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COMP25111: Operating Systems

Lecture 18: Linux Case Study

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Overview & Learning Outcomes

Background

Shell

Components: layers & managers
- Scheduling
- Memory
- Files
- Input/Output

UNIX History & Motivation

(weak pun on “MULTICS”)
Initially (1969) single-user, soon (1973) multi-user timesharing system
Written in C (developed at Bell Labs to support Unix)
Fundamental Architectural Design finished in 1978
POSIX standards 1988, 1992,3,5, 2001,4,8

by programmers, for programmers
small, modular, clean design
UI consistency, brevity
source distribution

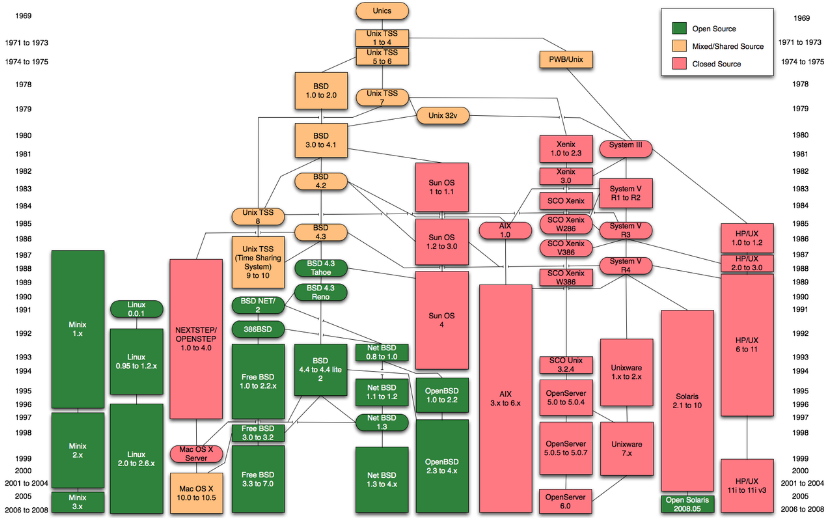
Unifying Themes

Everything is a file

Composition & re-usability:
– shell, I/O redirection, pipes, filters

Simplicity & minimality:
– 1 reusable best tool for each purpose

Development (wikimedia: Unix_history-simple.png)



Shell

user-level process, executes programs
(command interpreter, CLI)

– reads next user command
– searches path for program
– forks child process & execs program
– waits for termination of child

fork & exec (MOS figs 10-4, 10-7)

```
pid = fork();
if (pid < 0)       { /* error */ }
else if (pid > 0) { /* parent*/ }
else /* pid==0 */ { /* child */ }

while (1) {
  type_prompt();
  read_command(&command, &params);
  pid = fork();
  if (pid < 0)       { /* error */ }
  else if (pid > 0) waitpid(-1, &status, 0);
  else /* pid==0 */ execve(command, params, 0);
}
```

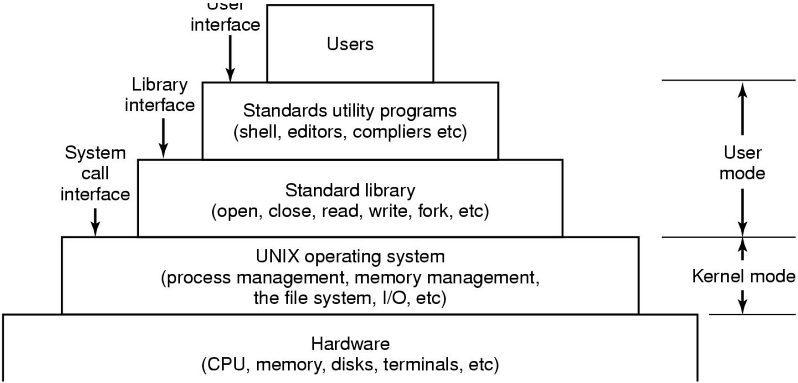
I/O redirection

processes start with 3 open files: standard input, output, error

Can redirect to/from files:
e.g. `compile <input >output 2>errors`

or another process in a pipeline:
e.g. `ls -la | grep Nov | grep 23`
`pipe()` system call

Interfaces (MOS fig. 10-1)



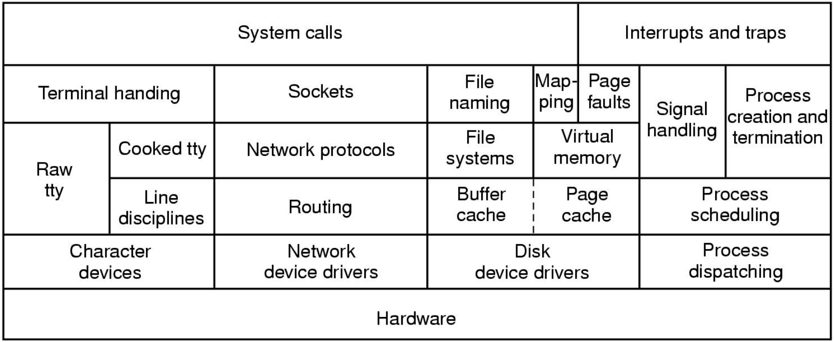
Architecture – Overview

User level (non-privileged):
user processes = application, library etc.

Programmer Interface:
– System programs (e.g., mkdir, rm, cp, ...)
– System calls (file manipulation; process control; information)

Kernel level (privileged):
managers (file, process, memory, ...) & device drivers

Kernel layers (MOS fig. 10-3)



Process

"process descriptor" (see handout 5 – PCB)
– unique PID
– address space
– UFIDs (handout 16)
– signal handling vector
– UID & GIDs (User/Group ID)
– scheduling priorities
– thread(s)

Properties inherited from parent

Process Management

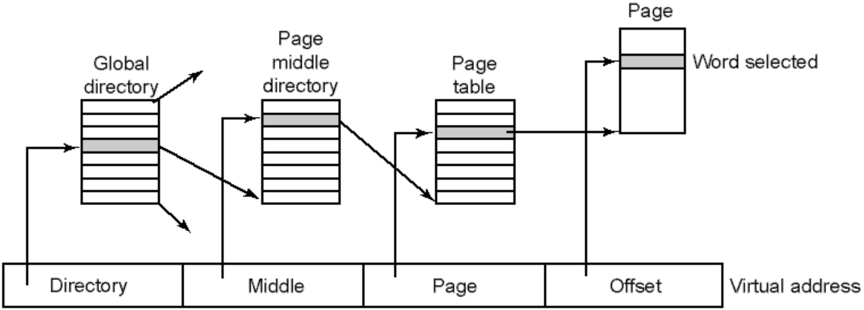
user-level (library) v. native/kernel (OS) threads

2-level scheduling:
– move complete process to/from disk
– select process/thread to run (handout 7 final e.g.)

Delayed jobs:
`at 0630 myjob` for one-off deferral
`cron` for regular jobs (hourly, daily, weekly, monthly, etc)

Virtual Memory

Paged (e.g. 4kB) 1GB Kernel, 3GB user
“segments”: Text (code), Data (& heap), Stack
can be shared
copy-on-write
memory-mapped files

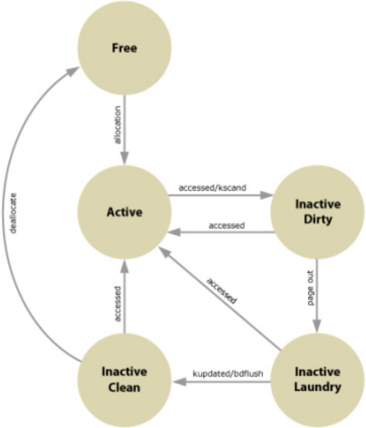


Page Tables (MOS fig 10-17)
– 3-level: DEC Alpha (43-bit virtual addresses)
– 2-level: Intel x86

Paging

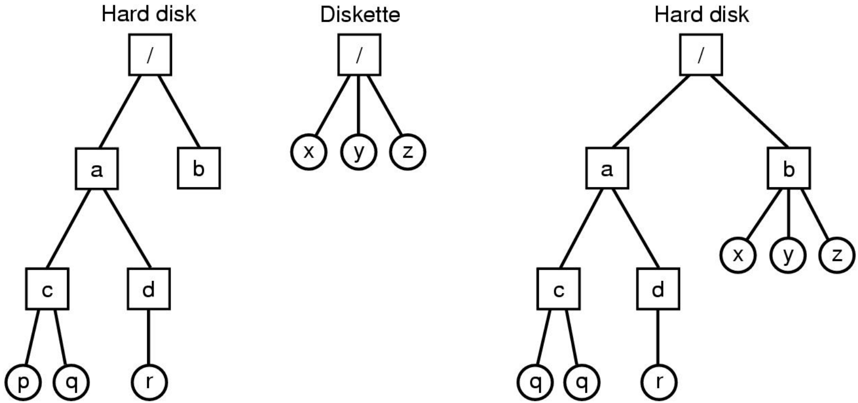
Demand-driven
Pages pre-cleaned

LRU approximation with second-chance
Reference bit (set when page accessed)
Round-robin check pages (& clear ref)



(www.redhat.com/magazine/001nov04/features/vm)

`mount` (MOS fig 10-26)



inode

(see handout 16)

Owner, last time info, permissions, size, links to the file

15 content pointers to disk blocks:
– 12 pointers to direct blocks
– 1 single-indirect; 1 double-indirect; 1 triple-indirect

ext2: groups inodes, which point to nearby blocks

ext3: + journaling

Protection Model

Process Concepts: UID GID

File Attributes: RWXRWXRWX
Owner, Group, Other – Read, Write, Execute

Primarily files, directories

Same mechanisms used by devices, network connections, ...

Security:
user particulars in /etc/passwd
Holes: read about the Morris Internet Worm (1988)

I/O and Device Drivers

Drivers are privileged code (not user-supplied)

user-access to devices via special files:
e.g. `/dev/fd` `/dev/tty`

Can be character or block devices

Summary of key points

Background

Shell

Components: layers & managers
- Scheduling
- Memory
- Files
- Input/Output

Your Questions

Exam Questions

In Unix, what is the use of the shell variable PATH? (2 marks)

Briefly explain how a shell implements a pipe between two commands (2 marks)

Briefly explain how Unix implements input redirection in a shell command. (2 marks)

Briefly explain that a Unix shell does to execute the following command /bin/who $>$ myfile (2 marks)

Glossary

I/O redirection
shell
pipe
filter
fork
exec (execve)
waitpid
2-level (high & low) scheduling
character & block devices

Reading

newer OSC/J: Ch. 21

older OSC/J: Ch. 20

MOS: Ch. 10

David A Rusling, The Linux Kernel
http://tldp.org/LDP/tlk/tlk-toc.html
(Linux 2.0.33, 1999)

http://www.cs.manchester.ac.uk/ugt/year1/linux-intro/notes/
COMP10120: lab 3 (shell scripts) & 5 (window manager)