CSE 451: Operating Systems

Section 2

Shells and System Calls

OSDI 2010

Finding a Needle in a Haystack: Facebook's Photo Storage

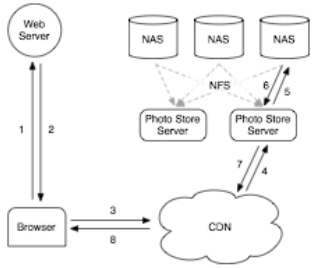


Figure 2: NFS-based Design

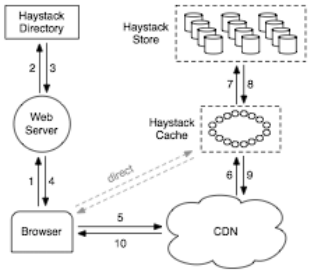


Figure 3: Serving a photo

OSDI 2010

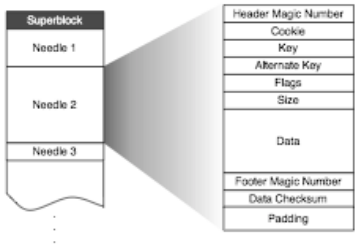


Figure 5: Layout of Haystack Store file

Results: storage costs reduced 28%; 4x greater read throughput

Project 0

∗How is it going?

Project 1

- Two main parts:
  - Write a simple shell in C
  - Add a simple system call to Linux kernel
- You'll learn:
  - How system calls work in Linux
  - How to work inside the Linux kernel
- Due: Monday Oct 18, 11:59pm
  - Electronic turnin: code + writeup

Project 1

- E-mail groups to Abdul & Pete by Monday October 11
  - After that, assigned to random groups
- One turnin per group
- Use CVS for version control
  - http://www.cs.washington.edu/education/courses/cse451/10au/projects/cvs.html

System calls

System calls

- Mechanism for applications to request service from the OS
- How do library calls differ from system calls?

System calls vs. library calls

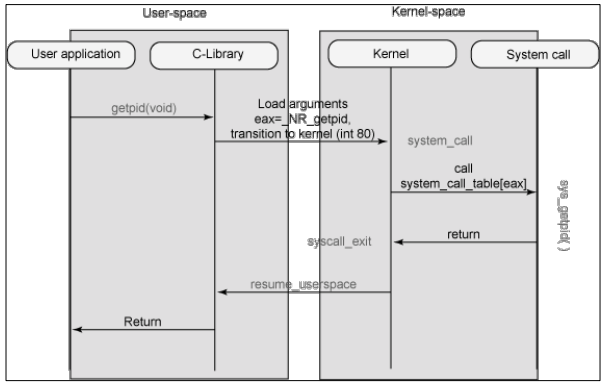


Image from: http://www.ibm.com/developerworks/linux/library/l-system-calls/

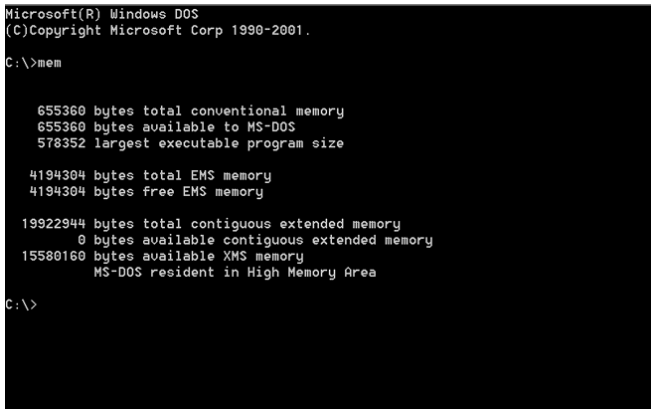
System calls vs. library calls

- Good example: *exec* family of calls
  - Library calls: *execl*, *execlp*, *execle*, *execv*, *execvp*
  - All map to one system call: *execve*
- Useful tools
  - ltrace
  - strace

Project 1: adding a system call

- Add *execcounts* system call to Linux
  - Purpose: count the number of times that some other system calls are called
- Steps:
  - Modify kernel to track these counts
  - Implement *execcounts* function in kernel
  - Add it to the system call table
  - Call it from your shell, print results

Shells



Shells

- Primary responsibilities:
  - Parse user commands
  - Execute commands / programs
  - Manage input and output streams
  - Job control
- Examples:
  - UNIX: bash, csh, …
  - Windows: Command Prompt, PowerShell

The UNIX shell

- Internal (built-in) commands
  - Execute routines embedded in the shell
  - Manage state of the shell (e.g., current working directory, environment variables)
- External programs
- How can you tell external from internal?

Other UNIX shell capabilities

- Redirect standard input / output / error streams

```
# ./parser < logfile > outfile 2> errfile
```

- Command pipelines

```
# ps –ef | grep java | awk '{print $2}'
```

- Background execution of process

```
# time make > make.out &
# jobs
[1]+  Running        time make > make.out &
```


The CSE451 shell

```
CSE451Shell% /bin/date
Fri Jan 16 00:05:39 PST 2004
CSE451Shell% pwd
/root
CSE451Shell% cd /
CSE451Shell% pwd
/
CSE451Shell% exit
```

The CSE451 shell

- Repeat these steps:
  - Print out prompt
  - Read and parse input
  - If built-in command:
    - Do it directly
  - Else (external program):
    - Launch specified program in new process
    - Wait for it to finish

Shell system calls

- *fork*
  - Create a child process
- *execve*
  - Execute a specified program
- *wait*
  - wait until child process terminates

Project 1: final product

```
CSE451Shell% execcounts clear
CSE451Shell% cd /
CSE451Shell% pwd
/
CSE451Shell% date
Wed Sep 29 16:52:41 PDT 2004
CSE451Shell% time
Usage: time [-apvV] [-f format] [-o file] [--append] [--
verbose] […]
CSE451Shell% execcounts
Statistics:
Fork:                   3       27%
VFork:                  0       0%
Clone:                  0       0%
Exec:                   8       72%
CSE451Shell% exit
```


Project 1: shell hints

- Useful library functions (see man pages):
  - Strings: *strcmp, strncpy, strtok, atoi*
  - I/O: *fgets*
  - Error reporting: *perror*
  - Environment variables: *getenv*

Programming in kernel mode

- Your shell will operate in user mode
- Your system call code will be in the Linux kernel, which operates in kernel mode
  - Be careful - different programming rules, conventions, etc.

Programming in kernel mode

- Can't use application libraries (i.e. libc); can only use functions defined by kernel
  - Can't use *printf*, for example: use *printk* instead
- Different set of header files
- Can't trust user space
  - Unsafe to directly access a pointer passed from user space
  - More details later

Linux development hints

- No man pages for Linux kernel functions!
  - Documentation/ directory in kernel source code
  - "The code is the documentation"

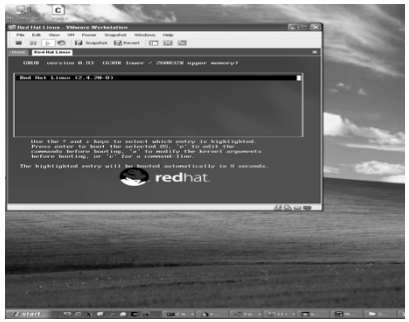
Navigating Linux code

- Invaluable tools:
  - ctags
  - cscope
- Linux Cross Reference (LXR)
  - http://lxr.linux.no/linux+v2.6.13/

Computing resources

- Develop your code on forkbomb
- Test your code on VMware PCs in 006
- **Do not use attu**

VMware



- Software simulation of x86 architecture
- Run an OS in a sandbox
  - Easily reset to known good state

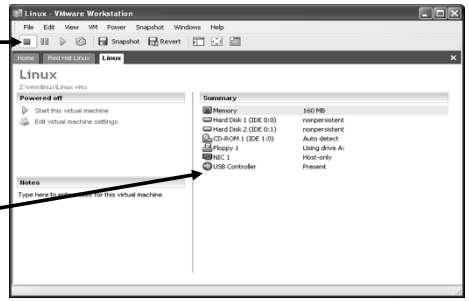
Using VMware

- Go through project setup first
  - http://www.cs.washington.edu/education/courses/cse451/10au/projinfo.htm

Using VMware

Power on / off, reset

VMWare config: **don't change!**



Using VMware

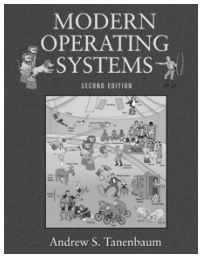
- All disks are non-persistent
  - Powering off loses your changes!
  - To reboot:
    - *shutdown –r now*

Using VMware

- There is only one user: root (password: rootpassword)
- You will need to:
  - Build a Linux kernel image on forkbomb
  - Run VMware Player on Windows or Linux desktop
  - Transfer kernel image to VM (use scp)
  - Boot your kernel in VM

Legends of computer science

- Andrew Tanenbaum: in class tomorrow!



- Come early to get a seat