Introduction to Bash

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Introduction

- **About me**
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Bash and Me

- Used throughout career
- Never learned formally
- Stumbled around, lots of mistakes
- Slowly learned concepts and key points
- Wrote a book

This Course

- Live Walkthroughs
  - Encourage you to follow - ‘Hard Way’ Method
- Exercises
- Polls / yes/no ‘temperature checks’
- Group chat
- Materials:
  - https://github.com/ianmiell/introduction-to-bash

Pre-Requisites

- **Familiar with command line**
- **Bash version 4+**
  - `$ echo $SHELL`
  - `$ bash --version`
  - <4 is still ok
- **Basic shell utilities (eg grep, cat, ls)**
- **Any editor (I use vim)**

Target Audiences

- **No knowledge assumed**
  - Advanced questions outside the course please
- **‘Hardly/never used bash’**
  - Coverage of 90% of bash features
- **‘Used bash casually for a while’**
  - Refresher on some topics, learn some new things
- **‘Used bash for years, but never studied’**
  - A-ha moments

Why This Course?

- **Bash is everywhere**
- **Shells are everywhere**
- **Work with it every day**
- **Taken for granted that it’s known**
- **Studying it pays massive dividends**
    - Gateway to deeper OS concepts

Bash is under-served

- Man page is hard to follow if you don’t know the jargon
- One-liners are easy to find but concepts give you real power
- Guides that assume knowledge you may not have

Ever been confused by…?

- Diffference between ‘[‘ and ‘[[‘
- Globs vs regexes
- Single vs double quotes
- Difference between `` and $()
- What a subshell is

Recently I’ve used bash to...

- Fix a Terraform script
- Robustly apply changes in a cloud-init VM script
- Automate the renaming of files with spaces in my backup folders
- Setup environments at work

Poll - Experience

- Never used bash
- Used bash for <2 years
- Used bash for >2 years
- Used bash for >5 years
- Studied bash seriously

Structure of Course

- Part I – Bash Basics
- Part II – Further Bash Basics
- Part III - Scripting
- Part IV - Advanced

Discussion

- **What do you want to achieve in bash?**
  - **Any specific goals?**
  - **What have you been frustrated by with bash?**

Part I – Bash Basics

- 1.1 Bash background
- 1.2 Variables
- 1.3 Globs
- 1.4 Pipes and Redirects

1.1 What is Bash?

- What is a shell?

- A program takes input from a terminal

- Translates input into:
  - System calls
  - Calls to other programs
  - Computation within the bash program

- Bash excels at ‘gluing’ other commands together

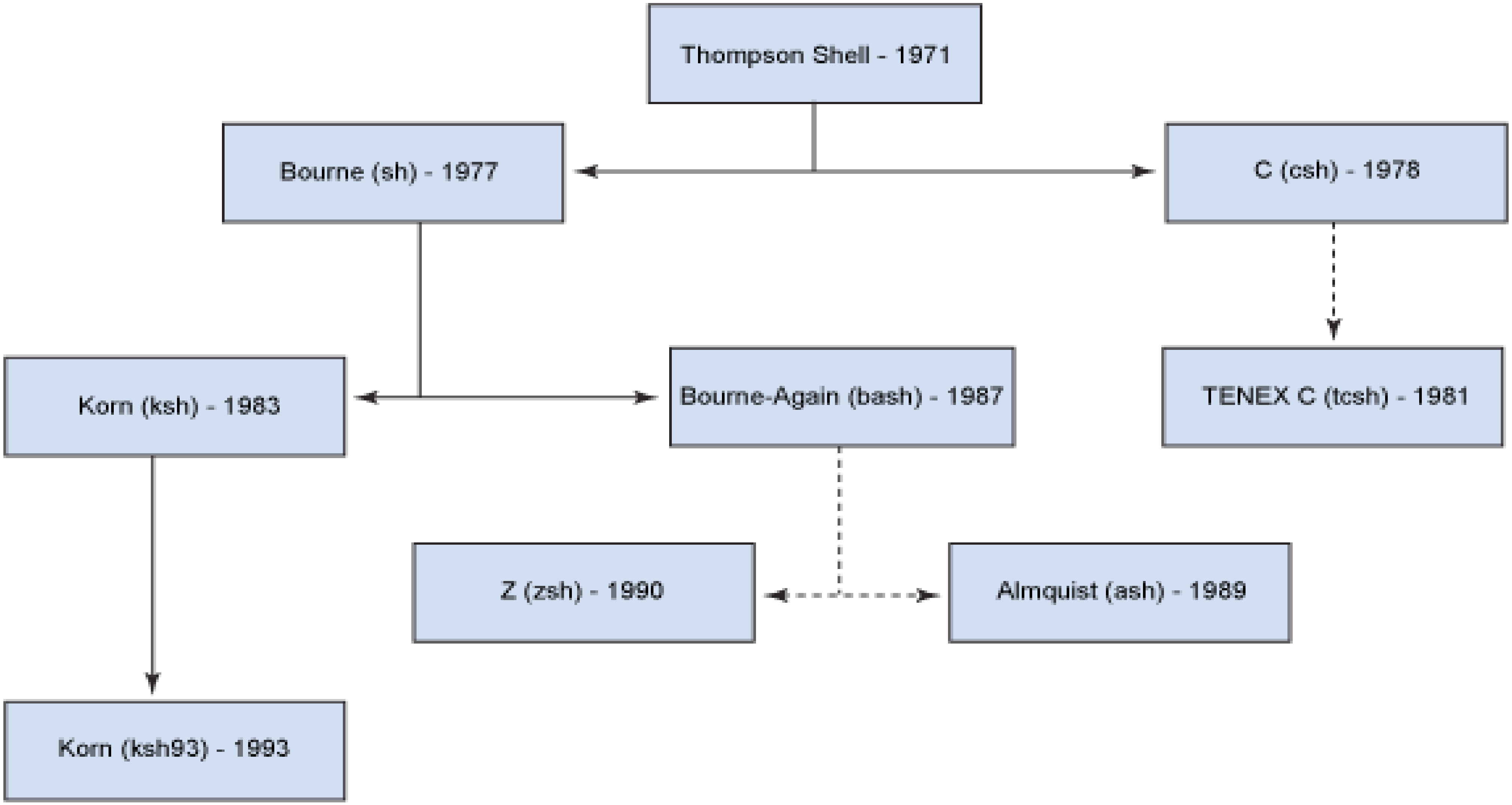
Other shells

- sh
- ash
- ksh
- tcsh
- tclsh

Walkthrough

- **Run tcsh from bash**

History of Shells



Bash in the Market

- Most popular shell

- Lots of competition:
  - zsh will be default on mac
  - fish is also popular

- Very rarely, you find servers that don’t have bash on still

1.2 Variables

- Basic variables
- Quoting variables
- ‘env’ and ‘export’
- Simple arrays

Walkthrough - Basic Variables

- **Assignment**
- **De-referencing**

Walkthrough – Variables and Quotes

- **Why Quote?**
- **Space separation**
- **Double quotes and variables**
- **Single quotes and variables**

Walkthrough – Shell Variables

- What are Shell Variables?
- Readonly variables
- Exporting variables
- Ouptutting exported and shell variables

Walkthrough - Arrays

- Zero-indexed
- Curly braces required
- All variables are arrays!
- declare -a

Recap - Variables

- $ dereferences
- Variables in double quotes are interpreted, single quotes not
- Exported variables are passed to programs run within the shell
- Env shows exported variables, compgen -v shows all variables

1.3 Globbing

- What does ‘*’ mean?
- Differences to regular expressions
- Not familiar with regexes?

Activity – Basic globbing

- ls *
- Shell interpretation
- Globbing and quoting

Activity – Other Glob Characters

- Character classes
- Dots and dotfiles
- .* vs *
- ?
- Special directories

Activity – Difference to Regexps

- Renaming a set of files
- ‘.*’ is not the same as ‘*’!
- Extended globbing available in bash (not covered)

Recap - Globs

- What a glob is
- What a dotfile is
- Special directory files
- Globs, regexps and dots

Exercise I

1.4 Pipes and Redirects

- Basic redirects
- Basic pipes
- File descriptors
- Special files
- Standard out vs standard error

Walkthrough – Basic Pipes and Redirects

- The ‘>’ operator
- Simple pipe

Walkthrough – Standard out / error

- Errors and pipes
- ‘Channels’
- File descriptors
  - 0 – standard input
  - 1 – standard output
  - 2 – standard error

Walkthrough – Standard out / error

- ‘n>’ notation
- 2>&1
- Ordering is important
- Bash parses left to right

Walkthrough – Pipes vs Redirects

- Pipes ‘eat’ standard output from a command
- Pipes ‘output’ standard input to another command
- Redirects send a channel of output to a file
- The ‘<’ operator
- The ‘>>’ operator

Recap – Pipes vs Redirects

- **The main 3 file descriptors**
- **‘>’ vs ‘>>’**
- ***n*> and standard error**
- **2>&1 and ordering**

Part I Recap

- Globs
  - vs regexps
- Variables, arrays
- Pipes and redirects
- File descriptors

Exercise II

Break

Part II – Further Bash Basics

- 2.1 Functions
- 2.2 Tests
- 2.3 Loops
- 2.4 Exit Codes
- 2.5 Process Substitution
- 2.6 Command Substitution

Discussion

- Is bash a programming language?
- What is a programming language?
- Why has bash lasted so long?

2.1 Functions in Bash

- **Four types of command:**

  - **Function**
  - **Alias**
  - **Program**
  - **Builtin**

Walkthrough - Basic Functions

- Declaring a function
- Function arguments
- Variable scope
- Local variables

Walkthrough - Builtins

- cd is a builtin
- Builtins can also be programs
- ‘builtin’ is a builtin!
- Functions and builtins
- unset -f
- declare -f / -F

Walkthrough - Programs

- **‘which’**

Walkthrough - Aliases

- ‘alias’
- ‘unalias’
- The ‘type’ builtin

2.2 Tests

- Bash tests
- Different ways of writing tests
- Logical operators
- Binary and unary operators
- ‘if’ statements

Walkthrough – Basic Tests

- Tests and exit codes
- Comparing values
- What is ‘[‘?

Walkthrough – Logical Operators

- ‘!’ means ‘NOT’
- ‘||’ means ‘OR’
- ‘&&’ means ‘AND’
- ‘(...)’ evaluates first
- ‘-a’ vs ‘&&’

Walkthrough – The ‘[[‘ Operator

- **Why do both exist?**
- **Confused?**

Walkthrough – Unary and Binary Operators

- ‘-z’
- ‘-a’
- ‘-d’
- Types in bash

Walkthrough – if Statements

- Basic ‘if’ statements
- Bare ‘if’ statements

Recap - Tests

- Tests in bash
- ‘[‘ vs ‘[[‘
- Unary vs Binary operators
- Types in bash (limited)

2.3 Loops

- ‘C’-style for loops
- ‘for’ loops over items ‘in’ lists
- ‘while’ and ‘until’ loops
- ‘case’ statements

Walkthrough – Loops

- C-style - ‘((‘
  - Different variable referencing
- ‘for f in $()’
  - Beware!
- ‘while’ and ‘until’
- Infinite loop form with ‘break’

Walkthrough – Loops

- ‘case’ statements
- ‘esac’, ;; and *)
- Command line options

Recap – Loops

- Two types of for loop
- while and until
- case statements
- command line options

2.4 Exit Codes

- What an Exit Code is
- How to set one
- Conventions
- Other ‘special’ parameters

Walkthrough – Exit Codes

- The ‘$?’ variable
- ‘0’ or ‘not 0’
- Exit codes and tests

Standard Exit Codes

- 0 – OK
- 1 – General Error
- 2 – Misuse of shell builtin
- 126 – Cannot execute
- 127 – No file found matching command
- 128 – Invalid exit value
- (128 + n) – Process killed with signal ‘n’

- (Signals covered in Part IV)

Walkthrough – Exit Codes

- **Exit codes used differently by different apps**
- **eg grep**
- **The ‘exit’ builtin**
- **The ‘return’ builtin**

Walkthrough – Special Parameters

- Special parameters == special variables
- $?
- $$
- man bash

Recap – Exit Codes

- Standard exit codes
- Exit code usage (eg grep)
- Setting exit codes
- ‘return’ing from functions
- Special parameters

Exercise III

2.5 Process Substitution

- **The ‘<()’ operator**
- **Substitution of file arguments**

Walkthrough – Process Subsitution

- **The ‘<()’ operator**
- **Substitution of file arguments**

2.6 Command Substitution

- **The ‘$()’ operator**

Walkthrough – Command Substitution

- The ‘$()’ operator
- $() vs ``
- Nesting

Discussion / Recap – Part II

- Bash more as programming language:
  - Functions
  - Tests / ifs
  - Loops
  - Return/Exit codes
  - Process and command substitution

- $() vs ``

Break

Part III - Scripting

- Scripts and Startup
- The ‘set’ Command
- Debugging in bash
- Subshells
- IFS

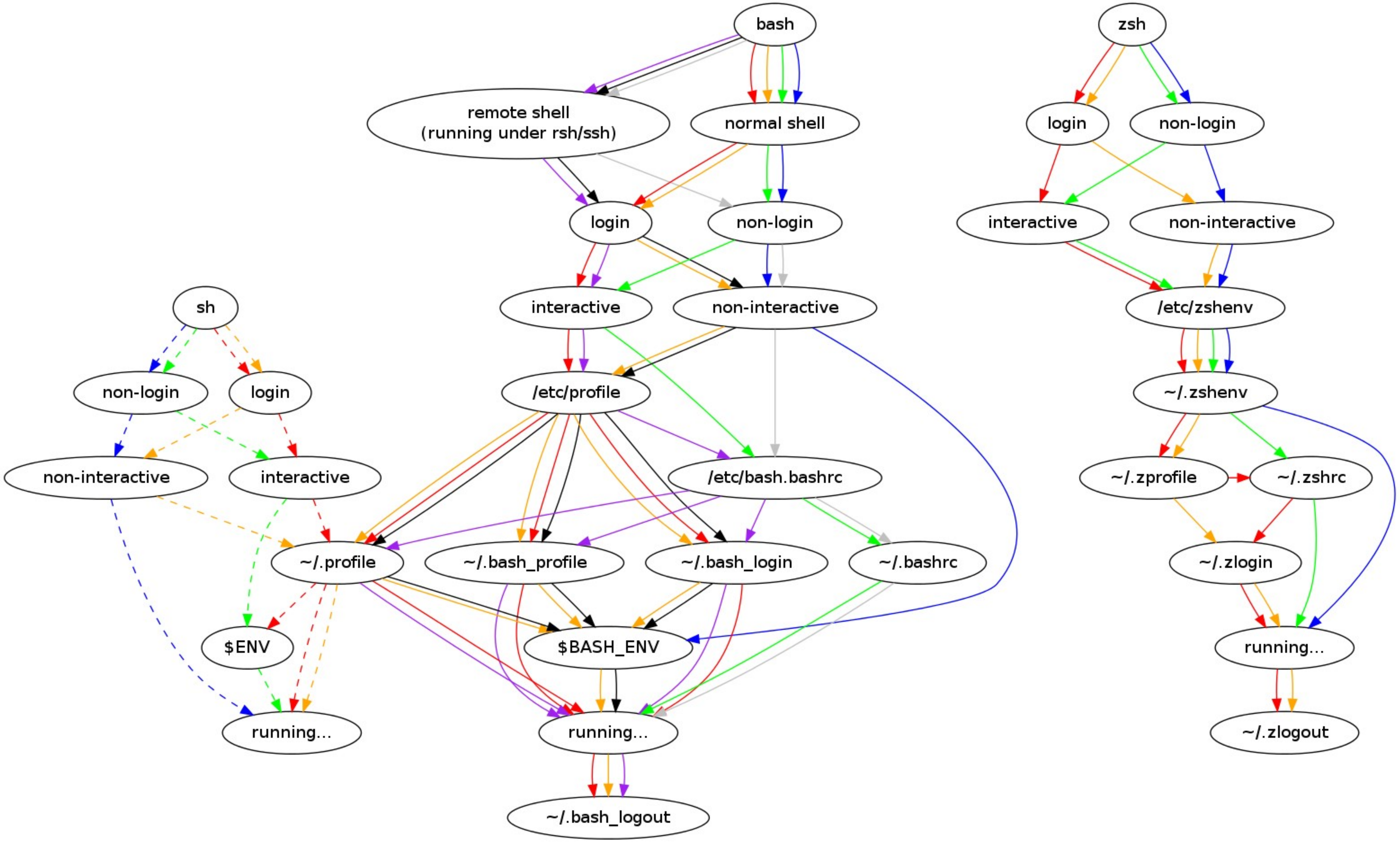
3.1 Scripts and Startup

- **What shell scripts are**
- **What happens on bash startup**
- **This has cost me many hours!**

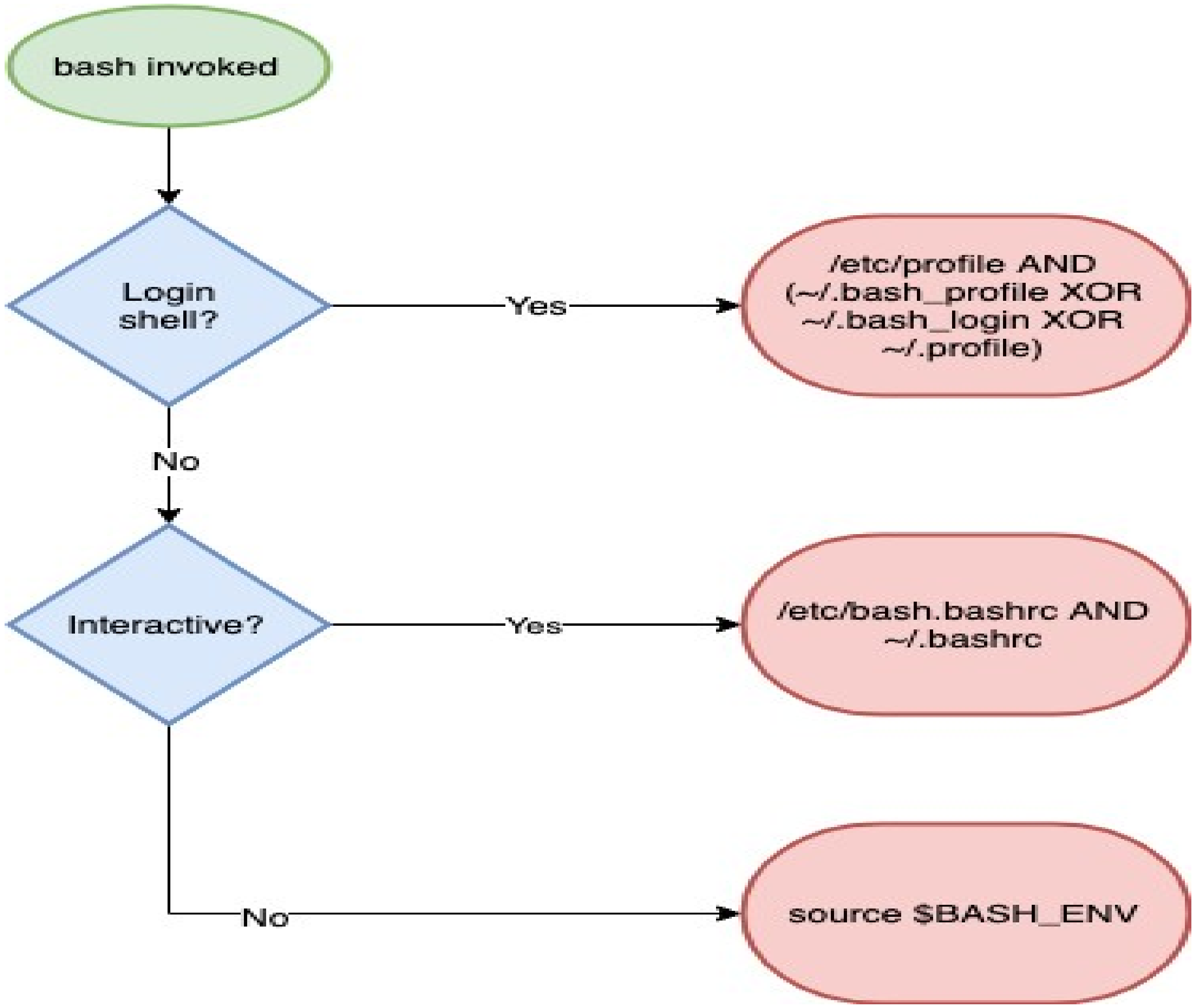
Walkthrough – Shell Startup

- The ‘shebang’ - ‘#!’
- What happens on bash startup
- Running an executable file
- Making a file executable

Walkthrough – Startup Explained



Walkthrough – Startup Explained (simpler)


bash invoked
Login shell?
Yes
/etc/profile AND (~/.bash_profile XOR ~/.bash_login XOR ~/.profile)
No
Interactive?
Yes
/etc/bash.bashrc AND ~/.bashrc
No
source $BASH_ENV

Walkthrough - sourcing

- The ‘source’ builtin
- ‘source’ vs ‘./’
- The ‘sh’ suffix
- Debugging with ‘env -i’

Recap - Scripts and Startup

- **What shell scripts are**
- **How complex bash startup can be**
- **Keep diagram handy!**

3.2 The ‘set’ builtin

- Setting options in bash
- What POSIX is
- Most useful options:
  - nounset
  - xtrace
  - errexit
  - pipefail
- ‘set’ vs ‘shopt’

Walkthrough – Running ‘set’

- ‘set’
- POSIX
- set POSIX off
- + is off – is on (this IS confusing)
- ‘set’ vs ‘env’

Walkthrough – ‘set’ Options

- **errexit**
- **xtrace**
- **nounset**
- **flags vs -o *name***
- **pipefail**
- **‘set’ vs ‘shopt’**

Recap - ‘set’

- Options: + off, - on
- POSIX
- Most common options
- shopt and set

3.3 Debugging bash

- ‘set’ flags already covered
- Syntax checking
- Profiling bash and ‘PS4’
- Shellcheck

Walkthrough – bash Arguments

- bash -n
- bash -v
- bash -x
- bash -x and PS4
- shellcheck my bashrc

Exercise IV

3.4 Subshells

- What is a subshell?
- How to create a subshell
- Why they are useful
- () vs {}

Walkthrough - subshells

- A simple subshell
- Subshells and variable scope
- Subshells and redirection
- () or {}?
- Subshells and working directory

3.5 Internal Field Separator

- aka IFS
- Why it’s important
- How to use it

Walkthrough – Spaces in Filenames

- **‘for’ looping over files**
- **The IFS shell variable**
- **The $’’ construct**

Walkthrough – Spaces in Filenames

- Setting IFS
- The ‘find’ command and ‘xargs’
- find, xargs and the null byte separator

Exercise V

Part III – Discussion / Recap

- Shell Startup
- Practical bash usage
  - Shell options
  - Shell debugging
  - IFS

Break

Part IV – Advanced Bash

- Traps
- String manipulation
- Autocomplete
- Walkthrough a ‘real’ script

4.1 Jobs and Traps

- Background jobs
- Traps and signals
- The ‘kill’ command
- The ‘wait’ builtin
- Trapping signals
- Process groups

Standard Exit Codes

- 0 – OK
- 1 – General Error
- 2 – Misuse of shell builtin
- 126 – Cannot execute
- 127 – No file found matching command
- 128 – Invalid exit value
- (128 + n) – Process killed with signal ‘n’

- (Signals covered in Part IV)

Exercise VI

4.2 String Manipulation

- Why use bash for this?
  - Quicker
  - No dependencies
- Editing/examining strings in bash
- Avoiding common quoting problems

Walkthrough – String Manipulation

- **Get string length**
  - **${#VAR}**

- **String slicing**
  - **${VAR:2}**
  - **${VAR:2:3}**

- **String editing**
  - **${VAR/234/432}**
  - **${VAR//234/432}**

Walkthrough – Advanced Strings

- **Requires 4.x+**

  - **${VAR,}**
  - **${VAR,,}**
  - **${VAR^}**
  - **${VAR^^}**

Walkthrough – Quoting Hell

- Quotes in quotes
- Changing quotes mid-line

4.3 – Autocomplete

- How autocomplete works
- The ‘shift’ command
- Writing your own autocompletes

Walkthrough – A Simple Program

- myecho
- ‘shift’
- Colours
- ‘$@’

Walkthrough – Autocomplete Script

- myechocomplete
- Sourcing
- Advanced autocompletion
- Write your own!

Discussion – cheapci script

- **https://github.com/ianmiell/cheapci**

Wrapup

- Feedback welcome
- Thanks!
- Any questions:
  - @ianmiell
  - ian.miell@gmail.com

Wrapup

- https://github.com/ianmiell/introduction-to-bash
- https://github.com/ianmiell/cheapci

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