

LPIC-1 Study Group

2 Managing Software

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1

This presentation
is based on
Roderick W. Smith's
*LPIC-1: Linux Professional Institute
Certification Study Guide,*
2nd edition
That said,
there are many
additions, subtractions, & changes

2

Introduction

3

Package Concepts

4

Windows installation files

setup.exe
install.msi

OS X installation files

foo.pkg
bar.dmg

5

Linux installation files are *packages*

foo.rpm

RPM-based distros

bar.deb

Debian-based distros

6

Just *having* a package
isn't enough
You have to somehow *manage*
the packages

7

Linux package managers

rpm

rpm -i foo.rpm

RPM-based distros

dpkg

dpkg -i bar.deb

Debian-based distros

8

Package managers
make it easy to
install, upgrade, uninstall, & query
packages,
create packages from source code,
& keep all that info
in a database

9

Another important thing
package managers do:

track *dependencies*

Some packages have dependencies:
they require other packages
in order to be installed or run

In order to install foo,
you must first find & install bar

10

Package managers are great,
but you still have to do things manually

Find packages

Download packages

Resolve dependencies

What we need is ... *automation!*

11

Automated package managers
sit on top of package managers
to alleviate manual tasks

YUM

RPM-based distros

APT

Debian-based distros

YUM & APT search & download software from
their "stores" on the Net & then use RPM or APT
to install them

12

To find software,
YUM & APT
look in *repositories*
of software online

Repos are like online stores

Your distro knows about
certain repos by default,
but you can tell YUM or APT
about more

13

Another GUI for YUM is KYUM

GUIs for
Automated Package Managers

Yumex (YUM Extender)
RPM-based distros

Synaptic
Debian-based distros

14

	RPM-based	Debian-based
GUI	Yumex	Synaptic
Automated Package Managers	↑ YUM	↑ APT
Package Managers	↑ rpm	↑ dpkg
Packages	↑ foo.rpm	↑ bar.deb

15

You can install & use RPM
on a Debian-based system,
& vice-versa

Don't mix & match, though
dpkg & rpm
use completely different databases

16

RPM

17

RPM Distributions & Conventions

18

A self-recursive acronym!

RPM was developed by Red Hat
Originally stood for
Red Hat Package Manager
Now stands for
RPM Package Manager
Used by many Linux distros,
even those not based on Red Hat

19

RPM packages
have certain naming conventions

20

packagename-a.b.c-x.arch.rpm
packagename
Name of package:
samba or ghostscript or libcups2
a.b.c
Version number: 1.5.3 or 3.0.25b
x
Build or release number: 1 or 5c
Minor changes
made by package maintainer,
not original programmer

21

packagename-a.b.c-x.arch.rpm

arch

Architecture: i386 or ppc or x86_64

All source RPMs use src

Example:

samba-3.0.25b-4.5mdv2008.0.x86_64.rpm

samba-|3.0.25b-|4.5mdv2008.0. |
x86_64.rpm

22

These are just conventions
You could just call it foo.rpm
Not very communicative, though

23

Compatibility problems
between RPMs on different distros

✓ Different versions of RPM

✓ Unmet dependencies

✓ Different names

for packages & dependencies

✓ Slightly different files

✓ Distribution-specific
scripts or config files

24

Safest to use RPMs
made for your distro,
but you can always try other RPMs,
& they'll often work

25

rpm

26

rpm [operation] [options] package
[operation] is what you want to do:
e.g., install, upgrade, uninstall, query
[options] change operation:
e.g., force, be verbose, test
Options change
depending on the operation

27

```
rpm -ihv foo.rpm
-i: Install
-h: Show hashmarks #####
-v: Be verbose
```

```
rpm -Uhv foo.rpm
-U: Upgrade if installed,
or install if not installed
```

28

```
rpm -e foo.rpm
Uninstall (or erase) a package
```

29

```
Other operations
-F or --freshen
Upgrade package
if earlier version already exists
-q
Query a package
-V or --verify
Verify a package
--rebuilddb
Rebuild RPM database
```

30

Options		Operations					
		-i	-U	-F	-e	-q	-V
Display hashmarks # to indicate progress	-h --hash	✓	✓	✓			
With -h, be verbose	-v	✓	✓	✓			
Do no dependency checks	--nodeps	✓	✓	✓	✓		
Dry run, but don't actually install	--test	✓	✓	✓			
Install to different directory	--prefix	✓	✓	✓			
Query or verify all packages	-a --all					✓	✓
Query or verify package that owns specified file	-f --file					✓	✓
Query uninstalled package	-p					✓	
Display package info	-i					✓	
Display packages on which the package depends	-R --requires					✓	
Display files contained in package	-l --list					✓	

31

Confusing things about rpm
 -i is both an operator & an option
 Operators & options are combined
 rpm -Uhv
 -U is an operator
 -h & -v are options

32

Extracting Data from RPMs

33

Extract data
without actually installing
RPM files are actually
modified cpio archives

34

```
rpm2cpio  
Converts RPM to cpio  
rpm2cpio foo.rpm > foo.cpio |  
cpio -i --make-directories
```

Extracts archive
& creates directories

Always do all this
in a new directory you created,
to avoid spewing files

35

Could also use alien
(covered later)

36

YUM

37

<http://linux.duke.edu/projects/yum/>

YUM was developed|
by Yellow Dog Linux
(Yellow Dog Update Manager)
but it's been adopted
by Red Hat & many other distros
Not all RPM-based distros use YUM,
like SUSE & Mandriva

38

`yum [options] [command] [package]`

`yum install foo`
Install package & dependencies

`yum remove foo`
`yum erase foo`
Delete package & dependencies

39

```
yum check-update
```

Check to see if updates are available
& list them if they are

```
yum update foo
```

Update package foo to latest version

```
yum update
```

Update *all* packages to latest version

```
yum upgrade
```

Upgrade the distro safely

40

```
yum list foo
```

Display **info** about foo

```
yum provides foo
```

```
yum whatprovides foo
```

Display info about packages providing
the foo program or feature

```
yum search foo
```

Search package names, summaries,
& more for foo

```
yum info foo
```

Display **info** about foo

41

```
yum clean
```

Clean up YUM cache directory at
/path/to/yum/cache

```
yum resolvedep foo
```

Display packages
matching dependency on foo

```
yum deplist foo
```

Display dependencies of foo

42

```
yum localinstall foo.rpm bar.rpm
    Install local RPM files,
using YUM to resolve dependencies
yum localupdate foo.rpm bar.rpm
    Update system
using only local RPM files,
using YUM to resolve dependencies
```

43

```
yum shell
Enter YUM shell mode,
so you can enter
multiple YUM commands
```

```
yumdownloader foo
Download latest version of foo
but don't install it
```

44

RPM & YUM Config

45

RPM config

46

`/usr/lib/rpm/rpmrc`
Main RPM config file,
but don't edit it

Use these:

`/etc/rmprc`

Global changes for all users

`~/.rpmrc`

Personal changes

47

Main reasons
to customize RPM config
are if you're
converting source RPMs
into binary RPMs:

Pass appropriate compiler options

Build for correct architecture

48

Pass appropriate compiler options to set architecture (CPU) optimizations when you convert source RPM into binary RPM

For example:
optflags: athlon -O2 -g -march=i686

Pass the -O2 -g -march=i686 options when building on athlon

49

Build for correct architecture

Default rpmsrc files include buildarchtranslate lines that cause rpmbuild to use one set of optimizations for a while family of CPUs

50

```
buildarchtranslate: athlon: i386
buildarchtranslate: i686: i386
buildarchtranslate: i586: i386
buildarchtranslate: i486: i386
buildarchtranslate: i386: i386
```

Guarantees portability at the expense of customization for your CPU

To customize:

```
buildarchtranslate: i686: i686
```

51

YUM config

52

`/etc/yum.conf`
Basic options

`/etc/yum.repos.d/`
Several file,
each describing a YUM repo

You can manually add files
pointing to repos,
or just download an RPM
that contains repo info & install it

53

Debian

54

Debian Distributions & Conventions

55

Debian packages
originated with Debian (duh)

Now used by Ubuntu
& many other distros

56

Naming conventions

`appport_2.0.1-0ubuntu12_all.deb`

`udev_175-0ubuntu9.1_amd64.deb`

amd64: 64-bit

all: CPU-independent

57

Use dpkg
for one or a few packages
Use APT
to manage several packages
or the system

58

dpkg

59

```
dpkg options action foo.deb bar.deb
```

60

dpkg actions

-i --install	Install package
--configure	Reconfigure installed package
-r --remove	Remove package, leaving config files
-P --purge	Remove package & config files

-i expects full package filename
(foo-1.0-0_1.0-0ubuntu9.1_all.deb)

All others are fine with foo

61

dpkg actions

-p --print-avail	Display info about installed package
-I --info	Display info about uninstalled package

-I expects full package filename
(foo-1.0-0_1.0-0ubuntu9.1_all.deb)

All others are fine with foo

62

dpkg actions

-l <i>pattern</i> --list <i>pattern</i>	List all installed packages matching <i>pattern</i>
-L --listfiles	List installed files for package
-S <i>pattern</i> --search <i>pattern</i>	List packages owning files matching <i>pattern</i>
-C --audit	Search for partially installed packages

63

dpkg options

<code>--force-things</code>	Force actions to be taken
<code>--no-act</code>	Check for dependencies, conflicts, & problems; don't actually install/remove
<code>-G</code>	Don't install if new version is already installed
<code>-E</code> <code>--skip-same-version</code>	Don't install if same version is already installed

64

apt-cache

65

apt-cache

Provide info about
Debian package database
(the *package cache*)

`apt-cache search foo`
Search for package

`apt-cache showpkg foo`
Display info about the package

66

`apt-cache stats`
View statistics
about the package cache

`apt-cache unmet`
Find unmet dependencies

`apt-cache depends foo`
View package's dependencies

`apt-cache pkgnames`
Show all installed packages

67

apt-get

68

Full-featured package manager

Uses list of repositories
in `/etc/apt/sources.list`
& `/etc/apt/sources.list.d`

69

```
$ cat /etc/apt/sources.list

## Note, this file is written by cloud-init on first boot of an instance
## modifications made here will not survive a re-bundle.
## if you wish to make changes you can:
## a.) add 'apt_preserve_sources_list: true' to /etc/cloud/cloud.cfg
##     or do the same in user-data
## b.) add sources in /etc/apt/sources.list.d
## c.) make changes to template file /etc/cloud/templates/sources.list.tpl

# See http://help.ubuntu.com/community/UpgradeNotes for how to
# upgrade to newer versions of the distribution.
deb http://us-east-1.ec2.archive.ubuntu.com/ubuntu/ precise main
deb-src http://us-east-1.ec2.archive.ubuntu.com/ubuntu/ precise main

## Major bug fix updates produced after the final release of the
## distribution.
deb http://us-east-1.ec2.archive.ubuntu.com/ubuntu/ precise-updates main
deb-src http://us-east-1.ec2.archive.ubuntu.com/ubuntu/ precise-updates main
```

70

apt-get options command package

71

```
apt-get update
Get updated info
about packages in repository

apt-get upgrade
Upgrade all installed packages

apt-get update && apt-get upgrade
```

```
apt-get dist-upgrade
Upgrade to a new distro version
```

72


```
apt-get install foo bar
  Install package(s)
apt-get remove foo bar
  Remove package(s)
apt-get source foo bar
  Install source packages
```

73

```
apt-get check
  Check database
  for consistency & broken installs
apt-get clean
  Remove installed packages from
  /var/cache/apt/archives
apt-get autoclean
  Removed installed packages from
  /var/cache/apt/archives
  that can no longer be downloaded
```

74

```
apt-get options
-d or --download-only
  Download but don't install
-f or --fix-broken
  Fix dependency problems
-s or --simulate
  or --dry-run or --no-act
  Simulate installation or removal
-y or --yes or --assume-yes
  Answer yes to any prompts
```

75

dselect, aptitude, & Synaptic

76

dselect

“A high-level interface for managing the installation & removal of Debian software packages.

Many users find dselect intimidating & new users may prefer to use apt-based user interfaces.”

77

Source: `apt-cache show dselect`

Written in the 1990s

According to Wikipedia:

“dselect has a text-mode user interface, a set of key bindings that is generally considered to be fairly non-intuitive,

& its dependency resolution mechanism is suboptimal.”

78

Source: <http://en.wikipedia.org/wiki/Dselect>

Text-mode interactive UI

```
altterm
dselect - main package listing (avail., priority) mark:+/- verbose:v help:?
#IOM Pri Section Package Inst.ver Avail.ver Description
*** Req base libncurses5 5.3.2002110 5.3.2002110 Shared libraries for term
*** Req base libpam-modul 0.76-9 0.76-9 Pluggable Authentication
*** Req base libpam-runti 0.76-9 0.76-9 Runtime support for the P
*** Req base libpam0g 0.76-9 0.76-9 Pluggable Authentication
*** Req base libreadline4 4.3-4 4.3-4 GNU readline and history
*** Req base libstdc++2.1 2.95.4-16 2.95.4-16 The GNU stdc++ library
*** Req base login 4.0.3-7 4.0.3-7 System login tools
*** Req base make-dev 2.3.1-62 2.3.1-62 Creates device files in /
*** Req base make 1.3.3-9 1.3.3-9 a pattern scanning and te
*** Req base modutils 2.4.19-3 2.4.19-3 Linux module utilities.
libreadline4 installed: install (was: install). Required
libreadline4 - GNU readline and history libraries, run-time libraries.
The GNU readline library aids in the consistency of user interface across
discrete programs that need to provide a command line interface.
The GNU history library provides a consistent user interface for recalling
lines of previously typed input.
description of libreadline4
```

79

aptitude

Package manager with both
text-mode interactive UI (like dselect)
& command line interface

80

In interactive mode,
it's easier than dselect
because aptitude adds menus
accessed by pressing Ctrl+t

81

aptitude search foo
Search repositories for package foo

aptitude update
Update package lists

aptitude install foo
Install package foo

aptitude remove foo
Remove package foo

82

Upgrade *all* installed packages

aptitude full-upgrade
More likely to work, but less safe

aptitude safe-upgrade
More conservative & safer,
but may fail

83

aptitude autoclean
Remove downloaded packages
that are no longer available,
but keeping others

aptitude clean
Remove *all* downloaded packages,
freeing space on your computer

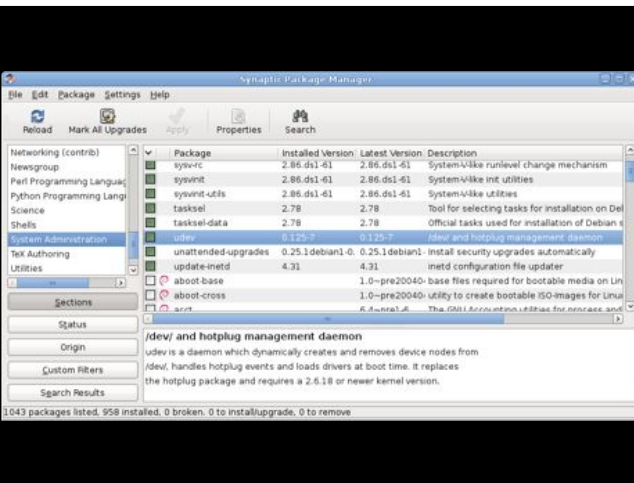
aptitude help
Show help

84

Replaced by Ubuntu Software Center (though still available)

Synaptic
GUI interface to APT

85



86

Reconfiguring Packages

87

When you install a Debian package,
you're sometimes asked
configuration questions

To re-configure later, use
`dpkg-reconfigure foo`

88

Debian Compared

89

Debian	RPM
Source packages are multiple files (source + patch + dsc)	Source packages are a single file
Source packages support 1 patch file	Source packages support >1 patch files
Debian packages more compatible across distros	RPM packages less compatible across distros

90

The author claims that
“it can be harder
to locate Debian packages
than RPM packages
for some exotic programs”

I would contend
that the opposite could be argued

91

Configuring Debian Package Tools

92

Most of the time,
you don't need to change
dpkg & APT's defaults

93

```
Config files for dpkg
/etc/dpkg/dpkg.cfg
~/ .dpkg.cfg
```

94

```
Config files for APT
are in /etc/apt
```

```
apt.conf
```

```
OR
```

```
apt.conf.d/
```

```
APT & dselect options
```

```
sources.list
```

```
List of repositories
```

```
Better to use sources.list.d/
```

95

```
$ pwd
/etc/apt
$ ls sources.list.d
alestic-ppa-precise.list
$ cat sources.list.d/alestic-ppa-
precise.list
deb http://ppa.launchpad.net/↵
alestic/ppa/ubuntu precise main
deb-src http://ppa.launchpad.net/↵
alestic/ppa/ubuntu precise main
```

96



`/var/lib/dpkg`

Lists of
available & installed packages

`/var/cache/apt`

Downloaded & installed packages

97

Converting Between Formats

98

`alien`

Convert RPM to dpkg,
& vice-versa

Can also convert to & from
tarballs

Gotta have dpkg & RPM installed

Not always perfect,
but worth a try

99

Convert between formats

```
alien --to-rpm foo.deb
```

```
alien --to-deb foo.rpm
```

```
alien --to-tgz foo.rpm
```

100

```
alien --to-deb --install foo.rpm
```

Convert to dpkg & install
so APT records info

101

If you convert or install
from a tarball,
keep in mind that files are installed
starting from /

You may need to untar,
move files around,
re-tar,
& then run alien

102

Dependencies & Conflicts

103

Sometimes, you'll run into
problems installing packages

You are far less likely
to have problems
if you stick to APT & YUM

104

Real & Imagined Problems

105

Missing libraries
or support programs
(QT, GTK, X.org)

Incompatible libraries
or support programs

Duplicate files or features

Mismatched names

106

Workarounds

107

Ways to fix the problem:

Forcing

Upgrading or replacing

Rebuilding

Locate another version

108



Forcing

Install anyway & ignore issues

Be careful!

109

```
rpm -i foo.rpm --nodeps
```

Install & ignore failed dependencies

```
rpm -i foo.rpm --force
```

Install & ignore errors

110

```
dpkg --ignore-depends=bar -i foo.deb
```

Ignore dependency checking
& only warn about conflicts

```
dpkg --force-depends -i foo.deb
```

Turn dependency problems
into warnings

```
dpkg --force-conflicts -i foo.deb
```

Install & ignore conflicts

111

Upgrading or Replacing

The “correct” way to fix problems

Turns into a problem
when you’re running distro A
& you upgrade a package
built for distro B

112

Rebuilding

When package was built,
certain libraries & support files
were assumed
that your systems lacks

Solution:
rebuild package from source
so it uses
your libraries & support files

113

```
rpmbuild --rebuild foo.src.rpm
```

Results in new RPM in
/usr/src/distname/RPMS/arch

Gotta get hold
of the source RPM first!

114

```
apt-get source foo
Download source to foo

apt-get build-dep foo
Get & install packages required
to rebuild foo

cd foo
debuild -us -uc

Rebuild foo binary package
without signing the .changes file
(since you're not the developer)

foo.deb is in parent directory
```

115

Locating Another Version

Get a package that's
newer, older, or
built for different distro

Of course,
you might really need the version
that doesn't work!

116

Good places to search for packages

RPM Find
www.rpmfind.net

Fresh RPMs
freshrpms.net

Debian Packages
www.debian.org/distrib/packages

117

Startup Script Problems

118

Startup scripts
may not always work
on different distros

119

Workarounds
Modifying existing startup script
Writing a new script
Starting the server
through a local startup script like
`/etc/rc.d/rc.local`
or `/etc/rc.d/boot.local`

120

Managing Shared Libraries

121

Library Principles

122

Libraries provide
commonly used code fragments

Helps developers
avoid rebuilding the wheel

123

Most programs
don't incorporate libraries
(bloated! slow!)

Instead, they reference
the *shared* (or *dynamic*) library files

Linux names them
`foo.so` or `foo.so.1`

Windows calls these
DLLs (Dynamic Link Libraries)

124

Sidenote

Linux also uses
static libraries:
code which is linked with,
& is incorporated into,
the program

`foo.a`

Windows calls these `.lib` files

125

Problems with shared libraries

Degrade program load time
if not already in use elsewhere

Changes to a library
can break programs

Programs need to know
where libraries are

Lots of libraries to manage

Problematic libraries
can break your system

126

Overall,
the benefits of shared libraries
outweigh the risks

127

Locating Library Files

128

Biggest admin challenge
with shared libraries:
making sure programs can find them

Programs can point to libraries
by name (`libc.so.6`)
or path (`/lib/libc.so.6`)

Library path provides programs
with a list of directories
in which to search for libraries

129

Setting the Library Path Systemwide

130

`/etc/ld.so.conf`

Sets library path systemwide

Usually never needs to be changed
unless you install a library manually
in an unusual location

After changing `ld.so.conf`,
use `ldconfig` to update system
(coming up!)

131

```
$ cat /etc/ld.so.conf
include /etc/ld.so.conf.d/*.conf
$ ls /etc/ld.so.conf.d
libc.conf  x86_64-linux-gnu.conf
$ cat /etc/ld.so.conf.d/*
# libc default configuration
/usr/local/lib

# Multiarch support
/lib/x86_64-linux-gnu
/usr/lib/x86_64-linux-gnu
```

132

Trusted library directories
/lib & /usr/lib
are always in the library path,
even though they're not
in ld.so.conf

133

Temporarily Changing the Path

134

Testing a new library?
Install shared libraries
& then set LD_LIBRARY_PATH
environment variable

```
export LD_LIBRARY_PATH=/path/to/lib
```

Added to start of search path

To set permanently,
edit your shell startup scripts
or edit /etc/ld.so.conf

135

Correcting Problems

Error?

```
$ gimp
gimp: error while loading shared
libraries: libXinerama.so.1:
cannot open shared object file: No
such file or directory
```

136

Is the library installed?

If not, install it

If it is,

add directory to

`LD_LIBRARY_PATH`

or `/etc/ld.so.conf`

137

Is path hard-coded into program?

(Stupid developer)

Create a symbolic (or soft) link
from actual location
to location program expects

Then run `ldconfig`

138

Library Management Commands

139

`ldd`

Display program's shared library dependencies

`ldconfig`

Update caches & links used by system for locating libraries by re-reading `/etc/ld.so.conf`

140

`ldd`

Display program's shared library dependencies

```
$ ldd /usr/bin/htop
linux-vdso.so.1 => (0x00007fff7d392000)
libncursesw.so.5 => /lib/x86_64-linux-gnu/libncursesw.so.5
(0x00007fcbf9365000)
libtinfo.so.5 => /lib/x86_64-linux-gnu/libtinfo.so.5 (0x00007fcbf913e000)
libm.so.6 => /lib/x86_64-linux-gnu/libm.so.6 (0x00007fcbf8e43000)
libc.so.6 => /lib/x86_64-linux-gnu/libc.so.6 (0x00007fcbf8a86000)
libdl.so.2 => /lib/x86_64-linux-gnu/libdl.so.2 (0x00007fcbf8882000)
/lib64/ld-linux-x86-64.so.2 (0x00007fcbf959b000)
```

141

ldconfig

Update caches & links
used by system
for locating libraries
by re-reading /etc/ld.so.conf
& rebuilding /etc/ld.so.cache

ldconfig is run automatically
when updating library packages

142

ldconfig -v
Be verbose

ldconfig -p
Print the current cache to stdout

143

Managing Processes

144

Command → Program → Process

Program can spawn
more than one process

145

Vital that you know
how to manage processes

Identifying
Moving into fore- & background
Killing
Adjusting priorities

146

The First Process

147

The 1st process during boot
is always `init`
(short for *initialization*)

Started by the kernel

Assigned PID 1

```
# ps aux
USER PID %CPU %MEM STAT COMMAND
root  1  0.0  0.0 Ss  /sbin/init
```

148

`uname`

Display info about the system

```
$ uname
Linux
```

149

<code>-n</code> <code>--nodename</code>	Network hostname	adam.websanity.com
<code>-s</code> <code>--kernel-name</code>	Kernel name	Linux
<code>-v</code> <code>--kernel-version</code>	Kernel build date & time	#46-Ubuntu SMP Fri Jul 27 17:23:50 UTC 2012
<code>-r</code> <code>--kernel-release</code>	Kernel version number	3.2.0-29-virtual
<code>-m</code> <code>--machine</code>	CPU	x86_64
<code>-p</code> <code>--processor</code>	CPU info	x86_64
<code>-i</code> <code>--hardware-platform</code>	Hardware info	x86_64
<code>-o</code> <code>--operating-system</code>	Operating system	GNU/Linux

150

-a or --all

```
$ uname -a  
Linux adam.websanity.com  
3.2.0-29-virtual #46-Ubuntu SMP  
Fri Jul 27 17:23:50 UTC 2012  
x86_64 x86_64 x86_64 GNU/Linux
```

151

Examining Process Lists

152

`ps`

Displays *processes'* status
Extremely important tool
for monitoring & managing
your Linux box

Unfortunately, also very complicated

153

ps [options]

3 styles for [options]

UNIX98

-aux

BSD

aux

GNU long

--user scott

154

Display all processes
with my user ID & on my terminal

\$ ps

```
PID TTY          TIME CMD
2612 pts/1        00:00:00 bash
7559 pts/1        00:00:00 ps
```

TTY: terminal associated with PID

TIME: cumulated CPU time
in [DD-]hh:mm:ss

CMD: executable name

155

ps aux

List all processes

```
$ ps aux
USER  PID %CPU %MEM    VSZ   RSS TTY      STAT START   TIME COMMAND
root    1  0.0  0.0  24412 2280 ?        Ss   Aug17   0:01 /sbin/init
root    2  0.0  0.0     0     0 ?        S    Aug17   0:00 [kthreadd]
root    3  0.0  0.0     0     0 ?        S    Aug17   1:34 [ksoftirqd/0]
root   192  0.0  0.0  25384 1312 ?        S    Aug17   0:00 mountall --daem
root   248  0.0  0.0  21520 1212 ?        Ss   Aug17   0:00 /sbin/udevd --d
root   522  0.0  0.0  49948 2876 ?        Ss   Aug17   0:07 /usr/sbin/sshd
root   599  0.0  0.0  14496  920 tty4    Ss+  Aug17   0:00 /sbin/getty -8
root   639  0.0  0.0  19104 1040 ?        Ss   Aug17   0:04 cron
mysql  690 17.0  2.0 1909084 360868 ?      Ssl  Aug17 1458:47 /usr/sbin/mysq
root   6628 0.0  0.0  16972 1760 pts/0    S+   23:16   0:00 /usr/bin/man ps
root   6638 0.0  0.0  12456  996 pts/0    S+   23:16   0:00 pager -s
www-data 6665 1.0  0.3 549808 57868 ?        S    23:17   0:03 /usr/sbin/apach
```

ps aux | grep foo
can be very helpful

156

--help
Display help

157

-A or -e
Display all processes on the system

x
Displays all processes
owned by the user running ps
Also increases amount of info
displayed about each process

158

-u *user* or U *user* or --User *user*
Display processes owned by *user*
User variable may be
username (scott) or a user ID (501)

159

Change info that ps provides

-f	Full-format listing, including command arguments
-l	Long format
j	BSD job control format
l	BSD long format
u	User-oriented format
v	Virtual memory format

There are many others...

160

View processes as a hierarchy, so you know what spawned what

-H

Show process hierarchy

f or --forest

Show process hierarchy using ASCII art (forest)

161

```

ps aux --forest
root      1  0.0  0.0  24412 2288 ?   Ss   Aug17  0:01 /sbin/init
root     192  0.0  0.0  25384 1312 ?   S    Aug17  0:00 mountall --daemon
root     242  0.0  0.0  17224  592 ?   S    Aug17  0:00 upstart-udev-bridge --daemon
root     248  0.0  0.0  21520 1212 ?   Ss   Aug17  0:00 /sbin/udev --daemon
root     307  0.0  0.0  21456  668 ?   S    Aug17  0:00 \_ /sbin/udev --daemon
root     308  0.0  0.0  21456  624 ?   S    Aug17  0:00 \_ /sbin/udev --daemon
root     399  0.0  0.0  15180  388 ?   S    Aug17  0:00 upstart-socket-bridge --daemon
root     426  0.0  0.0   7256 1048 ?   Ss   Aug17  0:00 dhclient3 -e IF_METRIC=100 -pf /var
root     522  0.0  0.0  49948 2876 ?   Ss   Aug17  0:07 /usr/sbin/sshd -D
root    31011 0.0  0.0  74664 4692 ?   Ss   Aug22  0:00 \_ sshd: root@pts/0
root    31157 0.0  0.0  26292 8848 pts/0   Ss   Aug22  0:00 | \_ -bash
root    6628  0.0  0.0  16972 1768 pts/0   S+  Aug22  0:00 | | \_ /usr/bin/man ps
root    6638  0.0  0.0  12456  996 pts/0   S+  Aug22  0:00 | | | \_ \_ pager -s
root    2513  0.0  0.0  73352 3648 ?   Ss   Aug22  0:00 | | | \_ sshd: root@pts/1
root    2012  0.0  0.0  26292 8844 pts/1   Ss   Aug22  0:00 | | | | \_ -bash
root    9578  0.0  0.0  16984 1224 pts/1   R+  00:11  0:00 | | | | | \_ \_ ps aux --forest
syslog  539  0.0  0.0  254184 3776 ?   S1   Aug17  0:39 rsyslogd -c5
102     541  0.0  0.0  23888  928 ?   Ss   Aug17  0:00 dbus-daemon --system --fork --activ
root     599  0.0  0.0  14496  928 tty4    Ss+  Aug17  0:00 /sbin/getty -8 38400 tty4
root     603  0.0  0.0  14496  928 tty5    Ss+  Aug17  0:00 /sbin/getty -8 38400 tty5
root     615  0.0  0.0  14496  924 tty2    Ss+  Aug17  0:00 /sbin/getty -8 38400 tty2
root     617  0.0  0.0  14496  924 tty3    Ss+  Aug17  0:00 /sbin/getty -8 38400 tty3
root     621  0.0  0.0  14496  916 tty6    Ss+  Aug17  0:00 /sbin/getty -8 38400 tty6
root     626  0.0  0.0   4392  636 ?   Ss   Aug17  0:00 acpid -c /etc/acpi/events -s /var/r
root     639  0.0  0.0  19184 1048 ?   Ss   Aug17  0:04 cron
daemon  642  0.0  0.0  16980  372 ?   Ss   Aug17  0:00 atd
mongod  667  0.3  2.5 5841772 453516 ?   Ssl  Aug17  27:39 /usr/bin/mongod --config /etc/mongo
mysql   698 17.0  2.0 1909884 368688 ?   Ssl  Aug17 14:44:48 /usr/sbin/mysqld
whoopsie 909  0.0  0.0  187580 2756 ?   Ssl  Aug17  0:00 whoopsie
109     916  0.0  0.0  47452 1180 ?   Ss   Aug17  0:02 /usr/sbin/exim4 -bd -q30m
redis   948  0.0  0.0  18650 1548 ?   Ss   Aug17  2:15 /usr/bin/redis-server /etc/redis/re
root    1389  0.0  0.0  14496  924 tty1    Ss+  Aug17  0:00 /sbin/getty -8 38400 tty1
root    31988  0.0  0.0   4392  612 ?   S    Aug17  0:00 sh -c RAILS_ENV=production VERBOSE=
root    31989  0.0  0.5 251260 96904 ?   S    Aug17  0:49 \_ rescue-1.20.0: Waiting for *
root    20216  0.2  0.1 541484 18172 ?   Ss   Aug17 17:00 /usr/sbin/apache2 -k start
root    22285  0.0  0.0   4392  612 ?   S    Aug19  0:00 \_ /bin/sh -c /usr/bin/cronolog /v
root    22290  0.0  0.0   4380  536 ?   S    Aug19  0:00 | \_ /usr/bin/cronolog /var/log/
    
```

162

ps aux --forest

ps normally truncates its output
so it fits on your screen

-w & w

Go wide & do not truncate

Best then to use
ps w > ps.txt

163

```
$ ps aux
USER      PID %CPU %MEM    VSZ   RSS TTY      STAT START   TIME COMMAND
root         1  0.0  0.0  24412  2280 ?        Ss   Aug17   0:01 /sbin/init
root         2  0.0  0.0      0     0 ?        S    Aug17   0:00 [kthreadd]
root        522  0.0  0.0  49948  2876 ?        Ss   Aug17   0:07 /usr/sbin/sshd
root        599  0.0  0.0  14496   920 tty4      Ss+  Aug17   0:00 /sbin/getty -8
root        639  0.0  0.0  19104  1040 ?        Ss   Aug17   0:04 cron
mysql       690 17.0  2.0 1909084 360868 ?    Ssl  Aug17 1458:47 /usr/sbin/mysq
root        6628 0.0  0.0  16972  1760 pts/0    S+   23:16   0:00 /usr/bin/man ps
www-data    6665 1.0  0.3 549808 57868 ?        S    23:17   0:03 /usr/sbin/apach
```

USER: User who started the process

PID: Number of the process

%CPU: Percentage of CPU time
the process uses while ps executes

164

```
$ ps aux
USER      PID %CPU %MEM    VSZ   RSS TTY      STAT START   TIME COMMAND
root         1  0.0  0.0  24412  2280 ?        Ss   Aug17   0:01 /sbin/init
root         2  0.0  0.0      0     0 ?        S    Aug17   0:00 [kthreadd]
root        522  0.0  0.0  49948  2876 ?        Ss   Aug17   0:07 /usr/sbin/sshd
root        599  0.0  0.0  14496   920 tty4      Ss+  Aug17   0:00 /sbin/getty -8
root        639  0.0  0.0  19104  1040 ?        Ss   Aug17   0:04 cron
mysql       690 17.0  2.0 1909084 360868 ?    Ssl  Aug17 1458:47 /usr/sbin/mysq
root        6628 0.0  0.0  16972  1760 pts/0    S+   23:16   0:00 /usr/bin/man ps
www-data    6665 1.0  0.3 549808 57868 ?        S    23:17   0:03 /usr/sbin/apach
```

%MEM: Percentage of memory process uses

VSZ: Virtual memory size of the process
in KiB (1024-byte units)

RSS: Resident Set Size
(non-virtual memory
used by the program & its data)
in KiB

165

```

$ ps aux
USER      PID %CPU %MEM    VSZ   RSS TTY      STAT START   TIME COMMAND
root         1  0.0  0.0  24412  2280 ?        Ss   Aug17   0:01 /sbin/init
root         2  0.0  0.0      0     0 ?        S    Aug17   0:00 [kthreadd]
root        522  0.0  0.0  49948  2876 ?        Ss   Aug17   0:07 /usr/sbin/sshd
root        599  0.0  0.0  14496   920 tty4      Ss+  Aug17   0:00 /sbin/getty -8
root        639  0.0  0.0  19104  1040 ?        Ss   Aug17   0:04 cron
mysql       690 17.0  2.0 1909084 360868 ?      Ss1  Aug17 1458:47 /usr/sbin/mysq
root        6628  0.0  0.0  16972  1760 pts/0    S+   23:16   0:00 /usr/bin/man ps
www-data   6665  1.0  0.3 549808 57868 ?        S    23:17   0:03 /usr/sbin/apach

```

TTY: Teletype code
 identifying a terminal session
 (Not all processes have TTY numbers,
 like X programs & daemons)
 STAT: Process State Code

166

D	Uninterruptible sleep (usually IO)
R	Running or runnable (in run queue)
S	Interruptible sleep (waiting for an event to complete)
T	Stopped
X	Dead (should never be seen)
Z	Zombie! Dead but not reaped by its parent



167

If you're using BSD formats...

<	High priority, so not <i>nice</i>
N	Low priority, so <i>nice</i>
L	Pages locked into memory (for real-time IO)
l	Multi-threaded
+	In foreground process group

168


```

$ ps aux
USER      PID %CPU %MEM    VSZ   RSS TTY      STAT START   TIME COMMAND
root         1  0.0  0.0  24412  2280 ?        Ss   Aug17   0:01 /sbin/init
root         2  0.0  0.0         0     0 ?        S    Aug17   0:00 [kthreadd]
root        522  0.0  0.0   49948  2876 ?        Ss   Aug17   0:07 /usr/sbin/sshd
root        599  0.0  0.0   14496   920 tty4      Ss+  Aug17   0:00 /sbin/getty -8
root        639  0.0  0.0   19104  1040 ?        Ss   Aug17   0:04 cron
mysql       690 17.0  2.0 1909084 360868 ?    Ssl  Aug17 1458:47 /usr/sbin/mysq
root       6628  0.0  0.0   16972  1760 pts/0    S+   23:16   0:00 /usr/bin/man ps
www-data   6665  1.0  0.3  549808  57868 ?        S    23:17   0:03 /usr/sbin/apach

```

START: Time the command started,
in HH:MM format (if <24 hours)
or MONDD (if >24 hours)

TIME: cumulated CPU time
in [DD-]hh:mm:ss format

COMMAND: What launched the process

169

top
Display *top* CPU processes
in real time
By default,
processes are sorted by CPU use,
with biggest at the top

170

```

top - 02:33:32 up 6 days, 1:40, 2 users, load average: 0.98, 0.92, 1.26
Tasks: 262 total, 1 running, 260 sleeping, 0 stopped, 1 zombie
Cpu(s): 9.0%us, 4.9%sy, 0.0%ni, 84.1%id, 1.6%wa, 0.0%hi, 0.2%si, 0.3%st
Mem: 17489832k total, 16727580k used, 762252k free, 638272k buffers
Swap: 0k total, 0k used, 0k free, 14317712k cached

```

PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+	COMMAND
18232	www-data	20	0	534m	34m	17m	S	18	0.2	0:01.46	apache2
17358	root	20	0	51028	11m	4012	S	7	0.1	1:54.84	s3cmd
690	mysql	20	0	1864m	352m	4992	S	6	2.1	1479:31	mysqld
170	root	20	0	0	0	0	S	0	0.0	0:30.88	jbd2/xvda1-8
18277	root	20	0	17468	1432	956	R	0	0.0	0:00.07	top
18288	www-data	20	0	0	0	0	Z	0	0.0	0:00.01	apache2 <defunct>
22456	root	20	0	865m	2532	1836	S	0	0.0	14:20.28	PassengerHelper
1	root	20	0	24412	2280	1244	S	0	0.0	0:01.67	init
2	root	20	0	0	0	0	S	0	0.0	0:00.00	kthreadd
3	root	20	0	0	0	0	S	0	0.0	1:35.40	ksoftirqd/0
4	root	20	0	0	0	0	S	0	0.0	0:00.00	kworker/0:0
5	root	20	0	0	0	0	S	0	0.0	0:00.00	kworker/u:0
6	root	RT	0	0	0	0	S	0	0.0	0:00.00	migration/0
7	root	RT	0	0	0	0	S	0	0.0	0:04.11	watchdog/0
8	root	RT	0	0	0	0	S	0	0.0	0:00.00	migration/1
9	root	20	0	0	0	0	S	0	0.0	0:00.00	kworker/1:0

171

Change top while it's running

h ?	Display help
k	Kill process (enter a PID)
r	<i>renice</i> : change a process' priority (enter a PID & a priority number)
s	Change display rate (default is 5 seconds)
M	Sort by memory usage
P	Sort by CPU usage (the default)
q	Quit top

172

Options you can pass top
when you run it

```
top -d 10
```

Change default delay
between updates, in seconds

```
top -p 10220 -p 10221 -p 10222
```

Monitor specific PIDs (up to 20)

```
top -n 10
```

Display number of iterations & quit

173

```
top -b > top.txt
```

Run top in batch mode,
without updating stdout

Must press Ctrl-c to cancel top!

```
top -b -n 5 > top.txt
```

Run top in batch mode
for 5 iterations

174

```
top - 02:33:32 up 6 days, 1:40, 2 users, load average: 0.98, 0.92, 1.26
Tasks: 262 total, 1 running, 260 sleeping, 0 stopped, 1 zombie
Cpu(s): 9.0%us, 4.9%sy, 0.0%ni, 84.1%id, 1.6%wa, 0.0%hi, 0.2%si, 0.3%st
Mem: 17489832k total, 16727580k used, 762252k free, 638272k buffers
Swap: 0k total, 0k used, 0k free, 14317712k cached
```

```
PID USER PR NI VIRT RES SHR S %CPU %MEM TIME+ COMMAND
18232 www-data 20 0 534m 34m 17m S 18 0.2 0:01.46 apache2
17358 root 20 0 51028 11m 4012 S 7 0.1 1:54.84 s3cmd
690 mysql 20 0 1864m 352m 4992 S 6 2.1 1479:31 mysqld
```

Load Average
shows average CPU usage
over 1-, 5-, & 15-minute intervals
0 = idle computer with no tasks
Each process increments by 1

175

1 CPU

Load average acts as a percentage
of system usage

0.98, 0.92, 1.26

0.98: Just about perfect (98% used)

0.92: Just about perfect (92% used)

1.26: Overloaded by 26%,
so .26 processes had to wait

If it was dual-CPU machine, or twice as fast, no
problems at all!

176

2 CPUs

$\frac{\text{Load average}}{\text{Number of CPUs}} = \text{Percentage of system utilization}$

0.98, 0.92, 1.26

$0.98/2 = .49$

49% used: Twice as fast as needed

$0.92/2 = .46$

46% used: Twice as fast as needed

$1.26/2 = .63$

63% used: Still underutilized

177

4 CPUs

$\frac{\text{Load average}}{\text{Number of CPUs}} = \text{Percentage of system utilization}$

1.73, 0.50, 7.98

$1.73/4 = .43$

43% used: Twice as fast as needed

$0.50/4 = .125$

13% used: 10x as fast as needed

$7.98/4 = 1.99$

199% used: Overloaded by 99%,
so 1 process had to wait

178

uptime

Shows how long computer
has been running

Also shows load average

`$ uptime`

14:34:03 up 10:43, 4 users,
load average: 0.06, 0.11, 0.09

179

Sidenote:

I prefer htop,
a 3rd party tool that's a better top

Scroll horizontally & vertically

Faster to start & quicker to use

htop.sourceforge.net

180

```

1  [|||||] 4.9% Tasks: 214, 47 thr: 1 running
2  [|||||] 34.9% Load average: 0.50 0.93 1.36
Mem [|||||] [1572/17079MB] Uptime: 6 days, 01:36:34
Swp [|||||] 0/0MB

PID USER PRI NI VIRT RES SHR S CPU% MEM% TIME+ Command
17869 www-data 20 0 538M 36988 16688 S 32.0 0.2 0:01.19 /usr/sbin/apache2 -k start
2164 mysql 20 0 1864M 352M 4992 S 8.0 2.1 4:00.07 /usr/sbin/mysqld
690 mysql 20 0 1864M 352M 4992 S 7.0 2.1 2:03:07 /usr/sbin/mysqld
18139 root 20 0 24684 2240 1428 R 2.0 0.0 0:00.18 htop
22463 root 20 0 865M 2532 1836 S 1.0 0.0 14:18.83 PassengerHelperAgent
17818 www-data 20 0 540M 44252 21376 S 0.0 0.3 0:01.53 /usr/sbin/apache2 -k start
3475 mysql 20 0 1864M 352M 4992 S 0.0 2.1 3:38.74 /usr/sbin/mysqld
21592 root 20 0 106M 3072 2128 S 0.0 0.0 1:26.32 /usr/bin/monit -c /etc/monit/monitrc
22456 root 20 0 865M 2532 1836 S 0.0 0.0 14:19.62 PassengerHelperAgent
20 root 20 0 24432 2288 1244 S 0.0 0.0 0:01.07 /sbin/init
192 root 20 0 25384 1312 856 S 0.0 0.0 0:00.01 mountall --daemon
242 root 20 0 17224 592 408 S 0.0 0.0 0:00.03 upstart-udev-bridge --daemon
248 root 20 0 21520 1212 712 S 0.0 0.0 0:00.03 /sbin/udev --daemon
387 root 20 0 21456 688 248 S 0.0 0.0 0:00.00 /sbin/udev --daemon
388 root 20 0 21456 624 216 S 0.0 0.0 0:00.00 /sbin/udev --daemon
399 root 20 0 15188 388 188 S 0.0 0.0 0:00.00 upstart-socket-bridge --daemon
426 root 20 0 7256 928 416 S 0.0 0.0 0:00.00 dhclient3 -e IF_METRIC=100 -pf /var/run
522 root 20 0 49948 2876 2272 S 0.0 0.0 0:07.42 /usr/sbin/sshd -D
551 syslog 20 0 248M 3776 844 S 0.0 0.0 0:37.42 rsyslogd -c5
552 syslog 20 0 248M 3776 844 S 0.0 0.0 0:01.70 rsyslogd -c5
553 syslog 20 0 248M 3776 844 S 0.0 0.0 0:00.00 rsyslogd -c5
539 syslog 20 0 248M 3776 844 S 0.0 0.0 0:40.00 rsyslogd -c5
541 messagebus 20 0 23888 928 636 S 0.0 0.0 0:00.02 dbus-daemon --system --fork --activati
599 root 20 0 14496 928 768 S 0.0 0.0 0:00.00 /sbin/getty -B 38400 tty4
683 root 20 0 14496 928 768 S 0.0 0.0 0:00.00 /sbin/getty -B 38400 tty5
615 root 20 0 14496 928 768 S 0.0 0.0 0:00.00 /sbin/getty -B 38400 tty2
617 root 20 0 14496 928 768 S 0.0 0.0 0:00.00 /sbin/getty -B 38400 tty3
621 root 20 0 14496 916 768 S 0.0 0.0 0:00.00 /sbin/getty -B 38400 tty6
626 root 20 0 4320 636 488 S 0.0 0.0 0:00.00 acpid -c /etc/acpi/events -s /var/run/
630 root 20 0 18184 1848 792 S 1.0 0.0 0:01:07 cron
642 daemon 20 0 16940 372 212 S 0.0 0.0 0:00.00 atd
F1Help F2Setup F3Search F4Alt+F5Free F6SortByF7Vice F8Vice F9Kill F10Quit

```

181

```

1  [|||||] 18.5% Tasks: 200 total, 4 running
2  [|||||] 4.6% Load average: 1.17 1.49 1.48
3  [|||||] 13.9% Uptime: 3 days, 04:03:39
4  [|||||] 4.6%
Mem [|||||] [8034/8192MB]
Swp [|||||] 0/0MB

PID USER PRI NI VIRT RES SHR S CPU% MEM% TIME+ Command
197 _coreaud 67 0 2450M 10992 0 C 4.0 0.2 0:47.56 /usr/sbin/coreaudiod
114 root 63 0 3453M 238M 0 S 7.0 2.0 1:38.76 /System/Library/Frameworks/ApplicationsS
57 root 33 0 3724M 6288 0 S 2.0 0.1 0:32.68 /Library/Application Support/iStat loca
13655 rsgrrane 97 0 1833M 151M 0 S 2.0 1.9 0:03.99 /Applications/Spotify.app/Contents/MacO
26415 root 27 20 3240M 254M 0 R 1.0 3.1 0:00.64 /usr/bin/java -Dapp=CrashPlanService -X
586 rsgrrane 40 0 2634M 32216 0 S 1.0 0.4 0:18.87 /Library/Little Snitch/Little Snitch Ag
615 rsgrrane 40 0 2618M 48072 0 S 1.0 0.6 0:33.66 /System/Library/CoreServices/SystemUse
34349 rsgrrane 62 0 4227M 451M 0 S 0.0 5.5 0:39.11 /Applications/Mailplane 3.app/Contents/
631 rsgrrane 48 0 2480M 42476 0 S 0.0 0.5 0:18.67 /Library/Little Snitch/Little Snitch Ne
1085 rsgrrane 63 0 810M 146M 0 S 0.0 1.8 1:00.06 /Applications/Dropbox.app/Contents/MacO
369 root 36 0 2489M 24452 0 S 0.0 0.3 0:11.96 /Library/Parallels/Parallels Service.ap
1030 rsgrrane 63 18 2480M 15100 0 S 0.0 0.2 0:06.48 /Applications/DNSCrypt-MenuBar.app/Cont
36 root 50 0 3737M 203M 0 S 0.0 2.5 0:24.51 /System/Library/Frameworks/CoreServices
41992 rsgrrane 31 0 2370M 1484 0 C 0.0 0.0 0:00.00 htop
94888 rsgrrane 63 0 2692M 99M 0 S 0.0 1.2 0:00.85 /Applications/iTerm.app/Contents/MacOS/
33 root 33 0 2442M 12444 0 R 0.0 0.1 0:00.68 /usr/libexec/openssldirectory
1 root 31 0 2414M 2788 0 S 0.0 0.0 0:05.28 /sbin/launchd
11 root 33 0 2427M 4652 0 S 0.0 0.1 0:00.03 /usr/libexec/UserEventAgent (System)
12 root 33 0 2489M 6744 0 S 0.0 0.3 0:00.03 /usr/libexec/kextd
14 root 33 0 2410M 2092 0 S 0.0 0.0 0:00.40 /usr/sbin/notifd
15 root 33 0 2431M 18556 0 S 0.0 0.1 0:00.21 /usr/sbin/securityd -s
16 root 33 0 2480M 1912 0 S 0.0 0.0 0:00.12 /usr/sbin/diskarbitrationd
17 root 33 0 2425M 2864 0 S 0.0 0.0 0:00.44 /System/Library/CoreServices/powerd.bundle
18 root 33 0 2413M 7284 0 S 0.0 0.1 0:01.36 /usr/libexec/configd
19 root 33 0 2417M 11288 0 S 0.0 0.1 0:00.47 /usr/sbin/syslogd
21 root 33 0 2425M 2188 0 S 0.0 0.0 0:00.13 /usr/sbin/distnoted_daemon
22 root 23 18 2413M 9384 0 S 0.0 0.1 0:00.02 /usr/libexec/warad
24 _usbmuxd 33 0 2423M 14536 0 S 0.0 0.2 0:00.16 /System/Library/PrivateFrameworks/Mobil
27 root 33 0 2407M 1140 0 S 0.0 0.0 0:00.00 /usr/libexec/stackshot -t
F1Help F2Setup F3Search F4Alt+F5Free F6SortByF7Vice F8Vice F9Kill F10Quit

```

181

jobs

Display info about processes associated with current session

List job ID numbers (not the same as PIDs)

Ensure all programs have terminated before shutting down

182

```
$ jobs -l
+[4] 139  Running  CC - C foo c&
-[3] 465  Stopped   mail alice
[2] 687  Done(1)   foo.bar&
```

+ identifies default job
for the fg or bg commands

- identifies job
that would become the new default
if current default job exits

183

Foreground & Background Processes

184

Normally,
when you run a program,
it takes over the terminal

What if you need
to run another program?

185

Use jobs command to get the list of jobs

186

187

188

Ctrl-z
Suspend current program
& go back to terminal prompt

fg
Restore suspended program
back to foreground

fg 3
Restore numbered job
if several are suspended

bg
Restore a job to running status
(after pressing Ctrl-z),
but in the background

foo &
Start a program
& run it in the background

Managing Priorities

Want to prioritize programs' CPU use?

Run CPU-intensive job
so it doesn't bog down system?

Give a job more CPU
because it's more important?

Be nice

189

`nice`

Assign CPU priority to a program

`renice`

Alter CPU priority
of a running program

190

Options for assigning priority

`-priority`

`-n priority`

`--adjustment=priority`

Priority can range from -20 to 19

Default is 0

-priority makes positive numbers look negative,
& negative numbers look weird

191


```
nice -n 12 foo
Start foo with a priority of 12
so it uses more CPU
```

192

```
renice priority PID
Change priority for PID
renice priority -g group
Change priority for group
renice priority -u user
Change priority for user
```

193

Or combine options
& change priority
for program, user, &/or group:

```
renice priority PID -g group -u user
renice -5 10010 -g staff -u frank
```

194

Killing Processes

195

```
kill
```

```
Terminate a process  
based on its PID
```

```
killall
```

```
Terminate a process  
based on its name
```

196

```
kill
```

```
Terminate a process  
based on its PID
```

```
(Get PID from ps or top)
```

```
kill -signal PID
```

```
kill -1 10110
```

```
kill -9 10111
```

```
kill -TERM 10112
```

197

1	HUP	Kill interactive programs & daemons reread config files
9	KILL	Kill program immediately, without saving
15	TERM	Kill program but allow it to close open files (the default)

```
kill -l  
See full list of signals
```

198

```
killall  
Terminate a process  
based on its name  
killall apache2  
killall vim
```

199

Use killall with process name,
& nothing else

```
$ ps aux  
www-data 31431 ... /usr/sbin/apache2↵  
-k start  
www-data 31434 ... /usr/sbin/apache2↵  
-k start  
www-data 31436 ... /usr/sbin/apache2↵  
-k start  
$ killall apache2
```

200

When you log out of a shell session,
the kernel sends programs
the SIGHUP signal to terminate

What if you want a program
to continue running
after you log out?

201

`$ nohup foobar`
Tells the program foobar
to run & ignore SIGHUP signals

202

screen is another method,
though not covered on the LPIC

`$ man screen`

Google *screen tutorial*

203

Review

204

Thank you!

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205

LPIC-1 Study Group 2 Managing Software

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206

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