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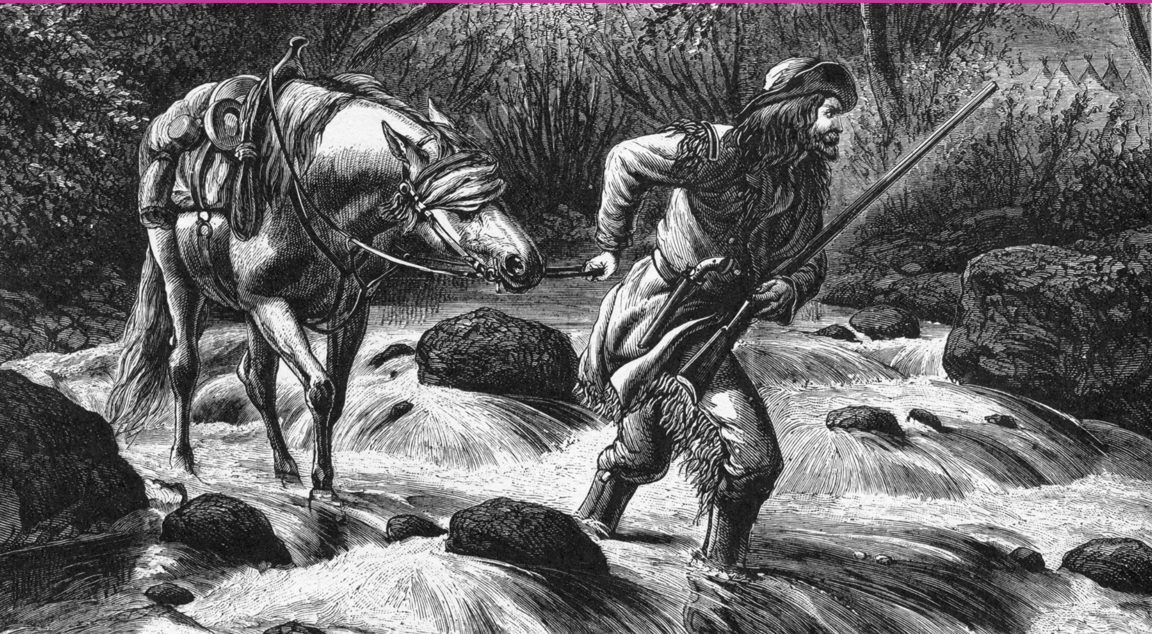
Ten Steps to Linux Survival

Essentials for Navigating the Bash Jungle



James Lehmer

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Ten Steps to Linux Survival

by James Lehmer

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[LSI]

Table of Contents

Introduction

And you may ask yourself, "Well, how did I get here?"

—Talking Heads, "Once in a Lifetime"

Why Are We Here?

This report grew out of a series of "lunch-and-learns" on Linux that I compiled for work. During that process, I ended up writing an ebook, and then condensing it into a one-hour presentation that focuses on the essentials needed for quick problem-solving on a Linux system. I turned that presentation into an O'Reilly webcast, and this report provides more details on those original 10 essentials.

Even in formerly "pure Windows" shops, Linux use is growing. Linux systems are everywhere! They may appear as *appliances* (machines) or, more likely, virtual machine (VM) images dropped in by a vendor.

Common examples of Linux systems that may appear in your shop as VMs or in the cloud include the following:

Web servers
: Apache, Nginx, Node.js

Database servers
: MongoDB, PostgreSQL

Mobile device management
: Various MDM solutions, such as MobileIron

Security and monitoring systems
: Security information and event management (SIEM) systems, network sniffers

Source-code control systems
: Git or Mercurial

As Linux use continues to grow, you need to know the basics. One day you might be the only one in the office when things go south, and you'll have to fix them—fast. This guide will help.

In this report, I focus on diagnosing problems and getting a system back up. I *don't* cover these topics:

- Modifying the system, other than restarting
- Forensics, other than looking at logs
- Shell scripting
- Distro differences—for example, Ubuntu versus CentOS
- Anything in depth, as this is just to get your feet wet

Who Is This For?

The intended audience of this book is *not* seasoned Linux administrators, or anyone with a passing knowledge of the Bash shell. Instead, it is for people who are working in small Windows shops, where everyone has to wear various hats. It is for Windows administrators, network admins, developers, and the like who have no knowledge of Linux but may still have to jump in during a problem. Imagine your boss rushing into your office and saying this:

> *The main www site is down, and all the people who know about it are out. It's running on some sort of Linux, I think, and the credentials and IP address are scrawled on this sticky note. Can you get in, poke around, and see if you can figure it out?*

In this report, you'll learn the basic steps to finding vital information that can help you quickly get the site back up. By reading this guide before disaster strikes, you will be better able to survive the preceding scenario.

How to Prepare

In small shops, sometimes things just *fall on you* because no one else is available. There is often no room for "It's not my job" when production is down and the one person who knows about it is backpacking in Colorado. So you need to be prepared as the use of Linux becomes more prevalent, turning "pure Microsoft" shops more and more into hybrids. Linux is coming, whether you like it or not. Be prepared.

First, pay *close attention* whenever you hear the word *appliance* used in terms of a system. Perhaps it will be mentioned in passing in a vendor presentation. Dig in and find out what the appliance image is running.

Second, note that *even Microsoft* is supporting Linux, and increasing that support daily. First, it started with making Linux systems first-class citizens on Azure. Now Microsoft is partnering with Docker and Ubuntu and others, and that coordination looks like it is only going to grow.

So now is the time to *start studying*. This report is a quick-help guide to prepare you for limited diagnostic and recovery tasks, and to get you used to how Linux commands work. But you should dig further.

One place to turn next is my ebook. It helps you take the next steps of understanding how to change Linux systems in basic ways. I've also included some useful references at the end of this report. Past that, obviously, O'Reilly has many good resources for learning Linux. And the Internet is just sitting there, waiting for you.

Play with It!

The best way to learn Linux is to stand up an environment where you can explore without fear of the consequences if you mess something up. One way is to create a Linux VM; even a moderately provisioned modern laptop will comfortably run a Linux VM. You can also create one in the cloud, and many vendors make that easy, including DigitalOcean, Linode, Amazon Elastic Compute Cloud (EC2), Microsoft Azure, and Google Compute Engine. Many of these even offer a free level, perfect for playing!

Documentation and Instrumentation

To protect yourself in case you are thrown into the scenario outlined at the beginning of this report, you should make sure the following are in place at your shop:

The Linux systems are documented.
: This should include their purpose, as-built documentation outlining the distro, virtual or physical hardware specs, packages installed, and so on.

These systems are being actively monitored.
: Are they tied in to Paessler Router Traffic Grapher (PRTG), SIEM, and other monitoring and alerting systems? Make sure you have access to those alerts and monitoring dashboards, as they can be a great source of troubleshooting information.

You have access to the system credentials.
: Ideally, your department uses secure vault software to store and share system credentials. Do you have access to the appropriate credentials if needed? You should make sure before the need arises.

Conventions

If a command, filename, or other computer code is shown inline in a sentence, it appears in a fixed-width font:

```
ls --recursive *.txt
```

If a command and its output is shown on a terminal session, it appears as shown in Figure P-1.

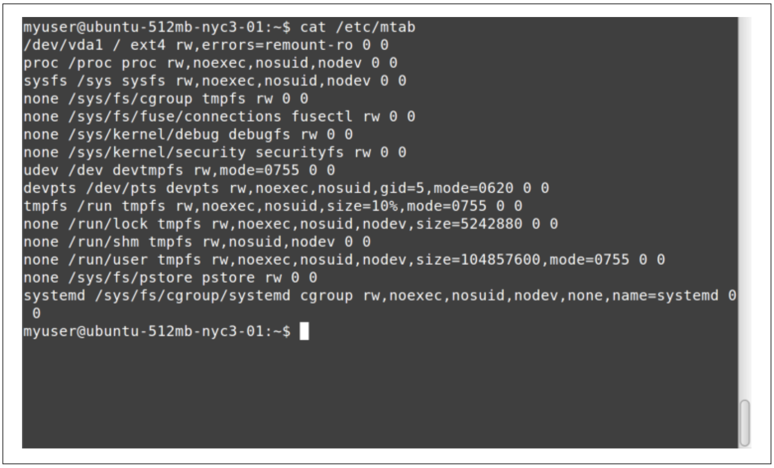


Figure P-1. cat command

All such blocks have been normalized to show a maximum of only 80 x 24 characters. This is intentional. Although most modern Linux systems and terminal windows such as `ssh` can handle any geometry, some systems and situations still give you the same terminal size that your grandfather would've used. It is best to learn how to deal with these by using `less`, redirection, and the like. In addition, screenshots are shown from a variety of systems, to get you used to the ways that command output and terminal settings can differ, *much* more than under the default Windows Command Prompt.

The examples in this book typically show something like `myuser@ubuntu-512mb-nyc3-01:~ $` before the command (as in the previous example). In other systems, you may simply see `~ #` (when logged in as root) or `%` (when running under `csh`). These command prompts are not meant to be typed in as part of the command. Although they may seem confusing in the samples, you need to get used to looking at a terminal and "parsing" what is being displayed. And in our scenarios, you won't have control over the command prompt format. Get used to it.

Typically, the screenshots are set up with the command entered at the prompt at the top of the screen, the command output immediately following, and in most cases a new command prompt waiting for another command at the end, as in the preceding example.

In the few places, where a Linux command is shown in comparison to a DOS command run under Windows Command Prompt, the latter is shown in all uppercase to help distinguish it from the Linux equivalent, even though Windows Command Prompt is case-insensitive. In other words, `cd temp` is shown for `bash`, and `CD TEMP` for `CMD.EXE`.

This element signifies a tip or suggestion.

This element signifies a general note.

This element indicates a warning or caution.

CHAPTER 0
Step 0: Don't Panic

The first, essential step is to stay calm. If you are dragged into trying to diagnose a Linux system and it isn't your area of expertise, you can only do so much. We're going to be careful to keep from changing system configurations, and we're going to restart services or the system only as a last resort.

So just try to relax, like Merv the dog (Figure 0-1). No one should expect miracles from you. And if you *do* figure out the problem, you'll be a hero!

Figure 0-1. Merv the dog sez, Don't panic

CHAPTER 1

Step 1: Getting In

Before I get too far, let's talk about how to connect to a Linux system in the first place. If you have an actual physical machine, you can use the console. In today's day and age, this isn't likely. If you are running VMs, you can use the VM software's console mechanism.

But most Linux systems run OpenSSH, a Secure Shell service, which creates an encrypted terminal connection via TCP/IP, typically to port 22. So, obviously, if you are connecting to an off-premise system, the appropriate firewall holes have to be in place on both sides. This allows you to connect from anywhere you want to work.

On Windows, you generally use PuTTY to establish SSH sessions with Linux systems. You typically need credentials as well, either from that sticky note your boss found, or preferably via your company's secure credentials management system.

> You also could connect using public/private key pairs, but that is beyond the scope of this report.

When you start PuTTY, it looks like Figure 1-1.

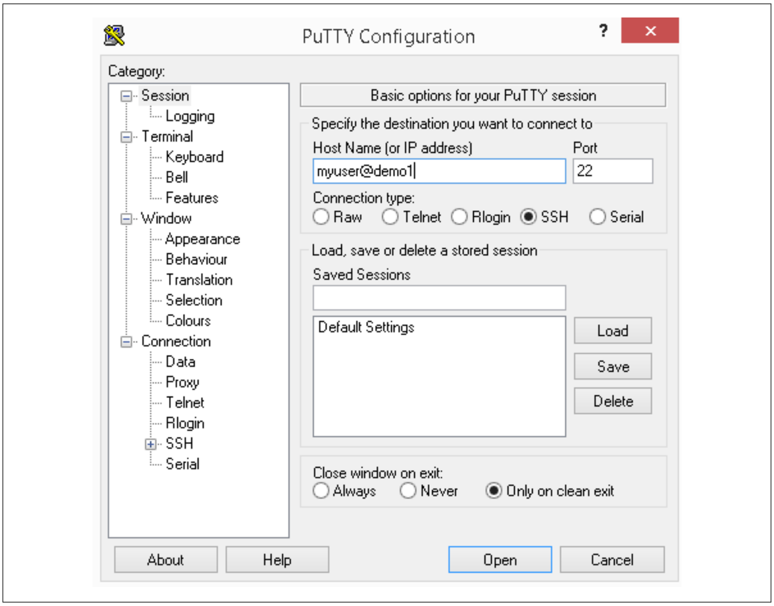


Figure 1-1. PuTTY prompt

You typically type in a user ID (in this example, **`myuser`**), followed by the at sign, **`@`**, and then the system's domain name or IP address (in this example, **`demo1`**).

When you click the Open button, if this is the first time you are connecting via SSH to a remote system, you will receive a warning similar to the one in Figure 1-2.

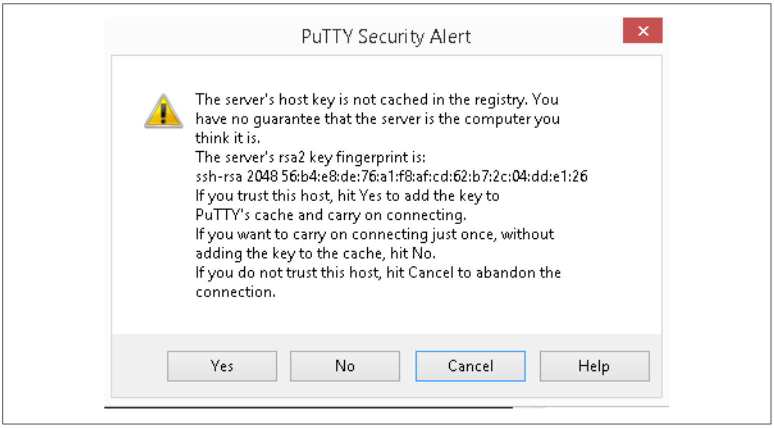


Figure 1-2. PuTTY alert

Simply click Yes, and the remote host's key fingerprint will be stored so you don't have to deal with this warning again. However, if you've already answered that prompt when connecting from your computer and you see it again *for the same remote system*, that means the remote machine's IP address or other configuration has changed. That is often OK—changing the hosting provider for your public web server will trigger the warning for sure. However, if you know of no such changes, it may be indication of a system compromise, and you should abort the login and ask around.

You will then be presented with a password prompt, as shown in Figure 1-3.

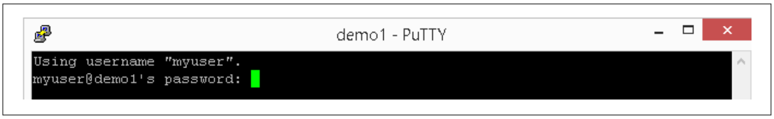


Figure 1-3. PuTTY password

Type in the password and hit Enter, and you should see something similar to Figure 1-4.

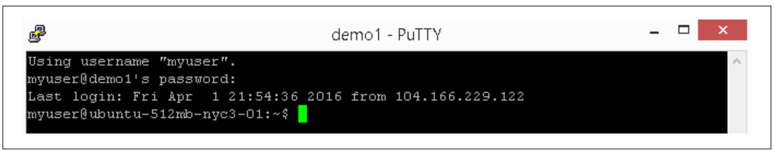


Figure 1-4. Successful login

You're in! Congratulations (or condolences, depending on how you feel about this assignment).

"sudo make me a sandwich"

I'm going to take a brief intermission to discuss the `sudo` command. It stands for *super-user do*. If a user is in the `sudo` user group, that user is allowed to execute privileged commands. It is similar to doing a `RUNAS` command in the Windows Command Prompt to run a command under an elevated account.

Logging in remotely as *root* (system administrator) is frowned upon, and in fact often forbidden for security purposes. Hence, you'll need to use `sudo` to run admin commands that you will see later.

When you try to run a command and get an Access Denied message, you can then try it with `sudo`—for example, `sudo cat /var/log/dmesg`. The first time you run `sudo`, you will get the lecture shown in Figure 1-5, which contains good words to live by anytime you are running as an administrator on any system!

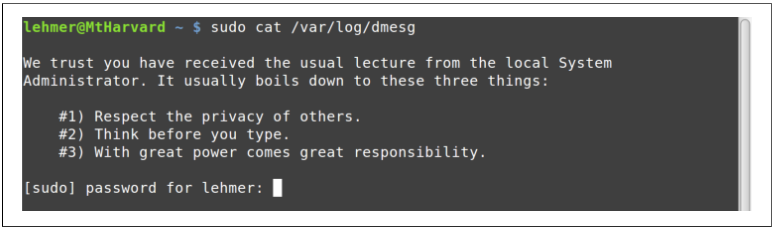


Figure 1-5. sudo lecture

Note that you have to enter your password when you invoke `sudo`. Be clear, this is *your* user ID's password, not root's. This is to ensure that a human being is in control and that someone else isn't trying to hijack your terminal session while you're getting another cup of coffee.

Now that you know about `sudo`, you should get the punchline to this comic, and hence the title of this section.

CHAPTER 2

Step 2: Getting Around

Now that you're logged in, the first thing you'll want to do is inspect what is going on and how the system is configured. To do that, you need to list files and directories, and move around within the filesystem. This chapter covers these basics.

Where Am I?

Some command prompts are set to show the current directory path. Others are not, and it can be tough to remember where you are in the filesystem. The `pwd` (print working directory) command shows you:

```
bash-4.2$ pwd
/etc/init.d
```

> Unlike in Windows, which is case-insensitive (but case-aware), in Bash and in Linux in general, *case matters*. By convention, most Linux commands are lowercase. If you try to type in an uppercase `PWD`, you will get a Command Not Found error.

Listing Files

In Bash, the `ls` (list) command is used to show directories and files. It is similar to the `DIR` command in Windows Command Prompt.

Figure 2-1 shows a simple sample of an `ls` command.

```
myuser@ubuntu-512mb-nyc3-01:~$ ls
CorporateSecrets.pdf  MyResume.docx  mysql.php  mysvc  Passwords.xlsx
myuser@ubuntu-512mb-nyc3-01:~$ 
```

Figure 2-1. ls command

> Some `ssh` sessions use color highlighting, as shown in these screenshots (in this case, green means the file is executable). Some do not. So don't be surprised if you see colors!

To see a more detailed listing of the files and directories, you can use the `ls -l` command, as shown in Figure 2-2.

```
myuser@ubuntu-512mb-nyc3-01:~$ ls -l
total 32
-rw-r--r-- 1 myuser myuser 9982 Apr  1 20:15 CorporateSecrets.pdf
-rw-r--r-- 1 myuser myuser 4027 Apr  1 20:15 MyResume.docx
-rw-r--r-- 1 myuser myuser 2627 Apr  1 20:15 mysql.php
-rwxrwx--- 1 myuser myuser   58 Apr  1 20:15 mysvc
-rw-r--r-- 1 myuser myuser 4723 Apr  1 20:15 Passwords.xlsx
myuser@ubuntu-512mb-nyc3-01:~$ 
```

Figure 2-2. ls -l command

From left to right, you see file permissions, owner, group, size, last modified date, and finally the file or directory name. File permissions are beyond the scope of this report, but if you continue your Linux education after reading this, you can learn more about them in my ebook.

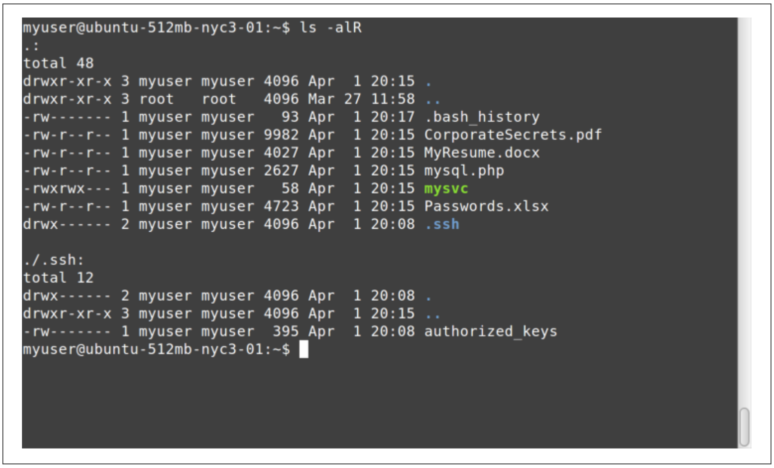
In Windows, a file is hidden by setting a file attribute (metadata) on the file. In Linux, a file is hidden if its name starts with a period, or dot. To show these dot files, you use the `ls -a` command shown in Figure 2-3.

```
myuser@ubuntu-512mb-nyc3-01:~$ ls -a
.   .bash_history         MyResume.docx  mysvc           .ssh
..  CorporateSecrets.pdf  mysql.php      Passwords.xlsx
myuser@ubuntu-512mb-nyc3-01:~$ 
```

Figure 2-3. ls -a command

On the left you see `.` and `..`, which mean *current directory* and *parent directory*, respectively, just as in Windows. You also see previously hidden files such as *.bash_history* and the *.ssh* directory (in this example, blue denotes a directory).

Finally, you can combine parameters. If you want to see a detailed listing (`-l`) of all files (`-a`), recursively descending into every child directory (`-R`), you simply combine them all (`ls -alR`), as shown in Figure 2-4.



```
myuser@ubuntu-512mb-nyc3-01:~$ ls -alR
.:
total 48
drwxr-xr-x 3 myuser myuser 4096 Apr  1 20:15 .
drwxr-xr-x 3 root   root   4096 Mar 27 11:58 ..
-rw------- 1 myuser myuser   93 Apr  1 20:17 .bash_history
-rw-r--r-- 1 myuser myuser 9982 Apr  1 20:15 CorporateSecrets.pdf
-rw-r--r-- 1 myuser myuser 4027 Apr  1 20:15 MyResume.docx
-rw-r--r-- 1 myuser myuser 2627 Apr  1 20:15 mysql.php
-rwxrwx--- 1 myuser myuser   58 Apr  1 20:15 mysvc
-rw-r--r-- 1 myuser myuser 4723 Apr  1 20:15 Passwords.xlsx
drwx------ 2 myuser myuser 4096 Apr  1 20:08 .ssh

./.ssh:
total 12
drwx------ 2 myuser myuser 4096 Apr  1 20:08 .
drwxr-xr-x 3 myuser myuser 4096 Apr  1 20:15 ..
-rw------- 1 myuser myuser  395 Apr  1 20:08 authorized_keys
myuser@ubuntu-512mb-nyc3-01:~$
```

Figure 2-4. ls -alR command

Note the `d` in the far left column for `.`, `..`, and `.ssh`. This tells you they are directories, and in terminal sessions that do not use color highlighting, this `d` will be the only way you know which entries are files and which are directories.

Changing Directories

To change to a different directory, use the `cd` (change directory) command.

> Linux uses the `/` character as the path delimiter, unlike Windows, which uses `\`. This *will* trip you up the first few times, especially because `\` has a different meaning in Bash (it is an escape character).

Linux doesn't use drive letters. Instead, all devices are mounted in a single hierarchical namespace starting at the root (`/`) directory. You will see examples of this later in this report.

On login, you are usually in the *home directory*, which is represented by ~. It is similar to the user directories under *C:\Users* on Windows. Hence, you will probably need to go elsewhere. Here's a list of common directories on Linux systems that are of interest:

/etc
: System configuration files (often pronounced *slash-et-see* if someone is instructing you what to do over the phone)

/var
: Installed software

/var/log
: Log files

/proc
: Real-time system information—similar to Windows Management Instrumentation (WMI), but easier!

/tmp
: Temp files, cleared on reboots

> Remember, case matters! And use `/`, not `\`!

Changing to another directory with `cd` is simple, as you can see in Figure 2-5.

Figure 2-5. cd /etc command

Be Lazy

Most modern interactive shells like Bash and Windows Command Prompt allow for tab expansion and command history, at least for the current session of the shell. This is a good thing in a crisis situation, because it saves you typing, and thus, time.

Tab expansion is like autocomplete for the command prompt. Let's say you have some files in a directory, as shown in Figure 2-6.

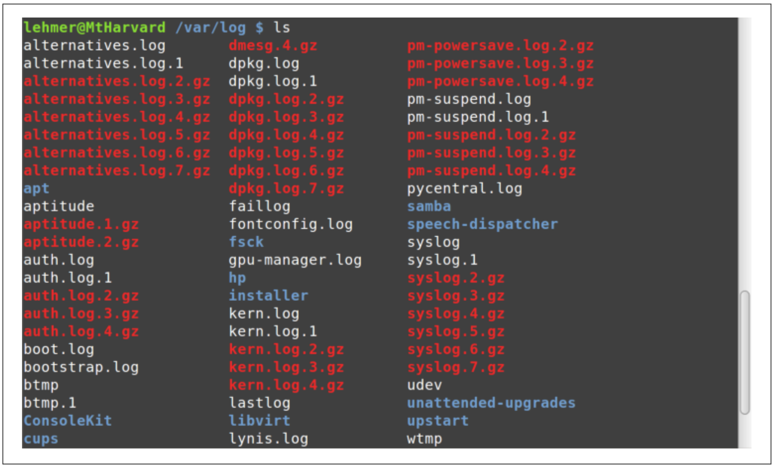


Figure 2-6. ls /var/log command

Without tab expansion, typing out something like this is slow and error-prone:

```
cd unattended-upgrades
```

But with tab expansion, you can simply type `cd un[Tab]`, where `[Tab]` represents hitting the Tab key, and because only one directory starts with *un*, tab expansion will fill in the rest of the directory name for you.

One way that tab completion in Bash is different than in Windows Command Prompt is that in Bash, if you hit Tab and there are multiple candidates, Bash will expand as far as it can and then show you a list of files that match up to that point. You can then type in more characters and hit Tab again to complete it.

For example, in the previous example, if you wanted to list the details of the *pm-powersave.log.2.gz* file, instead of typing out **`ls -l pm-powersave.log.2.gz`** (27 keystrokes to type and possibly get wrong), you could use tab expansion to get it in two simple steps:

1. Type `ls -l pm-p[Tab]`. This would expand to `ls -l pm-powersave.log.`, because only the files named *pm-powersave.log.* begin with *pm-p*. In this case, I specified just enough characters to distinguish between *pm-powersave.log* files and those beginning with *pm-suspend.log*.
2. Type `2[Tab]`. This would complete the rest, `.gz`, because only one *pm-powersave.log.* file has a *2* in the next character location.

Thus, a total of 13 keystrokes, with two tab characters, saved typing 14 more!

Tab expansion is your friend, and you should use it as often as possible. It gives at least three benefits:

- Saves you typing.
- Helps eliminate misspellings in long file and directory names.
- Acts as an error checker—if the tab doesn't expand, chances are you are specifying the beginning part of the name wrong.

Another thing to remember about the interactive shell is command history. Both Windows Command Prompt and Bash give you command history, but Bash supports a rich interactive environment for searching for, editing, and saving command history. However, the biggest thing you need to remember in an emergency is simply that the up and down arrows work in the command prompt and bring back your recent commands so you can update them and re-execute them. This saves typing and reduces errors—use it!

CHAPTER 3

Step 3: Peeking at Files

Now that you know how to move around in the filesystem, it is time to learn about how to inspect the content of files. In this chapter, I show a few commands that allow you to look inside files safely, without changing them.

Cool cat

The `cat` (concatenate) command dumps a file to the console, as shown in Figure 3-1.

Figure 3-1. cat command

We will be using `cat` a lot in the rest of this report. Because most Linux configuration and log files are text, this command is handy for examining files, knowing that we can't change them by accident. The `CMD.EXE` equivalent is the `TYPE` command.

less Is More

The `less` command paginates files or output, with each "page" based on the size of the console window.

In Bash, as in Windows Command Prompt, the output from one command can be redirected, or piped, to another command by using the `|` character. In Linux, where each command "does one thing, well," it is common practice to combine multiple commands, piping the output from one command to the next to accomplish a series of tasks in sequence. For example, later in this report you will see how to use the `ps` command to produce a list of running processes and then pipe that output to the `grep` command to search for a specific process by name. To demonstrate, although `less` can be passed a filename directly, here's how to pipe command output from `cat` to `less`:

```
~ $ cat /etc/passwd | less
```

The output from `less` clears the screen, and then shows the first page, as you can see in Figure 3-2.

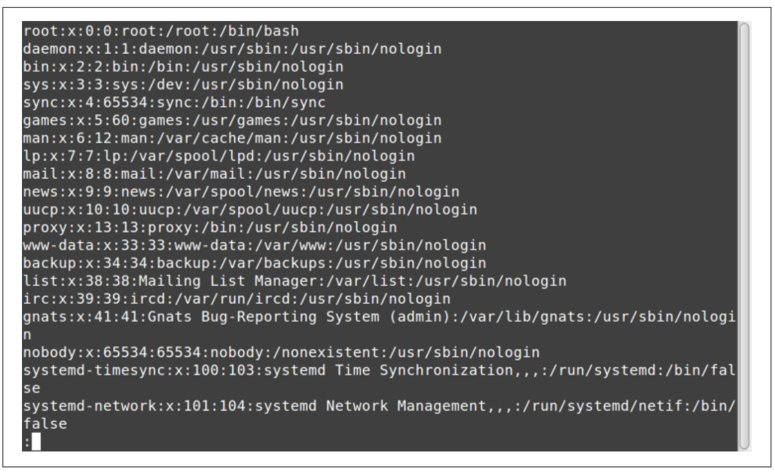


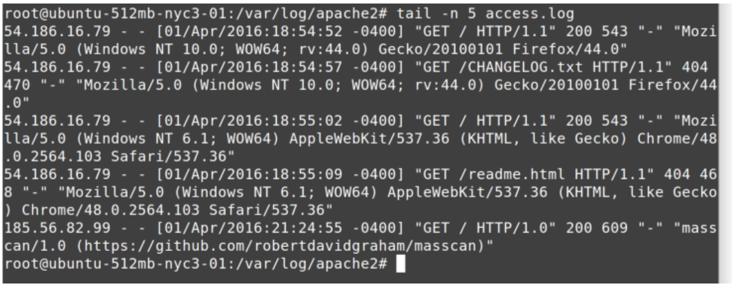
Figure 3-2. less output

The colon at the bottom of the screen indicates that `less` is waiting for a command. After `less` displays its output, you have various navigation options:

- *Space, Page Down, or the down arrow* scrolls down.
- *Page Up or the up arrow* scrolls up.
- `/` finds text searching forward (down) from the current cursor position, until the end of the file is reached; for example, `/error`.
- `?` finds text searching backward (up) from the current cursor position, until the beginning of the file is reached; for example, `?error`.
- `n` finds next instance of the text you're searching for (note that the meaning of this is reversed when using `?`).
- `p` finds previous instance of the text you're searching for (note that the meaning of this is reversed when using `?`).
- `q` quits the `less` command and returns you to the prior view of the console.

tail Wind

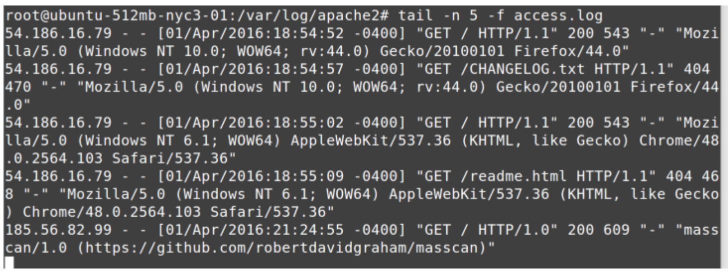
The `tail` command shows the last lines in a file. It is useful when you're looking at large log files and want to see just the last lines—for example, right after an error has occurred. By default, `tail` will show the last 10 lines, but you can adjust the number of lines displayed with the `-n` parameter. For example, Figure 3-3 shows how to display just the last five lines.



```
root@ubuntu-512mb-nyc3-01:/var/log/apache2# tail -n 5 access.log
54.186.16.79 - - [01/Apr/2016:18:54:52 -0400] "GET / HTTP/1.1" 200 543 "-" "Mozi
lla/5.0 (Windows NT 10.0; WOW64; rv:44.0) Gecko/20100101 Firefox/44.0"
54.186.16.79 - - [01/Apr/2016:18:54:57 -0400] "GET /CHANGELOG.txt HTTP/1.1" 404
470 "-" "Mozilla/5.0 (Windows NT 10.0; WOW64; rv:44.0) Gecko/20100101 Firefox/44
.0"
54.186.16.79 - - [01/Apr/2016:18:55:02 -0400] "GET / HTTP/1.1" 200 543 "-" "Mozi
lla/5.0 (Windows NT 6.1; WOW64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/48
.0.2564.103 Safari/537.36"
54.186.16.79 - - [01/Apr/2016:18:55:09 -0400] "GET /readme.html HTTP/1.1" 404 46
8 "-" "Mozilla/5.0 (Windows NT 6.1; WOW64) AppleWebKit/537.36 (KHTML, like Gecko
) Chrome/48.0.2564.103 Safari/537.36"
185.56.82.99 - - [01/Apr/2016:21:24:55 -0400] "GET / HTTP/1.0" 200 609 "-" "mass
can/1.0 (https://github.com/robertdavidgraham/masscan)"
root@ubuntu-512mb-nyc3-01:/var/log/apache2#
```

Figure 3-3. tail command

The `tail` command can also "follow" a file, remaining running and showing new lines on the console as they are written to the file. This is useful when you're watching a log file for a new instance of an error message, perhaps as you are testing to see if you can trigger the condition by visiting a web page on the site that is throwing an error. Figure 3-4 shows an example using the `-f` parameter to follow a log file.



```
root@ubuntu-512mb-nyc3-01:/var/log/apache2# tail -n 5 -f access.log
54.186.16.79 - - [01/Apr/2016:18:54:52 -0400] "GET / HTTP/1.1" 200 543 "-" "Mozi
lla/5.0 (Windows NT 10.0; WOW64; rv:44.0) Gecko/20100101 Firefox/44.0"
54.186.16.79 - - [01/Apr/2016:18:54:57 -0400] "GET /CHANGELOG.txt HTTP/1.1" 404
470 "-" "Mozilla/5.0 (Windows NT 10.0; WOW64; rv:44.0) Gecko/20100101 Firefox/44
.0"
54.186.16.79 - - [01/Apr/2016:18:55:02 -0400] "GET / HTTP/1.1" 200 543 "-" "Mozi
lla/5.0 (Windows NT 6.1; WOW64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/48
.0.2564.103 Safari/537.36"
54.186.16.79 - - [01/Apr/2016:18:55:09 -0400] "GET /readme.html HTTP/1.1" 404 46
8 "-" "Mozilla/5.0 (Windows NT 6.1; WOW64) AppleWebKit/537.36 (KHTML, like Gecko
) Chrome/48.0.2564.103 Safari/537.36"
185.56.82.99 - - [01/Apr/2016:21:24:55 -0400] "GET / HTTP/1.0" 200 609 "-" "mass
can/1.0 (https://github.com/robertdavidgraham/masscan)"
```

Figure 3-4. tail -f command

CHAPTER 4

Step 4: Finding Files

In the preceding chapter, you learned how to look inside files without changing them. But how do you know which files to look at? In this chapter, I cover searching for files, which can help narrow the scope for your troubleshooting.

find Files Fast

The `find` command is one of the most useful commands in Linux. The command works like this:

- Starting at location *x*
- Recursively find entries that *match* condition(s)
- *Do something* to each match

As a simple example, let's say you're in the */var/log* directory, and you want to find all files that end in *.log*. Because there may be a lot of them, you will pipe the output to `less` so you can page through it. Here is the command:

```
/var/log# find . -name \*.log -print | less
```

Remember that I said the `\` has a different meaning in Bash, that it is an escape character? Notice its use in this example, where it is preventing the Bash shell from expanding the wildcard character (`*`) into all matching files in the current directory. Instead, by escaping it, the `\` character is telling `find` to expand that wildcard in the current directory and all of its children.

Figure 4-1 shows the first page of the output I got from that command, awaiting our navigation via `less`.

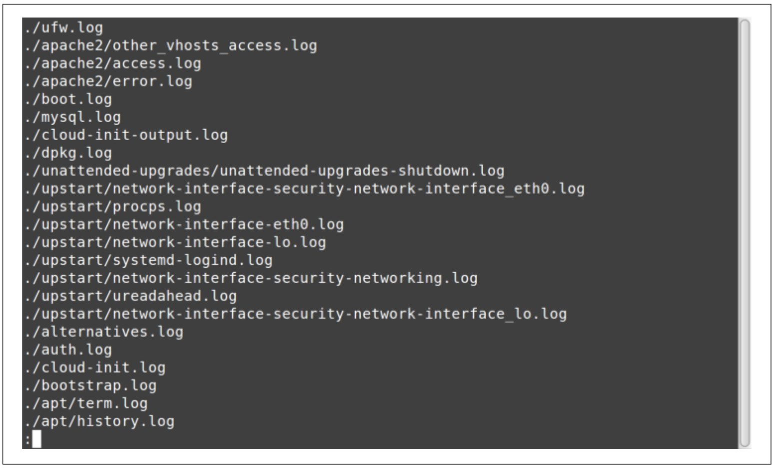


Figure 4-1. find results

The `find` command has a lot more power than this simple example! You can find files and directories based on creation and modification dates, file sizes, types, and much more. You can execute any variety of actions on each one as you find them, including Bash commands and shell scripts.

Figure 4-2 shows another example, where I am looking for all log files in */var/log* and its child directories that were modified in the last hour, using the `-mmin` (*m*odified *min*utes) parameter set to `-60` minutes. In this example no action parameter is given, so `-print` is implied.

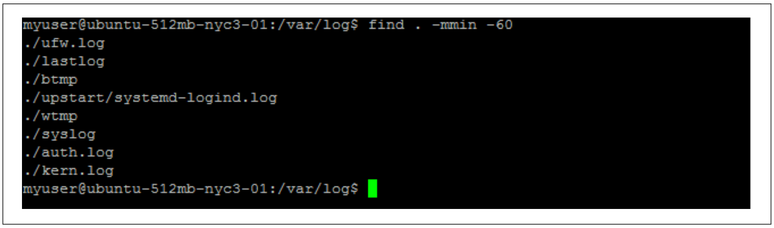


Figure 4-2. find -mmin

You can also combine multiple search conditions and multiple actions. For example, if you want to find all log files in */var/log* that were modified in the last minute (`-mmin -1`), and then print its path (`-print`) and display the last two lines of each log file found (using `tail -n 2`), you use the following:

```
sudo find . -mmin -1 -print -exec tail -n 2 \{\} \;
```

I will pick that apart for you. From left to right:

`sudo`
: Because some of the log files are protected unless you are root.

`find`
: Search for some files.

`.`
: Starting in the current directory (in this example, that's */var/log*).

`-mmin -1`
: Find files that were modified in the last minute (`-1`).

`-print`
: Print its full path.

`-exec`
: For each file found, execute a command.

`-tail -n 2`
: As you learned in the preceding chapter, `tail` shows you the final lines of a file; by default, it shows the last 10 lines, but here I have specified that it should show only the last 2 lines.

`\{\} \;`
: Passing in the full path of the filename found to the `tail` command.

That last little bit of magic is important, and you will do well to memorize it for using `-exec` with the `find` command. The `\{\}` is the syntax for “pass in the path of the file that was found” (it is actually `{}`, but the `\` characters are escaping the brackets because they have special meaning to the Bash shell). The `;` is terminating the `-exec` parameter, so that other action parameters could follow on the `find` command. It is similarly escaped by `\` because the semicolon also has special meaning to Bash. The intervening space between `\{\}` and `\;` is *required*!

Figure 4-3 shows it in action.

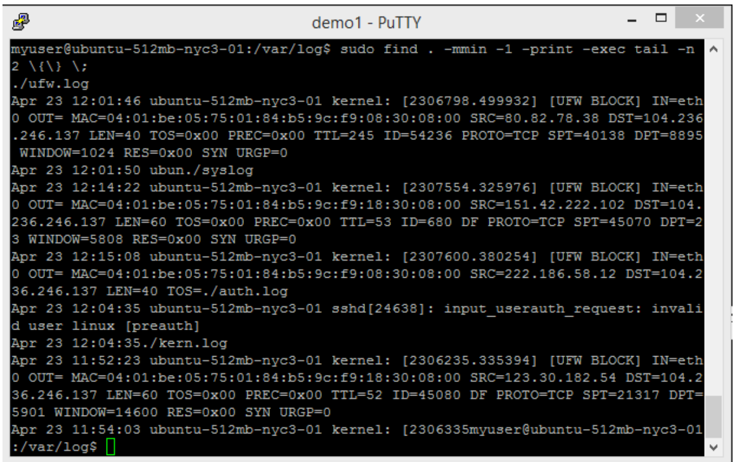


Figure 4-3. find tail

> Because of the usefulness of the `find` command, I recommend you study it and play with it if you get a chance.

Location, Location, Location

The `locate` command searches a list of all the filenames on the system. The filenames are gathered periodically by a service, so it does not update in real time, but usually close enough. If you know the name of a file you are looking for, perhaps the Apache *access.log* file (which can change location depending on the Linux distro), you can use the `locate` command to quickly find it. Because `locate` searches a pre-built list, it is much quicker for finding files by name than using `find -name`.

The `locate` command isn't "smart." It is simply looking for any file or directory with the string you pass it somewhere in the path. For example, if you execute `locate log | less` in the root (/) directory, you'll see something like Figure 4-4.

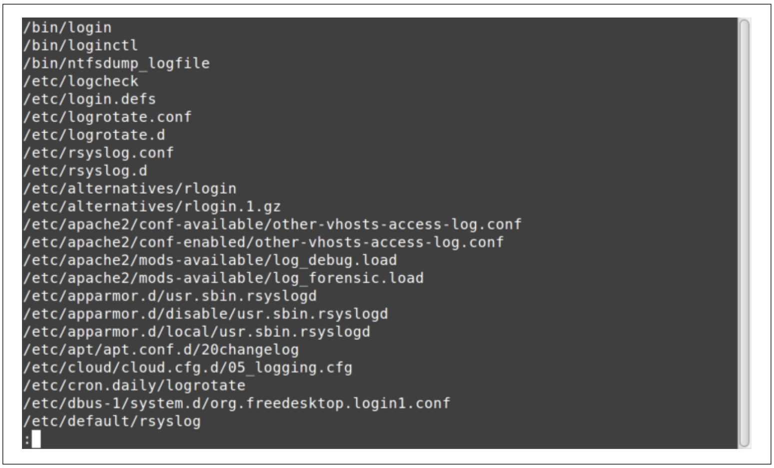


Figure 4-4. locate results

Note that *log* appears somewhere in each path, but doesn't necessarily lead to *log files*.

CHAPTER 5

Step 5: Search Me

In the preceding chapter, you learned to search for files by their attributes, such as name, last modified time, and the like. In this chapter, I show how to search *inside* a file, perhaps to find a specific error message.

Getting a grep

The `grep` command (whose name comes from *g*lobally search a *r*egular *e*xpression and *p*rint) searches within files. It uses regular expressions (regex) to match patterns inside the files. It can be used to search within binary files, but is most useful for finding things inside text files. There are lots of uses for this command in our crisis scenario, such as searching for certain error messages within log files, or finding every mention of a certain resource inside the source files for an entire website.

There is an old joke by Jamie Zawinski:

> *Some people, when confronted with a problem, think, "I know, I'll use regular expressions." Now they have two problems.*

Some regular expressions are simple—for example, `*`, which you should recognize as a valid wildcard in Windows Command Prompt. Others can be mind-blowingly complex. For example:

```
^\(*\d{3}\)*( |-)*\d{3}( |-)*\d{4}$
```

This regular expression is an (incomplete) approach to matching US phone numbers.

Because regexes are so inscrutable, sometimes I write a regex in a program or a script, come back to it six months later, and have no idea what it is doing. (Now I have two problems.) In this chapter, you're just going to look at a few simple examples.

Here are some samples of using regular expressions with `grep`. You will look at the output of some of them in the following screenshots.

`grep 500 access.log`
: Find any occurrence of *500* in *access.log*

`grep '\s500\s' access.log`
: Find *500* surrounded by whitespace (space, tab)

`grep '^159.203' access.log`
: Find *159.203* at *beginning* of lines (`^`)

`grep 'bash$' /etc/password`
: Find *bash* at *end* of lines (`$`)

`grep -i -r error /var/log`
: Find all case-insensitive (`-i`) instances of *error* in the */var/log* directory and its children (`-r`)

For that first example, you know that if a web program throws a server-side error, by convention it will send an HTTP status code of 500 to the client (browser). Most web servers also write that to their logs. So let's look for *500* in Apache's web log, as shown in Figure 5-1.

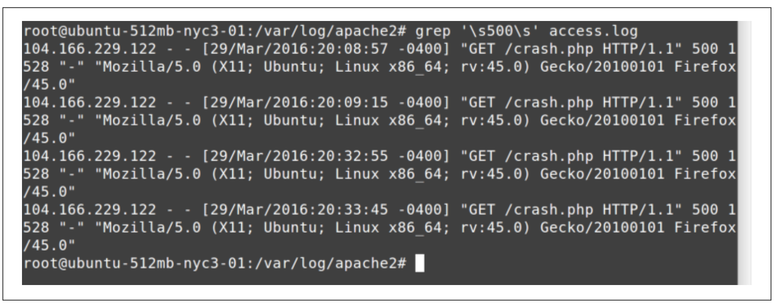


Figure 5-1. grep command

I use the `'\s500\s'` regular expression in this command to make sure that only instances of *500* surrounded by spaces (or tabs) are found. Web logs tend to put the HTTP status code in its own column, and I don't want to see extraneous 500s that are part of response sizes, time-zone offsets, or whatnot.

Perhaps you're being attacked by a block of IP addresses, maybe a bunch of botnets running on some cable modems. The IP block attacking you is `159.203`, so let's find all log lines that start with that client address, as shown in Figure 5-2.

```
root@ubuntu-512mb-nyc3-01:/var/log/apache2# grep '^159.203' access.log
159.203.76.169 - - [30/Mar/2016:18:57:57 -0400] "GET /muieblackcat HTTP/1.1" 404
 469 "-" "-"
159.203.76.169 - - [30/Mar/2016:18:57:57 -0400] "GET //phpMyAdmin/scripts/setup.
php HTTP/1.1" 404 485 "-" "-"
159.203.76.169 - - [30/Mar/2016:18:57:57 -0400] "GET //phpmyadmin/scripts/setup.
php HTTP/1.1" 404 485 "-" "-"
159.203.76.169 - - [30/Mar/2016:18:57:57 -0400] "GET //pma/scripts/setup.php HTT
P/1.1" 404 478 "-" "-"
159.203.76.169 - - [30/Mar/2016:18:57:57 -0400] "GET //myadmin/scripts/setup.php
 HTTP/1.1" 404 482 "-" "-"
159.203.76.169 - - [30/Mar/2016:18:57:57 -0400] "GET //MyAdmin/scripts/setup.php
 HTTP/1.1" 404 482 "-" "-"
root@ubuntu-512mb-nyc3-01:/var/log/apache2#
```

Figure 5-2. grep 159.203 command

In this case, note that the regular expression starts with `^`, which means to look for the following pattern only at the beginning of each line in the log file.

Similarly, you can look for patterns at the end of each line as well. The */etc/passwd* file holds every user ID on a Linux system. (Don't worry, it no longer holds the password, but once upon a time, it did!) Each user is defined by a line in the file, and the last entry on each line indicates the "shell" in which they run. Some user IDs are defined to not be allowed to have interactive logins, and so they might have something like */bin/false* or */usr/sbin/nologin* as their shell.

But user IDs that can log in will have `bash` or `csh` or similar. So if you want to find all user IDs that can log in interactively, you could use the command in Figure 5-3, which looks for `bash` at the end of the line by specifying the `$` in the regular expression.

```
root@ubuntu-512mb-nyc3-01:~# grep 'bash$' /etc/passwd
root:x:0:0:root:/root:/bin/bash
myuser:x:1000:1000:My User,,,:/home/myuser:/bin/bash
root@ubuntu-512mb-nyc3-01:~#
```

Figure 5-3. grep bash command

You then see that `root` and `myuser` are the only IDs allowed an interactive login on this system.

Finally, because you're trying to find out what is wrong with the Linux system you've been thrown into, perhaps you want to see each instance of the word *exception* in the log files. You could do that with something like this:

```
grep -i -r 'exception' /var/log | less
```

Here's what each part of that command does:

`grep`
: Searches through files

`-i`
: Ignores case (makes the search string case-insensitive)

`-r`
: Recursively searches through all directories

`'exception'`
: Looks for the string *exception*

`/var/log`
: Starts in the */var/log* directory

`| less`
: Pipes the output through `less` so you can look at it one "page" at a time

Figure 5-4 shows the first page of the output.

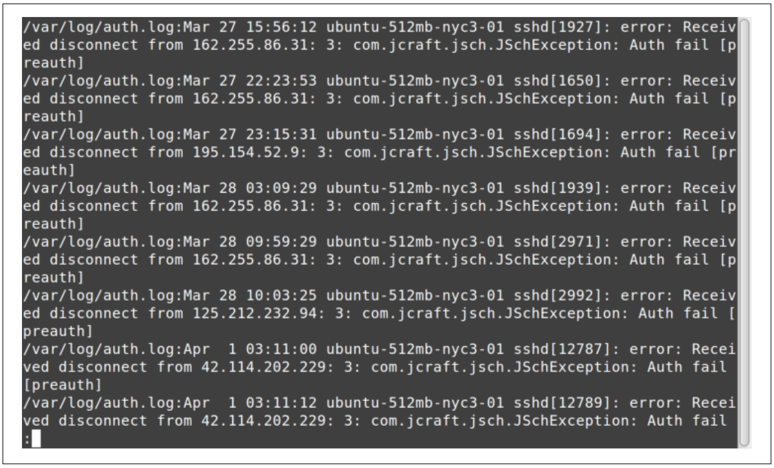


Figure 5-4. grep exception results

In this case, you see a bunch of authorization failures in the first page of output from the */var/auth* log. If the problem you are chasing includes an authentication error, perhaps on your website, this would show a good path to keep continuing down. Many times you have to change your search phrases multiple times and use your "tech intuition" to decide which errors are worth following further. Troubleshooting is often more of an art than a science, so "Use the Force, Luke."

CHAPTER 6
Step 6: What's Going On?

You have now learned how to navigate around, look inside files, and find files and search their contents. In this chapter and the next, I show you how to determine real-time system state, with an eye toward clues that may point to underlying problems.

It's All Part of the Process

The `ps` (process) command shows running processes, akin to the Windows Task Manager, as you can see in Figure 6-1.

Figure 6-1. ps command

By default, `ps` shows only the processes for the current user. In the preceding example, the active processes are the Bash shell and the `ps` command itself.

If you want to see all running processes, you add the `-A` parameter. To make it pretty and show the hierarchical relationship between parent and child processes, you add `-H`:

```
ps -AH | less
```

Figure 6-2 shows the output.

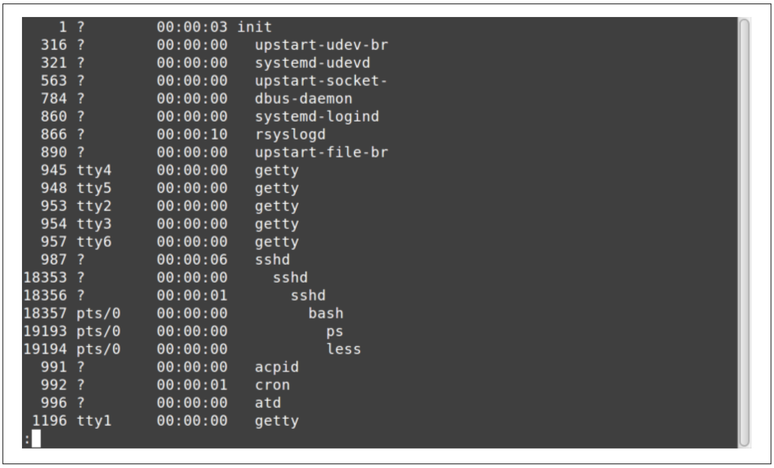


Figure 6-2. ps -AH command

Here you see many child processes running under `init`, which is typically the first process that runs (note that the left column shows `init` has a process ID of `1`). Also notice that under a series of `sshd` (SSH daemon, or service, processes) is our `bash` session running `ps`, which is piping output to `less`.

Who's on top?

The `top` command (Figure 6-3) shows processes sorted by resource consumption. It updates every few seconds, similar to Windows Task Manager.

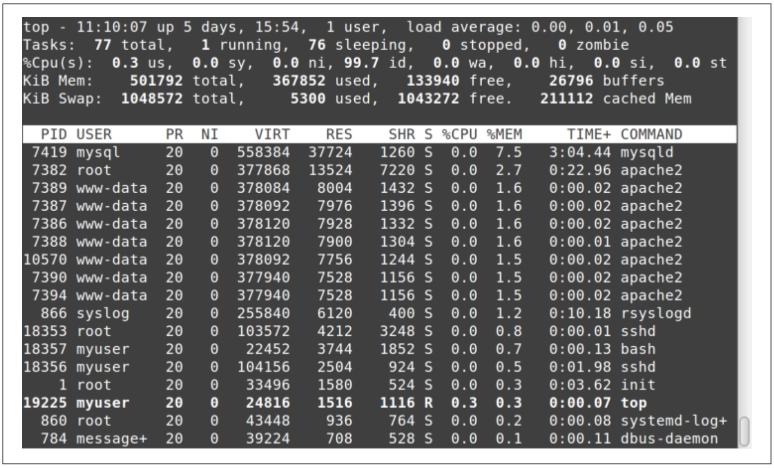
```
top - 11:09:03 up 5 days, 15:53,  1 user,  load average: 0.00, 0.01, 0.05
Tasks:  77 total,   2 running,  75 sleeping,   0 stopped,   0 zombie
%Cpu(s):  1.7 us,  4.3 sy,  0.0 ni, 94.0 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
KiB Mem:    501792 total,   368352 used,   133440 free,    26764 buffers
KiB Swap:  1048572 total,     5300 used,  1043272 free.   211112 cached Mem

  PID USER      PR  NI    VIRT    RES    SHR S %CPU %MEM     TIME+ COMMAND
    7 root      20   0       0      0      0 S  0.3  0.0   0:05.61 rcu_sched
    1 root      20   0   33496   1580    524 S  0.0  0.3   0:03.62 init
    2 root      20   0       0      0      0 S  0.0  0.0   0:00.00 kthreadd
    3 root      20   0       0      0      0 S  0.0  0.0   0:00.14 ksoftirqd/0
    5 root       0 -20       0      0      0 S  0.0  0.0   0:00.00 kworker/0:0H
    8 root      20   0       0      0      0 R  0.0  0.0   0:07.57 rcuos/0
    9 root      20   0       0      0      0 S  0.0  0.0   0:00.00 rcu_bh
   10 root      20   0       0      0      0 S  0.0  0.0   0:00.00 rcuob/0
   11 root      rt   0       0      0      0 S  0.0  0.0   0:00.00 migration/0
   12 root      rt   0       0      0      0 S  0.0  0.0   0:05.78 watchdog/0
   13 root       0 -20       0      0      0 S  0.0  0.0   0:00.00 khelper
   14 root      20   0       0      0      0 S  0.0  0.0   0:00.00 kdevtmpfs
   15 root       0 -20       0      0      0 S  0.0  0.0   0:00.00 netns
   16 root       0 -20       0      0      0 S  0.0  0.0   0:00.00 writeback
   17 root       0 -20       0      0      0 S  0.0  0.0   0:00.00 kintegrityd
   18 root       0 -20       0      0      0 S  0.0  0.0   0:00.00 bioset
   19 root       0 -20       0      0      0 S  0.0  0.0   0:00.00 kworker/u3:0
```

Figure 6-3. top command

Notice that the `top` output is divided into two sections. The, well, top section shows system-level statistics: up time, number of logged-in users, number of processes, CPU and memory utilization, and so on.

The bottom section shows the various processes running, sorted by CPU utilization. Some of the more important columns are `PID` (process ID), `USER`, `VIRT` (virtual memory), `%CPU`, `%MEM`, and `COMMAND`. Similar to `less`, you can quit `top` by typing `q` or hitting Ctrl-C.

If you want to have `top` sort its output by something other than CPU usage, you pass it the `-o` (order) parameter followed by the column name. In Figure 6-4, the output from `top -o '%MEM'` is sorted by memory utilization.



```
top - 11:10:07 up 5 days, 15:54,  1 user,  load average: 0.00, 0.01, 0.05
Tasks:  77 total,   1 running,  76 sleeping,   0 stopped,   0 zombie
%Cpu(s):  0.3 us,  0.0 sy,  0.0 ni, 99.7 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
KiB Mem:    501792 total,   367852 used,   133940 free,    26796 buffers
KiB Swap:  1048572 total,     5300 used,  1043272 free.   211112 cached Mem

  PID USER      PR  NI    VIRT    RES    SHR S %CPU %MEM     TIME+ COMMAND
 7419 mysql     20   0  558384  37724   1260 S  0.0  7.5   3:04.44 mysqld
 7382 root      20   0  377868  13524   7220 S  0.0  2.7   0:22.96 apache2
 7389 www-data  20   0  378084   8004   1432 S  0.0  1.6   0:00.02 apache2
 7387 www-data  20   0  378092   7976   1396 S  0.0  1.6   0:00.02 apache2
 7386 www-data  20   0  378120   7928   1332 S  0.0  1.6   0:00.02 apache2
 7388 www-data  20   0  378120   7900   1304 S  0.0  1.6   0:00.01 apache2
10570 www-data  20   0  378092   7756   1244 S  0.0  1.5   0:00.02 apache2
 7390 www-data  20   0  377940   7528   1156 S  0.0  1.5   0:00.02 apache2
 7394 www-data  20   0  377940   7528   1156 S  0.0  1.5   0:00.02 apache2
  866 syslog    20   0  255840   6120    400 S  0.0  1.2   0:10.18 rsyslogd
18353 root      20   0  103572   4212   3248 S  0.0  0.8   0:00.01 sshd
18357 myuser    20   0   22452   3744   1852 S  0.0  0.7   0:00.13 bash
18356 myuser    20   0  104156   2504    924 S  0.0  0.5   0:01.98 sshd
    1 root      20   0   33496   1580    524 S  0.0  0.3   0:03.62 init
19225 myuser    20   0   24816   1516   1116 R  0.3  0.3   0:00.07 top
  860 root      20   0   43448    936    764 S  0.0  0.2   0:00.08 systemd-log+
  784 message+  20   0   39224    708    528 S  0.0  0.1   0:00.11 dbus-daemon
```

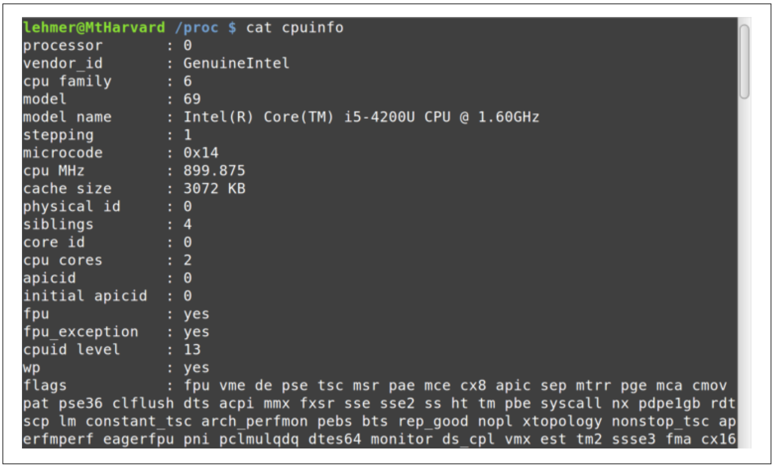
Figure 6-4. top -o command

If your symptoms seem performance-related, you can use `top` to see whether a process or processes are eating up all the CPU cycles or hogging memory and thus causing excessive paging. If a certain process keeps showing at or near the top of the list with every refresh, it may well be your culprit.

The /proc Directory

Linux doesn't mount devices under drive letters as in Windows, but instead uses a single hierarchical filesystem, with different resources mounted under the root (`/`) directory. In fact, because Linux uses an "everything is a file" paradigm, *virtual* filesystems that aren't backed by an actual device can be mounted in the hierarchy as well.

One of the best examples of this is the */proc* directory, a virtual filesystem that presents real-time system statistics as files and directories. This makes the information *way easier* to access than the rather opaque Windows WMI APIs. For example, you can see information on the CPUs being used on the system, as shown in Figure 6-5.

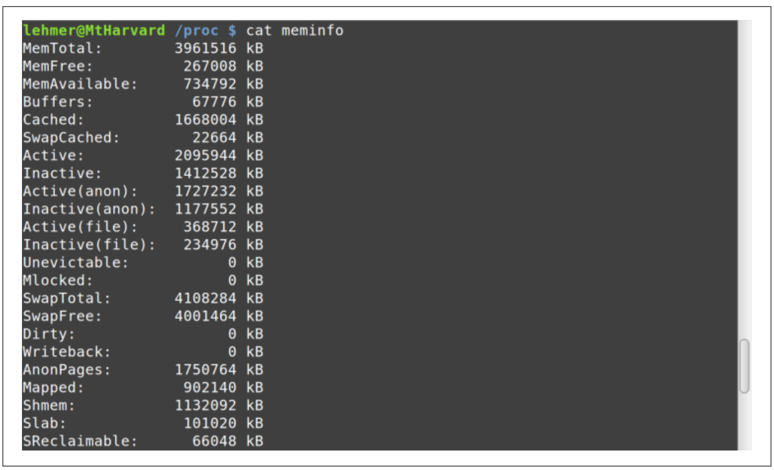


```
lehmer@MtHarvard /proc $ cat cpuinfo
processor       : 0
vendor_id       : GenuineIntel
cpu family      : 6
model           : 69
model name      : Intel(R) Core(TM) i5-4200U CPU @ 1.60GHz
stepping        : 1
microcode       : 0x14
cpu MHz         : 899.875
cache size      : 3072 KB
physical id     : 0
siblings        : 4
core id         : 0
cpu cores       : 2
apicid          : 0
initial apicid  : 0
fpu             : yes
fpu_exception   : yes
cpuid level     : 13
wp              : yes
flags           : fpu vme de pse tsc msr pae mce cx8 apic sep mtrr pge mca cmov
pat pse36 clflush dts acpi mmx fxsr sse sse2 ss ht tm pbe syscall nx pdpe1gb rdt
scp lm constant_tsc arch_perfmon pebs bts rep_good nopl xtopology nonstop_tsc ap
erfmperf eagerfpu pni pclmulqdq dtes64 monitor ds_cpl vmx est tm2 ssse3 fma cx16
```

Figure 6-5. /proc/cpuinfo

This image shows just the beginning of the “file” containing information about the CPU(s) in the system. For example, with multicore processors, there are repeating sections for each core.

Similarly, memory info can be displayed as shown in Figure 6-6.



```
lehmer@MtHarvard /proc $ cat meminfo
MemTotal:        3961516 kB
MemFree:          267008 kB
MemAvailable:     734792 kB
Buffers:           67776 kB
Cached:          1668004 kB
SwapCached:        22664 kB
Active:          2095944 kB
Inactive:        1412528 kB
Active(anon):    1727232 kB
Inactive(anon):  1177552 kB
Active(file):     368712 kB
Inactive(file):   234976 kB
Unevictable:           0 kB
Mlocked:               0 kB
SwapTotal:       4108284 kB
SwapFree:        4001464 kB
Dirty:                 0 kB
Writeback:             0 kB
AnonPages:       1750764 kB
Mapped:           902140 kB
Shmem:           1132092 kB
Slab:             101020 kB
SReclaimable:      66048 kB
```

Figure 6-6. /proc/meminfo

Let’s look at a listing of the */proc* directory contents in Figure 6-7.

```
lehmer@MtHarvard /proc $ ls
1     1594  2338  2658  3244  3864  7              consoles     mtrr
10    17    2351  2665  3257  3873  700            cpuinfo      net
1025  1743  2355  2694  328   39    720            crypto       pagetypeinfo
11    18    2358  27    329   40    74             devices      partitions
1185  1808  2366  2718  33    41    740            diskstats    sched_debug
1191  1870  24    2724  3301  42    748            dma          schedstat
12    19    2434  28    331   43    750            driver       scsi
1210  1910  2449  2863  334   44    753            execdomains  self
1216  192   25    2874  3351  45    759            fb           slabinfo
13    198   2526  29    3371  46    764            filesystems  softirqs
1342  2     2542  3     34    47    796            fs           stat
1388  20    2552  301   3420  477   799            interrupts   swaps
1390  2001  2556  302   35    478   8              iomem        sys
1398  2002  2561  3027  36    479   818            ioports      sysrq-trigger
1399  21    2566  3028  37    48    820            irq          sysvipc
14    2166  2569  303   3732  5     821            kallsyms     thread-self
1402  2175  2571  3032  3733  53    832            kcore        timer_list
142   2178  2575  3033  3760  54    9              keys         timer_stats
143   2184  2577  304   3766  55    916            key-users    tty
144   22    2582  305   3767  569   919            kmsg         uptime
1442  2255  2597  3073  38    601   93             kpagecount   version
145   226   2599  3092  380   646   94             kpageflags   version_signature
1453  227   26    31    3800  67    979            loadavg      vmallocinfo
```

Figure 6-7. proc dir

This gives an idea of all the various types of information available. The blue entries are directories containing even more data. Note the numbered directories on the left. Each of these directories contains real-time statistics for each running process, listed by process ID. If you change into one of those directories and list it, you see an incredible amount of information about that specific process, all of which will be updated in real time every time you display it, as shown in Figure 6-8.

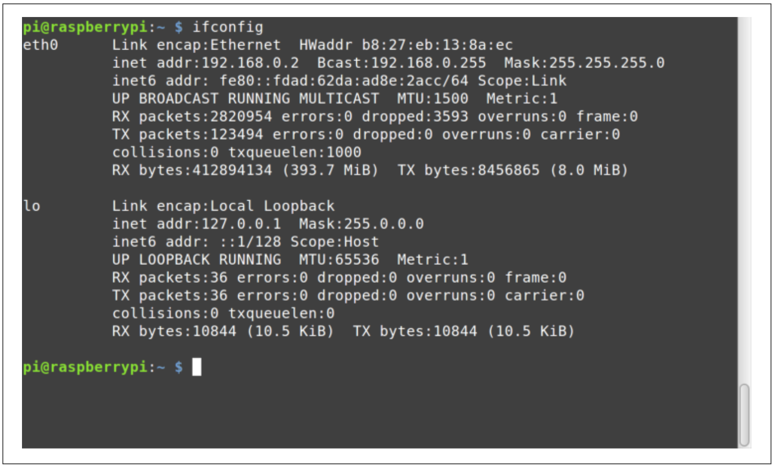
```
lehmer@MtHarvard /proc/3767 $ ls
attr             cpuset   limits      net            projid_map  stat
autogroup        cwd      loginuid    ns             root        statm
auxv             environ  map_files   numa_maps      sched       status
cgroup           exe      maps        oom_adj        schedstat   syscall
clear_refs       fd       mem         oom_score      sessionid   task
cmdline          fdinfo   mountinfo   oom_score_adj  setgroups   timers
comm             gid_map  mounts      pagemap        smaps       uid_map
coredump_filter  io       mountstats  personality    stack       wchan
lehmer@MtHarvard /proc/3767 $ 
```

Figure 6-8. proc pid

That is just a taste of the types of useful information you can gather by looking in */proc*.

Networking

The `ifconfig` command shows information on the system's network interfaces (similar to the `IPCONFIG` command in Windows), as you can see in Figure 6-9.

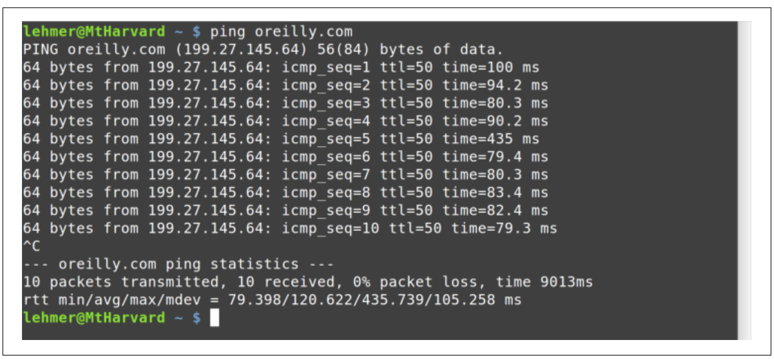


```
pi@raspberrypi:~ $ ifconfig
eth0      Link encap:Ethernet  HWaddr b8:27:eb:13:8a:ec
          inet addr:192.168.0.2  Bcast:192.168.0.255  Mask:255.255.255.0
          inet6 addr: fe80::fdad:62da:ad8e:2acc/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:2820954 errors:0 dropped:3593 overruns:0 frame:0
          TX packets:123494 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:412894134 (393.7 MiB)  TX bytes:8456865 (8.0 MiB)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:36 errors:0 dropped:0 overruns:0 frame:0
          TX packets:36 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:10844 (10.5 KiB)  TX bytes:10844 (10.5 KiB)

pi@raspberrypi:~ $
```

Figure 6-9. ifconfig command

Here you see that the system, my handy Raspberry Pi, has two network interfaces. The first is `eth0`, an Ethernet interface. The MAC address, IPv4 and IPv6 configuration, and various network statistics are shown. The second interface, `lo`, is the local loopback, `127.0.0.1`.

Most networking commands that you may be used to in Windows are also available in Linux, such as `ping`, shown in Figure 6-10.



```
lehmer@MtHarvard ~ $ ping oreilly.com
PING oreilly.com (199.27.145.64) 56(84) bytes of data.
64 bytes from 199.27.145.64: icmp_seq=1 ttl=50 time=100 ms
64 bytes from 199.27.145.64: icmp_seq=2 ttl=50 time=94.2 ms
64 bytes from 199.27.145.64: icmp_seq=3 ttl=50 time=80.3 ms
64 bytes from 199.27.145.64: icmp_seq=4 ttl=50 time=90.2 ms
64 bytes from 199.27.145.64: icmp_seq=5 ttl=50 time=435 ms
64 bytes from 199.27.145.64: icmp_seq=6 ttl=50 time=79.4 ms
64 bytes from 199.27.145.64: icmp_seq=7 ttl=50 time=80.3 ms
64 bytes from 199.27.145.64: icmp_seq=8 ttl=50 time=83.4 ms
64 bytes from 199.27.145.64: icmp_seq=9 ttl=50 time=82.4 ms
64 bytes from 199.27.145.64: icmp_seq=10 ttl=50 time=79.3 ms
^C
--- oreilly.com ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9013ms
rtt min/avg/max/mdev = 79.398/120.622/435.739/105.258 ms
lehmer@MtHarvard ~ $
```

Figure 6-10. ping command

One difference between `ping` on Linux versus Windows is that on Linux the output does not stop until you hit Ctrl-C. This is similar to `PING -T` on Windows.

The `traceroute` command, shown in Figure 6-11, is also available (note the spelling difference from `TRACERT` on Windows).

```
lehmer@MtHarvard ~ $ traceroute oreilly.com
traceroute to oreilly.com (199.27.145.65), 30 hops max, 60 byte packets
 1  192.168.5.1 (192.168.5.1)  30.524 ms  30.455 ms  101.139 ms
 2  192.168.0.1 (192.168.0.1)  142.903 ms  142.925 ms  152.775 ms
 3  * mo-65-40-250-1.sta.embarqhsd.net (65.40.250.1)  156.046 ms  156.062 ms
 4  mo-65-41-101-91.sta.embarqhsd.net (65.41.101.91)  156.049 ms  164.383 ms  20
0.681 ms
 5  208-110-248-130.centurylink.net (208.110.248.130)  202.431 ms  204.617 ms  2
05.743 ms
 6  bb-kscbmonr-jx9-01-ae0.core.centurytel.net (206.51.69.5)  233.785 ms  30.945
 ms  34.123 ms
 7  bb-dllstx37-jx9-02-xe-11-1-0.core.centurytel.net (206.51.69.25)  38.617 ms
44.930 ms  105.717 ms
 8  * * *
 9  dax-edge-03.inet.qwest.net (67.14.2.174)  111.375 ms  126.080 ms  126.114 ms
10  63-235-82-234.dia.static.qwest.net (63.235.82.234)  105.690 ms  106.674 ms
106.620 ms
11  be-15-cr02.dallas.tx.ibone.comcast.net (68.86.83.113)  133.635 ms be-12-cr02
.dallas.tx.ibone.comcast.net (68.86.82.137)  133.572 ms be-10-cr02.dallas.tx.ibo
ne.comcast.net (68.86.82.129)  133.602 ms
12  be-11524-cr02.losangeles.ca.ibone.comcast.net (68.86.87.173)  95.079 ms  88.
695 ms  113.372 ms
13  be-10915-cr01.sunnyvale.ca.ibone.comcast.net (68.86.86.97)  113.339 ms  112.
432 ms  112.383 ms
```

Figure 6-11. traceroute command

Two other network commands you may find useful during troubleshooting are `dig` and `whois`, both of which return DNS information for domain names or IP addresses.

CHAPTER 7

Step 7: Filesystems

You have just seen how to look at real-time system state in terms of processes, memory, and networking. Now I show how to check out the filesystems, with an eye toward disk utilization.

Displaying Filesystems

On any computer system, running out of disk space can cause many problems. On Linux, two commands are helpful in determining disk utilization.

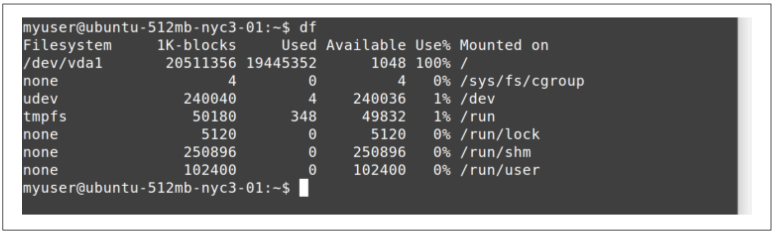
The `df` (display filesystems) command shows the mounted files systems along with statistics on space usage, as you can see in Figure 7-1.

```
myuser@ubuntu-512mb-nyc3-01:~$ df
Filesystem     1K-blocks    Used Available Use% Mounted on
/dev/vda1       20511356 2950652  16495748  16% /
none                   4       0         4   0% /sys/fs/cgroup
udev              240040       4    240036   1% /dev
tmpfs              50180     348     49832   1% /run
none                5120       0      5120   0% /run/lock
none              250896       0    250896   0% /run/shm
none              102400       0    102400   0% /run/user
myuser@ubuntu-512mb-nyc3-01:~$ 
```

Figure 7-1. df command

The main device you're interested in is the first one, which shows `/dev/vda1` mounted on `/`. Note the columns showing disk size, `Used`, `Available`, and `Use%`.

Figure 7-2 shows an example where disk utilization may be causing trouble.



```
myuser@ubuntu-512mb-nyc3-01:~$ df
Filesystem     1K-blocks     Used Available Use% Mounted on
/dev/vda1       20511356 19445352      1048 100% /
none                   4        0         4   0% /sys/fs/cgroup
udev              240040        4    240036   1% /dev
tmpfs              50180      348     49832   1% /run
none                5120        0      5120   0% /run/lock
none              250896        0    250896   0% /run/shm
none              102400        0    102400   0% /run/user
myuser@ubuntu-512mb-nyc3-01:~$
```

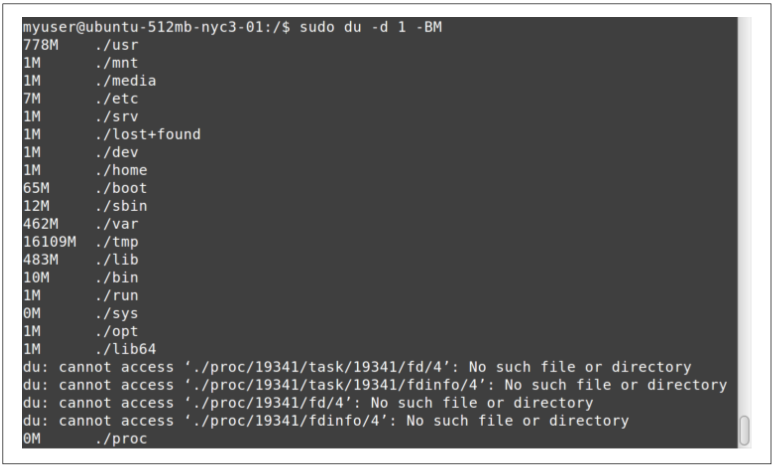
Figure 7-2. df showing full disk drive

The `/dev/vda1` device is 100% full!

Where Did All the Disk Space Go?

Once you've seen that there may be a problem with disk space, how do you find out *where* it is being used? You can use the `du` (disk utilization) command for that. By default, it descends through every directory and shows you disk usage for every subdirectory under which it is invoked (think `DIR /S` on `CMD.EXE`). That can generate a lot of output and can take a long time to run.

What we really want to do is start at the top and narrow our search to a specific problem directory. Let's just look at the top-level directories under `/`. For that, I pass in the `-d 1` (depth of 1) parameter. To make the output easier to read, I also pass `-BM` to show blocks in megabytes. Finally, as you can see in Figure 7-3, I'm using `sudo`, because otherwise I wouldn't have permission to descend into some system directories to calculate their disk space.



```
myuser@ubuntu-512mb-nyc3-01:/$ sudo du -d 1 -BM
778M    ./usr
1M      ./mnt
1M      ./media
7M      ./etc
1M      ./srv
1M      ./lost+found
1M      ./dev
1M      ./home
65M     ./boot
12M     ./sbin
462M    ./var
16109M  ./tmp
483M    ./lib
10M     ./bin
1M      ./run
0M      ./sys
1M      ./opt
1M      ./lib64
du: cannot access './proc/19341/task/19341/fd/4': No such file or directory
du: cannot access './proc/19341/task/19341/fdinfo/4': No such file or directory
du: cannot access './proc/19341/fd/4': No such file or directory
du: cannot access './proc/19341/fdinfo/4': No such file or directory
0M      ./proc
```

Figure 7-3. du command

You can see that */usr* is using 778 MB of space, followed by some fairly inconsequential directories, but */tmp* is using over 16 GB of space. It must be the culprit! From there, you can go look in */tmp* (which, remember, is cleared on reboots) to see what is taking up all the space.

> You can continue to use `du` to successively refine your search. If, instead of */tmp* in this simple example, the */var* directory was the one showing high disk utilization, you could `cd` into it and then run this `du` command again, and continue to traverse down the directories until you find what is using up all the space. You could remove the `-d` parameter and pipe the output to `less`, but you probably don't want to do that because on a large system with thousands of directories, you could be paging through the output for a long time!

CHAPTER 8

Step 8: Transferring Files

Perhaps you think you've found evidence of a system compromise, or you fear log files will be altered if you end up restarting services or the system itself. If you want to preserve files on another system so that someone more knowledgeable can look at them later, the commands in this chapter will come in handy.

> Most commands in this report will not alter system state. However, the commands in this chapter and the next have the potential to do so. In this chapter, the commands to transfer files from the Linux system to another system for later analysis can also work in reverse—that is, transfer files *to* the Linux box. So be careful!

Secure Copying

The `scp` (secure copy) command can be used to copy files over the SSH protocol (the same protocol that you're running your `ssh` terminal session over). This command allows us to copy files using an encrypted, compressed mechanism.

If you are going to copy files from Linux "down" to your Windows system, you need a program that will run on Windows. The creator of PuTTY made `PSCP.EXE` for precisely that purpose: to implement `scp` for Windows. You can download it from the same place as PuTTY.

The PSCP.EXE program, shown in Figure 8-1, is meant to run under Windows Command Prompt (CMD.EXE). It takes the same parameters as scp.

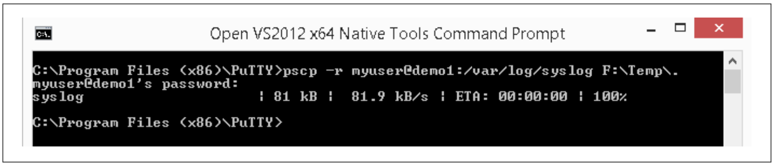


Figure 8-1. pscp command

In this example, the -r means to copy recursively. The myuser@demo1 is the user ID and machine address, exactly the same as what you specify when connecting with PuTTY. Note that immediately following that connection info (with no space) is a colon and then a path. This path is where you will be copying *from*—in this example, it's */var/log/syslog*. The final parameter is the *to* location—for example, *F:\Temp*.

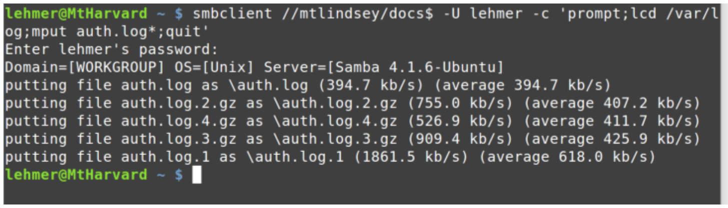
When you invoke PSCP.EXE, it will prompt you for the user's password, and then transfer the file(s) specified. In our example, only one file, *syslog*, is transferred.

Like the Windows COPY and MOVE commands, most copy and move commands on Linux specify *from* as the first path and *to* as the second. Make sure you specify these paths in the correct order!

Copying to a Windows Share

The PSCP.EXE command can be used to *pull* information from Linux to your local Windows machine. If the Linux system is on the same network as a Windows file share, you can use smbclient to *push* files to a CIFS/SMB file share. Both machines must be on the same network for this to work; it will *not* work across the Internet.

The smbclient command uses similar subcommands as ftp, so if you have ever done FTP transfers from the Windows command line, it should be familiar. One difference is that, instead of specifying the subcommands one at a time after connecting, you can pass a string of commands to execute to `smbclient` as a parameter on the command line, as in Figure 8-2.



```
lehmer@MtHarvard ~ $ smbclient //mtlindsey/docs$ -U lehmer -c 'prompt;lcd /var/l
og;mput auth.log*;quit'
Enter lehmer's password:
Domain=[WORKGROUP] OS=[Unix] Server=[Samba 4.1.6-Ubuntu]
putting file auth.log as \auth.log (394.7 kb/s) (average 394.7 kb/s)
putting file auth.log.2.gz as \auth.log.2.gz (755.0 kb/s) (average 407.2 kb/s)
putting file auth.log.4.gz as \auth.log.4.gz (526.9 kb/s) (average 411.7 kb/s)
putting file auth.log.3.gz as \auth.log.3.gz (909.4 kb/s) (average 425.9 kb/s)
putting file auth.log.1 as \auth.log.1 (1861.5 kb/s) (average 618.0 kb/s)
lehmer@MtHarvard ~ $
```

Figure 8-2. smbclient command

What's going on here? The first parameter, `//mtlindsey/docs$`, is the Windows share name. The only difference from how this is specified on Windows is the direction of the slashes. The `-U` parameter is the Windows user ID to use. The `-c` parameter then gives a list of semicolon-delimited subcommands to execute:

`prompt`
: Turn off prompting for each file

`lcd /var/log`
: Change the *local* (Linux) directory to */var/log*

`mput auth.log*`
: Send (put) multiple files with a name pattern of *auth.log** to the Windows share

`quit`
: Exit the command

After being prompted for a password, you then see the results. The files ending in *.gz* have been compressed using the GNU zip algorithm.

CHAPTER 9
Step 9: Starting and Stopping

If you are investigating a system that seems hung (perhaps the public website isn't responding and your management wants you to "do something"), the old tried-and-true method of restarting services or the entire system itself is often your last resort. Rebooting Windows always fixes problems, so you already know one method for approaching Linux issues too! In this chapter, I show you how to restart services and reboot the system.

> Most commands in this report will not alter system state. However, this chapter covers commands that start, stop, and restart Linux services and the entire system. Therefore, you could possibly stop something, and because of the situation you are investigating, not be able to restart it. So be careful!

Managing Services

Linux services (a.k.a. *daemons*, which is why so many Linux services end in `d`, such as `sshd` and `httpd`) are similar to Windows services. They are processes that run in the background, typically initiated at system startup. Examples of services include web services (Apache), database services (MySQL), and so on.

Typically, you use the `service` command to start, stop, and restart services. It requires `sudo`. Figure 9-1 shows how to start the `mysql` service.

```
myuser@ubuntu-512mb-nyc3-01:~$ sudo service mysql start
mysql start/running, process 19683
myuser@ubuntu-512mb-nyc3-01:~$
```

Figure 9-1. service start command

You can see that the process ID (PID) of the service is returned by the command. You stop a service the same way, as shown in Figure 9-2.

```
myuser@ubuntu-512mb-nyc3-01:~$ sudo service mysql stop
mysql stop/waiting
myuser@ubuntu-512mb-nyc3-01:~$
```

Figure 9-2. service stop command

As you can likely guess, restarting a service, just as on Windows, is simply a combination of stopping and then starting it; see Figure 9-3.

```
myuser@ubuntu-512mb-nyc3-01:~$ sudo service mysql restart
mysql stop/waiting
mysql start/running, process 19855
myuser@ubuntu-512mb-nyc3-01:~$
```

Figure 9-3. service restart command

You can check the status of a service with…wait for it…the `status` command (Figure 9-4).

```
myuser@ubuntu-512mb-nyc3-01:~$ sudo service mysql status
mysql start/running, process 19683
myuser@ubuntu-512mb-nyc3-01:~$
```

Figure 9-4. service status command

Another way to tell whether a service is running is to use our old friends `ps` and `grep` (Figure 9-5).

```
myuser@ubuntu-512mb-nyc3-01:~$ ps -A | grep mysql
19855 ?        00:00:00 mysqld
myuser@ubuntu-512mb-nyc3-01:~$
```

Figure 9-5. ps and grep commands

Note how I start and stop the `mysql` service, but under the covers it is the `mysqld` command (or daemon) that is running. That information can be useful when searching through log files.

When starting a service, you may get an error. Often, the output from the `service` command isn't helpful. On most systems, `service` is just a thin wrapper around a series of scripts in */etc/init.d*. You can often run one of the scripts directly from */etc/init.d* and get better error information (Figure 9-6).

```
myuser@ubuntu-512mb-nyc3-01:/etc/init.d$ sudo ./mysql start
 * ./mysql: ERROR: The partition with /var/lib/mysql is too full!
myuser@ubuntu-512mb-nyc3-01:/etc/init.d$
```

Figure 9-6. start mysql error

Hmmm…disk full. Does that remind you of anything? See Figure 9-7.

```
myuser@ubuntu-512mb-nyc3-01:/$ sudo du -d 1 -BM
778M    ./usr
1M      ./mnt
1M      ./media
7M      ./etc
1M      ./srv
1M      ./lost+found
1M      ./dev
1M      ./home
65M     ./boot
12M     ./sbin
462M    ./var
16109M  ./tmp
483M    ./lib
10M     ./bin
1M      ./run
0M      ./sys
1M      ./opt
1M      ./lib64
du: cannot access './proc/19341/task/19341/fd/4': No such file or directory
du: cannot access './proc/19341/task/19341/fdinfo/4': No such file or directory
du: cannot access './proc/19341/fd/4': No such file or directory
du: cannot access './proc/19341/fdinfo/4': No such file or directory
0M      ./proc
```

Figure 9-7. du command

Let's go to `/tmp`, as shown in Figure 9-8, and see if you notice anything wrong.

```
myuser@ubuntu-512mb-nyc3-01:~$ ls -l /tmp
total 16494688
-rw-rw-r-- 1 myuser myuser 16890556416 Apr  2 12:08 delete.me
myuser@ubuntu-512mb-nyc3-01:~$
```

Figure 9-8. ls /tmp command

Sure enough! That's one big file! Obviously, in real life it wouldn't be this easy. But you now should be seeing how the tools in the previous chapters are adding up to help determine what may be going wrong.

Killing a Process

The `kill` command sends *signals* to processes. The default behavior for a process is to stop when it receives a signal, although signals can also be used to tell a service to reload its configuration file, and so forth.

Sometimes a service may hang to the point where it won't respond to the `service` command. The next step is to try to kill it. First, you need to find its process ID. In Figure 9-9, we're finding the process ID for the `mysvc` process.

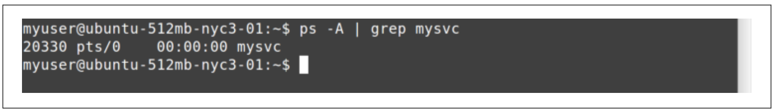


Figure 9-9. find mysvc process

After you have the process ID (`20330` in this case), you can try to kill it, as shown in Figure 9-10.

Figure 9-10. kill command

Let's look at Figure 9-11 to see if that worked.

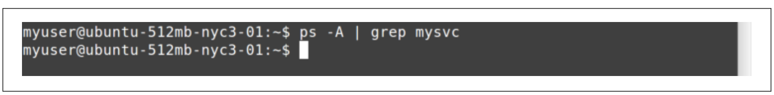


Figure 9-11. no more mysvc

Yup—`ps` piped through `grep` shows no active processes named `mysvc` running.

But sometimes even `kill` doesn't work. For one, programs can be written to intercept most signals, enabling communication with the background process from the command line. Or the process may really be “hung hard.” In that case, you need to *terminate, with prejudice*, as shown in Figure 9-12. The `-9` (minus nine) signal is one that processes *cannot* trap (intercept).

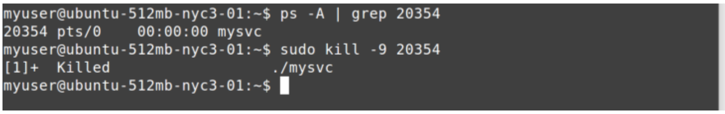


Figure 9-12. kill -9 command

> You should use the `kill -9` command with extreme caution. Notice that the first `kill` example returns `Terminated`, but in this case it comes back with `Killed`. Because the process cannot intercept a `-9` signal, it has no chance of ending cleanly. There may be open files, unflushed buffers, database transactions that haven’t been committed, and other in-flight processing that will be lost when you use the `kill -9` command. Invoke it only as a last resort!

When All Else Fails

Just as on Windows, sometimes a system restart is the ultimate cure. The `reboot` command does just what you’d expect. A `shutdown` command provides more options, such as waiting for a number of seconds first, but you probably won’t need it. In any case, both require `sudo` to run, and you will lose your `ssh` connection and will need to log back in again after the system comes back up to ensure everything is back in order.

CHAPTER 10

Step 10: Where to Go for Help

This report is just a quick flyover of Linux commands and how to use them to do quick troubleshooting. Even with the commands covered in the report, I excluded many, many options to keep it simple. But sometimes, even in the heat of troubleshooting a system problem, you need a bit more help. This chapter covers where you can go to get it.

Hey, man

The `man` (manual page) command provides documentation on commands, system configuration files, and much more. This command is good for when you can't access the Internet, or doing so isn't convenient because you are on a machine console or similar setup. Figure 10-1 shows the first page of output from `man reboot`.

```
reboot(8)                    System Manager's Manual                  reboot(8)

NAME
       reboot, halt, poweroff - reboot or stop the system

SYNOPSIS
       reboot [OPTION]...  [REBOOTCOMMAND]

       halt [OPTION]...

       poweroff [OPTION]...

DESCRIPTION
       These programs allow a system administrator to reboot, halt or poweroff
       the system.

       When called with --force or when in runlevel 0 or 6, this tool  invokes
       the  reboot(2)  system call itself (with REBOOTCOMMAND argument passed)
       and directly reboots the system.  Otherwise  this  simply  invokes  the
       shutdown(8) tool with the appropriate arguments without passing REBOOT-
       COMMAND argument.

       Before invoking reboot(2), a shutdown time record is first  written  to
 Manual page reboot(8) line 1 (press h for help or q to quit)
```

Figure 10-1. man command

The output is run through pagination similar to `less`, so all its navigation and find commands will work. You can, of course, find out more about how to use `man` by running `man man`.

Is That apropos?

How do you know what you don't know? Sometimes you might not know (or remember) the name of a command. For example, you may recall that this guide mentioned disk space, but can't remember the actual commands. Luckily, you can use the `apropos` command to jog your memory, as shown in Figure 10-2.

```
myuser@ubuntu-512mb-nyc3-01:~$ apropos space
arpd (8)             - userspace arp daemon.
df (1)               - report file system disk space usage
du (1)               - estimate file space usage
e2freefrag (8)       - report free space fragmentation information
expand (1)           - convert tabs to spaces
fallocate (1)        - preallocate space to a file
futex (7)            - fast user-space locking
growpart (1)         - extend a partition in a partition table to fill availa...
ip-netns (8)         - process network namespace management
namespace.conf (5)   - the namespace configuration file
netlink (7)          - communication between kernel and user space (AF_NETLINK)
pam_namespace (8)    - PAM module for configuring namespace for a session
Text::WrapI18N (3pm) - Line wrapping module with support for multibyte, fullw...
unexpand (1)         - convert spaces to tabs
unshare (1)          - run program with some namespaces unshared from parent
myuser@ubuntu-512mb-nyc3-01:~$
```

Figure 10-2. apropos command

The `apropos` command is simple. All it does is search through all the `man` page titles for the string you pass it. In this case, `apropos space` should be enough to help you recognize the `df` and `du` commands again.

Additional Resources

There are plenty of places to go for more help with Linux:

DuckDuckGo and Google
: Search engines, with DDG often providing direct help for a command as the first result

Stack Exchange
: A UNIX-specific Stack Exchange site for questions

Debian docs
: Provides good documentation, much of it applicable across distros

Arch docs
: Ditto

die.net
: Online man pages

CHAPTER 11
The End

Now you know what I know. Or at least what I keep loaded in my head versus what I simply search for when I need to know it, and you know how to do that searching, too. Hopefully, this report will help you sometime when you most need it.

Good luck, citizen!

APPENDIX A

Cheat Sheet

That rug really tied the room together, did it not?

—Walter Sobchak, *The Big Lebowski*

This chapter lists many of the commands covered in this report. Use `man` or other methods outlined in the report to find more information on them.

Redirection Command

See ***I/O Redirection***

`|`
: Pipe *stdout* from one process into *stdin* in another process.

System Directory Commands

See ***Important System Directories***

`/etc`
: Configuration files location

`/home`
: Home or user profile directories

`/proc`
: System runtime information

`/root`
: Home directory for root user (system admin)

`/tmp`
: Temporary files location

`/var/log`
: Log files location

Standard User Commands

These are "Section 1" commands, normal user commands that typically don't require any special privileges beyond permissions to access files and the like.

`apropos`
: Search for help on commands by title

`bash`
: The Bourne-again shell

`cat`
: Concatenate the input files to *stdout*

`cd`
: Change the current directory

`cp`
: Copy files or directories

`df`
: Show space utilization by filesystem

`dig`
: Look up DNS info on an address

`du`
: Estimate disk usage

`find`
: Find files based on various conditions and execute actions against the results

`grep`
: Search for a pattern (regular expression) in files

`less`
: Display the file one page at a time on *stdout*

`locate`
: Locate files by name

`ls`
: List directory contents

`man`
: Display manual pages; remember, `q` quits

`ps`
: List running processes

`pwd`
: Print the current (working) directory name

`scp`
: File copy over Secure Shell protocol

`smbclient`
: Copy files to and from Windows using the SMB/CIFS (Windows file share) protocol

`ssh`
: Secure Shell terminal program and protocol

`tail`
: Display the last lines of a file

`top`
: List processes by resource utilization (CPU)

`whois`
: Look up DNS ownership info on an address

System Commands

Most of these are "Section 8" commands, and *may* require special privileges such as `sudo` to run, depending on the system. Yes, some systems restrict the use of `ping`!

`ifconfig`
: Display network (interface) configuration

`kill`
: Terminate a process

`ping`
: Test for network connectivity to an IP address

`reboot`
: Restart the system

`shutdown`
: Shut down or restart the system

`sudo`
: Execute a command with elevated privileges

`traceroute`
: Trace the route to an IP address

About the Author

Jim Lehmer has been "in computers" for over three decades. He has held various software development roles, including programmer, systems programmer, software engineer, team lead, and architect.

Besides bragging about his wife, Leslie, his five children, and four grandchildren, his hobbies include reading, writing, running, hiking, and climbing.

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