Operating Systems — Linux and Lightweight kernels

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Popular Linux Distributions

RedHat and RedHat clones

Environment Modules

Compilers

Essential Linux commands

A note on "randomness"

Lightweight Kernels

Popular Linux Distributions

This list is by no means complete

- RedHat
- Fedora
- Scientific Linux
- CentOS
- SuSE/SLES
- OpenSuSE
- Debian
- Ubuntu
- Gentoo

RedHat and RedHat clones:

You can never have too much of a good thing!

Package Manager:	RPM
Package Format:	RPM

What *ARE* CentOS, Scientific Linux, and Fedora?

When to pick RedHat over one of its clones:

Pick RedHat when you have:

- Plenty of budget for the licenses
- Support concerns
- 3rd Party Support concerns (Oracle, etc.)
- ... to make your manager sleep better ;)

When to pick a RedHat clone:

- Pick any of the clones to save some money!
- Pick Fedora if you want the latest in the RedHat world
- Pick CentOS if you want a (free!) rebuild of RHEL
- Pick Scientific Linux if you want a (free!) rebuild of RHEL with a bit of a "scientific computing" bent to it.
- Pick any to be simpler to maintain than official RedHat IMHO :P

When to pick SuSE Enterprise Server:

Pick SLES when you have:

- Plenty of budget for the licenses
  Less budget required than RedHat!
- Support concerns
- 3rd Party Support concerns (Oracle, etc.)
- ... to make your manager sleep better ;)

... Or, choose OpenSuSE to save some cash (and, IMO, some headache!)

Other Popular Linux Distributions

- Debian Gnu/Linux – A very conservative stability oriented distribution. Installing and upgrading packages is simple, but graphical tools are lacking.
- Ubuntu Linux – Based on Debian. Timely releases. Focus on a nice user desktop. "Meant to compliment Debian".
- Gentoo Linux – Portage system inspired by FreeBSD Ports Tree. Pretty much the entire system is compiled (on your system) to be optimized for your hardware.

Environment Modules

Environment Modules provide a convienant, consistent way to modify a user's environment to enable the useage of a library, application, or piece of documentation.

Modules can:

- Set/Unset environment variables
- Add–to/Remove from PATHs & MANPATHs, etc.
- be loaded and *unloaded* dynamically
- be used to manage different versions of software
- be bundled into "meta-modules" to load complex sets of software
- be used by all popular shells:
  bash, ksh, zsh, sh, csh, tcsh, as well as some scripting languages such as perl

Using Environment Modules

First, we'll load the module for GCC 3.4.6:

```
$ module load gcc/3.4.6
$ which gcc
/opt/gcc-3.4.6/bin/gcc
```

Now, we'll switch to the module for GCC 4.1.2:

```
$ module load gcc/4.1.2
$ which gcc
/usr/bin/gcc
```

Now, we'll unload the module:

```
$ module unload gcc
$ which gcc
gcc not found
```

Popular Compilers & Languages

Compiler Vendor	Language(s)
GCC	C, C++, Objective-C, Fortran, Java, Ada
INTEL	C, C++, Fortran
Portland Group (PGI)	C, C++, Fortran
PathScale	C, C++, Fortran
IBM XLC	C, C++
IBM XLF	Fortran
NAG	Fortran

Popular Compilers & Supported Processors

Compiler Vendor	Processor(s)
GCC	... A lot ...
INTEL	INTEL
Portland Group (PGI)	x86, x86-64
PathScale	x86, x86-64, AMD64, EM64T
IBM XLC	Power Series, (Incl. PPC)
IBM XLF	Power Series, (Incl. PPC)
NAG	Several

Popular Compilers Advantages

Compiler Vendor	Advantages
GCC	Many platforms, No cost
INTEL	Heavily Optimized for INTEL Hardware
Portland Group (PGI)	Good x86, x86-64 performance
PathScale	Good 64 bit performance
IBM XLC	Heavily Optimized on Power processors
IBM XLF	Heavily Optimized on Power processors
NAG	*Great* for debugging!

Essential Linux commands

- top(1)
- ps(1)
- lsof(8)
- kill(1)
- df(1)

top output

```
top - 11:28:13 up 15 days,  1:47,  1 user,  load average: 4.01, 4.01, 4.00
Tasks:  85 total,   5 running,  80 sleeping,   0 stopped,   0 zombie
Cpu(s):100.0%us,  0.0%sy,  0.0%ni,  0.0%id,  0.0%wa,  0.0%hi,  0.0%si,  0.0%st
Mem:   8308224k total,  6491856k used,  1816368k free,    48616k buffers
Swap:  2104472k total,        0k used,  2104472k free,  6225268k cached

  PID USER      PR  NI  VIRT  RES  SHR S %CPU %MEM    TIME+  COMMAND
20375 dgxu      25   0  469m  21m 2036 R  100  0.3 837:48.90 c32a2.exe
20376 dgxu      25   0  469m  21m 2036 R  100  0.3 837:48.95 c32a2.exe
20377 dgxu      25   0  469m  21m 2036 R  100  0.3 837:37.18 c32a2.exe
20378 dgxu      25   0  469m  21m 2036 R  100  0.3 837:48.37 c32a2.exe
    1 root      16   0   720  280  244 S    0  0.0   0:02.45 init
    2 root      RT   0     0    0    0 S    0  0.0   0:00.04 migration/0
    3 root      34  19     0    0    0 S    0  0.0   0:00.00 ksoftirqd/0
    4 root      RT   0     0    0    0 S    0  0.0   0:00.00 migration/1
    5 root      34  19     0    0    0 S    0  0.0   0:00.00 ksoftirqd/1
    6 root      RT   0     0    0    0 S    0  0.0   0:00.00 migration/2
    7 root      34  19     0    0    0 S    0  0.0   0:00.00 ksoftirqd/2
    8 root      RT   0     0    0    0 S    0  0.0   0:00.00 migration/3
    9 root      34  19     0    0    0 S    0  0.0   0:00.00 ksoftirqd/3
   10 root      10  -5     0    0    0 S    0  0.0   0:00.12 events/0
   11 root      10  -5     0    0    0 S    0  0.0   0:00.00 events/1
   12 root      10  -5     0    0    0 S    0  0.0   0:00.00 events/2
   13 root      10  -5     0    0    0 S    0  0.0   0:00.08 events/3
```

ps output

```
download@nano31:~$ ps auxwww | grep -v root | grep -v download
USER       PID %CPU %MEM    VSZ   RSS TTY      STAT START   TIME COMMAND
100       2599  0.0  0.0   3416   988 ?        Ss   Sep17   0:01 /usr/bin/dbus-daemon --system
nobody    3157  0.0  0.0   1556   424 ?        Ss   Sep17   0:00 /sbin/portmap
daemon    3269  0.0  0.0   3252   916 ?        Ss   Sep17   0:00 /usr/sbin/slpd
ntp       3975  0.0  0.0   4164  4164 ?        SLs  Sep17   0:00 /usr/sbin/ntpd -p /var/lib/ntp/var/run/n
postfix   4118  0.0  0.0   5412  1672 ?        S    Sep17   0:00 qmgr -l -t fifo -u
dgxu     20279  0.0  0.0   4832  2004 ?        Ss   Oct01   0:00 -csh
dgxu     20331  0.0  0.0   1844   612 ?        S    Oct01   0:00 pbs_demux
dgxu     20370  0.0  0.0   4372  1664 ?        S    Oct01   0:00 /usr/bin/csh /var/spool/torque/mom_priv/
dgxu     20375 99.9  0.2 480564 21920 ?        R    Oct01 946:34 c32a2.exe
dgxu     20376 99.9  0.2 480576 21940 ?        R    Oct01 946:34 c32a2.exe
dgxu     20377 99.9  0.2 480576 21940 ?        R    Oct01 946:22 c32a2.exe
dgxu     20378 99.9  0.2 480568 21940 ?        R    Oct01 946:31 c32a2.exe
postfix  21805  0.0  0.0   5376  1644 ?        S    13:03   0:00 pickup -l -t fifo -u
```

lsof lists open files

- Currently open files
- Open Network connections — *-i*
- Open files in a given directory — *+d <directory>*
- Open NFS files — *-N*
- Unix Domain Sockets (used for IPC, etc.) — *-U*
- a bunch of other options. . . RTFM!

Without any arguments,
lsof lists all open files on the system

```
nano:~ # lsof | head -25
COMMAND     PID       USER   FD      TYPE     DEVICE     SIZE       NODE NAME
init          1       root  cwd       DIR        8,2      696          2 /
init          1       root  rtd       DIR        8,2      696          2 /
init          1       root  txt       REG        8,2   517716      31071 /sbin/init
init          1       root  mem       REG        0,0                   0 [heap] (stat: No such file or di
init          1       root   10u     FIFO       0,14                2550 /dev/initctl
migration     2       root  cwd       DIR        8,2      696          2 /
migration     2       root  rtd       DIR        8,2      696          2 /
migration     2       root  txt   unknown                                /proc/2/exe
ksoftirqd     3       root  cwd       DIR        8,2      696          2 /
ksoftirqd     3       root  rtd       DIR        8,2      696          2 /
ksoftirqd     3       root  txt   unknown                                /proc/3/exe
migration     4       root  cwd       DIR        8,2      696          2 /
migration     4       root  rtd       DIR        8,2      696          2 /
migration     4       root  txt   unknown                                /proc/4/exe
ksoftirqd     5       root  cwd       DIR        8,2      696          2 /
ksoftirqd     5       root  rtd       DIR        8,2      696          2 /
ksoftirqd     5       root  txt   unknown                                /proc/5/exe
migration     6       root  cwd       DIR        8,2      696          2 /
migration     6       root  rtd       DIR        8,2      696          2 /
migration     6       root  txt   unknown                                /proc/6/exe
ksoftirqd     7       root  cwd       DIR        8,2      696          2 /
ksoftirqd     7       root  rtd       DIR        8,2      696          2 /
ksoftirqd     7       root  txt   unknown                                /proc/7/exe
migration     8       root  cwd       DIR        8,2      696          2 /
```

lsof -i output

Have lsof list open Network "files"

```
nano:~ # lsof -i | head -25
COMMAND     PID     USER   FD   TYPE   DEVICE SIZE NODE NAME
ipmitool   1092     root   4u   IPv4   936203       UDP nano.nano.alliance.unm.edu:10422->nano16-admin.na
ipmitool   1689     root   4u   IPv4   838800       UDP nano.nano.alliance.unm.edu:4625->nano04-admin.nan
conserver  2786     root   3u   IPv4     7037       TCP *:console (LISTEN)
conserver  2790     root   3u   IPv4     6386       TCP *:47546 (LISTEN)
maui       2825     root   5u   IPv4     6531       TCP *:42559 (LISTEN)
maui       2825     root   6u   IPv4     6532       TCP *:42560 (LISTEN)
maui       2825     root   7u   IPv4 22318441       TCP nano.nano.alliance.unm.edu:28955->nano.nano.allia
maui       2825     root   8u   IPv4 22318455       TCP *:pbs_sched (LISTEN)
conserver  2833     root   3u   IPv4     6530       TCP *:47591 (LISTEN)
ipmitool   3425     root   4u   IPv4   943140       UDP nano.nano.alliance.unm.edu:11023->nano17-admin.na
sshd       4231     root   3u   IPv6   594518       TCP nano.alliance.unm.edu:ssh->ycg34884vig.dl.ac.uk:5
sshd       4233   gbassi   3u   IPv6   594518       TCP nano.alliance.unm.edu:ssh->ycg34884vig.dl.ac.uk:5
lmgrd      4358     root   0u   IPv4  1250597       TCP *:27000 (LISTEN)
lmgrd      4358     root   3u   IPv4  1250621       TCP localhost:27000->localhost:12969 (ESTABLISHED)
atomist    4359     root   0u   IPv4  1250597       TCP *:27000 (LISTEN)
atomist    4359     root   3u   IPv4  1250600       TCP *:18965 (LISTEN)
atomist    4359     root   5u   IPv4  1250620       TCP localhost:12969->localhost:27000 (ESTABLISHED)
atomist    4359     root  16u   IPv4  2561344       TCP nano.nano.alliance.unm.edu:18965->nano.nano.allia
ipmitool   4985     root   4u   IPv4   848505       UDP nano.nano.alliance.unm.edu:5366->nano05-admin.nan
sshd       5331     root   3u   IPv6  1276944       TCP nano.alliance.unm.edu:ssh->augerdata1.phys.unm.ed
sshd       5333  bbecker   3u   IPv6  1276944       TCP nano.alliance.unm.edu:ssh->augerdata1.phys.unm.ed
sshd       5333  bbecker   7u   IPv4  1277133       TCP localhost:6013 (LISTEN)
sshd       5333  bbecker   8u   IPv6  1277134       TCP localhost:6013 (LISTEN)
ipmitool   5345     root   4u   IPv4   948946       UDP nano.nano.alliance.unm.edu:11175->nano18-admin.na
```

lsof +d /tmp output

Have lsof list open files in a directory

```
COMMAND   PID     USER   FD   TYPE     DEVICE SIZE   NODE NAME
gdm     12029     root    6u  unix 0xf4c8be40       48458 /tmp/.gdm_socket
bash    13447 download  cwd    DIR        8,2   72 942748 /tmp/foo
emacs   18184 download  cwd    DIR        8,2   72 942748 /tmp/foo
sbcl    18193 download  cwd    DIR        8,2   72 942748 /tmp/foo
```

lsof -N output

Have lsof list open NFS files

```
nano:~ # lsof -N | head -25
COMMAND      PID     USER   FD   TYPE DEVICE     SIZE      NODE NAME
tcsh        4235   gbassi  cwd    DIR   0,19     4096  20480512 /users/gbassi/CSR_NANO/300lambda (serrano.a
tcsh        5335  bbecker  cwd    DIR   0,22    21408    312134 /nano/scratch/bbecker/anisop/DATA_Box (nan
tcsh        6028   dianah  cwd    DIR   0,19     4096  35405932 /users/dianah (serrano.alliance.unm.edu:/e
tcsh        6129   dianah  cwd    DIR   0,19     4096  35405932 /users/dianah (serrano.alliance.unm.edu:/e
sftp-serv   6151   dianah  cwd    DIR   0,19     4096  35405932 /users/dianah (serrano.alliance.unm.edu:/e
tcsh        9405   gsmith  cwd    DIR   0,21     4096  89833556 /nfs/scratch/gsmith/blact/L3/dyn (serrano.a
tcsh       10241  erbb123  cwd    DIR   0,19     4096    886392 /users/erbb123/SNL/R2LT/Run10 (serrano.alli
tcsh       15753  bbecker  cwd    DIR   0,22    21408    312134 /nano/scratch/bbecker/anisop/DATA_Box (nan
vi         18238   dianah  cwd    DIR   0,19     4096  35405932 /users/dianah (serrano.alliance.unm.edu:/e
vi         18238   dianah   4u    REG   0,19    16384 122110610 /users/dianah/.opt.out.swp (serrano.allian
tcsh       18501   dianah  cwd    DIR   0,19     4096  35405932 /users/dianah (serrano.alliance.unm.edu:/e
bash       18665 download  cwd    DIR   0,19     8192  66322440 /users/download (serrano.alliance.unm.edu:/
tcsh       18811 jsegroup  cwd    DIR   0,19     4096  45105785 /users/jsegroup/tomas/compile (serrano.alli
vnl        20496   dianah  cwd    DIR   0,19     4096  35405932 /users/dianah (serrano.alliance.unm.edu:/e
vnl_exec   20498   dianah  cwd    DIR   0,19     4096  35405932 /users/dianah (serrano.alliance.unm.edu:/e
vnl_exec   20498   dianah   5w    REG   0,19        0 121913498 /users/dianah/.vnl/vnl.log (serrano.allian
vnl_exec   20498   dianah   9r    REG   0,19    79515  35423375 /users/dianah/.vnl/saves/2_0_1/1220647684.
vnl_exec   20498   dianah  11r    REG   0,19    11026 122110623 /users/dianah/ada1.vnl (serrano.alliance.un
tcsh       27220   gsmith  cwd    DIR   0,21     4096   2113589 /nfs/scratch/gsmith/ospf/spvc_mm1 (serrano
tcsh       30608   dianah  cwd    DIR   0,19     4096  35405932 /users/dianah (serrano.alliance.unm.edu:/e
tcsh       30961   gsmith  cwd    DIR   0,19     4096     50698 /users/gsmith (serrano.alliance.unm.edu:/e
sftp-serv 30983   gsmith  cwd    DIR   0,19     4096     50698 /users/gsmith (serrano.alliance.unm.edu:/e
tcsh       31521  bbecker  cwd    DIR   0,19     4096     33210 /users/bbecker (serrano.alliance.unm.edu:/
tcsh       31685  bbecker  cwd    DIR   0,19     4096     33210 /users/bbecker (serrano.alliance.unm.edu:/
```

lsof -U output

Have lsof list open UNIX domain sockets (used for IPC, etc.)

```
nano:~ # lsof -U | head -25
COMMAND     PID       USER   FD   TYPE     DEVICE SIZE     NODE NAME
udevd      1115       root   3u   unix 0xdff57c80          2704 socket
resmgrd    2766       root   3u   unix 0xdff57580          6309 /var/run/.resmgr_socket
dbus-daem  2787 messagebus   3u   unix 0xdff573c0          6367 /var/run/dbus/system_bus_socket
dbus-daem  2787 messagebus   6u   unix 0xdff57740          6381 socket
dbus-daem  2787 messagebus   7u   unix 0xdff57900          6382 socket
dbus-daem  2787 messagebus   8u   unix 0xf596b580         19971 /var/run/dbus/system_bus_socket
acpid      2792       root   4u   unix 0xdff57200          6403 /var/run/acpid.socket
acpid      2792       root   5u   unix 0xf6d33200         15147 /var/run/acpid.socket
acpid      2792       root   7u   unix 0xf52fb580         48677 /var/run/acpid.socket
acpid      2792       root   8u   unix 0xf4c8bc80         48678 socket
hald       3108       root   7u   unix 0xdff57ac0          7493 socket
hald       3108       root   8u   unix 0xdff57040          7494 socket
hald       3108       root   9u   unix 0xf7de1040          7495 socket
hald       3108       root  11u   unix 0xdff57e40         15865 socket
hald       3108       root  12u   unix 0xf596b740         19970 socket
hald       3108       root  13u   unix 0xf596bac0         19621 socket
sshd       4231       root   5u   unix 0xf7a18200        594625 socket
sshd       4233     gbassi   4u   unix 0xf6d333c0        594624 socket
hald-addo  4830       root   3u   unix 0xf7de1c80         15144 socket
hald-addo  4830       root   4u   unix 0xf6d33040         15146 socket
sshd       5331       root   5u   unix 0xf4c8b200       1277100 socket
sshd       5333    bbecker   4u   unix 0xf37b53c0       1277099 socket
sshd       6020       root   5u   unix 0xc7422040      20698874 socket
sshd       6026     dianah   4u   unix 0xc7422580      20698873 socket
```

kill(1)

kill –9 kills processes *dead*

Use kill for, well, what it says.. to kill processes!
kill can also be used to send an arbitrary signal, such as SIGHUP or SIGUSR to a process.

df output

```
nano:~ # df
Filesystem           1K-blocks      Used Available Use% Mounted on
/dev/sda2             76017196  53164756  22852440  70% /
udev                   4154112       116   4153996   1% /dev
serrano.alliance.unm.edu:/export/home/alliance
                     1007930816 956196432    534432 100% /users
serrano.alliance.unm.edu:/nfs/scratch
                     960412336 910471520   1154624 100% /nfs/scratch
nanoserv.nano.alliance.unm.edu:/raid
                     3165816480 2180893184 984923296  69% /nano/scratch
```

A note on "Randomness"

How is /dev/random populated (in Linux)? Where does it get its entropy from?

- Disk interrupts
- Keyboard interrupts
- Mouse interrupts
- Internal Hardware Random Number Generators
  Lucky you!
- **THATS IT**

How do I see how much randomness is available?

/dev/random is blocking on me!

- /proc/sys/kernel/random/entropy_avail — available entropy (more is good!)
- /proc/sys/kernel/random/read_wakeup_threshold — when bytes will be available
- /proc/sys/kernel/random/write_wakeup_threshold — when the kernel will try to start collecting more entropy
- What if I *NEVER* get a larger number in entropy_avail? . . . and therefore /dev/random blocks forever?!!!
- About all you can do (under Linux) is rng-tools
- rng-tools allows you to "seed" /dev/random using /dev/urandom

Lightweight Kernels

Ligtweight Kernels were developed after observing that:

- Most applications have no need for most UNIX processes
- General-purpose multiprocessing activity gets in the way of compute jobs
- Process scheduling gets in the way of compute jobs
- The above combined on *MANY* machines can *destroy* your performance!