The Linux Operating System

An Overview

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Objectives

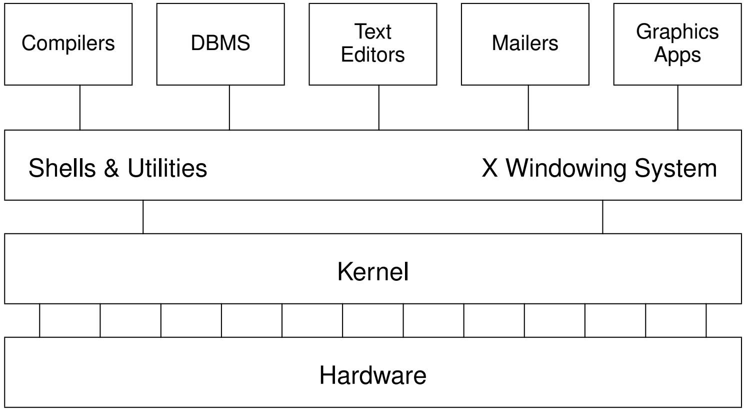
Having completed this module, you will have an overview of a Linux system, including its:

- Underlying philosophy
- System layering — kernel vs. applications
- Core services
- Multiuser and timesharing facilities
- File System
- Network Services
- Desktop and X windowing system

Generic Features of Unix

- Component-based systems
- Very popular with technically skilled
- Not ‘solution’ oriented
- Building blocks not the building
- Highly network-aware
- Robust, powerful, reliable

Linux — The Kernel of a System



Compilers

DBMS

Text Editors

Mailers

Graphics Apps

Shells & Utilities

X Windowing System

Kernel

Hardware

Figure 1: kernel-layering

- What is *called* Linux is actually a collection of

Fundamental Characteristics of Linux

- Multi-tasking
- Multi-user access
- Multi-processor
- Architecture independence
- POSIX 1003.1 plus basic System V and BSD
- Protected memory mode
- Multiple filesystem types
- Comprehensive networking (TCP/IP and others)
- Multiple executable formats (MS-DOS, iBCS UNIX, SCO, etc)

Multiuser Multitasking and Time-sharing

- Designed as a multi-user system
  - Each user’s shells, apps and commands are separate processes
  - Number of simultaneous users limited only by:
    - CPU speed and available memory
    - Min. response times required by users/apps
- Multi-tasking:
  - Many jobs can be under way at the same time
  - Jobs truly *simultaneous* on multi-cpu
- Time-sharing: A single cpu is shared by all processes
  - Processes exec briefly, passing cpu to others
  - *Process switches* occur in miliseconds or less
  - Kernel gives process a sense of total control

Protected memory mode

- Uses the processor’s protection mechanisms
- Prevent access to memory already allocated to kernel or other processes
- Bad programs can’t crash the system
  - Theoretically

Multiple Filesystem Types

- Native FS is ext3 (Third Extended File System)
  - File names up to 255 chars
  - More secure than conventional UNIX
- Others include:
  - MS-DOS (FAT16), VFAT, FAT32
  - ISO9660 (CD-ROM)
  - HPFS (OS/2)
  - NTFS (Windows NT)
  - reiserfs, XFS, other journalling file systems for Linux,
  - UPS, SysV and other proprietory UNIX
  - NFS (Unix network file system)
  - SMB / CIFS (MS Windows file sharing)

The Many Faces of a GNU/Linux System

- The user may see up to five aspects of Linux:
  - the *filesystem*
  - *processes*
  - the *shell*
  - the X *windowing system*
  - *Inter-Process Communication* (IPC)
- The system is very highly configurable
- Different users may experience totally different views of the same system
- Multiple simultaneous users are normal
  - Linux is designed from the ground up as a *multi-user system*, NOT a ‘personal’ system

The Filesystem

- The filesystem contains all data in the system
- A name in the filesystem can refer to:
  - a *data file*, which can be:
    - a *plain file*
    - a *directory*
  - a *device* (disk, tape etc.)
  - internal memory
  - OS information (the *proc* system)
- Directories are groups of files
  - Grouped in hierarchical *trees*
- Files are fully specified with their *pathname*
- An original Unix structure; copied by most OSs

Filenames

- Maximum length depends on filesystem type
  - Most allow up to 255 characters
- Can use almost any character in a filename, but avoid ambiguity by sticking to:
  - (A-Z) Uppercase letters
  - (a-z) Lowercase letters
  - (0-9) Numbers
  - (.) Full-stop
  - (,) Comma
  - (_) Underscore
  - (-) Hyphen
- Should convey meaningful info about contents
- Type longer filenames using completion for:
  - Filenames

Filename Extensions and File Types

- Filenames *don’t* determine other attributes of file,

  i.e. do not, *automatically*, cause command interpreters to treat them in a particular way
- However:
  - Extensions can enable meaningful naming and automatic file manipulation
  - C compilers and some other programs *do* depend on specific file extensions to carry out particular tasks
- Common conventions for extensions:

Filename	Meaning of Extension
program.c	C programming source file

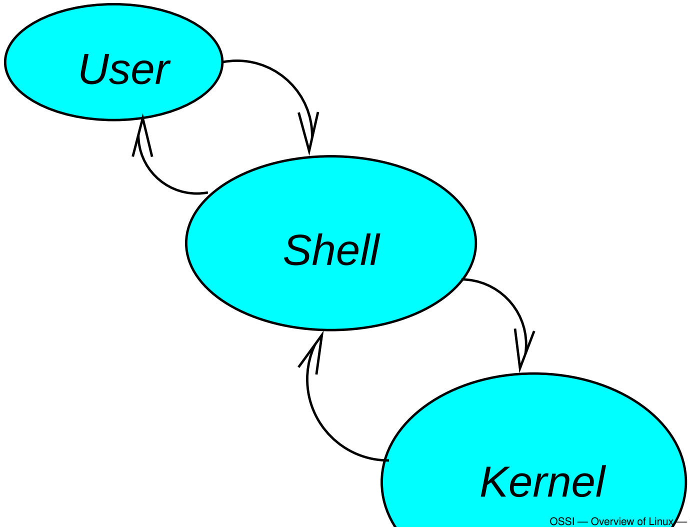
Hidden Filenames

- Filenames beginning with a full-stop are *hidden*
- Typically used:
  - To hide personal configuration files
  - To avoid cluttering dirs with rarely used files
- Every dir contains 2 special hidden files:

.	The current directory file
..	The parent directory file

The Shell (`bash`)

- A *shell* is a program that you interact with



Key Features of the Bash Shell

- Command history
- Command aliasing
- Shell scripting
- Filename completion
- Command completion
- Command line editing (`emacs` and `vi` styles)
- Job control
- Key Bindings
- Directory stacking
- Tilde directory notation
- Help function, e.g.

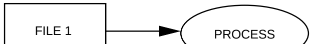
```
$ help history
```

Interacting with a Linux ‘Terminal’

- Linux can support any number of ‘terminal’ types
  - nowadays, monitor/keyboard combinations
  - previously, dumb terminals
  - occasionally, printers (debugging servers)
- Most will use the *console* or a windowed terminal, but if not:
  - Linux usually keeps a database of terminal capabilities in `/etc/termcap` [a]
  - If your terminal type is not recorded in `/etc/termcap`, you’ll have problems running certain programs e.g.
    - cursor driven apps (`top`, `linuxconf`, `vi` etc)
  - The *environmental variable* `TERM` tells programs what terminal type you are using

Software Tools: The UNIX Philosophy

- True UNIX-like systems treat programs as *tools*
  - Each tool should:
    - Do just one thing well
    - Be generic (untied to specific applications)
  - For new jobs, build new tools
  - (Re-)combine, don't complicate old tools
- Linux can do this because it has:
  - two simple *objects*:
    - the file
    - the process
  - simple methods of *connecting*:
    - processes to files
    - processes to processes



Tasks/Processes

- A *program* is an execut*able* object, stored in a file
- A *process* is an execut*ing* object, i.e. [a]
  - an *instance* of a program currently being run
- Existing processes can '*fork*' to create other processes
  - the only way to make new processes
- A user may run multiple copies of same program
- Multiple users may run single/multiple copies
- System tracks *ownership* and *permission*

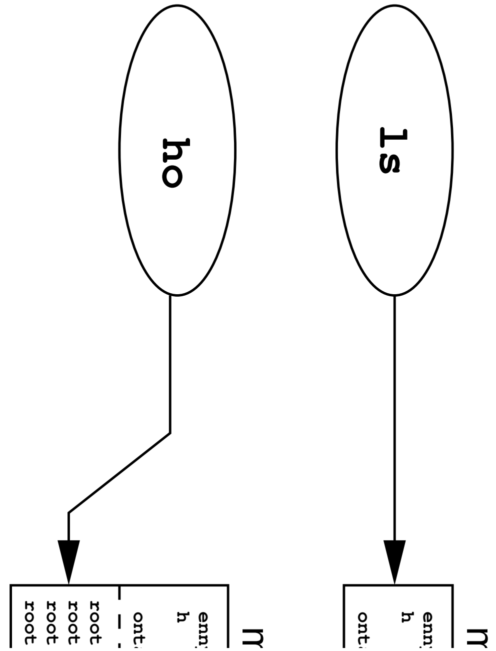
[a] Processes are often called *tasks*, as in 'multi-tasking'

Process Communication

- Processes may need to co-operate by
  - sharing files
  - signalling events
  - direct transfer of data
  - pipelines (data streams)
  - synchronising with each other
- Linux provides facilities for:
  - signals
  - shared memory
  - pipes, both named and unnamed
  - semaphores
  - and others
- Processes may use network connections for communication, permitting *client-server* model

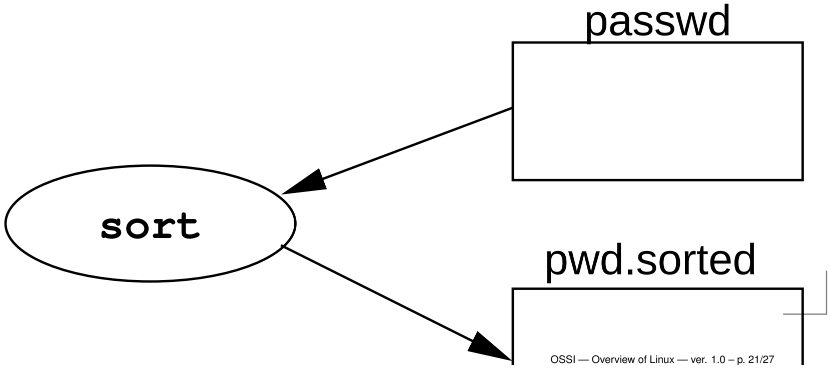
Re-directing I/O to and from Files

- Most processes will take input from the keyboard and output to the screen
- Both input and output streams can be *re-directed* to/from files
- Output to a file (creating or overwriting):
  `$ ls > my-system.txt`
- Appending output to a file: `$ who >> my-system.txt`



Re-directing I/O to and from Files (continued

- Take input from one file, output to another:
  ```
  $ sort < /etc/passwd > pwd.sorted
  ```



Pipes & Tools

- Linux tools act as filters:
  - taking data from input streams, modifying it, sending it elsewhere
  - expecting data to come from other tools
  - producing output which *any* other tool can process, e.g. ASCII text
- One tool's output is connected to another's input:
  - *Indirectly*, via a file created by the first tool
  - *Directly*, via a *pipe* or *pipeline*
- For example, to page through a reverse-sorted version of your password file on screen:
  ```
  $ sort -r < /etc/passwd | less
  ```

Linux as a Programming Environment

- *Hierarchical Filestore*
- Extensive set of *powerful tools*
  - for software production, admin and support
- A *common system interface*
  - only one set of procedures to learn
- Processes interface with *anonymous files*
  - programs output to files or devices identically
- *Modular architecture* provides for a completely customised OS, e.g.
  - An OS dedicated solely to graphics rendering
  - A general-purpose system on one floppy
- *Flexible user interface* allows for uniquely customised programming environments

Networking

- Linux is a network operating system.
- The Internet network protocols (TCP/IP) are implemented in the kernel
- Although other media are supported (e.g. radio, infra-red), links are usually across:
  - Ethernet
  - Serial Line (Point-to-point)
- Proprietary file/print serving protocols supported:
  - Appletalk
  - DECNET
  - IPX / Novell Netware
  - SMB / CIFS (MS Windows/NT)

TCP/IP

- A suite of Internet-standard protocols and apps for managing data transfers
- Depicted as a 'stack'
  - hardware and transport control protocols at the bottom
  - user applications (e.g. browsers) at the top
- Client-server apps provide facilities for:
  - Remote login
  - File transfer
  - Resource sharing (e.g. expensive peripherals)
  - Remote command execution
  - Email (internet/intranet/extranet)
  - Web browsing

Documentation

- Copious, but fragmented and/or duplicated

Programmer's Manual `/usr/man`	The classic '*man pages*', first stop for skilled users, worth learning
`info` pages	hypertext browsable texts, often identical or updated versions of n pages
`/usr/share/doc/`*`program-name`*	ascii/html docs installed with the named program
Howtos	Tutorials on Linux-related topics, available on-line if installed (usu in `/usr/share/doc`)
www	Recently-released programs are usually documented on authoris web sites, many (including older tools) are documented by third-party sites

Table 2: Sources of Linux Documentation

Using the *man pages* (On-Line Manual)

- Use `man` to see man pages on a named command, e.g

```
$ man date
```

- The result should be something like:

```
DATE(1)                        FSF

NAME
       date - print or set the system date and time

SYNOPSIS
       date [OPTION]... [+FORMAT]
       date [-u|--utc|--universal] [MMDDhhmm[[CC]YY][.ss]
```

- `DATE(1)` Shows page is in manual section 1
- To view a page from a certain section use:

```
$ man -S section-number command-name
```