# bash

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# Shells

- Each OS has one, but different levels of sophistication
  - Windows Command Prompt
  - sh – original /bin/sh
    - bash – Bourne-Again Shell, derived from sh
    - ksh – Korn shell = superset of sh
  - csh – shell with C-like syntax
    - tcsh – improved version of csh
  - …



# sh, bash – the first "scripting" language

- shell = macro processor that executes commands
- invokes Unix commands and has its own set of commands
- full programming language
- sources of input:
  - from terminal
  - files with sh commands can become commands (=/ C, Java)



# sh

- Shell is just another program:

```
while (1) {
  read line from terminal;
  parse into words;
  substitute variables;
  execute commands (execv or
  builtin);
}
```



# (ba)sh

- both synchronous and asynchronous execution
  - synchronous: wait for completion
  - in parallel with shell
- control stdin, stdout, stderr
- set environment for processes (using inheritance between processes)
- set default directory
- builtins:
  - `cd`, `break`, `continue`, `exec`, …
  - convenience: `history`, `getopts`, `kill`, `pwd`



# sh

- Language:
  - variables
  - flow-control constructs
  - functions

## (ba)sh operation

1. read input from file, from -c command line string or terminal
2. break input into words and operators; alias expansion
3. simple and compound commands
4. shell expansions (variables, glob, …)
5. perform redirections
6. execute command
7. optionally wait for command to complete



## Quoting and comments

- 'something': preserve literally
- "something": allow $ variable expansion
- $'C-escaped': e.g., $'\a'
- # comment



## Simple commands and pipelines

- Simple command = sequence of words
  - first word defines command
  - can combine with &&, ||, ;, etc.
- Pipeline = sequence of command | command | …
  - each command reads previous command output



## List of commands

- `cmd1; cmd2; …`: execute sequentially
- `cmd1 &` : execute asynchronously
- `cmd1 && cmd2` …: execute cmd2 if cmd1 has exit(0)
- `cmd1 || cmd2` : execute cmd2 only if cmd1 has non-zero exit status



## Variables and expressions

- Variables are placeholders for the value
- shell does variable *substitution*
- $var or ${var} is value of variable
- assignment with `var=value`
  - no space before or after!
  - Also, `let "x = 17"` or `let "b = b + 10"`
- uninitialized variables have no value
- variables are untyped, interpreted based on context



## Environment variables

- Shell variables are generally not visible to programs
- Environment = list of name/value pairs passed to sub-processes
- All environment variables are also shell variables, but **not** vice versa
- Make variables visible to processes with export, as in

```
export foo
export foo=17
```

- Show with `env`

## Shell variables

- ${M} = shell Mth parameter
- $$ = process ID
- $? = exit status
- standard environment variables include:
  - HOME = home directory
  - PATH = list of directories to search
  - TERM = type of terminal (vt100, …)
  - TZ = timezone (e.g., US/Eastern)



## Looping constructs

- Similar to C/Java constructs, but with commands:
  - until *test-commands*; do *consequent-commands*; done
  - while *test-commands*; do *consequent-commands*; done
  - for *name* [in *words* …]; do *commands*; done
- also on separate lines
- `break` and `continue` controls loop



## while example

- shell style

```
i=0
while [ $i -lt 10 ]; do
  echo "i=$i"
  ((i=$i+1))
done
```

- C style

```
((i = 0))
while (( i < 10 ))
do
  echo "i=$i"
  ((i++))
done
```



## sh: if

if *test-commands*; then
  *consequent-commands*;
  [elif *more-test-commands*; then
    *more-consequents*;]
  [else *alternate-consequents*;]
fi



## Functions

- Very limited support for functions:

```
function useless() {
  echo "First $1"
  echo "Second $2"
  echo "Third $3"
  echo "Fourth $4"
}
useless a b c
```



## Scripts

- Binaries and scripts are treated the same
- Make executable (chmod u+x) and add
  #! /usr/local/gnu/bin/bash
- More generically:
  #!/usr/bin/env bash
- Also,
  . *script*
  source *script*

## Expansion

- Biggest difference to traditional languages
  - shell substitutes and executes
  - mix variables and code
  - run-time code generation
- For bash:
  - brace expansion
  - tilde expansion
  - parameter and variable expansion
  - command substitution
  - arithmetic expansion
  - word splitting
  - filename expansion



## Brace expansion

- Expand comma-separated list of strings into separate words:

```
bash$ echo a{d,c,b}e
ade ace abe
```

- Useful for generating list of filenames:

```
mkdir
  /usr/local/{old,new,dist,bugs}
```



## Tilde expansion

- ~ expands to $HOME
- e.g.,

  ~/foo → /usr/home/foo

  ~hgs/src → /home/hgs/src



## Command substitution

- Replace $(command) or `command` by stdout of executing command
- Can use to execute content of variables:

```
x=ls
echo `ls`
```

- Danger!



## Filename expansion

- Any word containing *?([ is considered a *pattern*
- * matches any string
- ? matches any single character
- [...] matches any of the enclosed characters



## Redirections

- stdin, stdout and stderr may be redirected
- < redirects stdin (0) from file
- > redirects stdout (1) to file
- >> appends stdout to file
- &> redirects stderr (2)
- << magic

```
here-document
magic
```