Advanced Programming in the UNIX Environment

Week 13, Segment 3:
Restricted Shells, Chroots, and Jails

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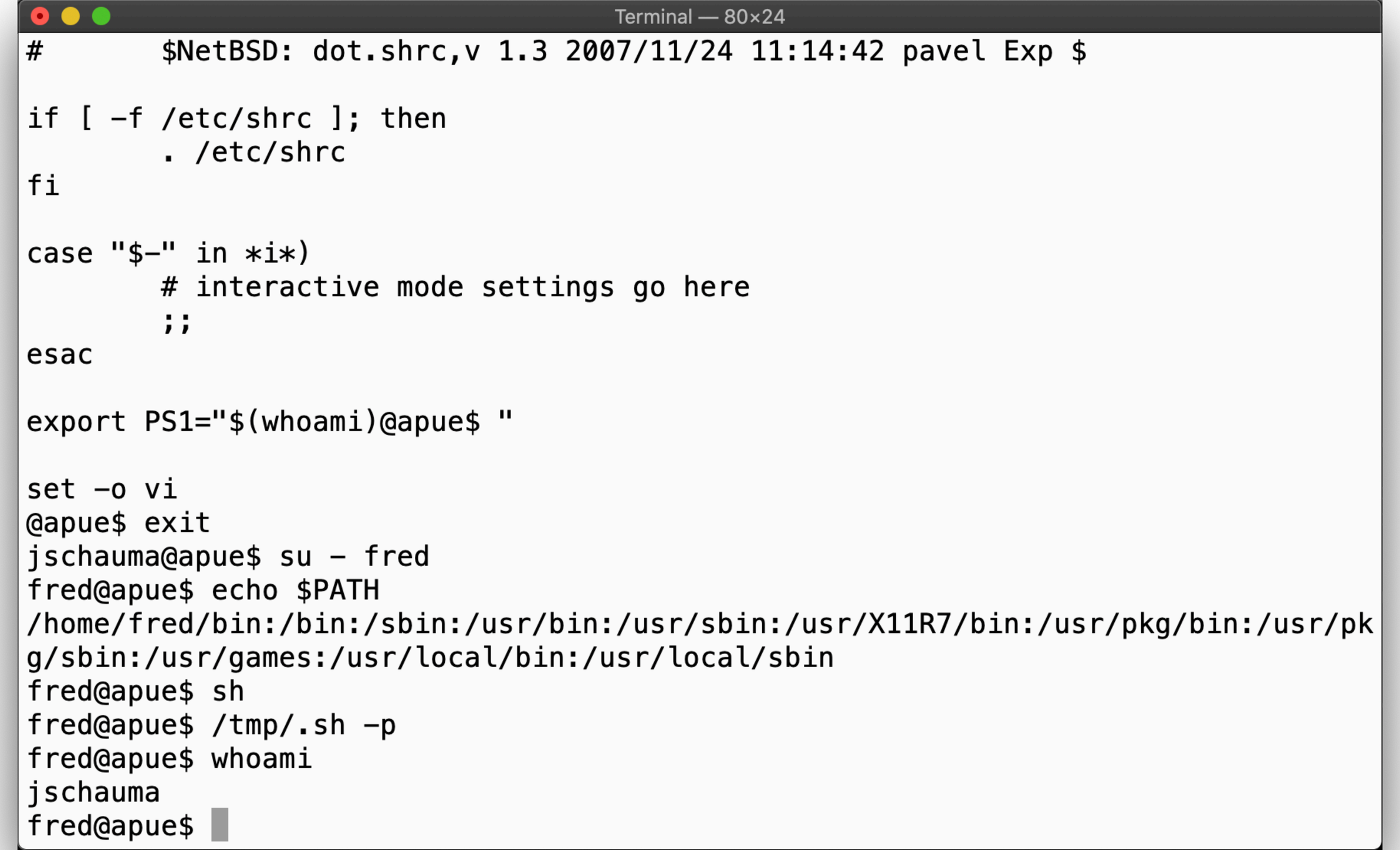
Restricted Shells

Another way of restricting what a user can do is to only allow them to execute specific commands, for example via a *restricted* shell:

- prohibit `cd`
- prohibit changing *e.g.*, `PATH` etc.
- prohibit use of commands containing a '/' (i.e., only commands found in the (fixed) `PATH` can be executed)
- prohibit redirecting output into files

Beware trivial break-outs via commands that allow invoking other commands!


Terminal — 80×24
#	$NetBSD: dot.shrc,v 1.3 2007/11/24 11:14:42 pavel Exp $
if [-f /etc/shrc]; then
	. /etc/shrc
fi
case "$-" in *i*)
	# interactive mode settings go here
	;;
esac
export PS1="$(whoami)@apue$ "
set -o vi
@apue$ exit
jschauma@apue$ su - fred
fred@apue$ echo $PATH
/home/fred/bin:/bin:/sbin:/usr/bin:/usr/sbin:/usr/X11R7/bin:/usr/pkg/bin:/usr/pk
g/sbin:/usr/games:/usr/local/bin:/usr/local/sbin
fred@apue$ sh
fred@apue$ /tmp/.sh -p
fred@apue$ whoami
jschauma
fred@apue$

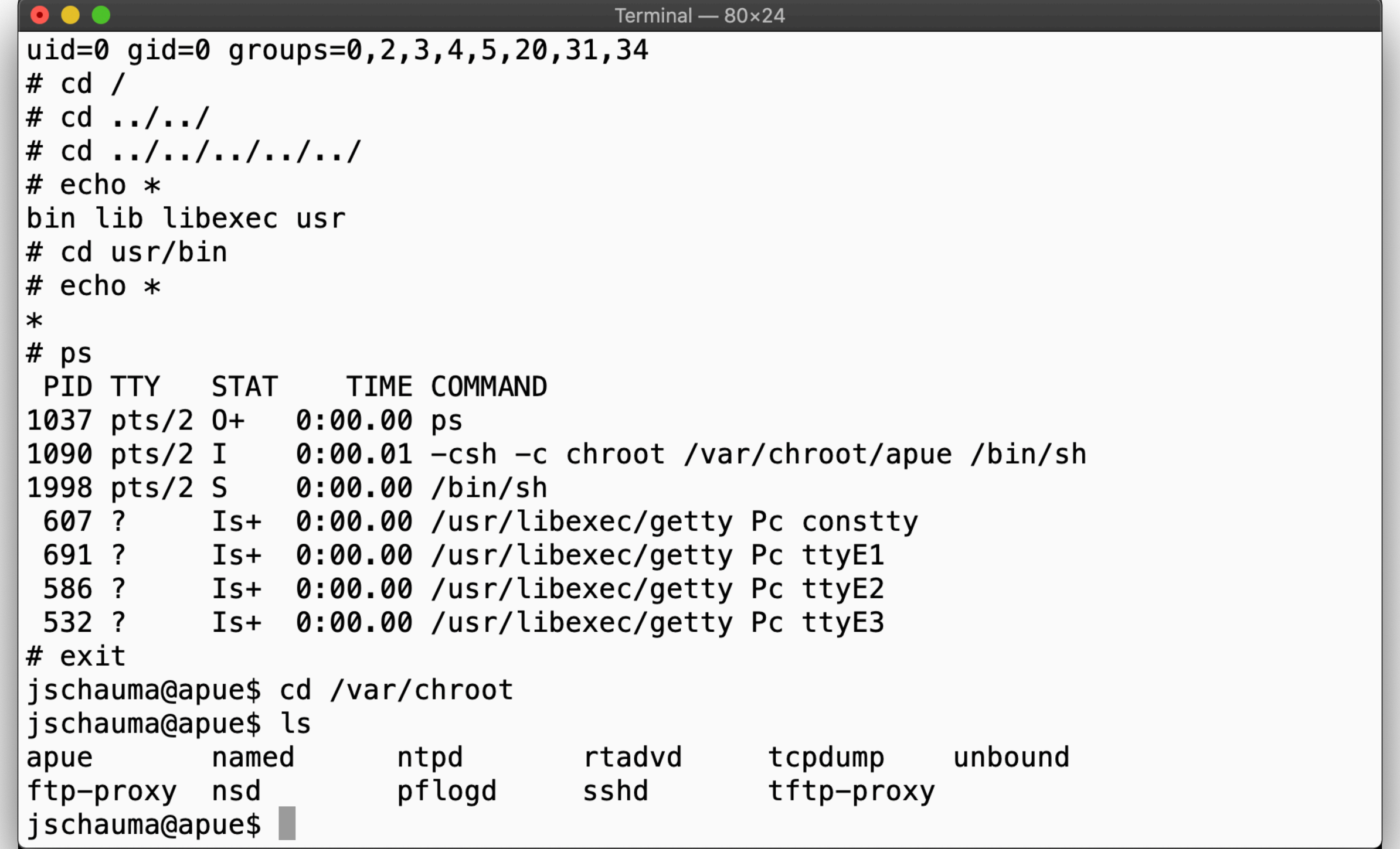
Restricted Shells

To properly restrict a user in this way:

- create a new directory, e.g., `/usr/local/rbin`
- carefully reviewed executables needed, then link them in there
- ensure those commands cannot shell out themselves
- set `PATH=/usr/local/rbin`
- mark user config files immutable via `chflags(1)`
- hope you didn't miss anything

Terminal — 80×24

```
NAME
     chroot -- change root directory

SYNOPSIS
     #include <unistd.h>

     int
     chroot(const char *dirname);

DESCRIPTION
     Dirname is the address of the pathname of a directory, terminated by an
     ASCII NUL.  chroot() causes dirname to become the root directory, that
     is, the starting point for path searches of pathnames beginning with `/'.

     In order for a directory to become the root directory a process must have
     execute (search) access for that directory.

WARNINGS
     There are ways for a root process to escape from the chroot jail.

HISTORY
     The chroot() function call appeared in 4.2BSD.

4.2 Berkeley Distribution       June 4, 1993       4.2 Berkeley Distribution
(END)
```


Terminal — 80×24
uid=0 gid=0 groups=0,2,3,4,5,20,31,34
# cd /
# cd ../../
# cd ../../../../../
# echo *
bin lib libexec usr
cd usr/bin
echo *
*
ps
PID TTY STAT TIME COMMAND
1037 pts/2 O+ 0:00.00 ps
1090 pts/2 I 0:00.01 -csh -c chroot /var/chroot/apue /bin/sh
1998 pts/2 S 0:00.00 /bin/sh
607 ? Is+ 0:00.00 /usr/libexec/getty Pc constty
691 ? Is+ 0:00.00 /usr/libexec/getty Pc ttyE1
586 ? Is+ 0:00.00 /usr/libexec/getty Pc ttyE2
532 ? Is+ 0:00.00 /usr/libexec/getty Pc ttyE3
exit
jschauma@apue$ cd /var/chroot
jschauma@apue$ ls
apue named ntpd rtadvd tcpdump unbound
ftp-proxy nsd pflogd sshd tftp-proxy
jschauma@apue$

Chroot

Expose a restricted copy or view of the filesystem to a process via `chroot(2)`/ `chroot(8)`:

- restrict a process's view of the filesystem hierarchy
- restrict commands by only providing needed executables
- must provide full evironment, shared libraries, config files, etc.
- combine with null mounts / mount options
- open file descriptors may be brought into the chroot
- processes outside the chroot are visible!

Jails

FreeBSD added the jail(2) system call and jail(8) utility around 2000. Jails…

- enforce a per-jail process view
- prohibit changing sysctls or securelevels
- prohibit mounting and unmounting filesystems
- can be bound to a specific network address
- prohibit modifying the network configuration
- disable raw sockets

Jails effectively implement a process sandbox environment, forming the first OS-level virtualization.

Summary

- Restricted shells run fully within the OS, with restrictions entirely enforced within the shell.
- A chroot(2) can create a severely restricted environment with a “changed root” filesystem:
  - present in most Unix versions since the 80s, but since removed from POSIX
  - requires root privileges
  - chroot escapes may be possible
  - process space outside of the chroot remains visible
- Jails were introduced in FreeBSD ~2000 as the first real version of OS-level virtualization and predecessor of true containers.