Introduction to Bash

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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**
- **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
- **Using zsh (eg on Mac)**
  - **Type ‘bash’ to get a bash shell**
- **Basic shell utilities (eg grep, cat, ls)**
- **Any editor (I use vim)**

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**

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

Ever been confused by…?

- Diffference between ‘[‘ and ‘[[‘
- Globs vs regexes
- Single vs double quotes
- Difference between `` and $()
- How a bash script is created

Recently I’ve used bash to…

- **Fix a Terraform script**
- **Write and debug various CI/CD pipelines**
- **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**

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

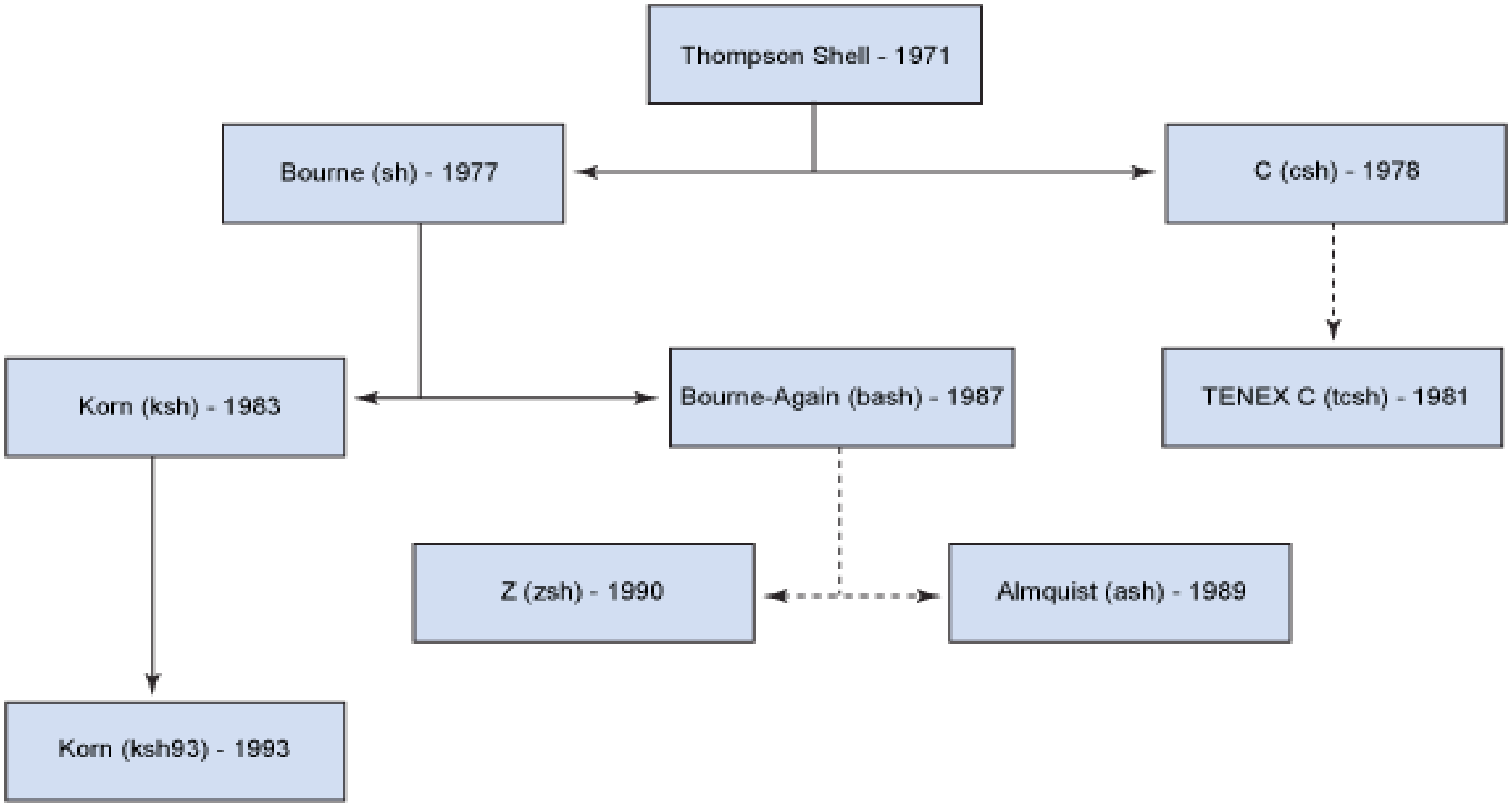
Other shells

- sh
- ash
- ksh
- tcsh
- zsh

What is Bash? - Walkthrough

- **Run tcsh from bash**

History of Shells



Bash in the Market

- **Most popular shell**
- **Lots of competition:**
  - **zsh now 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**

Variables - Recap

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

1.3 Globbing

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

Recap - Globs

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

1.4 Pipes and Redirects

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

Pipes and Redirects - Walkthrough

- **Simple pipes and redirects**
- **Standard in/out/error**
- **File Descriptors**

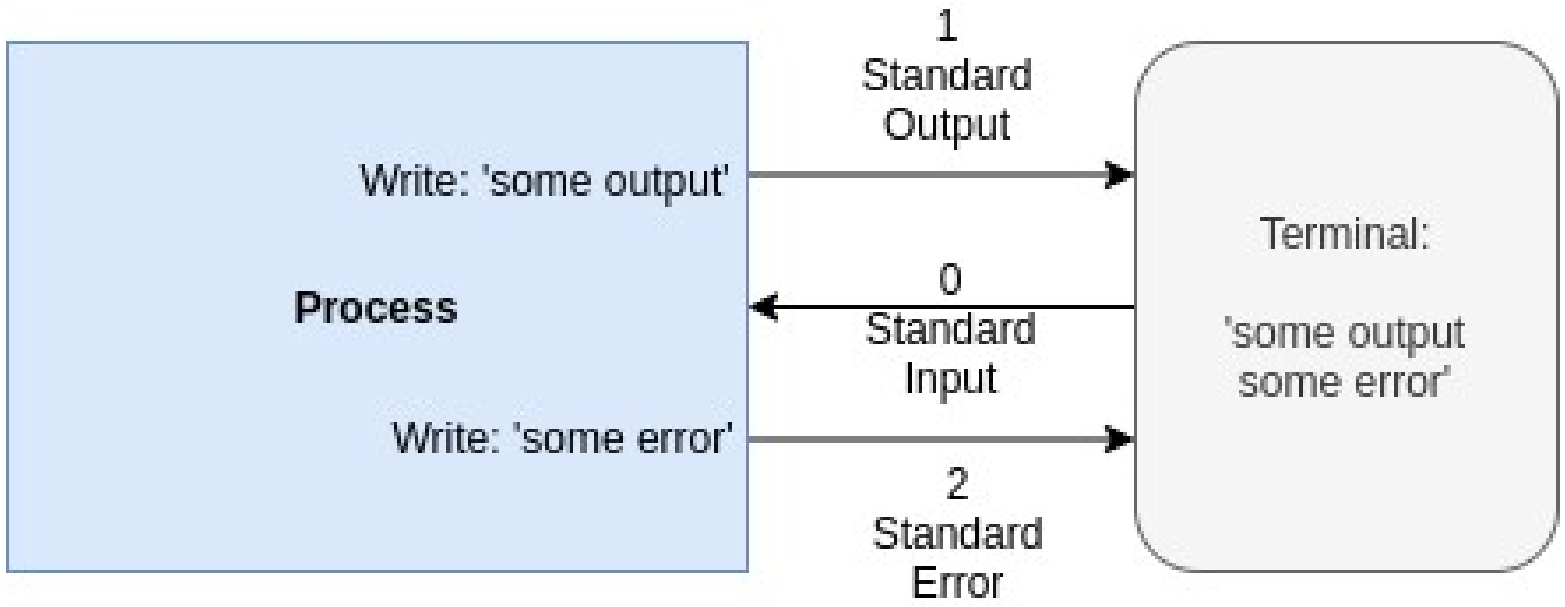
File Descriptors (I)

- Every process gets three file descriptors:
  - 0 - ‘standard input’
  - 1 - ‘standard output’
  - 2 - ‘standard error’
- ‘Normal’ output goes to file descriptor 1
- Programs generally output errors to file descriptor 2
- Normally ‘stderr’ and ‘stdout’ both go to the terminal – but you can change that!

Pipes and Redirects

Default

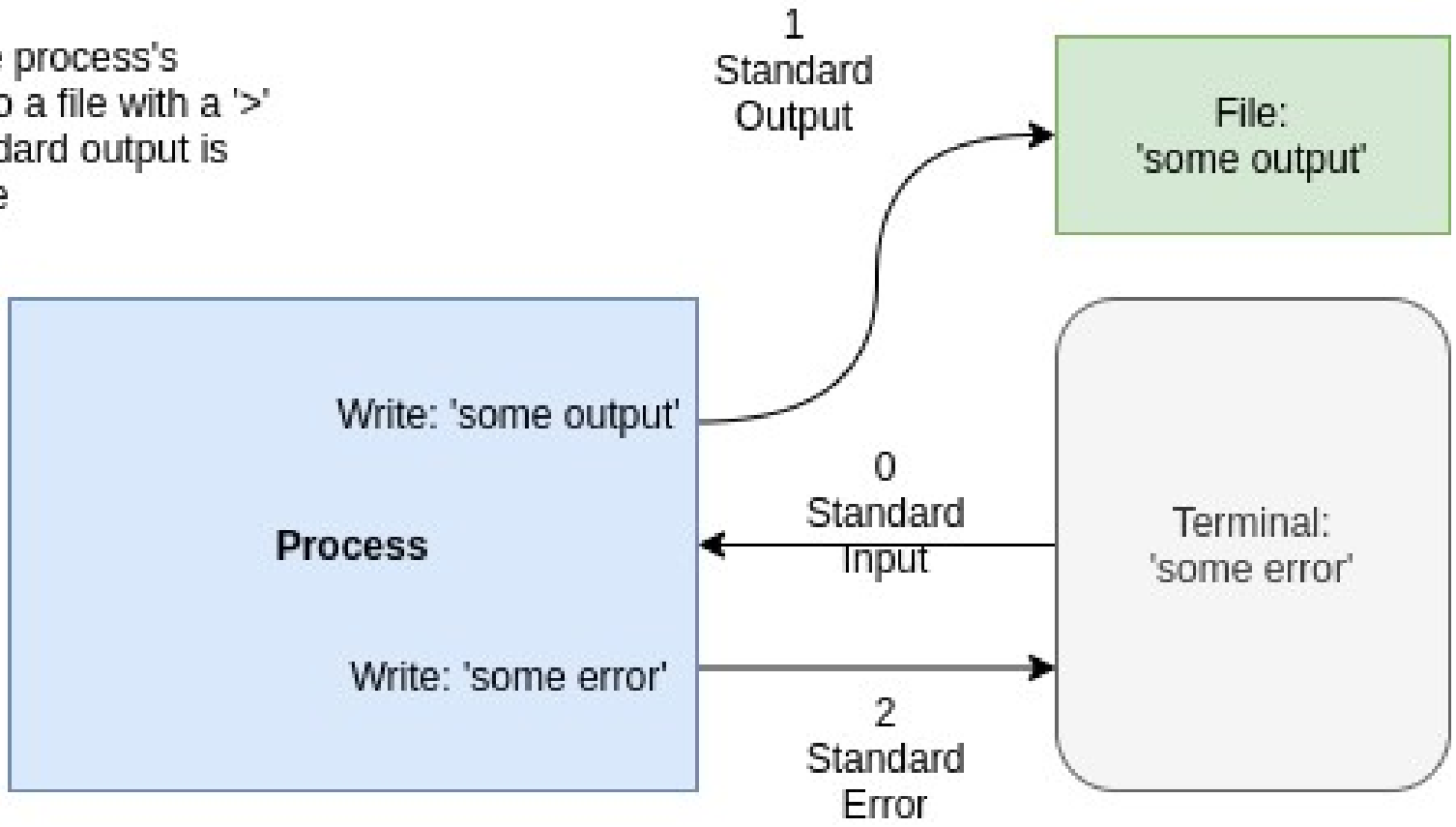
No redirects



Pipes and Redirects

Basic Redirect

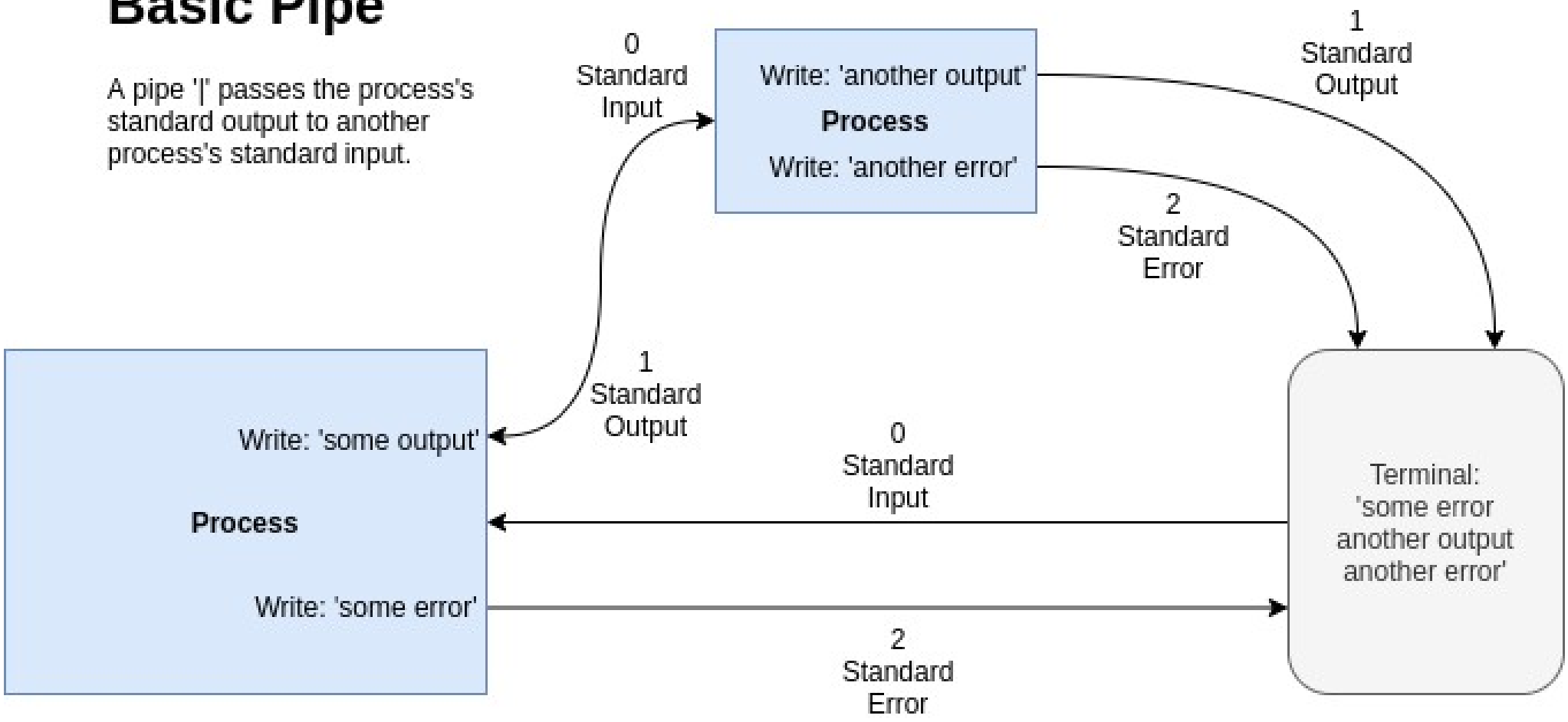
By redirecting the process's standard output to a file with a '>' (or '1>'), the standard output is redirected to a file



Pipes and Redirects

Basic Pipe

A pipe '|' passes the process's standard output to another process's standard input.



File Descriptors (II)

- ‘>’ operator sends standard output to a file
  - ‘1>’ is the same (1 is assumed)
- ‘2>’ sends standard error to a file
- ‘|’ sends standard output to a process
- Advanced, but often seen:
  - 2>&1 sends standard error to whatever standard output is pointed at
  - A way of sending ‘all’ output to a file

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 I / Break

Part II – Further Bash Basics

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

Discussion

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

2.1 Command Substitution

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

2.2 Functions in Bash

- **Four types of command:**
  - **Function**
  - **Alias**
  - **Program**
  - **Builtin**

2.3 Tests

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


2.4 Loops

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

2.5 Exit Codes

- What an Exit Code is
- The ‘$?’ variable
- How to set one
- Exit Code conventions
- Other ‘special’ parameters

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)

Recap – Exit Codes

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

Discussion / Recap – Part II

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

- **$() vs ``**

Exercise II / Break

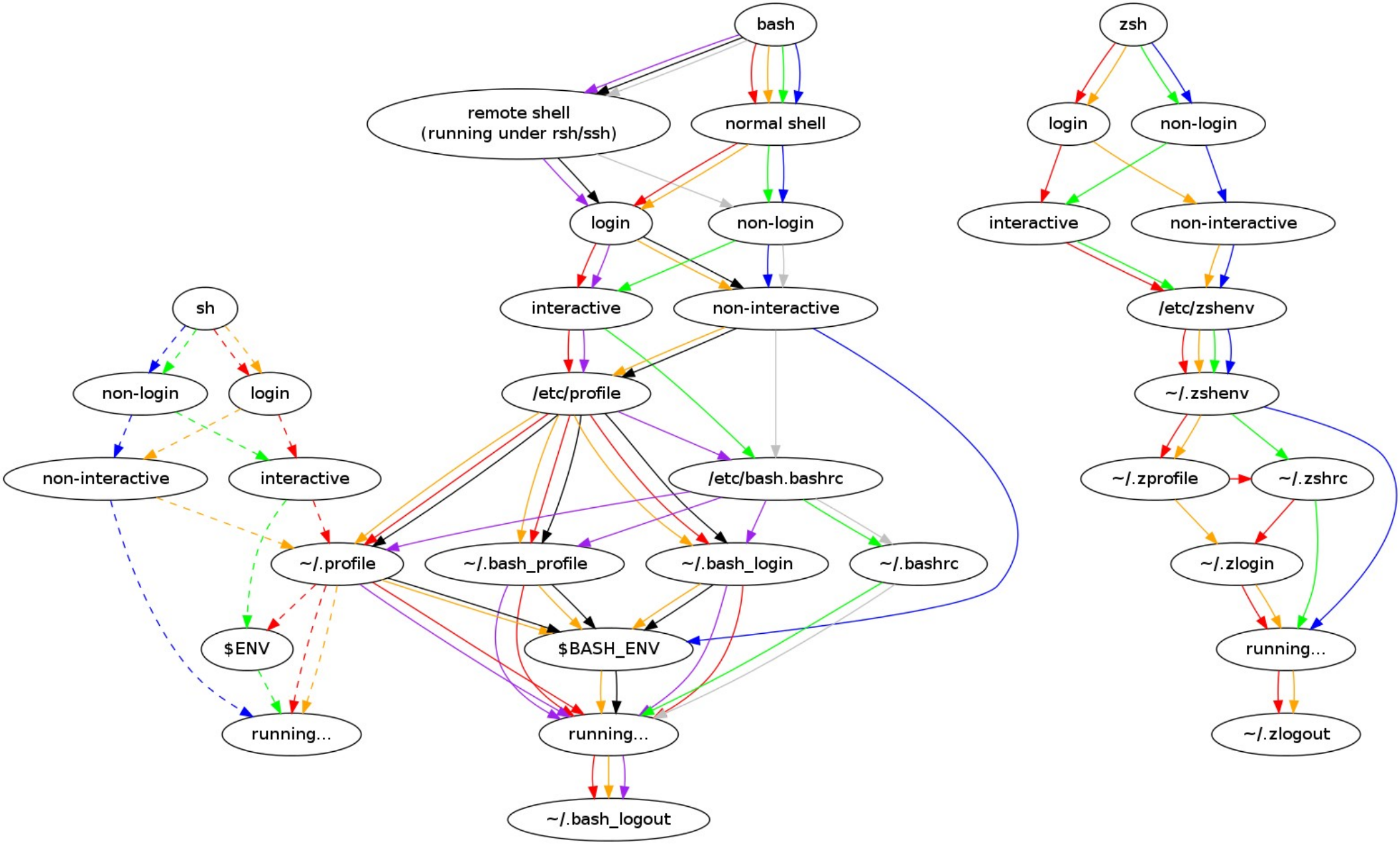
Part III - Scripting

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

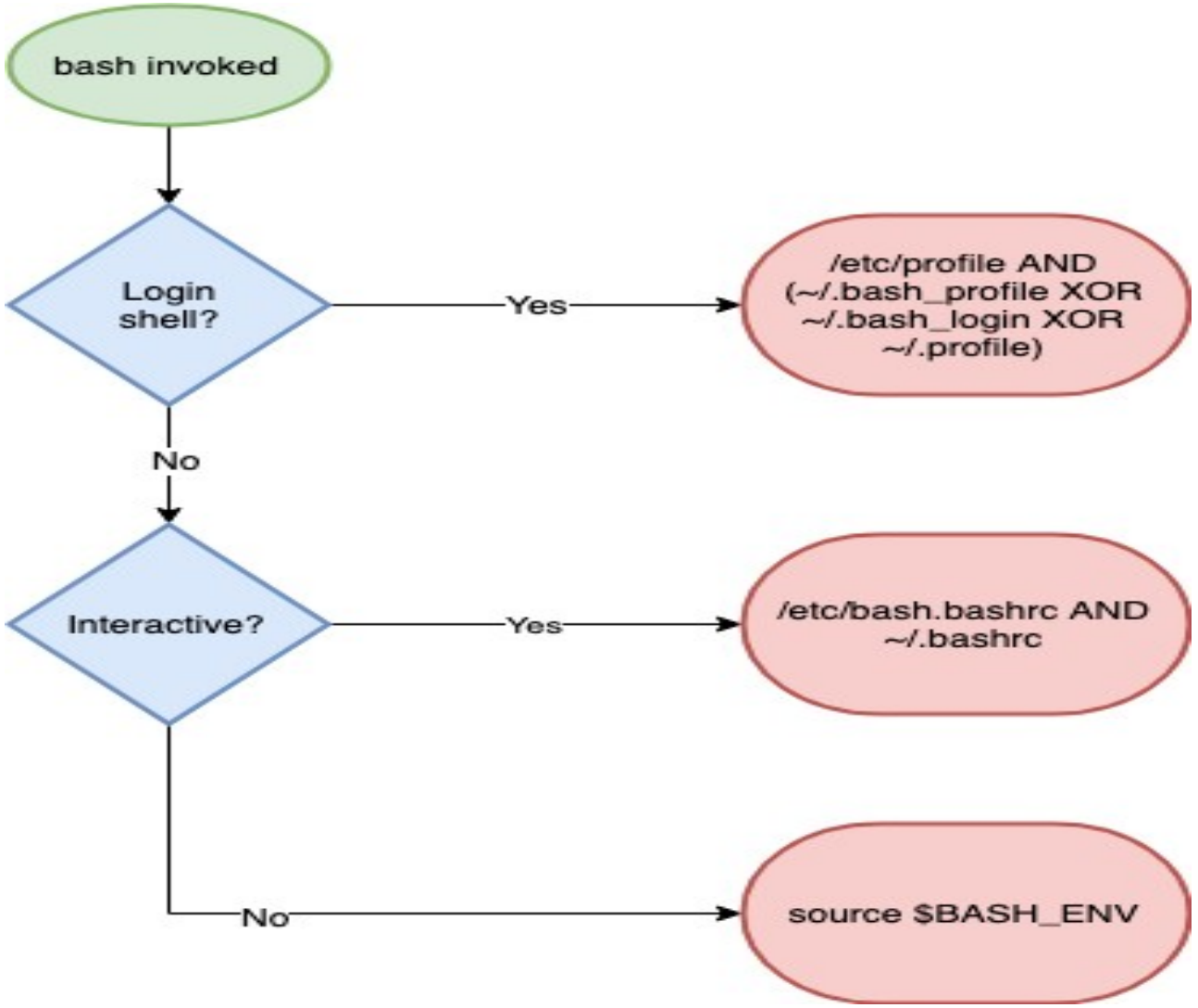
3.1 Scripts and Startup

- What shell scripts are
- What happens on bash startup
- This has cost me many hours!
- Executable files
- ‘source’ vs ‘./’

Walkthrough – Startup Explained



Walkthrough – Startup Explained (simpler)



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
- ‘set’ vs ‘shopt’

Recap - ‘set’

- **Options: + off, - on**
- **POSIX**
- **Most common options**
- **shopt and set**
- **xtrace, nounset, errexit**

Exercise III / Break

3.3 Subshells

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

3.4 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

Part III – Discussion / Recap

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

Exercise IV / 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 - Refresher

- 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’

4.2 Process Substitution

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

Process Subsitution - Walkthrough

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

Exercise V

Wrapup

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