RH033 - Red Hat Linux Essentials

Introduction

RH033: Red Hat Linux Essentials

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Copyright

Welcome

Please let us know if you need any special assistance while visiting our training facility.

Please introduce yourself to the rest of the class!

Red Hat Enterprise Linux

- Enterprise-targeted Linux operating system
- Focused on mature open source technology
- Extended release cycle between major versions
  - With periodic minor releases during the cycle
  - Certified with leading OEM and ISV products
- All variants based on the same code
  - Certify once, run any application/anywhere/anytime
- Services provided on subscription basis

Red Hat Enterprise Linux Variants

- Red Hat Enterprise Linux Advanced Platform
  - Unlimited server size and virtualization support
  - HA clusters and cluster file system
- Red Hat Enterprise Linux
  - Basic server solution for smaller non-mission-critical servers
  - Virtualization support included
- Red Hat Enterprise Linux Desktop
  - Productivity desktop environment
  - *Workstation* option adds tools for software and network service development
  - *Multi-OS* option for virtualization

Red Hat Subscription Model

- Red Hat sells subscriptions that entitle systems to receive a set of services that support open source software
    - Red Hat Enterprise Linux and other Red Hat/JBoss solutions and applications
- Customers are charged an annual subscription fee per system
    - Subscriptions can be migrated as hardware is replaced
    - Can freely move between major revisions, up and down
    - Multi-year subscriptions are available
- A typical service subscription includes:
    - Software updates and upgrades through Red Hat Network
    - Technical support (web and phone)
    - Certifications, stable APIs/versions, and more

Contacting Technical Support

- Collect information needed by technical support:
  - Define the problem
  - Gather background information
  - Gather relevant diagnostic information, if possible
  - Determine the severity level
- Contacting technical support by WWW:
  - http://www.redhat.com/support/
- Contacting technical support by phone:
  - See http://www.redhat.com/support/policy/sla/contact/
  - US/Canada: 888-GO-REDHAT (888-467-3342)

Red Hat Network

- A systems management platform providing lifecycle management of the operating system and applications
  - Installing and provisioning new systems
  - Updating systems
  - Managing configuration files
  - Monitoring performance
  - Redeploying systems for a new purpose
- "Hosted" and "Satellite" deployment architectures

Red Hat Services and Products

- Red Hat supports software products and services beyond Red Hat Enterprise Linux
  - JBoss Enterprise Middleware
  - Systems and Identity Management
  - Infrastructure products and distributed computing
  - Training, consulting, and extended support
- http://www.redhat.com/products/

Fedora and EPEL

- Open source projects sponsored by Red Hat
- Fedora distribution is focused on latest open source technology
  - Rapid six month release cycle
  - Available as free download from the Internet
- EPEL provides add-on software for Red Hat Enterprise Linux
- Open, community-supported proving grounds for technologies which may be used in upcoming enterprise products
- Red Hat does not provide formal support

Objectives

- A user who can use effectively employ Red Hat Enterprise Linux to customize his or her operating environment as well as accomplish common command-line tasks and desktop productivity roles

Audience and Prerequisites

- Audience: Users new to Linux and UNIX; users and administrators transitioning from another operating system
- User-level experience with any computer system; use of mouse, menus and any graphical user interface

Pre/Post-Assessments

- Some units begin with a pre-assessment
    - 3-5 simple questions about the unit's subject
    - Just leave blank if you don't know the answer
- Questions are asked again at the end of the unit

Lab Exercises

- Labs
  - Fundamental exercise providing basic goals, reinforcing the lecture
- Lab Solutions
  - Offers step-by-step detailed methodology
  - Found for all exercises that do not have specific steps themselves
- Challenge Labs
  - Advanced exercise, reinforcing more advanced topics from the lecture
  - Not all students may have the time to complete
- Optional Labs
  - Optional exercise that may depend on classroom specific environment

Classroom Network

- example.com network (192.168.0.0/24)
  - instructor.example.com (192.168.0.254)
    - Main classroom server: Provides DHCP, DNS, routing and other services
  - station*X*.example.com (192.168.0.*X*)
    - Student systems
  - server*X*.example.com (192.168.0.*X+100*)
    - Virtual server hosted on student stations (Not used in all classes)
- remote.test network (192.168.1.0/24)
  - cracker*X*.remote.test (192.168.1.*X*)
    - Virtual client hosted on student systems (Not used in all classes)

Notes on Internationalization

- Red Hat Enterprise Linux supports nineteen languages
- Default system-wide language can be selected
  - During installation
  - With **system-config-language** (System->Administration->Language)
- Users can set personal language preferences
  - From graphical login screen (stored in `~/.dmrc`)
  - For interactive shell (with `LANG` environment variable in `~/.bashrc`)
  - Alternate languages can be used on a per-command basis:

```
[user@host ~]$ LANG=ja_JP.UTF-8 date
```

Lecture 1

Linux Ideas and History

Objectives

Upon completion of this unit, you should be able to:

- Explain the nature of open source software
- Discuss the origins of Linux
- List the Red Hat operating system distributions
- Explain basic Linux principles

What is Open Source?

- Open source: software and source code available to all
- The Free Software Foundation specifies four freedoms
  - The freedom to run the program for any purpose.
  - The freedom to study and modify the source code
  - The freedom to redistribute the program
  - The freedom to create derivative programs
- Many open-source licenses exist, each with different particulars

Supplemental Media

Fedora developer Jeremy Katz on the advantages of open source

Linux Origins

- 1984: The GNU Project and the Free Software Foundation
  - Creates open source version of UNIX utilities
  - Creates the General Public License (GPL)
    - Software license enforcing open source principles
- 1991: Linus Torvalds
  - Creates open source, UNIX-like kernel, released under the GPL
  - Ports some GNU utilities, solicits assistance online
- Today:
  - Linux kernel + GNU utilities = complete, open source, UNIX-like operating system
    - Packaged for targeted audiences as *distributions*

Supplemental Media

Linus Torvalds on how to pronounce "Linux"

Red Hat Distributions

- Linux *distributions* are OSes based on the Linux kernel
- Red Hat Enterprise Linux
  - Stable, thoroughly tested software
  - Professional support services
  - Centralized management tools for large networks
- The Fedora Project
  - More, newer applications
  - Community supported (no official Red Hat support)
  - For personal systems

Supplemental Media

Fedora developer Jeremy Katz on the relationship between Red Hat Enterprise Linux and Fedora

Linux principles

- Everything is a file (including hardware)
- Small, single-purpose programs
- Ability to chain programs together to perform complex tasks
- Avoid captive user interfaces
- Configuration data stored in text

End of Lecture 1

- Questions and Answers
- Summary
  - Open source and the right to modify
  - The GNU Project and the Free Software Foundation
  - Linus Torvalds and the Linux kernel
  - Red Hat Enterprise Linux and the Fedora Project
  - Basic Linux Principles

Lecture 2

Linux Usage Basics

Objectives

Upon completion of this unit, you should be able to:

- Log into a Red Hat Enterprise Linux system
- Start X from a console
- Access the command line from X
- Change your password
- Understand the nature of root privileges
- Elevate your privileges
- Edit plain text files

Logging in to a Linux System

- Login using username and password
- Two types of login screens: text-based and graphical
    - Text-based login leaves you at a *shell prompt*
    - Graphical login starts a *desktop environment*
- Each user has a *home directory* for personal file storage
    - User-specific configuration data is often kept there as well

Switching between virtual consoles and the graphical environment

- A typical Linux system will run six virtual consoles and one graphical console
  - Server systems often have only virtual consoles
  - Desktops and workstations typically have both
- If graphical console is inactive, it may be started manually
  - The X server must be pre-configured by the system administrator
  - Log into a virtual console and run **startx**
- Switch among virtual consoles by typing: **Ctrl-Alt-F*[1-6]***
- Access the graphical console by typing **Ctrl-Alt-F7**

gnome-terminal

- Applications->Accessories->Terminal
- Graphical terminal emulator that supports multiple "tabbed" shells
  - **Ctrl**-**Shift**-**t** creates a new tab
  - **Ctrl**-**PgUp/PgDn** switches to next/prev tab
  - **Ctrl**-**Shift**-**c** copies selected text
  - **Ctrl**-**Shift**-**v** pastes text to the prompt
  - **Shift**-**PgUp/PgDn** scrolls up and down a screen at a time

Changing Your Password

- Passwords control access to the system
- General guidelines for best security:
  - Change the password the first time you log in
  - Change it regularly thereafter
  - Select a password that is hard to guess
- To change your password:
  - GUI: System->Preferences->About Me and then click Change Password
  - CLI: **passwd**

The *root* user

- The *root* user: a special administrative account
  - Also called the *superuser*
  - `root` has near complete control over the system
    - ...and a nearly unlimited capacity to damage it!
- Do not login as `root` unless necessary
  - Normal (*unprivileged*) users' potential to do damage is more limited

Changing Identities

- **su -** creates new shell as root
- **sudo *command*** runs ***command*** as root
  - Requires prior configuration by a system-administrator
- **id** shows information on the current user

Command Line Shortcuts
The Tab Key

- Type **Tab** to complete command lines:
  - For the command name, it will complete a command name
  - For an argument, it will complete a file name
- Examples:

```
$ xte<Tab>
$ xterm
$ ls myf<Tab>
$ ls myfile.txt
```

Command Line Shortcuts
History

- **bash** stores a history of commands executed
- **history** lists all commands
- **history *N*** lists the last *N* commands

```
$ history 5
14  cd /tmp
15  ls -l
16  cd
17  cp /etc/passwd .
18  vi passwd
```

More History Tricks

- Use the **up** and **down** keys to scroll through previous commands
- Type **Ctrl-r** to search for a command in command history.
  - *(reverse-i-search)`':*
- To recall last argument from previous command:
  - **Esc,.** (the escape key followed by a period)
  - **Alt-.** (hold down the alt key while pressing the period)
  - Can be pressed multiple times
  - **!$** (only valid for the last command)

Editing text files

- The **nano** editor
  - Easy to learn, easy to use
  - Not as feature-packed as some advanced editors
- Other editors:
  - **gedit**, a simple graphical editor
  - **vim**, an advanced, full feature editor
  - **gvim**, a graphical version of the vim editor

End of Lecture 2

- Questions and Answers
- Summary
  - Login name and password
  - **startx**
  - **gnome-terminal**
  - **passwd**
  - **su**
  - **nano**

Lecture 3

Running Commands and Getting Help

Objectives

Upon completion of this unit, you should be able to:

- Execute commands at the prompt
- Explain the purpose and usage of some simple commands
- Use the built-in help resources in Red Hat Enterprise Linux

Running Commands

- Commands have the following syntax:
  - **`command`** ***`options arguments`***
- Each item is separated by a space
- Options modify a command's behavior
  - Single-letter options usually preceded by **`-`**
    - Can be passed as **`-a -b -c`** or **`-abc`**
  - Full-word options usually preceded by **`--`**
    - Example: **`--help`**
- Arguments are file names or other data needed by the command
- Multiple commands can be separated by **;**

Some Simple Commands

- **date** - display date and time
- **cal** - display calendar

Getting Help

- Do not try to memorize everything!
- Many levels of help
  - **whatis**
  - ***command*** **--help**
  - **man** and **info**
  - `/usr/share/doc/`
  - Red Hat documentation

The whatis Command

- Displays short descriptions of commands
- Uses a database that is updated nightly
- Often not available immediately after install

```
$ whatis cal
cal      (1)  - displays a calendar
```

The --help Option

- Displays usage summary and argument list
- Used by most, but not all, commands

```
$ date --help
Usage: date [OPTION]... [+FORMAT] or:
date [-u|--utc|--universal] [MMDDhhmm[[CC]YY][.ss]]
Display the current time in the given FORMAT,
or set the system date.
...argument list omitted...
```

Reading Usage Summaries

- Printed by **--help**, **man** and others
- Used to describe the syntax of a command
  - Arguments in [] are optional
  - Arguments in CAPS or <> are variables
  - Text followed by ... represents a list
  - x|y|z means "x or y or z"
  - -abc means "any mix of -a, -b or -c"

The man Command

- Provides documentation for commands
- Almost every command has a man "page"
- Pages are grouped into "chapters"
- Collectively referred to as the Linux Manual
- **man [<chapter>] <command>**

Navigating man Pages

- While viewing a man page
  - Navigate with arrows, **PgUp**, **PgDn**
  - ***/text*** searches for text
  - **n**/**N** goes to next/previous match
  - **q** quits
- Searching the Manual
  - **man -k *keyword*** lists all matching pages
  - Uses **whatis** database

The info Command

- Similar to **man**, but often more in-depth
- Run **info** without args to list all page
- **info** pages are structured like a web site
  - Each page is divided into "nodes"
  - Links to nodes are preceded by *
  - **info [*command*]**

Navigating info Pages

- While viewing an **info** page
  - Navigate with arrows, **PgUp**, **PgDn**
  - **Tab** moves to next link
  - **Enter** follows the selected link
  - **n**/**p** /**u**/**l** goes to the next/previous/up-one/last node
  - **s** ***text*** searches for text (default: last search)
  - **q** quits **info**

Extended Documentation

- The `/usr/share/doc` directory
  - Subdirectories for most installed packages
  - Location of docs that do not fit elsewhere
    - Example configuration files
    - HTML/PDF/PS documentation
    - License details

Red Hat Documentation

- Available at http://www.redhat.com/docs/
  - Installation Guide
  - Deployment Guide
  - Virtualization Guide
- Knowledge base: http://kbase.redhat.com/
  - Common questions and their solutions
- Deployment Guide
  - System->Documentation->Deployment Guide
  - **yelp ghelp:Deployment_Guide**

End of Lecture 3

- Questions and Answers
- Summary
  - Running Commands
  - Getting Help

Lecture 4

Browsing the Filesystem

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Objectives

Upon completion of this unit, you should be able to:

- Describe important elements of the filesystem hierarchy
- Copy, move, and remove files
- Create and view files
- Manage files with Nautilus

Linux File Hierarchy Concepts

- Files and directories are organized into a single-rooted inverted tree structure
- Filesystem begins at the *root* directory, represented by / (forward slash).
- Names are case-sensitive
- Paths are delimited by /

Some Important Directories

- Home Directories: `/root`,`/home/`*`username`*
- User Executable: `/bin`, `/usr/bin`, `/usr/local/bin`
- System Executables: `/sbin`, `/usr/sbin`, `/usr/local/sbin`
- Other Mountpoints: `/media`, `/mnt`
- Configuration: `/etc`
- Temporary Files: `/tmp`
- Kernels and Bootloader: `/boot`
- Server Data: `/var`, `/srv`
- System Information: `/proc`, `/sys`
- Shared Libraries: `/lib`, `/usr/lib`, `/usr/local/lib`

File and Directory Names

- Names may be up to 255 characters
- All characters are valid, except the forward-slash
  - It may be unwise to use certain special characters in file or directory names
  - Some characters should be protected with quotes when referencing them
- Names are case-sensitive
  - Example: `MAIL`, `Mail`, `mail`, and `mAiL`
  - Again, possible, but may not be wise

Using Nautilus

- Gnome graphical filesystem browser
- Can run in *spatial* or *browser* mode
- Accessed via...
  - Desktop icons
    - Home: Your home directory
    - Computer: Root filesystem, network resources and removable media
  - Applications->System Tools->File Browser

Moving and Copying in Nautilus

- Drag-and-Drop
  - Drag: Move on same filesystem, copy on different filesystem
  - Drag + **Ctrl**: Always copy
  - Drag + **Alt**: Ask whether to copy, move or create symbolic link (alias)
- Context menu
  - Right-click to rename, cut, copy or paste

File Management from the Command-Line

- Shells typically start in the home directory
- Change directory with **cd**
- List directory contents with **ls**
- Manage files with **cp**, **mv** and **rm**

Determining your Current Directory

- Each shell and system process has a *current working directory*(cwd)
- **pwd**
  - Displays the absolute path to the shell's cwd

Absolute and Relative Pathnames

- Used when referring to files on the command-line
- Absolute pathnames
  - Begin with a forward slash
  - Complete "road map" to file location
  - Can be used anytime you wish to specify a file name
- Relative pathnames
  - Do not begin with a slash
  - Specify location relative to your current working directory
  - Can be used as a shorter way to specify a file name

Changing Directories

- **cd** changes directories
  - To an absolute or relative path:
    - **cd** `/home/joshua/work`
    - **cd** `project/docs`
  - To a directory one level up:
    - **cd** `..`
  - To your home directory:
    - **cd**
  - To your previous working directory:
    - **cd** `-`

Listing Directory Contents

- Lists the contents of the current directory or a specified directory
- Usage:
  - **ls [options] [*files_or_dirs*]**
- Example:
  - **ls -a** (include hidden files)
  - **ls -l** (display extra information)
  - **ls -R** (recurse through directories)
  - **ls -ld** (directory and symlink information)

Copying Files and Directories

- **cp** - copy files and directories
- Usage:
  - **cp [options]** ***file destination***
- More than one file may be copied at a time if the destination is a directory:
  - **cp [options]** ***file1 file2 destdir***

Copying Files and Directories: The Destination

- If the destination is a directory, the copy is placed there
- If the destination is a file, the copy overwrites the destination
- If the destination does not exist, the copy is renamed

Moving and Renaming Files and Directories

- **mv** - move and/or rename files and directories
- Usage:
  - **mv [options]** ***file destination***
- More than one file may be moved at a time if the destination is a directory:
  - **mv [options]** ***file1 file2 destdir***
- Destination works like **cp**

Creating and Removing Files

- **touch** - create empty files or update file timestamps
- **rm** - remove files
- Usage:
  - **rm [options] <*file*>...**
- Example:
  - **rm -i *file*** (interactive)
  - **rm -r *directory*** (recursive)
  - **rm -f *file*** (force)

Creating and Removing Directories

- **mkdir** creates directories
- **rmdir** removes empty directories
- **rm -r** recursively removes directory trees

Determining File Content

- Files can contain many types of data
- Check file type with file before opening to determine appropriate command or application to use
- **file [options] <filename>...**

End of Lecture 4

- Questions and Answers
- Summary
  - Files can be managed graphically using **nautilus**
  - Essential command-line file management tools include
    - **cd** to change directories
    - **ls** to list directory contents
    - **cp** to copy files
    - **mv** to move or rename files
    - **rm** to remove files
    - **rm -rf** to remove directories

Lecture 5

Users, Groups and Permissions

Objectives

Upon completion of this unit, you should be able to:

- Explain the Linux security model
- Explain the purpose of user and group accounts
- Read and set file permissions

Users

- Every user is assigned a unique User ID number (*UID*)
  - UID 0 identifies root
  - User accounts normally start at UID 500
- Users' names and UIDs are stored in `/etc/passwd`
- Users are assigned a home directory and a program that is run when they log in (usually a shell)
- Users cannot read, write or execute each others' files without permission

Groups

- Users are assigned to groups
- Each group is assigned a unique Group ID number (*gid*)
- GIDs are stored in `/etc/group`
- Each user is given their own private group
  - Can be added to other groups for additional access
- All users in a group can share files that belong to the group

Linux File Security

- Every file is owned by a UID and a GID
- Every process runs as a UID and one or more GIDs
  - Usually determined by who runs the process
- Three access categories:
  - Processes running with the same UID as the file (*user*)
  - Processes running with the same GID as the file (*group*)
  - All other processes (*other*)

Permission Precedence

- If UID matches, *user* permissions apply
- Otherwise, if GID matches, *group* permissions apply
- If neither match, *other* permissions apply

Viewing Permissions from the Command-Line

- File permissions may be viewed using **ls -l**

```
$ ls -l /bin/login
-rwxr-xr-x 1 root root 19080 Apr 1 18:26 /bin/login
```

- Four symbols are used when displaying permissions:
  - `r`: permission to read a file or list a directory's contents
  - `w`: permission to write to a file or create and remove files from a directory
  - `x`: permission to execute a program or change into a directory and do a long listing of the directory
  - `-`: no permission (in place of the `r`, `w`, or `x`)

Changing File Ownership

- Only root can change a file's owner
- Only root or the owner can change a file's group
- Ownership is changed with **chown**:
  - **chown [-R]** ***user_name file*|*directory*** **...**
- Group-Ownership is changed with **chgrp**:
  - **chgrp [-R]** ***group_name file*|*directory*** **...**

Changing Permissions - Symbolic Method

- To change access modes:
  - **chmod [-*OPTION*]... *mode*[,*mode*] *file*|*directory* ...**
- *mode* includes:
  - **u**,**g** or **o** for user, group and other
  - **+ -** or **=** for grant, deny or set
  - **r**, **w** or **x** for read, write and execute
- Options include:
  - **-R** Recursive
  - **-v** Verbose
  - **--reference** Reference another file for its mode
- Examples:
  - **chmod ugo+r *file***: Grant read access to all for *file*
  - **chmod o-wx *dir***: Deny write and execute to others for *dir*
  - **chmod --reference file1 file2**: Get the mode from `file1` and place it on `file2`

Changing Permissions - Numeric Method

- Uses a three-digit mode number
  - first digit specifies owner's permissions
  - second digit specifies group permissions
  - third digit represents others' permissions
- Permissions are calculated by adding:
  - 4 (for read)
  - 2 (for write)
  - 1 (for execute)
- Example:
  - **chmod 640 myfile**

Changing Permissions - Nautilus

- Nautilus can be used to set the permissions and group membership of files and directories.
    - In a Nautilus window, right-click on a file
    - Select Properties from the context menu
    - Select the Permissions tab

End of Lecture 5

- Questions and Answers
- Summary
  - All files are owned by one user and one group
  - The mode of a file is made up of three permissions: those of the user, the group and all others
  - Three permissions may be granted or denied: read, write and execute

Lecture 6

Using the bash Shell

Objectives

Upon completion of this unit, you should be able to:

- Use command-line shortcuts
- Use command-line expansion
- Use history and editing tricks
- Use the **gnome-terminal**
- Write simple shell scripts
- Set and reference shell variables

Command Line Shortcuts
File Globbing

- *Globbing* is wild card expansion:
  - **`*`** - matches zero or more characters
  - **`?`** - matches any single character
  - **`[0-9]`** - matches a range of numbers
  - **`[abc]`** - matches any one of the characters in the list
  - **`[^abc]`** - matches any one character except those in the list
  - **`[:alpha:]`** - characters in a predefined character class can be matched
- **`glob(7)`**

Command Editing Tricks

- **Ctrl-a** moves to beginning of line
- **Ctrl-e** moves to end of line
- **Ctrl-u** deletes to beginning of line
- **Ctrl-k** deletes to end of line
- **Ctrl-*arrow*** moves left or right by word

Command Line Expansion
The tilde

- Tilde (~)
- May refer to your home directory

```
$ cat ~/.bash_profile
```

- May refer to another user's home directory

```
$ ls ~julie/public_html
```

Command Line Expansion
Commands and Braced Sets

- Command Expansion: **$()** or ``
  - Prints output of one command as an argument to another

```
$ echo "This system's name is $(hostname)"
This system's name is server100.example.com
```

- Brace Expansion: **{ }**
  - Shorthand for printing repetitive strings

```
$ echo file{1,3,5}
file1 file3 file5
$ rm -f file{1,3,5}
```

Bash Variables

- Variables are named values
  - Useful for storing data or command output
- Set with ***VARIABLE*=*VALUE***
- Referenced with **${*VARIABLE*}**

```
$ HI="Hello, and welcome to $(hostname)."
$ echo ${HI}
Hello, and welcome to stationX.
```

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Environment Variables

- Bash variables are *local* to a single shell by default
    - Set with ***VARIABLE=VALUE***
- *Environment variables* are inherited by child shells
    - Set with **export** ***VARIABLE=VALUE***
    - Accessed by some programs for configuration

Some Common Variables

- Configuration variables
  - `PS1`: Appearance of the **bash** prompt
  - `HISTFILESIZE`: Number of commands in **bash** history
  - `PATH`: Directories to look for executables in
  - `EDITOR`: Default text editor
- Information variables
  - `HOME`: User's home directory
  - `EUID`: User's *effective UID*

Aliases

- Aliases let you create shortcuts to commands

```
$ alias dir='ls -laF'
```

- Use **alias** by itself to see all set aliases
- Use **alias** followed by an alias name to see alias value

```
$ alias dir
alias dir='ls -laF'
```

How bash Expands a Command Line

1. Shell statements are expanded
   - variables, command-substitution, aliases, etc
   - globbing characters, only if they match
2. I/O re-direction is set up
3. Command is executed
   - Command sees the results of expansion, not the shell characters!

Preventing Expansion

- Backslash (\ ) makes the next character literal

```
$ echo Your cost: \$5.00
Your cost: $5.00
```

- Quoting prevents expansion
  - Single quotes (') inhibit all expansion
  - Double quotes (") inhibit all expansion, except:
    - **$** (dollar sign) - variable expansion
    - ` (backquotes) - command substitution
    - \ (backslash) - single character inhibition
    - **!** (exclamation point) - history substitution

Scripting Basics

- Shell scripts are text files containing commands to be executed.
- Shell scripts are useful for:
  - Automating commonly used commands
  - Performing system administration and troubleshooting
  - Creating simple applications
  - Manipulation of text or files

Creating Shell Scripts

- Step 1: Create a text file containing commands
  - First line contains the magic *shebang* sequence: #!
    - **`#!/bin/bash`**
- Comment your scripts!
  - Comments start with a #

Creating Shell Scripts continued

- Step 2: Make the script executable:

```
$ chmod u+x myscript.sh
```

- To execute the new script:
  - Place the script file in a directory in the executable path, such as `~/bin` or `/usr/local/bin` -OR-
  - Specify the absolute or relative path to the script on the command line

Sample Shell Script

```
#!/bin/bash
# This script displays some information about your environment

echo "Greetings. The date and time are $(date)"

echo "Your working directory is: $(pwd)"
```

Login vs non-login shells

- Startup is configured differently for login and non-login shells
- Login shells are:
  - Any shell created at login (includes X login)
  - su -
- Non-login shells are:
  - su
  - graphical terminals
  - executed scripts
  - any other bash instances

Bash startup scripts: profile

- Stored in `/etc/profile` (global) and `~/.bash_profile` (user)
- Run for login shells only
- Used for
  - Setting environment variables
  - Running commands (eg mail-checker script)

Bash startup scripts: bashrc

- Stored in `/etc/bashrc` (global) and `~/.bashrc` (user)
- Run for all bash shells
- Used for
  - Setting local variables
  - Defining aliases

Sourcing files

- Changes to profile and bashrc files need to be *sourced*
- Two methods:
  - `.` ***`scriptname`***
  - **`source`** ***`scriptname`***
- Shell scripts can source other files

Bash Exit Tasks

- Stored in `~/.bash_logout` (user)
- Run when a login shell exits
- Used for
  - Creating automatic backups
  - Cleaning out temporary files

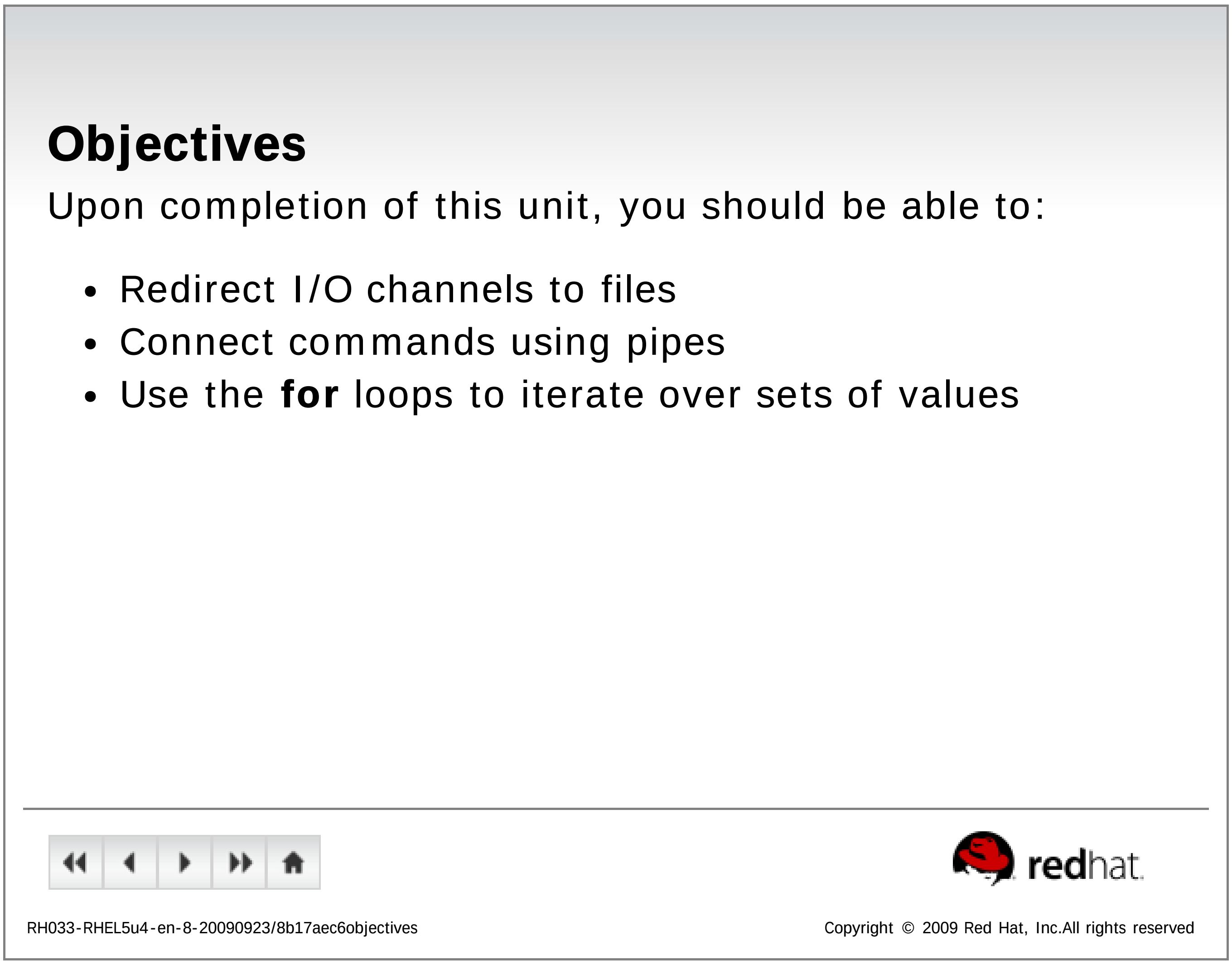
End of Lecture 6

- Questions and Answers
- Summary
  - Command expansion: **`$()`**
  - History recall: **`!`*`string`***, **`!`*`num`***
  - Shell scripting
  - Local variables (`VARNAME=VALUE`) only apply to the shell they are set in
  - Environment variables (`export VARNAME=VALUE`) are inherited by child shells
  - The value of a variable is referenced with `${VARNAME}`

Lecture 7

Standard I/O and Pipes

RH033-RHEL5u4-en-8-20090923/8b17aec6title



Objectives

Upon completion of this unit, you should be able to:

- Redirect I/O channels to files
- Connect commands using pipes
- Use the **for** loops to iterate over sets of values

Standard Input and Output

- Linux provides three I/O channels to Programs
  - Standard input (STDIN) - keyboard by default
  - Standard output (STDOUT) - terminal window by default
  - Standard error (STDERR) - terminal window by default

Redirecting Output to a File

- STDOUT and STDERR can be redirected to files:
  - *`command operator filename`*
- Supported operators include:
  - > Redirect STDOUT to file
  - 2> Redirect STDERR to file
  - &> Redirect all output to file
- File contents are overwritten by default. >> appends.

Redirecting Output to a File
Examples

- This command generates output and errors when run as non-root:

```
$ find /etc -name passwd
```

- Operators can be used to store output and errors:

```
$ find /etc -name passwd > find.out
$ find /etc -name passwd 2> /dev/null
$ find /etc -name passwd > find.out 2> find.err
```

Redirecting STDOUT to a Program (Piping)

- Pipes (the **|** character) can connect commands: ***command1* | *command2***
  - Sends STDOUT of command1 to STDIN of command2 instead of the screen.
  - STDERR is *not* forwarded across pipes
- Used to combine the functionality of multiple tools
  - ***command1* | *command2* | *command3*... etc.**

Useful Pipe Targets

- **less**: View input one page at a time:

  ```
  $ ls -l /etc | less
  ```

  - Input can be searched with **/**

- **mail**: Send input via email:

  ```
  $ echo "test email" | mail -s "test" user@example.com
  ```

- **lpr** : Send input to a printer:

  ```
  $ echo "test print" | lpr
  $ echo "test print" | lpr -P printer_name
  ```

Combining Output and Errors

- Some operators affect both STDOUT and STDERR
  - **&>**: Redirects all output:

    ```
    $ find /etc -name passwd &> find.all
    ```

  - **2>&1**: Redirects STDERR to STDOUT
    - Useful for sending all output through a pipe

    ```
    $ find /etc -name passwd 2>&1 | less
    ```

  - **()**: Combines STDOUTs of multiple programs

    ```
    $ ( cal 2007 ; cal 2008 ) | less
    ```

Redirecting to Multiple Targets (tee)

- `$` ***`command1`*** **`| tee`** ***`filename`*** **`|`** ***`command2`***
- Stores STDOUT of *`command1`* in *`filename`*, then pipes to *`command2`*
- Uses:
  - Troubleshooting complex pipelines
  - Simultaneous viewing and logging of output

Redirecting STDIN from a File

- Redirect standard input with **<**
- Some commands can accept data redirected to STDIN from a file:

```
$ tr 'A-Z' 'a-z' < .bash_profile
```

  - This command will translate the uppercase characters in `.bash_profile` to lowercase
- Equivalent to:

```
$ cat .bash_profile | tr 'A-Z' 'a-z'
```

Sending Multiple Lines to STDIN

- Redirect multiple lines from keyboard to STDIN with **<<*WORD***
  - All text until ***WORD*** is sent to STDIN
  - Sometimes called a *heretext*

```
$ mail -s "Please Call" jane@example.com <<END
> Hi Jane,
>
> Please give me a call when you get in. We may need
> to do some maintenance on the server.
>
> Details when you're on-site,
> Boris
> END
```

Scripting: for loops

- Performs actions on each member of a set of values
- Example:

```
for NAME in joe jane julie
do
        ADDRESS="$NAME@example.com"
        MESSAGE='Projects are due today!'
        echo $MESSAGE | mail -s Reminder $ADDRESS
done
```

Scripting: for loops continued

- Can also use command-output and file lists:
  - **for num in $(seq 1 10)**
    - Assigns 1-10 to $num
    - **seq X Y** prints the numbers X through Y
  - **for file in *.txt**
    - Assigns names of text files to $file

End of Lecture 7

- Questions and Answers
- Summary
    - Standard I/O channels
    - File redirection
        - Standard input (**<**)
        - Standard Output (**>**)
        - Standard Error (**2>**)
    - Pipes redirect standard output to standard input
    - **for** loops can perform commands on items from a program's standard output or an explicit list

Lecture 8

Text Processing Tools

Objectives

Upon completion of this unit, you should be able to:

- Use tools for extracting, analyzing and manipulating text data

Tools for Extracting Text

- File Contents: **less** and **cat**
- File Excerpts: **head** and **tail**
- Extract by Column or Field: **cut**
- Extract by Keyword: **grep**

Viewing File Contents
less and cat

- **cat**: dump one or more files to STDOUT
  - Multiple files are con*cat*enated together
- **less**: view file or STDIN one page at a time
  - Useful commands while viewing:
    - ***/text*** searches for *text*
    - **n**/**N** jumps to the next/previous match
    - **v** opens the file in a text editor (**vi** by default)
  - **less** is the pager used by **man**

Viewing File Excerpts
head and tail

- **head**: Display the first 10 lines of a file
  - Use **-n** to change number of lines displayed
- **tail**: Display the last 10 lines of a file
  - Use **-n** to change number of lines displayed
  - Use **-f** to "follow" subsequent additions to the file
    - Very useful for monitoring log files!

Extracting Text by Keyword
grep

- Prints lines of files or STDIN where a pattern is matched

```
$ grep 'john' /etc/passwd
$ date --help | grep year
```

- Use **-i** to search case-insensitively
- Use **-n** to print line numbers of matches
- Use **-v** to print lines *not* containing pattern
- Use **-A*X*** to include the *X* lines after each match
- Use **-B*X*** to include the *X* lines before each match
- Use **-r** to recursively search a directory
- Use **--color** to highlight the match in color

Extracting Text by Column or Field
cut

- Display specific columns of file or STDIN data

```
$ cut -d: -f1 /etc/passwd
$ grep root /etc/passwd | cut -d: -f7
```

- Use **-d** to specify the column delimiter (default is TAB)
- Use **-f** to specify the column to print
- Use **-c** to cut by characters

```
$ cut -c2-5 /usr/share/dict/words
```

Tools for Analyzing Text

- Text Stats: **wc**
- Sorting Text: **sort**
- Comparing Files: **diff**
- Spell Check: **aspell**

Gathering Text Statistics
wc (word count)

- Counts words, lines, bytes and characters
- Can act upon a file or STDIN

```
$ wc story.txt
39     237    1901 story.txt
```

- Use **-l** for only line count
- Use **-w** for only word count
- Use **-c** for only byte count
- Use **-m** for character count (not displayed)

Sorting Text
sort

- Sorts text to STDOUT - original file unchanged

```
$ sort [options] file(s)
```

- Common options
  - **-r** performs a reverse (descending) sort
  - **-n** performs a numeric sort
  - **-f** ignores (folds) case of characters in strings
  - **-u** (unique) removes duplicate lines in output
  - **-t *c*** uses *c* as a field separator
  - **-k *X*** sorts by *c*-delimited field *X*
    - Can be used multiple times

Eliminating Duplicate Lines
sort and uniq

- **sort -u**: removes duplicate lines from input
- **uniq**: removes duplicate *adjacent* lines from input
  - Use **-c** to count number of occurrences
  - Use with **sort** for best effect:

```
$ sort userlist.txt | uniq -c
```

Comparing Files
diff

- Compares two files for differences

```
$ diff foo.conf-broken foo.conf-works
5c5
<   use_widgets = no
---
>   use_widgets = yes
```

  - Denotes a difference (change) on line 5
- Use **gvimdiff** for graphical **diff**
  - Provided by `vim-X11` package

Spell Checking with aspell

- Interactively spell-check files:

```
$ aspell check letter.txt
```

- Non-interactively list and count mis-spelled words in STDIN

```
$ aspell list < letter.txt
$ aspell list < letter.txt | sort -u | wc -l
```

Tools for Manipulating Text
tr and sed

- Alter (**tr**anslate) Characters: **tr**
  - Converts characters in one set to corresponding characters in another set
  - Only reads data from STDIN

    ```
    $  tr 'a-z' 'A-Z' < lowercase.txt
    ```

- Alter Strings: **sed**
  - **s**tream **ed**itor
  - Performs search/replace operations on a stream of text
  - Normally does not alter source file
  - Use **-i.bak** to back-up and alter source file

sed
Examples

- Quote search and replace instructions!
- **sed** addresses
  - **sed 's/dog/cat/g' pets**
  - **sed '1,50s/dog/cat/g' pets**
  - **sed '/digby/,/duncan/s/dog/cat/g' pets**
- Multiple **sed** instructions
  - **sed -e 's/dog/cat/' -e 's/hi/lo/' pets**
  - **sed -f myedits pets**

Special Characters for Complex Searches
Regular Expressions

- **^** represents beginning of line
- **$** represents end of line
- Character classes as in **bash**:
  - **`[abc]`**, **`[^abc]`**
  - **`[[:upper:]]`**, **`[^[:upper:]]`**
- Used by:
  - **grep**, **sed**, **less**, others

End of Lecture 8

- Questions and Answers
- Summary
  - Extracting Text
    - **cat**, **less**, **head**, **tail**, **grep**, **cut**
  - Analyzing Text
    - **wc**, **sort**, **uniq**, **diff**,
  - Manipulating Text
    - **tr**, **sed**
  - Special Search Characters
    - **^**, **$**, **[abc]**, **[^abc]**, **[[:alpha:]]**, **[^[:alpha:]]**, etc.

Lecture 9

vim: An Advanced Text Editor

RH033-RHEL5u4-en-8-20090923/66ec118dtitle

Objectives

Upon completion of this unit, you should be able to:

- Use the three primary modes of **vi** and **vim**
- Navigate text and enter Insert mode
- Change, delete, yank, and put text
- Undo changes
- Search a document
- Save and exit

Introducing vim

- Newer version of **vi**, the standard Unix text editor
  - Executing **vi** runs **vim** by default
- **gvim**: Graphical version of **vim**
  - Applications + Programming -> Vi IMproved
  - Provided by `vim-X11` package
- Advantages:
  - Speed: Do more with fewer keystrokes
  - Simplicity: No dependence on mouse/GUI
  - Availability: Included with most Unix-like OSes
- Disadvantages
  - Difficulty: Steeper learning curve than simpler editors
    - Key bindings emphasize speed over intuitiveness

vim: A Modal Editor

- Keystroke behavior is dependent upon **vim**'s "mode"
- Three main modes:
  - Command Mode (default): Move cursor, cut/paste text, change mode
  - Insert Mode: Modify text
  - Ex Mode: Save, quit, etc.
- **Esc** exits current mode
- **EscEsc** always returns to command mode

vim Basics

- To use **vim**, you must learn to:
  - Open a file
  - Modify a file (insert mode)
  - Save a file (ex mode)

Opening a file in vim

- To start **vim**:
  - **vim *filename***
  - If the file exists, the file is opened and the contents are displayed
  - If the file does not exist, **vi** creates it when the edits are saved for the first time

Modifying a File
Insert Mode

- **`i`** begins insert mode at the cursor
- Many other options exist
  - **`A`** append to end of line
  - **`I`** insert at beginning of line
  - **`o`** insert new a line (below)
  - **`O`** insert new line (above)

Saving a File and Exiting vim
Ex Mode

- Enter Ex Mode with **:**
  - Creates a command prompt at bottom-left of screen
- Common write/quit commands:
  - **`:w`** writes (saves) the file to disk
  - **`:wq`** writes and quits
  - **`:q!`** quits, even if changes are lost

Using Command Mode

- Default mode of **vim**
- Keys describe movement and text manipulation commands
- Commands repeat when preceded by a number
- Example
  - **Right Arrow** moves right one character
  - **5**, **Right Arrow** moves right five characters

Moving Around
Command Mode

- Move by character: Arrow Keys, **h**, **j**, **k**, **l**
    - Non-arrow keys useful for remote connections to older systems
- Move by word: **w**, **b**
- Move by sentence: **)**, **(**
- Move by paragraph: **}**, **{**
- Jump to line *x*: ***x*G** or **:*x***
- Jump to end: **G**

Search and Replace
Command Mode and EX mode

- Search as in **less**
  - **/**, **n**, **N**
- Search/Replace as in **sed**
  - Affects current line by default
  - Use ***x,y*** ranges or **%** for every line
    - **`:1,5s/cat/dog/`**
    - **`:%s/cat/dog/gi`**

Manipulating Text
Command Mode

	Change (replace)	Delete (cut)	Yank (copy)
Line	`cc`	`dd`	`yy`
Letter	`cl`	`dl`	`yl`
Word	`cw`	`dw`	`yw`
Sentence ahead	`c)`	`d)`	`y)`
Sentence behind	`c(`	`d(`	`y(`
Paragraph above	`c{`	`d{`	`y{`
Paragraph below	`c}`	`d}`	`y}`

Put (paste)

- Use **p** or **P** to put (paste) copied or deleted data
- For line oriented data:
  - **p** puts the data below the current line
  - **P** puts the data above the current line
- For character oriented data:
  - **p** puts the data after the cursor
  - **P** puts the data before the cursor

Undoing Changes
Command Mode

- **u** undo most recent change
- **U** undo all changes to the current line since the cursor landed on the line
- **Ctrl-r** redo last "undone" change

Visual Mode

- Allows selection of blocks of text
  - *v* starts character-oriented highlighting
  - *V* starts line-oriented highlighting
  - Activated with mouse in **gvim**
- Visual keys can be used in conjunction with movement keys:
  - **`w`**, **`)`**, **`}`**, arrows, etc.
- Highlighted text can be deleted, yanked, changed, filtered, search/replaced, etc.

Using multiple "windows"

- Multiple documents can be viewed in a single **vim** screen
  - **Ctrl-w**, **s** splits the screen horizontally
  - **Ctrl-w**, **v** splits the screen vertically
  - **Ctrl-w**, ***Arrow*** moves between windows
- Ex-mode instructions always affect the current window
- **`:help windows`** displays more window commands

Configuring vi and vim

- Configuring on the fly
  - **`:set`** or **`:set all`**
- Configuring permanently
  - `~/.vimrc` or `~/.exrc` (do not include the colon [:] in these files)
- A few common configuration items
  - **`:set number`**
  - **`:set autoindent`**
  - **`:set textwidth=65 (vim only)`**
  - **`:set wrapmargin=15`**
  - **`:set ignorecase`**
- Run **`:help option-list`** for a complete list

Learning more

- **vi**/**vim** built-in help
  - **`:help`**
  - **`:help`** ***`topic`***
  - Use **`:q`** to exit help
- **vimtutor** command

End of Lecture 9

- Questions and Answers
- Summary
  - Use the three primary modes of **vi** and **vim**
  - Move the cursor and enter Insert mode
  - Change, delete, yank, and put text
  - Undo changes
  - Search a document
  - Save and exit

Lecture 10

Investigating and Managing Processes

Objectives

Upon completion of this unit, you should be able to:

- Explain what a process is
- Describe how to manage processes
- Use job control tools
- Schedule recurring jobs
- Employ decision making constructs in shell scripts

What is a Process?

- A process is a set of instructions loaded into memory
  - Numeric *Process ID* (PID) used for identification
  - UID, GID and SELinux context determines filesystem access
    - Normally inherited from the executing user

Listing Processes

- View Process information with **ps**
  - Shows processes by the current user on the current terminal by default
  - **-e** shows all processes
  - **-u *user*** shows all processes by ***user***
  - **-F** prints extra information
  - **-H** indents child processes
  - **-o PROPERTY1,PROPERTY2,...** prints custom information:
    - **pid**, **comm**, **%cpu**, **%mem**, **state**, **tty**, **euser**, **ruser**, etc.
- Example:
  - **`ps -eo pid,%cpu,comm`**

Finding Processes

- Most flexible: **ps** ***options*** **|** ***other commands***
  ps -eo comm,tty | grep ttyS0
- By predefined patterns: **pgrep**

```
$ pgrep -U root
```

```
$ pgrep -G student
```

- By exact program name: **/sbin/pidof**

```
$ ps -p $(/sbin/pidof bash)
```

Signals

- Sent directly to processes, no user-interface required
- Programs associate actions with each signal
- Signals are specified by name or number when sent:
  - Signal 15, TERM (default) - Terminate cleanly
  - Signal 9, KILL - Terminate immediately
  - Signal 1, HUP - Re-read configuration files
  - **man 7 signal** shows complete list

Sending Signals to Processes

- By PID: **kill [-*signal*] *pid* ...**
- By Name: **killall [-*signal*] *comm* ...**
- By pattern: **pkill [-*signal*] *pattern***

Scheduling Priority

- Scheduling priority determines access to the CPU
- Priority is affected by a process' *nice value*
- Values range from -20 to 19 but default to 0
  - Lower nice value means higher CPU priority
- Viewed with **ps -o comm,nice**

Altering Scheduling Priority

- Nice values may be altered...
  - When starting a process:

    ```
    $ nice -n 5 command
    ```

  - After starting:

    ```
    $ renice 5 PID
    ```

- Only root may decrease nice values

Interactive Process Management Tools

- CLI: **top**
- GUI: **gnome-system-monitor**
- Capabilities
  - Display real-time process information
  - Allow sorting, killing and re-nicing

Job Control

- Run a process in the background
  - Append an ampersand to the command line: **firefox &**
- Temporarily halt a running program
  - Use **Ctrl**-**z** or send signal 19 (STOP)
- Manage background or suspended jobs
  - List job numbers and names: **jobs**
  - Resume in the background: **bg [%*jobnum*]**
  - Resume in the foreground: **fg [%*jobnum*]**
  - Send a signal: **kill [-*SIGNAL*] [%*jobnum*]**

Exit Status

- Processes report success or failure with an exit status
  - 0 for success, 1-255 for failure
  - **$?** stores the exit status of the most recent command
  - **exit [*num*]** terminates and sets status to *num*
- Example:

```
$ ping -c1 -W1 station999 &> /dev/null
$ echo $?
2
```

Conditional Execution Operators

- Commands can be run conditionally based on exit status
  - **&&** represents conditional AND THEN
  - **||** represents conditional OR ELSE
- Examples:

```
$ grep -q no_such_user /etc/passwd || echo 'No such user'
No such user

$ ping -c1 -W2 station1 &> /dev/null  \
>        && echo "station1 is up"         \
>        || { echo 'station1 is unreachable'; exit 1; }
station1 is up
```

The test Command

- Evaluates boolean statements for use in conditional execution
  - Returns 0 for true
  - Returns 1 for false
- Examples in long form:

```
$ test "$A" =  "$B" && echo "Strings are equal"
$ test "$A" -eq "$B" && echo "Integers are equal"
```

- Examples in shorthand notation:

```
$ [ "$A" =  "$B" ] && echo "Strings are equal"
$ [ "$A" -eq "$B" ] && echo "Integers are equal"
```

File Tests

- File tests:
  - **-f** tests to see if a file exists and is a regular file
  - **-d** tests to see if a file exists and is a directory
  - **-x** tests to see if a file exists and is executable

```
[ -f ~/lib/functions ] && source
~/lib/functions
```

Scripting: if Statements

- Execute instructions based on the exit status of a command

```
if ping -c1 -w2 station1 &> /dev/null; then
    echo 'Station1 is UP'
elif grep "station1" ~/maintenance.txt &> /dev/null; then
    echo 'Station1 is undergoing maintenance'
else
    echo 'Station1 is unexpectedly DOWN!'
        exit 1
fi
```

End of Lecture 10

- Questions and Answers
- Summary
    - A process is any set of instructions in memory
    - Processes are managed with: **ps**, **kill**, **top**, **gnome-system-monitor**
    - Suspend jobs with **Ctrl**-**z**, manage with **fg**, **bg**
    - Every process returns a numeric *exit status* upon exit
    - **test** returns 0 or 1 depending on parameters
    - **if**/**else**, **&&** and **||** can execute commands based on predecessors' exit status

Lecture 11

Basic System Configuration Tools

RH033-RHEL5u4-en-8-20090923/4175ab48title

Objectives

Upon completion of this unit, you should be able to:

- Configure the network
- Configure and send text to a printer
- Set the system's date and time
- Schedule time-delayed tasks
- Schedule recurring tasks
- Know how to handle input with the **read** command and positional parameters

TCP/IP Network Configuration

- Important network settings:
  - IP Configuration
  - Device Activation
  - DNS Configuration
  - Default Gateway

Managing Ethernet Connections

- Network interfaces are named sequentially: `eth0`, `eth1`, etc.
  - Multiple addresses can be assigned to a device with *aliases*
  - Aliases are labeled `eth0:1`, `eth0:2`, etc.
  - Aliases are treated like separate interfaces
- View interface configuration with **/sbin/ip addr show [eth*X*]**
- Enable interface with **/sbin/ifup eth*X***
- Disable interface with **/sbin/ifdown eth*X***

Graphical Network Configuration
system-config-network

- System->Administration->Network
  - Activate/Deactivate interfaces
  - Assign IP Addresses/DHCP
  - Modify DNS settings
  - Modify gateway address

Network Configuration Files
Ethernet Devices

- Device configuration is stored in text files
  - `/etc/sysconfig/network-scripts/ifcfg-eth`*`X`*
  - Complete list of options in `/usr/share/doc/initscripts-*/sysconfig.txt`

Dynamic Configuration	Static Configuration

DEVICE=eth*X*
HWADDR=0:02:8A:A6:30:45
BOOTPROTO=dhcp
ONBOOT=yes
Type=Ethernet
	DEVICE=eth*X*
	HWADDR=0:02:8A:A6:30:45
	IPADDR=192.168.0.123
	NETMASK=255.255.255.0
	GATEWAY=192.168.0.254
	ONBOOT=yes
	Type=Ethernet

Network Configuration Files

Other Global Network Settings

- Global Settings in `/etc/sysconfig/network`
  - Many may be provided by DHCP
  - GATEWAY can be overridden in ifcfg file

```
NETWORKING=yes
HOSTNAME=server100.example.com
GATEWAY=192.168.0.254
```

Network Configuration Files

DNS Configuration

- Domain Name Service translates hostnames to network addresses
- Server address is specified by dhcp or in `/etc/resolv.conf`

```
search example.com remote.test
nameserver 192.168.0.254
nameserver 192.168.1.254
```

Printing in Linux

- Printers may be local or networked
- Print requests are sent to queues
- Queued jobs are sent to the printer on a first come first served basis
- Jobs may be canceled before or during printing

system-config-printer

- System->Administration->Printing
- Supported printer connections:
  - Local (parallel, serial or usb)
  - Unix/Linux print server
  - Windows print server
  - Netware print server
  - HP JetDirect
- Configuration stored in `/etc/cups/printers.conf`

Printing Commands

- **lpr** sends a job to the queue to be printed
  - Accepts ASCII, PostScript, PDF, others
- **lpq** views the contents of the queue
- **lprm** removes a job from the queue
- System V printing commands such as **lp**, **lpstat** and **cancel** are also supported

Printing Utilities

- **evince** views PDF and PostScript documents
- **lpstat -a** lists configured printers
- **enscript** and **a2ps** convert text to PostScript
- **ps2pdf** converts PostScript to PDF
- **mpage** prints multiple pages per sheet

Setting the System's Date and Time

- GUI: **system-config-date**
  - System->Administration->Date & Time
  - Can set date/time manually or use NTP
  - Additional NTP servers can be added
  - Can use local time or UTC
- CLI: **date [MMDDhhmm[[CC]YY][.ss]]**

  -
    ```
    # date 01011330
    # date 010113302007.05
    ```

Scheduling Commands To Execute Later

- One-time jobs use **at**, recurring jobs use **crontab**

Create	**at** ***time***	**crontab -e**
List	**at -l**	**crontab -l**
Details	**at -c** ***jobnum***	N/A
Remove	**at -d** ***jobnum***	**crontab -r**
Edit	N/A	**crontab -e**

- Non-redirected output is mailed to the user
- *root* can modify jobs for other users

Crontab File Format

- Entry consists of five space-delimited fields followed by a command line
  - One entry per line, no limit to line length
- Fields are minute, hour, day of month, month, and day of week
- Comment lines begin with #
- See **man 5 crontab** for details

Scripting: Taking input with positional Parameters

- Special variables that hold the command-line arguments to the script
  - Position-related names: $1, $2, $3, etc.
  - Arguments are space-delimited
  - Words can be grouped into a single argument with quotes
- Normally assigned to more meaningful variable names to improve clarity
- $* holds all command-line arguments
- $# holds the number of command-line arguments

Scripting: Taking input with the read command

- Use **`read`** to assign input values to one or more shell variables:
  - **`-p`** designates prompt to display
  - **`read`** reads from standard input and assigns one word to each variable
  - Any leftover words are assigned to the last variable
  - **`read -p "Enter a filename: " FILE`**

End of Lecture 11

- Questions and Answers
- Summary
    - **system-config-network** configures /etc/sysconfig/network-scripts/*
    - **ifup**, **ifdown**
    - **lpr** sends text to the printer
    - **date** configures date/time from CLI
    - **system-config-date** configures date/time from GUI
    - Use **at** to schedule time-delayed tasks
    - Use **crontab -e** to schedule recurring tasks
    - Administrative tasks may be defined in /etc/cron.d/cron.*
    - **read *VAR*** sets variable from STDIN
    - **$1**, **$2**, etc. map to command-line arguments
    - **$#** represents the number of arguments to a script

Lecture 12

Finding and Processing Files

Objectives

Upon completion of this unit, you should be able to:

- Use **locate**
- Use **find**
- Use **the Gnome Search tool**

The Gnome Search Tool

- Places->Search for Files...
- Graphical tool for searching by
  - name
  - content
  - owner/group
  - size
  - modification time

locate

- Queries a pre-built database of paths to files on the system
  - Database must be updated by administrator
  - Full path is searched, not just filename
- May only search directories where the user has read and execute permission

locate Examples

- **`locate passwd`**
  - Search for files with "passwd" in the name or path
- Useful options
  - **`-i`** performs a case-insensitive search
  - **`-n`** ***X*** lists only the first *X* matches

find

- **find [*dir1* ...] [*criteria*...] [*action*...]**
- Searches directory trees in real-time
  - Slower but more accurate than **locate**
  - CWD is used if no starting directory given
  - All files are matched if no criteria given
- Can execute commands on found files
- Can apply boolean logic to criteria
- May only search directories where the user has read and execute permission

Basic find Examples

- **`find -name snow.png`**
  - Search for files named `snow.png` in the current directory
- **`find -iname snow.png`**
  - Case-insensitive search for files named `snow.png`, `Snow.png`, `SNOW.PNG`, etc. in the current directory
- **`find / -name '*.txt'`**
  - Search for files anywhere on the system that end in `.txt`
  - Wild cards should always be quoted to avoid unexpected results
- **`find /etc -name '*pass*'`**
  - Search for files in `/etc/` that contain pass in their name
- **`find /home -user joe -group joe`**
  - Search for files owned by the user *joe* and the group *joe* in `/home/`

find and Logical Operators

- Criteria are ANDed together by default.
- Can be OR'd or negated with **-o** or **-not**
- Parentheses can be used to determine logic order, but must be escaped in bash
  - **`find -user joe -not -group joe`**
  - **`find -user joe -o -user jane`**
  - **`find -not \( -user joe -o -user jane \)`**

find and Permissions

- Can match ownership by name or id
  - **find / -user joe -o -uid 500**
- Can match octal or symbolic permissions
  - **find -perm 755**
    - matches if mode is *exactly* 755
  - **find -perm +222**
    - matches if *anyone* can write
  - **find -perm -222**
    - matches if *everyone* can write
  - **find -perm -002**
    - matches if other can write

find and Numeric Criteria

- Many **find** criteria take numeric values
- **`find -size 10M`**
  - Files with a size of *exactly* 10 megabytes
- **`find -size +10M`**
  - Files with a size *over* 10 megabytes
- **`find -size -10M`**
  - Files with a size *less than* 10 megabytes
- Other modifiers are available such as k for KB, G for GB, etc.

find and Access Times

- **find** can match by inode timestamps
  - **-atime** when file was last read
  - **-mtime** when file data last changed
  - **-ctime** when file data or metadata last changed
- Value given is in days
  - `find /tmp -ctime +10`
    - Files changed more than 10 days ago
- Can use a value of minutes
  - **-amin**
  - **-mmin**
  - **-cmin**
  - `find /etc -amin -60`

Executing Commands with find

- Commands can be executed on found files
  - Command must be preceded with **`-exec`** or **`-ok`**
    - **`-ok`** prompts before acting on each file
  - Command must end with **`Space\;`**
  - Can use {} as a filename placeholder
  - **`find -size +100M -ok mv {} /tmp/largefiles/ \;`**

find Execution Examples

- Back up configuration files, adding a .orig extension

```
$ find -name '*.conf' -exec cp {} {}.orig \;
```

- Prompt to remove Joe's tmp files that are over 3 days old

```
$ find /tmp -ctime +3 -user joe -ok rm {} \;
```

- Fix other-writable files in your home directory

```
$ find ~ -perm -002 -exec chmod o-w {} \;
```

- Do an **ls -l** style listing of all directories in /home/

```
$ find /home -type d -ls
```

- Find files that end in .sh but are not executable by anyone. For each file, ask to make it executable by everyone

```
$ find -not -perm +111 -name '*.sh' -ok chmod 755 {} \;
```

End of Lecture 12

- Questions and Answers
- Summary
  - Use **locate** to quickly find files that are not new
  - Use **find** to search based on very specific criteria and optionally run commands on matching files
  - Use the **Gnome Search Tool** for an intuitive, but powerful GUI search tool.

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Lecture 13

Network Clients

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Objectives

Upon completion of this unit, you should be able to:

- Browse the web
- Exchange email and instant messages
- Access a Linux system remotely
- Transfer files between systems
- Use network diagnostic tools

Web Clients

- GUI and Non-GUI web browsers
- **wget**

Firefox

- Fast, lightweight, feature-rich web browser
  - Tabbed browsing
  - Popup blocking
  - Cookie management
  - Multi-engine search bar
  - Support for many popular plug-ins
  - Themes and Extensions

links

- **links** a non-GUI web browser
  - Provided by the elinks rpm
  - Full support for frames and SSL
  - Examples
    - **links http://www.redhat.com**
    - **links -dump http://www.redhat.com**
    - **links -source http://www.redhat.com**
  - Particularly useful for
    - Connectivity testing when **ping** is blocked
    - File retrieval when you don't remember the full URL to type for **curl** or **wget**

wget

- Retrieves files via HTTP and FTP
- Non-interactive - useful in shell scripts
- Can follow links and traverse directory trees on the remote server - useful for mirroring web and FTP sites

Email and Messaging

- **Evolution**
- Thunderbird
- Mutt
- Pidgin

Graphical Mail Clients

- Available in Red Hat Enterprise Linux Client variant only
- Evolution
  - Flexible email and groupware tool
- Thunderbird
  - Standalone Mozilla email client

Non-GUI Mail Clients

- **mutt**
  - Supports pop, imap and local mailboxes
  - Highly configurable
  - Mappable hot keys
  - Message threading and colorizing
  - GnuPG integration
  - Context-sensitive help with '?'

Pidgin: Instant Messaging

- Formerly known as **GAIM**
- Available in Red Hat Enterprise Linux Client variant only
- Multi-protocol Instant messaging client
- Supports AIM, MSN, ICQ, Yahoo, Jabber, Gadu-Gadu, SILC, GroupWise Messenger, IRC and Zephyr networks
- Plugins can be used to add functionality

Remote Access and File Transfer with Nautilus

- Places->Connect to Server
- Graphically browse with multiple protocols
- Allows drag-and-drop file transfers
- Supported connection types: FTP, SFTP, SMB, WebDAV, Secure WebDAV
- Can also connect via url:
  - File->Open Location

OpenSSH: Secure Remote Shell

- Secure replacement for older remote-access tools
- Allows authenticated, encrypted access to remote systems
  - **ssh [*user@*]*hostname***
  - **ssh [*user@*]*hostname command***
    - Include **-X** for graphical applications
      - Beware: hostile systems can take advantage of this!
      - Only use **-X** on trusted systems!

scp: Secure File Transfer

- Secure replacement for rcp
- Layered on top of ssh
  - **scp** ***source destination***
  - Remote files can be specified using:
    - **[user@]host:/path/to/file**
  - Use **-r** to enable recursion
  - Use **-p** to preserve times and permissions
  - Use **-C** to compress data stream

rsync: Efficient File Sync

- Efficiently copies files to or from remote systems
- Uses secure **ssh** connections for transport
    - **rsync *.conf barney:/home/joe/configs/**
- Faster than **scp** - copies differences in like files

OpenSSH Key-based Authentication

- Optional, password-less, but still secure, authentication
- Uses two keys generated by **`ssh-keygen`**:
  - *private key* stays on your system
    - Usually passphrase-protected (*recommended*)
  - *public key* is copied to destination with **`ssh-copy-id`**
    - **`ssh-copy-id -i ~/.ssh/id_rsa.pub [user@]host`**

OpenSSH Key-based Authentication continued

- An *authentication agent* stores decrypted private keys
  - Thus, passphrase only needs to be entered once
  - An agent is provided automatically in GNOME
  - Otherwise, run **ssh-agent bash**
- Keys are added to the agent with **ssh-add**

FTP Clients

- CLI: **lftp**

```
$ lftp ftp.example.com
$ lftp -u joe ftp.example.com
```

  - Automated transfers with **lftpget**
- GUI: **gFTP**
  - Applications->Internet->gFTP
  - Allows Drag-and-Drop transfers
  - Anonymous or authenticated access
  - Optional secure transfer via ssh (sftp)

smbclient

- FTP-like client to access SMB/CIFS resources
- Examples:
  - **smbclient -L server100** lists shares on server100
  - **smbclient -U student //server100/homes** accesses a share

Network Diagnostic Tools

- **ping**
- **traceroute**
- **host**
- **dig**
- **netstat**
- **gnome-nettool** (GUI)

End of Lecture 13

- Questions and Answers
- Summary
  - Firefox, Evolution and Mutt
  - Basic network diagnostic tools
  - The importance of secure network clients

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Lecture 14

Advanced Topics in Users, Groups and Permissions

Objectives

Upon completion of this unit, you should be able to:

- Describe where Linux stores user, group and password information
- Set default permissions
- Use special permissions

User and Group ID Numbers

- User names map to user ID numbers
- Group names map to group ID numbers
- Data stored on the hard disk is stored numerically

`/etc/passwd`, `/etc/shadow`, and `/etc/group` files

- Authentication information is stored in plain text files:
    - `/etc/passwd`
    - `/etc/shadow`
    - `/etc/group`
    - `/etc/gshadow`

User Management Tools

- GUI
  - **system-config-users**
- CLI
  - **useradd**
  - **usermod**
  - **userdel [-r]**

System Users and Groups

- Server programs such as web or print servers typically run as unprivileged users, not as root
  - Examples: `daemon`, `mail`, `lp`, `nobody`
- Running programs in this way limits the amount of damage any single program can do to the system

Monitoring Logins

- Connected users: **w**
- Login and reboot history: **last**
- Failed login attempts: **lastb**
- Most recent logins: **lastlog**

Default Permissions

- Default permission for directories is 777 minus *umask*
- Default permission for files is the directory default without execute permission.
- *umask* is set with the **umask** command
- Non-privileged users' **umask** is 002
  - Files will have permissions of 664
  - Directories will have permissions of 775
- `root`'s **umask** is 022

Special Permissions for Executables

- Special permissions for executables:
  - **suid**: command run with permissions of the *owner* of the command, not executor of the command
  - **sgid**: command runs with group affiliation of the group of the command

Special Permissions for Directories

- Special permissions for directories:
    - sticky bit: files in directories with the sticky bit set can only be removed by the owner and root, regardless of the write permissions of the directory
    - sgid: files created in directories with the sgid bit set have group affiliations of the group of the directory

End of Lecture 14

- Questions and Answers
- Summary
  - User information is stored in `/etc/passwd`
  - Group information is stored in `/etc/group`
  - Special Permissions: Sticky Bit, SetUID, SetGID

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Lecture 15

The Linux Filesystem In-Depth

Objectives

Upon completion of this unit, you should be able to:

- Describe how filesystem information is organized
- Describe the function of dentries and inodes
- Describe how **cp**, **mv**, and **rm** work at the inode level
- Create symbolic links and hard links
- Access removable media
- Create archives using **tar** and **gzip**

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Partitions and Filesystems

- Disk drives are divided into *partitions*
- Partitions are formatted with *filesystems*, allowing users to store data
  - Default filesystem: ext3, the Third Extended Linux Filesystem
  - Other common filesystems:
    - ext2 and msdos (typically used for floppies)
    - iso9660 (typically used for CDs)
    - GFS and GFS2 (typically for SANs)

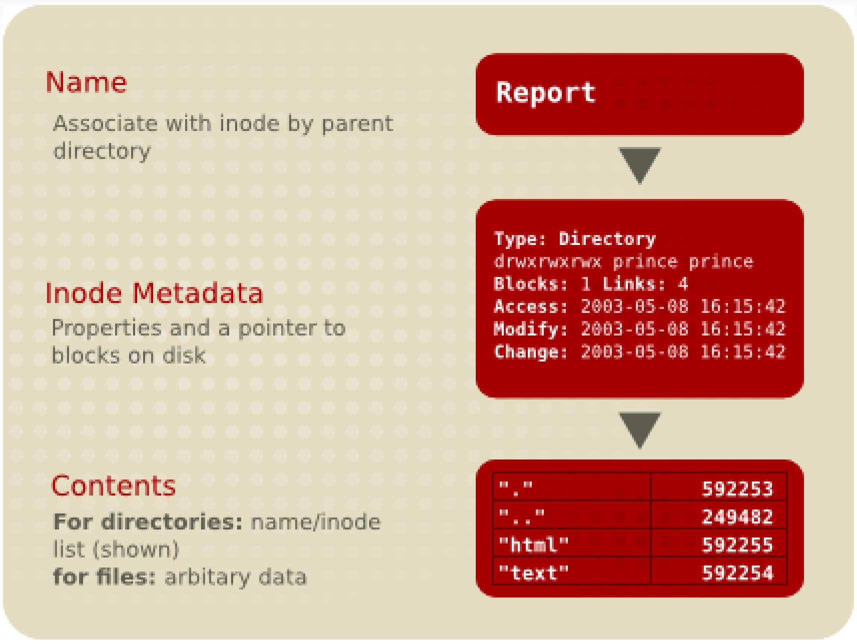
Inodes

- An *inode table* contains a list of all files in an ext2 or ext3 filesystem
- An *inode* (index node) is an entry in the table, containing information about a file (the *metadata*), including:
  - file type, permissions, UID, GID
  - the link count (count of path names pointing to this file)
  - the file's size and various time stamps
  - pointers to the file's data blocks on disk
  - other data about the file

Directories

- The computer's reference for a file is the *inode number*
- The human way to reference a file is by *file name*
- A *directory* is a mapping between the human name for the file and the computer's inode number

Inodes and Directories


Name
Associate with inode by parent directory
Inode Metadata
Properties and a pointer to blocks on disk
Contents
For directories: name/inode list (shown)
for files: arbitary data
Report

```
Type: Directory
drwxrwxrwx prince prince
Blocks: 1 Links: 4
Access: 2003-05-08 16:15:42
Modify: 2003-05-08 16:15:42
Change: 2003-05-08 16:15:42
```

"."	592253
".."	249482
"html"	592255
"text"	592254

cp and inodes

- The **cp** command:
  1. Allocates a free inode number, placing a new entry in the inode table
  2. Creates a dentry in the directory, associating a name with the inode number
  3. Copies data into the new file

mv and inodes

- If the destination of the **mv** command is on the same file system as the source, the **mv** command:
  1. Creates a new directory entry with the new file name
  2. Deletes the old directory entry with the old file name
- Has no impact on the inode table (except for a time stamp) or the location of data on the disk: no data is moved!
- If the destination is a different filesystem, **mv** acts as a copy and remove

rm and inodes

- The **rm** command:
  1. Decrements the link count, thus freeing the inode number to be reused
  2. Places data blocks on the free list
  3. Removes the directory entry
- Data is not actually removed, but will be overwritten when the data blocks are used by another file

Hard Links

- A hard link adds an additional dentry to reference a single file
  - One physical file on the filesystem
  - Each directory references the same inode number
  - Increments the link count
    - The **rm** command decrements the link count
    - File exists as long as at least one link remains
    - When the link count is zero, the file is removed
  - Cannot span drives or partitions
- Syntax:
  - **ln *filename* [*linkname*]**

Symbolic (or Soft) Links

- A symbolic link points to another file
  - **ls -l** displays the link name and the referenced file
    `lrwxrwxrwx 1 joe joe 11 Sep 25 18:02 pf -> /etc/passwd`
  - File type: **l** for symbolic link
  - The content of a symbolic link is the name of the file that it references
- Syntax:
  - **`ln -s filename`** ***`linkname`***

The Seven Fundamental File types

ls -l symbol	File Type
-	regular file
d	directory
l	symbolic link
b	block special file
c	character special file
p	named pipe
s	socket

Checking Free Space

- **baobab** produces graphical usage report by directory
  - Applications->System Tools->Disk Usage Analyzer
- **du** produces text usage report (in kilobytes) by directory
  - Lists size of every file in all sub-directories by default
    - **-h** and **-H** display sizes in easier-to-read units
    - **-s** summarizes sub-directories instead
- **df** produces text usage report (in kilobytes) by filesystem
  - Also takes **-h** and **-H** options
  - **-T** includes filesystem types

Removable Media

- *Mounting* integrates a foreign filesystem into the main tree
- Before accessing, media must be mounted
- Before removing, media must be unmounted
- In Gnome and KDE, devices auto-mount under `/media/`
- In console, root can manually mount devices under `/mnt/`

```
# mkdir /mnt/floppy
# mount /dev/fd0 /mnt/floppy
# umount /dev/fd0
```

- In console, non-root users can use **gnome-mount** and **gnome-umount**

```
$ gnome-mount -t -d /dev/cdrom
$ gnome-mount -t -d /dev/sda
$ gnome-umount -t -d /dev/sdb1
```

CDs and DVDs

- Automatically mounted in Gnome/KDE
  - Accessible from:
    - Computer desktop icon, CD-ROM
    - CD-ROM Desktop icon
    - `/media/`*`disk_label`* or `/media/CDROM`
- Ejected with:
  - Right Click->Eject
  - **eject /dev/cdrom**
- From command-line, use **gnome-mount** and **gnome-umount**

  -
    ```
    $ gnome-mount -t -d /dev/cdrom
    $ gnome-umount -t -d /dev/cdrom
    ```

USB Media

- Detected by the kernel as SCSI devices
  - /dev/sda, /dev/sda*X*, /dev/sdb, /dev/sdb*X*, etc.
- Automatically mounted in Gnome/KDE
  - Similar location as CDs
    - /media/*disk_label* or /media/disk
  - Unmounted with:
    - Right Click->Unmount Volume
    - **umount /dev/sda*X***
- From command-line, use **gnome-mount** and **gnome-umount**

  -
    ```
    $ gnome-mount -t -d /dev/sda1
    $ gnome-umount -t -d /dev/sda1
    ```

Archiving Files and Compressing Archives

- Archiving places many files into one target file
  - Easier to back up, store, and transfer
  - **tar** - standard Linux archiving command
- Archives are commonly compressed
  - Algorithm applied that compresses file
  - Uncompressing restores the original file
  - **tar** natively supports compression using **gzip** and **gunzip**, or **bzip2** and **bunzip2**

Essential tar Options

- Actions (one is required):
  - **-c** create an archive
  - **-t** list an archive
  - **-x** extract files from an archive
- Typically required:
  - **-f** ***archivename*** name of file archive
- Optional:
  - **-z** use **gzip** compression
  - **-j** use **bzip2** compression
  - **-v** be verbose
  - **--xattrs** store SELinux and ACL properties

Creating File Archives: Other Tools

- **zip** and **unzip**
  - Supports **pkzip**-compatible archives
  - Example:

```
zip -r etc.zip /etc
unzip etc.zip
```

- **file-roller**
  - Graphical, multi-format archiving tool

End of Lecture 15

- Questions and Answers
- Summary
  - Linux filesystem structure
  - Using removable media
  - Using unformatted floppies
  - Archiving and compression

Lecture 16

Essential System Administration Tools

Objectives

Upon completion of this unit, you should be able to:

- Explain the process of installing Red Hat Enterprise Linux
- Identify services, their status and be able to manage the runlevels which start and stop them
- Install software using multiple installation methods
- Understand the basic principles of Red Hat Enterprise Linux security, firewalls, and SELinux

Planning an Installation

- What hardware does the system use?
  - Check hardware compatibility
- Read the `RELEASE-NOTES` file on the first DVD/CD or at http://www.redhat.com
  - Provides valuable summary of features and gotchas

Performing an Installation

- Installer can be started from:
  - CD-ROM or DVD-ROM
  - USB Device
  - Network (PXE)
- Supported installation sources:
  - Network Server (ftp, http or nfs)
  - CD-ROM or DVD-ROM
  - Hard Disk

Accessing the Installer

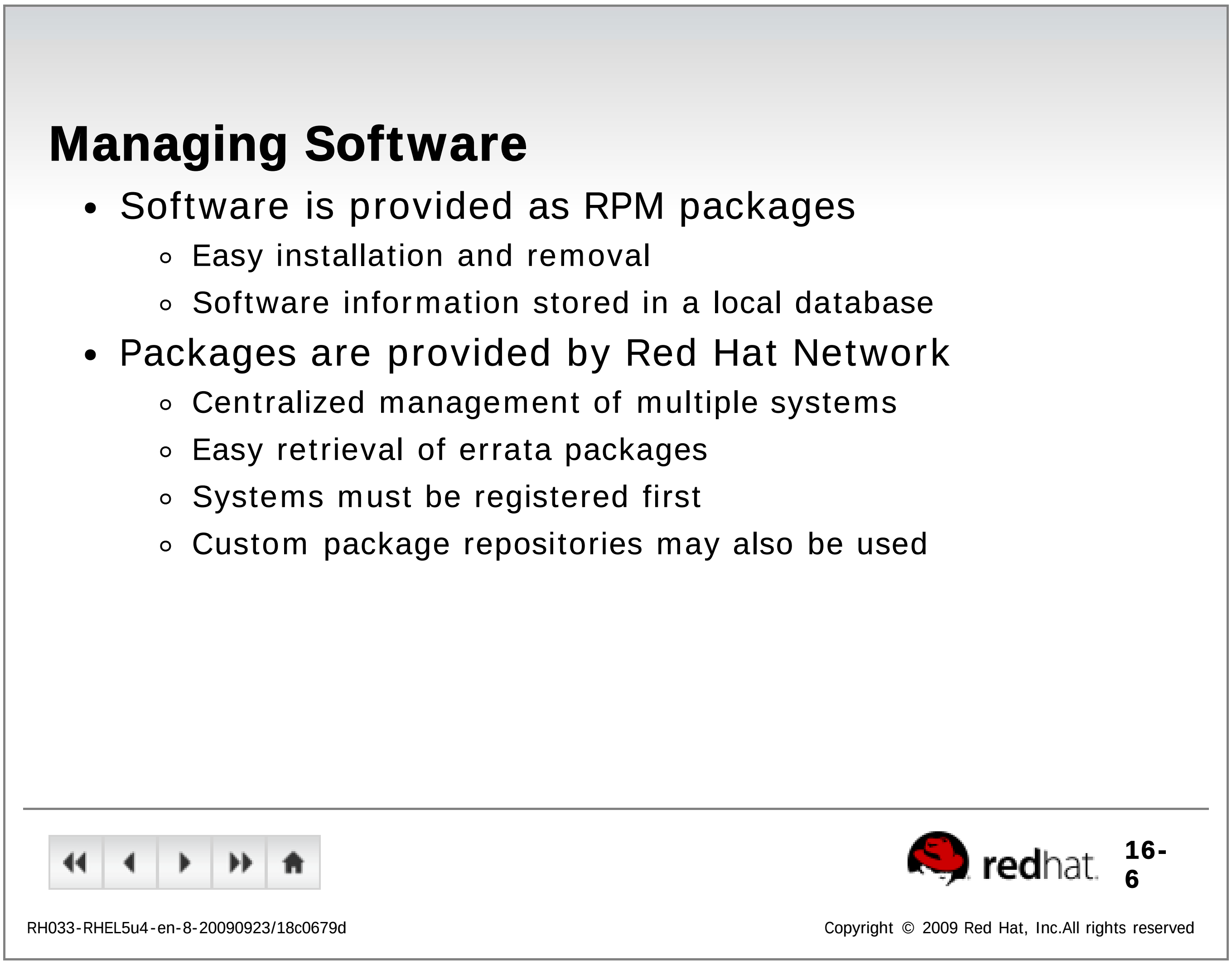
- Graphical installation
  - Default installation type
  - Useful switches: **lowres**, **resolution**, **skipddc**
- VNC based installation
  - Activate with **vnc** and protect the session with **vncpassword=*password***
  - Set network parameters with **ip=*IPAddress*** and **netmask=*NetworkMask***
- Text based installation
  - Started with the **text** switch
  - Menu-based terminal interface
- Serial installation
  - Used automatically when no graphic card is detected
  - Enable with: **serial=*device***

First Boot: Post-Install Configuration

- Configure X Window System if necessary
- Firewall and SELinux Setup
- Kdump setup
- Set date and time
- Register with Red Hat Network and get updated RPMs
- Create a first user
- Configure sound card
- Install additional RPMs or Red Hat documentation from CDROM

Managing Services

- What is a service?
- Graphical Interface to Service Management
  - **system-config-services**
- Command Line Interface to Service Management
  - ***/sbin/service***
  - ***/sbin/chkconfig***



Managing Software

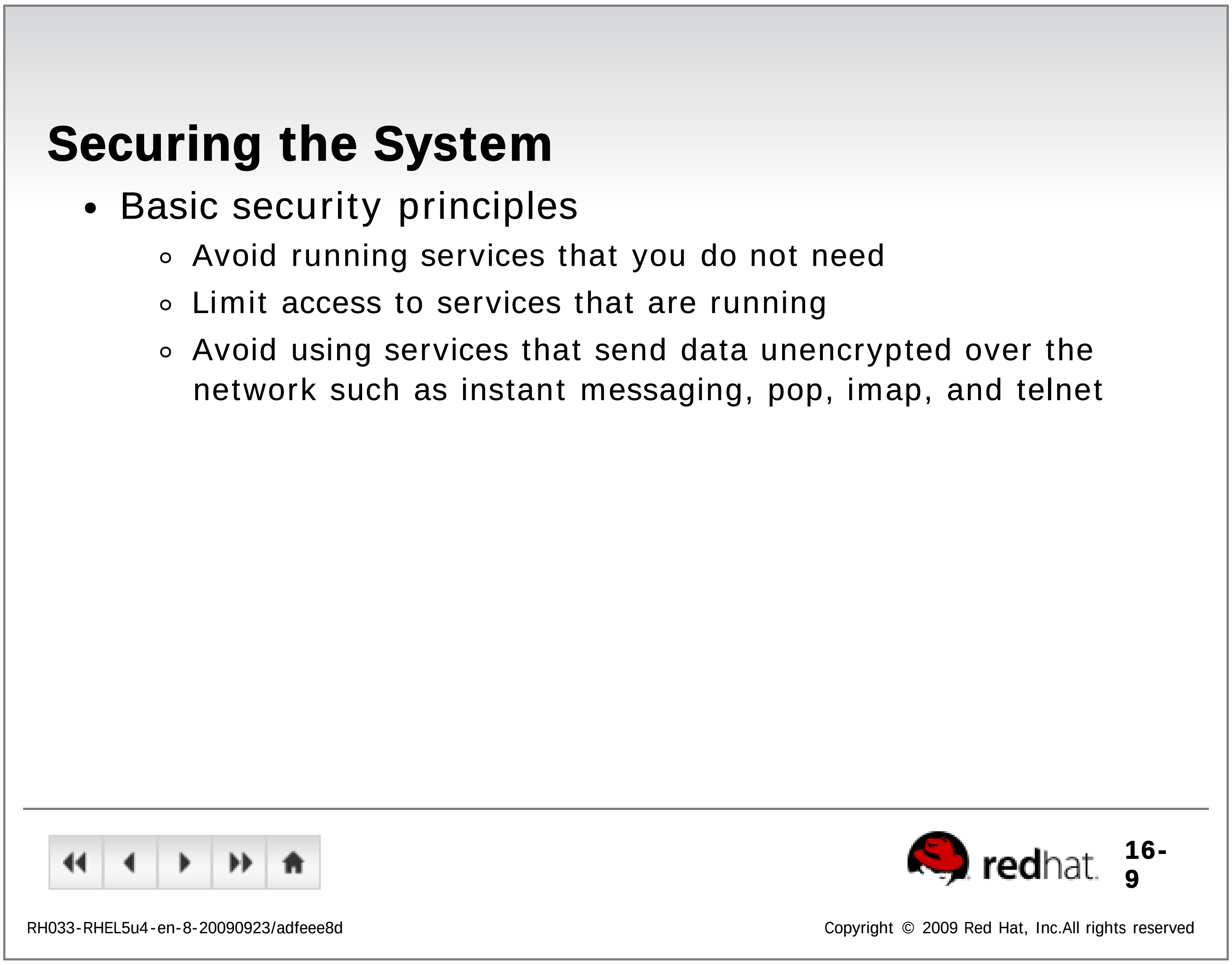
- Software is provided as RPM packages
  - Easy installation and removal
  - Software information stored in a local database
- Packages are provided by Red Hat Network
  - Centralized management of multiple systems
  - Easy retrieval of errata packages
  - Systems must be registered first
  - Custom package repositories may also be used

Graphical Package Management

- **pup**
  - Applications->System Tools->Software Updater
  - List and install software updates
- **pirut**
  - Applications->Add/Remove Software
  - View, install and un-install other packages

The Yum Package Management Tool

- Front-end to **rpm**, replacing **up2date**
- Configuration in `/etc/yum.conf` and `/etc/yum.repos.d/`
- Used to install, remove and list software
  - **yum install** ***packagename***
  - **yum remove** ***packagename***
  - **yum update** ***packagename***
  - **yum info** ***packagename***
  - **yum list available**
  - **yum list installed**



Securing the System

- Basic security principles
  - Avoid running services that you do not need
  - Limit access to services that are running
  - Avoid using services that send data unencrypted over the network such as instant messaging, pop, imap, and telnet

SELinux

- Kernel-level security system
- All processes and files have a *context*
- SELinux *Policy* dictates how processes and files may interact based on context
  - Policy rules cannot be overridden
  - Default policy does not apply to all services

Managing SELinux

- SELinux violations are logged in the System Log
- SELinux can be disabled in an emergency
- Disabling SELinux is discouraged!
- **system-config-selinux**
    - System->Administration->SELinux Management

Packet Filtering

- Network traffic is divided into packets
- Each packet has source/destination data
- Firewalls selectively block packets

Firewall and SELinux Configuration
system-config-securitylevel

- System-> Administration->Security Level and Firewall
  - Selectively allow incoming connections by port
  - Responses to outbound queries always accepted
  - Alternate interface for basic SELinux configuration
- More advanced configuration possible with other tools

End of Lecture 16

- Questions and Answers
- Summary
  - System Installation Process
  - Managing Services
  - Software Installation Tools
  - System Security

Lecture 17

So, What Now?

Objectives

Upon completion of this unit, you should be able to:

- Explore further Red Hat training
- Participate in the Linux community

Next Up...

- RH131: Red Hat Enterprise Linux System Administration
  - Install virtual and physical systems
  - Manage local and centralized user accounts
  - Manage partitions, RAID arrays and logical volumes
  - Advanced package management
  - Troubleshooting
  - More
- Bundled with RHCT exam as RH133

Other Red Hat System Administration Courses

- RH253: Red Hat Linux Networking & Security Administration
- RH300: Red Hat Certified Engineer Rapid Track Course
- Advanced certifications: RHCA, RHCSS, and RHCDS

Red Hat Developer Classes

- RHD251: Red Hat Enterprise Linux Development
- RHD361: Red Hat Enterprise Linux Kernel Internals
- RHD362: Red Hat Enterprise Linux Device Drivers

JBoss Middleware Courses

- JB336: JBoss for Application Administrators
- JB295: JBoss Enterprise Application Development
- JB325: JBoss for Advanced Java EE Developers
- Other courses on Hibernate and Seam

Participate in the Linux Community

- Participate in the Fedora Project
- Join a local Linux User Group (LUG)
- Subscribe to topical mailing lists
- Read news or participate in forums at Linux web sites
- Chat with developers and users on IRC

End of Lecture 17

- Questions and Answers
- Summary
  - What to do from here?
    - Further training
    - Community involvement
    - Something else? Explore!