively on system boot will:

1. Set environment variables. It would have been possible to read the values for IPADDR, DNSSRV and NTPSRV from files in `/etc` but this script is meant to be easy to read in order to keep it maintainable.
2. Set the policies of all chains to DROP and flush the rule set.

3. Accept everything going to the loopback interface, but drop incoming packets from the network with destination address 127.0.0.1 (loopback).
4. Drop incoming packets coming from illegal sources (IP addresses that are not expected respectively not routed within our network).
5. Drop incoming packets with illegal TCP flags sequences.
6. Drop incoming packets with invalid states.
7. Drop incoming ICMP packets.
8. Accept incoming related and established connection.
9. Accept incoming SSH connections.
10. Accept everything coming from loopback interface.
11. Drop outgoing packets with invalid states.
12. Accept outgoing related and established connection.
13. Accept outgoing echo-requests (ping) packets.
14. Accept outgoing traceroute packets for user root.
15. Accept outgoing NTP time synchronization requests for user root.
16. Accept outgoing DNS requests.
17. Read the file `/etc/iptables.accept` and set outgoing accept rules for specific `<user>:<destination_ip>:<destination_port>` triples.

All the traffic in and out of the jumphost is logged via `syslog` facility. Depending on how much traffic will be seen, logging will be reduced. The `/etc/iptables.accept` file looks like this:

```
# ----- /etc/iptables.accept -----  
#  
# iptables accept file (per user)  
# syntax: <user>:<dest_ip>:<dest_port>  
# note:   for tcp connection only!  
#  
  
# outgoing ssh, ftp, telnet  
root:192.168.254.50:22  
user1:192.168.254.51:21  
user2:192.168.254.52.23  
user2:192.168.254.51.21
```

```
# apt-get update mirror and security.debian.org
root:192.168.254.60:80
root:192.168.254.61:80
```

```
# smtp
root:192.168.254.40:25
# -----
```

4.3 Kernel

In previous sections the Kernel source has been unpacked (see 4.1) and patched with the Iptables Owner-socketlookup functionality (see 4.2.2). This section describes how to patch the Kernel with Grsecurity, disable modules and unneeded Kernel features.

4.3.1 Patching with Grsecurity

Grsecurity (<http://www.grsecurity.ca>) adds additional layers of security to the Kernel. It is especially interesting for the jumphost because it hardens the Chroot environment. With simple, on the Internet available and compile-ready code, it is possible to break-out of the Chroot environment. This is threatening security of the jail environment.

There are many other security features Grsecurity is adding to the Kernel. Many of the options have been enabled (see Appendix B). Importantly all of the Chroot options were enabled except “Capability restrictions within chroot”. Ping does not work with this option enabled.

```
buildhost# ls -d linux-2.4.26
linux-2.4.26
buildhost# wget http://www.grsecurity.ca/grsecurity-2.0-2.4.26.patch
buildhost# wget http://www.grsecurity.ca/grsecurity-2.0-2.4.26.patch.sign
buildhost# gpg http://www.grsecurity.ca/grsecurity-2.0-2.4.26.patch.sign
buildhost# patch -p0 <./grsecurity-2.0-2.4.26.patch
```

4.3.2 Configuring and making the Kernel

It is not in the scope of this paper to describe the configuration of the Kernel. Important for the security of the system is the fact that module-support and unneeded Kernel functionality had been disabled. See the Kernel configuration in Appendix B for all settings.

`strip vmlinux` minimizes the size of the Kernel image. This is necessary because the Kernel can not be loaded if it is too big.

```
buildhost# make menuconfig
buildhost# make dep && make vmlinux
buildhost# strip vmlinux
```

4.3.3 Configuring Silo

The new Kernel had been transferred to the jumphost and moved to `/boot/vmlinuz-2.4.26`. The `silo.conf` had to be adjusted to load the new Kernel when booting the system. To keep things consistent the link from `/boot/vmlinuz` to `/vmlinux` had to be removed. Then just the two Kernel images remained, both in `/boot`.

The old Kernel should be left in place to leave an opportunity to boot with it, in case the new Kernel cannot boot. This is especially important when booting the new Kernel for the first time. Later on the module utilities will be removed and the old Kernel image will still be bootable but the system will not function fully because of the missing user-level module support.

In the past boot loader passwords had been set. It often caused problems because it is used rarely and system administrators tend to forget it or have changed their employer. The server was put in the data center with restricted access. For these reasons no boot password was set.

The `partition` keyword refers to the disk partition where `/boot` resides. In the case of the jumphost this is a partition on its own (`sda1`). The `image=` statement points to the relative location of the Kernel image of the named partition. The default Kernel image is labelled `linux`.

```
# ----- /etc/silo.conf -----
partition=1
root=/dev/sda2
timeout=100
read-only
image=1/vmlinuz-2.4.26-cc
  label=linux
image=1/vmlinuz-2.4.18-sun4u
  label=linuxorg
# -----
```

4.4 Openssh

The version of Openssh (<http://www.openssh.org/>) provided by Debian could not be used because it needed to be patched. After a successful authentication the according users have to be chrooted into the jail environment.

To distinguish between normal system users and users that have to be change-rooted the home directory needs a special marker. A normal system users' home directory defined in `/etc/passwd` is e.g. `/home/user1` while a change-rooted users' home directory looks `/jail/./home/jailusr1` alike. This tells the patched Openssh to chroot into `/jail` once the authentication was successful.

4.4.1 Getting, verifying, unpacking and patching

The sources for Openssh have to be downloaded and verified with GnuPG. There are also already patched versions of Openssh available on <http://chrootssh.sourceforge.net>.

```
buildhost# wget ftp://ftp.de.openbsd.org/pub/unix/OpenBSD/OpenSSH/portable/openssh-3.8.1p1.tar.gz
buildhost# wget ftp://ftp.de.openbsd.org/pub/unix/OpenBSD/OpenSSH/portable/openssh-3.8.1p1.tar.gz.sig
buildhost# gpg openssh-3.8.1p1.tar.gz.sig
buildhost# wget http://chrootssh.sourceforge.net/download/osshChroot-3.8.1p1.diff
buildhost# wget http://chrootssh.sourceforge.net/download/MD5.txt
buildhost# grep osshChroot-3.8.1p1.diff MD5.txt |md5sum -c

buildhost# tar xjf openssh-3.8.1p1.tar.gz
buildhost# patch -p0 < osshChroot-3.8.1p1.diff
```

4.4.2 Configuring and making

There are a lot of possible `configure` options available. For the jump host:

- `--prefix` was set to `/usr`. The binaries and the man pages will be installed in `/usr/bin` respectively in `/usr/man`.
- As a habit the configuration files are expected to be in `/etc/ssh` which can be controlled with `--sysconfdir`.
- The `--with-MD5-passwords` flag had to be enabled in order to read the MD5 hashed passwords.
- As IPV6 is not used yet it was be disabled with `--without-4in6`.
- PAM was not enabled because it seems to be broken when used with `Privilege Separation`.

```
buildhost# cd openssh-3.8.1p1
buildhost# ./configure \
--prefix=/usr \
--sysconfdir=/etc/ssh \
--with-md5-passwords \
--without-4in6
```

will produce the following summary:

```

OpenSSH has been configured with the following options:
    User binaries: /usr/bin
    System binaries: /usr/sbin
    Configuration files: /etc/ssh
    Askpass program: /usr/libexec/ssh-askpass
    Manual pages: /usr/man/manX
    PID file: /var/run
Privilege separation chroot path: /var/empty
    sshd default user PATH: /usr/bin:/bin:/usr/sbin:/sbin
    Manpage format: doc
    PAM support: no
    KerberosV support: no
    Smartcard support: no
    S/KEY support: no
    TCP Wrappers support: no
    MD5 password support: yes
IP address in DISPLAY hack: no
    Translate v4 in v6 hack: no
    BSD Auth support: no
    Random number source: OpenSSL internal ONLY

    Host: sparc64-unknown-linux-gnu
    Compiler: gcc
    Compiler flags: -g -O2 -Wall -Wpointer-arith -Wno-uninitialized
Preprocessor flags:
    Linker flags:
    Libraries: -lresolv -lcrypto -lutil -lz -lnsl -lcrypt

```

After making Openssh an init script was added. In addition to start the daemon it creates a RSA and DSA public/private key-pair when run for the first time. The script included in the Debian Openssh binary package is doing exactly that.

```

buildhost# make
buildhost# mkdir tmp
buildhost# make install DESTDIR=tmp
buildhost# mkdir tmp/etc/init.d
buildhost# vi tmp/etc/init.d/sshd
buildhost# chmod 755 tmp/etc/init.d/sshd
buildhost# mkdir tmp/DEBIAN
buildhost# vi tmp/DEBIAN/control
# ----- DEBIAN/control -----
Package: openssh-cc
Version: 3.8.1p1
Section: net
Priority: standard
Architecture: sparc
Maintainer: intern
Description: OpenSSH

```



```
# -----  
buildhost# fakeroot dpkg-deb --build tmp openssh-cc_3.8.1p1_sparc.deb
```

4.4.3 Configuring Openssh

The initial SSH server configuration file, found in `/etc/ssh/sshd_config`, had to be customized for the jumphost. There is not much point in restricting the client configuration file `/etc/ssh/ssh_config` because each user is allowed to have his own `~/.ssh/config` which overrides the defaults.

The following settings had been changed compared with the initial `sshd_config`. The complete `sshd_config` can be found in Appendix D.

- By default `Protocol` allows SSH version 1 and 2. For the jumphost only 2 was allowed.
- The `LogLevel` was changed to `VERBOSE` instead of `INFO`.
- `root` logins had been disabled.
- The version 1 RSA authentication had been disabled.
- By default the `authorized_keys` file is maintained by the users. For the jumphost it is controlled by the jumphost administrators. This was enforced by setting `AuthorizedKeysFile` to `/etc/ssh/authorized_keys.%u`. The `%u` is replaced by the user login name.
- `X11Forwarding` has to be enabled for jumphost users.
- `Banner` is set to `/etc/issue` which will be used system wide.

```
# ----- sshd_config -----  
Protocol 2  
LogLevel VERBOSE  
PermitRootLogin no  
RSAAuthentication no  
AuthorizedKeysFile      /etc/ssh/authorized_keys.%u  
X11Forwarding yes  
Banner /etc/issue  
# -----
```

4.5 Quota-tools

The Quota-tools (<http://sourceforge.net/projects/linuxquota/>) were used to restrict available disk space for jailed users. Because these users are permitted to use SCP to transfer

files from and to the jumphost it is advisable to set limits. The jumphost is often used in emergency cases and it is therefore crucial to have enough available disk space for each user.

I encountered problems using the Quota-tools with `ext3` and while looking for solutions I found that the `xfs` file system has built-in support for quotas, which means that no additional init script needed to be run when the system starts up. To add the `usrquota` option to `/etc/fstab` for the `xfs` file system is sufficient to turn quota support on. A newer version of the user level Quota-tools (3.01-pre2 onward) is recommended in `/usr/share/doc/xfsprogs/README.q`. That was the reason why the default Quota-tools provided by Debian were not used.

4.5.1 Getting, making and packaging

```
buildhost# wget http://switch.dl.sourceforge.net/sourceforge/linuxquota/quota-3.12.tar.gz
buildhost# tar xzf quota-3.12.tar.gz
buildhost# cd quota-tools
buildhost# ./configure --prefix=/usr
buildhost# make
buildhost# mkdir -p tmp/DEBIAN
buildhost# make install ROOTDIR=tmp
buildhost# vi tmp/DEBIAN/control
# ----- DEBIAN/control -----
Package: quota-tools-cc
Version: 3.12
Section: admin
Priority: extra
Architecture: sparc
Maintainer: intern
Description: QuotaTool
# -----
buildhost# fakeroot dpkg-deb --build tmp quota-tools-cc_3.12_sparc.deb
```

The creation of the `xfs` file system on the second hard disk, the mount options and the setting of quotas per user will be discussed in section 6.

4.6 Monit

In order to let the jailed users change their passwords a workaround had to be found. The problem with the SSH user Chroot environment is that the user authenticates himself to the `/etc/passwd` and `/etc/shadow` file. As soon as the authentication was successful he finds himself in the `/jail` Chroot environment. The user is only allowed to change her password within the jail (`/jail/etc/passwd` and `/jail/etc/shadow`) which will not have any effect on future logins.

A mechanism to timely and safely synchronize passwords from the jail to the system password files had to be put in place. The idea is that a daemon running in the main system environment is listening for changes of the `/jail/etc/shadow` file. Monit (<http://www.tildeslash.com/monit/>) provides besides other features this functionality. Monit is not in the stable Debian tree it had to be built from source.

4.6.1 Getting, making and packaging

```

buildhost# wget http://www.tildeslash.com/monit/dist/monit-4.3.tar.gz
buildhost# wget http://www.tildeslash.com/monit/dist/monit-4.3.tar.gz.md5
buildhost# md5sum -c monit-4.3.tar.gz.md5
buildhost# tar xzf monit-4.3.tar.gz
buildhost# cd monit-4.3
buildhost# ./configure --prefix=/usr --sysconfdir=/etc --without-ssl
buildhost# make
buildhost# mkdir -p tmp/DEBIAN
buildhost# make install DESTDIR=tmp
buildhost# vi tmp/DEBIAN/control
# ----- DEBIAN/control -----
Package: monit-cc
Version: 4.3
Section: admin
Priority: extra
Architecture: sparc
Maintainer: intern
Description: Monit
# -----
buildhost# mkdir -p tmp/etc/init.d
buildhost# vi etc/init.d/monit
buildhost# chmod 755 etc/init.d/monit
buildhost# fakeroot dpkg-deb --build tmp monit-cc_4.3_sparc.deb

```

The `etc/init.d/monit` script uses the standard Debian `start-stop-daemon` procedure to start and stop the `/usr/sbin/monit`.

4.6.2 Configuring

After installing the `monit` package on the jump host and enabling it to run at system boot (`update-rc.d monit defaults`) the configuration file `/etc/monitrc` had to be created. The `monit` daemon polls every 10 seconds if the checksum of the `/jail/etc/shadow` has changed. If this is the case it executes `/usr/local/bin/sync_shadow.sh` with the parameter `monit`.

```

# ----- /etc/monitrc -----

```

```
set daemon 10 # Poll intervals
check file shadow with path /jail/etc/shadow
    if failed checksum then exec "/usr/local/bin/sync_shadow.sh monit"
# -----
```

4.6.3 Synchronizing passwords

The security risks involved in the synchronization of passwords had to be considered. A jailed user could try to abuse the synchronization process to get the `root` password copied into the jail environment or to set the root password to his password. Several security measures had to be put in place to mitigate these risks:

- Checks are done before synchronization can start.
- Only users belonging to the group `jail` are synchronized.
- The `pam` configuration within the jail environment is very restrictive.

The entire `/usr/local/bin/sync_shadow.sh` script can be found in Appendix E. This script is able to perform two tasks:

System-to-Jail If the administrator (with root privileges) sets the password of a jailed user the new password has to be copied from the system password files to the jail password files. Before doing this task two requirements have to be fulfilled.

1. `/etc/shadow` has to be newer than `/jail/etc/shadow`.
2. The script was called without any parameters.

If the checks are OK:

1. All the entries in `/jail/etc/passwd` belonging to the group 1000 are copied into `/jail/etc/passwd`. Mark that `/jail/etc/passwd` is rewritten. The home directory field needs to be riden of the string `"/jail/."`.
2. For all the members of group 1000 the `/etc/shadow` entries are copied to `/jail/etc/shadow`.

Jail-to-System If a jailed user changes his password with the command `passwd` the `monit` daemon will detect the changed `/jail/etc/shadow` file and run `sync-shadow.sh` `monit`. Two requirements have to be fulfilled to let the script update the system `/etc/passwd` and `/etc/shadow`.

1. `/jail/etc/shadow` has to be newer than `/etc/shadow`.
2. The script was called with the parameter `monit`.

If the checks are OK the `usermod -p` is run for every user in `/jail/etc/shadow` after checking that the user is a member of the group `jail`.

5 Packages and services

The configuration of the self-compiled packages has been discussed earlier. In this section all the other services and packages will be described.

5.1 Configuring Apt

`apt-get` is one of the package management tools provided by Debian to keep packages up-to-date. `apt-setup` configures how the Debian archives should be accessed. Possible choices are `ftp`, `http`, `cdrom` or `filesystem`. The sources for the Debian archives can also be modified by hand in the following file. It is important to add the IP addresses of these hosts to the Iptables control file `/etc/iptables.accept`.

```
# ----- /etc/apt/sources.list -----
deb http://sunsite.cnlab-switch.ch/ftp/mirror/debian/ stable main non-free contrib
deb-src http://sunsite.cnlab-switch.ch/ftp/mirror/debian/ stable main non-free contrib
deb http://non-us.debian.org/debian-non-US stable/non-US main contrib non-free
deb-src http://non-us.debian.org/debian-non-US stable/non-US main contrib non-free
deb http://security.debian.org/ stable/updates main contrib non-free
# -----
```

The last entry pointing to `security.debian.org` is crucial in order to keep the system up-to-date. As soon as Debian releases a security update it can be fetched with `apt-get <package-name>`.

After configuring the Debian archive sources it is time to update all the current packages with the command `apt-get update` and `apt-get upgrade`. `apt-get` with the parameter `update` command fetches the current package lists while the parameter `upgrade` will upgrade all the packages with newer versions if available.

5.2 Remove and add some packages

The fewer packages installed the less possible vulnerabilities threaten the system. The base installation of Debian is already very small. There are still some packages that can be removed:

Package	Description	Removal reason
at	Delayed job execution	Only regular jobs are executed. Cron can do that.
cpio	Archive management	Rarely used on modern systems. Not needed on the jumphost.
dhcpc-client	DHCP client	IP address will be configured statically.
ed	Editor for dinosaurs	Vi is used to modify files.
eject	CD operator	Not necessary. CDROM will be detached after installation anyway.
exim	Mail transfer agent	Exim will be replaced with ssmtp.
fdutils	Floppy utilities	No floppy drive available.
info	Info documentation browser	Man pages are sufficient.
ipchains	Firewalling	Iptables is used instead.
libldap2	LDAP libraries	Was needed by exim which was removed.
libpcre3	Perl regular expression library	Not needed by any other package.
modconf	GUI for configuring modules	Jumphost Kernel does not support modules.
modutils	Module utilities	Jumphost Kernel does not support modules.
nano	Simple editor	Vi is used to modify files.
ppp, pppconfig, pppoe	Point-to-point protocol	Not used on this system.

Some packages need to be added to the jumphost. `apt-get install <package name>` can be used.

Package	Description	Install reason
ethtool	Change Ethernet settings	Used to set 100 Mbit/s full duplex and disable auto negotiation.
integrit	Integrity verification	Monitor file integrity (configuration will be described in section 5.8)
libgpmg1	General purpose mouse library	Is a vim dependency.
libssl0.9.6	SSL shared libraries	Used by Openssh.
logcheck, logcheck- database	Monitors system logfiles	Used to mail unusual system events to administrator (configuration will be explained in section 5.7).
logtail	Returns parts of logfiles	Logcheck depends on it.
lsof	Swiss army knife diagnostic tool	To get a quick overview of the system state.
ntpdate	Time update utilities	Update system time from NTP server (configuration will be explained in section 5.5).
perl, perl- modules	Scripting language	Logtail dependency.
ssmtp	Simple MTA	Replacing Exim.
vim	Vi improved	Some administrators are lost without it.
xfsprogs	XFS filesystem utilities	Used to create xfs file systems.
zlib1g	Compression library	Openssh dependency.

In addition the self-compiled packages have been installed:

Package	Description	Install reason
iptables-cc	Patched Iptables	Firewalling.
monit-cc	Daemon	Watch for shadow file changes.
openssh-cc	Patched Openssh	SSH daemon including user Chroot functionality.
quota-tools-cc	Disk quotas	Used to restrict available disk space for jump host users.

The complete list of installed packages can be found in Appendix C.

5.3 Ethernet settings

`ethtool` was used to configure Ethernet settings. In the productive environment speed 100 Mbit/s and full duplex had to be set.

```
# ----- /etc/init.d/networking -----
..
start)
..
    echo -n "set duplex Full speed 100Mb/s "
    /usr/sbin/ethtool -s eth0 autoneg off
    /usr/sbin/ethtool -s eth0 speed 100 duplex full
..
# -----
```

5.4 Disable unused services

Per default on Debian only the `inetd` services are running. It was disabled because those services are not needed and would be a security risk. It was done with the command `update-rc.d -f inetd remove`. There was another unnecessary service available in `/etc/init.d` which has been removed as well: `update-rc.d -f audioclock remove`.

After that, `netstat -l` showed one listening port only, namely `ssh`:

```
jumphost# netstat -l
Proto Recv-Q Send-Q Local Address           Foreign Address         State
tcp        0      0 *:ssh                   *:*                     LISTEN
Active UNIX domain sockets (only servers)
..
```

5.5 Configure ntpdate

It is important for the security of the system that the system has the correct time, especially if log files have to be cross-compared with other systems. The correct time can be fetched from NTP (Network Time Protocol) servers around the world. After the installation of the `ntpdate` package an init script to run `ntpdate` at system startup was put in place. The IP address of the NTP servers have to be defined in `/etc/default/ntp-servers`.

To adjust the time at least once every day an entry in `crontab` is required. The following line tells cron to run `ntpdate` every day at two o'clock in the morning. Iptables had to be configured to allow the outgoing NTP request.

```
jumphost# crontab -e
# ----- /var/spool/cron/crontabs/root -----
# synchronize clock
0 2 * * * /etc/init.d/ntpdate start >/tmp/out 2>&1
# -----
```


5.6 Harden mail

The jumphost does not require to act as a mail server and there is no need to deliver mail to local users. `exim` could do all of that and much more. Instead of hardening `exim` to only send out mails via mail hub it is also possible to install `ssmtp` (secure SMTP) which does exactly that and nothing more. It was also possible to remove additional packages `exim` depended on.

The configuration of `ssmtp` can be found in `/etc/ssmtp/ssmtp.conf`. The mailhub had been set to the mail hub used in the enterprise.

5.7 Configure logcheck

Logcheck is a handy tool to detect unusual entries in the system logfiles and send them via email to the administrator of the server. Depending on the requirements, Logcheck sends too many or too few system events. Anyway it has to be tailored to suit a specific system. The configuration is in `/etc/logcheck`. In the installation dialog the email address the reports will be sent to and the report level can be chosen. For the jumphost `server` was the configuration to start with.

The goal of the logcheck configuration is to not get any emails except an intruder really made it to break in. Because the machine is facing the Internet there will be many port scans etc. which will produce Iptables logs. An attacker could cause a certain damage with filling up the administrators mailbox without actually breaking in. An administrator will also ignore or filter regular mails and not pay attention to them. For these reasons the usage of Logcheck has to be considered closely. The Logcheck facility should not introduce a new security hole.

Usually an administrator does not check the system log files on a regular basis. Therefore an intruder has not to fear to get discovered even he would produces a lot of suspicious log entries. Remounting file systems, adding new users or booting the system etc are definitely events we want the administrator be informed about. That are the tasks, Logcheck has to serve on the jumphost.

The `logcheck` utility is ran at system boot and on a regular basis every hour. The `logcheck` cron job is defined in `/etc/cron.d/logcheck`.

To ignore all Iptables log entries starting with the string `ACCEPT` or `DROP` OUT a new file had been created in `/etc/logcheck/ignore.d.server`.

```
# ----- /etc/logcheck/ignore.d/iptables -----  
kernel: ACCEPT .*
```

```
kernel: DROP OUT:.*
```

```
# -----
```

Similar entries have been made for SSH logs that are not unusual:

```
# ----- /etc/logcheck/ignore.d/iptables -----
sshd.*: Accepted publickey for .* from .* port .*
sshd.*: Connection closed by .*
sshd.*: Closing connection to .*
sshd.*: Connection from .* port .*
sshd.*: Found matching DSA key: .*
sshd.*: Postponed publickey for .* from .* port .* ssh2
sshd.*: Accepted password for .* from .* port .* ssh2
# -----
```

After the Logcheck package had been installed the behavior of a normal user was imitated (log in, jump, change password etc). Logcheck then sent a mail containing a list of unusual system event. The report had to be examined closely and all the entries Logcheck should not consider as unusual had to be copied into the corresponding files in `/etc/logcheck`. Specific information like IP address or user name had to be replaced with `.*`.

If logcheck wrongly considered an event as a security violation the same configuration steps as with the `ignore.d` were repeated with `violations.ignore.d`. It took some time and patience to configure logcheck to the needs of the jumphost server but without configuring it correctly it would not do any good.

5.8 Configure Integrit

Another layer of security had been added with the installation of the integrity checking tool Integrit. If files located in directories that are not supposed to change nevertheless have changed Integrit will send a mail to the system administrator. Integrit had been installed as a normal Debian package. A daily cronjob (`/etc/cron.daily/integrit`) compares the `current.db` with the `known.db`. Emails should only be sent if there were changes. This again is to ensure administrators do not ignore the mails because of regularity. Both databases are stored in `/var/lib/integrit`.

The configuration files for Integrit can be found in `/etc/integrit`. Configuration can either be done via editing `integrit.conf` first and then running `dpkg-reconfigure integrit` to enter the email address etc. interactively or modifying `integrit.debian.conf` manually.

All the directories or files starting with `!` should not be checked for changes. These are files expected to change regularly. Directories starting with `=` should be checked but not descended into.

```
# ----- /etc/integrit/integrit.conf -----
root=/
known=/var/lib/integrit/known.cdb
current=/var/lib/integrit/current.cdb
!/lost+found
!/boot/lost+found
!/dev
!/etc/adjtime
!/etc/iptables.allow
!/etc/network/ifstate
!/etc/passwd
!/etc/passwd-
!/etc/shadow
!/etc/shadow-
!/home
!/home/lost+found
!/jail/etc/passwd
!/jail/etc/shadow
!/jail/home
!/proc
!/root
!/tmp
!/tmp/lost+found
!/usr/lost+found
!/var
!/var/lost+found
=/usr/doc
=/usr/info
=/usr/share
# -----
```

The `integrit.debian.conf` is read by the daily cronjob.

```
# ----- /etc/integrit/integrit.debian.conf -----
CONFIGS="/etc/integrit/integrit.conf"
EMAIL_RCPT="adminemail@company.com"
EMAIL_SUBJ="[integrit] report on changes in the filesystem"
SAVECYCLE=10
# -----
```

This configuration of `integrit` should not be trusted. This is not the weakness of `integrit` itself but of human and technical nature. Some issues should be considered.

Setting/Situation	Advantage	Disadvantage
Reports are only sent if there were changes.	Administrators will not filter or ignore the mails.	An intruder might prevent emails from being sent.
Database is stored locally.	Easy configuration.	An intruder could change files and copy the <code>current.db</code> to the <code>known.db</code> .
Integrit binary is stored locally.	Easy configuration.	An intruder could modify the binary.
Cronjob will update the database if there was a change.	No manual interaction necessary (copying <code>current.db</code> to <code>known.db</code>)	If the administrator ignores the mail no further mails will be sent the following days.

Of course these problems could be solved or worked around. It would be possible to mount the database and the integrity binary from a CDROM or via NFS. Cronjob could be instructed to not overwrite the `known.db`. Unfortunately if a skilled intruder becomes `root` he would be able to circumvent all these measures, except all the file systems would be mounted and checked by another system.

In the case of the jumphost `integrit` adds a layer of security without a lot of additional work. It is also meant to protect the administrators from themselves. Sometimes files are unintentionally changed by administrators. `integrit` informs accordingly.

After the installation and configuration of the jumphost a copy of `known.db` had been stored on the build machine. In case of doubt the `current.db` should be compared to this one.

6 Configure Jail (Chroot-Environment)

In this section the setup of the Chrooted environment for the jailed users will be described. It is also common to call the system within the system a “jail” to emphasize the situation of the user. He is meant to roam the jail only.

The setup of a Chrooted environment involved a lot of trial and error work. For this reason I wrote a script which sets up the environment.

6.1 Prepare partition

The home directories of the jumphost users had been put on their own partition in order to use disk quotas and to mount it with restrictive options. As discussed earlier the `xfs` filesystem had been chosen for this because of its convenient (no init scripts) fashion to

support quotas.

Problems arose when defining the `xfs` partition as the first partition of a hard disk. After a reboot the `xfs` partition was always lost. As a workaround the first partition consisting of one cylinder only with filesystem type `ext3` had been created without using it any further.

```
Disk /dev/sdb (Sun disk label): 16 heads, 135 sectors, 3880 cylinders
Units = cylinders of 2160 * 512 bytes
```

Device	Flag	Start	End	Blocks	Id	System
/dev/sdb1		0	1	1080	83	GNU/Linux native
/dev/sdb2	u	1	3880	4189320	83	GNU/Linux native
/dev/sdb3		0	3880	4190400	5	Whole disk

```
jumphost# mkfs.ext3 /dev/sdb1
```

```
jumphost# mkfs.xfs /dev/sdb2
```

6.2 Setting up Jail

The `create_jail.sh` script does all the work to setup a brand new jail. It can be found in Appendix F. The script:

1. Sets `umask` to `666` which means to create files with permissions `000`.
2. Removes the existing jail including unmounting `/jail/home`.
3. Defines all the binaries that should be included in the jail (`bash`, `passwd`, `ls`, `mv`, `rm`, `ssh`, `ping`, `scp`, `telnet`, `ftp`).
4. Creates the basic directory structure within `/jail` (`etc`, `bin`, `lib`, `dev`).
5. Creates device files in `/jail/dev` (`null`, `urandom`, `tty`).
6. Creates empty `passwd` and `shadow` files.
7. Creates `/jail/etc/services` with entries for `ftp`, `telnet` and `icmp`.
8. Creates `/jail/etc/pam.conf`. More details about this later in this section.
9. Copies `/etc/resolv.conf` to `/jail/etc/resolv.conf`.
10. Copies binaries and corresponding libraries (detected with `ldd`) to `bin` and `lib`.
11. Copies name service and PAM libraries to `/jail/lib`.

12. Sets strict permissions (lib[555], bin[111], etc[444], shadow[640], passwd[644]) and change group of `shadow` to `shadow`.
13. Sets `user-ID-on-execution-bit` (SUID Bit) on `ping` and `passwd`. Both `ping` and `passwd` need to be SUID to root. This means the user will run the binaries with root permissions.

The complete jail environment can be found in [Appendix G](#).

6.3 Jail PAM configuration

PAM (Pluggable Authentication Modules) had to be configured within the jail in order to let the jail users change their password. To disable any other PAM services the configuration needs to be restrictive.

The first line of the jumphost `/jail/etc/pam.conf` configuration allows the `passwd` service. It requires the user to enter his current password first. The new MD5 password has to be between six and twenty characters long. The `obscure` option enables additional checks on the password to enforce strong passwords. All other `pam` services are denied with help of `pam_deny.so`.

```
# ----- /jail/etc/pam.conf -----
passwd password      required           /lib/pam_unix.so obscure min=6 max=20 md5
other  auth           required         /lib/pam_deny.so
other  account        required         /lib/pam_deny.so
other  password        required         /lib/pam_deny.so
other  session          required         /lib/pam_deny.so
# -----
```

6.4 Add jailed users

To let an administrator adding jailed users correctly a script was required. It can be found in [Appendix H](#). The script requires two parameters: login name and comment. Running the script without any parameters it will display the syntax. The comment field consists of first name, last name, company and email address. In the following example the user `exampleusr` is added with the help of the script.

```
jumphost# addjailuser.sh exampleusr "John Miller XYcompany john.miller@xycompany.com"
```

Besides adding the user to the system the disk quota is set. The first parameter (80000) sets the soft limit to 80 MBytes. The hard limit (100MBytes) will be enforced after the grace period expired. The grace period can be set with `edquota -t`. The default setting are 7 days. `sync_shadow.sh` (see section 4.6.3) will update the jail `passwd` and `shadow` file. For the example user `exampleusr` the script executes the following commands:

```
jumphost# useradd -g jail -d "/jail/./home/exampleusr" \  
-c "John Miller XYcompany exampleusr@xycompany.com" -m exampleusr  
jumphost# chmod 700 /jail/home/exampleusr  
jumphost# setquota exampleusr 80000 100000 0 0 /jail/home  
jumphost# passwd exampleusr  
jumphost# sync_shadow.sh
```

7 System hardening

Besides disabling services, removing packages and application hardening the system, additional hardening can be done on the system. This will be described in this section. Most tasks have been done according to the SANS “Securing UNIX/GNU/Linux” documentation.

7.1 Users

7.1.1 Administrators and root

In previous sections the jail environment has been restricted. The system users need to be considered as well. On the jumphost only administrators are allowed to login with their personal account. Once logged in they are allowed to become `root` with issuing the `su` (switch user) command. The reason why the administrators have personal logins is to know who and when somebody logged into the system.

For the jumphost only one file needed to be put in the user skeleton, namely `.bash_profile`. It sets the `umask` to the value `066` which will create files with the permission `600`. The `UMASK` environment variable should also be set to `066` in `/etc/login.defs`. On Debian the `umask` is also defined in `/etc/profile`. It should be changed to `066` there as well.

The `PATH` environment variable is set to `/bin:/usr/bin`. It is not necessary to add `/usr/local/bin` where the `addjailuser.sh` and `sync_shadow.sh` scripts reside because they are only executable as `root`. Because there are only a few users on the jumphost and all of them are allowed to be `root` it is not necessary to install and configure `sudo` at this point. If more users with different roles would have access to the jumphost `sudo` would definitely make sense.

```
# ----- /etc/skel/.bash_profile -----  
umask 066  
export PATH=/bin:/usr/bin  
export PS1='\u@\h:\$ '  
# -----
```

There are two ways an administrator can log into the system. Usually she will use SSH. In order to enforce personal login in SSH instead of root the `PermitRootLogin` option in `sshd_config` had been set to `no`. If the user will login on the console which is possible via terminal server he will be allowed to login as root. It would be possible to prohibit root login on the console by editing `/etc/securetty`. To not break with the personal login policy it is not possible to login on the terminal server as root.

Administrators and jump host users should be presented with a warning banner before logging into the system. The banner should state that only authorized users are allowed to login. The text is put into `/etc/issue` than linked to `/etc/motd`. In addition the `Banner` option in `/etc/ssh/sshd_config` had been set to `/etc/issue`. This will display the warning banner when presenting the login screen and again after a successful login.

According to SANS standards the limits set by the PAM module `pam_limits.so` should be set to reasonable values. After uncommenting `session required pam_limits.so` in `/etc/pam.d/login` the settings had to be adjusted in `/etc/security/limits.conf`. Unfortunately these settings are not enforced for SSH logins because it was compiled without PAM support because this would break the `PrivilegeSeparation` option.

```
# ----- /etc/pam.d/login -----  
..  
session    required    pam_limits.so  
..  
# -----
```

```
# ----- /etc/security/limits.conf -----  
*          soft      nproc     65  
*          hard      nproc     128  
*          soft      nofile    256  
*          hard      nofile    1024  
# -----
```

7.1.2 System users

The `/etc/passwd` contains a lot of users that may be used by a daemon installed at a later point of time. On the jump host no additional daemons will be installed and it is therefore a good idea to remove unused users. If there is uncertainty if a user owns any files on

the system it can be checked with `find`. Users that cannot be removed, but will never be expected to log into the system, should be locked and the home directory set to `/dev/null`.

```
jumphost# # find which users own files
jumphost# for i in `cut -d: -f1 /etc/passwd`; do echo $i
  find / -user $i 2>/dev/null |wc -l; done
jumphost# # remove some users
jumphost# for i in sync games lp list mail news uucp proxy \
  postgres www-data backup irc gnats; do userdel $i; done
jumphost# # lock some users
jumphost# for i in daemon bin sys man operator list
  do usermod -s /dev/null -L $i; done
```

After this tasks has been finished `/etc/passwd` contains the following entries (the administrator accounts are not listed):

```
# ----- /etc/passwd -----
root:x:0:0:root:/root:/bin/bash
daemon:x:1:1:daemon:/usr/sbin:/dev/null
bin:x:2:2:bin:/bin:/dev/null
sys:x:3:3:sys:/dev:/dev/null
man:x:6:100:man:/var/cache/man:/dev/null
operator:x:37:37:Operator:/var:/dev/null
nobody:x:65534:65534:nobody:/home:/bin/sh
sshd:x:100:100:./var/empty:/bin/bash
# -----
```

7.1.3 Restrict cron

It is advisable to restrict the usage of `cron`. On the jumphost only `root` should be allowed to use the `cron` facilities. This can be enforced with the file `/etc/cron.allow`. If this file is not empty everybody not listed will not be permitted to use `cron`. In addition the file permissions of the directories read by `cron` should be restricted.

```
jumphost# echo root > /etc/cron.allow
jumphost# chown -R root:root /etc/cron* /var/spool/cron
jumphost# chmod -R go-rwx /etc/cron* /var/spool/cron
```

7.2 SUID/SGID bits and mount options

7.2.1 Executable with SUID Bit set

Before setting the correct mount options it is important to know where the SUID/SGID executables are located. Anyway it is good to have an idea which SUID/SGID executables are installed on a system and what they are supposed to do. `find` can be used to list all of them.

Only directories in `/var/cache/man` are SGID to root. The group of new directories created within `/var/cache/man` will be set to root as well. Only directories can get SGID. They are no security threat (see <http://lists.debian.org/debian-devel/2000/10/msg01889.html>).

```
jumphost# # Find executables with SGID bit set to root
jumphost# find / -group root -perm +g+s
/var/cache/man
/var/cache/man/...
```

The “danger” lies in the executables with SUID set to root. It would be possible to remove the SGID from all of these executables except `su`, `login` and the two jail binaries `passwd` and `ping`. This would be possible on the jumphost because all the administrators are allowed to become superusers and therefore could `ping`, `mount`, change their password etc after becoming root. There are reasons why this is not done on the jumphost:

- Next time a package, containing one of these files, will be upgraded, the permissions will be reverted. It could be more dangerous to wrongly assume to not have any SUID executables then to keep in mind that there are SUID on the system.
- Administrators should not be encouraged to become root to do simple tasks like pinging or changing their own password. This for example would circumvent the PAM `obscure` option.

```
jumphost# # Find executables with SUID bit set to root
jumphost# find / -user root -perm +g+s
/usr/bin/newgrp
/usr/bin/chfn
/usr/bin/chsh
/usr/bin/gpasswd
/usr/bin/passwd
/usr/bin/crontab
/usr/bin/traceroute
/usr/lib/pt_chown
```

```
/usr/libexec/ssh-keysign
/sbin/unix_chkpwd
/bin/login
/bin/su
/bin/mount
/bin/umount
/bin/ping
/jail/bin/passwd
/jail/bin/ping
```

Even if no changes had been made, it is still wise to find all the SUID executables after a system installation just to make sure no unknown binaries have this bit set.

7.2.2 Mount options

After the SUID executables had been located mount options can be adjusted. Per default all the file systems are mounted `rw` without additional options except `/` which has been mounted with the option `rw,errors=remount-ro`.

- All the file systems which do not have device files (character special files) can be mounted `nodev`. `/dev` and `/jail/dev` are the only directories containing device files. All the other partitions are mounted with the option `nodev`.
- `/cdrom`, `/var` and `/home` are not allowed to run any SUID executables and can therefore be mounted with the option `nosuid`.
- `/usr` should not be written to. It can be mounted with the option `ro`. Before doing a system upgrade `/usr` has to be remounted `rw` with the command `mount -o remount,rw`.
- File execution is not allowed from `/boot`, `/tmp`, `/jail/home` and `/proc`. This can be configured with the mount option `noexec`.
- `/jail/home` has to be mounted with the option `usrquota` in order to enable the disk quota restrictions.
- `/boot` and `/cdrom` do not need to be mounted on system startup. The option `noauto` can be used.

To enable the mount-options after the next reboot `/etc/fstab` has to be modified accordingly.

```
# /etc/fstab: static file system information.
#
```

# <file system>	<mount point>	<type>	<options>	<dump>	<pass>
/dev/sda2	/	ext3	errors=remount-ro	0	1
/dev/sda7	none	swap	sw	0	0
proc	/proc	proc	rw,noexec,nodev	0	0
/dev/cdrom	/cdrom	iso9660	ro,nosuid,nodev,noauto	0	0
/dev/sda1	/boot	ext2	nodev,noauto,noexec	0	2
/dev/sda4	/usr	ext3	nodev,ro	0	2
/dev/sda5	/var	ext3	nodev,nosuid	0	2
/dev/sda6	/tmp	ext3	nodev,noexec	0	2
/dev/sda8	/home	ext3	nodev,nosuid	0	2
/dev/sdb2	/jail/home	xfs	usrquota,noexec,nodev	0	0

After remounting mount `-o remount,<options> /mount-point` respectively rebooting the system the mount table looks like this:

```
jumphost# mount
/dev/sda2 on / type ext3 (rw,errors=remount-ro)
proc on /proc type proc (rw,noexec,nodev)
/dev/sda4 on /usr type ext3 (ro,nodev)
/dev/sda5 on /var type ext3 (rw,nosuid,nodev)
/dev/sda6 on /tmp type ext3 (rw,noexec,nodev)
/dev/sda8 on /home type ext3 (rw,nosuid,nodev)
/dev/sdb2 on /jail/home type xfs (rw,noexec,nodev,usrquota)
```

7.3 Other hardening tasks

7.3.1 Network configuration parameters

SANS recommends reasonable `sysctl` settings. With the command `/sbin/sysctl -a` the currently set values were compared with the SANS recommendations. The settings that were different had been added to `/etc/sysctl.conf`.

```
# ----- /etc/sysctl.conf -----
net.ipv4.conf.all.log_martians = 1
net.ipv4.conf.all.send_redirects = 0
net.ipv4.conf.all.secure_redirects = 0
# -----
```

In Debian spoof protection is enabled when running the `/etc/init.d/networking` script. Spoof protection compares incoming packets with the routing table. Because the jumphost only has one interface `rp_filter` is not really necessary, except for the case when a packet with the loopback address is coming in via `eth0`. But this case is already handled by `Iptables`.

7.3.2 Anonymous shutdowns

Per default the key combination Ctrl+Alt+Del causes a system to reboot. This behavior had to be disabled. Instead of a reboot the event will be logged.

```
# ----- /etc/inittab -----  
..  
::ca:12345:ctrlaltdel:/usr/bin/logger 'ctrl-alt-del trapped'  
..  
# -----
```

8 Maintenance procedures

The maintenance of the system is done by the system administrators. There are three areas the maintenance tasks can be divided into.

8.1 Updates and patches

The system administrator is responsible to keep the system up-to-date in terms of security. Operating system, software and security related mailing lists inform the administrator of security relevant updates respectively vulnerabilities that require action.

In general it is not necessary to update packages when new features have been added. Remote exploits have to be fixed immediately, local exploits within a reasonable time frame because users may have to be informed.

- A Debian package which fixes a security hole can be installed very easily. First the newest package lists have to be downloaded using the command `apt-get update`. Once this is done `apt-get install <package-name>` will replace the old package with the newer version. Note that the `/usr` partition has to be remounted `read-write` to allow installation of new packages in `/usr`.

```
jumphost# mount -o remount,rw /usr  
jumphost# apt-get update  
jumphost# apt-get install <package-name>  
jumphost# mount -o remount,ro /usr
```

- Self-compiled software, namely Kernel, Openssh, Iptables, Monit and Quota-tools have to be handled according to the procedures described in the section 4. Before installing these packages on the production jumphost they have to be tested on a jumphost clone in the lab.

8.2 Users

There are several tasks that have to be done on a regular basis by the system administrator.

8.2.1 SSH Keys

As `sshd_config` set the `AuthorizedKeysFile` option to `/etc/ssh/authorized_keys.%u` (see 4.4.3) the keys need to be maintained by the administrator. For every user who is authorizing himself with the keys a file is created in `/etc/ssh`. The name of the file is `authorized_keys` followed by the user name.

As an additional security measure this file should belong to root and should only be readable by root. Anyway this should automatically be the case because only root can create files in `/etc/ssh` and `umask` had been set to 066.

```
jumphost# vi /etc/ssh/authorized_keys.exampleusr
jumphost# chmod 600 /etc/ssh/authorized_keys.exampleusr
```

8.2.2 Add and remove jailed users

Because there are only a few administrators the adding and removing of administrators will not be detailed here.

The adding and removing of jailed users differs from the standard procedures.

This is the way to add a new user. The script to do this task has been described in section 6.4. To allow the jailed users to connect to any servers they want, the servers and ports have to be added to `/etc/iptables.accept` accordingly (see 4.2.4).

```
jumphost# addjailuser.sh exampleusr "John Miller XYcompany exampleusr@xycompany.com"
jumphost# vi /etc/iptables.accept
```

The removal of a jailed user is standard. The `-r` flag will also remove the home directory. `sync_shadow.sh` (see 4.6.3) has to be run in order to update the jail password files. The entries in `/etc/iptables.accept` belonging to the removed user have to be cleaned out.

```
jumphost# deluser -r exampleusr
jumphost# sync_shadow.sh
jumphost# vi /etc/iptables.accept
```

8.3 Monitoring

The administrator is responsible to read mails sent to him by `logcheck` (see 5.7) and `integrit` (see 5.8). If log entries sent to the administrator which are not security relevant the `logcheck` configuration files need to be adjusted. The same is valid for `integrit`. If files are allowed to change without noticing, the `integrit` configuration files need to be changed.

9 Testing

The following tests have been done to ensure the jumphost server is configured as expected:

9.1 System

- Except for the Kernel processes only `syslogd`, `klogd`, `monit`, `sshd`, `cron` and `bash` of the currently logged in user showed up.

```

jumphost# ps -ef
..
20642 ?          00:00:09 syslogd
11942 ?          00:15:21 klogd
24357 ?          00:41:06 monit
14076 ?          00:00:00 sshd
 8322 ?          00:00:15 cron
 6659 ?          00:00:22 sshd
 1349 ttyp0       00:00:00 bash
28903 ttyp0       00:00:00 bash

```

- `netstat -l` lists all the listening ports. Only `ssh` was in the `LISTEN` state.
- It's always good to get a second option. `lsof` had been run. The output is listed in Appendix I.
- `nmap -P0 -sX -sU -p 1-65535 jumphost` was run from another host within the same network (no firewalls in between).
- `apt-get update` and `/etc/init.d/ntpdate start` were run. If this does not work, probably `/etc/iptables.accept` was not properly configured.
- A file `Integrit` is monitoring was changed (added an empty line to `/etc/fstab`). A mail was sent indicating that `/etc/fstab` has been changed. To force `integrit` to check now instead of waiting for `cron` to do it (even though this is better to test `cron` as well) `/etc/cron.daily/integrit` can be issued.

```

changed: /etc/fstab s(invalidchecksum454g16c5ffd53f5faa13deejls89044543f8f)

```

- Remounted `/usr` with running `mount -o rw /usr`. This created a log event, logcheck picked it up and sent a mail. The impatient could run `/etc/cron.d/logcheck` to get informed immediately.

```
jumphost kernel: grsec: .. mount /dev/sda4 to /usr by /bin/mount..
```

9.2 Jailed users

An important security test is to check if the jailed users can only do what they are allowed to. To test this behavior a test user with name `testusr` was created. Note the difference of the `passwd` entry on the system and on the jail.

```
jumphost# addjailuser.sh testusr "test"
Enter new UNIX password:
Retype new UNIX password:
passwd: password updated successfully
User testusr added successfully.
jumphost# grep testusr /etc/passwd
testusr:x:1003:1000:test:/jail/./home/testusr:/bin/bash
jumphost# grep testusr /jail/etc/passwd
testusr:x:1003:1000:test:/home/testusr:/bin/bash
```

After the user logged in he finds himself jailed. The user was able to ping the target machine `10.1.1.1` but failed the SSH connection attempt failed because `/etc/iptables.accept` did not have entries for this user yet. As soon as `iptables.accept` had been modified and `iptables` restarted by root, `testusr` could successfully connect to `10.1.1.1`.

```
jumphost(testusr)# pwd
/home/testusr
jumphost(testusr)# ping 10.1.1.1
PING 10.1.1.1 (10.1.1.1): 56 data bytes
64 bytes from 10.1.1.1: icmp_seq=0 ttl=253 time=171.4 ms
jumphost(testusr)# ssh 10.1.1.1
ssh: connect to host 10.1.1.15 port 22: Connection timed out

jumphost# echo "testusr:10.1.1.1:22" >> /etc/iptables.accept
jumphost# /etc/init.d/iptables restart
jumphost# iptables -L |grep testusr
ACCEPT tcp .. 10.1.1.1 .. dpt:ssh .. OWNER UID match testusr

jumphost(testusr)# ssh 10.1.1.1
testusr@10.1.1.1's password:

jumphost# grep testusr /var/log/messages
Sep 18 18:11:32 jumphost kernel: grsec: .. chdir to /jail/home/testusr by /usr/sbin/sshd ..
Sep 18 18:24:09 jumphost kernel: ACCEPT TCP22 (testusr): .. DST=10.1.1.1 .. PROTO=TCP .. DPT=22
```


The user changed his password. In the background `monit` detected that the MD5 hash of `/jail/etc/shadow` had changed and ran `sync_shadow.sh` which updated `/etc/shadow`.

```

jumphost(testusr)# passwd
Changing password for testusr
(current) UNIX password: oldpassword
Enter new UNIX password: simplepassword
Retype new UNIX password: simplepassword
Bad: new password is too short
Enter new UNIX password: strongpassword
Retype new UNIX password: strongpassword
passwd: password updated successfully
jumphost(testusr)# exit
testusr@jumphost's password: newpassword
jumphost(testusr)#

```

A jailed user is allowed to fill up maximum of 100 MBytes of disk space. For testing purposes this was reduced to 2 MBytes and a file bigger than 2 MBytes was copied. As a result not the whole file had been copied but only the first 2 MBytes.

```

jumphost# repquota /jail/home
*** Report for user quotas on device /dev/sdb2
Block grace time: 7days; Inode grace time: 7days

```

User	used	Block limits			File limits			
		soft	hard	grace	used	soft	hard	grace
root	-- 0	0	0		3	0	0	
testusr	-- 24	80000	100000		5	0	0	

```

jumphost# setquota testusr 2000 2500 0 0 /jail/home
jumphost# repquota /jail/home |grep testusr
testusr -- 24 2000 2000 5 0 0
jumphost(testusr)# scp security@10.1.1.1:/var/adm/messages .
messages: Disk quota exceeded
jumphost(testusr)# ls -l
-rw----- 1 testusr 1000 1966080 Sep 18 17:04 messages
jumphost# repquota /jail/home |grep testusr
testusr -- 1944 2000 2000 6 0 0

```

Last but not least a common breakout of jail was tried. A jailed user is not allowed to execute files from his home (mounted with `noexec` option). Still, for a test `/jail/home` has been remounted without `noexec`. Without `Grsecurity` compiled into the Kernel the following code compiled and ran by a jailed user was able to break out of the Chrooted environment. With `Grsecurity` this was not possible anymore.

```

/* Using Chroot Securely
By Anton Chuvakin, Ph.D.

```

```
2/10/2002 17:19
http://www.linuxsecurity.com/feature_stories/feature_story-99.html
*/
#include <stdlib.h>
#include <stdio.h>
#include <unistd.h>
#include <sys/stat.h>
#include <sys/types.h>
int main(void)
{
    int i;
    mkdir("breakout", 0700);
    chroot("breakout");
    for (i = 0; i < 100; i++)
        chdir("../") ;
    chroot(".");
    execl("/bin/sh", "/bin/sh", NULL);
}
```

10 Backup and clone

The jumphost is meant to be a system without important user data on it. If the hard disks of a jumphost crash, a new jumphost will be put into place. Because the jumphost user data is stored on a another disk than the passwords either one of them will be lost. New passwords respectively new empty home directories would be created.

The work that has been done for this jumphost only pays of if it can be cloned. One reason to choose this hardware was that spare machines are available. Here comes a short description of how the jumphost was cloned.

1. The whole system (ca. 200MBytes) was archived and transfered to another machine where it was burned on a CD.

```
debian# cd /
debian# tar cf /home/jumphost.tar .
debian# scp /home/jumphost.tar myburner:
myburner# mkisofs -V jumphost -o jumphost.iso jumphost.tar
myburner# crecord dev=0,0,0 -data jumphost.iso
```

2. The new hardware had been booted with the Debian installation CD. The first installation steps (swap, partitioning and mounting) have been done as usual. Then "Execute a shell" was chosen from the installation menu. The Debian installation CD was ejected and the jumphost CD inserted. After the jumphost CD had been mounted `jumphost.tar` was extracted in `/target`.

```
debian# mount -o ro /dev/scd0 /mnt
debian# cd /target
debian# tar xf /mnt/jumphost.tar
```

3. The new system was installed. The good thing about using `tar` (instead of `dd` for example) is that the partitioning and mount points do not need to be identical on the new jumphost.

It is important to adjust `/target/etc/fstab` if the partitioning is not identical to the “originating” jumphost. The next step was to make the system bootable. This has been achieved by chrooting into the new system, modifying `/etc/silo` and running `silo -f`.

```
debian# cd /target
debian# chroot .
debian# vi /etc/fstab
debian# vi /etc/silo.conf
debian# silo -f
debian# reboot
```

11 References

- GNU/Linux manual pages and `/usr/share/doc`
- Hal Pomeranz, Copyright 2000-2004, SANS GCUX course material
- Debian GNU/Linux, Debian developers
<http://www.debian.org>
- Linux Kernel, Copyright 1997-2003 The Kernel.Org Organization, Inc.
<http://www.kernel.org>
- Grsecurity, Brad Spengler and Michael Dalton
<http://www.grsecurity.net>
- Iptables/Netfilter, Netfilter Core Team
<http://www.netfilter.org>
- Iptables/Netfilter Owner-socketlookup patch, Patrick McHardy
<http://www.netfilter.org/patch-o-matic/pom-extra.html#pom-extra-owner-socketlook>
- Openssh, Openssh developers
<http://www.openssh.org>
- james@firstaidmusic.com, Chroot SSH,
<http://chrootssh.sourceforge.net/index.php>
- Quota-tools, Linuxquota developers
<http://sourceforge.net/projects/linuxquota>
- Monit, The monit project group
<http://www.tildeslash.com/monit/>

- Logcheck, Rami Dass
<http://www.astro.uiuc.edu/~r-dass/logcheck/>
- Integrit, Integrit developers
<http://integrit.sourceforge.net/>
- 1996 Bruce Perens, 1996, 1997 Sven Rudolph, 1998 Igor Grobman, James Treacy
1998-2002 Adam Di Carlo, "Installing Debian GNU/Linux 3.0 For SPARC"
<http://www.debian.org/releases/stable/sparc/install>
- <http://www.spi-inc.org/SPI>, Copyright 1997-2004,
"Downloading Debian CD images via HTTP/FTP"
<http://www.debian.org/CD/http-ftp>
- XFS filesystem FAQ, "Do quotas work?",
<http://oss.sgi.com/projects/xfs/faq.html#quotaswork>
- nathans@sgi.com, XFS quota Readme, "QUOTA on XFS",
/usr/share/doc/xfsprogs/README.quota.gz
- Ethan Benson jerbenson@alaska.net, "Re: Why is /var/cache/man/ sgid root?"
<http://lists.debian.org/debian-devel/2000/10/msg01889.html>

A Iptables init script

```
# ----- /etc/init.d/iptables -----
#!/bin/sh

stop() {
    PROG="/usr/sbin/iptables"
    $PROG -P INPUT ACCEPT
    $PROG -P FORWARD DROP
    $PROG -P OUTPUT ACCEPT
    $PROG --flush
}

start() {
    PROG="/usr/sbin/iptables"
    IPT_ACCEPT="/etc/iptables.accept"
    CUT="/usr/bin/cut"
    GREP="/bin/grep"
    IPADDR=192.168.254.10
    DNSSRV=192.168.254.20
    NTPSRV=192.168.254.30
    ILLEGAL_TCP_FLAGS="SYN,FIN PSH,FIN SYN,ACK,FIN SYN,FIN,PSH SYN,FIN,RST
    SYN,FIN,RST,PSH SYN,FIN,ACK,RST SYN,ACK,FIN,RST,PSH ALL RST"
```

```
$PROG -P INPUT DROP
$PROG -P FORWARD DROP
$PROG -P OUTPUT DROP
$PROG --flush

# INPUT

# accept LOOPBACK on loopback, log and drop on eth0
$PROG -A INPUT -i lo -j ACCEPT
$PROG -A INPUT -d 127.0.0.1 -i eth0 -j LOG --log-level 6 --log-prefix \
  "DROP INVALID_SOURCE: "
$PROG -A INPUT -d 127.0.0.1 -i eth0 -j DROP

# log and drop INVALID RANGES
$PROG -A INPUT -s 224.0.0.0/240.0.0.0 -i eth0 -j LOG --log-level 6 \
  --log-prefix "DROP INVALID_SOURCE: "
$PROG -A INPUT -s 224.0.0.0/240.0.0.0 -i eth0 -j DROP
$PROG -A INPUT -s 240.0.0.0/248.0.0.0 -i eth0 -j LOG --log-level 6 \
  --log-prefix "DROP INVALID_SOURCE: "
$PROG -A INPUT -s 240.0.0.0/248.0.0.0 -i eth0 -j DROP

# log and drop ILLEGAL FLAGS
for flag in $ILLEGAL_TCP_FLAGS; do
  $PROG -A INPUT -i eth0 -p tcp --tcp-flags ALL $flag \
    -j LOG --log-level 6 --log-prefix "DROP ILLEGAL_TCP_FLAGS: " \
    --log-ip-options --log-tcp-options
  $PROG -A INPUT -i eth0 -p tcp --tcp-flags ALL $flag -j DROP
done
$PROG -A INPUT -i eth0 -p tcp -m tcp ! --tcp-flags SYN,RST,ACK SYN -m state \
  --state NEW -j LOG --log-level 6 --log-prefix "DROP ILLEGAL_TCP_FLAGS: " \
  --log-ip-options --log-tcp-options
$PROG -A INPUT -i eth0 -p tcp -m tcp ! --tcp-flags SYN,RST,ACK SYN -m state \
  --state NEW -j DROP

# log and drop INVALID STATE
$PROG -A INPUT -i eth0 -m state --state INVALID -j LOG --log-prefix \
  "DROP INVALID_STATE: " --log-level 6
$PROG -A INPUT -i eth0 -m state --state INVALID -j DROP

# log and drop ICMP
$PROG -A INPUT -d $IPADDR -i eth0 -p icmp -f -j LOG --log-prefix \
  "DROP ICMP_IN: " --log-level 6
$PROG -A INPUT -d $IPADDR -i eth0 -p icmp -f -j DROP

# accept ESTABLISHED
$PROG -A INPUT -d $IPADDR -i eth0 -m state --state RELATED,ESTABLISHED -j ACCEPT
# log and accept incoming ssh
$PROG -A INPUT -d $IPADDR -i eth0 -p tcp -m tcp --sport 1024:65535 --dport 22 \
  -m state --state NEW -j LOG --log-prefix "ACCEPT SSH_IN: " --log-level 6
$PROG -A INPUT -d $IPADDR -i eth0 -p tcp -m tcp --sport 1024:65535 --dport 22 \
  -m state --state NEW -j ACCEPT

# log all incoming dropped traffic
#$PROG -A INPUT -j LOG --log-prefix "DROP IN: " --log-level 6
```

```

# OUTPUT

# GENERAL
# -----

# accept LOOPBACK
$PROG -A OUTPUT -o lo -j ACCEPT

# log and drop INVALID STATE
$PROG -A OUTPUT -o eth0 -m state --state INVALID -j LOG --log-prefix \
  "DROP INVALID_STATE: " --log-level 6
$PROG -A OUTPUT -o eth0 -m state --state INVALID -j DROP

# accept ESTABLISHED
$PROG -A OUTPUT -s $IPADDR -o eth0 -m state --state RELATED,ESTABLISHED \
  -j ACCEPT

# accept and log outgoing ICMP (echo request)
$PROG -A OUTPUT -s $IPADDR -o eth0 -p icmp -m icmp --icmp-type 8 -m state \
  --state NEW -j LOG --log-prefix "ACCEPT ICMP_OUT: " --log-level 6
$PROG -A OUTPUT -s $IPADDR -o eth0 -p icmp -m icmp --icmp-type 8 -m state \
  --state NEW -j ACCEPT

# accept and log outgoing TRACEROUTE (root only)
$PROG -A OUTPUT -s $IPADDR -o eth0 -p udp -m udp --sport 32769:65535 --dport \
  33434:33523 -m state --state NEW -m owner --uid-owner root -j LOG --log-prefix \
  "ACCEPT TRACEROUTE_OUT: " --log-level 6
$PROG -A OUTPUT -s $IPADDR -o eth0 -p udp -m udp --sport 32769:65535 --dport \
  33434:33523 -m state --state NEW -m owner --uid-owner root -j ACCEPT

# accept and log outgoing NTP (root only)
$PROG -A OUTPUT -s $IPADDR -d $NTPSRV -o eth0 -p udp --sport 32768:61000 \
  --dport 123 -m state --state NEW,ESTABLISHED --uid-owner root -j LOG --log-prefix \
  "ACCEPT NTP_OUT: " --log-level 6
$PROG -A OUTPUT -s $IPADDR -d $NTPSRV -o eth0 -p udp --sport 32768:61000 \
  --dport 123 -m state --state NEW,ESTABLISHED --uid-owner root -j ACCEPT

# accept and log outgoing DNS
$PROG -A OUTPUT -s $IPADDR -d $DNSSRV -o eth0 -p udp --sport 32768:61000 \
  --dport 53 -m state --state NEW,ESTABLISHED -j LOG --log-prefix \
  "ACCEPT DNS_OUT: " --log-level 6
$PROG -A OUTPUT -s $IPADDR -d $DNSSRV -o eth0 -p udp --sport 32768:61000 \
  --dport 53 -m state --state NEW,ESTABLISHED -j ACCEPT

# USER $SPECIFIC
# -----

# accept and log outgoing SSH
IFS='
'
for i in `cat $IPT_ACCEPT |$GREP -v ^\# | $GREP -v ^$`; do
  owner="`echo $i |$CUT -d: -f 1`"
  dest="`echo $i |$CUT -d: -f 2`"

```

```
port="'echo $i |$CUT -d: -f 3'"
$PROG -A OUTPUT -s $IPADDR -d $dest -o eth0 -p tcp -m tcp \
  --sport 32768:61000 --dport $port -m state --state NEW \
  -m owner --uid-owner $owner \
  -j LOG --log-prefix "ACCEPT TCP$port ($owner): " --log-level 6
$PROG -A OUTPUT -s $IPADDR -d $dest -o eth0 -p tcp -m tcp \
  --sport 32768:61000 --dport $port -m state --state NEW \
  -m owner --uid-owner $owner \
  -j ACCEPT
done
IFS=

# LOG ALL
# -----

# LOG ALL outgoing dropped traffic
$PROG -A OUTPUT -j LOG --log-prefix "DROP OUT: " --log-level 6
}

case "$1" in
  start)
    start
    ;;
  stop)
    stop
    ;;
  restart)
    stop
    start
    ;;
  *)
    echo "Syntax: $0 start|stop|restart"
    ;;
esac
# -----
```

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B Kernel configuration

```

CONFIG_EXPERIMENTAL=y
CONFIG_BBC_I2C=y
CONFIG_VT=y
CONFIG_VT_CONSOLE=y
CONFIG_SPARC64=y
CONFIG_HAVE_DEC_LOCK=y
CONFIG_RWSEM_XCHGADD_ALGORITHM=y
CONFIG_SBUS=y
CONFIG_SBUSCHAR=y
CONFIG_BUSMOUSE=y
CONFIG_SUN_MOUSE=y
CONFIG_SERIAL=y
CONFIG_SUN_SERIAL=y
CONFIG_SERIAL_CONSOLE=y
CONFIG_SUN_KEYBOARD=y
CONFIG_SUN_CONSOLE=y
CONFIG_SUN_AUXIO=y
CONFIG_SUN_IO=y
CONFIG_PCI=y
CONFIG_RTC=y
CONFIG_NET=y
CONFIG_BSD_PROCESS_ACCT=y
CONFIG_SYSCTL=y
CONFIG_KCORE_ELF=y
CONFIG_SPARC32_COMPAT=y
CONFIG_BINFMT_ELF32=y
CONFIG_BINFMT_ELF=y
CONFIG_PROM_CONSOLE=y
CONFIG_SUN_OPENPROMIO=y
CONFIG_SUN_MOSTEK_RTC=y
CONFIG_BLK_DEV_LOOP=y
CONFIG_PACKET=y
CONFIG_PACKET_MMAP=y
CONFIG_NETFILTER=y
CONFIG_UNIX=y
CONFIG_INET=y
CONFIG_SYN_COOKIES=y
CONFIG_IP_NF_CONTRACK=y
CONFIG_IP_NF_FTP=y
CONFIG_IP_NF_IPTABLES=y
CONFIG_IP_NF_MATCH_LIMIT=y
CONFIG_IP_NF_MATCH_MAC=y
CONFIG_IP_NF_MATCH_MULTIPORT=y
CONFIG_IP_NF_MATCH_STATE=y
CONFIG_IP_NF_MATCH_CONTRACK=y
CONFIG_IP_NF_MATCH_OWNER=y
CONFIG_IP_NF_FILTER=y
CONFIG_IP_NF_TARGET_REJECT=y
CONFIG_IP_NF_TARGET_LOG=y
CONFIG_IP_NF_TARGET_ULOG=y
CONFIG_IP_NF_ARPTABLES=y
CONFIG_IP_NF_ARPFILTER=y
CONFIG_IP_NF_ARP_MANGLE=y
CONFIG_SCSI=y
CONFIG_BLK_DEV_SD=y
CONFIG_SD_EXTRA_DEVS=40
CONFIG_BLK_DEV_SR=y
CONFIG_SR_EXTRA_DEVS=2
CONFIG_CHR_DEV_SG=y
CONFIG_SCSI_SYM53C8XX_2=y
CONFIG_SCSI_SYM53C8XX_DMA_ADDRESSING_MODE=1
CONFIG_SCSI_SYM53C8XX_DEFAULT_TAGS=16
CONFIG_SCSI_SYM53C8XX_MAX_TAGS=64
CONFIG_SCSI_QLOGIC_ISP=y
CONFIG_SCSI_QLOGIC_FC=y
CONFIG_SCSI_QLOGIC_FC_FIRMWARE=y
CONFIG_NETDEVICES=y
CONFIG_NET_ETHERNET=y
CONFIG_HAPPYMEAL=y
CONFIG_EXT3_FS=y
CONFIG_JBD=y
CONFIG_TMPFS=y
CONFIG_RAMFS=y
CONFIG_ISO9660_FS=y
CONFIG_PROC_FS=y
CONFIG_EXT2_FS=y
CONFIG_XFS_FS=y
CONFIG_XFS_QUOTA=y
CONFIG_MSDOS_PARTITION=y
CONFIG_SUN_PARTITION=y
CONFIG_LOG_BUF_SHIFT=0
CONFIG_CRYPT=y
CONFIG_CRYPTO_HMAC=y
CONFIG_CRYPTO_NULL=y
CONFIG_CRYPTO_MD4=y
CONFIG_CRYPTO_MD5=y
CONFIG_CRYPTO_SHA1=y
CONFIG_CRYPTO_SHA256=y
CONFIG_CRYPTO_SHA512=y
CONFIG_CRYPTO_DES=y
CONFIG_CRYPTO_BLOWFISH=y
CONFIG_CRYPTO_AES=y
CONFIG_CRYPTO_CAST5=y
CONFIG_CRYPTO_CAST6=y
CONFIG_CRYPTO_ARC4=y
CONFIG_ZLIB_INFLATE=y
CONFIG_ZLIB_DEFLATE=y
CONFIG_GRKERNSEC=y
CONFIG_CRYPT=y
CONFIG_CRYPTO_SHA256=y
CONFIG_GRKERNSEC_CUSTOM=y
CONFIG_GRKERNSEC_PAX_EI_PAX=y
CONFIG_GRKERNSEC_PAX_PT_PAX_FLAGS=y
CONFIG_GRKERNSEC_PAX_NO_ACL_FLAGS=y
CONFIG_GRKERNSEC_PAX_NOEXEC=y

```



```

CONFIG_GRKERNSEC_PAX_PAGEEXEC=y
CONFIG_GRKERNSEC_PAX_MPROTECT=y
CONFIG_GRKERNSEC_PAX_EMUPLT=y
CONFIG_GRKERNSEC_PAX_DLRESOLVE=y
CONFIG_GRKERNSEC_PAX_ASLR=y
CONFIG_GRKERNSEC_PAX_RANDUSTACK=y
CONFIG_GRKERNSEC_PAX_RANDMMAP=y
CONFIG_GRKERNSEC_PAX_RANDEXEC=y
CONFIG_GRKERNSEC_KMEM=y
CONFIG_GRKERNSEC_PROC_MEMMAP=y
CONFIG_GRKERNSEC_HIDESYM=y
CONFIG_GRKERNSEC_ACL_HIDEKERN=y
CONFIG_GRKERNSEC_ACL_MAXTRIES=3
CONFIG_GRKERNSEC_ACL_TIMEOUT=30
CONFIG_GRKERNSEC_PROC=y
CONFIG_GRKERNSEC_PROC_USER=y
CONFIG_GRKERNSEC_PROC_ADD=y
CONFIG_GRKERNSEC_LINK=y
CONFIG_GRKERNSEC_FIFO=y
CONFIG_GRKERNSEC_CHROOT=y
CONFIG_GRKERNSEC_CHROOT_MOUNT=y
CONFIG_GRKERNSEC_CHROOT_DOUBLE=y
CONFIG_GRKERNSEC_CHROOT_PIVOT=y
CONFIG_GRKERNSEC_CHROOT_CHDIR=y
CONFIG_GRKERNSEC_CHROOT_CHMOD=y
CONFIG_GRKERNSEC_CHROOT_FCHDIR=y
CONFIG_GRKERNSEC_CHROOT_MKNOD=y
CONFIG_GRKERNSEC_CHROOT_SHMAT=y
CONFIG_GRKERNSEC_CHROOT_UNIX=y
CONFIG_GRKERNSEC_CHROOT_FINDTASK=y
CONFIG_GRKERNSEC_CHROOT_NICE=y
CONFIG_GRKERNSEC_CHROOT_SYSCTL=y
CONFIG_GRKERNSEC_AUDIT_GROUP=y
CONFIG_GRKERNSEC_AUDIT_GID=1000
CONFIG_GRKERNSEC_EXECLOG=y
CONFIG_GRKERNSEC_RESLOG=y
CONFIG_GRKERNSEC_CHROOT_EXECLOG=y
CONFIG_GRKERNSEC_AUDIT_CHDIR=y
CONFIG_GRKERNSEC_AUDIT_MOUNT=y
CONFIG_GRKERNSEC_AUDIT_IPC=y
CONFIG_GRKERNSEC_SIGNAL=y
CONFIG_GRKERNSEC_FORKFAIL=y
CONFIG_GRKERNSEC_TIME=y
CONFIG_GRKERNSEC_EXECVE=y
CONFIG_GRKERNSEC_DMESG=y
CONFIG_GRKERNSEC_RANDPID=y
CONFIG_GRKERNSEC_TPE=y
CONFIG_GRKERNSEC_TPE_GID=1000
CONFIG_GRKERNSEC_RANDNET=y
CONFIG_GRKERNSEC_RANDISN=y
CONFIG_GRKERNSEC_RANDID=y
CONFIG_GRKERNSEC_RANDSRC=y
CONFIG_GRKERNSEC_RANDRPC=y
CONFIG_GRKERNSEC_SOCKET=y

```

```

CONFIG_GRKERNSEC_SOCKET_SERVER=y
CONFIG_GRKERNSEC_SOCKET_SERVER_GID=1000
CONFIG_GRKERNSEC_FLOODTIME=10
CONFIG_GRKERNSEC_FLOODBURST=4

```

C List of installed packages

```

adduser
apt
apt-utils
base-config
base-files
base-passwd
bash
bsdmainutils
bsdutils
console-common
console-data
console-tools
console-tools-
cron
debconf
debianutils
diff
dpkg
e2fsprogs
ethtool
fileutils
findutils
ftp
gettext-base
grep
groff-base
gzip
hostname
ifupdown
integrit
iptables
iptables-cc
klogd
less
libc6
libcap1
libdb2
libdb3
libgdbmg1
libgpmg1
libident
liblockfile1
libncurses5

```

```
libnewt0
libpam-modules
libpam-runtime
libpam0g
libpcap0
libperl5.6
libpopt0
libreadline4
libsasl7
libssl0.9.6
libstdc++2.10-
libwrap0
logcheck
logcheck-datab
login
logrotate
logtail
lsof
mailx
makedev
man-db
manpages
mawk
monit-cc
mount
ncurses-base
ncurses-bin
net-tools
netbase
netkit-inetd
netkit-ping
ntpdate
nvi
openssh-cc
passwd
pciutils
perl
perl-base
perl-modules
procps
quota-tools-cc
sed
shellutils
silo
slang1
sparc-utils
ssmtp
strace
sysklogd
sysvinit
tar
tasksel
tcpd
telnet
textutils
traceroute
util-linux
vim
whiptail
xfsprogs
zlib1g
```

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D SSH daemon configuration file

```
# ----- /etc/ssh/sshd_config -----
#      $OpenBSD: sshd_config,v 1.68 2003/12/29 16:39:50 millert Exp $

# This is the sshd server system-wide configuration file.  See
# sshd_config(5) for more information.

# This sshd was compiled with PATH=/usr/bin:/bin:/usr/sbin:/sbin

# The strategy used for options in the default sshd_config shipped with
# OpenSSH is to specify options with their default value where
# possible, but leave them commented.  Uncommented options change a
# default value.

#Port 22
Protocol 2
#ListenAddress 0.0.0.0
#ListenAddress ::

# HostKey for protocol version 1
#HostKey /etc/ssh/ssh_host_key
# HostKeys for protocol version 2
#HostKey /etc/ssh/ssh_host_rsa_key
#HostKey /etc/ssh/ssh_host_dsa_key

# Lifetime and size of ephemeral version 1 server key
#KeyRegenerationInterval 1h
#ServerKeyBits 768

# Logging
#obsoletes QuietMode and FascistLogging
#SyslogFacility AUTH
LogLevel VERBOSE

# Authentication:

#LoginGraceTime 2m
PermitRootLogin no
#StrictModes yes

RSAAuthentication no
#PubkeyAuthentication yes
AuthorizedKeysFile      /etc/ssh/authorized_keys.%u

# For this to work you will also need host keys in /etc/ssh/ssh_known_hosts
#RhostsRSAAuthentication no
# similar for protocol version 2
#HostbasedAuthentication no
# Change to yes if you don't trust ~/.ssh/known_hosts for
# RhostsRSAAuthentication and HostbasedAuthentication
#IgnoreUserKnownHosts no
# Don't read the user's ~/.rhosts and ~/.shosts files
```

```
#IgnoreRhosts yes

# To disable tunneled clear text passwords, change to no here!
#PasswordAuthentication yes
#PermitEmptyPasswords no

# Change to no to disable s/key passwords
#ChallengeResponseAuthentication yes

# Kerberos options
#KerberosAuthentication no
#KerberosOrLocalPasswd yes
#KerberosTicketCleanup yes
#KerberosGetAFSToken no

# GSSAPI options
#GSSAPIAuthentication no
#GSSAPICleanupCredentials yes

# Set this to 'yes' to enable PAM authentication (via challenge-response)
# and session processing. Depending on your PAM configuration, this may
# bypass the setting of 'PasswordAuthentication' and 'PermitEmptyPasswords'
#UsePAM no

#AllowTcpForwarding yes
#GatewayPorts no
X11Forwarding yes
#X11DisplayOffset 10
#X11UseLocalhost yes
#PrintMotd yes
#PrintLastLog yes
#TCPKeepAlive yes
#UseLogin no
#UsePrivilegeSeparation yes
#PermitUserEnvironment no
#Compression yes
#ClientAliveInterval 0
#ClientAliveCountMax 3
#UseDNS yes
#PidFile /var/run/sshd.pid
#MaxStartups 10

# no default banner path
Banner /etc/issue

# override default of no subsystems
Subsystem      sftp      /usr/libexec/sftp-server
# -----
```

E Password synchronization script

```
# ----- /usr/local/bin/sync_shadow.sh -----
#!/bin/sh

#
# Author:      Roland Mathis
# Description: This script synchronizes /jail/etc/shadow with
#              /etc/shadow, but only for the users of the group
#              jail
# Version history:
# 2004-08-23   Roland Mathis   initial version
#

# variable definitions
passwd=/etc/passwd
shadow=/etc/shadow
jpasswd=/jail/etc/passwd
jshadow=/jail/etc/shadow

# umask
umask 066

# if (system shadow is newer than jail shadow and no param was given)
# then synchronize from system to jail
# -----

if [ $shadow -nt $jshadow -a "x$1" == "x" ]; then

    # search system-passwd for users who belong to group 1000
    # and rewrite jail-passwd accordingly
    awk ' BEGIN { FS=OFS=":"; } {
        if ($4 == 1000) {
            split($6,home,"\\\\.");
            print $1, $2, $3, $4, $5, home[2], $7;
        }
    } ' $passwd >$jpasswd

    # get shadow-entry for each jail-user from system-shadow and rewrite
    # jail-shadow accordingly
    rm $jshadow
    for i in `cat $jpasswd |cut -d: -f 1`; do
        grep "^$i:" $shadow >>$jshadow
    done

# if (jail shadow is newer than system shadow and param 'monit' was given)
# then synchronize from jail to system
# -----

elif [ $jshadow -nt $shadow -a "$1" == "monit" ]; then
    for usr in `cut -d: -f 1 $jshadow`; do
        # is usr a member of group jail?

```

```

        if [ "'groups $usr |grep jail'" ]; then
            usermod -p 'grep ^$usr $jshadow |cut -d: -f 2' $usr
        fi
    done

# syntax
# -----

else
    echo
    echo "ERROR: No sync was done!"
    echo
    echo "1) to synchronize from $passwd to $jpasswd "
    echo "   condition 1: $passwd is newer than $jpasswd"
    echo "   condition 2: user is a member of group jail"
    echo "   Syntax: $0"
    echo
    echo "2) to synchronize from $jpasswd to $passwd "
    echo "   condition 1: $jpasswd is newer than $passwd"
    echo "   condition 2: user is a member of group jail"
    echo "   Syntax: $0 monit"
    echo
fi
# -----

```

F Create jail environment script

```

# ----- create_jail.sh -----
#!/bin/bash

#
# Author:      Roland Mathis
# Description: This script creates a new jail environment in /jail
# Version history:
# 2004-08-12  Roland Mathis  initial version
#

# create jail
umask 666
jail=/jail
umount $jail/home
if [ $? -ne 0 ]; then
    echo "abort, cannot umount $jail/home"
    exit 1
fi
rm -rf $jail
mkdir -p $jail/home
mount /jail/home
rm -rf $jail/home/*

```

```
# binaries in the jail
bins="/bin/bash /usr/bin/passwd /bin/ls /bin/mv /bin/rm /usr/bin/ssh
/bin/ping /usr/bin/scp /usr/bin/ssh /usr/bin/telnet /usr/bin/ftp"

# create skel
cd $jail
mkdir etc
mkdir bin
mkdir lib
mkdir dev

# mknod
mknod $jail/dev/null c 1 3
chmod 666 $jail/dev/null
mknod $jail/dev/urandom c 1 9
chmod 444 $jail/dev/urandom
mknod $jail/dev/tty c 5 0
chmod 666 $jail/dev/tty

# prepare passwd and shadow (empty)
touch $jail/etc/passwd
touch $jail/etc/shadow

# ftp and telnet need services
echo "ftp      21/tcp" >$jail/etc/services
echo "telnet   23/tcp" >>$jail/etc/services
# icmp
echo "icmp     1      ICMP" >>$jail/etc/protocols

# pam.conf
echo "passwd   password      required      /lib/pam_unix.so obscure min=6 max=20 md5
other    auth          required      /lib/pam_deny.so
other    account        required      /lib/pam_deny.so
other    password        required      /lib/pam_deny.so
other    session         required      /lib/pam_deny.so
" >$jail/etc/pam.conf

# resolv.conf
cp /etc/resolv.conf $jail/etc

# copy files and libs
for i in $bins; do
  cp $i bin
  ldd $i >/dev/null
  libs='ldd $i | grep -v "not a dynamic executable" |awk '{ print $3 }'
  for l in $libs; do
    cp $l lib
  done
done

# nameservices libs
cp /lib/libnss_compat.so.2 /lib/libnss_dns.so.2 /lib/libnsl.so.1 \
/lib/libnss_files.so.2 /lib/security/pam_unix.so /lib/security/pam_deny.so $jail/lib
```

```
# adjust perms
chmod 555 $jail/lib/*
chmod 111 $jail/bin/*
chmod 444 $jail/etc/*
chmod 640 $jail/etc/shadow
chmod 644 $jail/etc/passwd
chgrp shadow $jail/etc/shadow

# ping and passwd needs suid :/
chmod u+s $jail/bin/ping
chmod u+s $jail/bin/passwd
# -----
```

G Jail environment

```
/jail/:
total 4
d--x--x--x    2 root    root    1024 Sep 11 18:51 bin
d--x--x--x    2 root    root    1024 Sep 11 18:51 dev
d--x--x--x    2 root    root    1024 Sep 11 18:51 etc
drwxr-xr-x    2 root    root     6 Sep 11 18:51 home
d--x--x--x    2 root    root    1024 Sep 11 18:51 lib

/jail/bin:
total 1387
---x--x--x    1 root    root    631484 Sep 11 18:51 bash
---x--x--x    1 root    root     75808 Sep 11 18:51 ftp
---x--x--x    1 root    root     55316 Sep 11 18:51 ls
---x--x--x    1 root    root     52332 Sep 11 18:51 mv
---s--x--x    1 root    root     86692 Sep 11 18:51 passwd
---s--x--x    1 root    root     21248 Sep 11 18:51 ping
---x--x--x    1 root    root     33668 Sep 11 18:51 rm
---x--x--x    1 root    root     38924 Sep 11 18:51 scp
---x--x--x    1 root    root    238396 Sep 11 18:51 ssh
---x--x--x    1 root    root    167100 Sep 11 18:51 telnet

/jail/dev:
total 0
crw-rw-rw-    1 root    root      1,  3 Sep 11 18:51 null
crw-rw-rw-    1 root    root      5,  0 Sep 11 18:51 tty
cr--r--r--    1 root    root      1,  9 Sep 11 18:51 urandom

/jail/etc:
total 4
-r--r--r--    1 root    root     229 Sep 11 18:51 pam.conf
-rw-r--r--    1 root    root      0 Sep 11 18:51 passwd
-r--r--r--    1 root    root     21 Sep 11 18:51 protocols
-r--r--r--    1 root    root     68 Sep 11 18:51 resolv.conf
-r--r--r--    1 root    root     25 Sep 11 18:51 services
-rw-r-----    1 root    shadow    0 Sep 11 18:51 shadow
```



```
/jail/home:
total 0
```

```
/jail/lib:
total 3750
-r-xr-xr-x  1 root  root    118262 Sep 11 18:51 ld-linux.so.2
-r-xr-xr-x  1 root  root  1304548 Sep 11 18:51 libc.so.6
-r-xr-xr-x  1 root  root    83804 Sep 11 18:51 libcrypto.so.1
-r-xr-xr-x  1 root  root   856492 Sep 11 18:51 libcrypto.so.0.9.6
-r-xr-xr-x  1 root  root    67520 Sep 11 18:51 libdl.so.2
-r-xr-xr-x  1 root  root   365076 Sep 11 18:51 libncurses.so.5
-r-xr-xr-x  1 root  root   136716 Sep 11 18:51 libnsl.so.1
-r-xr-xr-x  1 root  root   101000 Sep 11 18:51 libnss_compat.so.2
-r-xr-xr-x  1 root  root    12716 Sep 11 18:51 libnss_dns.so.2
-r-xr-xr-x  1 root  root    39472 Sep 11 18:51 libnss_files.so.2
-r-xr-xr-x  1 root  root    37796 Sep 11 18:51 libpam.so.0
-r-xr-xr-x  1 root  root    13336 Sep 11 18:51 libpam_misc.so.0
-r-xr-xr-x  1 root  root    94565 Sep 11 18:51 libpthread.so.0
-r-xr-xr-x  1 root  root   185660 Sep 11 18:51 libreadline.so.4
-r-xr-xr-x  1 root  root   119188 Sep 11 18:51 libresolv.so.2
-r-xr-xr-x  1 root  root    84596 Sep 11 18:51 librt.so.1
-r-xr-xr-x  1 root  root     7896 Sep 11 18:51 libutil.so.1
-r-xr-xr-x  1 root  root   121676 Sep 11 18:51 libz.so.1
-r-xr-xr-x  1 root  root     3696 Sep 11 18:51 pam_deny.so
-r-xr-xr-x  1 root  root    47876 Sep 11 18:51 pam_unix.so
```

H Script to add jailed users

```
# ----- /usr/local/bin/addjailuser.sh -----
#!/bin/sh

#
# Author:      Roland Mathis
# Description: This script adds a new jail user.
#
# Version history:
# 2004-08-12  Roland Mathis  initial version
#

# check params, display syntax
if [ $# -ne 2 ]; then
    echo "syntax: $0 <loginname> \"<firstname lastname company email@address>\""
    exit 1
fi

# create home dir, passwd and shadow entry
useradd -g jail -d "/jail/./home/$1" -c "$2" -m $1
if [ $? -ne 0 ]; then
    echo "ERROR: cannot useradd. Exit."
```

```

    exit 1
fi

# adjust dir perms
chmod 700 /jail/home/$1

# set quota (80MB soft, 100MB hard)
setquota $1 80000 100000 0 0 /jail/home
if [ $? -ne 0 ]; then
    echo "ERROR: cannot set quota. Exit."
    exit 1
fi

# set initial password
check=1
while [ $check -eq 1 ]; do
    passwd $1
    if [ $? -eq 0 ]; then check=0; fi
done

# get passwd and shadow entries
/usr/local/bin/sync_shadow.sh
if [ $? -ne 0 ]; then
    echo "ERROR: cannt sync to jail. Exit."
    exit 1
fi

echo "User $1 added successfully. "
# -----

```

I Output of lsof

COMMAND	PID	USER	FD	TYPE	DEVICE	SIZE	NODE NAME
init	1	root	cwd	DIR	8,2	1024	2 /
init	1	root	rtd	DIR	8,2	1024	2 /
init	1	root	txt	REG	8,2	93852	12323 /sbin/init
init	1	root	mem	REG	8,2	118262	26640 /lib/ld-2.2.5.so
init	1	root	mem	REG	8,2	1304548	26643 /lib/libc-2.2.5.so
init	1	root	10u	FIFO	8,2		46314 /dev/initctl
keventd	2	root	cwd	DIR	8,2	1024	2 /
keventd	2	root	rtd	DIR	8,2	1024	2 /
ksoftirqd	3	root	cwd	DIR	8,2	1024	2 /
ksoftirqd	3	root	rtd	DIR	8,2	1024	2 /
kswapd	4	root	cwd	DIR	8,2	1024	2 /
kswapd	4	root	rtd	DIR	8,2	1024	2 /
bdfldush	5	root	cwd	DIR	8,2	1024	2 /
bdfldush	5	root	rtd	DIR	8,2	1024	2 /
kupdated	6	root	cwd	DIR	8,2	1024	2 /
kupdated	6	root	rtd	DIR	8,2	1024	2 /
xfsbufd	7	root	cwd	DIR	8,2	1024	2 /

xfsbufd	7	root	rtd	DIR	8,2	1024	2	/
xfslogd/0	8	root	cwd	DIR	8,2	1024	2	/
xfslogd/0	8	root	rtd	DIR	8,2	1024	2	/
xfsdatad/	9	root	cwd	DIR	8,2	1024	2	/
xfsdatad/	9	root	rtd	DIR	8,2	1024	2	/
scsi_eh_0	10	root	cwd	DIR	8,2	1024	2	/
scsi_eh_0	10	root	rtd	DIR	8,2	1024	2	/
kjournald	11	root	cwd	DIR	8,2	1024	2	/
kjournald	11	root	rtd	DIR	8,2	1024	2	/
less	1233	root	cwd	DIR	8,2	1024	2	/
less	1233	root	rtd	DIR	8,2	1024	2	/
less	1233	root	txt	REG	8,4	169316	4346	/usr/bin/less
less	1233	root	mem	REG	8,2	118262	26640	/lib/ld-2.2.5.so
less	1233	root	mem	REG	8,2	365076	26685	/lib/libncurses.so.5.2
less	1233	root	mem	REG	8,2	1304548	26643	/lib/libc-2.2.5.so
less	1233	root	0r	FIFO	0,5		7354634	pipe
less	1233	root	1u	CHR	3,0		45320	/dev/tty0
less	1233	root	2u	CHR	3,0		45320	/dev/tty0
less	1233	root	3r	CHR	5,0		45105	/dev/tty
lsof	2133	root	cwd	DIR	8,2	1024	2	/
lsof	2133	root	rtd	DIR	8,2	1024	2	/
lsof	2133	root	txt	REG	8,4	173368	8210	/usr/sbin/lsof
lsof	2133	root	mem	REG	8,2	118262	26640	/lib/ld-2.2.5.so
lsof	2133	root	mem	REG	8,2	1304548	26643	/lib/libc-2.2.5.so
lsof	2133	root	0u	CHR	3,0		45320	/dev/tty0
lsof	2133	root	1w	FIFO	0,5		7354633	pipe
lsof	2133	root	2u	CHR	3,0		45320	/dev/tty0
lsof	2133	root	3r	DIR	0,2	0	1	/proc
lsof	2133	root	4r	DIR	0,2	0	139788296	/proc/2133/fd
lsof	2133	root	5w	FIFO	0,5		7354640	pipe
lsof	2133	root	6r	FIFO	0,5		7354641	pipe
kjournald	2811	root	cwd	DIR	8,2	1024	2	/
kjournald	2811	root	rtd	DIR	8,2	1024	2	/
kjournald	4706	root	cwd	DIR	8,2	1024	2	/
kjournald	4706	root	rtd	DIR	8,2	1024	2	/
kjournald	7320	root	cwd	DIR	8,2	1024	2	/
kjournald	7320	root	rtd	DIR	8,2	1024	2	/
cron	8322	root	cwd	DIR	8,5	4096	29280	/var/spool/cron
cron	8322	root	rtd	DIR	8,2	1024	2	/
cron	8322	root	txt	REG	8,4	26740	8186	/usr/sbin/cron
cron	8322	root	mem	REG	8,2	118262	26640	/lib/ld-2.2.5.so
cron	8322	root	mem	REG	8,2	37796	26687	/lib/libpam.so.0.72
cron	8322	root	mem	REG	8,2	1304548	26643	/lib/libc-2.2.5.so
cron	8322	root	mem	REG	8,2	67520	26646	/lib/libdl-2.2.5.so
cron	8322	root	mem	REG	8,2	83804	26644	/lib/libcrypt-2.2.5.so
cron	8322	root	mem	REG	8,2	101000	26649	/lib/libnss_compat-2.2.5.so
cron	8322	root	mem	REG	8,2	136716	26648	/lib/libnsl-2.2.5.so
cron	8322	root	0r	CHR	1,3		45098	/dev/null
cron	8322	root	1w	CHR	1,3		45098	/dev/null
cron	8322	root	2w	CHR	1,3		45098	/dev/null
cron	8322	root	3u	REG	8,5	5	29291	/var/run/crond.pid
sed	11180	root	cwd	DIR	8,2	1024	2	/
sed	11180	root	rtd	DIR	8,2	1024	2	/
sed	11180	root	txt	REG	8,2	27604	4177	/bin/sed

sed	11180	root	mem	REG	8,2	118262	26640	/lib/ld-2.2.5.so
sed	11180	root	mem	REG	8,2	1304548	26643	/lib/libc-2.2.5.so
sed	11180	root	0r	FIFO	0,5		7354633	pipe
sed	11180	root	1w	FIFO	0,5		7354634	pipe
sed	11180	root	2u	CHR	3,0		45320	/dev/tty0
sshd	11326	root	cwd	DIR	8,2	1024	2	/
sshd	11326	root	rtd	DIR	8,2	1024	2	/
sshd	11326	root	txt	REG	8,4	342708	8243	/usr/sbin/sshd
sshd	11326	root	mem	REG	8,2	118262	26640	/lib/ld-2.2.5.so
sshd	11326	root	mem	REG	8,2	119188	26655	/lib/libresolv-2.2.5.so
sshd	11326	root	mem	REG	8,4	856492	38736	/usr/lib/libcrypto.so.0.9.6
sshd	11326	root	mem	REG	8,2	7896	26657	/lib/libutil-2.2.5.so
sshd	11326	root	mem	REG	8,4	121676	38734	/usr/lib/libz.so.1.1.4
sshd	11326	root	mem	REG	8,2	136716	26648	/lib/libnsl-2.2.5.so
sshd	11326	root	mem	REG	8,2	83804	26644	/lib/libcrypt-2.2.5.so
sshd	11326	root	mem	REG	8,2	1304548	26643	/lib/libc-2.2.5.so
sshd	11326	root	mem	REG	8,2	67520	26646	/lib/libdl-2.2.5.so
sshd	11326	root	mem	REG	8,2	101000	26649	/lib/libnss_compat-2.2.5.so
sshd	11326	root	0u	CHR	1,3		45098	/dev/null
sshd	11326	root	1u	CHR	1,3		45098	/dev/null
sshd	11326	root	2u	CHR	1,3		45098	/dev/null
sshd	11326	root	3r	FIFO	0,5		7339721	pipe
sshd	11326	root	4u	IPv4	7339526		TCP	10.16.21.65:ssh->62.2.22.178
sshd	11326	root	5w	FIFO	0,5		7339721	pipe
sshd	11326	root	6u	CHR	2,0		45319	/dev/ptyp0
sshd	11326	root	7u	CHR	2,0		45319	/dev/ptyp0
sshd	11326	root	8u	unix	0xffffffff8002fddaea0		7339727	/tmp/ssh-HUVDV11326/agent.11
sshd	11326	root	9u	CHR	2,0		45319	/dev/ptyp0
klogd	11942	root	cwd	DIR	8,2	1024	2	/
klogd	11942	root	rtd	DIR	8,2	1024	2	/
klogd	11942	root	txt	REG	8,2	25376	12339	/sbin/klogd
klogd	11942	root	mem	REG	8,2	118262	26640	/lib/ld-2.2.5.so
klogd	11942	root	mem	REG	8,2	1304548	26643	/lib/libc-2.2.5.so
klogd	11942	root	0r	REG	0,2	0	4110	/proc/kmsg
klogd	11942	root	1u	unix	0xffffffff8002fdd9c20		212	socket
bash	13466	intern	cwd	DIR	8,8	4096	32705	/home/romath
bash	13466	intern	rtd	DIR	8,2	1024	2	/
bash	13466	intern	txt	REG	8,2	631484	4134	/bin/bash
bash	13466	intern	mem	REG	8,2	118262	26640	/lib/ld-2.2.5.so
bash	13466	intern	mem	REG	8,2	365076	26685	/lib/libncurses.so.5.2
bash	13466	intern	mem	REG	8,2	67520	26646	/lib/libdl-2.2.5.so
bash	13466	intern	mem	REG	8,2	1304548	26643	/lib/libc-2.2.5.so
bash	13466	intern	mem	REG	8,2	101000	26649	/lib/libnss_compat-2.2.5.so
bash	13466	intern	mem	REG	8,2	136716	26648	/lib/libnsl-2.2.5.so
bash	13466	intern	0u	CHR	3,0		45320	/dev/tty0
bash	13466	intern	1u	CHR	3,0		45320	/dev/tty0
bash	13466	intern	2u	CHR	3,0		45320	/dev/tty0
bash	13466	intern	255u	CHR	3,0		45320	/dev/tty0
sshd	14076	root	cwd	DIR	8,2	1024	2	/
sshd	14076	root	rtd	DIR	8,2	1024	2	/
sshd	14076	root	txt	REG	8,4	342708	8243	/usr/sbin/sshd
sshd	14076	root	mem	REG	8,2	118262	26640	/lib/ld-2.2.5.so
sshd	14076	root	mem	REG	8,2	119188	26655	/lib/libresolv-2.2.5.so
sshd	14076	root	mem	REG	8,4	856492	38736	/usr/lib/libcrypto.so.0.9.6

sshd	14076	root	mem	REG	8,2	7896	26657	/lib/libutil-2.2.5.so
sshd	14076	root	mem	REG	8,4	121676	38734	/usr/lib/libz.so.1.1.4
sshd	14076	root	mem	REG	8,2	136716	26648	/lib/libnsl-2.2.5.so
sshd	14076	root	mem	REG	8,2	83804	26644	/lib/libcrypt-2.2.5.so
sshd	14076	root	mem	REG	8,2	1304548	26643	/lib/libc-2.2.5.so
sshd	14076	root	mem	REG	8,2	67520	26646	/lib/libdl-2.2.5.so
sshd	14076	root	0u	CHR	1,3		45098	/dev/null
sshd	14076	root	1u	CHR	1,3		45098	/dev/null
sshd	14076	root	2u	CHR	1,3		45098	/dev/null
sshd	14076	root	3u	IPv4	51174			TCP *:ssh (LISTEN)
bash	17965	root	cwd	DIR	8,2	1024	2	/
bash	17965	root	rtd	DIR	8,2	1024	2	/
bash	17965	root	txt	REG	8,2	631484	4134	/bin/bash
bash	17965	root	mem	REG	8,2	118262	26640	/lib/ld-2.2.5.so
bash	17965	root	mem	REG	8,2	365076	26685	/lib/libncurses.so.5.2
bash	17965	root	mem	REG	8,2	67520	26646	/lib/libdl-2.2.5.so
bash	17965	root	mem	REG	8,2	1304548	26643	/lib/libc-2.2.5.so
bash	17965	root	mem	REG	8,2	101000	26649	/lib/libnss_compat-2.2.5.so
bash	17965	root	mem	REG	8,2	136716	26648	/lib/libnsl-2.2.5.so
bash	17965	root	0u	CHR	3,0		45320	/dev/tty0
bash	17965	root	1u	CHR	3,0		45320	/dev/tty0
bash	17965	root	2u	CHR	3,0		45320	/dev/tty0
bash	17965	root	255u	CHR	3,0		45320	/dev/tty0
kjournald	18006	root	cwd	DIR	8,2	1024	2	/
kjournald	18006	root	rtd	DIR	8,2	1024	2	/
lsuf	18643	root	cwd	DIR	8,2	1024	2	/
lsuf	18643	root	rtd	DIR	8,2	1024	2	/
lsuf	18643	root	txt	REG	8,4	173368	8210	/usr/sbin/lsuf
lsuf	18643	root	mem	REG	8,2	118262	26640	/lib/ld-2.2.5.so
lsuf	18643	root	mem	REG	8,2	1304548	26643	/lib/libc-2.2.5.so
lsuf	18643	root	4r	FIFO	0,5		7354640	pipe
lsuf	18643	root	7w	FIFO	0,5		7354641	pipe
xfssyncd	19129	root	cwd	DIR	8,2	1024	2	/
xfssyncd	19129	root	rtd	DIR	8,2	1024	2	/
syslogd	20642	root	cwd	DIR	8,2	1024	2	/
syslogd	20642	root	rtd	DIR	8,2	1024	2	/
syslogd	20642	root	txt	REG	8,2	31936	12349	/sbin/syslogd
syslogd	20642	root	mem	REG	8,2	118262	26640	/lib/ld-2.2.5.so
syslogd	20642	root	mem	REG	8,2	1304548	26643	/lib/libc-2.2.5.so
syslogd	20642	root	mem	REG	8,2	39472	26651	/lib/libnss_files-2.2.5.so
syslogd	20642	root	0u	unix	0xfffff8002fdd9780		163	/dev/log
syslogd	20642	root	2w	REG	8,5	25674	44027	/var/log/auth.log
syslogd	20642	root	3w	REG	8,5	7514	43928	/var/log/syslog
syslogd	20642	root	4w	REG	8,5	374	44003	/var/log/daemon.log
syslogd	20642	root	5w	REG	8,5	14148	44032	/var/log/kern.log
syslogd	20642	root	6w	REG	8,5	0	43985	/var/log/lpr.log
syslogd	20642	root	7w	REG	8,5	1528	44036	/var/log/mail.log
syslogd	20642	root	8w	REG	8,5	0	43987	/var/log/user.log
syslogd	20642	root	9w	REG	8,5	0	43988	/var/log/uucp.log
syslogd	20642	root	10w	REG	8,5	1528	44014	/var/log/mail.info
syslogd	20642	root	11w	REG	8,5	0	43990	/var/log/mail.warn
syslogd	20642	root	12w	REG	8,5	0	43991	/var/log/mail.err
syslogd	20642	root	13w	REG	8,5	0	43976	/var/log/news/news.crit
syslogd	20642	root	14w	REG	8,5	0	43977	/var/log/news/news.err

syslogd	20642	root	15w	REG	8,5	0	43978	/var/log/news/news.notice
syslogd	20642	root	16w	REG	8,5	0	44012	/var/log/debug
syslogd	20642	root	17w	REG	8,5	23110	44043	/var/log/messages
syslogd	20642	root	18u	FIFO	8,2		46331	/dev/xconsole
monit	24357	root	cwd	DIR	8,2	1024	2	/
monit	24357	root	rtd	DIR	8,2	1024	2	/
monit	24357	root	txt	REG	8,4	292740	4351	/usr/bin/monit
monit	24357	root	mem	REG	8,2	118262	26640	/lib/ld-2.2.5.so
monit	24357	root	mem	REG	8,2	94565	26659	/lib/libpthread-0.9.so
monit	24357	root	mem	REG	8,2	83804	26644	/lib/libcrypt-2.2.5.so
monit	24357	root	mem	REG	8,2	119188	26655	/lib/libresolv-2.2.5.so
monit	24357	root	mem	REG	8,2	136716	26648	/lib/libnsl-2.2.5.so
monit	24357	root	mem	REG	8,2	1304548	26643	/lib/libc-2.2.5.so
monit	24357	root	mem	REG	8,2	101000	26649	/lib/libnss_compat-2.2.5.so
monit	24357	root	0u	CHR	1,3		45098	/dev/null
monit	24357	root	1u	CHR	1,3		45098	/dev/null
monit	24357	root	2u	CHR	1,3		45098	/dev/null

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