
CSE 374

Programming Concepts & Tools

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Winter 2013

Lecture 3 – I/O Redirection, Shell Scripts

Standard I/O streams and redirection

- Recall: every command has 3 standard streams: stdin (0, input), stdout (1, output), stderr (2, error messages)
- Default is keyboard (stdin), screen (stdout, stderr)
- Can redirect to a file with `<`, `>`
 - `echo hello > there`
 - `cat < there; cat <there > here`
- Can “pipe” output (stdout) of one command to input (stdin) of another with `|`
 - `man bash | less`
- Done entirely in the shell – programs are oblivious; they just use streams 0,1,2

File redirection in (more) detail

- Somewhat cryptic; some common usages:
 - redirect input: `cmd < file`
 - redirect output, overwriting file: `cmd > file`
 - redirect output, appending to file: `cmd >> file`
 - redirect error output: `cmd 2> file`
 - redirect output and error output to file: `cmd &> file`
 - ...

See bash manual sec. 3.6 for other variations
- Useful special file: `/dev/null`
 - Immediate eof if read; data discarded if written

Pipes

cmd1 | cmd2

- Change the stdout of cmd1 and the stdin of cmd2 to be the same, new stream!
- Very powerful idea:
 - In the shell, larger command out of smaller commands
 - To the user, combine small programs to get more usefulness
 - Each program can do one thing and do it well!
- Examples:
 - ps aux | less
 - djpeg me.jpg | pnmscale -xysize 100 150 | cjpeg > thumb.jpg
 - (you'll need to add jpeg/cjpeg to your copy of the vm if you want to run the last example. Both have been added to klaatu.)

Combining commands

- Combining simpler commands to form more complicated ones is very programming-like. In addition to pipes, we have:

`cmd1 ; cmd2` (sequence)

`cmd1 || cmd2` (or, using int result – the “exit status”
– run `cmd2` if `cmd1` “fails”)

- Example: `do_something || echo “Didn’t work!”`

`cmd1 && cmd2` (and, like or; run `cmd2` only if `cmd1`
“succeeds” – i.e., “returns” 0)

- Example: `check_if_ok && launch_missiles`

`cmd1 ‘cmd2’` (use output of `cmd2` as input to `cmd1`). (Note `cmd2` surrounded by backquotes, not regular quotes)

- Useless example: `cd ‘pwd’`
- Non-useless example: `mkdir ‘whoami’A‘whoami’`

(Non)-alphabet soup

- List of characters with special (before program/built-in runs) meaning is growing: ' ! % & * ~ ? [] " ' \ > < | \$ (and we're not done)
- If you ever want these characters or (space) in something like an argument, you need some form of escaping; each of " ' \ have slightly different meaning
- First approximation:
 - "stuff" treats stuff as a single argument but allows some substitutions for \$variables
example: `cat "to-do list" # filename with spaces(!)`
 - 'stuff' suppresses basically all substitutions and treats stuff literally

Shell Expansion and Programs

- Important but sometimes overlooked point: shell metacharacter expansion, I/O redirection, etc. are done by the shell before a program is launched
 - The program usually never knows if stdin/stdout are connected to the keyboard/screen or files
 - Program doesn't see original command line – just expanded version as a list of arguments
 - Expansion is uniform for all programs since it's done in one place – the shell

Shell as a programming language

- The shell is an interpreter for a strange programming language (of the same name). So far:
 - “Shell programs” are program names and arguments
 - The interpreter runs the program (passing it the arguments), prints any output, and prints another prompt. The program can affect the file-system, send mail, open windows, etc.
 - “Builtins” such as `cd`, `exit` give directions to the interpreter.
 - The shell interprets lots of funny characters differently, rather than pass them as options to programs.
- It’s actually even more complicated:
 - (two kinds of) variables
 - some programming constructs (conditionals, loops, etc.)

Toward Scripts...

- A running shell has a state, i.e., a current
 - working directory
 - user
 - collection of aliases
 - History
 - Streams (files, etc.)
 - ...
- In fact, next time we will learn how to extend this state with new shell variables.
- We learned that source can execute a file's contents, which can affect the shell's state.

Running a script

- What if we want to run a bunch of commands without changing our shell's state?
- Answer: start a new shell (sharing our stdin, stdout, stderr), run the commands in it, and exit
- Better answer: Automate this process
 - A shell script as a program (user doesn't even know it's a script).
 - Now we'll want the shell to end up being a programming language
 - But it will be a bad one except for simple things

Writing a script

- Make the first line exactly: `#!/bin/bash`
- Give yourself “execute” permission on the file (`chmod +x`)
- Run it
 - Probably need to precede filename with `./` if current directory isn’t normally searched for commands (i.e., `.` is not normally included in `$PATH` – and it shouldn’t be for security reasons)
- Note: The shell consults the first line of the file:
 - If a shell-program is there, launch it and run the script (similar trick works for perl, python, etc.)
 - Else if it’s a “real executable” run it (more later)
- Example: `listhome`

More expressions

- bash expressions can be:
 - math or string tests (e.g., -lt)
 - logic (&&, ||, !) (if you use double-brackets)
 - file tests (very common; see Pocket Guide)
 - math (if you use double-parens)
- Gotcha: parens and brackets must have spaces before and after them!
- Example: dcdls (double cd and ls) can check that arguments are directories
- Exercise: script that replaces older file with newer one
- Exercise: make up your own

Accessing arguments

- The script accesses the arguments with $\$i$ to get the i th one (name of program is $\$0$)
 - Example: make thumbnail1
- Also very useful for homework: shift (manual Section 4.1)
 - Example: countdown
- We would like optional arguments and/or usage messages. Need:
 - way to find out the number of arguments
 - a conditional
 - some stuff we already have
 - Example: make thumbnail2

Review

- The shell runs programs and builtins, interpreting special characters for filenames, history, I/O redirection
- Some builtins like `if` support rudimentary programming
- A script is a program to its user, but is written using shell commands
- So the shell language is okay for interaction and “quick-and-dirty” programs, making it a strange beast.
- For both, shell *variables* are extremely useful

Preview: Variables

```
i=17 # no spaces
set
echo $i
set | grep i
echo $i
unset i
echo $i
f1=$1
```

- (The last is very useful in scripts before shifting)
- Enough for next homework (arithmetic, conditionals, shift, variables, redirection, ...)
- Gotcha: using undefined variables (e.g., because of typo) doesn't fail (just the empty string)