# CSC209 Summer 2015 — Software Tools and Systems Programming

www.cdf.toronto.edu/~csc209h/summer/

Week 12 — July 30, 2015

Peter McCormick
pdm@cs.toronto.edu

Some materials courtesy of Karen Reid

# Course Evaluations

Please fill them out! All feedback is welcome and appreciated!

# Announcements

- Extra office hours
  - Tuesday, August 4, 2-4pm (BA3201)
  - Friday, August 7, 12:30-3pm (BA3289)
  - Monday, August 10, 1-4pm (BA3201)
- Labs are open and staffed tonight:
  - BA2210 and BA2220
- A4 is due next Friday, August 7 by 11:59pm

# Tutorial Ideas

- Get your questions answered
- Discuss A4
- Work on *Suggested Exercises* from week 9 onward:
  - https://github.com/pdmccormick/csc209-summer-2015/tree/master/lectures
- If you haven't already been doing so, practise your code reading comprehension skills by reading all of the lecture examples

# Cloning the Course Website

```
$ git clone https://github.com/...
$ cd csc209-summer-2015
$ cd lectures/weekN
$ ./run.sh example.c
```

```
$ git pull
```

# Agenda

- Shell Scripting

# Shell Scripting

See http://tldp.org/HOWTO/Bash-Prog-Intro-HOWTO.html
for a more detailed Bash tutorial

# *Scripting* Languages

# Programming *vs* Scripting Languages

C

Java

C++

JavaScript

Ruby

Python

- Compiled
- High(er) runtime performance
- More difficult to write
- *“Serious”*

- Interpreted
- Slower performance
- Easy to write
- *“Toy”*

# Programming *vs* Scripting Languages

Shell

# Shell as an Interactive Application

- Use *interactively* as our command interpreter
- Use for day-to-day tasks
  - Manipulating files and directories
  - Various pre-installed programs and our own

# Shell as an Scripting Language

- Bundle up a pre-existing sequence of commands into a *(shell) script* file

- Begin the file with the *shebang line* and set the file to be executable with **`chmod u+x`**

  - **`#!/bin/bash`**

  - Other command interpreters available (**`/bin/sh`**, **`/bin/zsh`**, your own **`./sh209`**), and you can use this trick with other scripting languages (i.e. **`/usr/local/bin/python`**)

# Builtins

- As we saw in A3, some shell commands are *built-in* and do *not* need to **`fork+exec`** to run

- `cd`
- `exit`
- *`echo`*
- `read`
- `test`
- `shift`
- `wait`
- `set`
- `unset`
- `export`
- `expr`

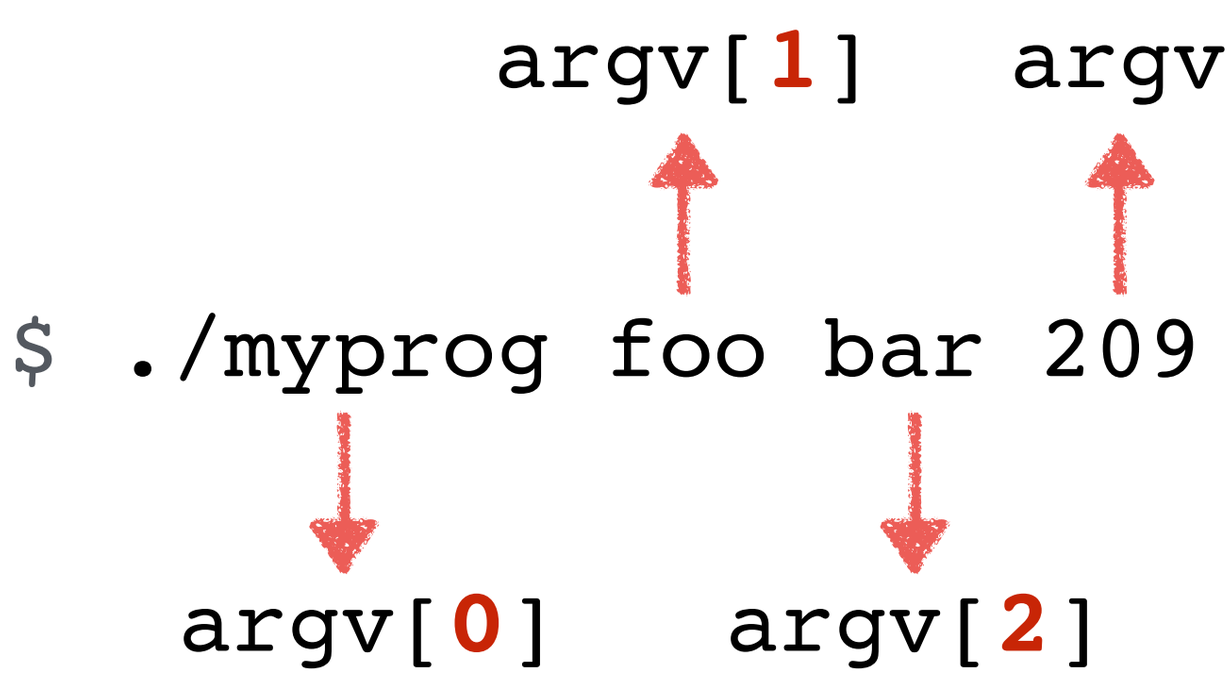
See **`man bash-builtins`** to learn about these and many more

# *String*-ly typed

The only data type is string

# Program Arguments

- Recall that your *sh209* implementation made a call to **`execvp`** and passed in an **`argv`** array:



# argv.c

```
$ ./argv foo bar 209
argv[0] = "./argv"
argv[1] = "foo"
argv[2] = "bar"
argv[3] = "209"
```

# Environment Variables

- We've seen a few of these before:
  `USER`, `HOME`, `PATH`
- Inspect their value as `$` variables:

```
$ echo $USER

g5stdnt
```

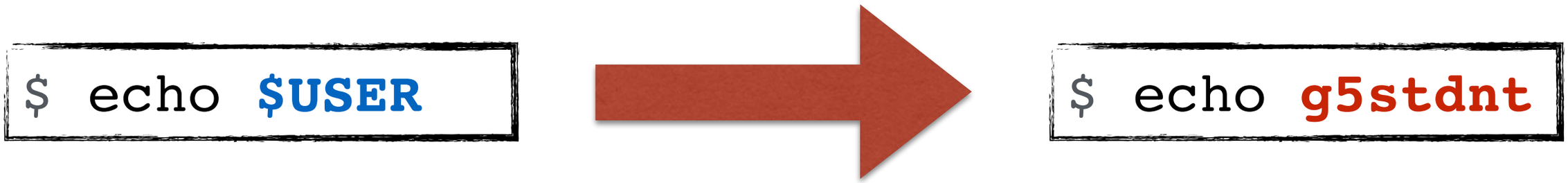
# Environment Variables

- What happens if we pass a variable in to one of our programs?

```
$ ./myprog $USER
```

# String Replacement

- The shell *substitutes* or expands expressions (like `$` variables) through string replacement *before* execution:



# Environment Variables

- **`env`**: print the environment (also runs programs in a modified environment)

```
$ env

USER=g5stdnt

HOME=/h/u15/c5/00/g5stdnt

PATH=/bin:/usr/bin:…

…
```

# Environment Variables

- You can create new environment variables or assign new values using the **`export`** builtin:

```
$ export FOO=bar
$ echo $FOO
bar
$ export FOO=209
$ echo $FOO
209
```

# Environment Variables

- You can remove an environment variable using **`unset`**:

```
$ export FOO=bar

$ echo FOO is $FOO

FOO is bar

$ unset FOO

$ echo FOO is $FOO

FOO is
```

# Environment Variables

- Child processes also *inherit* the environment mapping
- C programs can access it using the **`getenv()`** call

`getenv.c`

# envp.c

```
int main(int argc, char *argv[], char *envp[]);
```

The *true* signature of the main function actually has a **third** argument `envp`, a `NULL`-terminated array of `KEY=VALUE` pairs from the shell environment!

# Wildcard Substitution

- What arguments does the program get when you run the following?

```
$ ./myprog *.c
```

(these are called *glob expressions*)

# Local Variables

- Different than environment variables, but are `$` substituted in the same way
  - But unlike environment variables, child processes do *not* see them
- Assignment:

```
$ name=value
```

- Single assignment:

```
$ BIN209=“/u/csc209h/summer/pub/bin"

$ echo $BIN209
```

- Lists of values are typically *space separated*:

```
$ STAFF=“pdm t5champ”
```

# Local Variables

- The shell will perform substitutions anywhere it sees them, including in assignments!

```
$ REPO=$HOME/csc209-summer-2015

$ ALL_SRC=*.c
```

# Quoting

- You can use single (‘), double (“) or backtick (`) quotes to change how the shell performs substitutions

- *Double quotes* inhibit wildcard replacement only

```
$ echo “*.c”
*.c
```

- *Single quotes* inhibit wildcard replacement, variable substitution and command substitution.

```
$ echo ‘$USER *.c `ls`’

$USER *.c `ls`
```

# Quoting — Command Substitution

- *Backtick quotes* perform command substitution, capturing the standard output of a program as a string:

```
$ FOO=`echo hello world`

$ echo $FOO

hello world
```

*The backtick quote is on the same key as* **~**, *beside* ***1***

# Quoting — Command Substitution

- `$(…)` is an alternate syntax for backticks

```
$ LS_OUT=$(ls *.c)
$ echo $LS_OUT

argv.c getenv.c envp.c …
```

# Quoting — Examples

- Easy to make mistakes and over-quote or under-quote!

```
$ echo Today is date

Today is date

$ echo Today is `date`

Today is Thu Jul 30 14:13:11 EDT 2015

$ echo "Today is `date`"

Today is Thu Jul 30 14:13:11 EDT 2015

$ echo 'Today is `date`'

Today is `date`
```

# Quoting — Practise

- What do the following statements produce if the current directory contains the following non-executable files?

```
a b c
```

```
$ echo *
```

```
$ echo ls *
```

```
$ echo `ls *`
```

```
$ echo "ls *"
```

```
$ echo 'ls *'
```

```
$ echo `*`
```

# Control Statement — `for`

- Iterate through a space separated list

```
for colour in red green blue orange; do
   echo My favourite is $colour
done
```

```
My favourite is red
My favourite is green
My favourite is blue
My favourite is orange
```

# Control Statement — `for`

- Remember the quoting rules…

```
for colour in "red green blue orange"; do
   echo My favourite is $colour
done
```

```
My favourite is red green blue orange
```

# Control Statement — `for`

- Remember the quoting rules…

```
COLOURS=“red green blue orange"
for colour in $COLOURS; do
    echo My favourite is $colour
done
```

```
My favourite is red
My favourite is green
My favourite is blue
My favourite is orange
```

# Control Statement — `for`

- Remember the quoting rules…

```
COLOURS=“red green blue orange"
for colour in “$COLOURS”; do
   echo My favourite is $colour
done
```

```
My favourite is red green blue orange
```

# Exit Status Code

- Recall that C programs can terminate by either calling **`exit(`*`status`*`)`** or by returning a *status* from **`main()`**

- Convention: an exit status of **0** indicates *success*, and anything else is a failure

    - Think Boolean for *failed* (so 1, which is true in C, indicates that there was a failure, while 0 is false, there was *not* a failure, hence it was a success)

# Exit Status Code

- In the shell, special variable **`$?`** contains the exit status of the last command executed:

```
$ echo Hello!
Hello!
$ echo $?
0
```

- Apparently, **`echo`** exited successfully!

# Exit Status Code

- There are two simple programs which do nothing except return a status code

- `true`: do nothing, *successfully*

```
$ true
$ echo $?
0
```

- `false`: do nothing, un*successfully*

```
$ false
$ echo $?
1
```

# && and | |

- Shell operators corresponding to Boolean AND/OR that *short-circuit* (like in C, Java and Python!) depending on the exit status codes

```
$ false && false; echo $?

1

$ false && true; echo $?

1

$ true && false; echo $?

1

$ true && true; echo $?

0
```

# && and ||

- Shell operators corresponding to Boolean AND/OR that either succeed or fail depending on the success or failure (i.e. the exit status codes) of the operands

```
$ false || false; echo $?

1

$ false || true; echo $?

0

$ true || false; echo $?

0

$ true || true; echo $?

0
```

# && and | |

- Shell operators corresponding to Boolean AND/OR that either succeed or fail depending on the success or failure (i.e. the exit status codes) of the operands

```
$ true && echo always

always

$ echo $?

0


$ true || echo never

$ echo $?

0
```

# && and | |

- These operators *short-circuit* (like they do C, Java and Python) meaning they may not have to execute the second argument

```
$ false && echo never

$ echo $?
1


$ false || echo always
always
$ echo $?
0
```

# && and | |

- These operators *short-circuit* (like they do C, Java and Python) meaning they may not have to execute the second argument

```
$ echo first && echo second

first

second

$ echo $?

0


$ echo first || echo second

first

$ echo $?

0
```

# Control Statement — `if`

```
if condition; then
    # condition succeeded (status 0)
    …
else
    # condition failed (status != 0)
    …
fi
```

```
if condition; then
    # condition succeeded (status 0)
    …
fi
```

- **`condition`** is a command that is executed and its exit status is checked for success/failure

# Builtin `test`

- Construct conditional statements, returning a suitable exit status
- Also usable as `[ [ … ] ]`

```
if test …; then
   …
fi
```

```
if [[ … ]]; then
   …
fi
```

# Builtin `test`

| | |
|---|---|
| `-d filename` | Exists as a directory |
| `-f filename` | Exists as a regular file |
| `-r filename` | Exists as a readable file |
| `-w filename` | Exists as a writable file |
| `-x filename` | Exists as an executable file |
| `-z string` | True if empty `string` |
| `str1 = str2` | True if `str1` equals `str2` |
| `str1 != str2` | True if `str1` not equal to `str2` |
| `int1 -eq int2` | True if `int1` equals `int2` |
| `-ne -gt -lt -le -ge` | Not equal, greater than, less than, less than or equal, greater than or equal |
| `-a -o` | And, or |

# Builtin `test` — Examples

```
if test -f  run.sh; then
  echo “A file named run.sh exists”
fi
```

```
if [[ -x  run.sh ]]; then
  echo “run.sh exists and is executable”
fi
```

```
# Ensure directory “bin” exists
[[ ! -d bin ]] && mkdir bin
```

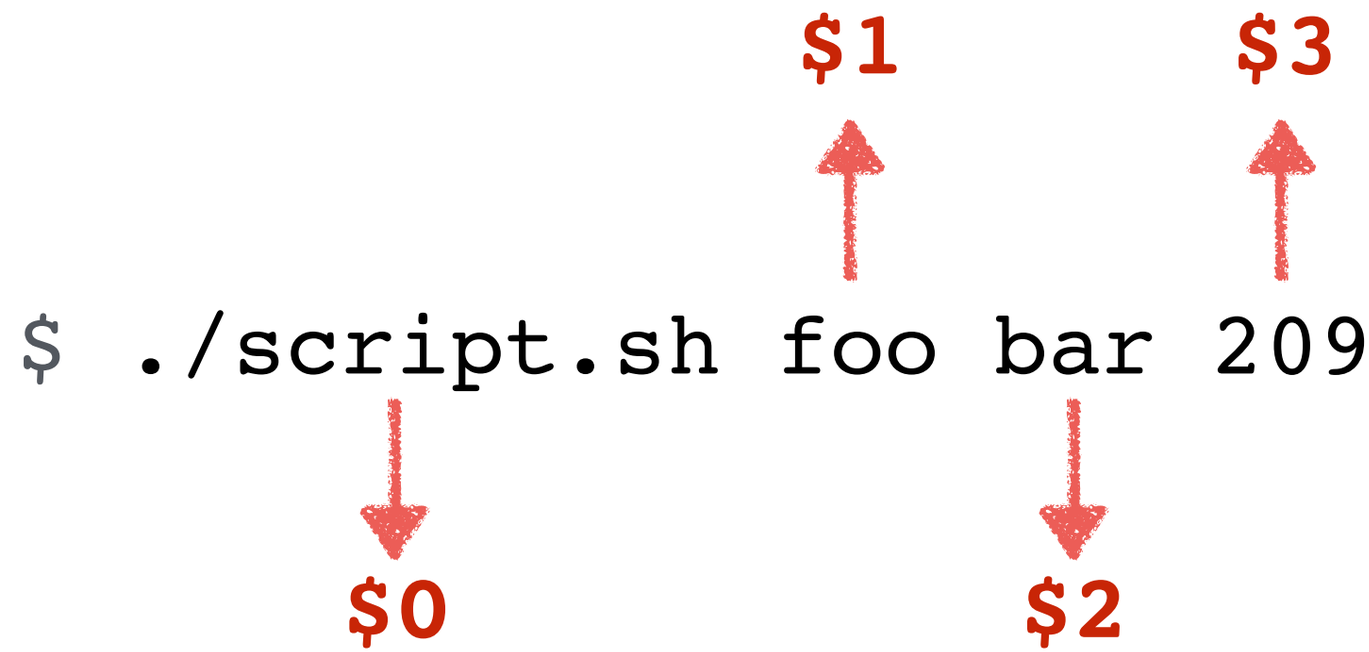
# Control Statement — `while`

- Loops as long as ***`condition`*** succeeds

```
while condition; do
    ...
done
```

# Positional Parameters

- The shell gives us *special* builtin variables that correspond to the arguments passed into a shell script:



# Positional Parameters

posargs.sh:

```
#!/bin/bash

echo arg0: $0
echo arg1: $1
echo arg2: $2
echo all : $*
```

```
$ ./posargs.sh foo bar quux
arg0: ./posargs.sh
arg1: foo
arg2: bar
all : foo bar quux
```

Don’t forget to **`chmod u+x`** to make your script executable!

# Positional Parameters

| | **What it references** |
|---|---|
| **`$0`** | Name of the script |
| **`$#`** | Number of positional parameters |
| **`$*`** | Lists all positional parameters |
| **`$@`** | Same as **`$*`** except when in quotes |
| **`"$*"`** | Expands to a single argument (**`"$1 $2 $3"`**) |
| **`"$@"`** | Expands to separate arguments (**`"$1" "$2" "$3"`**) |
| **`$1 .. $9`** | First 9 positional parameters |
| **`${10}`** | 10th positional parameter |

# Looping over Quoted Positional Parameters

- Correctly quoting in a **`for`** loop can be tricky!

```
for ARG in "$*"; do
    echo “$ARG”
done
```

Quotes mean arguments are all in *one* string.

```
for ARG in $*; do
    echo “$ARG”
done
```

One element for each argument (*irrespective of how it was passed*)

# Looping over Quoted Positional Parameters

```
for ARG in "$@"; do
    echo “$ARG”
done
```

Quotes in original argument list are preserved

```
for ARG in $@; do
    echo “$ARG”
done
```

Same as `$*`, does *not* preserve original quotes

# loopquotes.sh

# set

- `set`: assigns positional parameters to its arguments

```
$ set foo 209 BAZ

$ echo $3 $2 $1

BAZ 209 foo
```

- Useful in conjunction with command expansion:

```
$ set `date`

$ echo “Today is $2 $3, $6”

Today is Jul 30, 2015
```

# shift

- `shift`: throws away `$0` and assigns `$0` ← `$1`, then `$1` ← `$2`, etc.

```
$ set first second third

$ echo $1 $2 $3

first second third

$ shift

$ echo $1 $2 $3

second third

$ shift

$ echo $1 $2 $3

third
```

# shift

- Use **`shift`** with a **`while`** loop to handle a variable number of arguments to your script:

**`peel.sh:`**

```
#!/bin/bash

while [[ "$1" ]]; do
    echo ARG: "$1"
    shift
done
```

```
$ ./peel.sh a “b c” d
ARG: a
ARG: b c
ARG: d
```

# run.sh

# `expr` — evaluate expression

- Since the shell only deals with strings, to perform arithmetic we need some extra help:

```
$ x=1

$ x=`expr $x + 1`

$ y=`expr 3 \* 5`

$ echo $x $y

2 15
```

# `expr` — evaluate expression

- `expr` can also check if one string is a *substring* of another

```
$ expr "Hello World" : Hello

5

$ expr "Hello World" : Bonjour

0
```

- This is very weak! Use `awk`/`sed` or Python if you need more

# `read` — consume standard input

- **`read`** will read one line from standard input and assigns successive space separated words to the specified variables
- Leftover words are assigned to the last variable

name.sh:

```
#!/bin/bash
echo "Enter name: ”
read FIRST LAST
echo "First: $FIRST"
echo "Last : $LAST"
```

```
$ ./name.sh
Enter name: A B C
First: A
Last : B C
```

# prefixcat.sh

# Subroutines

- You can create your own functions or subroutines:

```
myfunc() {
  arg1=$1
  arg2=$2
  echo $arg1 $globalvar
  return 0
}
```

- globalvar="I am global"
- myfunc num1 num2

# Defining Subroutines

- The shell lets you group code into reusable subroutines or functions

```
#!/bin/bash


helper() {
   echo “$0“
    echo “$@“
   return 10
}

helper a “B C” d
echo $?
```

# Next Week

- Extra office hours: Tuesday and Friday (plus a week Monday)
- A4 due on Friday
- Next Thursday's lecture will be exam review
    - Bring your questions

# Labs

- Go ask questions and get help!
- **BA2210** and **BA2220**