How Linux is Organized

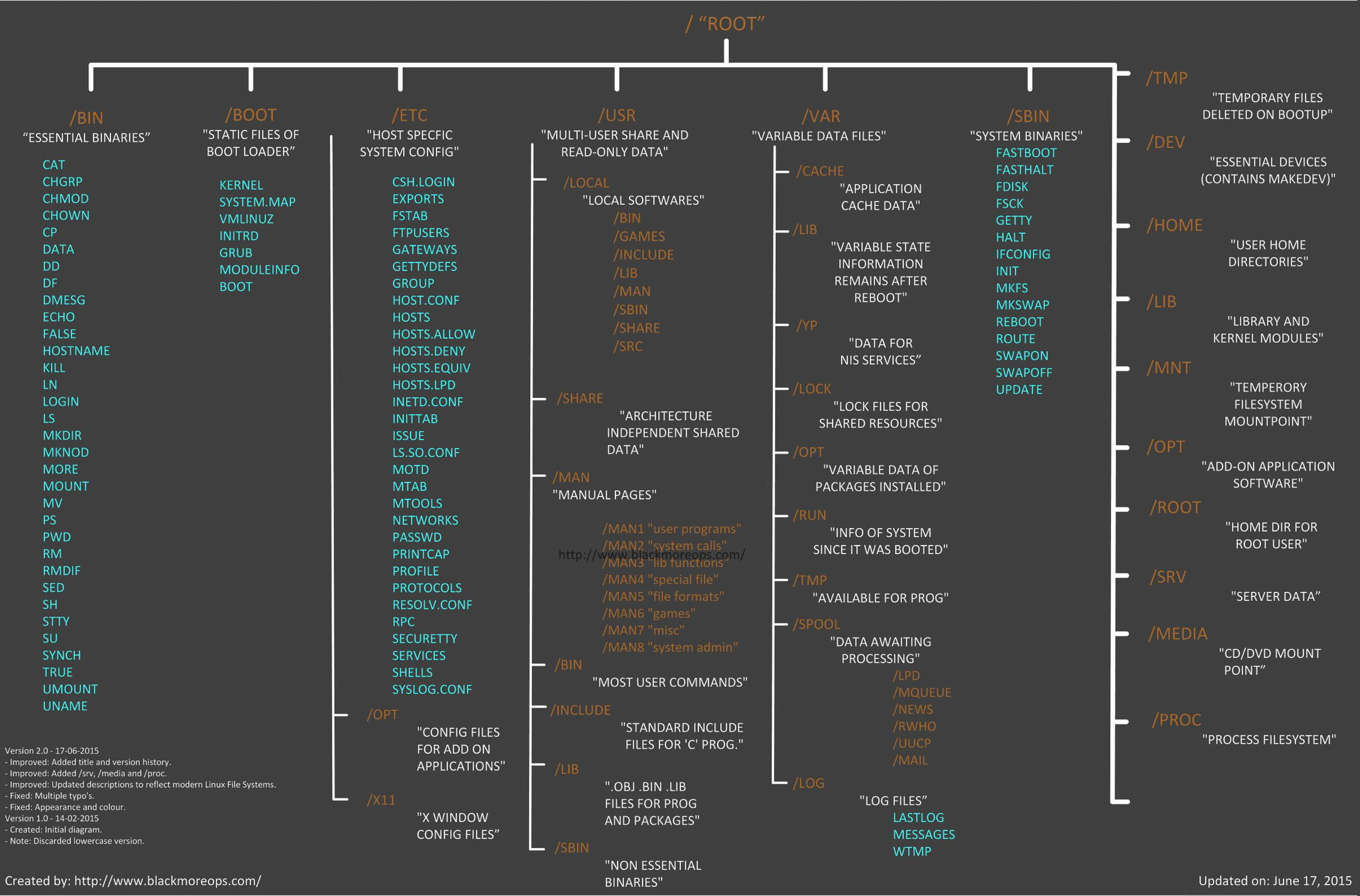
Or, “Where do I find things?”

Terminology

- Mount: making something and its contents available on your system

- Mountpoint: Where you mount something
    - Linux doesn’t use drive letters. You can mount things anywhere you want.

Linux File System Hierarchy v2.0



/ "ROOT"

- /BIN "ESSENTIAL BINARIES"
  - CAT
  - CHGRP
  - CHMOD
  - CHOWN
  - CP
  - DATA
  - DD
  - DF
  - DMESG
  - ECHO
  - FALSE
  - HOSTNAME
  - KILL
  - LN
  - LOGIN
  - LS
  - MKDIR
  - MKNOD
  - MORE
  - MOUNT
  - MV
  - PS
  - PWD
  - RM
  - RMDIF
  - SED
  - SH
  - STTY
  - SU
  - SYNCH
  - TRUE
  - UMOUNT
  - UNAME
- /BOOT "STATIC FILES OF BOOT LOADER"
  - KERNEL
  - SYSTEM.MAP
  - VMLINUZ
  - INITRD
  - GRUB
  - MODULEINFO
  - BOOT
- /ETC "HOST SPECFIC SYSTEM CONFIG"
  - CSH.LOGIN
  - EXPORTS
  - FSTAB
  - FTPUSERS
  - GATEWAYS
  - GETTYDEFS
  - GROUP
  - HOST.CONF
  - HOSTS
  - HOSTS.ALLOW
  - HOSTS.DENY
  - HOSTS.EQUIV
  - HOSTS.LPD
  - INETD.CONF
  - INITTAB
  - ISSUE
  - LS.SO.CONF
  - MOTD
  - MTAB
  - MTOOLS
  - NETWORKS
  - PASSWD
  - PRINTCAP
  - PROFILE
  - PROTOCOLS
  - RESOLV.CONF
  - RPC
  - SECURETTY
  - SERVICES
  - SHELLS
  - SYSLOG.CONF
  - /OPT "CONFIG FILES FOR ADD ON APPLICATIONS"
  - /X11 "X WINDOW CONFIG FILES"
- /USR "MULTI-USER SHARE AND READ-ONLY DATA"
  - /LOCAL "LOCAL SOFTWARES"
    - /BIN
    - /GAMES
    - /INCLUDE
    - /LIB
    - /MAN
    - /SBIN
    - /SHARE
    - /SRC
  - /SHARE "ARCHITECTURE INDEPENDENT SHARED DATA"
  - /MAN "MANUAL PAGES"
    - /MAN1 "user programs"
    - /MAN2 "system calls"
    - /MAN3 "lib functions"
    - /MAN4 "special file"
    - /MAN5 "file formats"
    - /MAN6 "games"
    - /MAN7 "misc"
    - /MAN8 "system admin"
  - /BIN "MOST USER COMMANDS"
  - /INCLUDE "STANDARD INCLUDE FILES FOR 'C' PROG."
  - /LIB ".OBJ .BIN .LIB FILES FOR PROG AND PACKAGES"
  - /SBIN "NON ESSENTIAL BINARIES"
- /VAR "VARIABLE DATA FILES"
  - /CACHE "APPLICATION CACHE DATA"
  - /LIB "VARIABLE STATE INFORMATION REMAINS AFTER REBOOT"
  - /YP "DATA FOR NIS SERVICES"
  - /LOCK "LOCK FILES FOR SHARED RESOURCES"
  - /OPT "VARIABLE DATA OF PACKAGES INSTALLED"
  - /RUN "INFO OF SYSTEM SINCE IT WAS BOOTED"
  - /TMP "AVAILABLE FOR PROG"
  - /SPOOL "DATA AWAITING PROCESSING"
    - /LPD
    - /MQUEUE
    - /NEWS
    - /RWHO
    - /UUCP
    - /MAIL
  - /LOG "LOG FILES"
    - LASTLOG
    - MESSAGES
    - WTMP
- /SBIN "SYSTEM BINARIES"
  - FASTBOOT
  - FASTHALT
  - FDISK
  - FSCK
  - GETTY
  - HALT
  - IFCONFIG
  - INIT
  - MKFS
  - MKSWAP
  - REBOOT
  - ROUTE
  - SWAPON
  - SWAPOFF
  - UPDATE
- /TMP "TEMPORARY FILES DELETED ON BOOTUP"
- /DEV "ESSENTIAL DEVICES (CONTAINS MAKEDEV)"
- /HOME "USER HOME DIRECTORIES"
- /LIB "LIBRARY AND KERNEL MODULES"
- /MNT "TEMPERORY FILESYSTEM MOUNTPOINT"
- /OPT "ADD-ON APPLICATION SOFTWARE"
- /ROOT "HOME DIR FOR ROOT USER"
- /SRV "SERVER DATA"
- /MEDIA "CD/DVD MOUNT POINT"
- /PROC "PROCESS FILESYSTEM"

Version 2.0 - 17-06-2015
- Improved: Added title and version history.
- Improved: Added /srv, /media and /proc.
- Improved: Updated descriptions to reflect modern Linux File Systems.
- Fixed: Multiple typo's.
- Fixed: Appearance and colour.

Version 1.0 - 14-02-2015
- Created: Initial diagram.
- Note: Discarded lowercase version.

Created by: http://www.blackmoreops.com/

Updated on: June 17, 2015

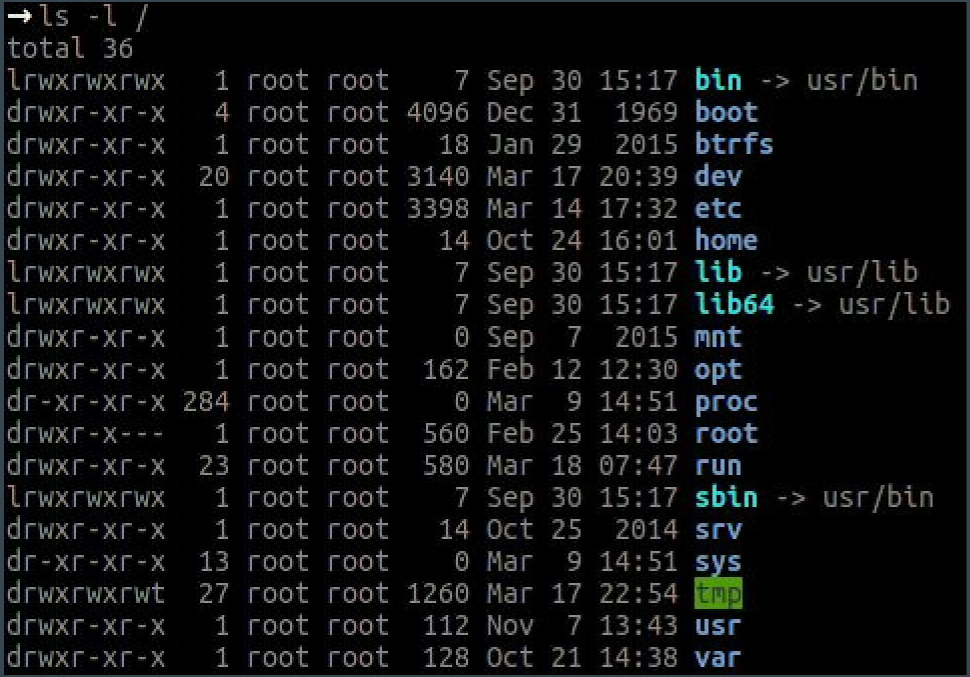
“/”

- Where your system’s files start

- Most Unix-like systems have a similar structure

- Other drives or locations are mounted somewhere under “/”

A typical “/”



```
→ls -l /
total 36
lrwxrwxrwx   1 root root    7 Sep 30 15:17 bin -> usr/bin
drwxr-xr-x   4 root root 4096 Dec 31  1969 boot
drwxr-xr-x   1 root root   18 Jan 29  2015 btrfs
drwxr-xr-x  20 root root 3140 Mar 17 20:39 dev
drwxr-xr-x   1 root root 3398 Mar 14 17:32 etc
drwxr-xr-x   1 root root   14 Oct 24 16:01 home
lrwxrwxrwx   1 root root    7 Sep 30 15:17 lib -> usr/lib
lrwxrwxrwx   1 root root    7 Sep 30 15:17 lib64 -> usr/lib
drwxr-xr-x   1 root root    0 Sep  7  2015 mnt
drwxr-xr-x   1 root root  162 Feb 12 12:30 opt
dr-xr-xr-x 284 root root    0 Mar  9 14:51 proc
drwxr-x---   1 root root  560 Feb 25 14:03 root
drwxr-xr-x  23 root root  580 Mar 18 07:47 run
lrwxrwxrwx   1 root root    7 Sep 30 15:17 sbin -> usr/bin
drwxr-xr-x   1 root root   14 Oct 25  2014 srv
dr-xr-xr-x  13 root root    0 Mar  9 14:51 sys
drwxrwxrwt  27 root root 1260 Mar 17 22:54 tmp
drwxr-xr-x   1 root root  112 Nov  7 13:43 usr
drwxr-xr-x   1 root root  128 Oct 21 14:38 var
```

You might have noticed some things are symlinks

- While the general structure of the filesystem is pretty consistent between distros, some move things around a little
    - Some locations exist for historic reasons that don’t really apply anymore

- ArchLinux combined some of the directories to make things cleaner, but symlinks are there so everything still works

/bin

- Application binaries available to everyone on the system
  - This does not imply users have access to the things these applications can do
  - If you’re more familiar with Windows, this is kind of like a less nested C:\ProgramFiles

- Most applications you run have their main entry point in here

- Mostly managed by your package manager, but you can manually place scripts and binaries here

/boot

- Your bootloader files
    - This is what handles starting Linux and starting your init system

- Linux initramfs images
    - The image of your Linux kernel that gets dumped into RAM at boot

- Possibly, an EFI directory which is your UEFI stuff

/dev

- Your devices!
    - Yes, this means you can access much of your hardware just like files

Cool things in /dev

- /dev/null: a black hole. You can dump anything into /dev/null if you want it to disappear
    - You’ll often see this in scripts that do something like `echo foo > /dev/null`
    - Many applications dump things here

- /dev/shm: your RAM. You can store things here in memory.
    - RAM is not persistent storage, it disappears when you shut down or reboot

- /dev/urandom: get random numbers!

Naming conventions in /dev

- Modern hard drives are usually /dev/sd{a..z}
    - If you have a LOT of drives, it'll add letters, e.g. /dev/sdaa
    - If you're on a server, you can find which drive is which by doing "cat /dev/sdx > /dev/null" to make its light flash
    - Partitions on drives are numbered, e.g. /dev/sd{a..z}{1..}
        - You normally don't mount a drive, you mount a partition

- SD cards are usually /dev/mmcblk*

/etc

- Configuration files
  - If you write an application with multiple config files, please use a subdirectory
  - Normally just plaintext files

- Init scripts for starting and stopping applications
  - /etc/init.d for sysvinit systems (legacy)
  - /etc/systemd/system for modern systemd-based systems

Interesting things in /etc

- /etc/passwd
  - Where your user configurations live (username, userid, shell, home directory, etc but NOT password)
  - Anyone can look in this file unless you modify its permissions
- /etc/shadow
  - User credentials. Only root can access this file.
- /etc/issue
  - What distro and version you’re using
- /etc/fstab
  - What additional mounts you want set up when you boot

/home

- User files!
  - Yours usually live in /home/<your username>
  - Applications sometimes create a user for themselves and store things here
  - You can configure different locations for user files on a per-user basis

- Sometimes this is mounted from somewhere else
  - On my server I store user files in my storage pool, /tank/home which is mounted to /home

/lib and /lib64

- Shared libraries for applications, additional things they use
    - Things like encryption, SSL certificates, and others
    - Windows would call these DLLs

- Managed by your package manager most of the time, you usually won’t deal with these yourself

/mnt

- Not used automatically by most distros

- This is the standard place for creating temporary filesystems
  - Usually if your system auto-mounts things it will not be here

/opt

- Additional applications that are not core to the system running

- Not many applications place things here anymore, they use the normal /bin, /lib, /usr/bin, and /usr/lib.

- Applications that will places things here include
  - Telegram
  - Android Studio
  - Adobe Reader
  - ...And others

/opt

- Some embedded systems make heavy use of /opt
    - For example, if you have a jailbroken Kindle Keyboard, the package manager you can install will use /opt for packages

/proc

- Virtual filesystem (doesn’t really exist or take up disk space)

- Only mounted when your system is running

- Contains your running programs (slight simplification)
    - You can get a lot of information about things your system is running from here

- You can modify things in /proc to tune your system

/proc

- You can do a lot of advanced stuff in /proc that we won’t get into here
  - It’s super magical
  - Intimate knowledge of what’s in /proc isn’t required for being proficient at Linux’s internals

- One useful thing: Check what binary belongs to a process ID
  - `readlink -f /proc/<process id>/exe`
    - To see what shell you’re currently running, use $$ for the process id

/root

- This is the home directory for the superuser (root)
    - This is configurable, but leaving it here is best

- Only root has access to this directory

- Don’t mount this somewhere else unless you’re absolutely sure, because things might get weird if you need to log in as root and your mount didn’t come up

/run

- Runtime information about your system
  - Such as the last time you ran sudo so sudo knows if it should ask for a password again, logged in users, and daemons

- /run/mount/<user> is often where auto-mounted drives are mounted

/sbin

- “Essential” system binaries that only root has permission to use
  - Things like fsck (partition check and repair)

- No longer used on some distros
  - Arch makes this a symlink to /bin

/srv

- Not used on all distros
    - Some distros use /var, e.g. apache on debian uses /var/www

- Data used by system services such as webservers
    - /srv/http - files and scripts served by the webserver
    - /srv/gogs - Go Git Server files
    - ...

/sys

- Similar idea to /proc, but for devices instead of processes

- Device and driver information and tuning

/tmp

- System temporary files. Cleared at every boot

- Anyone can write here, but only the owner of a file can see it

- Used by users and applications for temporary storage
  - This can be a good place to keep your downloaded files if you download a lot of stuff you don’t need to keep

/usr

- Other third party applications
- Kind of mirrors /
    - /usr/etc
    - /usr/bin
    - /usr/lib
    - Some distros don’t differentiate anymore

- Contains other things like icon packs and themes
    - Usually in /usr/share

/var

- “Variable files”
    - Files that are expected to change continuously while the system is running

- Log files, mailboxes, cache files, lockfiles, etc

/media

- Mountpoint for removable things (like flash drives)
    - Once again, not really used anymore and doesn’t always exist on distros

Other things you might see

- /btrfs
  - BTRFS filesystem snapshots if / is on a BTRFS filesystem
- /tank
  - Default location for ZFS [sub]volumes
- /.zfs
  - “Invisible” directory for ZFS snapshots and data, if / is on a ZFS filesystem
- /lost+found
  - Recovery directory for EXT filesystems if / is on an EXT filesystem

How do I…

…Have the application I built find its config files?

- Most applications search for their config files in the following order:
    - ~/.<app>
        - It may not always be appropriate for your application to look here
    - /usr/etc/
    - /etc

...Figure out what /dev node the drive I plugged in is?

- Run `dmesg` right after you connect it. You should be able to find log entries near the bottom that say it discovered drive /dev/...

...Install an icon pack?

- For just you: /home/.icons

- For everyone: /usr/share/icons

…Get a lot of zeroes?

- This is useful if you want to “zero out” (overwrite something with 0’s) to destroy the partition table, file, or whatever
- /dev/zero is your source! `cat /dev/zero > /thing/to/zero/out`

...Manually mount a drive?

- Figure out what the device is
- Create a directory to mount it in
- Run `sudo mount /dev/your_device_partition /directory/to/put/it/in`

…Block a website?

- Edit /etc/hosts and add an entry that points the website to 127.0.0.1
  - There can be better ways of doing this
  - Windows’ equivalent is C:\Windows\System32\drivers\etc\hosts

...Find a log file?

- Look in /var/log
    - Most are pretty self explanatory from there
    - Systemd does not use plaintext logs, you need to use the journalctl utility