Virtualization, Compilation, Intro to Project 2

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COP4610 / CGS5765
Kernel Coding

The next project requires modification of running kernel code!

- Fun but challenging….
A Choice to Make…

- You may either work in the lab (LOV 16) on bare machines or on your own system with a virtual machine
- Project 2 will require a live demo
  - Can go down to lab
  - Can bring virtual machine on laptop to my office
  - Can bring virtual machine on portable hard drive to my office
Virtualization
Virtual Motivating Factor

Wouldn’t it be great if we could run a test OS in a protected environment inside of our already-installed OS?
Virtualization Software

- Runs operating systems in full emulated environment
  - VMware
  - VirtualBox
  - Virtual PC
  - Xen
Virtualization Terminology

- **Host OS** – running on physical computer
  - Only one host OS may run at a time
  - “Hosts” the other running operating systems
- **Guest OS** – running in emulated environment
  - Can run multiple guests at the same time
  - Guest *thinks* it is running on actual hardware
- **Virtual machine** – set of files that make up a guest OS
Virtual Machine Files

![Virtual Machine Files](image)

- **COP4610.vmx.lck**
  - **Date modified**: 9/12/2010 10:07 PM
  - **Type**: File folder
  - **Size**: 9 KB
- **COP4610.nvram**
  - **Date modified**: 9/8/2010 1:38 PM
  - **Type**: VMware virtual machine BIOS
  - **Size**: 1 KB
- **COP4610.vmdk**
  - **Date modified**: 9/7/2010 3:54 PM
  - **Type**: VMware virtual disk file
  - **Size**: 0 KB
- **COP4610.vmsd**
  - **Date modified**: 8/17/2010 1:25 PM
  - **Type**: VMware snapshot metadata
  - **Size**: 2 KB
- **COP4610.vmx**
  - **Date modified**: 8/17/2010 1:25 PM
  - **Type**: VMware virtual machine configuration
  - **Size**: 1 KB
- **COP4610.vmf**
  - **Date modified**: 9/8/2010 1:38 PM
  - **Type**: VMware team member
  - **Size**: 1 KB
- **COP4610-s001.vmdk**
  - **Date modified**: 8/8/2010 1:38 PM
  - **Type**: VMware virtual disk file
  - **Size**: 1,831,488 KB
- **COP4610-s002.vmdk**
  - **Date modified**: 9/8/2010 1:38 PM
  - **Type**: VMware virtual disk file
  - **Size**: 1,982,592 KB
- **COP4610-s003.vmdk**
  - **Date modified**: 8/8/2010 1:38 PM
  - **Type**: VMware virtual disk file
  - **Size**: 1,906,944 KB
- **COP4610-s004.vmdk**
  - **Date modified**: 8/8/2010 1:38 PM
  - **Type**: VMware virtual disk file
  - **Size**: 136,960 KB
- **COP4610-s005.vmdk**
  - **Date modified**: 8/8/2010 1:38 PM
  - **Type**: VMware virtual disk file
  - **Size**: 64 KB
- **vmware.log**
  - **Date modified**: 9/8/2010 1:38 PM
  - **Type**: Text Document
  - **Size**: 72 KB
- **vmware-0.log**
  - **Date modified**: 8/25/2010 3:50 PM
  - **Type**: Text Document
  - **Size**: 67 KB
- **vmware-1.log**
  - **Date modified**: 8/25/2010 12:52 PM
  - **Type**: Text Document
  - **Size**: 89 KB
- **vmware-2.log**
  - **Date modified**: 8/25/2010 12:32 PM
  - **Type**: Text Document
  - **Size**: 63 KB

There are 15 items in total.
Virtual Machine Advantages

- Can distribute a pre-configured OS
- Create multiple snapshots
  - If something goes wrong, roll-back to a previously saved snapshot
- Portable
  - Run on any host OS
  - Store on portable hard drive or laptop
Virtual Machine Advantages

- Sandbox
  - Does not affect anything on host OS
- Networked
  - Can access over the network
Class Virtualization Software

- VMware Workstation 6.5.4
  - Linux and Windows
  - [http://downloads.vmware.com/d/info/desktop_downloads/vmware_workstation/6_5](http://downloads.vmware.com/d/info/desktop_downloads/vmware_workstation/6_5)

- VMware Fusion
  - Mac

- Academic license will be sent to class in email
Project Virtual Machine

- May use class virtual machine to complete Project 2
  - http://www.cs.fsu.edu/~cop4610t/cop4610.tar.gz
Open the Virtual Machine

- Vmware interface:
  - File->Open…->COP4610.vmx
- Double-click on “COP4610.vmx”
Opened Virtual Machine
Virtual Memory Setting

- You should set the amount of memory that is allocated to your guest OS
  - Cannot be shared between host and guest
- Edit Virtual Machine Settings -> Hardware -> Memory
- Rule of thumb: Give your host at least 1GB-1.5GB, give guest the rest
Adjust Virtual Memory
Adjust Virtual Memory

Slide to blue triangle
Start the Machine

- Press green start arrow
Using the Virtual Machine

- To type or use the mouse inside the virtual machine
  - Click inside the virtual machine window

- To type or move the mouse back to the host machine
  - Press CTRL+ALT
Creating a Snapshot

- Why would we want to create a snapshot?
Create a Snapshot
Create a Snapshot

- Name it something that describes this moment in time

![Snapshot creation interface](image-url)
Roll Back to a Snapshot

Not starting internet superserver: no services enabled.
Starting DHCP D-Bus daemon: dhcdbus.
Starting Hardware abstraction layer: hal.
Starting network connection manager: NetworkManager.
Starting network events dispatcher: NetworkManagerDispatcher.
Starting GNOME Display Manager: gdm.
Starting anac(h)ronistic cron: anacron.
Starting deferred execution scheduler: atd.
Starting periodic command scheduler: crond.

Debian GNU/Linux 5.0 cop4610 tty1

cop4610 login: root
Password:
Last login: Wed Aug 18 20:12:36 EDT 2010 on tty1
Linux cop4610 2.6.26-2-686 #1 SMP Mon Jun 21 05:58:44 UTC 2010 i686

The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.

cop4610:~ #

To direct input to this VM, click inside or press Ctrl+G.
Roll Back to a Snapshot
Copy & Paste / File Transfer

- Copy & paste from host to guest
  - Will work in default kernel
  - Will not work in kernel you build

- Preferred method
  - Use ssh / pretend it is a remote machine
Project 2 Virtual Machine

- Username: root
- Password: root

- Username: user
- Password: user

- You can and probably should change these
Lab Machines

- If you sent me your FSU card # and pin #, you now have access to the room
- Use computers on right half of lab
  - All but last row
- Username/passwords
  - os/os
  - root/root
  - Change these to show your computer is taken!
Lab Machines

- Must develop directly on bare machines
  - Not enough memory to run virtual machine environment!
- Debian 5.0 Stable
  - Same OS as virtual machines
Booting

GNU GRUB  version 0.97  (638K lower / 2095040K upper memory)

Debian GNU/Linux, kernel 2.6.26-2-686
Debian GNU/Linux, kernel 2.6.26-2-686 (single-user mode)

Use the ↑ and ↓ keys to select which entry is highlighted. Press enter to boot the selected OS, 'e' to edit the commands before booting, or 'c' for a command-line.

The highlighted entry will be booted automatically in 4 seconds.
Booting

Start with this kernel – never modify this kernel!

Debian GNU/Linux, kernel 2.6.26-2-686
Debian GNU/Linux, kernel 2.6.26-2-686 (single-user mode)

Use the ↑ and ↓ keys to select which entry is highlighted. Press enter to boot the selected OS, 'e' to edit the commands before booting, or 'c' for a command-line.

The highlighted entry will be booted automatically in 4 seconds.
Booting

This kernel is only if you really get into trouble...
Debian Networking

- I like to ssh into my virtual machine
- To figure out guest’s IP:
  $>/sbin/ifconfig -a

- To restart guest networking (if problem)
  $>dhclient eth<num>

where num found using the ifconfig command
Debian Networking

cop4610:~# ifconfig -a
eth0    Link encap:Ethernet  HWaddr 00:0c:29:6e:38:f5
        inet6 addr: fe80::20c:29ff:fe6e:38f5/64 Scope:Link
        UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
        RX packets:12 errors:0 dropped:0 overruns:0 frame:0
        TX packets:68 errors:0 dropped:0 overruns:0 carrier:0
        collisions:0 txqueuelen:1000
        RX bytes:2073 (2.0 KiB)  TX bytes:12103 (11.8 KiB)
        Interrupt:19 Base address:0x2024

lo      Link encap:Local Loopback
        inet addr:127.0.0.1  Mask:255.0.0.0
        inet6 addr: ::1/128 Scope:Host
        UP LOOPBACK RUNNING  MTU:16436  Metric:1
        RX packets:0 errors:0 dropped:0 overruns:0 frame:0
        TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
        collisions:0 txqueuelen:0
        RX bytes:560 (560.0 B)  TX bytes:560 (560.0 B)
Debian Networking

cop4610:~# dhclient eth0
Internet Systems Consortium DHCP Client V3.1.1
All rights reserved.
For info, please visit http://www.isc.org/sw/dhcp/

Listening on LPF/eth0/00:0c:29:6e:38:f5
Sending on LPF/eth0/00:0c:29:6e:38:f5
Sending on Socket/fallback
DHCPDISCOVER on eth0 to 255.255.255.255 port 67 interval 8
DHCPOFFER from 192.168.216.254
DHCPREQUEST on eth0 to 255.255.255.255 port 67
DHCPACK from 192.168.216.254
bound to 192.168.216.129 -- renewal in 819 seconds.
cop4610:~# _
Debian Packaging System

- Search for a package name
  
  \$> apt-cache search SEARCH_STRING

- Show the details of a package
  
  \$> apt-cache show PACKAGE_NAME

- Download a specific package
  
  \$> apt-get install PACKAGE_NAME
Debian Packaging System

cop4610:~# apt-cache search cowsay
cowsay - A configurable talking cow

cop4610:~# apt-get install cowsay
Reading package lists... Done
Building dependency tree
Reading state information... Done
Suggested packages:
  filters
The following NEW packages will be installed:
  cowsay

0 upgraded, 1 newly installed, 0 to remove and 40 not upgraded.
Need to get 19.8kB of archives.
After this operation, 295kB of additional disk space will be used.
Fetched 19.8kB in 0s (45.2kB/s)
Selecting previously deselected package cowsay.
(Reading database ... 110626 files and directories currently installed.)
Unpacking cowsay (from .../cowsay_3.03-9.2_all.deb) ...
Processing triggers for man-db ...
Setting up cowsay (3.03-9.2) ...
cop4610:~# _
Debian Logging into X

- Must use the “user” user
  - Debian does not allow root X logins
Disclaimer

- But I want to use <X> distro or <X> virtualization software instead….
  - Ok, but…
- I will not help you with configuration problems!
Kernel Compilation
Example of Kernel Compilation....
Choosing a Kernel

- The next project will involve kernel development
  - We all need to be in the same boat…
- The class version will be 2.6.32
Kernel Repository

- [http://kernel.org](http://kernel.org) – place to download latest and greatest Linux kernels!
- Direct download link
- Traditional place for kernel is in /usr/src/
Compiling the Kernel

- Compiles based on configuration of .config file located in the kernel source directory

How can I correctly configure my kernel?

1. Use the ‘make menuconfig’ command
2. Use the ‘make oldconfig’ command
3. Combination of the two
‘make menuconfig’

- Manually select and deselect drivers and options for your kernel
  - * -- compiled directly into kernel
  - M – compiled into a module (driver) that can be dynamically added

- Can be tough to figure out what you need and don’t need
  - Command ‘lspci’ shows hardware on computer
'make menuconfig'
‘lspci’

```
user@cop4610:~$ lspci
00:00.0 Host bridge: Intel Corporation 440BX/ZX/DX - 82443BX/ZX/DX Host bridge (rev 01)
00:01.0 PCI bridge: Intel Corporation 440BX/ZX/DX - 82443BX/ZX/DX AGP bridge (rev 01)
00:07.0 ISA bridge: Intel Corporation 82371AB/EB/MB PIIX4 ISA (rev 08)
00:07.1 IDE interface: Intel Corporation 82371AB/EB/MB PIIX4 IDE (rev 01)
00:07.3 Bridge: Intel Corporation 82371AB/EB/MB PIIX4 ACPI (rev 08)
00:07.7 System peripheral: VMware Inc Virtual Machine Communication Interface (rev 10)
00:0f.0 VGA compatible controller: VMware Inc Abstract SVGA II Adapter
00:10.0 SCSI storage controller: LSI Logic / Symbios Logic 53c1030 PCI-X Fusion-MPT Dual Ultra320 SCSI (rev 01)
00:11.0 PCI bridge: VMware Inc Device 0790 (rev 02)
00:15.0 PCI bridge: VMware Inc Device 07a0 (rev 01)
02:00.0 USB Controller: Intel Corporation 82371AB/EB/MB PIIX4 USB
02:01.0 Ethernet controller: Advanced Micro Devices [AMD] 79c970 [PCnet32 LANCE] (rev 10)
02:02.0 Multimedia audio controller: Ensoniq ES1371 [AudioPCI-97] (rev 02)
02:03.0 USB Controller: VMware Inc Abstract USB2 EHCI Controller
user@cop4610:~$ 
```
General Linux Source Organization

- Memory Management
- Networking Layer
- Security
- Sound Processing
- Architecture-specific Code
- Disk Drivers
- Devices
- File Systems
‘make oldconfig’

Build a new configuration file based on an old working configuration file!

1. **Find** a working configuration file
   - Look in `/boot` for the current kernel’s config file
2. **Copy** (don’t move) the current kernel’s config file into the new kernel source and rename it to ‘.config’
3. **Issue** command ‘make oldconfig’ inside the new kernel source
4. **Accept** new default changes
Combine the Methods

- Can use ‘make oldconfig’ to get a working config file
- Can use ‘make menuconfig’ to take some unneeded things out of the new kernel
  - Saves time when compiling
Config Example (Inside Source Dir)

>`$ cp /boot/config-2.6.26-2-686 .config`

>`$ make oldconfig`

>`$ make menuconfig`
Compiling the Kernel

- Issue ‘make’ inside the source directory

$> make

- Grab some coffee....
Installing the Kernel

1. Install the modules (drivers)
   - $> \text{sudo make modules\_install}$

2. Install the actual kernel
   - $> \text{sudo make install}$

- What does ‘sudo’ do?
Boot Driver Problem

- Suppose you compiled the disk drivers and root file system drivers as modules
  - Boot process loads the kernel image
  - Kernel image does not contain disk drivers
Boot Driver Solutions

- **Hard**: Figure out all drivers needed to read the root file system and compile into kernel
  - May take a few tries…
- **Easy**: Create a root file system image file that will load the right modules for you
  - initramfs
initramfs

- Create the initramfs image

$> cd /boot

$> sudo mknitramfs -o /boot/initrd.img-2.6.32

2.6.32
Configure the Boot Loader (Grub)

- Open up the boot loader configuration file

```bash
$> sudo <favorite_editor>
/boot/grub/menu.lst
```
Configure the Boot Loader (Grub)

- Add information about your new kernel
  - Hint: copy section pertaining to current kernel, substitute kernel numbers

```
title          Debian GNU/Linux, kernel 2.6.32
root           (hd0,0)
kernels        /boot/vmlinux-2.6.32 root=/dev/sda1 ro quiet
initrd          /boot/initrd.img-2.6.32
```

- Save, quit, and reboot!
- (Default booting kernel is on top of the list)
Uh oh….

- If it doesn’t boot, go back into the original kernel
  - Always important to have one working kernel!
- Make sure you didn’t skip a step…
- You may have taken too much out of the kernel…
  - Start with bloated kernel, take things out one by one
- Look to additional resources…
Additional Resources

- http://www.tuxradar.com/content/how-compile-linux-kernel
Project 2

- Investigate system calls
- Make a simple /proc kernel module
  - /proc from the other side!!
- Make an elevator
- Due October 18th
System Calls

- Write a program that uses exactly 5 system calls
  - Not ANSI C calls, POSIX system calls…
- How do we know how many system calls are actually being called…?
strace

strace [-o output_file] [command [arg...]]

- Traces your program and displays all the system calls being called.

> $ strace -o out.txt ./myprog
Until Next Time

- Finish project 1
- Homework 4 assigned tomorrow
- Study hard for test next week (next Friday)
- Get your environment set up
  - VMware or lab machine
- Do part 1 of project 2 (system calls)
Next Recitation

- More on Project 2
  - Create a test module!
  - How /proc works
  - Kernel debugging techniques
  - Elevator