Bash Workshop II: Advanced

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What's a regex

Regex: "regular expressions"

It is a string... to match patterns in other strings.

What can (and can't) a regex do

A regex can (attempt to):

- Match a cell phone number: `[0-9]{11}`
- Match a .com domain: `([A-Za-z0-9-]+\.)+com`
- Match *Star Wars* subtitles but not *Star Trek*: `m | [tn]|b`[1] [2]

It cannnot:

- Parse Python code
- Detect homework plagiarism
- Moderate a Minecraft server

[1] Credit: https://xkcd.com/1313/

[2] The art of regex golf: https://alf.nu/RegexGolf

Regex is a mess

Quote

I define UNIX as 30 definitions of regular expressions living under one roof.

— Donald Knuth[3]

Two dominant standards:

- **ERE** (Extended RegEx, POSIX compliant)
- **PCRE** (Perl Compatible RegEx, used in Perl and Python)

Our focus today will be ERE.

[3] Digital Typography, ch. 33, p. 649 (1999)

Regex patterns: .

The dot is the simplest pattern:

Pattern	Matches
`.`	any character

Example

`c.t` matches `cat`, `cut`, and `c t`.

Note

`\.` matches a literal dot. Same goes for `\(` `\[` etc.

Regex patterns: []

Brackets match any of the characters inside, but `^` and `-` are special:

`[aeiou]`	any vowel
`[^aeiou]`	anything but a vowel
`[0-9]`	any digit
`[^A-Za-z]`	anything but letters

Example

`[A-C][01][0-9]` matches `A00` up to `C19`.

Regex patterns: character classes

`\w`	`[A-Za-z0-9_]`
`\W`	anything `\w` does not match
`\s`	whitespace (space, tab, linebreak, etc)
`\S`	anything but whitespace

Note

Character classes in brackets like `[\w\s]` won't work.

Regex patterns: | ()

Vertical bars separate patterns, and matches one of them.
Parentheses can be used to group patterns.

`[bc]at|[dh]og`	bat, cat, dog, or hog
`(ls|cd|rm -r) dir`	`ls dir`, `cd dir`, or `rm -r dir`

Regex patterns: repeat

A repeated pattern can be matched:

`A?`	zero or one A
`A+`	one or more A's
`A*`	zero or more A's
`A{6}`	6 A's
`A{4,6}`	4–6 A's
`A{4,}`	more than 4 A's

Example

`[0-9]{1,3}(,[0-9]{3})*` matches `13` and `420,691,337`.

Regex patterns: location

These do not match literal characters. Instead, they specify the location of the character before/after it.

`^`	beginning of string
`$`	end of string [4]
`\b`	word boundary
`\B`	not word boundary

Example

- `^$` matches an empty string only
- `\bwork\B` matches `bash workshop` and `worker`, but not `homework`

[4] Beginning or end of line sometimes

Quiz: Does it match?

What strings does this regex match?

`^cat|cat$`

- `cat`
- `^cat$`
- `cats`
- `cat /etc/fstab`
- `I have a cat.`
- `Cats are the best.`
- `Concatenate these files`

Quiz: Does it match?

What matches `+86 021` but not `+86021`?

- `\+86\s+[0-9]{3}`
- `\+86\s*[0-9]{3}`

What does `[um]jicanvas.com` match?

- `umjicanvas.com`
- `jicanvas.com`

Challenge

How to fix this regex?

But how to use a regex, anyway?

Try this in `04-regex/`: [5]

```
1 $ grep -E '.+\..+@sjtu.edu.cn' faculty
```

[5] For Mac users, instead of `grep` you might have to type `ggrep`

But how to use a regex, anyway?

Try this in `04-regex/`: [5]

```
1 $ grep -E '.+\..+@sjtu.edu.cn' faculty
```

Observation

The regex matches all email addresses in the file `faculty` that look like "firstname.lastname@sjtu.edu.cn".

`-E` stands for Extended regex.

[5] For Mac users, instead of `grep` you might have to type `ggrep`

One more example

Try this in `04-regex/`:

```
$ grep -oE '^[^@]{,8}' faculty
```

One more example

Try this in `04-regex/`:

```
1 $ grep -oE '^[^@]{,8}' faculty
```

Observation

"@sjtu.edu.cn" are all gone, and each line is at most 8 characters long.

Explanation

`^`	From beginning of each line
`[^@]`	Keep any character except @
`{,8}`	Until we reach length 8

Your turn

Extract all course codes from `04-regex/courses`.

Example

VG100 Introduction to Engineering		VG100
VM020 Machineshop Training	$\Longrightarrow$	VM020
VP140 Physics I		VP140

Your turn

Extract all course codes from `04-regex/courses`.

Example

VG100 Introduction to Engineering		VG100
VM020 Machineshop Training	$\Longrightarrow$	VM020
VP140 Physics I		VP140

Solution (naïve version)

```
1 $ grep -oE 'V[A-Z][0-9]+' courses
```

Find and replace with sed

sed is a powerful tool for transforming text. [6] We will be using one very specific syntax for substitution:[7]

```
$ COMMAND | sed -E 's/FIND/REPLACE/FLAGS'
$ sed -E 's/FIND/REPLACE/FLAGS' FILE
```

-E again stands for Extended regex, and flags are optional. This command redacts all the IPv4 addresses in the file ipv4:

```
$ sed -E 's/([0-9]{1,3}\.){3}[0-9]{1,3}/redacted/g' \
    ipv4
```

Observe

What will happen without the g at the end?

---

[6] For Mac users, this may be called gsed.

[7] When the pattern/replacement contains slashes, you can use things like ! and , as delimiters.

Capturing groups

A **capturing group**, or simply **group**, is a pattern inside parentheses that mark a region of text you want to keep in the replaced text.

It can be accessed with a respective **backreference** which looks like \1, \2, up to \9.
When nested, the position of (determines order, so the outside group is \1 and the inside is \2.

Capturing groups with sed

What if you only want to redact the subnet (i.e. last part) of the IP addresses?

```
$ sed -E 's/(([0-9]{1,3}\.){3})[0-9]{1,3}/\1xxx/g' \
    ipv4
```

Observation

IP addresses like `192.168.1.1` become `192.168.1.xxx`

Your turn

From `04-regex/courses`, select 100- and 200-level math courses and convert legacy "VV" course codes into modern "MATH" codes. Do not print other courses.

Example

VV156		MATH1560J
VV214	$\Longrightarrow$	MATH2140J
VV417		*not printed*

Your turn

From `04-regex/courses`, select 100- and 200-level math courses and convert legacy "VV" course codes into modern "MATH" codes. Do not print other courses.

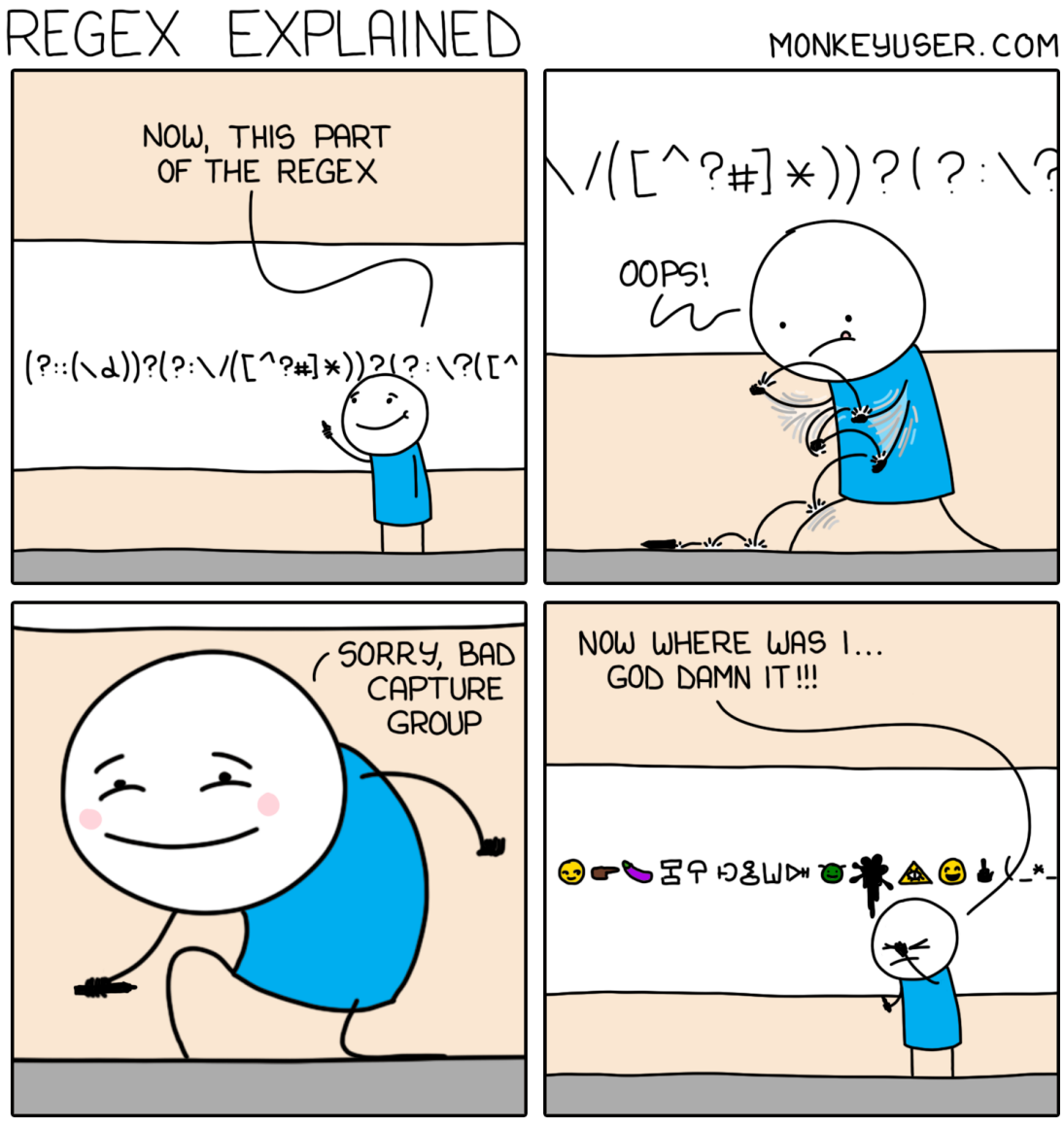
Example

VV156		MATH1560J
VV214	$\Longrightarrow$	MATH2140J
VV417		*not printed*

Solution

```
$ grep -E 'VV[12]' courses | \
    sed -E 's/VV([0-9]{3})/MATH\10J/'
```

When not to use regex?



If your regex:

- is 50 characters long
- handles lots of Unicode
- has too many backslashes

consider something else.

Atrocities under regex's name

If you match a Chinese resident ID with `[0-9]{18}`, people whose ID ends with X will be mad at you.

Apart from ignorance, people also abuse regex for fun. This is a regex that matches a regex:

```
/\/((?![*+?])(?:[^\r\n\[/\\]|\\.|\[(?:[^\r\n\]\\]|\\.)*\])+)\/((?:g(?:im?|mi?)?|i(?:gm?|mg?)?|m(?:gi?|ig?)?)?)/
```

And here's one that matches integers that are divisible by 3:

```
^(?:[0369] |
(?:[147](?:[147][0369]*[258]|[0369])*[258]) |
(?:[258](?:[258][0369]*[147]|[0369])*[147]))+$
```

(These two examples are not ERE.)

Beyond the workshop

Regex101 (https://regex101.com/) is an online regular expression evaluator that supports ERE, PCRE, and many others.

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Bash is a programming language

Let's say you want to print many files at once.

Try this simple example:

```
$ for i in {01..05}; do \
    cat um-logo-$i.txt; \
  done
```

Variables

A variable in bash is defined this way:

```
$ i=0
$ s='s'
```

Surprisingly these do **not** work:

```
$ i = 0    # WRONG
$ s = 's' # WRONG
```

They can be accessed with a dollar sign:

```
$ echo $i   # 0
$ echo $s   # s
```

Environment variables

An **environment variable** can be set and accessed like this:

```
$ export VAR=VALUE   # set
$ echo $VAR          # access
```

`export` exposes the variable to programs that are not part of the shell [8], such as Python.

Note

If an environment variable works for utility A, it may or may not work for utility B. Refer to documentation when in doubt.

[8] aka not child processes

Environment variables

Let's say you're downloading something from a completely legal website, and you want the traffic to go through your completely legal local proxy for completely legal reasons.

```
# set environment variable for local proxy
$ export HTTPS_PROXY=http://localhost:8080/
# download the thing
$ curl -O https://legal.website/legal-thing
```

Shell scripts

Open your favorite text editor and edit `05-scripting/um.sh`:

```
# 05-scripting/um.sh
for i in {01..05}; do
    cat um-logo-$i.txt
done
```

Save file, then come back to bash, `cd` into `05-scripting` and run:

```
$ bash um.sh
```

Exit status

When a program exits, it emits an **exit status** (also called exit code). By convention, an exit status of 0 implies success, and everything else means something went wrong (consult respective man pages).

For this very reason, in bash, **0 is boolean true** and **everything else is false**.

Note

When you `return 0;` at the end of `int main()`, you are emitting an exit status of zero.

if statements

Usually, we use an **if** statement to:

- Run a command and see if it succeeds
- Test the value of a variable
- Check if a file exists

It looks like this:

```
1 if CONDITION; then
2     BODY
3 elif CONDITION; then
4     BODY
5 fi
```

if statements: exit code

```
# if-prog.sh
if mkdir temp; then
    # write to file only if mkdir emits exit code 0
    echo "temporary dir created" >> temp/log
fi
```

if statements: compare integers

```
1 # if-comp.sh
2 i=3
3 if [[ $i -eq 3 ]]; then
4     echo "i is 3"
5 fi
```

Other operators:

`-ge`	$\geq$
`-gt`	$>$
`-le`	$\leq$
`-lt`	$<$
`-ne`	$\neq$

Note

Spaces after `[[` and before `]]` are **required**. [9]

[9] Trivia: In bash the `[[ ]]` is built-in, but in some shells it's an executable called `/usr/bin/[[`. See https://serverfault.com/questions/138951/what-is-usr-bin

if statements: arithmetic

```
1 # if-arith.sh
2 i=3
3 if (( $i % 2 == 1 )); then
4     echo "i is odd"
5 fi
```

Note

We do not use -eq, -gt etc. inside (( )).

if statements: test string variable

```
1 # if-str.sh
2 str="something"
3 if [[ -z $str ]]; then
4     echo "str is empty"
5 elif [[ $str = 'something' ]]; then
6     # = and == are both ok
7     echo "str is 'something'"
8 fi
```

Complementary operators to `-z` and `=`:

`-n`	not empty
`!=`	not equal to

if statements: file exists

```
1 # if-file.sh
2 file="something.txt"
3 if [[ -e $file ]]; then
4     echo "$file exists"
5 fi
```

Common counterparts to `-e`:

`-f`	exists and is regular file
`-d`	exists and is directory

for statements

The `for` statement is usually used to:

- Iterate over a range
- Iterate over a list of strings

It looks like:

```
for VAR in LIST; do
    BODY
done
```

for statements: range

```
# for-timer.sh
for t in {10..1}; do
    echo "$t seconds left"
    sleep 1
done
```

Note

In **double quotes**, variables will be expanded.

for statements: list of strings

A string is split into a list with respect to whitespace.

Let's say you want to create a backup of every file inside current directory:

```
1 # for-backup.sh
2 for file in $(ls); do
3     cp $file $file.backup
4 done
```

Explanation

`$()` executes a command and takes its output. It is called "command substitution".

Observation

Why does bash think "My Documents" are two files?

for statements: IFS

Bash splits strings on spaces, tabs, and newlines. This is why `My Documents` was split into `My` and `Documents`.

Adjust the **IFS** environment variable to delimit on `\n` only:

```
# for-backup.sh (modified)
IFS=$'\n'
for file in $(ls); do
    cp $file $file.backup
done
```

Explanation

`$''` is called "ANSI-C quoting". It is not used very often. [10]

[10] More on this: https://www.gnu.org/software/bash/manual/html_node/ANSI_002dC-Quoting.html

for statements: accumulator

Let's try keeping count with an integer variable.

```
# for-backup.sh (modified)
IFS=$'\n'
count=0
for file in $(ls); do
    cp $file $file.backup
    count=$(( count + 1 ))
done
echo "$count files backed up"
```

Explanation

`$(())` is called "arithmetic expansion".

Your turn

Print the odd numbered lines of `05-scripting/logos.txt`.

Your turn

Print the odd numbered lines of `05-scripting/logos.txt`.

Solution

```
IFS=$'\n'
count=0
for line in $(cat logos.txt); do
    count=$(( count + 1 ))
    if (( count % 2 == 1 )); then
        echo $line
    fi
done
```

The Ultimate Challenge

Each line in `05-scripting/obf.txt` begins with an 8-digit number. Print every line with its number greater than any of the lines above.

The Ultimate Challenge

Each line in `05-scripting/obf.txt` begins with an 8-digit number. Print every line with its number greater than any of the lines above.

Solution

```
IFS=$'\n'
max=0
for line in $(cat obf.txt); do
    num=$(echo $line | grep -oE '^[0-9]{8}')
    if [[ $num -gt $max ]]; then
        echo $line
        max=$num
    fi
done
```

Conclusion

- Regex matches apparent patterns in strings
- Many tools support regex, but beware of standards
- Bash scripts are for basic automation
- When unwieldy, consider alternatives

The End

Thank You For Coming!

Credits

- Monkey User, Regex Explained.
  https://www.monkeyuser.com/2020/regex-explained/