OpenRHCE

A Creative Commons Courseware for RHCE Preparation

Course Outline

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Session One: Introduction

Introductions: Your Instructor

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Introductions: Your Instructor

Qualifications:

- RHCSA, RHCE #110-008-877 (RHEL6)
- Also: CTT+, CLA, CLP, CNI, LPIC1, Linux+
- Curriculum Developer and Trainer for a major computer manufacturer for going on 11 years
- Linux Enthusiast since 2000

Personal:

- Husband, father, disciple and
- Fun: Part-time Balloon Entertainer

Introductions: Fellow Students

Please Introduce Yourselves

- Name
- Where you work or what you do.
- What Linux experience do you already have?
- What goals do you have for this class?
- Something fun about yourself.

Introductions: The Course

Expectations

- Should I be able to pass the RHCE on this class alone?

  A stunning number of seasoned professionals taking Red Hat's own prep courses fail to pass on first attempt.

- Planning for more than one attempt is prudent.
- Maximizing your out-of-class preparation time is prudent.

Preparation Recommendations

- Practice/Study Environment
  - 2 or 3 systems or VMs, networked together. Virtualized hosting providers may be an alternative.
  - RHEL 6 (eval), CENTOS 6 (when available), or Fedora (Fedora 13 will be closest to RHEL 6)
  - Red Hat docs at:

    http://docs.redhat.com/docs/en-US/Red_Hat_Enterprise_Linux/index.htm
  - RHCE Objectives and other information at:

    http://www.redhat.com/certification/
  - Take initiative -- form a study group.
  - Practice, practice, practice!

Red Hat Enterprise Linux

- Overview
- Server and Desktop variants
- Add-on Functionality
- LifeCycle

The Red Hat Certification Landscape

- RHCSA

  RHCSA is new, replacing the RHCT. It is the "core" sysadmin certification from Red Hat. To earn RHCE and other system administration certs will require first earning the RHCSA.

- RHCE

  RHCE is a senior system administration certification. It is an eligibility requirement for taking any COE exams and is thus a requirement for the upper-level credentials as well.

- Certificates of Expertise

  COEs are incremental credentials demonstrating skills and knowledge in specialized areas. They are worthy credentials in their own right, but also the building blocks of the upper level credentials.

- RHCSS, RHCDS, RHCA

  These upper level credentials recognize those who have achieved expertise in several related specialized areas. Each one requires multiple COEs.

RHCSA Objectives

RHCSA Objectives: Understand & Use Essential Tools

- Access a shell prompt and issue commands with correct syntax
- Use input-output redirection (>, >>, |, 2>, etc.)
- Use grep and regular expressions to analyze text
- Access remote systems using ssh and VNC
- Log in and switch users in multi-user runlevels
- Archive, compress, unpack and uncompress files using tar, star, gzip, and bzip2

RHCSA: ...Essential Tools... (cont)

- Create and edit text files
- Create, delete, copy and move files and directories
- Create hard and soft links
- List, set and change standard ugo/rwx permissions
- Locate, read and use system documentation including man, info, and files in /usr/share/doc .

  [Note: Red Hat may use applications during the exam that are not included in Red Hat Enterprise Linux for the purpose of evaluating candidate's abilities to meet this objective.]

RHCSA: Operate Running Systems

- Boot, reboot, and shut down a system normally
- Boot systems into different runlevels manually
- Use single-user mode to gain access to a system
- Identify CPU/memory intensive processes, adjust process priority with renice, and kill processes
- Locate and interpret system log files
- Access a virtual machine's console
- Start and stop virtual machines
- Start, stop and check the status of network services

RHCSA: Configure Local Storage

- List, create, delete and set partition type for primary, extended, and logical partitions
- Create and remove physical volumes, assign physical volumes to volume groups, create and delete logical volumes
- Create and configure LUKS-encrypted partitions and logical volumes to prompt for password and mount a decrypted file system at boot
- Configure systems to mount file systems at boot by Universally Unique ID (UUID) or label
- Add new partitions, logical volumes and swap to a system non-destructively

RHCSA: Create and Configure File Systems

- Create, mount, unmount and use ext2, ext3 and ext4 file systems
- Mount, unmount and use LUKS-encrypted file systems
- Mount and unmount CIFS and NFS network file systems
- Configure systems to mount ext4, LUKS-encrypted and network file systems automatically
- Extend existing unencrypted ext4-formatted logical volumes
- Create and configure set-GID directories for collaboration
- Create and manage Access Control Lists (ACLs)
- Diagnose and correct file permission problems

RHCSA: Deploy, Configure & Maintain

- Configure networking and hostname resolution statically or dynamically
- Schedule tasks using cron
- Configure systems to boot into a specific runlevel automatically
- Install Red Hat Enterprise Linux automatically using Kickstart
- Configure a physical machine to host virtual guests
- Install Red Hat Enterprise Linux systems as virtual guests
- Configure systems to launch virtual machines at boot
- Configure network services to start automatically at boot
- Configure a system to run a default configuration HTTP server
- Configure a system to run a default configuration FTP server
- Install and update software packages from Red Hat Network, a remote repository, or from the local filesystem
- Update the kernel package appropriately to ensure a bootable system
- Modify the system bootloader

RHCSA: Manage Users and Groups

- Create, delete, and modify local user accounts
- Change passwords and adjust password aging for local user accounts
- Create, delete and modify local groups and group memberships
- Configure a system to use an existing LDAP directory service for user and group information

RHCSA: Manage Security

- Configure firewall settings using system-config-firewall or iptables
- Set enforcing and permissive modes for SELinux
- List and identify SELinux file and process context
- Restore default file contexts
- Use boolean settings to modify system SELinux settings
- Diagnose and address routine SELinux policy violations

RHCE Objectives

RHCE: System Configuration and Management

- Route IP traffic and create static routes
- Use iptables to implement packet filtering and configure network address translation (NAT)
- Use /proc/sys and sysctl to modify and set kernel run-time parameters
- Configure system to authenticate using Kerberos
- Build a simple RPM that packages a single file
- Configure a system as an iSCSI initiator that persistently mounts an iSCSI target
- Produce and deliver reports on system utilization (processor, memory, disk, and network)
- Use shell scripting to automate system maintenance tasks
- Configure a system to log to a remote system
- Configure a system to accept logging from a remote system

RHCE: Network Services

Network services are an important subset of the exam objectives. RHCE candidates should be capable of meeting the following objectives for each of the network services listed below:

- Install the packages needed to provide the service
- Configure SELinux to support the service
- Configure the service to start when the system is booted
- Configure the service for basic operation
- Configure host-based and user-based security for the service

RHCE candidates should also be capable of meeting the following objectives associated with specific services:

RHCE: HTTP/HTTPS

- Install the packages needed to provide the service
- Configure SELinux to support the service
- Configure the service to start when the system is booted
- Configure the service for basic operation
- Configure host-based and user-based security for the service
- Configure a virtual host
- Configure private directories
- Deploy a basic CGI application
- Configure group-managed content

RHCE: DNS

- Install the packages needed to provide the service
- Configure SELinux to support the service
- Configure the service to start when the system is booted
- Configure the service for basic operation
- Configure host-based and user-based security for the service
- Configure a caching-only name server
- Configure a caching-only name server to forward DNS queries
- Note: Candidates are not expected to configure master or slave name servers

RHCE: FTP

- Install the packages needed to provide the service
- Configure SELinux to support the service
- Configure the service to start when the system is booted
- Configure the service for basic operation
- Configure host-based and user-based security for the service
- Configure anonymous-only download

RHCE: NFS

- Install the packages needed to provide the service
- Configure SELinux to support the service
- Configure the service to start when the system is booted
- Configure the service for basic operation
- Configure host-based and user-based security for the service
- Provide network shares to specific clients
- Provide network shares suitable for group collaboration

RHCE: SMB

- Install the packages needed to provide the service
- Configure SELinux to support the service
- Configure the service to start when the system is booted
- Configure the service for basic operation
- Configure host-based and user-based security for the service
- Provide network shares to specific clients
- Provide network shares suitable for group collaboration

RHCE: SMTP

- Install the packages needed to provide the service
- Configure SELinux to support the service
- Configure the service to start when the system is booted
- Configure the service for basic operation
- Configure host-based and user-based security for the service
- Configure a mail transfer agent (MTA) to accept inbound email from other systems
- Configure an MTA to forward (relay) email through a smart host

RHCE: SSH

- Install the packages needed to provide the service
- Configure SELinux to support the service
- Configure the service to start when the system is booted
- Configure the service for basic operation
- Configure host-based and user-based security for the service
- Configure key-based authentication
- Configure additional options described in documentation

RHCE: NTP

- Install the packages needed to provide the service
- Configure SELinux to support the service
- Configure the service to start when the system is booted
- Configure the service for basic operation
- Configure host-based and user-based security for the service
- Synchronize time using other NTP peers

Boot, Reboot, Shutdown

- GRUB Menu
- Display Manager Screen
- Gnome or KDE
- Terminal commands: shutdown, halt, poweroff, reboot, init

Runlevels

- Default
- From GRUB Menu

Single User Mode

- Password Recovery

Note: SELinux bug prevents password changes while set to "Enforcing".

Log Files

`/var/log/*`

View with `cat`, `less` or other tools

Search with `grep`

Start/Stop Virtual Machines

- Using virt-manager
- Using virsh commands

Virtual Machine Consoles

- virt-manager
- virt-viewer

Virtual Machine Text Console

With libguestfs-tools installed and the VM in question shut-down, from the host:

```
# virt-edit {VMname} /boot/grub/menu.lst
```

There, append to the kernel line:

```
console=tty0 console=ttyS0.
```

After saving, the following commands should allow a console based view of the boot process and a console login:

```
# virsh start {VMname} ; virsh console {VMname}
```

Virtual Machine Text Console Caveat

After this change, some messages that appear only on the default console will be visible only here. For example, the passphrase prompt to decrypt LUKS-encrypted partitions mounted in /etc/fstab will not be visible when using virt-viewer and the vm will appear to be hung. Only by using virsh console can the passphrase be entered to allow the boot process to continue.

Start, stop, and check the status of network services

Modify the system bootloader

Session 2 Storage and filesystems

"Filesystem" - Disambiguation

Several meanings for the term:

- The way files are physically written to storage devices, as in the ext3, Fat-32, NTFS filesystems, or etc.
- The unified directory structure which logically organizes files
- The standard which defines how directories should be structured and utilized in Linux

Linux Filesystem Hierarchy

The directory structure of a Linux system is standardized through the Filesystem Hierarchy Standard (explained at http://www.pathname.com/fhs)

The Linux Manual system has an abbreviated reference:

```
$ man 7 hier
```

Red Hat has a more complete description, along with RedHat-specific implementation decisions in their **Deployment Guide** at http://www.redhat.com/docs/en-US/Red_Hat_Enterprise_Linux/5/html/Deployment_Guide/ch

Disk and Filesystem tools

- `fdisk` or `parted` -- Used to partition hard disks or other block devices
- `mkfs` and variants -- Used to create filesystems on block devices (actually a front-end for a variety of FS-specific tools)
- `fsck` and variants -- Used to run filesystem checks (a front-end to FS specific tools)
- `mount` -- Used to mount a filesystem to a specific location in the directory structure
- `/etc/fstab` -- Configuration file used to describe the filesystems that should be persistently mounted
- `blkid` -- used to identify filesystems or other in-use devices by UUID or filesystem labels.
- `df` -- used to display the capacity and utilization % of mounted filesystems.
- `partx` -- used to force implementation of a new partition table on an in-use device w/o the need to reboot.

Working with Partitions

Overview of process for using Basic Storage Devices:

- Install the device or otherwise make it available to the system.
- Partition it with `fdisk` or `parted`.
- Create a filesystem on the partition with mkfs or other tools.
- Choose or create a directory to serve as a mount point.
- Mount the partition.
- Add an entry to `/etc/fstab` to make it persistent.

Working with Logical Volume Management

Overview of process for using Logical Volume Management:

- Install the device or otherwise make it available to the system.
- Create a type `8e` partition with `fdisk` or `parted`.
- Initialize the partition as a physical volume with `pvcreate`.
- Add the storage of the PV to a volume group with `vgcreate`.
- Allocate storage from the volume group to a logical volume with `lvcreate`.
- Create a filesystem on the logical volume with mkfs or other tools.
- Choose or create a directory to serve as a mount point.
- Mount the partition.
- Add an entry to `/etc/fstab` to make it persistent.

Removing Logical Volume structures

- Unmount the lv you want to remove
- Edit /etc/fstab to remove its entry
- Remove the logical volume: `lvremove /dev/<vg>/<lv>`
- Before removing a VG, ensure there are no more LVs within it.
- Remove the volume group: `vgremove /dev/<vg>`
- Remove the LVM signature from the partitions: `pvremove /dev/<part>`

Commands to Know

fdisk

- Always use -u and -c for best compatibility with newer storage devices
- Can't create partitions >= 2TB, use parted with GPT instead

mkfs

- Used to create filesystems on devices
- Front-end for other filesystem-specific tools (usually named mkfs.<fstype>)

blkid

- Shows device name, Fileystem Labels, and UUID of detected block devices.
- May not show block devices until a filesystem is created on them.
- May not show block devices used in non-standard ways (for example, a filesystem on a whole disk instead of on a partition)

mount

- used to make a new filesystem available

Working with LUKS encrypted storage

cryptsetup-luks-1.1.2-2.el6.x86_64

Overview of process for using LUKS encryption:

- Create a new partition
- Encrypt it with `cryptsetup luksFormat /dev/<partition>`
- Open the encrypted device and assign it a name with `cryptsetup luksOpen /dev/<partition> <name>`
- Create a filesystem on the named device (/dev/mapper/<name>)
- Create a mountpoint for the device
- Mount the device

To lock the volume:

- unmount it
- Use `cryptsetup luksClose <name>` to remove the decryption mapping

Persistent mounting of LUKS devices

To persistently mount it

- Create an entry in /etc/crypttab:

```
<name> /dev/<partition> <password (none|<blank>|<path/to/file/with/password>)>
```

- If the password field is "none" or left blank, the system will prompt for a password.
- Create an entry in /etc/fstab

> ***Note***
>
> At reboot, the password prompt goes only to the default console. If console redirection is enabled, as it might be in the case of enabling a virtual machine to accessible through `virsh console <name>`, then the only place where the prompt is seen and the passphrase can be entered is at that redirected console.

Working with SWAP

Overview of process for adding SWAP space using a partition:

- Create a type 82 partition
- Initialize as swap with `mkswap /dev/<partition>`
- Identify the UUID with `blkid`
- Add an `/etc/fstab` line:

```
UUID=<UUID> swap swap defaults 0 0
```

- Activate the new swap space with: `swapon -a`

Using a file for SWAP

Overview of process for adding SWAP space using a file:

- create a pre-allocated file of the desired size:

```
dd if=/dev/zero of=/path/to/<swapfile> bs=1M count=<size in MB>
```

  - Initialize as swap with `mkswap /path/to/<swapfile>`
  - Add an `/etc/fstab` line:

```
/path/to/<swapfile> swap swap defaults 0 0
```

  - Activate the new swap space with: `swapon -a`

Mounting Using UUIDs and Filesystem Labels

Configure systems to mount file systems at boot by Universally Unique ID (UUID) or label

Local Storage: Adding New Storage

Add new partitions, logical volumes, and swap to a system non-destructively

File systems: Working with Common Linux Filesystems

Create, mount, unmount and use ext2, ext3 and ext4 file systems

Extend existing unencrypted ext4-formatted logical volumes

Filesystem Permissions: Basic Permissions

Linux permissions are organized around:

- Three sets of permissions -- User, Group, and Other
- Three types of permissions -- Read, Write, and Execute
- Three extended attributes -- SUID, SGID, and Stickybit

Three Sets of Permissions:

Any given file or directory can be owned by one (and only one) user and one (and only one) group. Three different sets of permissions can be assigned.

- User -- User permissions apply to the individual user who owns the file or directory.
- Group -- Group permissions apply to any user who is a member of the group that owns the file or directory.
- Other -- Other permissions apply to any user account with access to the system that does not fall into the previous categories.

Three Types of Permissions:

- Read ("r")
  - On a file, allows reading
  - On a directory, allows listing
- Write ("w")
  - On a file, allows editing
  - On a directory, allows creation and deletion of files
- Execute ("x")
  - On a file, allows execution if the file is otherwise executable (script or binary)
  - On a directory, allows entry or traversal (`# cd {dirname}`)

Three Extended Attributes:

- **SUID (Set User ID)**

  On an executable, runs a process under the UID of the file owner rather than that of the user executing it.

- **SGID (Set Group ID)**

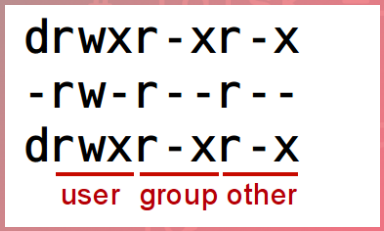
  On a directory, causes any files created in the directory to belong to the group owning the directory.

- **"Stickybit"**

  On a directory, ensures that only the owner of a file or the owner of the directory can delete it, even if all users or other members of a group have write access to the directory.

Viewing Permissions

Permissions are displayed with positions 2-10 of a "long" filelisting:



Setting Permissions

The `chmod` command is used to set permissions on both files and directories. It has two modes -- one using symbolic options and one using octal numbers.

`chmod [option] [ugoa...][+-=][rwxst] filename`

where ugo are user, group, other, or all and rwxst are read, write, execute, s{u/g}id, stickybit.

`chmod [option] XXXX filename`

where XXXX is a number representing the complete permissions on the file.

Setting Permissions with Numeric Options

	User			G		Other			
Permissions	r	w	x	r	w	x	r	w	x
Numeric Value	4	2	1	4	2	1	4	2	1
Sum	0-7			0-7	0-7				

example.txt	User			G		Other			
Permissions	r	w	x	r	-	x	-	-	x
Numeric Value	4	2	1	4	0	1	0	0	1
Sum	7			5	1				

```
# chmod 751 myfile.txt
```

Setting Extended Attributes with Numeric Options

chmod numeric options are actually 4 digits (not three). Missing digits are assumed to be leading zeroes.

The leftmost place is for extended attributes:

Attribute	SUID	SGID	Stickybit
Value	4	2	1

Example: `$ chmod 3775 MySharedDir`

Setting Extended Attributes with Symbolic Values:

`chmod +t {filename}`

Sets the sticky bit

`chmod u+s {filename}`

Sets suid

`chmod g+s {filename}`

Sets sgid

Extended Attributes in Directory Listings

-rwxrwxrwx	Normal Permissions, All permissions granted
-rwSrwxrwx	Indicates SUID set
-rwsrwxrwx	Indicates SUID and execute permission set
-rwxrwSrwx	Indicates SGID set
-rwxrwsrwx	Indicates SGID and execute permission set
-rwxrwxrwT	Indicates Stickybit set
-rwxrwxrwt	Indicates Stickybit and execute permission set

Umask

- The umask value determines the permissions that will be applied to newly created files and directories.
- As a "mask" it is subtractive -- representing the value of the permissions you DO NOT want to grant.
- Execute rights are automatically withheld (w/o regard for the umask) for *files* but not for *directories*.
- Extended attributes are not addressed -- even though a umask is four characters.
- The default umask value is set in /etc/bashrc and can be modified (non-persistently!) with the bash built-in command `umask`.

Umask Examples

- Umask of 0002 yields permissions of 0775 on new directories and 0664 on new files
- Umask of 0022 yields permissions of 0755 on new directories and 0644 on new files

SGID and Stickybit Use Case -- Collaborative Directories

- Create a Group for Collaboration
- Add users to the group
- Create a directory for collaboration
- Set its group ownership to the intended group
- Set its group permissions appropriately
- Recursively set the SGID and sticky bits on the directory

This ensures that:

1. All files created in this directory will be owned by the intended group (SGID effect)
2. All files created in this directory can only be deleted by the user who owns the file or the user who owns the directory (stickybit effect)

File Access Control Lists

- Provide more granular control of permissions.
- Filesystem must be mounted with the 'acl' option or be compiled with that option by default

getfacl

setfacl

getfacl

Example of "getfacl acldir"

```
# file: acldir
# owner: frank
# group: frank
user::rwx
user:bob:-wx
user:mary:rw-
group::rwx
mask::rwx
other::r-x
```

Example of `ls -l acldir`:

```
drwxrwxr-x+ 2 frank frank 4096 2009-05-27 14:15 acldir
```

Working with CIFS network file systems

Will be covered in more detail later.

Mount and unmount CIFS network file systems

Working with NFS file systems

Mount and unmount NFS file systems

iSCSI Devices

Package: iscsi-initiator-utils

Allows a system to access remote storage devices with SCSI commands as though it were a local hard disk.

Terms:

- iSCSI initiator: A client requesting access to storage
- iSCSI target: Remote storage device presented from an iSCSI server or "target portal"
- iSCSI target portal: A server providing targets to the initiator
- IQN: "iSCSI Qualified Name" -- a unique name. Both the initiator and target need such a name to be assigned

Accessing iSCSI Devices

- Install the iscsi-initiator-utils package
- Start the `iscsi` and `iscsid` services (and configure them persistently on)
- Set the initiator IQN in /etc/iscsi/initiatorname.iscsi
- Discover targets with:

```
iscsiadm -m discovery -t st -p <portal IP address>
```

- Log in to the target using the name displayed in discovery:

```
iscsiadm -m node -T <IQN> -p <portal IP address> -l
```

- Identify the SCSI device name with `dmesg`, `tail /var/log/messages` or `ls -l /dev/disk/by-path/*iscsi*`
- Use the disk as though it were a local hard disk

Important

Be certain to use UUIDs or labels for persistent mounts in `/etc/fstab`. Also, provide `_netdev` as a mount option so that this device will not be mounted until the network is already up.

Disconnecting from iSCSI Devices

- Ensure the device is not in use
- Unmount the device
- Remove its `/etc/fstab` entry
- Logout from the target:

```
iscsiadm -m node -T <IQN> -p <portal IP> -u
```

- Delete the local record:

```
iscsiadm -m node -T <IQN> -p <portal IP> -o delete
```

Additional References

r 4 of the Storage Administration Guide for
ocs.redhat.com/docs/en-US/Red_Hat_Enterprise_Linux/6/html/Storage_Administration_Guide/in
the usage of parted.

- Man pages for fdisk(8), fstab(5), mkfs(8), blkid(8), partprobe(8), mount(8), parted(8), cryptsetup(8), and crypttab(5)

Session 3 Managing software, processes, kernel attributes, and users and groups

The Red Hat Network (RHN)

The primary delivery mechanism for installable software, updates, errata and bug fixes and systems management functions for an installation of RHEL 6 is the Red Hat Network or RHN.

The "cost" of RHEL 6 is really a subscription to this support network.

These commands are using in managing an RHN subscription:

```
# man -k rhn
rhn-profile-sync     (8)  - Update system information on Red Hat Network
rhn_check            (8)  - Check for and execute queued actions on RHN
rhn_register         (8)  - Connect to Red Hat Network
rhnplugin            (8)  - Red Hat Network support for yum(8)
rhnplugin.conf [rhnplugin] (5)  - Configuration file for the rhnplugin(8) yum(8) plugin
rhnreg_ks            (8)  - A program for non interactively registering systems to Red Hat Network
rhnsd                (8)  - A program for querying the Red Hat Network for updates and information
```

RHN Subscription Activation

A new user of RHEL6 should receive information similar to this:

```
Red Hat subscription login:
    Account Number       : *******
    Contract Number      : *******
    Item Description     : Red Hat Enterprise Linux <Edition>
    RHEL Subscription Number : ******************
    Quantity             : #
    Service Dates        : 12-JUN-10 through 11-JUN-11
    Customer Name : ********************************
    Account Number: ************
    Log into the new portal here: access.redhat.com
    Login: *************
    Password: **************
    Email address: ***************************
```

That information can then be used with `rhn_register` to activate a new subscription

3rd Party Yum Repositories

These are other repositories of installable software, updates, or bugfixes. The `yum` command can be configured to use them in addition to or instead of the RHN.

- Configuration of repositories other than the RHN is accomplished through text configuration files located in the directory: `/etc/yum.repos.d/`
- A configuration file for each repository (or group of related repos) should be created in `/etc/yum.repos.d/`
- The name of each repo config file should end in ".repo".
- This allows repos to be easily temporarily disabled simply by renaming the file to something like: `myrepo.repo.disabled`

Yum Repository Mandatory Configuration Items

Repository ID

Short name for identifying this repository in reports

```
[MyRepo]
```

Name

Longer description of this repository

```
name=My Custom Repository
```

Baseurl

Description of protocol and location needed to locate the repo files.

```
baseurl=ftp://192.168.5.200/pub/rhel6
```

Yum Repository Common Optional Configuration Items

gpgcheck

Defines whether yum should attempt to validate package signatures. "0" = "off", "1" = "on".

```
gpgcheck=1
```

gpgkey

Defines (via URL) where the keys for signature validation are located (typically `file:///etc/pki/rpm-gpg/<key name>`)

```
gpgkey=file:///etc/pki/rpm-gpg/RPM-GPG-KEY-redhat-release
```

enabled

(Optional) Defines whether this repository should be currently active. "0" = "off", "1" = "on".

```
enabled=1
```

Managing Software: Using yum

Common commands:

`yum help`

Displays usage information.

`yum list`

Lists all available packages and indicates which are installed.

`yum search KEYWORD`

Searches for packages with a keyword in the package metadata.

`yum info PACKAGENAME`

Displays information about a package taken from the package metadata.

`yum install PACKAGENAME`

Installs a package (obtained from the repository) and any required dependencies.

`yum localinstall RPMFILENAME`

Installs a local .rpm file, but uses the repository to satisfy dependencies.

`yum remove PACKAGENAME`

Uninstalls a package and any other packages dependent upon it.

`yum update PACKAGENAME`

Installs a newer version of the package, if available.

`yum update`

Updates an installed package for which a newer version is available.

Yum-related man pages

```
# man -k yum
qreposync             (1)  - synchronize yum repositories to a local directory
rhnplugin             (8)  - Red Hat Network support for yum(8)
rhnplugin.conf [rhnplugin] (5)  - Configuration file for the rhnplugin(8) yum(8) plugin
yum                   (8)  - Yellowdog Updater Modified
yum [yum-shell]       (8)  - Yellowdog Updater Modified shell
yum-groups-manager    (1)  - create and edit yum's group metadata
yum-utils             (1)  - tools for manipulating repositories and extended package management
yum.conf [yum]        (5)  - Configuration file for yum(8)
```

RPM Architecture

`rpm` executable

RPM packages -- Files to install + SPEC file (metadata)

Local RPM database -- retains metadata from all installed packages

- Database is kept in /var/lib/rpm

RPM Package Naming

- name-version-release.architecture*.rpm
- Version is the version of the "upstream" open source code
- Release refers to Red Hat internal patches to the source code
- Architecture is one of:
    - i386,i686 -- 32 bit x86 compatible
    - x86_64 -- Intel/AMD 64 bit
    - ppc64 -- Power PC 64 bit
    - ia64 -- Intel Itanium 64 bit
    - noarch -- Arch-independent code (scripts, docs, images, etc)
    - src -- Source code

Package Naming Example

bash-3.2-24.el5.x86_64.rpm

Name	Project Version	RH Release	Arch
bash	3.2	24.el5	x86_64

This package starts with version 3.2 of bash (from ftp.gnu.org/gnu/bash), applies a RH patch identified as 24.el5 to it, and is then built to run on an Intel/AMD 64 bit processor.

Installing and Upgrading Packages

 # rpm -i[v,h] name-ver-rel.arch.rpm

Installs a package

 # rpm -U[v,h] name-ver-rel.arch.rpm

Upgrades a package if an older version was previously installed. Otherwise, simply installs the new version.

 # rpm -F[v,h] name-ver-rel.arch.rpm

Upgrades a package if an older version is installed. Otherwise, does nothing -- **does not install new packages if no older version was installed.**

Upgrading a Kernel

- Always use `#rpm -i ...`
- This leaves the previously installed kernel on the system and in the GRUB menu as a fall-back in case the new version has problems.

RPM and Modified Config Files

Scenario: niftyapp-1.0-1.el5.rpm uses a config file, `/etc/nifty.conf`. You tweaked `/etc/nifty.conf` to fit your system. Now niftyapp-2.0-1.el5.rpm is available with new features that require changes in the .conf file and provides a new default config file. What to do?

- If the previous version provided a default config file, the changes are detected. Your modified version of the .conf file is saved as `/etc/nifty.conf.rpmsave` and the new default config is installed. You can compare the files and modify as needed.
- If the previous version did NOT provide a default config file, your version of the .conf file is saved as `/etc/nifty.conf.rpmorig` and the new default config is installed. You can compare the files and modify as needed.

Uninstalling

```
# rpm -e name[-ver][-rel]
```

- Package removal is never verbose, never shows progress (-v, -h have not effect)
- Package removal only needs the name (or when multiple versions of the same package are installed, sometimes the version or release) but not the architecture or the .rpm extension.

RPM over a Network

```
# rpm -ivh ftp://{Host}/path/to/packagename-ver-rel.arch.rpm
# rpm -ivh http://{Host}/path/to/packagename-ver-rel.arch.rpm
```

And wildcard "globbing" is allowed:

```
# rpm -ivh http://{Host}/path/to/packagename*
```

Common RPM Queries

Query	Result
rpm -qa	lists all installed packages.
rpm -q pkg	Reports the version of the package.
rpm -qf /path/file	Reports which package provided the file.
rpm -qc pkg	Lists all configuration files of the package.
rpm -qd pkg	Lists all documentation of the package.
rpm -qi pkg	Reports a description of the package.
rpm -ql pkg	Lists all files contained in the package.
rpm -qR pkg	Lists all dependencies.
rpm -q --scripts	Lists the scripts that run when installing/removing.

rpm -q{c|d|i|l|R}p /path/to/packagename-ver-rel-arch.rpm

Reports the same info as above, but pulls info from the .rpm file instead of the rpm database.

RPM Verification

The RPM system satisfies two types of security concerns:

1. Is this package *authentic*? How do I know it came from Red Hat?
2. Has this package retained *integrity*? How do I know they haven't been modified?

Authenticity and integrity of packages can be confirmed prior to installation with GPG signing and MD5 checksums of the RPM packages.

Integrity of files can be confirmed after installation with verification of installed files against the recorded metadata in the package.

Validate Package Signatures

1. Import the Red Hat GPG public key (It can be found on the installation CD or in the /etc/pki/rpm-gpg/ directory):

```
# rpm --import /media/disk/RPM-GPG-KEY-redhat-release
```

or:

```
# rpm --import /etc/pki/rpm-gpg/RPM-GPG-KEY-redhat-release
```

2. Check the signature of the package in question:

```
# rpm --checksig /path/to/package-ver-rel.arch.rpm
```

RPM Checksig Sample Output

```
$ rpm --checksig ftp://linuxlib.us.dell.com/
pub/Distros/RedHat/RHEL5/5.3/Server/x86_64/
install-x86_64/Server/ImageMagick-6.2.8.0-4 .el5_1.1.i386.rpm

ftp://linuxlib.us.dell.com/pub/Distros/RedHat
/RHEL5/5.3/Server/x86_64/install-x86_64/Server
/ImageMagick-6.2.8.0-4.el5_1.1.i386.rpm: (sha1) dsa sha1 md5
gpg OK
```

Verify Installed Files

`rpm -V` (or `--verify`) will compare existing files on the system to their pristine state in the packages they came from.

There are 8 points of comparison as shown in the following table, in the Michael Jang book and in the rpm man page:

Change Codes from rpm --verify

Change Code	Meaning
5	MD5 checksum
S	File size
L	Symbolic Link
T	Modification time
D	Device
U	User
G	Group
M	Mode

RPM Verify Sample Output

```
#rpm -Va
...

S.5....T  c /etc/ntp.conf
..?.....  c /etc/ntp/keys
S.5....T    /usr/bin/aspell
.......T    /usr/share/ImageMagick-6.2.8/config/magic.xml
.......T  d /usr/share/doc/ImageMagick-6.2.8/images/arc.png
.......T  d /usr/share/doc/ImageMagick-6.2.8/images/background.jpg

...
```

Identifying Installed Packages

View a list of the packages originally installed on the system:

```
# less /root/install.log
```

View a list of the packages installed through yum:

```
# less /var/log/yum.log
```

Query the RPM database for the packages installed right now:

```
# rpm -qa
```

Managing Software: Building RPMs

As of this writing, Red Hat is pointing users to the following RPM Guide from the Fedora project for more information on RPM creation:

http://docs.fedoraproject.org/en-US/Fedora_Draft_Documentation/0.1/html/RPM_Guide/

Inside an RPM package

- files
- scripts
- metadata

The package is defined by a "build specification file" or *spec file*.

A good example of a spec file can be obtained from the source rpm for redhat-release.

ftp://ftp.redhat.com/pub/redhat/linux/enterprise/6Server/en/os/SRPMS/redhat-release-server

> ***Tip***
>
> Open .spec files in vim for color highlighting

Main contents of a .spec file

- Introduction or preamble: Contains metadata about the package
- Build instructions on how to compile the source code or otherwise prepare the package payload.
- Scriptlets that perform the installation, uninstallation, or upgrade.
- Manifest of files to be installed, along with their permissions.
- Changelog recording the changes made to the package with each revision.

Preamble directives

Name

Name of the package

Version

Version identifier

Release

Indicates incremental changes within a version.

Group

The package group that should include this package. This can come from the list at `/usr/share/doc/rpm-*/GROUPS` or can be unique to you. Not related to yum package groups.

License

Short License Identifier as described at http://fedoraproject.org/wiki/Packaging/LicensingGuidelines

Summary

Short (<=50 chars) one-line description.

Source

The file to be used as the source code. Add'l sources can be specified as Source0, Source1, etc.

BuildArch

Arch to use when building. Defaults to the existing system arch. May also be "noarch" for arch-independent packages.

Requires

Requirements that this package needs to run. Can be in the form of files or other packages

BuildRequires

Requirements needed to build this package.

Required Spec file sections

%description

%prep

%build

%install

%clean

%files

%changelog

Package Building Tools

These packages will provide tools for setting up a build environment and the ability to create your own packages.

- rpm-build
- rpmdevtools
- rpmlint

Setting up a Build Environment

As a non-privileged user, run:

```
$ rpmdev-setuptree
```

This should create the following directory structure in your home directory:

```
 ~/rpmbuild
|-- BUILD
|-- RPMS
|-- SOURCES
|-- SPECS
\-- SRPMS
```

In that structure, your source files (in a tarball) should be placed ~/rpmbuild/SOURCES/ and your .spec file in ~/rpmbuild/SPECS/. The ~/rpmbuild/BUILD/ directory will be a temporary working directory for the build process. And, after the rpmbuild process is complete, the finished binary and source RPMs will be placed in ~/rpmbuild/RPMS/ and ~/rpmbuild/SRPMS/, respectively.

Viewing the Build Environment

When diagnosing build problems, it is sometimes useful to see what files are actually being created in the build environment in order to identify deviations of actual behavior from expected behavior. The tree utility is useful for that.

Install tree with `# yum install tree`.

Invoke tree with `$ tree ~/rpmbuild` to show the contents of the build environment.

Building the RPM

With the source files in place and a properly configured `.spec` file written, the `rpmbuild` command can be used to build the rpm either at once, or (for troubleshooting) in stages

`$ rpmbuild -bp <spec file>`

Builds through the `%prep` section -- unpacks sources and applies patches.

`$ rpmbuild -bc <spec file>`

Builds through compile -- processes the `%prep` and `%build` sections.

`$ rpmbuild -bi <spec file>`

Builds through `%install` -- processes `%prep`, `%build`, and `%install`.

`$ rpmbuild -bb <spec file>`

Builds only the binary rpm file.

`$ rpmbuild -bs <spec file>`

Builds only the source rpm file.

`$ rpmbuild -ba <spec file>`

Builds both the binary and source rpm files.

Use `rpmbuild --help` or `man rpmbuild` for other options.

RPM Building Exercise

As root, install rpm-build, rpmlint, rpmdevtools:

```
# yum -y install rpmbuild rpmdevtools rpmlint
```

As a non-privileged user, create a project directory:

```
$ mkdir ~/hello-1.0
```

Name this according to the convention: <projname>-<majorver>.<minorver>

Create bash script: ~/hello-1.0/hello.sh

```
#!/bin/bash
# hello.sh
echo 'hello'
exit 0
```

Create a tarball of the project directory:

```
$ tar cvzf hello-1.0.tar.gz ~/hello-1.0/
```

Create an rpm development environment:

```
$ rpmdev-setuptree
```

Move the tarball to the SOURCES directory

Create a .spec file in the SPECS directory:

```
$ vim pkgname.spec
```

or:

```
$ rpmdev-newspec -o pkgname.spec
```

Insert a name (Match the pkgname on the tarball and direcotory)

Insert a version (Match the version)

Leave the release alone

Insert a summary (one line)

Insert a group (package group)

Insert a license

Insert a URL or delete the line

Insert on the Source0 line, the name of your tarball

Leave the BuildRoot line alone

Unless your package has prerequisites needed before it can be compiled, delete the BuildRequires line

Unless your package has prerequisites needed before it can work, delete the Requires line

On a blank line below %description, insert a brief description of your package

Leave the %prep and %setup lines alone

If your package does not need to be "built" (compiled), delete the %build, %configure, and make lines.

Leave the %install section header alone.

Under the %install section, leave the rm line alone.

If your package does not need to be built, modify the make install line to something like this:

```
install -D myfile $RPM_BUILD_ROOT/path/to/install/dest/myfile
```

Leave the %clean and the rm -rf lines alone.

Under %files, use the following syntax to list each of the files your package will place on the target system:

```
%attr(770,owner,group)/path/to/file
```

Use the following syntax to list each of the directories you package will place on the target system:

```
%dir /root/bin
```

The changelog section can be deleted or left alone.

Signing Your RPMs

Your RPMs can be digitally signed to protect users from the possibility of forged packages (any RPM package can execute scripts w/ root privileges when installed!). To implement this, first generate and identify a gpg key:

```
$ gpg --gen-key
gpg (GnuPG) 2.0.14; Copyright (C) 2009 Free Software Foundation, Inc.
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the extent permitted by law.

Please select what kind of key you want:
   (1) RSA and RSA (default)
   (2) DSA and Elgamal
   (3) DSA (sign only)
   (4) RSA (sign only)
Your selection?
RSA keys may be between 1024 and 4096 bits long.
What keysize do you want? (2048)
Requested keysize is 2048 bits
Please specify how long the key should be valid.
         0 = key does not expire
      <n>  = key expires in n days
```

```
      <n>w = key expires in n weeks
      <n>m = key expires in n months
      <n>y = key expires in n years
Key is valid for? (0)
Key does not expire at all
Is this correct? (y/N) y

GnuPG needs to construct a user ID to identify your key.

Real name: Scott Purcell
Email address: scott@texastwister.info
Comment:
You selected this USER-ID:
    "Scott Purcell <scott@texastwister.info>"

Change (N)ame, (C)omment, (E)mail or (O)kay/(Q)uit? O
You need a Passphrase to protect your secret key.

We need to generate a lot of random bytes. It is a good idea to perform
some other action (type on the keyboard, move the mouse, utilize the
disks) during the prime generation; this gives the random number
generator a better chance to gain enough entropy.
gpg: key B9AED1DE marked as ultimately trusted
```

```
public and secret key created and signed.
```

```
gpg: checking the trustdb
gpg: 3 marginal(s) needed, 1 complete(s) needed, PGP trust model
gpg: depth: 0  valid:   1  signed:   0  trust: 0-, 0q, 0n, 0m, 0f, 1u
pub   2048R/B9AED1DE 2011-02-22
      Key fingerprint = 9987 B276 A24A 1210 13A7  4D05 9F3F 8934 B9AE D1DE
uid                  Scott Purcell <scott@texastwister.info>
sub   2048R/0DA4CCE9 2011-02-22

[scott@Client1 rhel6]$
```

The key ID can be seen in the output above, or can be found with gpg --fingerprint

Export the key to a file:

```
$ gpg --armor --output ~/RPM-GPG-KEY-ScottPurcell --export B9AED1DE
```

[scott@Client1 ~]$ cat RPM-GPG-KEY-ScottPurcell -----BEGIN PGP PUBLIC KEY BLOCK----- Version: GnuPG v2.0.14 (GNU/Linux)

mQENBE1jVagBCADVDTOvRl3Z5xPZb6AAl2D3bM/H4kEhyJ+yk1pbVPmu8yu0Cbsl . . . R+J9rjvN8rNpQwm40Gx6RpM7qtP/LodzD46dNfbr87lJ4F+4A3U= =f4Gq -----END PGP PUBLIC KEY BLOCK-----

Configure rpm-related tools to use your signature:

```
$ echo '%_gpg_name Scott Purcell'>> ~/.rpmmacros
```

or:

```
$ echo '%_gpg_name B9AED1DE'>> ~/.rpmmacros
```

Now packages can be created and signed at the same time with rpmbuild using the --sign option. Or existing packages can be retroactively signed with rpm using the --addsign or --resign options.

With a signed package in place, the user intending to install it now needs to import the key:

```
# rpm --import /home/scott/RPM-GPG-KEY-ScottPurcell
```

And with the key imported, the package can be verified:

```
$ rpm -K rpmbuild/RPMS/x86_64/rhel6rhce-0.5-1.el6.x86_64.rpm
rpmbuild/RPMS/x86_64/rhel6rhce-0.5-1.el6.x86_64.rpm: rsa sha1 (md5) pgp md5 OK
```

Create a Repo with your files

(Assumes httpd already installed)

```
# yum -y install createrepo
# mkdir -p /var/www/html/repo/Packages
# cp MyPackage.rpm /var/www/html/repo/Packages
# createrepo -v /var/www/html/repo
# cp /home/me/RPM-GPG-KEY-me /var/www/html/repo
```

RPM Packaging, Other Documentation:

Red Hat Enterprise Linux Deployment Guide, section on "Querying RPM"

Man Pages:

- rpm (8)
- rpm2cpio (8)
- cpio (1)

Manage Processes and Services

Start a service:

- `service <servicename> start`
- `/etc/init.d/<servicescript> start`

Stop a service:

- `service <servicename> stop`
- `/etc/init.d/<servicescript> stop`

Check status of a service:

- `service <servicename> status`
- `/etc/init.d/<servicescript> status`

Reload a service's config:

- `service <servicename> reload`
- `/etc/init.d/<servicescript> reload`

Persistent Configuration of Services

Configure a service to start at boot:

- `chkconfig <servicename> on`
- `system-config-services`
- `ntsysv`

Manage Processes and Services: Configure systems to boot into a specific runlevel automatically

`/etc/inittab`

Monitoring Processes

ps

Highly configurable command to list running processes

top

Command to provide realtime reports of the most active running processes

Killing Processes

kill

kills a process by PID. Optionally sends "signals" other than "kill".

kill-all

Kills a process by name. Use care not to match names you don't intend to kill.

pkill

Also kills processes by name. Use care not to match names you don't intend to kill.

pgrep

Searches processes by name. Useful for verifying which processes would be killed by pkill.

Prioritizing Processes

The kernel calculates the priority of each process through a variety of factors. One input into that calculation is a user-modifiable value called "niceness".

- A process with higher niceness has lower priority and is thus more willing to share resources with other processes.
- niceness can range from -20 (highest priority) to 19 (lowest priority).

nice and renice commands

nice

Launches commands with a specified "niceness" value affecting process priority.

- Default niceness is "0".
- Root can set any value.
- Non-privileged users can only use positive values.

renice

Modifies the niceness of an already-running process.

- Root can modify the niceness of any process in either direction.
- Non-privileged users can only modify their own processes and by increasing niceness (lowering priority)

Manage system performance

- Use /proc/sys and sysctl to modify and set kernel run-time parameters
- Produce and deliver reports on system utilization (processor, memory, disk, and network)
- Use iostat and vmstat to report on system performance
- Use shell scripting to automate system maintenance tasks

Manage Users and Groups

- Create, delete, and modify local user accounts
- Change passwords and adjust password aging for local user accounts
- Create, delete and modify local groups and group memberships
- Configure a system to use an existing LDAP directory service for user and group information
- Configure system to authenticate using Kerberos

Session 4 Networking and Routing

Network Configuration and Troubleshooting

Class discussion -- Populate a table explaining for each of the following aspects of network configuration: 1) How to view or verify the existing configuration, and 2) How to change the configuration.

- IP Address and Subnet Mask
- Routing and Default Gateway
- Hostname
- Name Resolution

IP Address and Subnet Mask

- Verifying configuration

  `ip a`, `ifconfig`

- Changing configuration

  `nm_applet`, `system-config-network`, manual editing of interface config files

Routing and Default Gateway

- Verifying configuration

  `route`, `ip r`

- Changing configuration

  `route`, `ip r`, manual editing of route config files,

Hostname

- Verifying configuration
- Changing configuration

Name Resolution

- Verifying configuration
- Changing configuration

Two Controlling Services

NetworkManager

- RHEL6 default
- Ideal for client systems and systems with dynamic network conditions
- No support for bonding/bridging/aliases, etc.

network

- RHEL5 and earlier default
- Ideal for systems with static network conditions
- Bonding/bridging/aliases supported.

Switching between Controlling Services

To disable NetworkManager and enable network:

```
# service NetworkManager stop; chkconfig NetworkManager off
# service network start; chkconfig network start
```

To disable network and enable NetworkManager:

```
# service network stop; chkconfig network off
# service NetworkManager start; chkconfig NetworkManager on
```

To exempt a particular interface from control by NetworkManager, but leave it in control of other interfaces:

- In the interface configuration file of the interface to be exempted, insert the line:

```
NM_CONTROLLED=no
```

- Ensure both services are configured on and running.

- Configured interfaces can be brought up with `ifup eth<x>` or down with `ifdown eth<x>` regardless of whether they are managed by NetworkManager or not.

Network Configuration Files

/etc/hosts

Static hostname-to-IP resolution.

/etc/resolv.conf

Client configuration for DNS.

/etc/sysconfig/network

Main system networking config file. Enables/disables networking in general, sets the hostname, and configures routing.

/etc/sysconfig/network-scripts/ifcfg-<ifname>

Config file for each configured interface.

/etc/sysconfig/network-scripts/route-<name>

Config file for static routes (where needed)

> ***Note***
>
> /etc/sysconfig/networking/ is used by system-config-network and should not be manually edited.

Reference

/usr/share/doc/initscripts-9.03.17/sysconfig.txt

Future (Near!) Network Device Naming Scheme

http://linux.dell.com/files/whitepapers/consistent_network_device_naming_in_linux.pdf

Troubleshooting Toolkit

Session 5 Firewalls and SELinux

Firewalling in RHEL6

RHEL6 implements a packet filtering firewall called iptables. You should know several key terms:

rule

A one-line rule defining a packet type and how it should be handled.

chain

A list of rules.

table

A list of rules aggregating all of the chains and rules taking a particular path through the network stack.

policy

A default rule that applies in the absence of other rules.

iptables Built-in Chains

INPUT

Applies to traffic with your server as the destination.

OUTPUT

Applies to traffic origination on your server as the source.

FORWARD

Applies to traffic being routed by your system from one network to another

iptables Targets

ACCEPT

Allows the packet to proceed to its destination.

DROP

Silently drop the packet.

REJECT

Drop the packet with a rejection message

LOG

Log the packet and move to next rule in the chain (which may then accept, drop, or reject)

Connection Tracking States

Iptables can filter packets based on their relationship with previous traffic.

NEW

The packet has started a new connection.

ESTABLISHED

Applies to packets that are part of an established TCP connection (packets have already been delivered in both directions).

RELATED

The packet is starting a new connection, but associated with an existing connection.

INVALID

The packet is associated with no known connection.

Iptables Command Options

-vnl --line-numbers

List all rules with line numbering

-A <chain> <rule> -j <target>

Adds a rule to the end of the chain

-D <chain> <rule#>

Deletes a rule by number

-F <chain>

Flushes all rules from the chain

Matching packets

A source IP or network:

```
-s 192.0.2.0/24
```

A destination IP or network:

```
-d 10.0.0.1
```

UDP/TCP and ports:

```
-p udp --sport 68 --dport 67
```

ICMP and types:

```
-p icmp --icmp-type echo-reply
```

Inbound network interface:

```
-i ETH0
```

Outbound network interface:

```
-o ETH0
```

State tracking:

```
-m state --state ESTABLISHED,RELATED
```

Iptables Tips

Use `system-config-firewall` to enable and select FTP and SSH to generate a sample set of rules and load the connection tracking module.

Show connections being accepted or rejected in realtime:

```
# watch -d -n 2 `iptables -nvL`
```

SELinux

SELinux is a set of security rules that determine which processes can access which files, directories, ports, and other system resources.

Purposes:

- Provide another method of securing a system.
- Implement Mandatory Access Control policies (required in some institutional contexts).
- Protect the system and its data from system services that have been compromised.

SELinux in Action

- httpd allows remote anonymous access.
- This allows the possibility of attempts to compromise the httpd daemon with security exploits.
- httpd runs with the identity of the user "apache" and the group "apache" -- a successful exploit gains system access with the permissions granted to that user and group.
- In addition to the filesystem areas needed to run a webserver, the apache user and group also have access to other "world-readable" and "world-writeable" location such as `/tmp`.
- SELinux ensures that a compromised service cannot gain access to these filesystem location where it should not need access in the normal course of events.

SELinux Enforcement Modes

Disabled

No rules are enforced and the SELinux filesystem contexts are stripped away. Moving to or from this mode to one of the others requires a reboot -- during which the entire filesystem will be processed to add or remove the SELinux filesystem context labels.

Permissive

Rules are in place, violations are logged, but access is permitted (rules not enforced). Useful for troubleshooting.

Enforcing

Rules are in place and enforced. Attempted violations are logged and access is denied.

Important SELinux Filesystem locations

`/etc/sysconfig/selinux`

Used to set enforcement mode and policy set.

`/var/log/audit/audit.log`

Extensive log of SELinux messages

`/var/log/messages`

Contains short summaries of SELinux messages when `setroubleshoot-server` is installed and active

- Watch for "AVC" (Access Vector Cache) in log messages.

Related Packages

coreutils

Always installed. Provides some default elements of SELinux.

policycoreutils

Provides `restorecon`, `secon`, `setfiles`, et al.

libselinux-utils

Provides `getenforce`, `setenforce`, `getsebool`, `setsebool`, et al.

policycoreutils-gui

Provides `system-config-selinux` and `sepolgen`, et al.

policycoreutils-python

Provides `semanage`, `audit2allow`, `audit2why`, et al.

setroubleshoot

Provides `seapplet`

setroubleshoot-server

Provides `sealert`, `sedispatch`, `setroubleshootd`, et al.

Useful Commands

`sestatus`

Displays information about the current SELinux parameters.

`chcon`

Changes context labels on files (but non-persistently! Use with `semanage` for persistent changes.

`semanage`

Modifies SELinux contexts persistently.

Additional Documentation

http://docs.redhat.com/docs/en-US/Red_Hat_Enterprise_Linux/6/html/Security-Enhanced_L

Setting the SELinux Enforcement Mode

View the current setting:

```
# getenforce
Enforcing
```

Change the current setting:

```
# setenforce <mode>
```

To make persistent changes, edit `/etc/sysconfig/selinux`

SELinux Policy Types

Targeted (default)

Default policy set that aims to protect the most high-risk system services.

Strict

(Deprecated? Unable to find RHEL6 information about this policy type. Replaced by MLS?)

MLS

Implements Multi-Level Security policies -- a much stricter policy set than the default

Minimum

A less intrusive implementation of minimal aspects of SELinux

The RHCE exam will likely only be concerned with the default "Targeted" policy set.

SELinux Contexts

When SELinux is not disabled, every file, directory, and process has an SELinux context label. These labels are used to determine which protected service(s) can operate in this location.

View SELinux contexts of processes:

`ps -eZ`, `ps -axZ`, `ps -Zc <process name>`, etc.

View SELinux contexts of files and directories:

`ls -Zd /path/to/dir/`, `ls -Z /path/to/file`, etc.

View SELinux contexts of users:

```
id -Z
```

Setting SELinux file contexts

The initial contexts are created based on a set of rules, which are also used by `restorecon` to restore contexts to the default. When using the default "targeted" policy, these rules are stored in `/etc/selinux/targeted/contexts/files/file_contexts`. New customized rules are stored in `/etc/selinux/targeted/contexts/files/file_contexts.local`.

View these rules with:

```
# semanage fcontext -l
```

Or search for a specific service or path:

```
# semanage fcontext -l | grep "/var/ftp"
/var/ftp(/.*)?                                     all files          system_u:object_r:public_content_t:s0
/var/ftp/bin(/.*)?                                 all files          system_u:object_r:bin_t:s0
/var/ftp/etc(/.*)?                                 all files          system_u:object_r:etc_t:s0
/var/ftp/lib(64)?(/.*)?                            all files          system_u:object_r:lib_t:s0
/var/ftp/lib(64)?/ld[^/]*\.so(\.[^/]*)*            regular file       system_u:object_r:ld_so_t:s0
```

In these rules the regular expression `(/.*)?` is a match for the preceding directory and everything within it, recursively.

Add/delete/modify rules with:

```
#semanage fcontext -[a|d|m] -f <ftype> -t <context> '<regex>'
```

SELinux Booleans

SELinux uses a collection of boolean variables to allow users to change SELinux policy in pre-defined ways without the need to reload or recompile SELinux policies.

Show all booleans and their current values:

```
# getsebool -a
```

Show all booleans with current values and meanings:

```
# semanage boolean -l
```

Show a specific boolean value:

```
# getsebool <boolean-name>
```

Modifying SELinux Booleans

Modify a boolean non-persistently (for testing, or temporary use):

```
# setsebool <variablename> <value>
```

Modify a boolean persistently:

```
# setsebool -P <variablename> <value>
```

Use the graphical tool: `system-config-selinux`

Help for SELinux with regard to specific services

Many targeted services have specialised man pages dealing with SELinux configuration.

Display these pages with:

```
# man -k '_selinux'
ftpd_selinux          (8)  - Security-Enhanced Linux policy for ftp daemons
httpd_selinux         (8)  - Security Enhanced Linux Policy for the httpd daemon
kerberos_selinux      (8)  - Security Enhanced Linux Policy for Kerberos
named_selinux         (8)  - Security Enhanced Linux Policy for the Internet Name server (named) daemon
nfs_selinux           (8)  - Security Enhanced Linux Policy for NFS
pam_selinux           (8)  - PAM module to set the default security context
rsync_selinux         (8)  - Security Enhanced Linux Policy for the rsync daemon
samba_selinux         (8)  - Security Enhanced Linux Policy for Samba
ypbind_selinux        (8)  - Security Enhanced Linux Policy for NIS
```

Monitor SELinux Violations

Installing `setroubleshoot-server` sends SELinux error messages to `/var/log/messages`. These can be further parsed with `sealert`.

`audit2why` and `audit2allow` can be used to parse the messages in /var/log/audit/audit.log and explain why access was denied, and how to modify your configuration to allow it.

Session 6 Virtualization

Virtualization Terms

Physical Machine

The actual physical machine with RAM, disk space, etc.

Virtual Machine

A logical construct provided by hardware and/or software capabilities that can run an independent OS and perform work as though it were a physical machine.

Hypervisor

A specialized OS that provides virtual machines.

Xen

A hypervisor previously available on Red Hat operating systems that was implemented as a modified version of the Linux kernel.

KVM

Kernel Virtual Machine, the hypervisor Red Hat currently supports on RHEL6. It is implemented within (as a set of kernel modules) the mainstream Linux kernel.

Guest

The operating system that runs on a virtual machine.

Host

The operating system that runs on a physical machine hosting virtual machines (i.e. the hypervisor).

RHEL6 KVM requirements

- 64-bit Intel or AMD processor

  To confirm, search `/proc/cpuinfo` for the string `lm` on the flags line.

- CPU Hardware assisted virtualization extensions (enabled in BIOS)

  To confirm, search `/proc/cpuinfo` for the string `vmx` (for Intel) or `svm` (for AMD)

- 64-bit version of RHEL6

  To confirm, look for `x86_64` in the output of `uname -m`.

KVM Virtualization Components

- KVM kernel modules
- libvirt
- `virsh` virtualization shell
- `virt-manager`

Installing Virtualization Capabilities

At OS Installation:

Select the `Virtual Host` server role --or-- customize packages and select the `Virtualization` package group. In a kickstart file, these packages can be installed as a group with the `@kvm` group name.

After Installation:

With entitlement to the Virtualization packages, or access to them through a 3rd party repository,: `yum install kvm`

Other recommended packages:

- python-virtinst
- libvirt
- libvirt-python
- virt-manager
- libvirt-client

Virsh Commands

Power on a virtual machine:

```
virsh start <vm name>
```

Gracefully shut down a virtual machine:

```
virsh shutdown <vm name or id>
```

Power off a virtual machine:

```
virsh destroy <vm name or id>
```

Connect to a virtual machine console (requires guest configuration):

```
virsh console <vm name or id>
```

Disconnect from a console of a virtual machine:

```
^]  ( "ctrl + ]" )
```

Set a VM to start at boot:

```
virsh autostart <vm name or id>
```

Creating Virtual Machines with Virt-Manager

Demonstrated and practiced in the classroom.

Creating Virtual Machines with virt-install

`virt-install` is a command-line tool used to create virtual machines.

See the syntax with `man virt-install` or `virt-install --help`.

Sample command:

```
# virt-install --name StXVM3 --ram 768 \
--disk path=/var/lib/libvirt/images/StXVM3disk1.img,size=8\
--network network=default --cdrom /dev/cdrom
```

SELinux considerations

- SELinux expects file-based guest images to be stored in `/var/lib/libvirt/images/`. Use of other locations with SELinux enforcing will require adding the location to the SELinux policies.

1. Find the context applied to the expected location:

```
# ll -Z /var/lib/libvirt/

drwx--x--x. root root system_u:object_r:virt_image_t:s0 images
```

2. Add a new context policy:

```
# semanage fcontext -a -t virt_image_t "/virtstorage(/.*)?"
```

3. Set the context to match the newly created policy:

```
# restorecon -R -v /virtstorage/
restorecon reset /virtstorage context unconfined_u:object_r:
default_t:s0->system_u:object_r:virt_image_t:s0
```

Session 7 Logging and remote access

RHEL 6 Logging with Rsyslog

Red Hat uses `rsyslog` for its logging facility. `rsyslog` can be configured to for local logging only, to send log messages to a remote destination as well, and to recieve log messages from other systems as well.

Terms

facility

A name that indicates what the message concerns or from what service it originates.

priority

A name that indicates the importance of the messages in that category.

The man pages for logger(1) and syslog(3) have more information.

`rsyslog` is configured in `/etc/rsyslog.conf` and defaults to using port 514 (TCP or UDP) to send and receive messages.

Accepting Remote Logs

By default, `rsyslog` is configured for only local logging. To enable it to receive log messages from other systems, uncomment one of the following groups of lines in the config file (depending on which transport protocol, tcp or udp, you prefer to use):

For UDP (more widely supported but less reliable):

```
# Provides UDP syslog reception
#$ModLoad imudp.so
#$UDPServerRun 514
```

For TCP (less widely supported but more reliable):

```
# Provides TCP syslog reception
#$ModLoad imtcp.so
#$InputTCPServerRun 514
```

After changing the appropriate lines, restart the service.

Rsyslog Configuration: Message Selection

In `/etc/rsyslog.conf` in the "RULES" section, ensure that a rule exists (or write one) for the kind of messages you want to send. The format is:

```
<facility>.<priority>        <action>
```

facility

One of: auth, authpriv, cron, daemon, kern, lpr, mail, news, syslog, user, uucp, local0-7, or "*"

priority

One of (in ascending priority): debug, info, notice, warning (warn), err (error), crit, alert, emerg (panic), none, or "*"

- Multiple facilities can be specified with the same priority with the use of a comma.

```
uucp,news.crit        /var/log/spooler
```

- Multiple selectors (facility/priority pairs) can be specified for the same action with the use of a semicolon.

```
*.info;mail.none;authpriv.none;cron.none   /var/log/messages
```

Rsyslog Configuration: Actions

action

One of the following:

- A file, specified with a full path name.
- A named pipe (fifo)
- A terminal (tty) or console
- A remote machine's IP or hostname, prefaced with "@" (for UDP), "@@" (for TCP), or ":omrelp:" for the RELP protocol.
- A list of users (comma-delimited). This notifies them via console message if they are logged in. An asterisk (*) includes all logged-in users
- A tilde, to indicate that these messages should be discarded.
- See the documentation for others.

Practice

Configure one system to receive remote log messages. Configure the other to log only a particular facility or priority to the remote syslog server.

Use `logger` to generate test messages.

Remember to investigate firewall and SELinux considerations.

Remote Access via SSH

RedHat installs by default both the OpenSSH client package (openssh) and the server package (openssh-server)

Client behavior is configured in `/etc/ssh/ssh_config`

Server behavior is configured in `/etc/ssh/sshd_config`

Start the service:

```
# service sshd start
```

Configure it persistently on:

```
# chkconfig sshd on
```

Investigate SELinux implications for SSH

Find SELinux Filesystem contexts that might affect ssh:

```
semanage fcontext -l | grep "ssh"
```

Find SELinux port contexts that might affect ssh:

```
semanage port -l | grep "ssh"
```

Find SELinux booleans that might affect ssh:

```
getsebool -a | grep ssh
```

SSH key-based authentication

Generate a key with `ssh-keygen`

Transmit a key to a remote system with `ssh-copy-id`

- The key you want is usually named `~/.ssh/id_rsa.pub`. Be certain to use the .pub version of the key instead of the private key!

SSH Security Considerations

Allow root logins?

Disallow with `PermitRootLogin no` in `/etc/ssh/sshd_config`

Listen on specific interfaces?

Specify with `ListenAddress x.x.x.x` in `/etc/ssh/sshd_config`

Allow legacy versions?

Specify allowed versions of the protocol in `/etc/ssh/sshd_config` (read comments).

Allow X11 forwarding?

Configure with `X11Forwarding yes|no` in `/etc/ssh/sshd_config`

Specify alternate port?

Configure with `Port xx` in `/etc/ssh/sshd_config`. Multiple ports on multiple lines accepted. Don't forget firewall and SELinux implications though!

Remote Access via VNC

For remote management when a GUI is desired or required, Red Hat provides VNC services through tigervnc.

Install the package with `yum -y install tigervnc-server`.

Configure the service at /etc/sysconfig/vncservers

Start the service:

```
# service vncserver start
```

Configure it persistently on:

```
# chkconfig vncserver on
```

Configuring a VNC remote display

In `/etc/sysconfig/vncservers` uncomment and modify the lines below:

```
# VNCSERVERS="2:myusername"
# VNCSERVERARGS[2]="-geometry 800x600 -nolisten tcp -localhost"
```

As the user who will connect, set a VNC password with `vncpasswd`.

Start or restart the service.

Connect to the remote system using a vnc client with the `-via` option:

```
vncviewer localhost:<x> -via y.y.y.y
```

Where X is the display number and y.y.y.y is the IP address of the remote machine.

Investigate SELinux implications for VNC

Find SELinux Filesystem contexts that might affect vnc:

```
# semanage fcontext -l | grep "vnc"
```

Find SELinux port contexts that might affect vnc:

```
# semanage port -l | grep "vnc"
```

Find SELinux booleans that might affect vnc:

```
# getsebool -a | grep vnc
```

Session 8 Network Time Protocol and System Performance Reports

NTP Overview

NTP (Network Time Protocol) provides a standardized way for systems to provide and obtain correct time over the network.

This service is increasingly critical for today's networking environments. Synchronized time information is required for accurate handling of email, for clustering, for cloud computing, and for virtualization (just to name a few).

NTP Packages

ntp

Provides the daemon and utilities

system-config-date

Provides a graphical interface for changing the time and configuring an NTP client.

ntpdate

Provides a command line utility for setting the date and time with NTP

NTP Documentation

Many man pages:

- ntp.conf (5)
- ntp_misc (5)
- ntp_acc (5)
- ntp_auth (5)
- ntp_clock (5)
- ntp_mon (5)
- ntpd (8)

Installing, Starting, and Configuring Persistence

Install the service (likely already installed):

```
# yum -y install ntp
```

Starting the service:

```
# service ntpd start
```

Configuring it to be on persistently:

```
# chkconfig ntpd on
```

Defining NTP Terms

Stratum0

A clock device such as an atomic, radio, or GPS clock device. Not usually attached to the network but connected to a server.

Stratum1

A server attached to a high accuracy time device that also allows queries for its time information.

Stratum{2..16}

Servers that acquire time information from servers above them in the hierarchy and share that information with peers or clients.

Server (in ntp.conf)

A time server that is a more authoritative time-source (higher stratum) than the system being configured, and from which this system obtains time information.

Peer (in ntp.conf)

A time server that is considered equally authoritative (same stratum) with the system being configured, and with which this system shares time information.

Configuration of NTP

Configured in `/etc/ntp.conf`

`restrict` lines

Define the access to be allowed or restricted for other hosts that communicate with this service. Each server or peer configured must be included in a `restrict` line.

`server` lines

Define a host to be queried as a more authoritative time source.

`peer` lines

Define a host to be queried as an equally authoritative time source.

`broadcast` or `multicast` lines

Define ways to obtain or provide time information apart from unicast queries.

NTP "restrict" options

```
restrict <address> [mask <subnet mask> ] [flag] [flag] ...
```

address and optional mask

The address, in dotted-quad notation, of the host or network to be restricted. Alternatively, the address can be a valid DNS name.

ignore (flag)

Disallows all packets

kod (flag)

Sends a "kiss of death" packet to misbehaving (usually fire-walled) clients.

nomodify (flag)

Allows queries for information, but denies attempts to modify the time.

noquery (flag)

Deny ntpq and ntpdc queries. The time service is unaffected.

nopeer (flag)

Deny packets related to peering

notrap (flag)

Deny "trap" messages (used in logging).

Configure as a Client

1. Include at least one server (three are preferred) in `/etc/ntp.conf`:

```
server <server1 IP> iburst
server <server2 IP> iburst
```

2. With the ntp service stopped, synchronize time with ntpdate:

```
# ntpdate -v <IP of ntp server>
```

3. Start the ntp service.
4. Verify that the service sees the configured servers (this may take a few minutes):

```
# ntpq -p
```

Configure as a Server

1. Follow the steps for Client Configuration.
2. Add one or more restrict lines to allow appropriate access from those systems that will be clients (or peers):

```
restrict 10.37.112.0 mask 255.255.240.0 nomodify notrap
restrict 10.37.112.13
```

3. Restart the service after making changes.

Configure as a Peer

1. Follow the steps for Client Configuration
2. Add one or more restrict lines to allow appropriate access from those systems that will be clients (or peers):

```
restrict 10.37.112.0 mask 255.255.240.0 nomodify notrap
restrict 10.37.112.13
```

3. Add one or more peer lines:

```
peer <peer IP or hostname> [options]
```

4. Restart the service after making changes.
5. Verify that the service sees the configured peers and servers (this may take a few minutes):

```
# ntpq -p
```

Investigate SELinux implications for NTP

Find SELinux Filesystem contexts that might affect NTP:

```
# semanage fcontext -l | grep "ntp"
```

Find SELinux port contexts that might affect NTP:

```
# semanage port -l | grep "ntp"
```

Find SELinux booleans that might affect NTP:

```
# semanage boolean -l | grep ntp
```

Investigate Firewall Implications for NTP

Find ports that may need to be opened for NTP:

```
# grep ntp /etc/services
```

Rules to open up the required ports:

```
-A INPUT -m state --state NEW -m tcp -p tcp --dport 123 -j ACCEPT
-A INPUT -m state --state NEW -m udp -p udp --dport 123 -j ACCEPT
```

Reporting on System Performance

One of the more vague of the RHCE Objectives says: "Produce and deliver reports on system utilization (processor, memory, disk, and network)."

This loosely defined objective can be very wide-ranging -- this section will cover some of the tools that might be useful in meeting it.

Tools for System Utilization Reporting

df

"diskfree", reports on disk space utilization for all mounted filesystems. Part of the coreutils package.

iostat

Provided by the sysstat package.

vmstat

Provided by the procps package.

top

Provided by the procps package.

Explore the man pages for these utilities and be prepared to use them with scripting to write reports to a file.

Session 9 HTTP and FTP

Apache Web Server

Service name: httpd

Package name: httpd-{ver}.{arch}.rpm

Main config: /etc/httpd/conf/httpd.conf

Module config: /etc/httpd/conf.d

Default DocRoot: /var/www/html

Apache Configuration Items

Min/Max Spare Servers

Log files

Host Name lookup

Modules

Virtual Hosts

user/group settings

Minimum Config for Basic Page

Install, start, and turn on the service

yum install httpd

chkconfig httpd on

service httpd start

Put index.html in /var/www/html

Virtual Host Configuration

Near the end of httpd.conf, uncomment the line:

#NameVirtualHost *:80

Create a section for each vhost:

Apache Access Control

Per-directory options

Firewall and SELinux for httpd

Very Secure File Transfer Protocol Daemon

`vsftpd` is Red Hat's preferred FTP daemon. The "Very Secure" descriptor refers to the daemon and not to the protocol!

The only mention of FTP in the RHCSA objectives is concerned with enabling a default configuration

The only mention of FTP in the RHCE objectives is concerned with securely configuring anonymous access.

Installation and Basic Configuration

Package: vsftpd

Install:

```
# yum -y install vsftpd
```

Start and Configure Persistence:

```
# service vsftpd start; chkconfig vsftpd on
```

In this default configuration, anonymous downloads are allowed from `/pub` (as shown to the client) and are placed in `/var/ftp/pub/` (as viewed on the server). Additionally, system users are able to login by username and password and access their home directories with read/write permissions. No anonymous uploads are permitted by default.

FTP Documentation

Man Pages:

- vsftpd.conf (5)
- ftpd_selinux (8)

Investigate SELinux implications for FTP

Find SELinux Filesystem contexts that might affect FTP:

```
# semanage fcontext -l | grep "ftp"
```

Find SELinux port contexts that might affect FTP:

```
# semanage port -l | grep "ftp"
```

Find SELinux booleans that might affect FTP:

```
# semanage boolean -l | grep ftp
```

Investigate Firewall Implications for FTP

Find ports that may need to be opened for FTP:

```
# grep ftp /etc/services
```

Configuring a Secure "Drop-box" for Anon Upload

1. Create an upload directory owned by `root.ftp` and with 730 permissions:

```
cd /var/ftp
mkdir incoming
chgrp ftp incoming
chmod 730 incoming
```

2. Modify SELinux

   - Set context of `public_content_rw_t` on the upload directory:

```
semanage fcontext -a -t public_content_rw_t '/var/ftp/incoming(/.*)?'
restorecon -rvv /var/ftp/
```

   - Enable the `allow_ftp_anon_write` boolean:

```
setsebool -P allow_ftpd_anon_write on
```

3. Modify `/etc/vsftpd/vsftpd.conf` as follows:

```
anonymous_enable=YES
local_enable=NO
write_enable=YES
anon_upload_enable=YES
chown_uploads=YES
chown_username=daemon
anon_umask = 077
```

4. Modify iptables for inbound ftp

- in `/etc/sysconfig/iptables_config`:

```
IPTABELS_MODULES="nf_conntrack_ftp nf_nat_ftp"
```

- Set rules:

```
# iptables -A INPUT -p tcp --dport 21 -j ALLOW
# iptables -A INPUT -m state --state ESTABLISHED,RELATED -j ALLOW
```

Session 10 NFS and Samba

Session 11 DNS and SMTP

Session 12 Finish uncompleted topics, Review, or Practice Exam

Supplemental Topics

Manage Processes and Services: Schedule tasks using cron