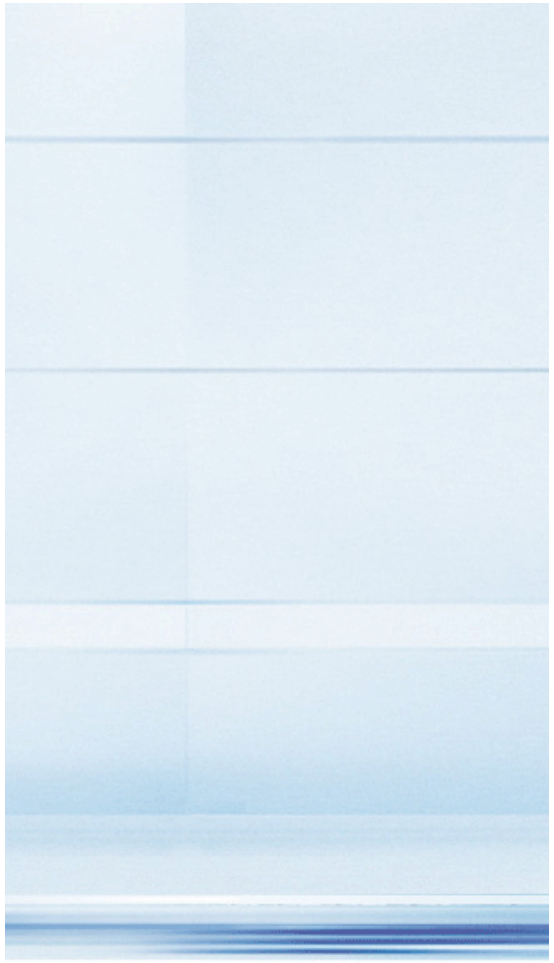

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Linux Basics

An Introductory Exploration for those wishing to understand the Linux Operating System

Neale Ferguson
Sine Nomine Associates

Objectives

- **Develop a feel for and an understanding of Linux**
  - Kernel
  - File systems
  - Device Drivers
- **Be able to interact on the command line**
  - Common commands
  - Navigation through file systems
- **Be able to perform the lab exercises back at the office**
  - Use "knoppix" www.knoppix.org to obtain an ISO image of bootable linux system that won't overwrite your disk
  - Boot it, do the labs, remove DVD, reboot original system

Class Agenda...

- **Logically - Two parts of class**
  - Part 1
    - Linux Concepts
    - Getting Started
    - Daemons
    - File Systems

Class Agenda

- Part 2
  - Accessing Your Data
  - vi – The System Editor
  - Self-study

    bash – The Scripting Language

    Never really divides into 2 equal parts!

The Linux Kernel

A quick look under the covers

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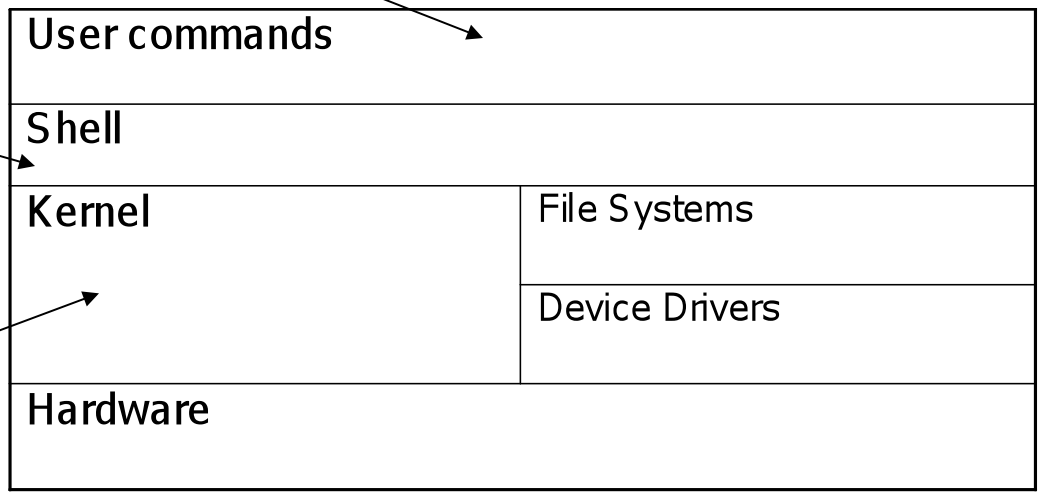
The Linux System

User commands includes executable programs and scripts

The shell interprets user commands. It is responsible for finding the commands and starting their execution. Several different shells are available. Bash is popular.

The kernel manages the hardware resources for the rest of the system.



The Kernel Layer

- Basic Operating System
- Device support
- Memory Management
- Process Management
- Interface to the hardware
- A set of APIs
- TCP/IP integrated into kernel

Kernel - Processes

- **Processes are the basic dispatchable unit of work**
- **Processes may belong to a "Process Group"**
  - Linux's implementation of threads

Device Layer

- **Exploits API from kernel**
- **Register driver with kernel**
- **Handle I/O requests for "type" of device**
- **Examples:**
  - DASD
  - VDU
  - Tape

File Systems

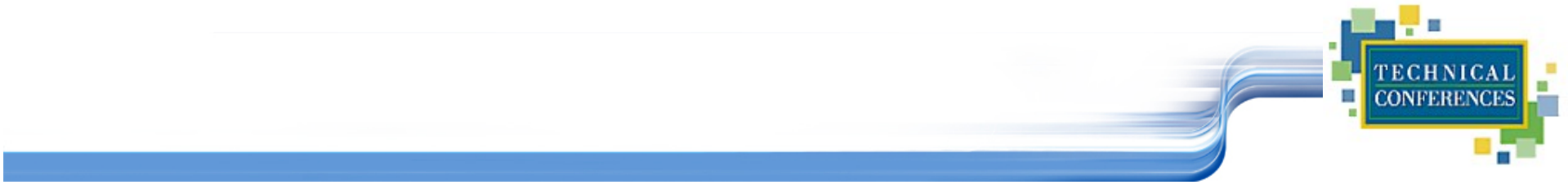
- An layer of abstraction between underlying file scheme and device(s) [if any!]
- VFS provides a single API between user and file system
- Handles “mounting”, I/O requests that get implemented (eventually) by a device driver

Shells

- Interface between user and kernel
- Can be more than one
- User can swap between them
- Command line and GUI
- More later…

Booting the Operating System

- Bootstrap read from initial medium
- Loads kernel
- Passes control to initialization
- Memory and I/O setup
- 1st process "init" started: all other processes are descendants of this one
- Invokes a shell
- Begins startup processes




```
IPL 151 CLEAR
Booting default (linux-2.6.32-220.cl6.s390x)...
Initializing cgroup subsys cpuset
Initializing cgroup subsys cpu
Linux version 2.6.32-220.cl6.s390x (mockbuild@clefos-build-image02.devlab.sinenomine.net) (gcc
version 4.4.6 20110731 (Red Hat 4.4.6-3) (GCC) ) #1 SMP Tue May 22 05:37:15 EDT 2012
setup: Linux is running as a z/VM guest operating system in 64-bit mode
Zone PFN ranges:
DMA      0x00000000 -> 0x00080000
Normal   0x00080000 -> 0x00080000
Movable zone start PFN for each node
early_node_map[1] active PFN ranges
0: 0x00000000 -> 0x00020000
PERCPU: Embedded 12 pages/cpu @00000000010e4000 s18688 r8192 d22272 u65536
pcpu-alloc: s18688 r8192 d22272 u65536 alloc=16*4096
:
Built 1 zonelists in Zone order, mobility grouping on.  Total pages: 129280
Kernel command line: root=/dev/disk/by-path/ccw-0.0.0201-part1 rd_NO_LUKS
LANG=en_US.UTF-8  KEYTABLE=us rd_NO_MD SYSFONT=latarcyrheb
-sun16 crashkernel=auto rd_NO_LVM rd_NO_DM rd_DASD=0.0.0201 hvc_iucv=5 BOOT_IMAGE=0
PID hash table entries: 2048 (order: 2, 16384 bytes)
Dentry cache hash table entries: 65536 (order: 7, 524288 bytes)
Inode-cache hash table entries: 32768 (order: 6, 262144 bytes)
Memory: 493288k/524288k available (4940k kernel code, 0k reserved, 3668k data, 256k init)
Write protected kernel read-only data: 0x100000 - 0x7fffff
```

```
cpu: 1 configured CPUs, 0 standby CPUs
cpu: Processor 0 started, address 0, identification 01B47B
Brought up 1 CPUs
:
IP route cache hash table entries: 4096 (order: 3, 32768 bytes)
TCP established hash table entries: 16384 (order: 6, 262144 bytes)
TCP bind hash table entries: 16384 (order: 6, 262144 bytes)
:
Trying to unpack rootfs image as initramfs...
Freeing initrd memory: 9193k freed
:
cio: Channel measurement facility initialized using format basic
(mode autodetected)
:
dasd-eckd 0.0.0201: New DASD 3390/0C (CU 3990/02) with 2500
cylinders, 15 heads,224 sectors
dasd-eckd 0.0.0201: DASD with 4 KB/block, 1800000 KB total size, 48
KB/track, compatible disk layout
dasda:VOL1/  SC0201: dasda1
```

```
EXT3-fs (dasda1): mounted filesystem with ordered data mode
dracut: Mounted root filesystem /dev/dasda1
:
                    Welcome to CentOS
Starting udev:
udev: starting version 147
qeth: loading core functions
qeth: register layer 2 discipline
qdio: 0.0.c602 OSA on SC 6 using AI:1 QEBSM:0 PCI:1 TDD:1 SIGA:RW AO
qeth 0.0.c600: MAC address 02:00:00:00:00:0f successfully registered
on device eth0
qeth 0.0.c600: Device is a Guest LAN QDIO card (level: V620)
with link type GuestLAN QDIO (portname: )
qeth 0.0.c600: The LAN is offline
:
Checking filesystems
Checking all file systems.
[/sbin/fsck.ext3 (1) -- /] fsck.ext3 -a /dev/dasda1
/dev/dasda1: clean, 20673/105056 files, 178383/449976 blocks[  OK  ]
Remounting root filesystem in read-write mode:  EXT3-fs (dasda1):
using internal journal
```

```
iptables: Flushing firewall rules:                         [  OK  ]
iptables: Setting chains to policy ACCEPT: filter          [  OK  ]
iptables: Unloading modules:                               [  OK  ]
iptables: Applying firewall rules:
ip_tables: (C) 2000-2006 Netfilter Core Team               [  OK  ]
30 Jul 09:37:53 ntpdate[1723]: no server suitable for synchronization found
Starting ntpd:                                             [  OK  ]
:
Starting sshd:                                             [  OK  ]
Starting cpi:                                              [  OK  ]
Loading VMCP device driver:                                [  OK  ]
Starting the Primary Controller:
server params:  srv_name=srv1, srv_type="Generic", type=Primary Controller
NET: Registered protocol family 32
Configuring virtual networking environment for the grid
- shutting down network interfaces.....ok
- setting up virtual switches.............ok
- granting access to virtual switches.....ok
- linking server interfaces to vswitches…ok
- initializing network interfaces.....

Starting VRM (please ignore subsequent warnings):
Cleaning up possible leftover VM users with our prefix...
```

CentOS release 6.2 (Final)
Kernel 2.6.32-220.cl6.s390x on an s390x

Grid1-srv1 login:

Introduction to Linux

Basic Concepts

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Users and Groups

Users are identified by user identifications (UIDs), each of which is associated with an integer in the range of 0 to 4 294 967 295 (X'FFFFFFFF'). Users with UID=0 are given *superuser* privileges.

Users are placed in groups, identified by group identifications (GIDs). Each GID is associated with an integer in the range from 0 to 4 294 967 295

Let the system assign UID to avoid duplicates

Use `id` to display your user and group information

```
uid=500(neale) gid=500(neale) groups=500(neale),3(sys),4(adm)
```

Users and Groups

- Groups define functional areas/responsibilities
- They allow a collection of users to share files
- A user can belong to multiple groups
- You can see what groups you belong to using the `groups` command:

```
neale sys adm
```

Group Setup

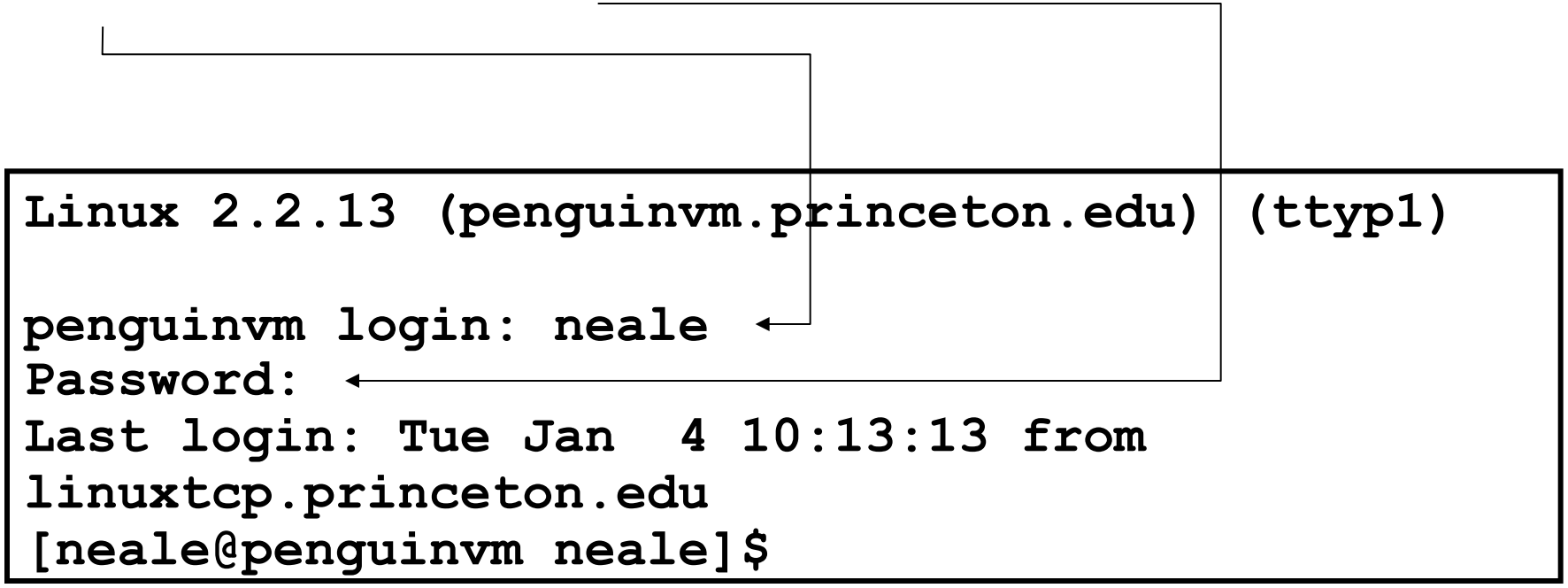
- **Typical**
  - sys
  - bin
  - adm
  - staff
  - users
- **Software AG**
  - odessy
  - adabasd
  - peport
  - pcc
  - intprod
  - network

Logging In

- **Connect to the Linux system using ssh:**
  - vt100, vt220, vt320
  - ansi
  - xterm
  - X-windows
- **Able to login more than once with same user**
- **No 'MW' problems!**

Logging In

- **Before you can use it you must login by specifying your account and password:**



Rule Number 1

- **Do not login as root unless you have to**
- **root is the superuser**
  - Protection mechanisms can be overridden
  - Careless use can cause damage
  - Has access to everything by default
- **root is only user defined when you install**
  - First thing is to change root's password
  - The second job is to define "normal" users for everyday use
- **Use the `su` command to switch users to root**
- **Use `sudo` command to issue privileged commands**

Creating a new user

- Use the `useradd` command
- Use the `passwd` command to set password

```
[root@penguinvm]# useradd scully
[root@penguinvm]# passwd scully
Changing password for user scully
New UNIX password:
Retype new UNIX password:
passwd: all authentication tokens updated
successfully
[root@penguinvm]#
```

Adding a new user

- **Limits on users can be controlled by**
  - Quotas
  - `ulimit` command
- **Authority levels for a user controlled by group membership**

Adding a New User

- **Writes a new entry in `/etc/passwd`**
- **Also in `/etc/shadow`**
- **Why?**
  - For security reasons
  - Explanation when we get to the section on files

Lab One

- **Use ssh to connect to the lab machine**
- **Login using ID supplied**
  - Userid **linlab***nn* where *nn* = 01-20
  - Password: linx101 -- PLEASE DO NOT CHANGE IT!
- **Logout using the `exit` or `logout` command**

Introduction to Linux

Command Basics

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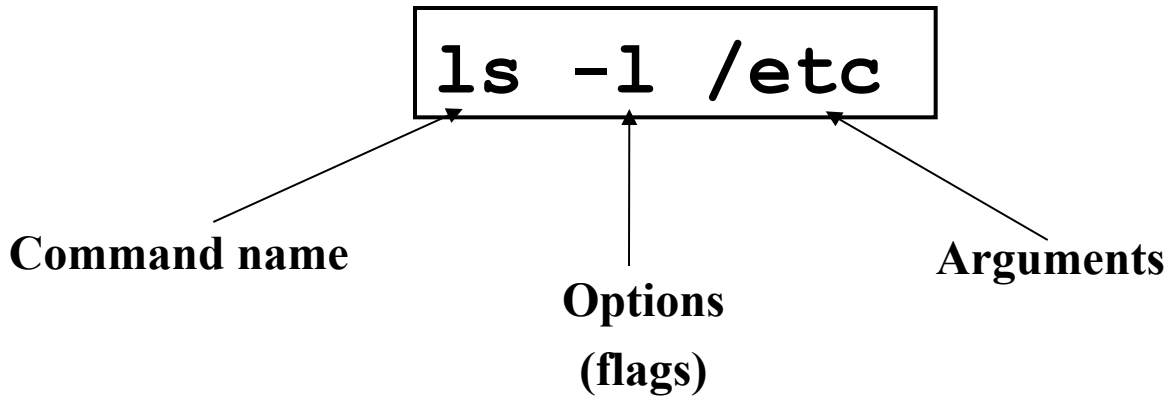
Linux Command Basics

- To execute a command, type its name and arguments at the command line



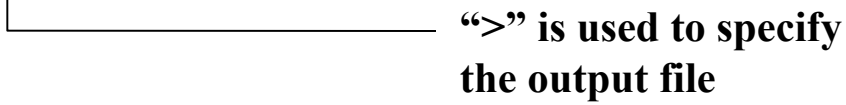
Standard Files

- **UNIX concept of "standard files"**
  - standard input (where a command gets its input) - default is the terminal
  - standard output (where a command writes it output) - default is the terminal
  - standard error (where a command writes error messages) - default is the terminal

Redirecting Output

- The output of a command may be sent to a file:

```
ls -l >output
```

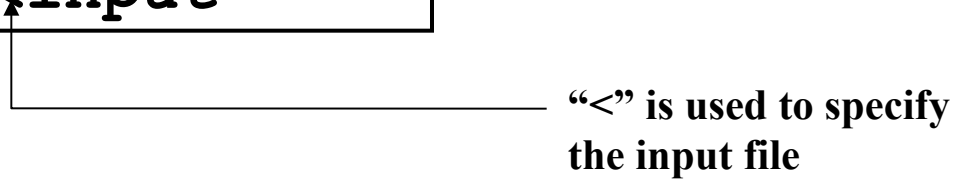


- To redirect the output of standard error use 2>
- To append to an existing file use >>

Redirecting Input

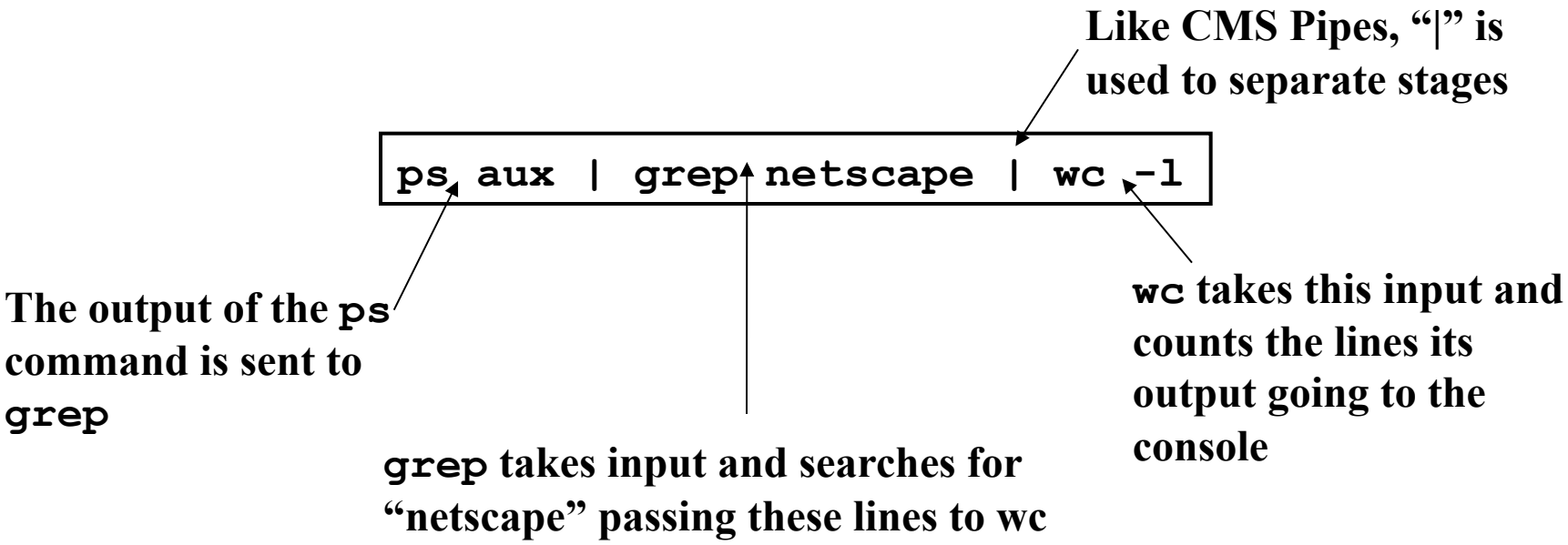
- The input of a command may come from a file:

```
wc <input
```



Connecting commands with Pipes

- **Not as powerful as CMS/TSO Pipes but the same principle**
- **The output of one command can become the input of another:**



Command Options

- **Command options allow you to control a command to a certain degree**
- **Conventions:**
  - Usually being with a single dash and are a single letter ("`-l`")
  - Sometimes have double dashes followed by a keyword ("`--help`")
  - Sometimes follow no pattern at all

You need help?

- **The Linux equivalent of HELP is `man` (manual)**
  - Use `man -k <keyword>` to find all commands with that keyword
  - Use `man <command>` to display help for that command
    - Output is presented a page at a time. Use `b` for to scroll backward, `f` or a space to scroll forward and `q` to quit

Common Commands

- `pwd` - print (display) the working directory
- `cd <dir>` - change the current working directory to *dir*
- `ls` - list the files in the current working directory
- `ls -l` - list the files in the current working directory in long format
- `shutdown -[hr] [now|time] [message]`
  - Shutdown or restart the system

More Commands

- **who** or **w**
  - List who is currently logged on to the system
- **whoami**
  - Report what user you are logged on as
- **ps**
  - List your processes on the system
- **ps aux**
  - List all the processes on the system
- ***echo "A string to be echoed"***
  - Echo a string (or list of arguments) to the terminal

Who's Logged On Right Now?

- The `w` command lists all users logged on right now

```
 5:16pm  up 2 days,  8:46,  1 user,  load average: 0.00, 0.00, 0.00
USER     TTY      FROM              LOGIN@   IDLE   JCPU   PCPU  WHAT
neale    ttyp0    websurfer.reston  4:28pm  1.00s  0.52s  0.18s  w
```

Lab Two

- **Logon to your test machine**
  - Get help on the `ls` command
  - Find out who else is on the system
  - What is your current directory
  - Redirect the output of the `ls -l /` command to `ls.output` and see what you get
  - Logout

Introduction to Linux

Daemons

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Agenda

- What are Daemons?
- Common Daemons
- Additional Daemons

The Daemon Concept

- **Daemons provide functions that are not available in the base operating system**
- **Comparable to**
  - Services in NT
  - Service Virtual Machines in VM
  - Started tasks and built-in subsystems in z/OS
- **Listen for work requests**
- **Perform service then disconnect**

Common Daemons

- **Apache - httpd / httpd2 / httpd2-prefork ...**
- **LDAP - sldapd**
- **DNS - bind**
- **sendmail**
- **Samba - smbd/nmbd**
- **FTP - ftpd**
- **Usenet - innd**
- **Superdaemon - inetd / xinetd**

INETD/XINETD

INETD/XINETD

- Internet Super Daemon
- Automatically starts other daemons upon request from client
- Can be used to start Samba, Apache, Daytime
- Can have multiple INET daemons
- Also has internal services
  - chargen
  - discard
  - Echo
- Configuration: /etc/inetd.conf or /etc/xinetd.d/…

Lab Three

- **ssh and Login to ID**
- **`ps -ef | more` -- Do you see any of the daemons we've talked about?**
  - httpd
  - inetd
- **Logout**

Introduction to Linux

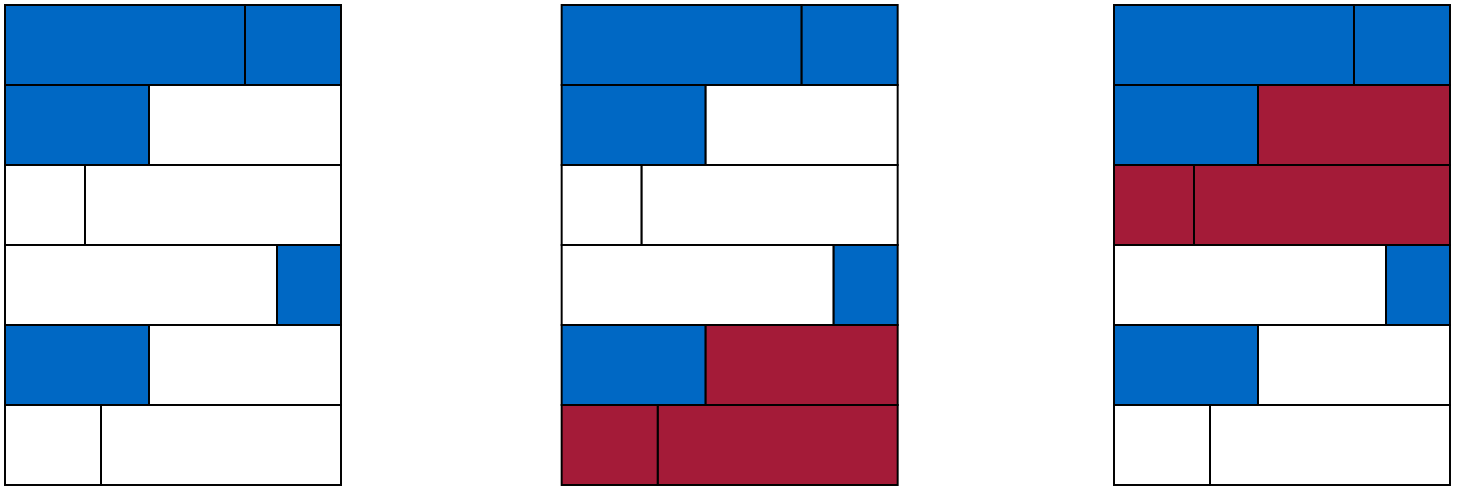
The Linux File Systems

Introduction to File Systems

- A file system is a way of storing data on a medium: the way it is organized and managed
- Examples: NTFS, HPFS, DOS, FAT, ext2, JFS, ISO9660
- Every media for data can be considered as an array of small units holding information (i.e. blocks)

Introduction to File Systems

- Every file system manages these blocks differently
- For example, insert a file that will use two blocks:



Introduction to File Systems

- **The most widely used on Linux is *ext2fs* (extended 2 file system)**
- **Every file is represented by an "inode"**
  - A file descriptor holding, among other things, file access permissions, physical block addresses holding data, etc.

About the Linux File Systems

- **Linux files reside on:**
  - Fullpack DASD
  - Minidisks
  - SCSI!
  - Partitions of any of the above
- **Linux supports multiple file systems:**
  - extfs2
  - fat/vfat
  - hpfs
  - jfs

Linux Device Handling

- **Devices are the way Linux talks to the world**
- **Devices are special files in the `/dev` directory (try `ls /dev`)**

/dev/ttyx	TTY devices
/dev/hdb	IDE hard drive
/dev/hdb1	Partition 1 on the IDE hard drive
/dev/dasda	ECKD/CKD/FBA DASD
/dev/dasda1	Partition 1 on DASD
/dev/null	The null device (“hole”)
/dev/zero	An endless stream of zeroes
/dev/mouse	Mouse (not /390)

Devices and Drivers

- **Each `/dev` file has a major and minor number**
  - Major defines the device type
  - Minor defines device within that type
  - Drivers register a device type

```
brw-r--r--   1 root     root       64,   0 Jun  1  1999 /dev/mnda
crw-r--r--   1 root     root        5,   0 Jan  5 09:18 /dev/tty
```

Special Files - /proc

- **Information about internal Linux processes are accessible to users via the `/proc` file system (in memory)**

/proc/cpuinfo	**CPU Information**
/proc/interrupts	**Interrupt usage**
/proc/version	**Kernel version**
/proc/modules	**Active modules**

```
cat /proc/cpuinfo
vendor_id       : IBM/S390
# processors    : 1
bogomips per cpu: 86.83
processor 0: version = FF, identification = 045226, machine = 9672
```

File Systems

- **Linux supports many different types**
- **Most commonly, ext2fs**
  - Filenames of 255 characters
  - File sizes up to 2GB
  - Theoretical limit 4TB
- **Derived from extfs**
- **Highly reliable and high performer**

File Systems

Other file systems:

- sysv - SCO/Xenix
- ufs - SunOS/BSD
- vfat - Win9x
- msdos - MS-DOS/Win
- umsdos - Linux/DOS
- ntfs - WinNT (r/o)
- hpfs - OS/2
- cms - CMS (r/o)

Other File systems:

- iso9660 (CD-ROM)
- nfs - NFS
- coda - NFS-like
- ncp - Novell
- smb - LANManager
- afs - Andrew File System

File Systems

- **mount**
  - Mounts a file system that lives on a device to the main file tree
  - Start at Root file system
    - Mount to root
    - Mount to points currently defined to root
  - **/etc/fstab** used to establish boot time mounting

```
/dev/dasda1     /              ext2    defaults,errors=remount-ro 0 1
/dev/dasdb1     /bin           ext2    defaults,errors=remount-ro 0 1
/dev/dasdc1     /usr           ext2    defaults,errors=remount-ro 0 1
/dev/dasdd1     /usr/local     ext2    defaults,errors=remount-ro 0 1
/dev/dasde1     /usr/man       ext2    defaults,errors=remount-ro 0 1
/dev/dasdf1     /home          ext2    defaults,errors=remount-ro 0 1
/dev/dasdg1     swap           swap    defaults     0        0
none            /proc          proc    defaults     0        0
```

File Systems

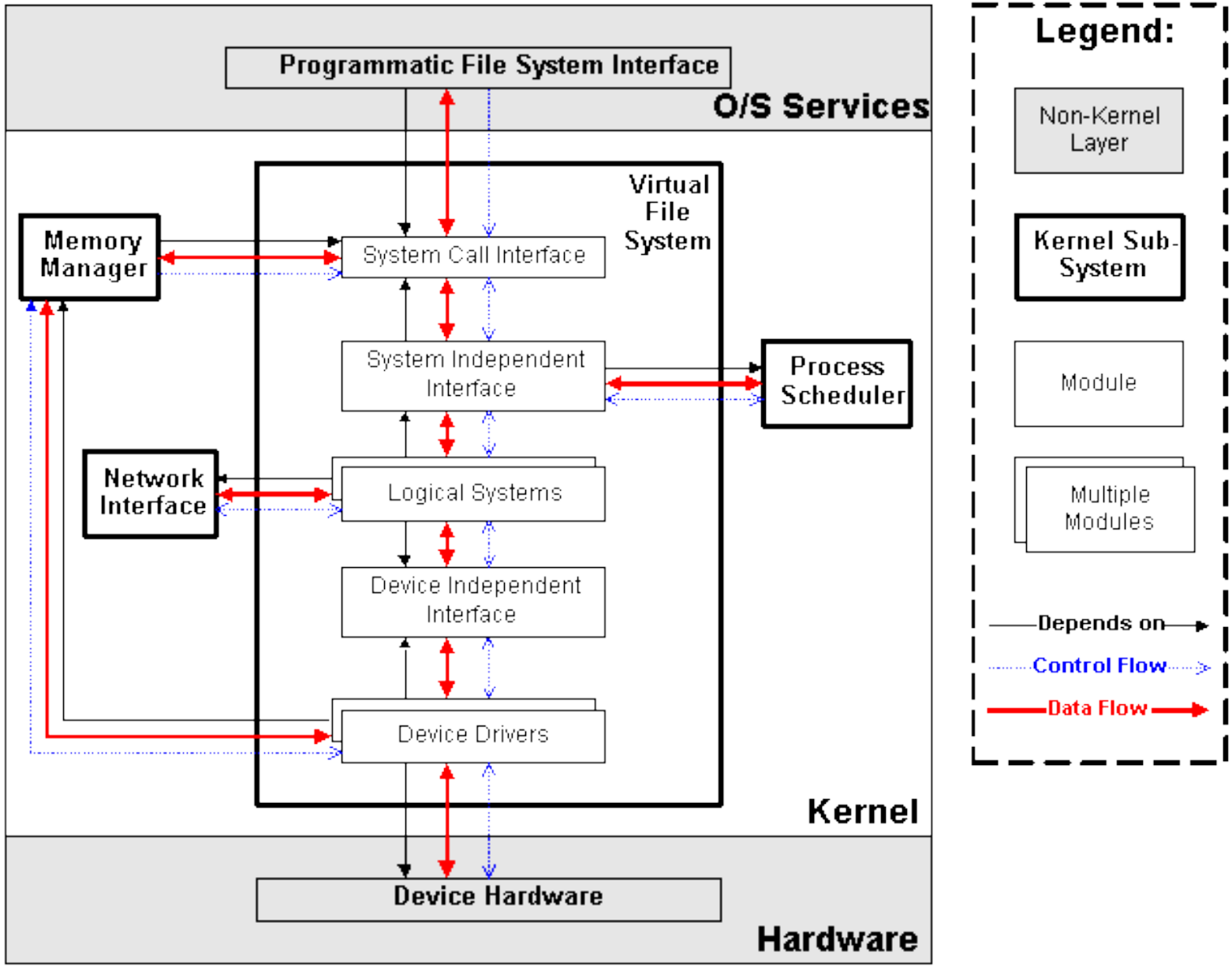
- **You can view what file systems are mounted using either:**
  - `mount`
  - `df`

Virtual File System

- **VFS is designed to present a consistent view of data as stored on hardware**
- **Almost all hardware devices are represented using a generic interface**
- **VFS goes further, allowing the sysadmin to mount *any* of a set of logical file systems on *any* physical device**

Virtual File System

- **Analogous to CMS:**
  - SFS
  - Minidisks
- **Two different designs**
- **Common/transparent access**

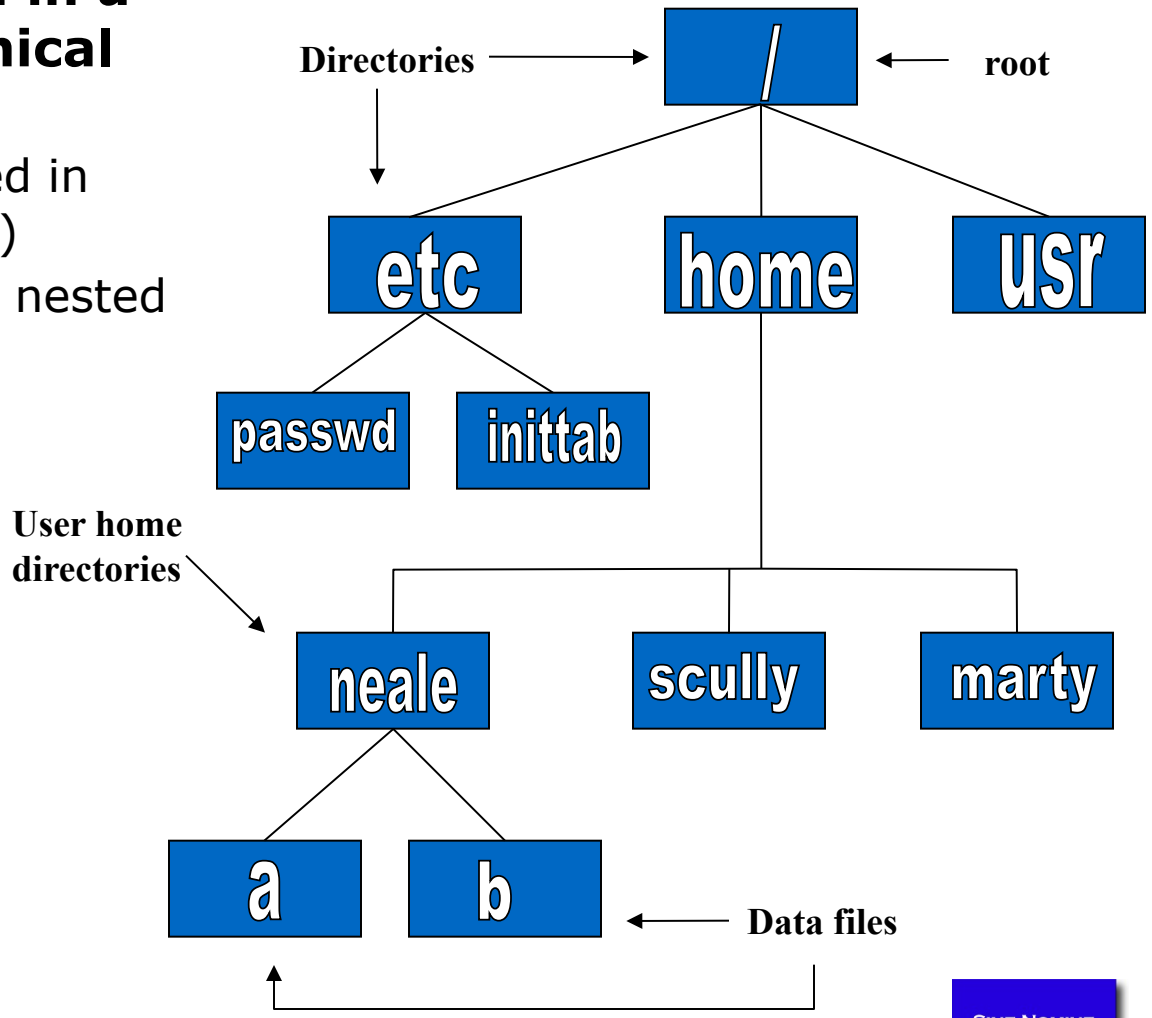

Programmatic File System Interface
O/S Services
Virtual File System
Memory Manager
System Call Interface
System Independent Interface
Process Scheduler
Network Interface
Logical Systems
Device Independent Interface
Device Drivers
Kernel
Device Hardware
Hardware
Legend:
Non-Kernel Layer
Kernel Sub-System
Module
Multiple Modules
Depends on
Control Flow
Data Flow

Lab Four

- ssh and login to ID
- Find out what devices are mounted and what file systems are in use
- Examine a couple of the `/proc` files using the `more` command
- Logout

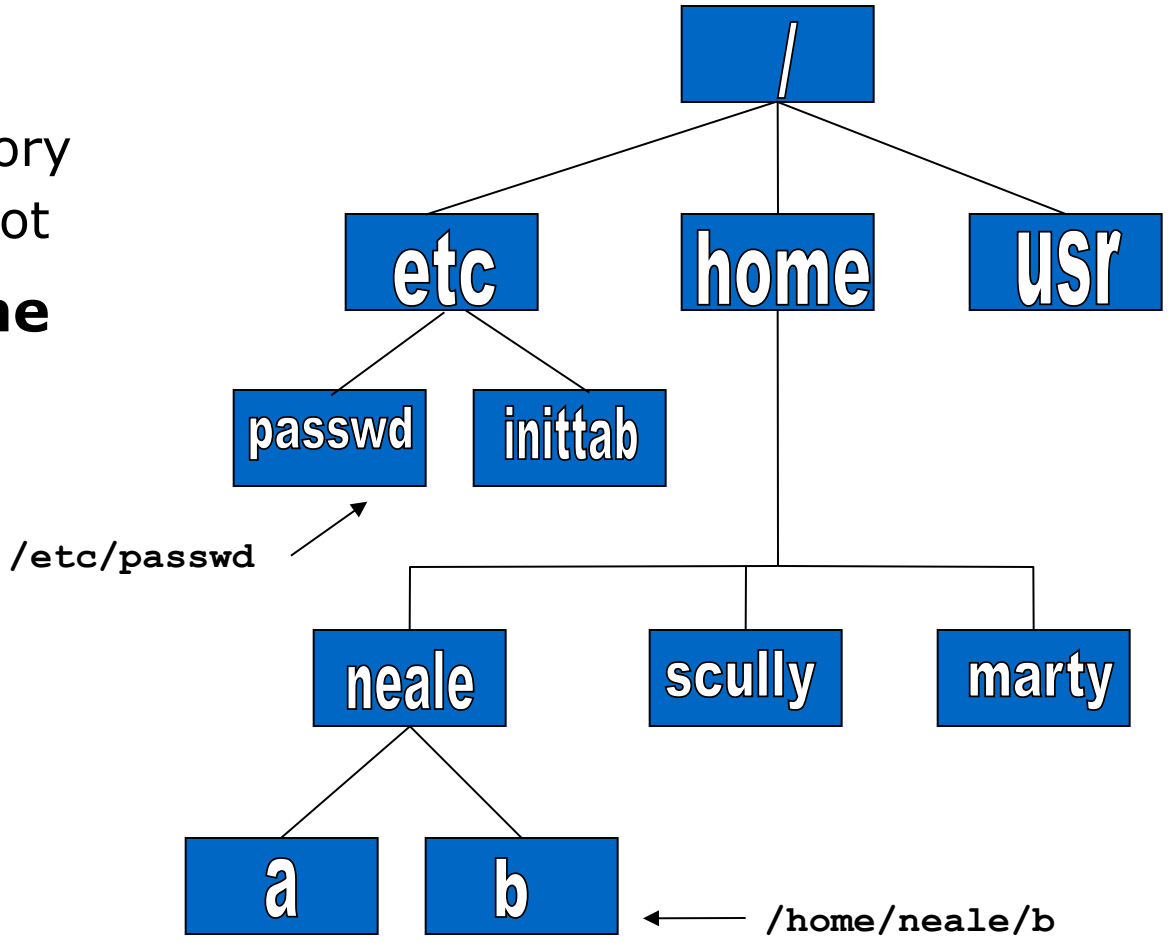
Linux File System Basics

- **Linux files are stored in a single rooted, hierarchical file system**
  - Data files are stored in directories (folders)
  - Directories may be nested as deep as needed



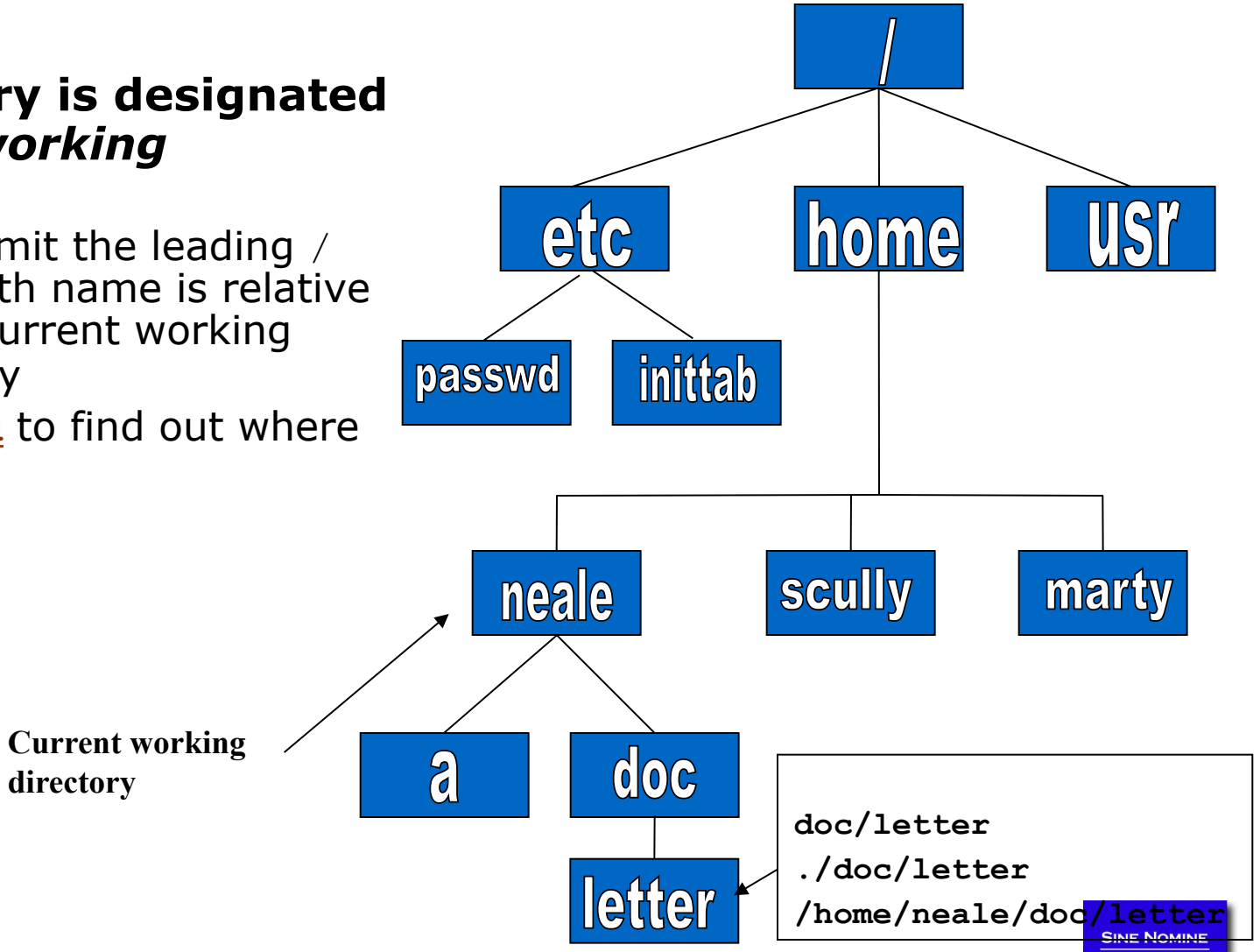
Naming Files

- **Files are named by**
  - naming each containing directory
  - starting at the root
- **This is known as the *pathname***



The Current Directory

- **One directory is designated the *current working directory***
  - if you omit the leading / then path name is relative to the current working directory
  - Use `pwd` to find out where you are



Some Special File Names

- **Some file names are special:**
  - `/` The root directory (don't confuse with the root user)
  - `.` The current directory
  - `..` The parent (previous) directory
  - `~` My home directory
  - `~jane` Jane's home directory
- **Examples:**
  - `./a` same as `a`
  - `../jane/x` go up one level then look in directory `jane` for `x`

Special Files

- `/home` - all users' home directories are stored here
- `/bin`, `/usr/bin` - system commands
- `/sbin`, `/usr/sbin` - commands used by sysadmins
- `/etc` - all sorts of configuration files
- `/var` - logs, spool directories etc.
- `/dev` - device files
- `/proc` - special system files
- `/sys` – System I/O configuration

Lab Five

- **Explore the file system**
  - Use the `cd` command to go the "root" of the file system
  - Use `ls` to list the files and directories
  - Use the `cd` command to go to your home directory
  - Use the `pwd` command to display the name of the present working directory

Creating Files and Directories

- **Files can be created in a number of ways**
  - The output of a command
  - Being edited using vi or your favorite editor
  - By using the `touch` command which creates an empty file or updates the modification and access time information of an existing file
- **Directories are created using the `mkdir` command**

File Permissions

- **Every file:**
  - Is owned by someone
  - Belongs to a group
  - Has certain access permissions for owner, group, and others
  - Default permissions determined by **`umask`**
    - You don't want to make all files accessible by everyone by default
    - umask is used to set the default policy
    - Disables certain permissions

File Permissions

- **Every user:**
  - Has a uid (login name), gid (login group) and membership of a "groups" list:
    - The *uid* is who you are (name and number)
    - The *gid* is your initial “login group” you normally belong to
    - The *groups list* is the file groups you can access via group permissions

File Permissions

- **Linux provides three kinds of permissions:**
  - Read - users with read permission may read the file or list the directory
  - Write - users with write permission may write to the file or new files to the directory
  - Execute - users with execute permission may execute the file or lookup a specific file within a directory

File Permissions

- **Under MS-DOS, Windows, OS/2**
  - File extensions determine if a file is "executable"
  - Uses .EXE .CMD .BAT
- **UNIX/Linux**
  - File privileges determine if a file should be executed
  - Contents of header or 1st line of file tell system how to execute

File Permissions

- **The long version of a file listing (`ls -l`) will display the file permissions:**

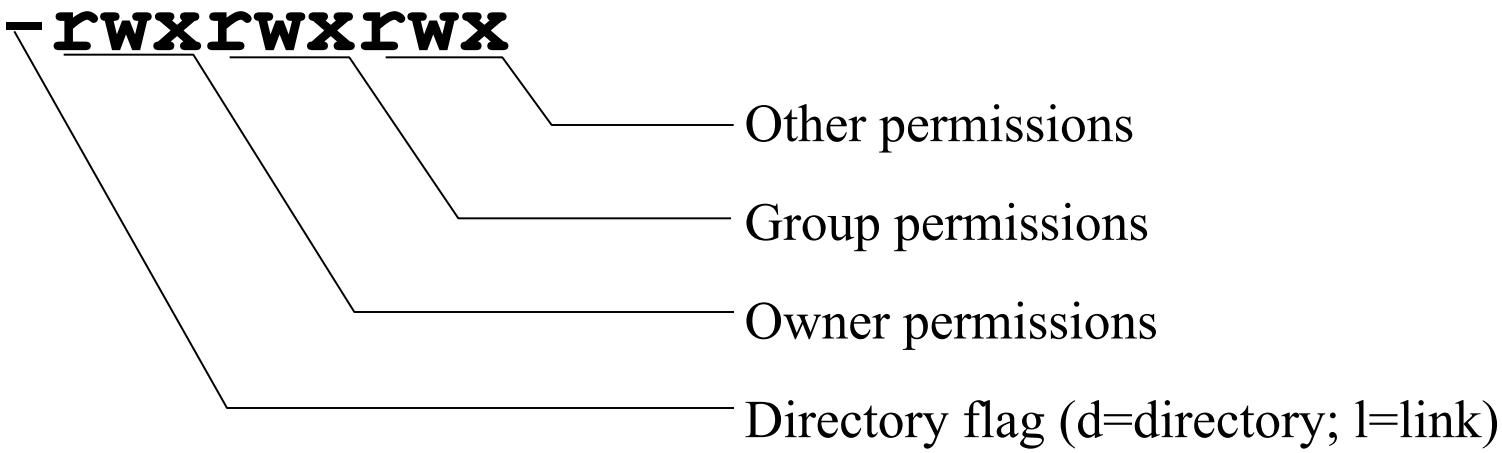
```
-rwxrwxr-x  1 rvdheij  rvdheij      5224 Dec 30 03:22 hello
-rw-rw-r--  1 rvdheij  rvdheij       221 Dec 30 03:59 hello.c
-rw-rw-r--  1 rvdheij  rvdheij      1514 Dec 30 03:59 hello.s
drwxrwxr-x  7 rvdheij  rvdheij      1024 Dec 31 14:52 posixuft
:
-rw-r--r--  1 neale users       1039 2009-09-10 12:47 a.a
drwxr-xr-x  5 neale users       4096 2011-08-16 20:34 benchmark
drwxr-xr-x  2 neale users       4096 2009-07-30 08:55 bin
drwxr-xr-x  3 neale users       4096 2009-05-16 12:17 BINUTILS
-rw-r--r--  1 neale users       3776 2012-02-24 09:32 bluefin.cs
```

Permissions

Owner

Group

Interpreting File Permissions



Changing File Permissions

- **Use the `chmod` command to change file permissions**
  - The permissions are encoded as an octal number

User			Group			Other		
Read r	Write w	Execute x	Read r	Write w	Execute x	Read r	Write w	Execute x
400	200	100	40	20	10	4	2	1

```
chmod 0755 file  # Owner=rwx Group=r-x Other=r-x
chmod 0500 file2 # Owner=r-x Group=--- Other=---
chmod 0644 file3 # Owner=rw- Group=r-- Other=r--

chmod +x  file   # Add execute permission to file for all
chmod u-r file   # Remove read permission for owner
chmod a+w file   # Add write permission for everyone
```

Remember /etc/passwd?

- Originally file permissions allowed "world read"
- Weakly encrypted passwords could be read by anyone!!
- /etc/shadow implemented with stricter permissions and stronger encrypting

```
[usanefe@dali157 - usanefe] ls -l /etc/passwd /etc/shadow
-rw-r--r--    1 root     root          2985 Jul  6 18:16 /etc/passwd
-rw-r-----    1 root     shadow        1468 Jul  7 13:32 /etc/shadow
```

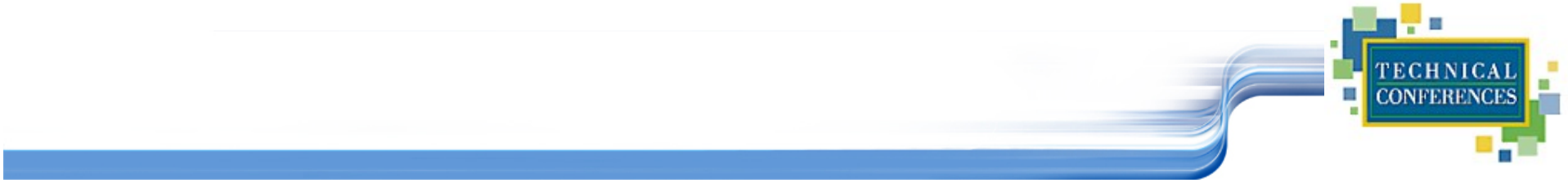
Links?

- **Links are references to files (aliases)**
- **Two forms:**
  - Hard
  - Symbolic
    - Can point to files on different physical devices
    - Delete of original leaves link / Delete of link leaves original
    - Can be created for directories
- **Create using `ln` or `ln -s` command**
- **The `ls -l` command will show you the links:**

```
train01@reslx390:~ > ls -l /lib
total 10780
-rwxr-xr-x   1 root     root       367598 Nov  3  2000 ld-2.1.3.so
lrwxrwxrwx   1 root     root           11 Nov 29  2000 ld.so.1 -> ld-2.1.3.so
-rwxr-xr-x   1 root     root        21498 Nov  3  2000 libBrokenLocale.so.1
```

Lab Six

- **Explore your filesystem:**
  - Identify 1st level directories
  - Locate a symbolic link
- **Create 3 files (‘`all`’, ‘`group`’, ‘`owner`’) & assign permissions:**
  - `all` - r/w to owner, group, and others
  - `group` - r/w to owner and group, r/o to others
  - `owner` - r/w to owner, r/o to group, none to others
- **Create a directory ‘`test`’ under your home directory**
  - Create a file ‘`real.file`’ in the test subdirectory
  - Create a symbolic link in your home directory to ‘`real.file`’ called ‘`symbolic.link`’



Questions and Answers

Class Agenda -- Part 2

- Accessing Your Data
- vi – The System Editor
- the – XEDIT/ISPF clone
- bash – The Scripting Language

Shells

- **An interface between the Linux system and the user**
- **Used to call commands and programs**
- **An interpreter**
- **Powerful programming language**
  - "Shell scripts" = .bat .cmd EXEC REXX

Shells

- sh — **Bourne shell - the original**
- csh — **C shell - compatible with Bourne shell**
- bash — **Bourne again shell - most common on Linux**
- tcsh — **The enhanced C shell**
- zsh — **Z shell - new, compatible with Bourne shell**
- ksh — **Korn shell - most popular UNIX shell**

Another definition of a Shell

- **A shell is any program that takes input from the user, translates it into instructions that the operating system can understand, and conveys the operating system's output back to the user.**
  - i.e. Any User Interface
  - Character Based v Graphics Based

Why Do I Care About The Shell?

- **Shell is Not an Integral Part of O/S**
  - UNIX Among First to Separate
  - Compare to MS-DOS, Mac, Win95, VM/CMS
  - GUI is NOT Required
  - Default Shell Can Be Configured
    - `chsh -s /bin/bash`
    - `/etc/passwd`
  - Helps To Customize Environment

Using the Shell

- **Useful keys:**
  - Cursor arrows:
    - Up/down - scroll through previous commands
    - Left/right - move over characters within the command line
    - Backspace/Delete - delete character
  - Control characters
    - CTRL-C - Abort command
    - CTRL-U - Delete the whole line
    - CTRL-Z - Suspend current process
    - CTRL-T - Swap current/next characters in command line
    - CTRL-R - Search through past commands
- **Shortcuts**
  - Word completion: Press TAB key to have Shell complete the line for you

Lab Seven

- **Using the Shell**
  - What shell are you using:
  - Editing the command line:
    - Scrolling through past commands
    - Inserting/deleting characters on command line
    - Using editing key: CTRL-R
    - Try command completion. What happens when: **`ls /etc/pro<TAB>`**
  - Invoke the C shell

Shell Scripts


```
#!/bin/bash
while
true
do
   cat somefile > /dev/null
   echo .
done
```

```
/* */
do forever
   'PIPE < SOME FILE | hole'
   say '.'
end
```

Filename Expansion

- **Shell will scan for special characters**
- **Process called "globbing"**
- **Not the same as regular expressions**
- **Performs expansion:**
  - `ls *.c` List all files with extension of 'c'
  - `ls *.[ch]` List all files with extension of 'c' or 'h'
  - `ls *[0-9]*.c` List all files with extension of 'c' with a name consisting of 0 or more numeric characters
  - `ls ab?de.c` List all files with extension of 'c' whose first two letter of the file name are "ab" and last two letters are "de"

Switching Users

- **su <accountname>**
  - switch user accounts. You will be prompted for a password. When this command completes, you will be logged into the new account. Type **exit** to return to the previous account
- **su**
  - Switch to the root user account. Do not do this lightly

Note: **The root user does not need to enter a password when switching users. It may become any user desired. This is part of the power of the root account.**

- **sudo**
  - Perform a command as the superuser
  - Configurable via **/etc/sudoers**

Environment Variables

- **Environment variables are global settings that control the function of the shell and other Linux programs. They are sometimes referred to global shell variables.**
- **Setting:**
  - `VAR=/home/fred/doc`
  - `export TERM=ansi`
  - `SYSTEMNAME=\`uname -n\``
- **Similar to GLOBALV SET ... in CMS**

Environment Variables

- **Using Environment Variables:**
  - `echo $VAR`
  - `cd $VAR`
  - `cd $HOME`
  - `echo "You are running on $SYSTEMNAME"`
- **Displaying - use the following commands:**
  - `set` (displays local & environment variables)
  - `export`
- **Variables can be retrieved by a script or a program**

Some Important Environment Variables

- **HOME**
  - Your home directory (often be abbreviated as "~")
- **TERM**
  - The type of terminal you are running (for example vt100, xterm, and ansi)
- **PWD**
  - Current working directory
- **PATH**
  - List of directories to search for commands

PATH Environment Variable

- **Controls where commands are found**
  - PATH is a list of directory pathnames separated by colons. For example:

    `PATH=/bin:/usr/bin:/usr/X11R6/bin:/usr/local/bin:/home/scully/bin`
  - If a command does not contain a slash, the shell tries finding the command in each directory in PATH. The first match is the command that will run

PATH Environment Variable

- **Similar to setting the CMS search order**
- **Usually set in `/etc/profile` (like the SYSPROF EXEC)**
- **Often modified in `~/.profile` or `~/.bashrc` or `~/.login` (like the PROFILE EXEC)**

File Commands

- **cp <fromfile> <tofile>**
  - Copy from the <fromfile> to the <tofile>
- **mv <fromfile> <tofile>**
  - Move/rename the <fromfile> to the <tofile>
- **rm <file>**
  - Remove the file named <file>
- **mkdir <newdir>**
  - Make a new directory called <newdir>
- **rmdir <dir>**
  - Remove an (empty) directory

More Commands

- alias - used to tailor commands:
  - alias erase=rm
  - alias grep="grep -i"
- ar - Maintain archive libraries: a collection of files (usually object files which may be linked to a program, like a CMS TXTLIB)

```
ar -t libgdbm.a
__.SYMDEF
dbmopen.o
```

More Commands

- **awk - a file processing language that is well suited to data manipulation and retrieval of information from text files**
- **chown - sets the user ID (UID) to owner for the files and directories named by pathname arguments. This command is useful when from test to production**

```
chown -R apache:httpd /usr/local/apache
```

More Commands

- `diff` - attempts to determine the minimal set of changes needed to convert a file specified by the first argument into the file specified by the second argument
- `find` - Searches a given file hierarchy specified by path, finding files that match the criteria given by expression

More Commands

- `grep` - **Searches files for one or more pattern arguments. It does plain string, basic regular expression, and extended regular expression searching**

```
find ./ -name "*.c" | xargs grep -i "fork"
```

In this example, we look for files with an extension "c" (that is, C source files). The filenames we find are passed to the xargs command which takes these names and constructs a command line of the form: `grep -i fork <file.1>…<file.n>`. This command will search the files for the occurrence of the string "fork". The "`-i`" flag makes the search case insensitve.

More Commands

- **kill - sends a signal to a process or process group**
  - You can only kill your own processes unless you are root

```
UID         PID   PPID   C STIME TTY          TIME CMD
root       6715   6692   2 14:34 ttyp0    00:00:00 sleep 10h
root       6716   6692   0 14:34 ttyp0    00:00:00 ps -ef
[root@penguinvm log]# kill 6715
[1]+  Terminated              sleep 10h
```

More Commands

- `make` - helps you manage projects containing a set of interdependent files (e.g. a program with many source and object files; a document built from source files; macro files)
- `make` keeps all such files up to date with one another: If one file changes, `make` updates all the other files that depend on the changed file
- Roughly the equivalent of VMFBLD

More Commands

- `sed` - applies a set of editing subcommands contained in a script to each argument input file

```
find ./ -name "*.c,v" | sed 's/,v//g' | xargs grep "PATH"
```

This `find`s all files in the current and subsequent directories with an extension of c,v. `sed` then strips the ,v off the results of the find command. `xargs` then uses the results of `sed` and builds a `grep` command which searches for occurrences of the word PATH in the C source files.

More Commands

tar - manipulates archives

- An archive is a single file that contains the complete contents of a set of other files; an archive preserves the directory hierarchy that contained the original files.

```
tar -tzf imap-4.7.tar.gz
imap-4.7/
imap-4.7/src/
imap-4.7/src/c-client/
imap-4.7/src/c-client/env.h
imap-4.7/src/c-client/fs.h
```

Introduction to Linux

Accessing Your Data

Accessing Your Data

- **Data files are accessed by pathname (relative or absolute)**
- **Command files are accessed via PATH environment variable**
- **System wide PATH set in `/etc/profile`**
- **User specific PATH may be set in `~/.profile` `~/.bashrc` `~/.login`**

Listing Your Files

- The `ls` command is used for listing files and their attributes:
  - `ls <pathname>`
  - `ls -l <pathname>`
  - `ls -la <pathname>`

ls

```
[neale@penguinvm neale]$ ls /etc
DIR_COLORS          ftpusers        login.defs      quota.conf
DOMAINNAME          gettydefs       logrotate.d     rc.d
HOSTNAME            group           mail.rc         resolv.conf
HOSTNAME.orig       group-          man.config      resolv.old
X11                 group.OLD       mime-magic      rpc
adjtime             group~          mime-magic.dat  security
aliases             host.conf       mime.types      sendmail.cf
aliases.db          hosts           motd            sendmail.st
aliases~            hosts.allow     mtab            services
bashrc              hosts.allow~    named.conf      shells
conf.linuxconf      hosts.deny      named.conf~     ssh_config
cron.d              hosts~          nscd.conf       ssh_host_key
cron.daily          httpd           nsswitch.conf   ssh_host_key.pub
cron.weekly         inetd.conf      nsswitch.conf~  ssh_random_seed
csh.login           inetd.conf~     pam.d           sshd_config
default             info-dir        passwd          sysconfig
exports             initlog.conf    passwd-         syslog.conf
fdprm               inittab         ppp             termcap
fstab               inputrc         printcap        zlogin
ftpaccess           ioctl.save      profile         zlogout
ftpconversions      ld.so.cache     profile.d       zprofile
ftpgroups           ld.so.conf      protocols       zshenv
ftphosts            localtime       pwdb.conf       zshrc
```

ls

- **Color output?**
  - `/etc/DIR_COLORS`

```
COLOR tty
# Below, there should be one TERM entry for each termtype that is colorizable
TERM linux
EIGHTBIT 1
# 00=none 01=bold 04=underscore 05=blink 07=reverse 08=concealed
# Text color codes:
# 30=black 31=red 32=green 33=yellow 34=blue 35=magenta 36=cyan 37=white
# Background color codes:
# 40=black 41=red 42=green 43=yellow 44=blue 45=magenta 46=cyan 47=white
NORMAL 00       # global default, although everything should be something.
FILE 00         # normal file
DIR 01;34       # directory
```

ls -l

- "DIR" like output:

```
[neale@penguinvm neale]$ ls -l
total 1612
-rw-r--r--   1 neale    neale      148119 Jan 14 10:12 %backup%~
-rw-------   1 neale    neale         511 Jan 18 10:58 Linux
drwxrwxr-x   7 neale    neale        1024 Mar 17 12:47 ORBit-0.5.1
drwxr-xr-x   7 neale    neale        1024 Mar 13 09:08 apache_2.0
-rw-rw-r--   1 neale    neale     1476724 Mar 11 22:18 apache_2.0a1.tar.gz
drwxrwxr-x   9 neale    neale        1024 Feb 14 20:58 classpath-0.00
-rw-rw-r--   1 neale    neale        1215 Jan 12 15:54 config.patch
drwxrwxr-x   2 neale    neale        1024 Mar 20 19:12 cpint
drwxrwxrwx   2 neale    develope     1024 Feb  9 11:26 html
-rw-r--r--   1 neale    neale         994 Feb 24 22:05 ip.num
-rw-rw-r--   1 neale    neale        1344 Feb 24 22:06 ip.num.sh
drwxrwxr-x  11 neale    neale        1024 Feb 25 21:08 japhar-0.08
drwxrwxr-x   5 neale    neale        1024 Jan 17 09:42 ltxml-1.1
-rw-rw-r--   1 neale    neale          81 Mar  7 17:57 test.c
-rwxrwxr-x   1 neale    neale         790 Mar  7 17:59 test.s
drwxrwxr-x   2 neale    neale        1024 Feb 29 15:13 tmp
```

ls -la

- List "hidden" files:

```
[neale@penguinvm neale]$ ls -la .*[a-zA-Z]
-rw-------   1 neale    neale         985 Mar 20 10:52 .Xauthority
-rw-------   1 neale    neale       15044 Mar 22 12:49 .bash_history
-rw-r--r--   1 neale    neale           6 Jan 18 10:58 .mailboxlist
-rw-rw-r--   1 neale    neale         153 Feb 23 14:17 .profile
-rw-rw-r--   1 neale    neale         250 Dec 31 12:04 .therc
```

Viewing Files

- `cat` — **"Concatenate"**
- `more` — **Display one page at a time**
- `less` — **Variant of `more`**
- **Editors**
  - `vi` — Visual editor, the default
  - `the` — XEDIT/KEDIT/ISPF clone
  - `xedit` — X windows text editor
  - `emacs` — Extensible, Customizable Self-Documenting Display Editor
  - `pico` — Simple display-oriented text editor
  - `nedit` — X windows Motif text editor

cat

- **Concatenate files and print on the standard output**

```
[neale@penguinvm neale]$ cat .profile
alias dir="ls --color -laA"
alias ls="ls --color"
export PATH=./:/sbin:/usr/sbin:$PATH:/usr/local/japhar/bin
export JAPHAR_LOG="ALL,999,/tmp/japhar.log"
```

more

- File perusal filter for page-at-a-time viewing

```
[neale@penguinvm neale]$ more test.s
        .file   "test.c"
        .version        "01.01"
gcc2_compiled.:
.text
:
:
.L$CO1: AHI     13,.L$PG1-.L$CO1
        ST      0,0(15)
        LR      11,15
        LR    9,7
        ST    2,96(11)
--More--(71%)
```

Lab Eight

- **Listing and displaying files**
  - Use the `ls -a` command to display directories (where did all those files come from??)
  - Use the `-R` option of `ls` to display down file tree
  - Use `cat` to display a file
  - Use `more` to display a file one page at a time
  - Erase the link '`symbolic.link`', erase the '`test`' directory and its contents, then erase the '`all`', '`group`', and '`owner`' files.

Introduction to Linux

Editors

vi Basics...

'Editors are like religion; the one you grew up with is the only "true" one'

- **`vi` was the first real screen-based editor for UNIX**
- **`vi` comes with every UNIX system**
- **`vi` may be invoked from the command line by typing the command followed by the file identifier of the file to be edited**

```
vi <pathname>
```

vi Basics

- **Pronounced: *vee-eye***
- **When using `vi` you are in one of three modes:**
  - Command mode: the mode you start in
  - Edit mode: allows you to do "editing"
  - Ex mode: where you communicate with **`vi`** to do things with the file
- **Only a few things you *need* to know, lots of things you *could* know**
- **Best way to learn is by doing...**

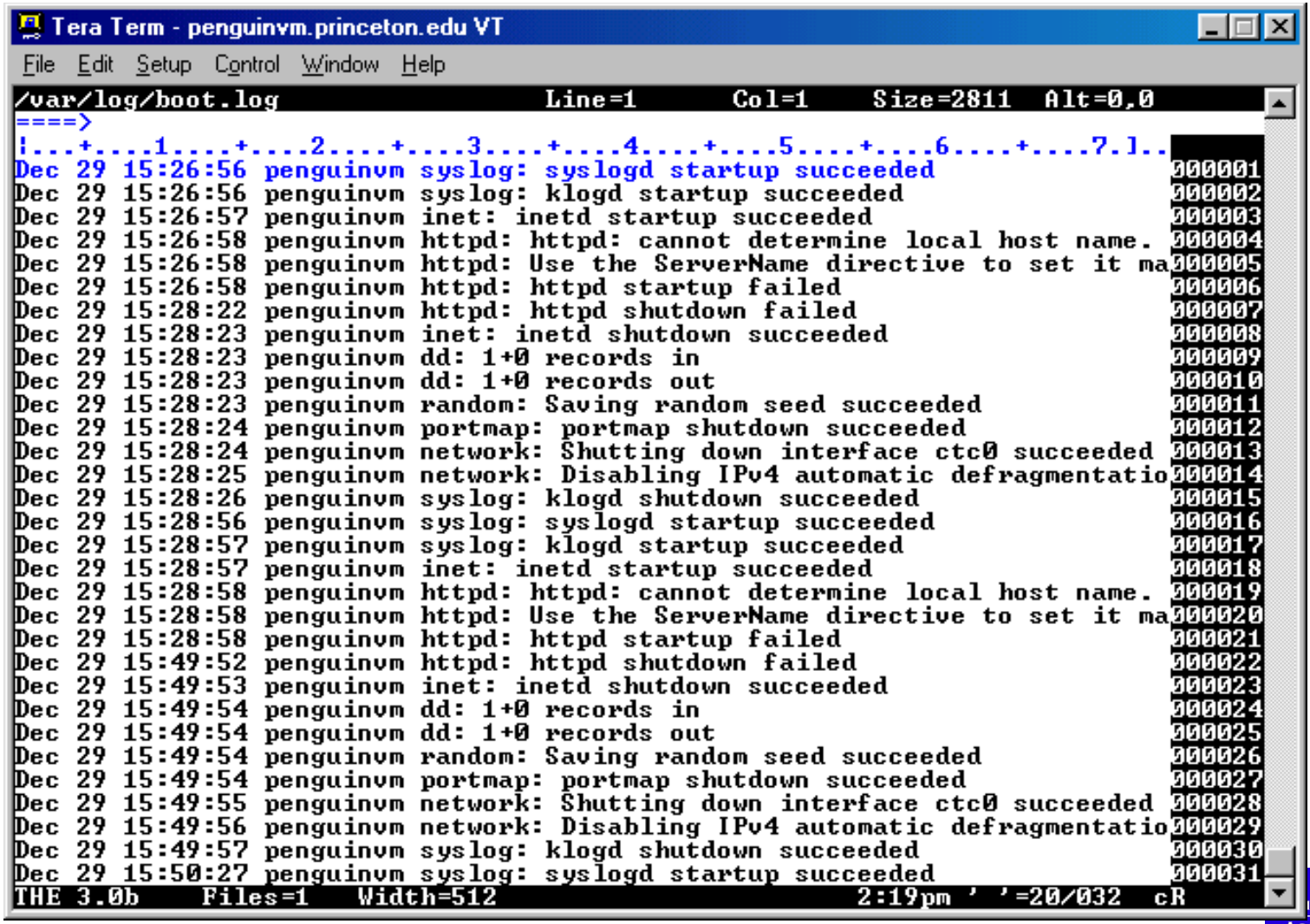
Lab Nine

- Use "vi Primer"
- Perform actions according to the guide

THE Basics

- **The THE environment provides an additional set of commands oriented toward editing a file**
  - An input area (command line) is provided for the entry of commands
  - Linux commands may be executed by prefacing them with `DOS`

Default Look of a THE Session



THE Commands: Things of Note

- **The screen is considered a "window" on the file**
- **Movement commands (UP, DOWN, LEFT, RIGHT) describe movement of the *window* relative to the file**
  - The command "down 6" moved the window down -- or forward -- 6 lines in the file
- **Additional movement commands are available**
  - TOP and BOTTOM move the window to the top or bottom of the file
  - Use ':n' to request a particular line
  - The requested line is positioned on the "current line"

THE Prefix Commands

- **In addition to the command line, you can also enter commands in the prefix area of a line**
- **Some common prefix commands include:**
  - **`I`** - insert
  - **`si`** - insert a series of lines
  - **`/`** - make this the current line
  - **`M`** or **`MM`** - move a line, **`M`**, or a group of lines, **`MM`**
  - `C` or `CC` - copy a line, `C`, or a group of lines, `CC`
  - **`P`** - execute move or copy Preceding this line
  - **`F`** - execute more of copy Following this line

THE Input Area Commands

- SET
  - Change characteristics of your default view
  - Change characteristics of your file
- Input **- Creates an input area for free form typing**
- **Scrolling and positioning commands**
- LOCATE **- find strings in the file**
- CHANGE **command - change commands in the file**
- SAVE **and** FILE

THE Macros

- **Create your own `.therc` to customize your view of `the`**
  - Color (if available)
  - Placement of items discussed
    - scale
    - messages
    - command line, etc.
  - Autosave frequency
- **`the` macros are REXX (Regina) programs that run in the `the` environment to perform specific tasks**

This Looks Like the ISPF Editor

- **The editors do share many characteristics**
- **There's just enough similarity to lull you into a false sense that you know what you're doing. E.g.**
  - The biggest area of conflict/confusion is prefix commands
    - 'A' in THE is "add a line following this one"
    - 'A' in ISPF is a target for moving or copying lines ("move/copy the lines after this one")
    - The THE equivalent of ISPF's 'A' prefix command is the 'F' prefix command ("move or copy following this line")
  - "Insert mode" (for adding multiple lines to a file) works very differently in the two environments

THE Exercises...

- Edit the file `the.sample`
- Insert a line at the top of the file and type your name
- Copy that line to the bottom of the file
- Move the 2nd paragraph behind the 3rd paragraph
- Split the first line of the first paragraph before the word 'honorably,'
- Join the 4th line to the new 3rd line new text after the word on that line
- Duplicate the 2nd line with your name 8 times
- File the file when you are done

...THE Exercises

- **Edit the file `~/.therc`**
- **Change the prefix area to numbers with no leading zeros**
- **Move the scale to line 3**
- **Move the command line to line 22**
- **Allow mixed case input**
- **Move the current line to line 4**
- **File the file, then `the` it again. Are you happy with the changes?**