Programming in Shell 1

Command-line parsing and meta-characters. Command execution. Shell variabes.

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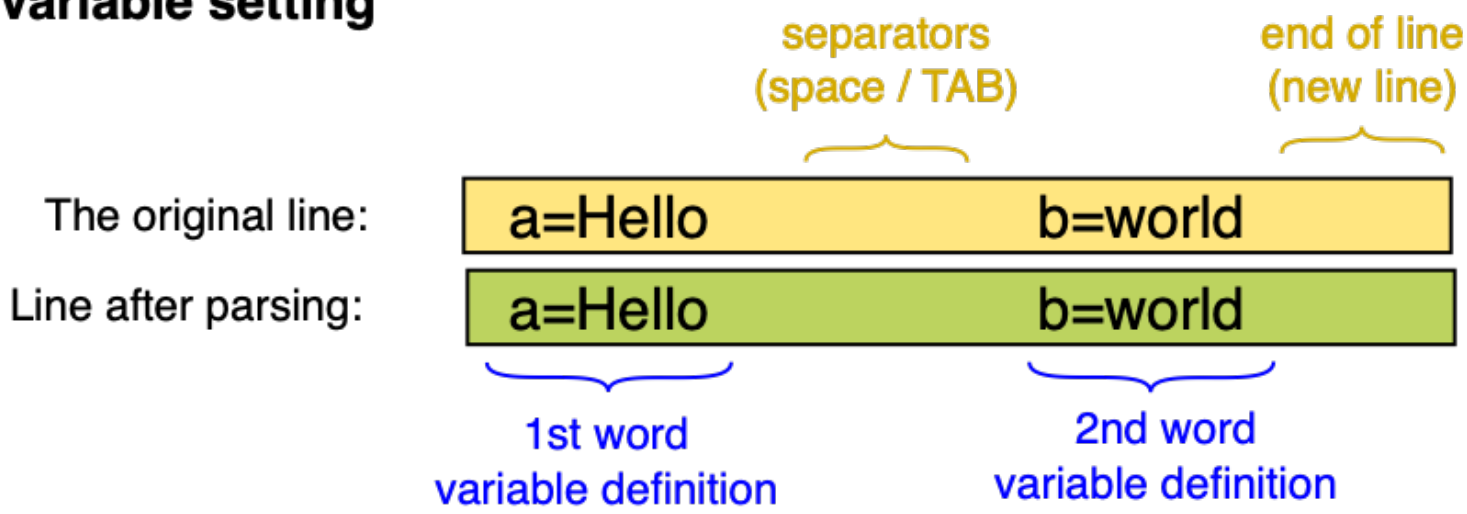
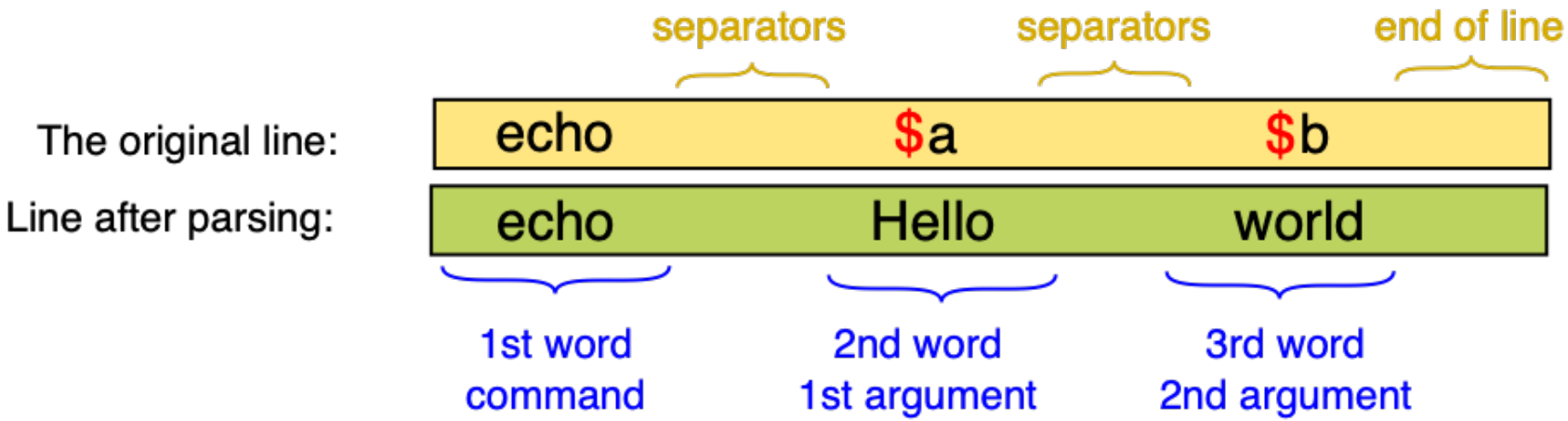
Content

Example: variable setting and simple command

Variable setting



Simple command



Shell behavior

- **Variables**

```
A="Hello world"
```

```
B="Number of logged-in users:  $(finger | tail -n+2 | wc -l)"
```

- **Commands**

```
ls -la /
```

```
echo "$A"
```

```
finger | tail -n+2 | wc -l
```

```
:(){ [ $1 -gt $2 ] && echo $1 || echo $2; }; : 1 3; : 2 1
```

- **Meta-characters**
  - Characters that represent something other than its literal meaning (depending on the context).
  - #, " ", ' ', \, $, |, {}, ( ), [ ], ...

Shell behavior

- Shell repeatedly performs the following steps
  1. Command-line reading.
  2. Command-line parsing.
  3. Variable setting and command execution.

- During the command-line parsing, the meta-characters are interpreted/replaced by the shell in the "exact" order.

- **Command-line parsing order**
  1. Quoting: `\`, `'...'`, `"..."`.
  2. Comments: `#`.
  3. Command line splitting: `|`, `;`, `&`, `&&`, `||`.
  4. Special characters: `{...}`, `~`, `` `...` ``, `$`, `$(...)`, `$((...))` .
  5. Word splitting: `space`, `tab`, `new-line`.
  6. Pathname expansion: `*`, `?`, `[...]`, `[!...]`, `[^...]`.
  7. I/O redirection: `<`, `>`, `>>`, `<<END`.
  8. Options and arguments setting.

Quiting

- Turning off the special meaning of meta-characters.
- Backslash \
  - It turns off the special meaning of the following character.

```
echo \$HOME = $HOME
```

- Apostrophes '...'
  - They turn off the special meaning of all characters between them (except apostrophe).

```
echo 'Meta-characters: $ \ * < > | & ; ...'
```

- Double quotes "..."
  - They turn off the special meaning of all characters except
    - \,
    - $variable, $(cmd), $((exp)),
    - `cmd`.

```
echo "\$HOME is $HOME."          # variable substitution

echo "Today is $(date +%A)"      # command substitution
echo "Today is `date +%A`"

echo "1 + 1 = $((1+1))"          # arithmetic expansion
```

Comment

- Hashtag #
  - Line/word beginning with a # indicate that the # and a text after is comment.
  - Example of script

```
#! /bin/bash

# Example of script

uname -s    # OS
uname -m    # hw architecture

echo Hello world#this is not comment
```

Command line splitting

- Simple command
  - Sequence of optional variable assignment followed by blank-separated words.

```
A="Hello world"
```

  - Command name followed by options and arguments.

```
ls -l /etc
```

- Pipeline
  - Sequence of one or more commands separated by the character `|`.
  - The standard output of the previous command is redirected as the standard input of the next command.

```
ls -a | wc -w
```

- List
  - Sequence of one or more pipelines separated by one of the operators `;`, `&`, `&&` or `||`, and optionally terminated by one of `;`, `&`, `newline`.

```
printf "Number of files in $PWD:" ; ls -a | wc -w
```

- Compound command
  - `(`list`)`, `{`list`}`, `((`expression`))`, `[[`expression`]]`, for, while, until, if, case, ...

Command line splitting – examples

- `cmd1 ; cmd2`
  - Commands are executed sequentially; the shell waits for each command to terminate in turn.

```
date ; sleep 2 ; date
```

- `cmd1 & cmd2 &`
  - The shell executes command in parralel.

```
date & sleep 2 & date &
```

- `cmd1 | cmd2`
  - The standard output of cmd1 is connected via a pipe to the standard input of cmd2.
  - Commands are executed in parallel.
  - The return status of a pipeline is the exit status of the last command.

```
ls -a | wc -w
```

- `( cmd1 ; cmd2 )`
  - Commands are executed sequentially by the subshell.

```
ps ; ( ps ; ps ; ) > out.txt
```

```
date ; ( LC_ALL=zh_TW.UTF-8 ; date ) ; date
```

Command line splitting – examples

- `{ cmd1 ; cmd2 ; }`
  - Commands are executed sequentially by current shell.

```
ps ; { ps ; ps ; } > out.txt
```

```
date ; { LC_ALL=zh_TW.UTF-8 ; date } ; date
LC_ALL=C
```

- Exit status/return code
  - Number passed from a child process to a parent process when it has finished executing.
  - Meaning of exit code
    - Success: 0
    - Error: 1,2,3,..., 255
- `cmd1 && cmd2`
  - cmd2 is executed if and only if cmd1 returns an exit status of zero.

```
date && echo "Everything is OK"
```

- `cmd1 || cmd2`
  - cmd2 is executed if and only if cmd1 returns a non-zero exit status.

```
date foo || echo "Bad argument"
```

Special characters

- Brace expansion
  - Mechanism by which arbitrary strings may be generated.
  - String list: pattern $\{s_1, s_2, \ldots s_n\}$ is replaced by strings s_1, s_2, ...,s_n.

```
$> echo {aa,bb,cc}
aa bb cc
```

```
$> echo X{aa,bb,cc}Y
XaaY XbbY XccY
```

```
$> echo {a,b}{,1,2}.{c,txt}
a.c a.txt a1.c a1.txt a2.c a2.txt b.c b.txt b1.c b1.txt
b2.c b2.txt
```

  - Range list: pattern `{x..y[..incr]}` is replaced by range of values (`x` and `y` are either integers or single characters, and `incr`, an optional increment, is an integer).

```
$> echo {1..10}
1 2 3 4 5 6 7 8 9 10
```

```
$> echo {1..10..2}
1 3 5 7 9
```

Special characters

- Home directory abbreviation by tilde
  - `~` represents a home directory of the current user.
  - `~username` represents a path to home directory of the given user.
- Variable substitution
  - Shell replaces the variable substitution with the content of the variable.
  - `$`variable or `${`variable`}`
- Command substitution
  - Shell executes a command and replaces the command substitution with the standard output of the command.
  - ‘ cmd ‘... old syntax
  - `$(` cmd `)` ... better syntax
- Arithmetic expressions
  - Shell evaluates an arithmetic expression and replaces the arithmetic expression with the result.
  - `$((` expression `))`

Word splitting

- Shell splits the content of command-line into words.
- Default word separators are
  - space,
  - tab,
  - new-line.
- Default word separators can be change by shell variables IFS.

```
#! /bin/bash

OLDIFS="$IFS"                    # remember current value of IFS
IFS=":"                          # set new value of IFS

# Read lines from the file /etc/passwd
while read name foo uid gid comment home shell
  do
    echo "name = $name  uid = $uid"
  done < /etc/passwd

IFS="$OLDIFS"                    # set previous value of IFS
```

File name substitution (globing)

- The following metacharacters are expanded into an alphabetically sorted set of file names from a given directory that match the specified pattern.
- Asterisk *
  - Matching zero or more characters, except the leading . (period) of a hidden file.

```
ls -l *.txt *.c
```

- Question mark ?
  - Matches exactly one character, except the leading . (period) of a hidden file.

```
ls -l *.???
```

- Square brackets [ ]
  - Matching one character in the set or in the range, except the leading . (period) of a hidden file.

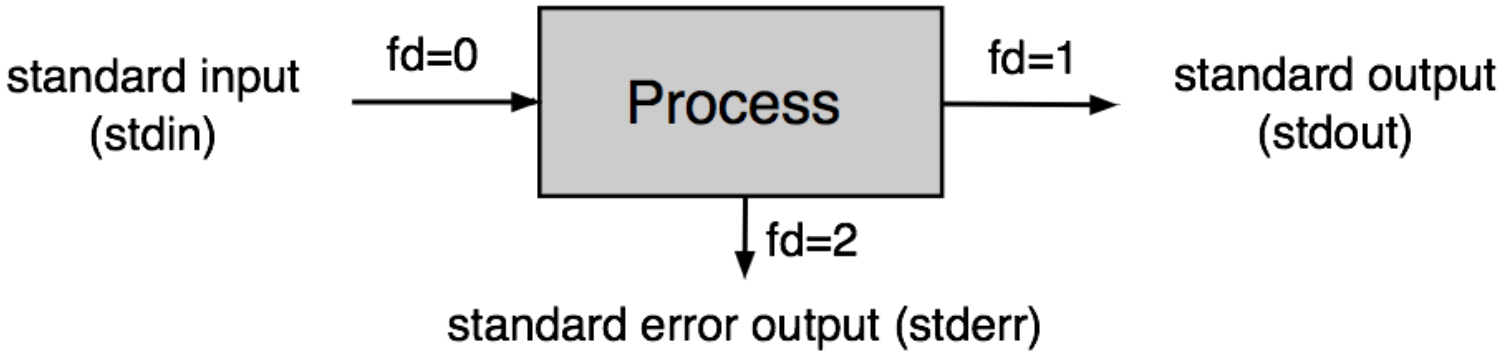
```
ls -l file[0-9].html
ls -l file[367].html
```

- Square brackets [^] or [!]
  - Matching one character not in the set or in the range, except the leading . (period) of a hidden file.

```
ls -l [^A-Z]*
```

Input/output redirection

- File descriptor is an abstract indicator for accessing a file (0,1,2,...).
- Every process has 3 standard POSIX file descriptors by default
  - 0 – standard command input (stdin)
  - 1 – standard command output (stdout)
  - 2 – standard command error output (stderr)



- New process inherits file descriptors from his parent process by default.
- User can redefine/redirect every file descriptor by special characters.
- I/O redirection is evaluated from left to right.

Input/output redirection

- `cmd < file`
  - Shell executes `cmd`, using `file` as the source of the standard input.

```
wc -l < /etc/passwd
```

- `cmd > file`
  - Shell executes `cmd`, placing the standard output in `file`.

```
date > out.txt
date > out.txt
```

- `cmd >> file`
  - Shell executes `cmd`, appends the standard output to the end of the `file`.

```
date > out.txt
date >> out.txt
```

- `cmd << string`
  - Here-document, shell reads lines until the line begining with the given string, then all lines are sent to standard input.

```
cat > out.txt <<END
> 1. line
> 2. line
> END
```

Input/output redirection

- `cmd 2> file`
  - Shell executes `cmd`, placing the standard error output in the `file`.

```
ls  /etc /XYZ > out.txt 2> err.txt
ls  /etc /XYZ > out.txt 2> /dev/null
```

- `cmd >&n`
  - Shell executes `cmd`, placing the standard output in file defined by file descriptor `n`.

```
ls  /etc /XYZ > out.txt 2>&1
```

- `cmd m>&n`
  - Shell executes `cmd`, placing the output defined by file descriptor `m` in file defined by file descriptor `n`.

```
ls  /etc /XYZ > out.txt 2>&1
```

Command `eval` [advanced topic]

- The command line is scanned twice by the shell.
- First, the shell interprets the command line when it passes to the eval command.
- Then shell interprets it a second time as a result of executing the eval command.

```
~> unset B ; A='$B' ; B=date ; echo $A
$B
```

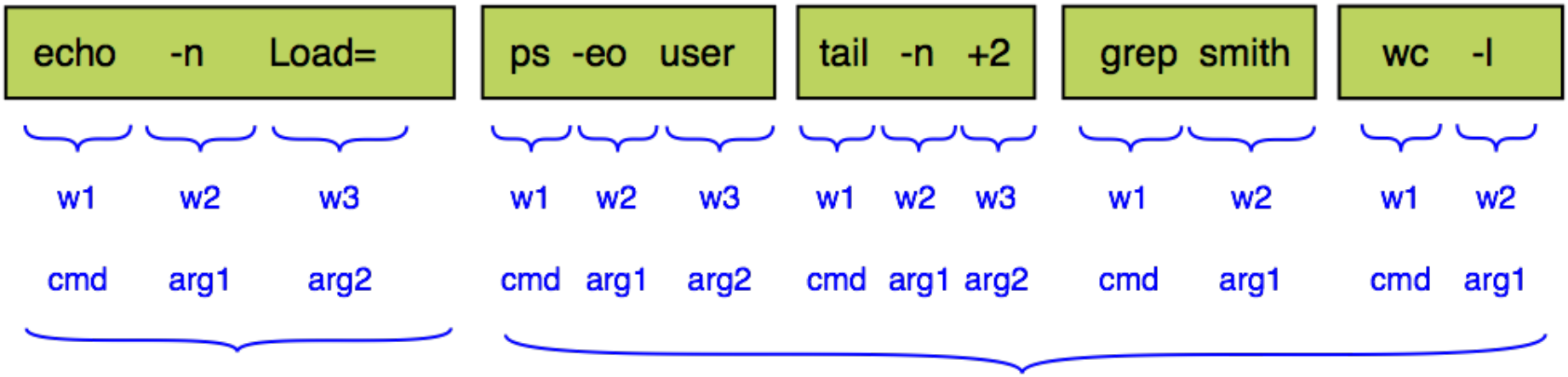
```
~> unset B ; A='$B' ; B=date ; eval echo $A
date
```

Example: Command Line Parse Order

The original line:

```
echo -n " Load= " > l.txt ; ps -eo user | tail -n +2 | grep $USER | wc -l >> l.txt
```

Line after parsing:



This command is executed first.
The input is from keybord and
the output is written to file.

This goup of commands are executed in parallel after
the termination of the first command.
The output of every command is redirected like input of the next one.
Only the output of the last command is added to the end of file.

Command Execution

- Which program will be executed?
  - Command `type` displays information about command type.

```
type date
```

- Absolute path to command

```
/usr/bin/echo "Hello world"
```

- Relative path to command

```
cd /usr/bin  ;  ./echo "Hello world"
```

- only the command name

```
echo "Hello world"
```

  - Shell function
  - Shell built-in command
  - Program in filesystem
    - Shell variable `PATH` contains list of directories.
    - The shell makes search through each of these directories (from left to right, one by one), until it finds a directory where the executable program exists.

```
~> echo "$PATH"
/usr/gnu/bin:/usr/bin:/usr/sbin:/opt/sfw/svn/bin
```

Shell Variables

- Local shell variable
  - The variable is define only in the current shell.
  - Definition: `NAME=VALUE`
- Environment shell variable definition
  - The variable is define in the current shell and in all its descendants.
  - Definition: `export NAME="VALUE"`
- How to print value of variable?
  - By command `echo "$NAME"`.
- How to print list of all variables (locale + environment)?
  - By command `set`.
- How to print list of environment variables?
  - By command `env`.

Built-in shell variables

- They have special meaning for shell.

`HOME`	home directory
`PWD`	current working directory
`PS1`	prompt definition
`PATH`	list of directories for command searching
`0`	program name
`1, ..., 9`	command line arguments
`#`	number of command line arguments
`$`	process ID of current shell
`?`	exit status of the last executed command

- They are described in manual page of the shell.

```
~> man bash
/^ *Shell Variables
```