Introduction to the Unix Shell

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July 13, 2015

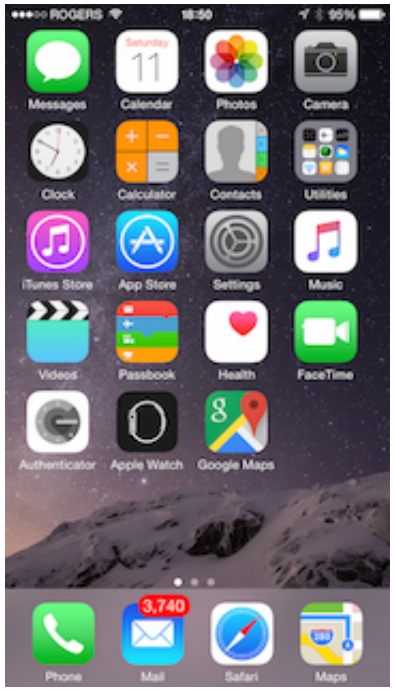
What is a shell?

A shell is a meta-program.

It's a program to run other programs.

All general purpose computers have a shell of some sort.

Graphical "shell"



For example, the main screen of a smartphone can be considered a kind of shell. It lists the available programs, which you tap to start.

(However, most people would call this a launcher, not a shell.)

Text shells

The first shells were written in the early 1970s, when you talked to computers like this:

So why still use text shells?

We don't use teletypes anymore, so why isn't everything graphical?

A graphical user interface is pretty, but limited. The only thing you can do is start a program, and that's pretty much it.

As we'll see, a text interface allows you to combine simple programs together in powerful ways.

A shell is not just a *program* to launch programs, but a *language* to launch programs. We use text shells for the same reason we still write code in text -- it's more expressive.

Getting setup

- Linux:
  - Look for a Terminal application (`gnome-terminal`, `konsole`, `xterm`, ...)
- OS X:
  - Open `Applications/Utilities/Terminal`
- Windows:
  - Start `MobaXterm`;
  - Go to *Settings* > *Configuration* and set "persistent HOME directory" to a permanent location.

The shell prompt

You should now see the shell prompt, awaiting input:

- Linux:

```
[username@hostname ~]$
```

- OS X:

```
hostname:~ username$
```

- Windows (MobaXterm):

```
[username.hostname]
```

In these slides i'll use

```
$
```

as the shell prompt.

Running a program

Instead of tapping an icon, in a text shell you type the name of the program you want to run and hit *Enter*. Let's run the `date` program:

```
$ date
Thu  9 Jul 2015 11:55:48 EDT
```

`date` is the name of the program we want to run, which prints the current time.

Program arguments

The first word is the command, and any subsequent words are passed to the command as arguments, where the words are separated by whitespace.

The `echo` program prints the arguments you give it:

```
$ echo a b c
a b c
```

Here we've passed three arguments: "a", "b", and "c".

The `seq` program prints a sequence of integers:

```
$ seq 3
1
2
3
$ seq 4 2
4
3
2
```

Getting help

Use the `man` command (short for manual) to get help

```
$ man echo

ECHO(1)                   BSD General Commands Manual                  ECHO(1)

NAME
     echo -- write arguments to the standard output

SYNOPSIS
     echo [-n] [string ...]

DESCRIPTION
     The echo utility writes any specified operands, separated by single blank (`
     characters and followed by a newline (`\n') character, to the standard output
...
```

Let's write our own `echo`

```c
// print_args.c : print command line arguments

#include <stdio.h>

int main(int argc, char *argv[])
{
    for (int i = 0; i < argc; i++)
        printf("arg $d is %s\n", i, argv[i]);
    return 0;
}
```

```
$ gcc -o print_args print_args.c
$ ./print_args a b c
arg 0 is ./print_args
arg 1 is a
arg 2 is b
arg 3 is c
```

String literals

String literals are delimited by single quotes:

```
$ echo 'the cake cost $10 dollars'
the cake cost $10 dollars
```

If a single-quoted string is preceded by a `$`, standard C character escape sequences are expanded:

```
$ echo 'a\nb\nc'
a\nb\nc
$ echo $'a\nb\nc'
a
b
c
```

`\n` is a newline, `\t` is a tab, etc.

Field Splitting

Quotes prevent argument splitting, allowing you to pass spaces in a single argument:

```
$ ./print_args a b
arg 0 is ./print_args
arg 1 is a
arg 2 is b
```

```
$ ./print_args 'a b'
arg 0 is ./print_args
arg 1 is a b
```

Variables

If you want to pass the same argument to multiple commands, you can define a variable:

```
$ var='a b'
```

Valid variable names start with a letter, and consist only of letters, numbers, and underscores.

Note that there can be no spaces around the equal sign -- `var = x` is interpreted as "run the 'var' command with arguments '=' and 'x'".

To get a variable's value, prefix with a dollar sign:

```
$ echo $var
a b
```

String literals (2)

There's another form of string literal, delimited by double-quotes. It's like a single-quoted string, but interpolates variables:

```
$ var='a b'
$ echo 'the value of var is $var'
the value of var is $var
$ echo "the value of var is $var"
the value of var is a b
```

When ambiguous, surround the variable name with braces:

```
$ echo "the value of var is $vars"
the value of var is
$ echo "the value of var is ${var}s"
the value of var is a bs
```

Field Splitting (2)

Newlines and tabs can also delimit arguments, unless protected by quotes.

```
$ X=$'a\nb\nc'
```

```
$ echo $X
a b c
```

```
$ echo "$X"
a
b
c
```

Where are these programs?

The which command shows you the location a program:

```
$ which echo
/bin/echo
$ which seq
/usr/bin/seq
```

But what does `/bin/echo` mean?

The Filesystem

The Unix Filesystem

Like Windows and OS X, the Unix filesystem is hierarchical, with files stored in nested directories (folders). Directories can hold both files and other directories (called subdirectories).

A *path* is a string representing a route through the filesystem, tracing a path through the directories, with the names separated by `/`.

There are two kinds of paths: absolute and relative.

- absolute paths start with a `/`, and refer to a fixed location;
- relative paths do not start with a `/`, and are relative to the current working directory.

Unlike Windows, the Unix filesystem is *unified*, every file and directory descends from `/`, the root. There are no drive letters, e.g., `C:\Folder\File.txt`.

Filesystem layout

- `/` is the root of the filesystem
- `/usr` holds system software:
  - `/usr/bin` holds system programs (aka binaries)
  - `/usr/lib` holds system libraries
- `/etc` holds system configuration files.
- `/home` holds user home directories
- `/tmp` holds temporary files

Navigating the Filesystem: `pwd` & `cd`

Print current (working) directory:

```
$ pwd
/Users/nolta
```

This is my home directory (on OS X).

Change current directory with `cd`:

```
$ cd /usr
$ pwd
/usr
$ cd bin
$ pwd
/usr/bin
```

Note the `cd bin` command is interpreted relative to our current location (i.e., "change to the 'bin' subdirectory").

Navigating the Filesystem: `ls`

List the files in the current directory:

```
$ ls
Desktop     Library     Pictures    chime
Documents   Movies      Public      julia
Downloads   Music       asciinema   talks
```

List the files in a specific directory:

```
$ ls /
bin   dev  home  lib64       media  mnt  nixon  proc  run   scratch  sys  usr
boot  etc  lib   lost+found  misc   net  opt    root  sbin  srv      tmp  var
```

Creating & Removing Directories

Make a new directory:

```
$ mkdir tmp
```

Remove directory:

```
$ rmdir tmp
```

`rmdir` will fail if the directory contains any files or directories.

Removing files

```
$ rm filename
```

Adding the `-r` option lets you recursively remove a directory and all its subdirectories & files.

```
$ rm -r dir
```

Renaming Files & Directories

```
$ mv oldname newname
```

Copy a File

```
$ cp original copy
```

Special directories: `.`, `..`, `~`

`.` refers to the current directory, so `ls` and `ls .` are equivalent.

`..` refers to the parent directory.

```
$ cd /usr/local/bin
$ cd ../../lib
$ pwd
/usr/lib
```

`~` refers to your home directory.

```
$ cd ~/data
$ pwd
/Users/nolta/data
```

Recap

- `cp` copy file
- `cp -r` copy directory
- `mkdir` make new directory
- `mv` move file or directory
- `rm` remove file
- `rm -r` remove directory
- `rmdir` remove empty directory

The Environment

Environment Variables

Ok, where were we? Right,

```
$ which seq
/usr/bin/seq
```

So the `seq` program is located in the `/usr/bin` directory. When the shell sees `seq`, it runs `/usr/bin/seq`.

But how did the shell know to run `/usr/bin/seq`?

There's a special environment variable called `PATH` that lists the directories the shell searches for programs.

```
$ echo $PATH
/opt/local/bin:/opt/local/sbin:/usr/local/bin:/usr/bin:/bin:/usr/sbin:/sbin:/opt/X
```

Other interesting environment variables

- `HOME`: user home directory

```
$ echo $HOME
/Users/nolta
```

- `PWD`: current working directory (same as `pwd` command)
- `PS1`: prompt string

```
$ PS1=" yo: "
yo:
```

Wildcards (aka Globbing)

File globbing

Say you have a directory with thousands of files, but only a few files have the extension `.html`. You can list only those files using the `*` pattern:

```
$ ls *.html
index.html
intro_to_unix_shell.html
```

Before the command is run, the shell expands `*.html` into a list of filenames ending in `.html`, and then passes that list as arguments to `ls`.

As usual, quoting protects arguments from globbing

```
$ ls "*.html"
ls: *.html: No such file or directory
```

Globbing patterns

- `*` matches any sequence of zero-or-more characters
- `?` matches any single character
- `[...]` matches any single character in `...`
- `[!...]` matches any single character not in `...`
- any other character just matches itself

Globbing examples

- `*.pdf` matches any string ending in `.pdf`
- `???` matches any 3-character string
- `[a-z]*` matches any string starting with a lowercase letter
- `[!a-z]*` matches any string not starting with a lowercase letter
- `[A-Za-z0-9_]` matches any letter (upper or lower), digit, or underscore

Standard I/O & Redirection

Redirect Output to a File

Often you want to save the output of a command to a file, not dump it to the screen:

```
$ seq 4 2
4
3
2
```

This is accomplished via the `>` operator:

```
$ ls
$ seq 4 2 > output
$ ls
output
$ cat output
4
3
2
```

Here the output of the `seq 3` command has been redirected to the new file `output`. The `cat` program dumps files to the screen.

Append Output to a File

`>` clobbers the file:

```
$ echo a > output
$ echo b > output
$ cat output
b
```

Use `>>` to append to the file, if it exists:

```
$ echo a > output
$ echo b >> output
$ cat output
a
b
```

Redirect Input from a File

Similarly, you can redirect the input of a command to come from a file, not the terminal, with `<`:

```
$ seq 4 2 > output
$ sort < output
2
3
4
```

The `sort` command sorts the lines of its input.

Pipelines

This pattern is so common

```
$ cmd1 > tmpfile
$ cmd2 < tmpfile
```

that there's a special pipeline syntax to connect the output of one command to the input of another command:

```
$ seq 4 2
4
3
2
$ seq 4 2 | sort
2
3
4
```

Behind the Scenes

Don't worry if you don't understand this material -- it's optional!

Files

A **file** is a source and/or sink of bytes, which supports the following API:

- `fd = open(filename, mode)`
- `read(fd, buf, n)`, read at most *n* bytes from *fd* into *buf*;
- `write(fd, buf, n)`, write *n* bytes from *buf* to *fd*;
- `close(fd)`

This is a powerful abstraction. Files are typically thought of, e.g., a PDF on a disk drive, but they can be anything you can read and/or write to. For example, a network connection can be thought of as a file.

Standard I/O

Each process starts life with 3 open files:

- standard input (aka stdin)
- standard output (aka stdout)
- standard error (aka stderr)

Their file ids are 0, 1, 2 respectively.

Not surprisingly, the process reads from stdin, writes to stdout, and writes errors to stderr.

Redirection

For a shell, stdin/stdout/stderr are typically the same file, a terminal:

```
$ tty
/dev/ttys009
```

When the shell runs a program, by default the program reads & writes to the same stdin, stdout, and stderr as the shell.

However, you can redirect I/O, i.e., read/write from different files.

Under the hood

`> filename` is the same as `1> filename`, i.e., "redirect the output of file descriptor 1 to filename".

`n> filename` gets translated into something like

```
close(n);
open(filename, O_WRONLY|O_CREATE);
```

Because `open` is called immediately after `close`, it's guaranteed to return the same file descriptor (in this case, `n`).

Stupid redirection tricks

```c
// write_to_3.c : write a short message to file descriptor 3

#include <stdio.h>
#include <string.h>
#include <unistd.h>

int main(int argc, char *argv[])
{
    const char *s = "this is file descriptor 3";
    if (write(3, s, strlen(s)) == -1)
        fprintf(stderr, "error: couldn't write to file descriptor 3\n");
    return 0;
}
```

```
$ ./write_to_3
error: couldn't write to file descriptor 3
```

```
$ ./write_to_3 3>output
$ cat output
this is file descriptor 3
```

Here Documents: `<<`

```
$ sort <<EOF
> pear
> apple
> tophat
> EOF
apple
pear
tophat
```

`EOF` is an arbitrary string. It marks the beginning and end of the input.

Here Documents: `<<<`

`<<<` lets you pass cmd-line strings to stdin.

Example -- let:

```
$ X=$'pear\napple\ntophat'
```

So instead of

```
$ echo "$X" | sort
apple
pear
tophat
```

you can write

```
$ sort <<<"$X"
apple
pear
tophat
```

Redirecting output to another stream: `>&`

```
$ ls *.nope
ls: *.nope: No such file or directory
$ ls *.nope >output
ls: *.nope: No such file or directory
```

The error message is still printed to the terminal because it's written to stderr, not stdout.

To redirect stderr, use `2>`:

```
$ ls *.nope >output 2>err
```

What if you want to direct both stdout & stderr to the same file?

```
$ ls *.nope >output 2>&1
$ cat output
ls: *.nope: No such file or directory
```

Redirecting output to another stream: `>&`

`n>filename` turns into

```
close(n);
open(filename, WRITE);
```

`n>&m` turns into

```
close(n);
dup(m);
```

`dup` duplicates the file descriptor, and like `open` it reuses the last closed file descriptor (i.e., `dup(m) == n`).

Redirecting output to another stream: `>&`

Redirections are processed in order from left to right.

`>filename 2>&1`

```
close(1);
open(filename, WRITE);
close(2);
dup(1);
```

```
0    /dev/tty   -->   /dev/tty   -->    /dev/tty
1    /dev/tty   -->   filename   -->    filename
2    /dev/tty   -->   /dev/tty   -->    filename
```

Redirecting output to another stream: `>&`

Redirections are processed in order from left to right.

`2>&1 >filename`

```
close(2);
dup(1);
close(1);
open(filename, WRITE);
```

```
0    /dev/tty   -->   /dev/tty   -->    /dev/tty
1    /dev/tty   -->   /dev/tty   -->    filename
2    /dev/tty   -->   /dev/tty   -->    /dev/tty
```

Chaining Commands

Command Chains

Commands can be chained together in 4 ways:

- `command1 ; command2 ; ...` run commands in sequence.
- `command1 & command2 & ...` run commands in parallel.
- `command1 && command2 ...` run command only if previous command succeeded.
- `command1 || command2 ...` run command only if previous command failed.

A command succeeds when it returns 0, any other value indicates failure.

```
int main(void) { return 0; } // success
int main(void) { return 1; } // failure
```

The exit status of the last command is stored in the special environment variable `$?`.

Pipelines are left-associative

What's the output of

```
$ false && echo foo || echo bar
```

and

```
$ true || echo foo && echo bar
```

?

Pipelines are left-associative

What's the output of

```
$ false && echo foo || echo bar
```

and

```
$ true || echo foo && echo bar
```

?

Both output `bar`.

Job Control

Job Control

Job control refers to managing background processes.

To list all the current background processes, use `jobs`:

```
$ sleep 50 & sleep 60 & sleep 70 &
[1] 18383
[2] 18384
[3] 18385
$ jobs
[1]   Running                 sleep 50 &
[2]-  Running                 sleep 60 &
[3]+  Running                 sleep 70 &
```

Jobs can be referred to either by their PID (e.g., `18383`) or job number (e.g., `%1`).

Suspending Jobs

If you started a job, but forgot to add `&`, use `Control-Z` to suspend it:

```
$ ping freebsd.org
PING freebsd.org (8.8.178.110) 56(84) bytes of data.
64 bytes from wfe0.ysv.freebsd.org (8.8.178.110): icmp_seq=1 ttl=49 time=69.1 ms
64 bytes from wfe0.ysv.freebsd.org (8.8.178.110): icmp_seq=2 ttl=49 time=68.9 ms
64 bytes from wfe0.ysv.freebsd.org (8.8.178.110): icmp_seq=3 ttl=49 time=68.9 ms
^Z
[1]+  Stopped                 ping freebsd.org
```

The job is now stopped, and not executing. Use `fg` to bring it back to the foreground.

```
$ jobs
[1]+  Stopped                 ping freebsd.org
$ fg
ping freebsd.org
64 bytes from wfe0.ysv.freebsd.org (8.8.178.110): icmp_seq=4 ttl=49 time=68.8 ms
64 bytes from wfe0.ysv.freebsd.org (8.8.178.110): icmp_seq=5 ttl=49 time=68.9 ms
64 bytes from wfe0.ysv.freebsd.org (8.8.178.110): icmp_seq=6 ttl=49 time=68.6 ms
...
```

Useful Programs

`head`, `tail`: first or last lines of file

Take first 3 lines:

```
$ seq 7 | head -n 3
1
2
3
```

Take last 3 lines:

```
$ seq 7 | tail -n 3
5
6
7
```

`head`, `tail`, continued

Drop first 2 lines:

```
$ seq 7 | tail -n+3
3
4
5
6
7
```

Drop last 2 lines (*doesn't work on OS X*):

```
$ seq 7 | head -n-2
1
2
3
4
5
```

`sort`: sort lines

Normal (lexicographic) sort:

```
$ seq 9 11 | sort
10
11
9
```

Numerical sort (`-n`):

```
$ seq 9 11 | sort -n
9
10
11
```

Reverse sort (`-r`):

```
$ seq 9 11 | sort -n -r
11
10
9
```

`uniq`: unique lines

`uniq` removes consecutive duplicate lines from a stream or file. Usually paired with sort.

```
$ uniq <<EOF
> a
> b
> a
> EOF
a
b
a
```

```
$ uniq <<EOF
> a
> a
> b
> EOF
a
b
```

`uniq`, continued

Add the `-c` option to get a duplicate count:

```
$ uniq -c <<EOF
> a
> a
> b
> EOF
   2 a
   1 b
```

`cut`: cut columns

```
$ echo abcdefghijklmnopqrstuvwxyz > alphabet
```

First 10 columns

```
$ cut -c-10 alphabet
abcdefghij
```

Columns 10 and greater

```
$ cut -c10- alphabet
jklmnopqrstuvwxyz
```

Columns 10-20

```
$ cut -c10-20 alphabet
jklmnopqrst
```

`cut`, continued

Columns 4-6 and 8-13

```
$ cut -c4-6,8-13 alphabet
defhijklm
```

Fields 2-4 and 6, where fields are separated by commas:

```
$ echo 'a,b,c,d,e,f,g' | cut -d',' -f2-4,6
b,c,d,f
```

Be careful, multiple delimiters are not combined:

```
$ echo 'a   b   c' | cut -d' ' -f2

$ echo 'a   b   c' | cut -d' ' -f4
b
```

`paste`: concatenate lines

Concatenate columns, separated by space

```
$ paste -d' ' <(seq 3) <(seq 3)
1 1
2 2
3 3
```

Concatenate lines, separated by comma

```
$ paste -d, <(seq 3) <(seq 4)
1,1
2,2
3,3
,4
```

"Transpose" with the `-s` option

```
$ paste -s -d, <(seq 3) <(seq 4)
1,2,3
1,2,3,4
```

`tr`: translate characters

Convert ASCII lowercase to uppercase

```
$ cat alphabet | tr 'a-z' 'A-Z'
ABCDEFGHIJKLMNOPQRSTUVWXYZ
```

Convert arbitrary lowercase to uppercase

```
$ echo 'αβ' | tr '[:lower:]' '[:upper:]'
AB
```

Convert spaces to commas

```
$ echo 'a  b   c' | tr ' ' ','
a,,b,,,c
```

Convert spaces to commas, but squeeze commas together

```
$ echo 'a  b   c' | tr -s ' ' ','
a,b,c
```

`tr`, continued

Delete characters

```
$ echo 'a,b,c' | tr -d ','
abc
```

Delete all characters except

```
$ echo 'a,b,c' | tr -c -d ','
,,
```

(`-c` takes the complement of `','`)

`sed`: stream editor

Substitute "brown" with "red"

```
$ echo "quick brown fox" | sed -e 's/brown/red/'
quick red fox
```

Substitute "/bin" with "/usr/local/bin"

```
$ echo "/bin/bash" | sed -e 's:/bin:/usr/local/bin:'
/usr/local/bin/bash
```

Replace all occurrences of "a" with "b"

```
$ echo "a a a" | sed -e 's/a/b/'
b a a
$ echo "a a a" | sed -e 's/a/b/g'
b b b
```

awk: stream text processing

Named after the initials of its creators.

Invert column 1

```
$ seq 3 | awk '{print $1, 1/$1}'
1 1
2 0.5
3 0.333333
```

Unlike bash, where all arithmetic is integer, in awk all arithmetic is floating point.

More useful programs

- `diff` : file differences
- `find`
- `rsync`
- `ssh`
- `scp`
- `top`
- `ps`
- `vi`
- `nohup`
- `screen`
- `tee`
- `curl`
- `wget`
- `wc`
- `join`
- `du`
- `mount`
- `chown`
- `chmod`
- `ln`
- `tar`

Stupid Shell Tricks

Example: sum fields in XML file

Say we have an XML file,

```
$ curl -O http://www.canfar.phys.uvic.ca/vospace/nodes
$ cat nodes
<?xml version="1.0" encoding="UTF-8"?>
<?xml-stylesheet type="text/xsl" href="http://www.canfar.phys.uvic.ca/vospace/vosp
<vos:node xmlns:vos="http://www.ivoa.net/xml/VOSpace/v2.0" xmlns:xsi="http://www.w
  <vos:properties>
    <vos:prop uri="ivo://ivoa.net/vospace/core#ispublic" readOnly="false">true</vo
  </vos:properties>
  <vos:nodes>
    <vos:node uri="vos://cadc.nrc.ca!vospace/APASS" xsi:type="vos:ContainerNode">
      <vos:properties>
        <vos:prop uri="ivo://ivoa.net/vospace/core#length" readOnly="true">-532343
        <vos:prop uri="ivo://ivoa.net/vospace/core#date" readOnly="true">2015-07-0
        <vos:prop uri="ivo://ivoa.net/vospace/core#ispublic" readOnly="false">true
        <vos:prop uri="ivo://ivoa.net/vospace/core#creator" readOnly="false">CN=we
      </vos:properties>
      <vos:nodes />
    </vos:node>
...
```

and we'd like to sum up the "length" fields.

Example: sum fields in XML file (2)

First, filter out the "length" lines

```
grep 'core#length' nodes \
```

Next, grab just the number

```
| egrep -o '[0-9]+' \
```

Finally, sum the entries

```
| { s=0; while read x; do s=$((s+x)); done; echo $s; }
```

All together,

```
$ grep 'core#length' nodes \
> | egrep -o '[0-9]+' \
> | { s=0; while read x; do s=$((s+x)); done; echo $s; }
69189164087043
```

Example: sum fields in XML file (3)

You can also define a `sum` function, and use it as the last step of the pipe:

```
$ sum() {
>   local s=0
>   while read x; do
>     s=$((s+x))
>   done
>   echo $s
> }
$ grep 'core#length' nodes | egrep -o '[0-9]+' | sum
69189164087043
```

Example: find the biggest users on SciNet

```
$ showstats -u
statistics initialized Thu Jun 25 22:39:14

        |------ Active ------|--------------- Completed --------------|
user     Jobs Procs ProcHours   Jobs  PHDed    %   FSTgt   Effic  WCAcc
user001    19  2496  58790.76    503  2.80M   6.44 -----   97.84  87.43
user002     1   152   5133.38    486  2.31M   5.32 -----    8.51  52.71
user003     1   512  12941.65   6957  2.06M   4.73 -----  159.68  55.40
user004     2    16    260.71    868  1.26M   2.90 -----   96.80  21.12
user005     4  1536  54752.64    213  1.19M   2.74 -----   98.20  46.37
user006     1   192   9098.40    164 978.8K   2.25 -----   98.58  76.00
user007     1   128   3316.02   1839 911.1K   2.10 -----    6.66   9.02
user008    33  1056  32067.62    580 879.0K   2.02 -----   98.00  97.59
user009    31   732   3118.31   3718 873.9K   2.01 -----  190.14  82.13
user010     0     0      0.00   5938 871.3K   2.00 -----   93.36  75.05
user011     0     0      0.00   2073 861.2K   1.98 -----   11.54  30.07
user012     1   520   4735.32    258 795.1K   1.83 -----    2.41  66.35
user013    20   480  17312.31   1441 712.3K   1.64 -----   31.78  52.24
user014    38  1520  30901.51    774 700.0K   1.61 -----   98.20  45.77
user015     8   320   7443.33   4419 663.1K   1.52 -----   39.80  12.38
...
```

Example: find the biggest users on SciNet (2)

First, multiply columns 7 (percent nodes used) and 9 (efficiency) together. `NF` is the number of fields per line.

```
showstats -u | awk 'NF == 16 {print $1, $7*$9}' \
```

Next, reverse numeric sort by column 2

```
| sort -r -n -k 2,2
```

Finally, just grab the top 10

```
| head -n 10
```

Example: find the biggest users on SciNet (3)

Altogether,

```
$ showstats -u | awk 'NF == 10 {print $1, $7*$9}' \
  | sort -r -n -k 2,2 | head -n 10
user003 755.286
user001 630.09
user009 382.181
user004 280.72
user005 269.068
user006 221.805
user008 197.96
user024 187.475
user010 186.72
user014 158.102
```

Writing Scripts

Our first script:

```
$ cat >script1 <<EOF
> #!/bin/bash
> echo "hello, world!"
> EOF
$ cat script1
#!/bin/bash
echo "hello, world!"
```

Change permissions

```
$ ls -l script1
-rw-r--r--  1 nolta  staff  33 13 Jul 08:21 script1
$ chmod +x script1
-rwxr-xr-x  1 nolta  staff  33 13 Jul 08:21 script1
```

Run the script

```
$ ./script1
hello, world!
```

Thanks! Questions?