Demystifying systemd

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Scott Seighman
Solutions Architect
Red Hat

sseighma@redhat.com
CleRHUG

Agenda

- Brief History
- Concepts & Basic Usage
- Modifying Units
- Resource Management
- Converting init scripts
- The Journal
- nspawn
- Sneak peek at what's coming in RHEL 7.2

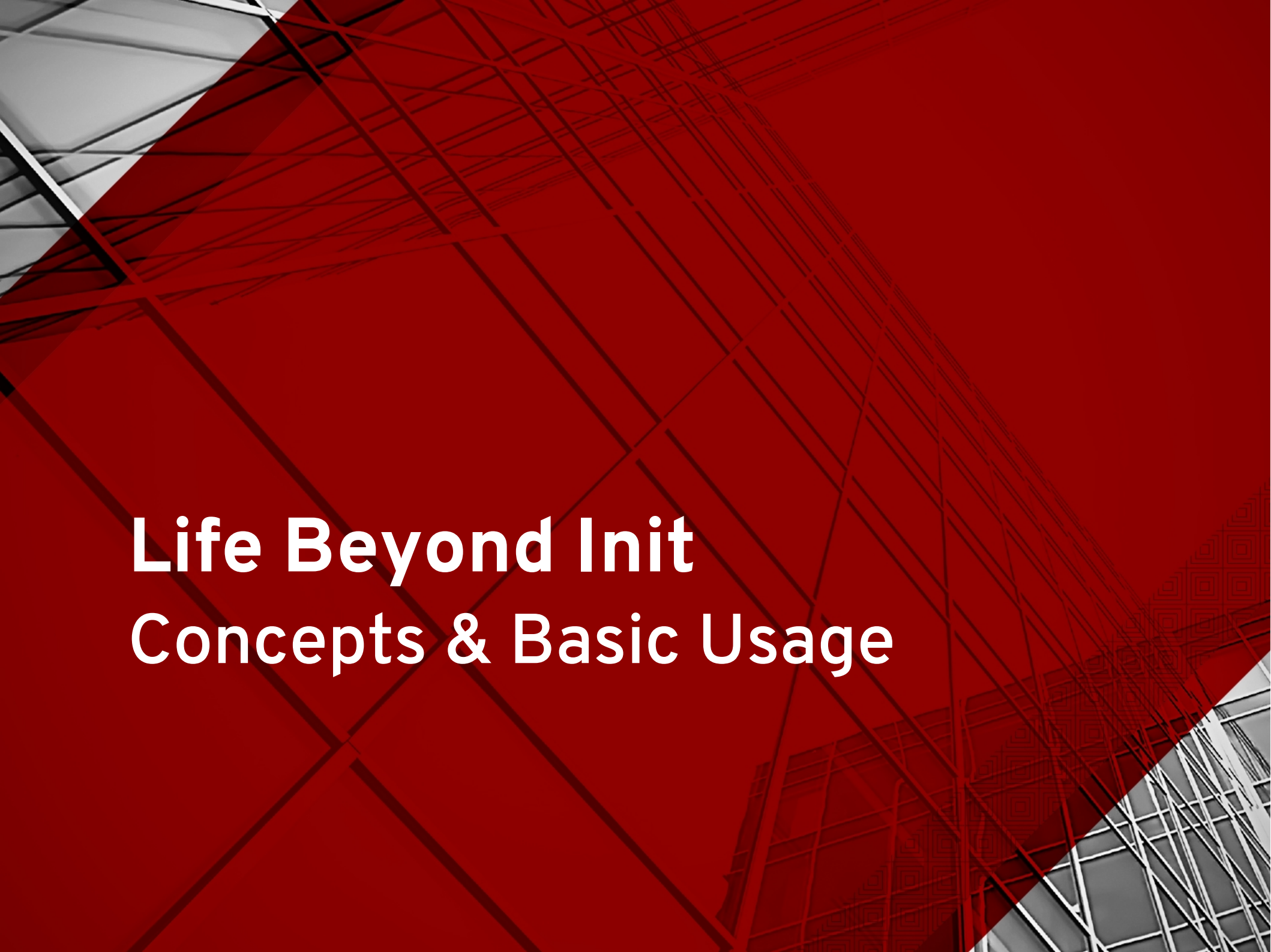
Keep an open mind … and please refrain from cussing or throwing objects at the speaker

Brief History

init, Upstart and systemd

Brief History of the Init Process

- init
  - Referenced inittab → rc scripts
  - Unexpected pauses could cause delays in boot process (serial)
  - Needed to be sequenced for dependencies (manual process)
- Upstart
  - Introduced as init replacement
  - Added async service startup, auto restart, event-based start
  - Also referenced inittab → /etc/init → /etc/rc.d
  - Used `initctl` for service control
- systemd
  - Supersedes its predecessors in terms of speed and capabilities

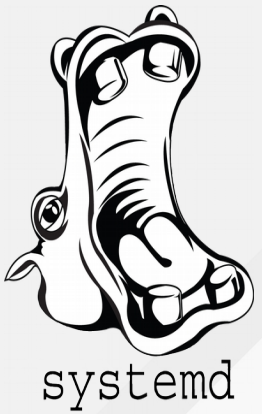


Life Beyond Init

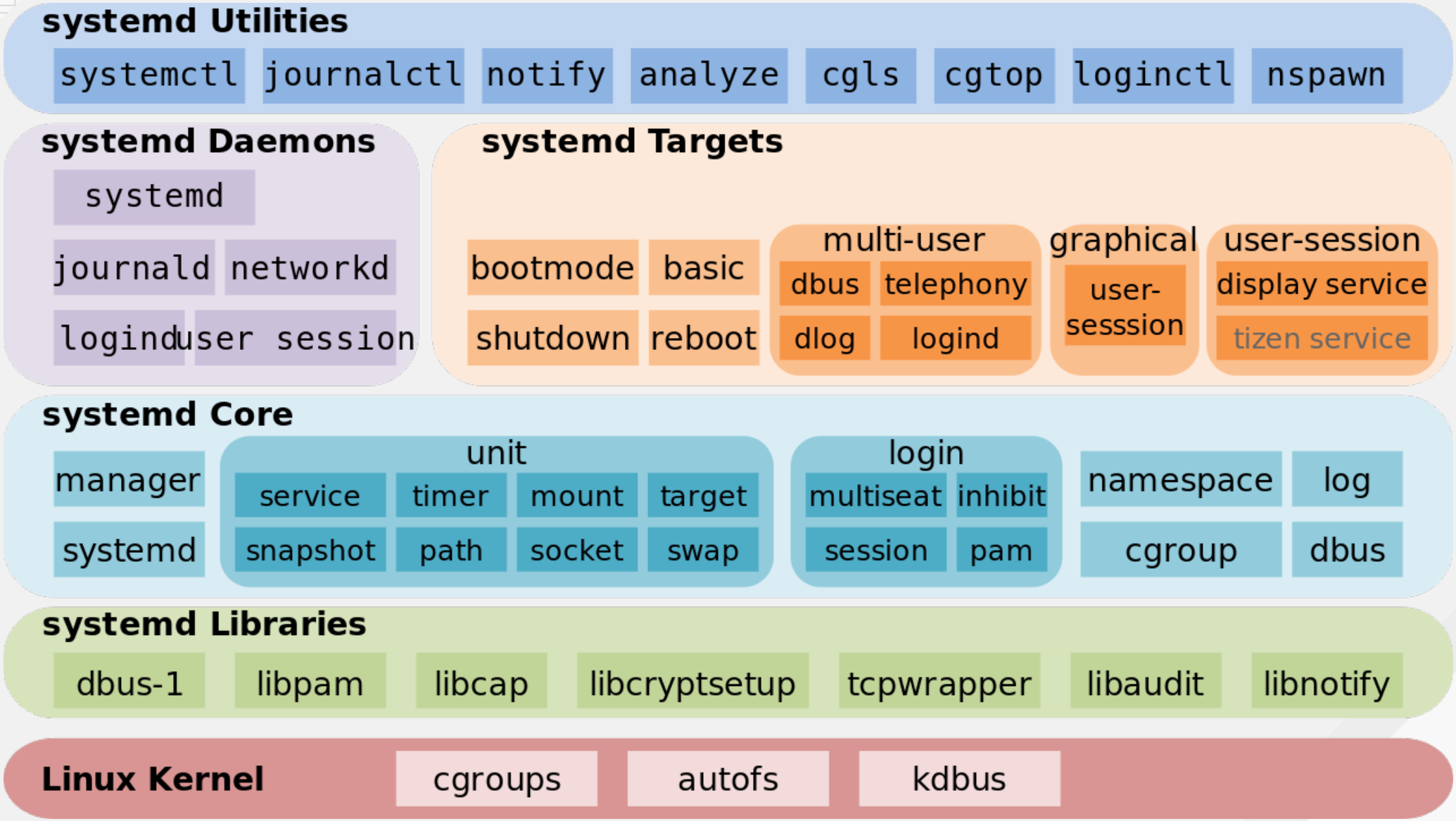
Concepts & Basic Usage

systemd

- Default init system for most Linux distributions
- Controls “units” rather than just daemons
- Handles dependency between units
- Tracks processes with service information
  - Services are owned by a cgroup.
  - Simple to configure “SLAs” for CPU, Memory, and IO
- Properly kill daemons
- Minimal boot times
- Debuggability – no early boot messages are lost
- Easy to learn and backwards compatible



systemd Structure



systemd Concepts: Units

- Init scripts have been replaced with service units
- Units are `systemd` objects used for organizing boot and maintenance tasks
- Units have a name and type
- Unit configs are stored in respective config files
- Service units end with the .service file extension and serve a similar purpose as init scripts:
  - To view, start, stop, restart, enable, or disable system services, use the `systemctl` command

Available systemd Unit Types

Unit Type	File Extension	Description
Service Unit	.service	A system service
Target Unit	.target	A group of systemd units
Automount Unit	.automount	A filesystem automount point
Device Unit	.device	A device file recognized by the kernel
Mount Unit	.mount	A filesystem mount point
Path Unit	.path	A file or directory in a filesystem
Scope Unit	.scope	An externally created process
Slice Unit	.slice	A group of hierarchically organized units that manage system processes
Snapshot Unit	.snapshot	A saved state of the systemd manager

Available systemd Unit Types

Unit Type	File Extension	Description
Socket Unit	.socket	An inter-process communications socket
Swap Unit	.swap	A swap device or swap file
Timer Unit	.timer	A systemd timer

systemd Units: httpd.service

```
[Unit]
Description=The Apache HTTP Server
After=remote-fs.target nss-lookup.target

[Service]
Type=notify
EnvironmentFile=/etc/sysconfig/httpd
ExecStart=/usr/sbin/httpd $OPTIONS -DFOREGROUND
ExecReload=/usr/sbin/httpd $OPTIONS -k graceful
ExecStop=/usr/sbin/httpd $OPTIONS -k graceful-stop
PrivateTmp=true

[Install]
WantedBy=multi-user.target
```

*Comments were removed for readability

systemd Units: Locations

Directory	Description
/usr/lib/systemd/system/	Systemd units distributed with RPM installed packages.
/run/systemd/system/	Systemd units created at runtime. This directory takes precedence over the directory with installed service units. **Non-persistent.**
/etc/systemd/system/	Systemd units created and managed by the **system administrator**. This directory takes precedence over the directory with runtime units.

Note: Unit files in /etc take precedence over /usr

Compatibility Changes

- `systemd` has only limited support for runlevels
- `systemctl` utility does not support custom commands
- `systemctl` utility does not communicate with services not started by `systemd`
- `systemd` stops only running services
- System services are unable to read from the standard input stream

Compatibility Changes *(cont.)*

- System services do not inherit any context (such as the HOME and PATH environment variables) from the invoking user and their session
- When loading a SysV init script, `systemd` reads dependency information encoded in the Linux Standard Base (LSB) header and interprets it at run time
- All operations on service units are subject to a timeout of 5 minutes to prevent a malfunctioning service from freezing the system

systemd startup flow

Initiates services concurrently

Allows `systemd` to handle service order dependencies; services start without delay

Instantaneously creates sockets for enabled services

`systemd` creates all sockets first, daemons next

Passes to daemon processes to start in parallel

Daemons need not be running, they only need the correct socket to be available

Maintains sockets and uses them to reconnect services

Daemons not yet running are cached in socket buffer and filled when daemons come online

Managing Services: Start/Stop

Init

```
service httpd {start,stop,restart,reload}
```

systemd

```
systemctl httpd.service {start,stop,restart,reload}
```

Managing Services: Start/Stop

- Glob units to work with multiple services

  ```
  systemctl restart httpd mariadb
  ```

- When the unit “type” isn't specified, .service is assumed.

  ```
  systemctl start httpd = systemctl start httpd.service
  ```

- Make life easy and install shell completion
  - `yum install bash-completion`
  - `systemctl [tab] [tab]`
  - Add bash-completion to your SOE and minimal kickstarts
- Connect directly to remote hosts

  ```
  systemctl -H [hostname] restart httpd
  ```

Managing Services: Status

Init

- `service httpd status`

systemd

- `systemctl status httpd`

Tip: pass -l if the logs are cutoff

Managing Services: Status

```
[root@fedora-22 ~]# systemctl status httpd
● httpd.service - The Apache HTTP Server
   Loaded: loaded (/usr/lib/systemd/system/httpd.service; disabled; vendor preset: disabled)
   Active: active (running) since Wed 2015-08-26 17:07:12 EDT; 11s ago
 Main PID: 7014 (httpd)
   Status: "Total requests: 0; Idle/Busy workers 100/0;Requests/sec: 0; Bytes served/sec:   0 B/sec"
   CGroup: /system.slice/httpd.service
           ├─7014 /usr/sbin/httpd -DFOREGROUND
           ├─7136 /usr/sbin/httpd -DFOREGROUND
           ├─7137 /usr/sbin/httpd -DFOREGROUND
           ├─7139 /usr/sbin/httpd -DFOREGROUND
           ├─7140 /usr/sbin/httpd -DFOREGROUND
           └─7141 /usr/sbin/httpd -DFOREGROUND

Aug 26 17:07:12 fedora-22.example.com systemd[1]: Starting The Apache HTTP Server...
Aug 26 17:07:12 fedora-22.example.com systemd[1]: Started The Apache HTTP Server.
[root@fedora-22 ~]#
```

Managing Services: Status

- List loaded services:
  - `systemctl -t service`
- List installed services:
  - `systemctl list-unit-files -t service` (like `chkconfig –list`)
- Check for services in failed state:
  - `systemctl --state failed`

Managing Services: Enable/Disable

Init

- `chkconfig httpd {on,off}`

systemd

- `systemctl {enable, disable} httpd`

Tip: Globing units will clean up your kickstarts

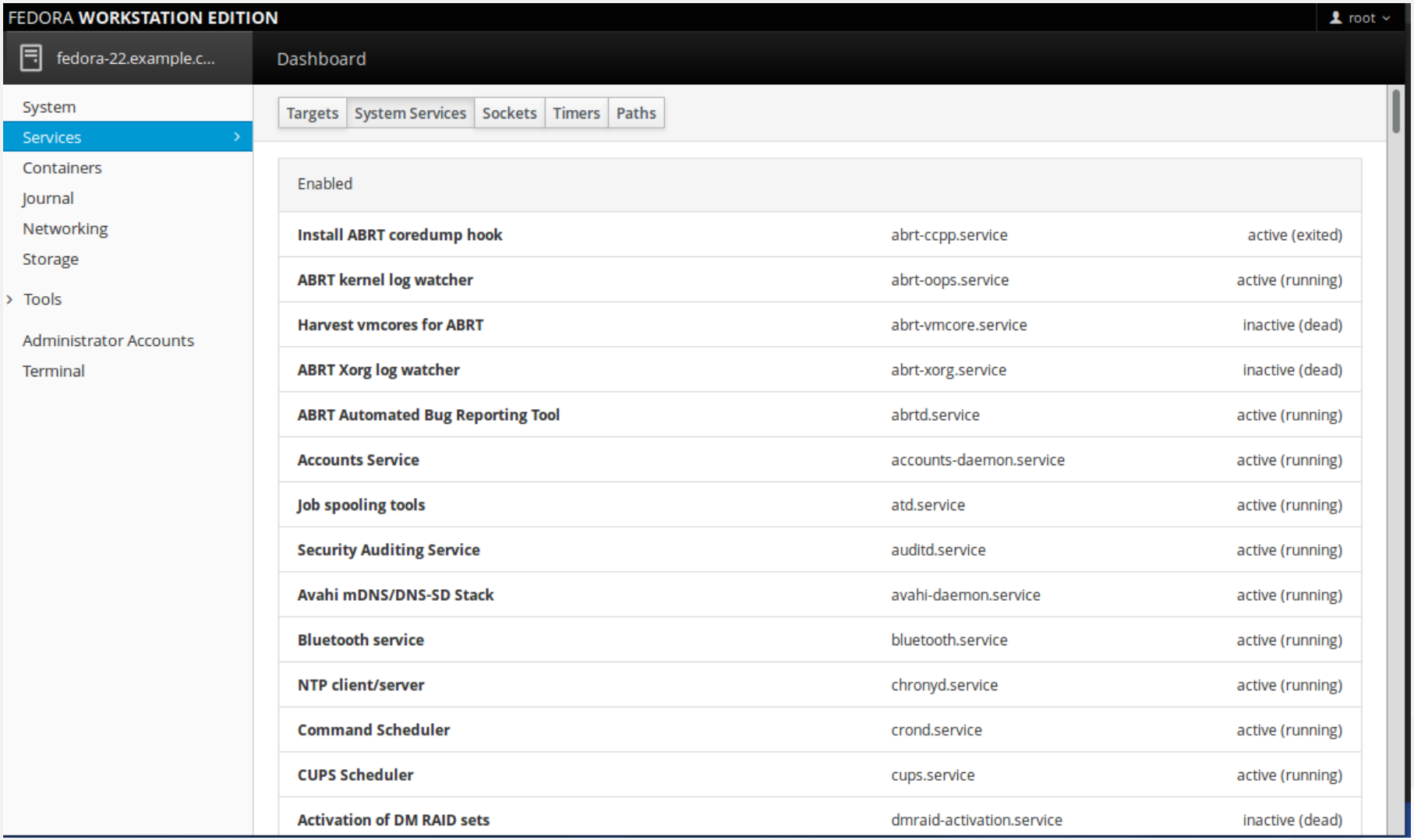
  - `systemctl enable httpd mariadb ntpd lm_sensors [etc]`

Targets == Runlevels

- “Runlevels” are exposed as target units
- More meaningful names:
  - multi-user.target vs. runlevel3
  - graphical.target vs. runlevel5
- View the default target: `systemctl get-default`
- Set the default target: `systemctl set-default [target]`
- Change at run-time: `systemctl isolate [target]`

Note: /etc/inittab is no longer used.

Cockpit is now in RHEL Extras



systemd Sockets

- Have a .socket extension
- Represent inter-process communication (IPC) sockets
- Used to delay start of a service at boot time and to start less frequently used apps on demand
- Similar in principle to services which use xinetd

Sockets

tftp.socket

```
[Unit]
Description=Tftp Server
Activation Socket

[Socket]
ListenDatagram=69

[Install]
WantedBy=sockets.target
```

tftp.service

```
[Unit]
Description=Tftp Server

[Service]
ExecStart=/usr/sbin/initft
pd -s /var/lib/tftpboot
StandardInput=socket
```

```
man systemd.socket
```

Sockets

cockpit.socket

```
[Unit]
Description=Cockpit Web Server Socket
Documentation=man:cockpit-ws(8)

[Socket]
ListenStream=9090

[Install]
WantedBy=sockets.target
```

cockpit.service

```
[Unit]
Description=Cockpit Web Server
Documentation=man:cockpit-ws(8)

[Service]
ExecStartPre=/usr/sbin/remotectl cert --ensure --user=root --group=cockpit-ws
ExecStart=/usr/libexec/cockpit-ws
PermissionsStartOnly=true
User=cockpit-ws
Group=cockpit-ws
```

Timers

fstrim.timer

```
[Unit]
Description=Discard unused
blocks once a week

[Timer]
OnStartupSec=10min
OnCalendar=weekly
AccuracySec=1h
Persistent=true
[Install]
WantedBy=multi-user.target
```

fstrim.service

```
[Unit]
Description=Discard unused
blocks

[Service]
Type=oneshot
ExecStart=/usr/sbin/fstrim /
```

```
man systemd.timer
```

Customizing Units

What's Available?

- List a unit's properties:
  - `systemctl show --all httpd`
- Query a single property:
  - `systemctl show -p Restart httpd`
  - `Restart=no`
- Helpful man files: `systemd.exec` and `systemd.service`
  - Restart, Nice, CPUAffinity, OOMScoreAdjust, LimitNOFILE, etc

Disclaimer: just because you **can** configure something doesn't mean you **should**!

Customizing Units: Drop-ins

1) Create directory

```
mkdir /etc/systemd/system/[name.type.d]/
```

2) Create drop-in

```
vi /etc/systemd/system/httpd.service.d/50-httpd.conf
   [Service]      Remember the 'S' is capitalized
   Restart=always
   CPUAffinity=0 1 2 3
   OOMScoreAdjust=-1000
```

3) Notify systemd of the changes

```
systemctl daemon-reload
```

Customizing Units: Drop-ins

root@host243:/etc/systemd/system/httpd.service.d

File Edit View Search Terminal Help

```
[root@host243 httpd.service.d]# systemctl status httpd
httpd.service - The Apache HTTP Server
   Loaded: loaded (/usr/lib/systemd/system/httpd.service; enabled)
  Drop-In: /etc/systemd/system/httpd.service.d
           └─50-httpd.conf
   Active: active (running) since Sun 2014-03-16 14:31:08 CDT; 2min 6s ago
  Process: 686 ExecStop=/bin/kill -WINCH ${MAINPID} (code=exited, status=0/SUCCESS)
 Main PID: 689 (httpd)
   Status: "Total requests: 15884; Current requests/sec: 133; Current traffic:  60KB/sec"
   CGroup: /system.slice/httpd.service
           ├─689 /usr/sbin/httpd -DFOREGROUND
           ├─691 /usr/sbin/httpd -DFOREGROUND
           ├─692 /usr/sbin/httpd -DFOREGROUND
           ├─693 /usr/sbin/httpd -DFOREGROUND
           ├─694 /usr/sbin/httpd -DFOREGROUND
           ├─695 /usr/sbin/httpd -DFOREGROUND
           └─715 /usr/sbin/httpd -DFOREGROUND

Mar 16 14:31:08 host243.local systemd[1]: Started The Apache HTTP Server.
```

Customizing Units: Drop-ins

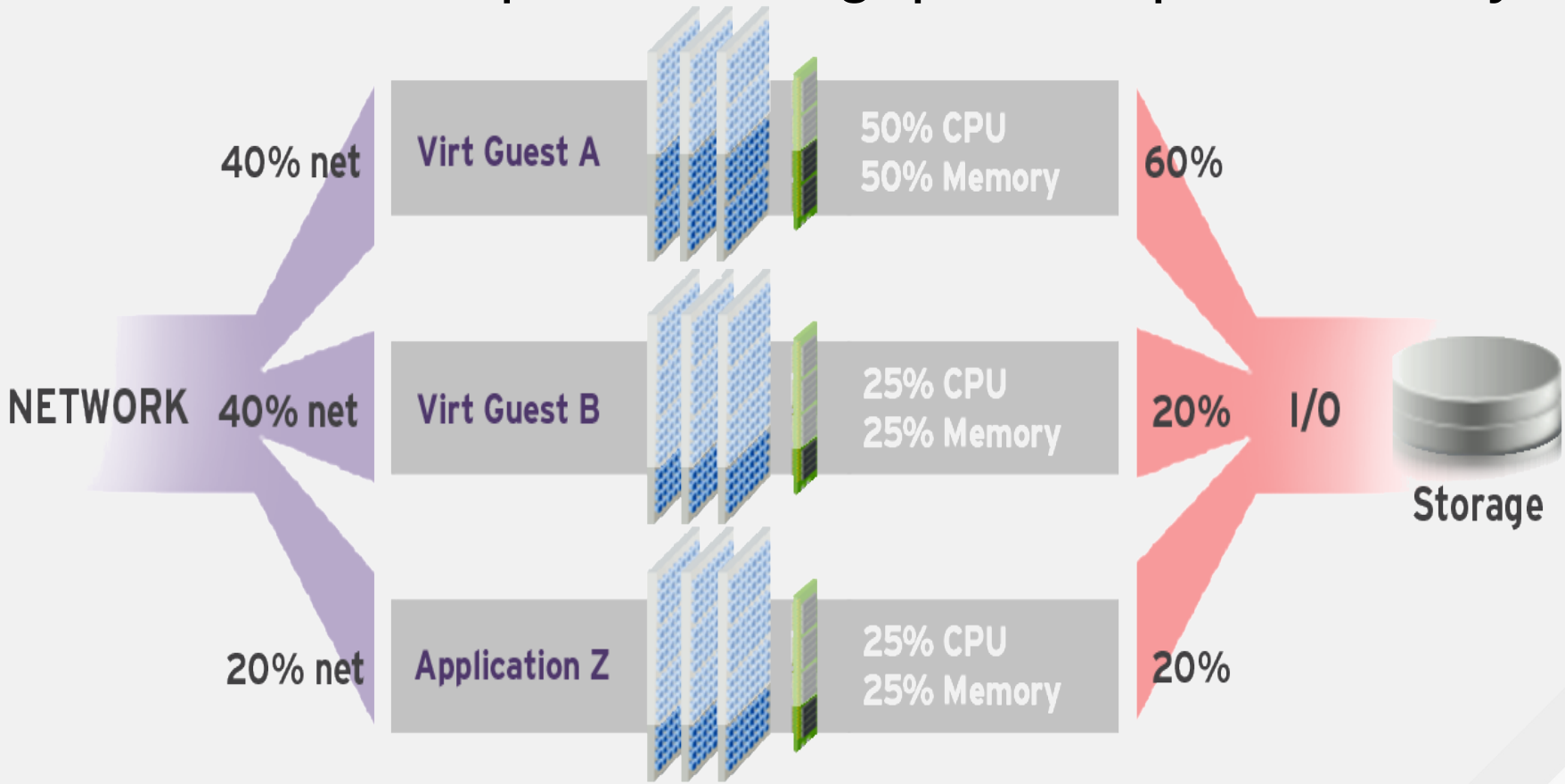
- Safe to apply on running services
  - Note: some options require a service restart to take effect
- Use `systemd-delta` to see what's been altered on a system
- Simple to use with configuration tools like Satellite, Puppet, etc.
- Simply delete the drop-in to revert to defaults.
- Don't forget `systemctl daemon-reload` when modifying units

Resource Management

Slices, scopes, services

Control Groups Made Simple

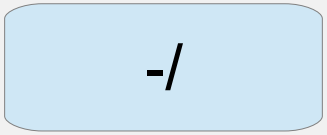
Resource Management with cgroups can reduce contention and improve throughput and predictability



Slices, Scopes, Services

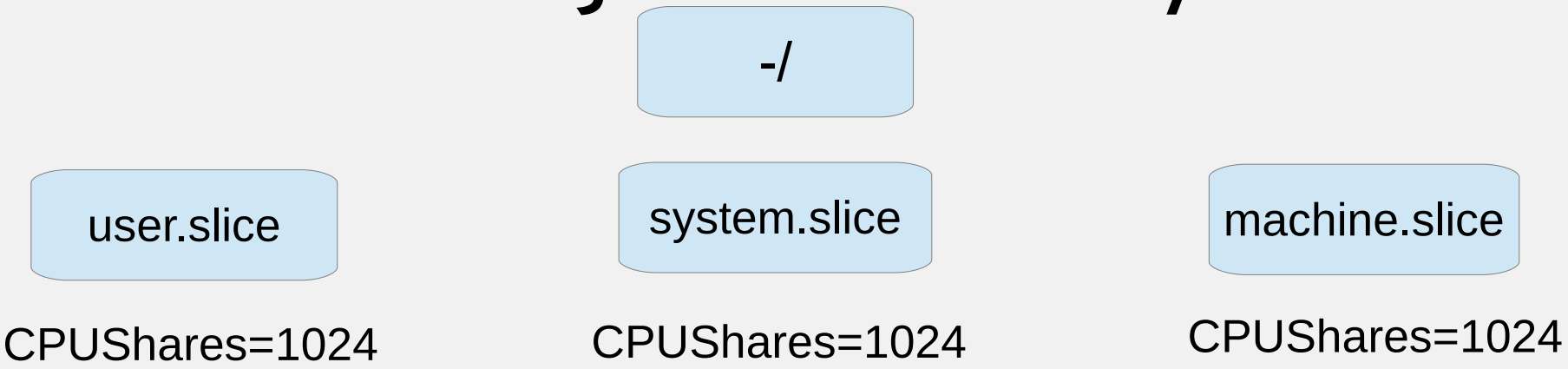
- **Slice** – Unit type for creating the cgroup hierarchy for resource management.
- **Scope** – Organizational unit that groups a services' worker processes.
- **Service** – Process or group of processes controlled by systemd

Understanding the Hierarchy



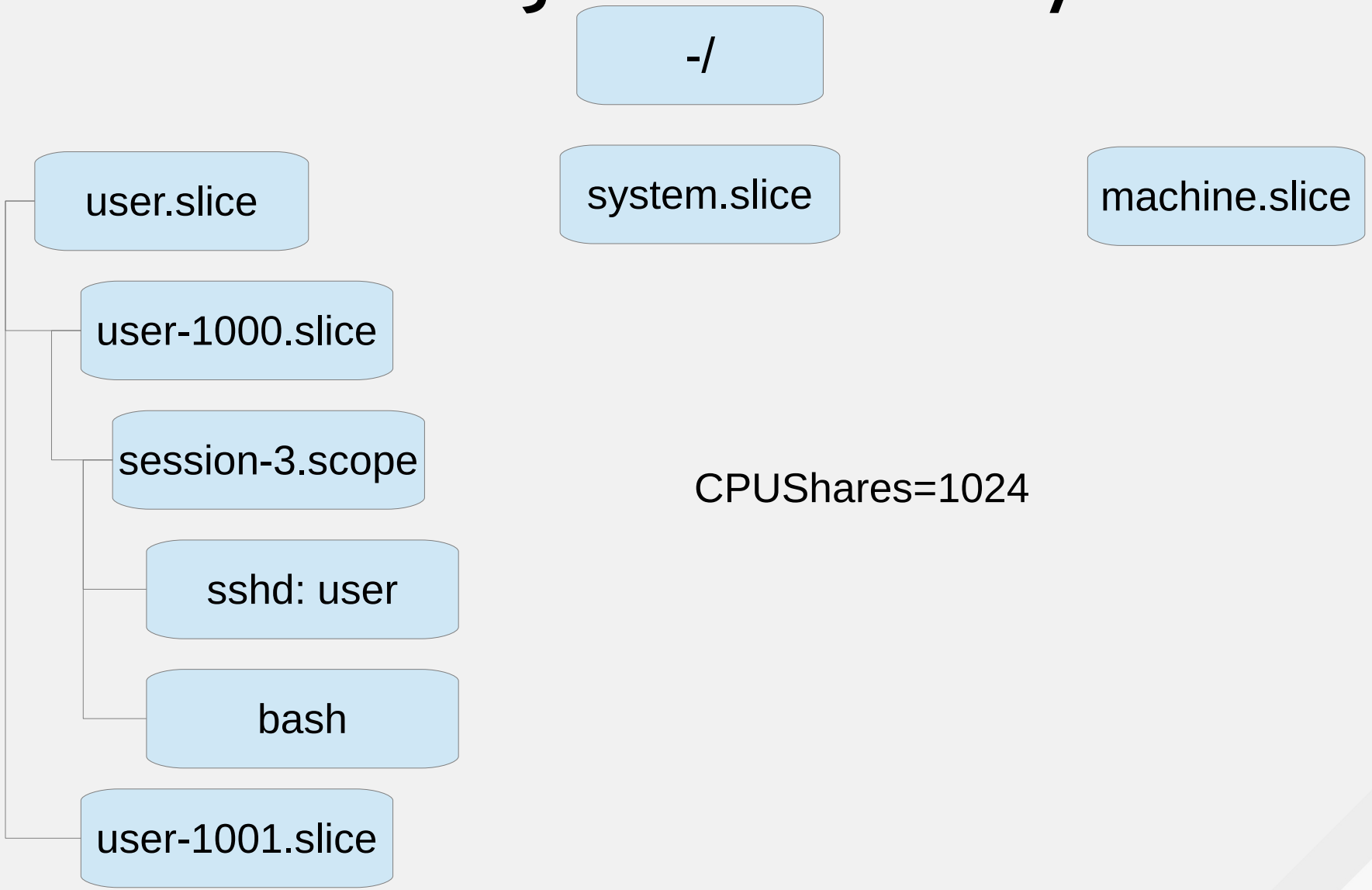
- systemd implements a standard, single-root hierarchy under /sys/fs/cgroup

Understanding the Hierarchy

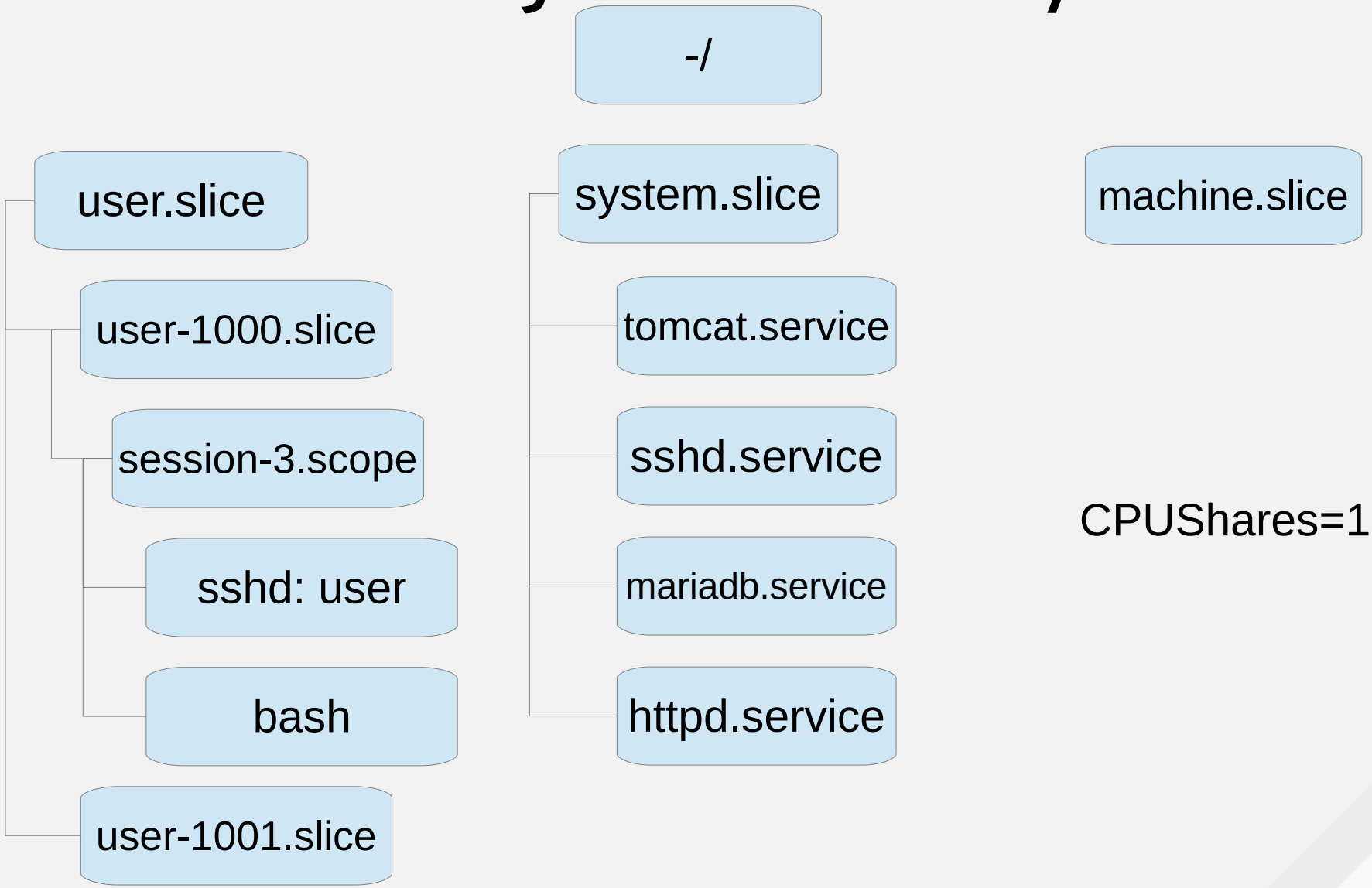


- Each slice gets equal CPU time on the scheduler.

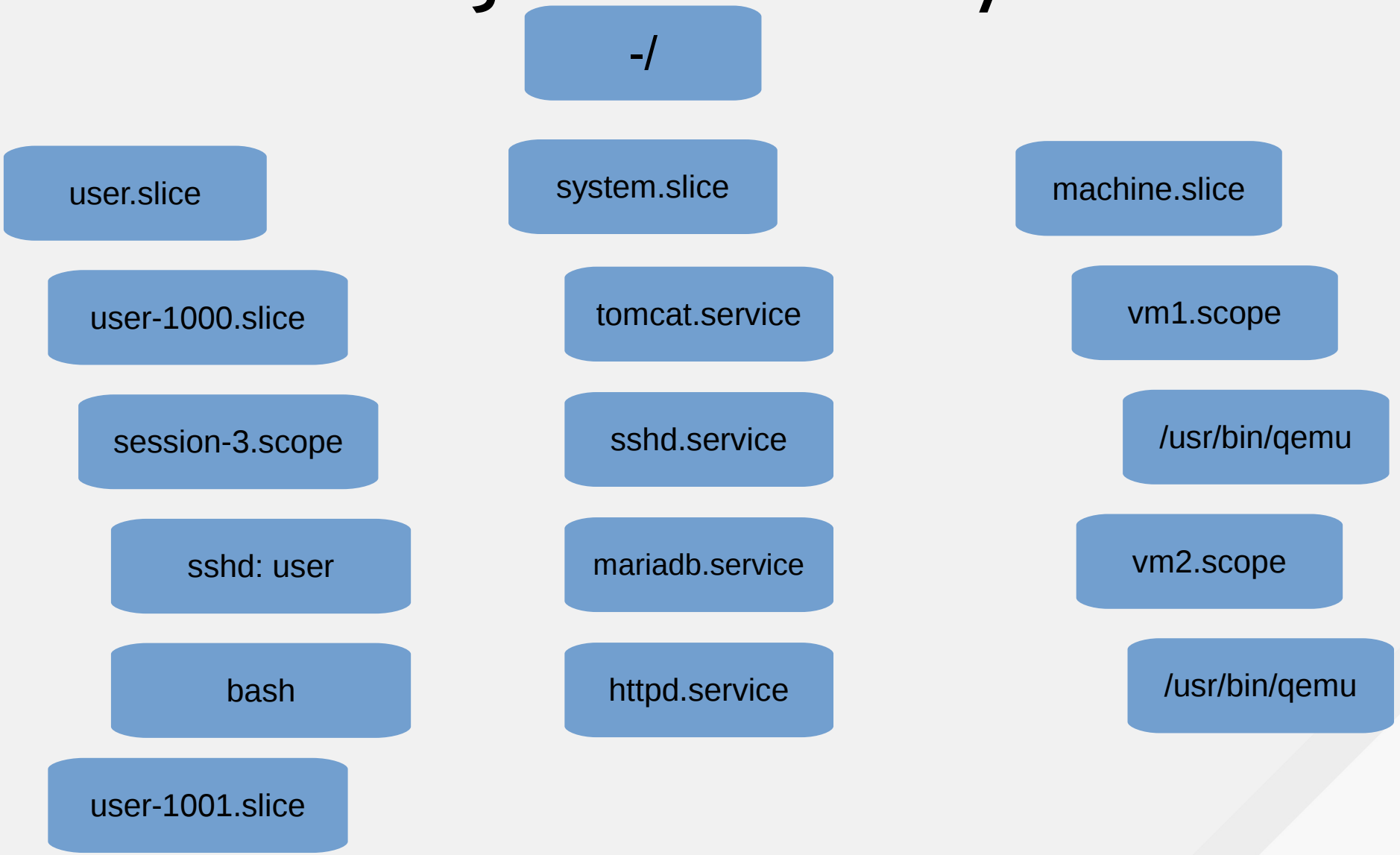
Understanding the Hierarchy



Understanding the Hierarchy



Understanding the Hierarchy



Viewing Resources

- Show top control groups by their resource usage:
  `systemd-cgtop`
- Recursively show control group contents:
  `systemd-cgls`

Resource Management – Configuration

- Configure cgroup attributes:

```
systemctl set-property --runtime httpd /
CPUShares=2048
```

- Drop "--runtime" to persist:

```
systemctl set-property httpd CPUShares=2048
```

- Or place in the unit file:

```
[Service]
CPUShares=2048
```

http://0pointer.de/blog/projects/resources.html

Resource Management – CPU & MEM

- CPUAccounting=1 to enable
- CPUShares – default is 1024.
- Increase to assign more CPU to a service
  - e.g. CPUShares=1600
- MemoryAccounting=1 to enable
- MemoryLimit=
- Use K, M, G, T suffixes
  - MemoryLimit=1G

https://www.kernel.org/doc/Documentation/scheduler/sched-design-CFS.txt
https://www.kernel.org/doc/Documentation/scheduler/sched-design-CFS.txt
https://www.kernel.org/doc/Documentation/cgroups/memory.txt

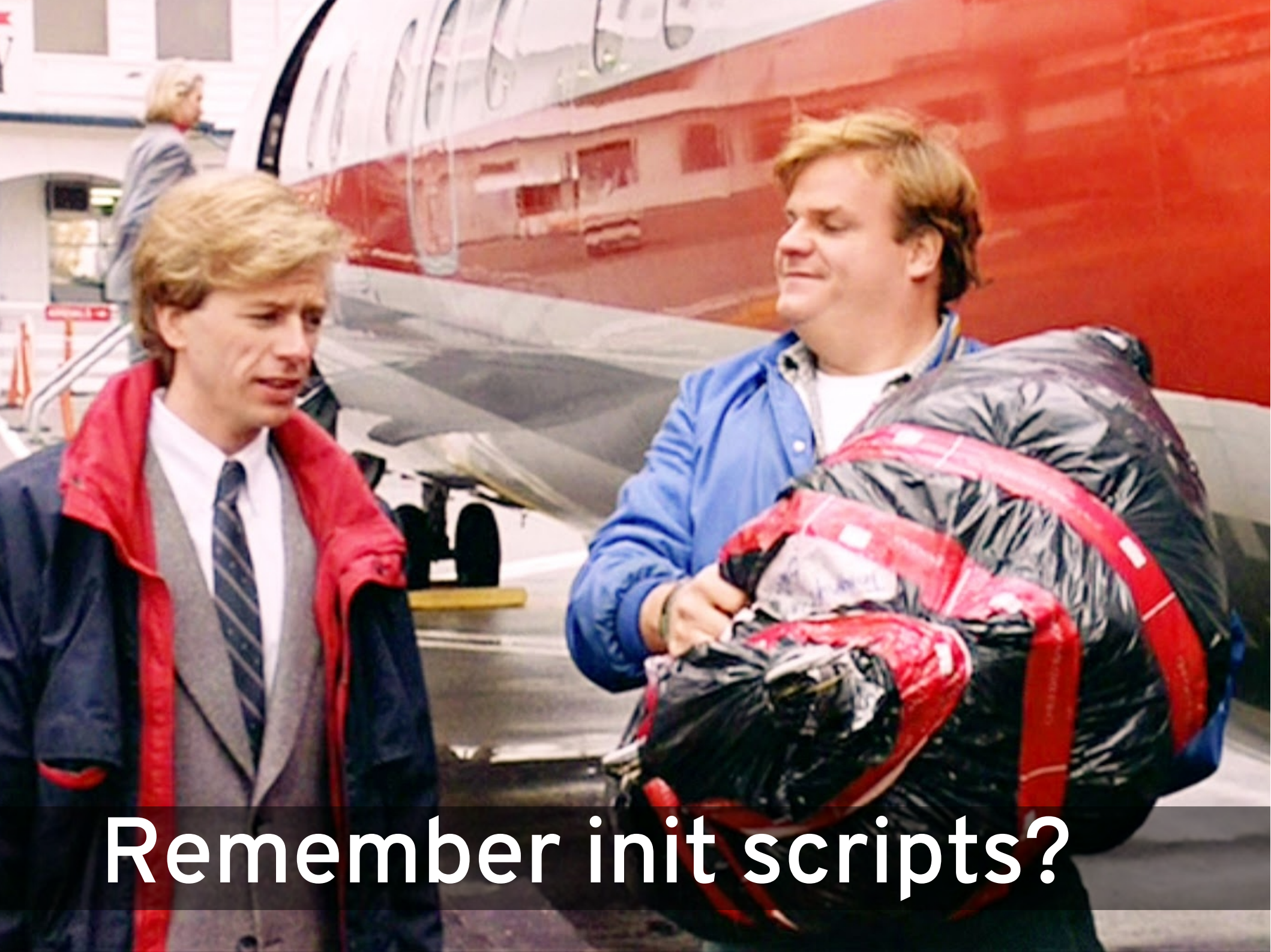
Resource Management - BlkIO

- BlockIOAccounting=1
- BlockIOWeight= assigns an IO weight to a specific service (requires CFQ)
  - Similar to CPU shares
  - Default is 1000
  - Range 10 – 1000
  - Can be defined per device (or mount point)
- BlockIOReadBandwidth & BlockIOWriteBandwidth
  - BlockIOWriteBandwith=/var/log 5M

https://www.kernel.org/doc/Documentation/cgroups/blkio-controller.txt

Converting Init Scripts

You can do it ... it's easy!


Remember init scripts?

/etc/init.d/httpd

```
. /etc/rc.d/init.d/functions
if [ -f /etc/sysconfig/httpd ]; then
        . /etc/sysconfig/httpd
fi
HTTPD_LANG=${HTTPD_LANG-"C"}
INITLOG_ARGS=""
apachectl=/usr/sbin/apachectl
httpd=${HTTPD-/usr/sbin/httpd}
prog=httpd
pidfile=${PIDFILE-/var/run/httpd/httpd.pid}
lockfile=${LOCKFILE-/var/lock/subsys/httpd}
RETVAL=0
STOP_TIMEOUT=${STOP_TIMEOUT-10}
start() {
        echo -n $"Starting $prog: "
        LANG=$HTTPD_LANG daemon --pidfile=${pidfile} $httpd $OPTIONS
        RETVAL=$?
        echo
        [ $RETVAL = 0 ] && touch ${lockfile}
        return $RETVAL
}
stop() {
        echo -n $"Stopping $prog: "
        killproc -p ${pidfile} -d ${STOP_TIMEOUT} $httpd
        RETVAL=$?
        echo
        [ $RETVAL = 0 ] && rm -f ${lockfile} ${pidfile}
}
```

From RHEL 6.4; comments removed

/etc/init.d/httpd – continued

```
reload() {
   echo -n $"Reloading $prog: "
   if ! LANG=$HTTPD_LANG $httpd $OPTIONS -t >&/dev/null; then
      RETVAL=6
      echo $"not reloading due to configuration syntax error"
      failure $"not reloading $httpd due to configuration syntax error"
   else
      LSB=1 killproc -p ${pidfile} $httpd -HUP
      RETVAL=$?
      if [ $RETVAL -eq 7 ]; then
         failure $"httpd shutdown"
      fi
   fi
   echo
}

case "$1" in
 start)
      start
      ;;
 stop)
      stop
      ;;
 status)
      status -p ${pidfile} $httpd
      RETVAL=$?
      ;;
```

/etc/init.d/httpd – continued

```
 restart)
      stop
      start
      ;;
 condrestart|try-restart)
      if status -p ${pidfile} $httpd >&/dev/null; then
            stop
            start
      fi
      ;;
 force-reload|reload)
      reload
      ;;
 graceful|help|configtest|fullstatus)
      $apachectl $@
      RETVAL=$?
      ;;
 *)
      echo $"Usage: $prog {start|stop|restart|condrestart|try-restart|force-reload|reload|status|fullstatus|graceful|help|configtest}"
      RETVAL=2
esac
exit $RETVAL
```

httpd.service

```
[Unit]
Description=The Apache HTTP Server
After=remote-fs.target nss-lookup.target

[Service]
Type=notify
EnvironmentFile=/etc/sysconfig/httpd
ExecStart=/usr/sbin/httpd $OPTIONS -DFOREGROUND
ExecReload=/usr/sbin/httpd $OPTIONS -k graceful
ExecStop=/usr/sbin/httpd $OPTIONS -k graceful-stop
PrivateTmp=true

[Install]
WantedBy=multi-user.target
```

*Comments were removed for readability

To be clear

- Systemd maintains 99% backwards compatibility with LSB compatible initscripts and the exceptions are well documented.
- While we do encourage everyone to convert legacy scripts to service unit files, it's not a requirement.
- Incompatibilities are listed here:
  http://www.freedesktop.org/wiki/Software/systemd/Incompatibilities/
- Converting SysV Init Scripts:
  http://0pointer.de/blog/projects/systemd-for-admins-3.html

Unit file layout: Custom App Example

```
[Unit]
Description=Describe the daemon
After=network.target

[Service]
ExecStart=/usr/sbin/[myapp] -D
Type=forking
PIDFile=/var/run/myapp.pid

[Install]
WantedBy=multi-user.target
```

The Journal

Journal

- Indexed
- Formatted
  - Errors in red
  - Warnings in bold
- Security
- Reliability
- Intelligently rotated

http://0pointer.de/blog/projects/journalctl.html

Journal

- Does not replace rsyslog in RHEL 7
  - rsyslog is enabled by default
- The journal is not persistent by default.
  - Enable persistence: `mkdir /var/log/journal`
- Stored in key-value pairs
  - `journalctl [tab] [tab]`
  - `Man 7 systemd.journal-fields`
- Collects event metadata along with the message
- Simple to filter
  - Interleave units, binaries, etc.


nspawn

nspawn

- Store containers under /var/lib/container to align w/ @systemd-nspawn.service
  - `mkdir /var/lib/container`
- Install a minimal OS w/ yum; 306 rpms ~360MB on disk:

```
yum -y --releasever=7Server
--installroot=/var/lib/container/rhel7 install systemd passwd
yum redhat-release vim-minimal
```

integration points with container managers, to allow seamless management of services across container boundaries.

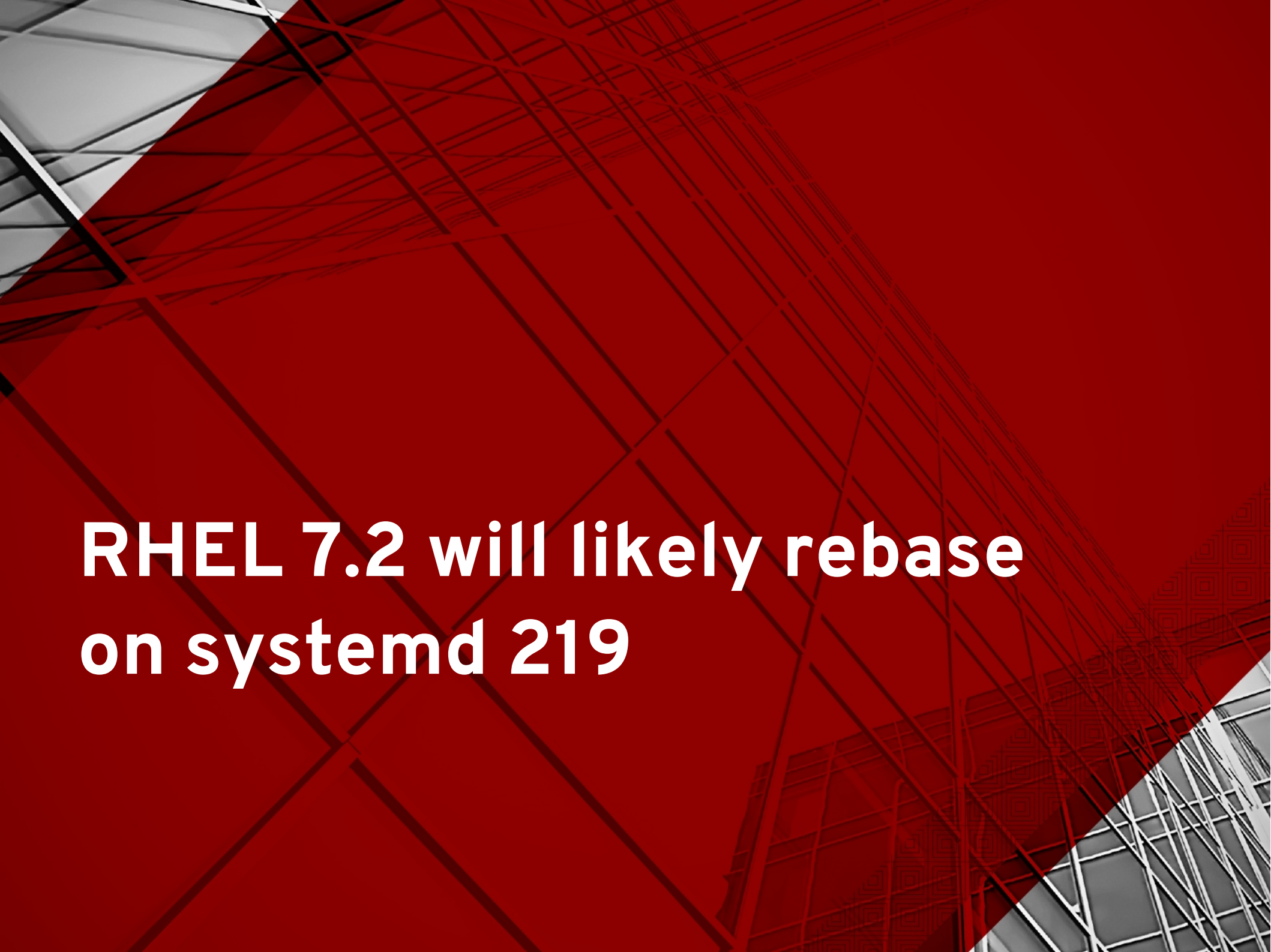
- Point nspawn at the directory and go
  - `systemd-nspawn -D /var/lib/container/rhel7`
- To “boot with an init system”, we need to, start the container, set the root password, and configure the system if necessary, etc
  - `systemd-nspawn -D /var/lib/container/rhel7`

```
passwd ; systemctl disable kdump postfix firewalld
```

man systemd-

systemd-nspawn

- Mini-container manager that is shipped with `systemd` itself
- A container manager that is as simple to use and "just works"
- An integration points with container managers, to allow seamless management of services across container boundaries
- An init system runs inside the container, and the container hence in most ways appears like an independent system of its own


RHEL 7.2 will likely rebase
on systemd 219

219 Highlights

- systemctl – enhancements edit, cat, etc
- CPUQuota – “cap” CPU usage for services
- systemd-socket-proxy – add socket activation to daemons that don't support it natively
- systemd-nspawn
  - Improved networking
  - Ephemeral & template support
  - “-M [container]” option for systemctl, journalctl, etc
  - Import and run Docker containers & raw cloud images
- networkd – DHCP srv/clt, bridge, bond, vlan, vxlan, macvlan, tun

Additional Resources

- RHEL 7 documentation:
  https://access.redhat.com/site/documentation/Red_Hat_Enterprise_Linux/
- systemd project page:

  http://www.freedesktop.org/wiki/Software/systemd/
- Lennart Poettering's systemd blog entries: (read them all)
  http://0pointer.de/blog/projects/systemd-for-admins-1.html
- Red Hat System Administration II & III (RH134/RH254)
  http://redhat.com/training/
- systemd FAQ
- Tips & Tricks


Ohh my pretty
little systemd,
I love you!

THANK YOU!

Scott Seighman
Solutions Architect
Red Hat

sseighma@redhat.com
CleRHUG


plus.google.com/+RedHat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linkedin.com/company/red-hat


twitter.com/RedHatNews


youtube.com/user/RedHatVideos

Tips & Troubleshooting

- Early boot shell on tty9
  - `systemctl enable debug-shell.service`
  - `ln -s /usr/lib/systemd/system/debug-shell.service \ /etc/systemd/system/sysinit.target.wants/`
- `systemctl list-jobs`
- Interactive boot append: `systemd.confirm_spawn=1`
- Enable debugging append:
  - `debug`
  - `debug systemd.log_target=kmsg log_buf_len=1M`
  - `debug systemd.log_target=console console=ttyS0`

http://freedesktop.org/wiki/Software/systemd/Debugging/

Tips & Troubleshooting

- `rc.local` is supported, but no longer runs last
  - `chmod +x /etc/rc.d/rc.local`
- `systemd-analyze`
  - Use 'blame', 'plot', or 'critical-chain' for more details
- Append systemd.unit=[target] to the kernel
  - Rescue mode: single, s, S, or 1
  - Emergency (similar to init=/bin/bash): -b or emergency