CSE 451 Section #3

- Project 0 Recap
- Project 1 Overview
- Shells & System Calls
- Sean's awesome examples

Project 0

- Part 1:
  - Mean = 1.59
  - Median = 2
- Part 2:
  - Mean = 1.32
  - Median = 1

Project 0 Part 1 Problems

- Sort didn't work
  - Need to test on more than 4 values!
  - Need non-deterministic tests!
- Failed to free(oldHead)
  - Memory leak...
  - Free *after* last access to variable

Project 0 Part 2 Problem #1

- Comparing key pointers directly
  - key == ht[loc].key
    Not OK in general, or for this project!
  - hash_func(key) == hash_func(ht[loc].key)
    OK for this project, but not OK in general
  - equals_func(key, ht[loc].key)
    Best solution, not required for this class

Project 0 Part 2 Problem #2

- Linear probing misunderstandings
  - If using linear probing, you MUST mark a cell as vacated, which is different than free
- Consider hash table size of 10
  - Insert key1, hash = 5 & Insert key2, hash = 15
  - Occupy positions 5 & 6
  - Delete key1
  - Lookup key2 – 5 is empty but need to look at six also

Project 1

- Your first *Operating System* project.
- Goals:
  - To understand the relationship between shells, system calls, and the kernel
  - To become familiar with the tools and skills needed to understand, modify, compile, install, and debug the Linux kernel
  - To design and implement an extremely simple shell and system call

Project 1

- Teaches you:
  - how to handle processes
  - how to build & run Linux in VMware
- Two main parts:
  - Write a simple shell in C
  - Add a simple system call to Linux kernel
- Due: Friday, April 24, 2009 at 11:59pm
  - Electronic turnin: code + writeup

The shell

- What is it?

The shell

- "A program that works with the operating system as a command processor, used to enter commands and initiate their execution."

  -- *American Heritage ® Dictionary of the English Language*

- Examples of shells:
  - UNIX: bash, csh, …
  - Windows: command prompt

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)
  - Examples?
- External commands
  - Examples?
- How can you tell external from internal?

Other UNIX shell capabilities

- Redirect stdin / stdout / stderr

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

- Background execution of process

```
# ./my_parser < logfile > outfile 2> errfile &
```

- Command pipelines

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

The CSE451 shell

- Print out prompt
- Accept input
- Parse input
- If built-in command
  - do it directly
- Else spawn new process
  - Launch specified program
  - Wait for it to finish
- Repeat

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

CSE451 Shell Hints

- In your shell:
  - Use *fork* to create a child process
  - Use *execvp* to execute a specified program
  - Use *wait* to wait until child process terminates
- Useful library functions (see man pages):
  - Strings: *strcmp*, *strncpy*, *strtok*, *atoi*
  - I/O: *fgets*
  - Error report: *perror*
  - Environment variables: *getenv*

System Calls

- What's a system call?
- Examples?
- How do system calls compare to library calls?

System calls & library calls

- System call
  - Using some OS service
  - Process/Signal/File/Network/IPC/…
- Library call
  - Not using any OS service
  - Provide a high level interface for OS service
- What happens when we call
  - strncpy(3) ?
  - fgets(3) ?

Project 1: Adding a System Call

- Add *execcounts* system call to Linux:
  - Purpose: collect statistics
  - Count number of times you call *fork*, *vfork*, *clone*, and *exec* system calls.
- Steps:
  - Modify kernel to keep track of this information
  - Add *execcounts* to return the counts to the user
  - Use *execcounts* in your shell to get this data from kernel and print it out.

Example of execcounts

```
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%
Clone:                  0       0%
VFork:                  0       0%
Exec:                   8       72%
CSE451Shell% exit
```

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 (e.g. libc)
  - E.g. can't use printf
- Use only functions defined by the kernel
  - E.g. use printk instead
- Include files are different in the kernel
- Don't forget you're in kernel space
  - *You cannot trust user space*
  - E.g. unsafe to access a pointer from user space directly

Kernel development hints

- Best way to learn: read existing code
- Use grep –r *search_string* *
- Use LXR (Linux Cross Reference):
  - *http://lxr.linux.no/*

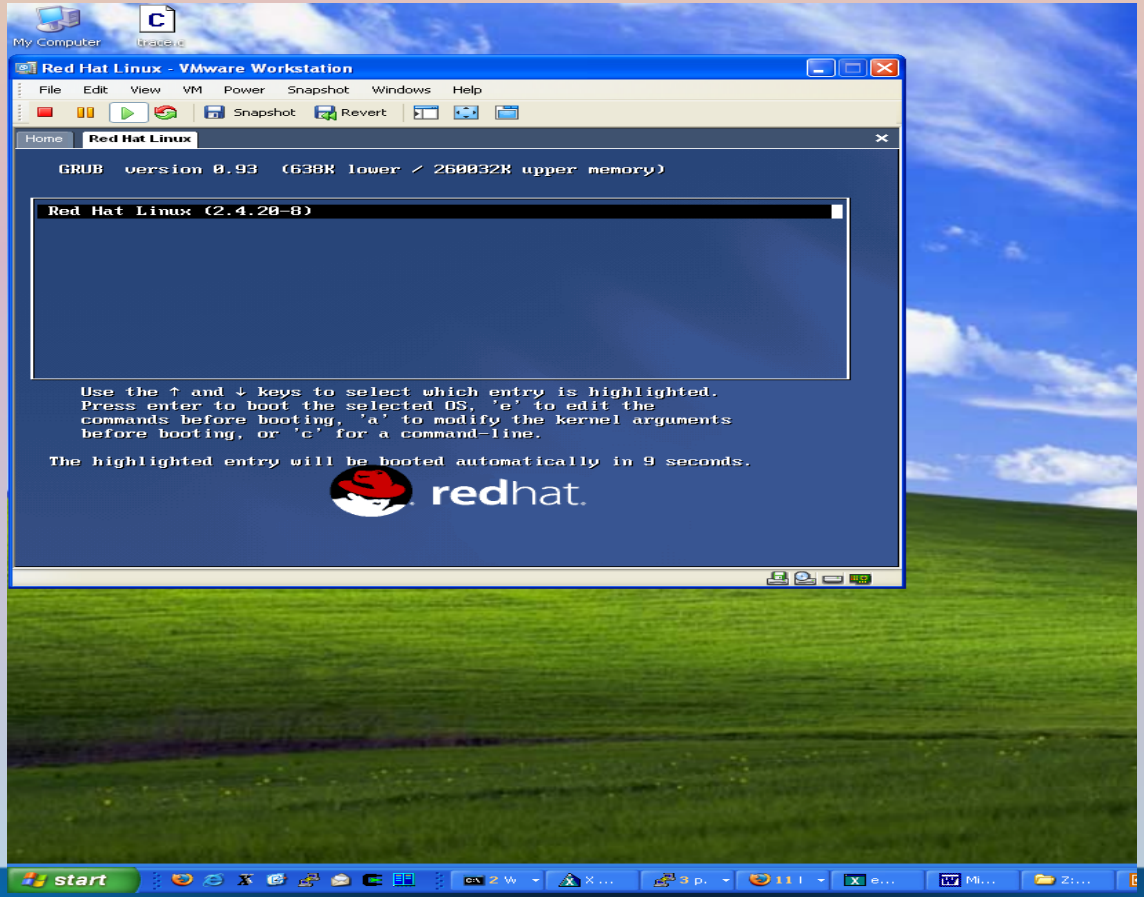
Computing Resources

- 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

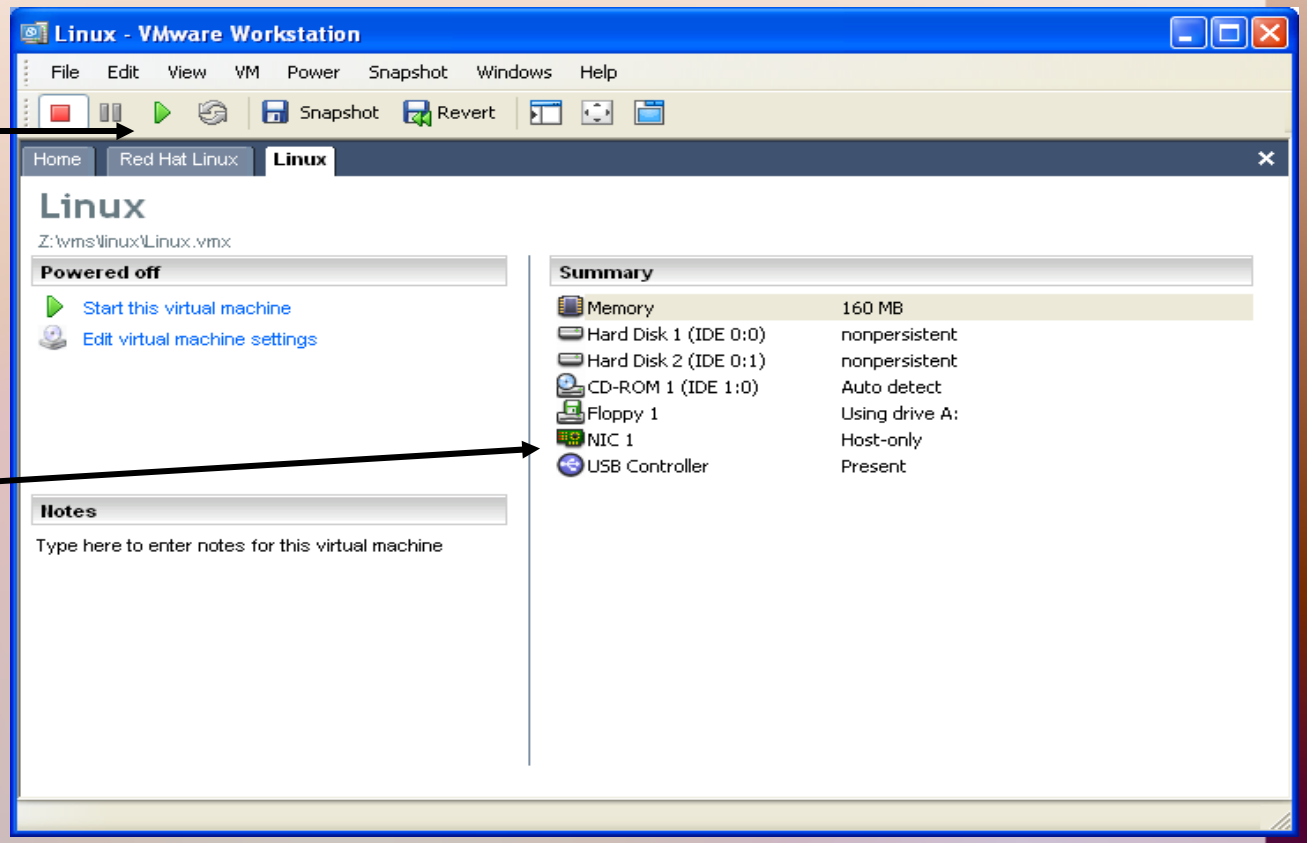


Using VMWare

Power on/off, reset

VMWare config

Don't change!



- All disks are nonpersistent
  - *Powering off loses your changes!* Use "shutdown –r now" instead

Linux & VMware

- There is only one user: *root* (password: *rootpassword*)
- You will need to:
  - Build a kernel image on forkbomb
  - Transfer it to Linux running inside VMware (you can use scp from the hosting OS)
  - Boot your new Linux kernel in VMware
- Instructions at:
  http://www.cs.washington.edu/education/courses/451/09sp/projinfo.html