UNIX/Linux environment

Regular expressions and find

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Regular expressions (RE)

- Introduced in 1956 by the mathematician Stephen Cole Kleene in the automaton and formal language domain
- Used from the seventies in the UNIX environment
  - Editors (vi, emacs, etc.)
  - Shell commandi di shell (find, grep, etc.)
  - Scripting languages (sed, awk, perl, python, etc.)

Regular expressions (RE)

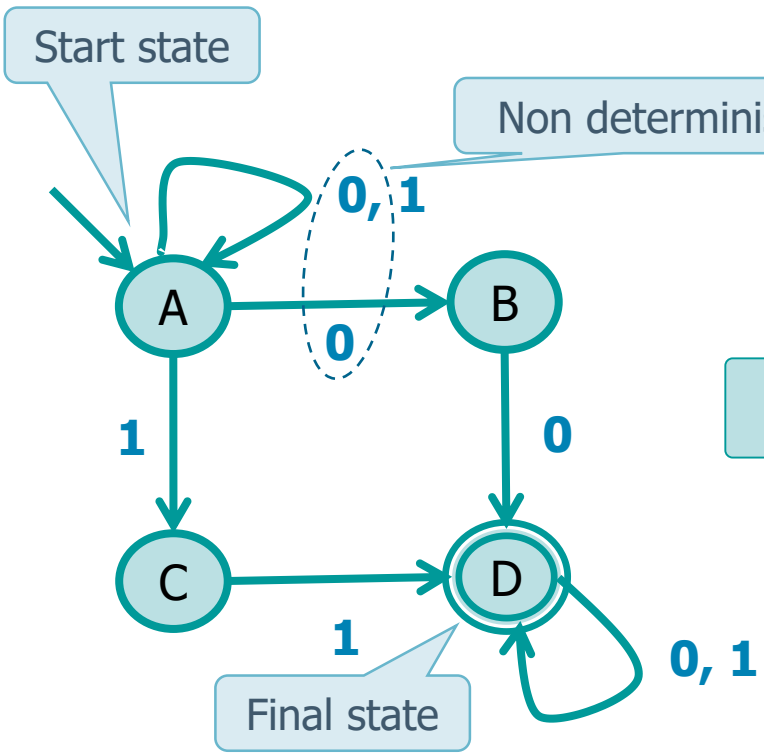
- A standard defined for POSIX in 1992
- Several versions exist, using similar but **different** formalisms
  - BRE, Basic Regular Expression
  - ERE, Extended Regular Expression
  - PCRE, Perl Compatible Regular Expression
    - C Library of Regular Expressions (Hazel, 1997)
    - More flexible than POSIX version
    - De-facto standard with Perl 5
- In this course
  - We will use simple regular expressions in find, grep, and shell scripting

Regular expressions (RE)

- A regular expression (or **pattern**) is an expression that specifies a set of strings
  - Compact operators are used to represent complex sequences of characters
    - Example
      - a | b* represents the set of strings {a, ϕ, b, bb, bbb, bbbb, …}
- Expressions are useful to find if a **match** exists between objects
  - Directories or file names, lines or fields of a file, strings or sub-strings, etc.

Regular expressions and automata

- A regular expression corresponds to a Non Deterministic Automaton (NFA)



Sequence of symbols accepted by the automaton

```
(0 | 1)* (00|11) (0 | 1)*
```

* = 0 to ∞ times

| = logic OR

Definitions

- Literal
  - Any character (or character sequence) used in the search of a match
    - ind matches w**ind**ows, **ind**ifferent, etc.
- Metacharacter
  - One or more characters having special meaning
    - * indicates 0 to ∞ preceding symbols, e.g., b* = {ϕ, b, bb, bbb, …}
- Escape sequence
  - Allows using literally a metacharacter
    - Character '.' must be given as '\.'

The power of RE is hidden in the use of metachaaracters

Metacharacters

Operator	Meaning
[...]	Specifies a list or range of symbols
(...)	Manages operator precedence Groups sub-expressions Allows reference to previous expressions (backward reference)
|	Logical OR between REs

Basic RE: \[...\] and \(...\)

Anchors	Meaning
\<	Beginning of word
\>	End of word
^	Beginning of line
$	End of line

Special characters	Meaning
\+ \? \.	Characters '+', '?', '.'
\n	New line
\t	TAB

Meta-characters

Quantifiers And ranges	Meaning
*	[0, ∞] times
+	[1, ∞] times
?	[0, 1] times
$[c_1c_2c_3]$	Any character in parenthesis
$[c_1\text{-}c_5]$	Any character in range
$[\hat{}c_1\text{-}c_5]$	Any character not in range
{n}	Exactly n times
$\{n_1,n_2\}$	n_1 to n_2 times

Superset

grep command:
Allows also $\{n_1,\}$ or $\{,n_2\}$

Meta-characters

Characters	Meaning
c	Any symbol c (excluding special ones)
.	Any character (excluding '\n')
\c	Any control character
\s	A space or TAB
\d	A digit [0-9]
\D	Not a digit [^0-9]
\w	Letters, numbers and _ [0-9A-Za-z_]
\W	Not letters, numbers and _ [^0-9A-Za-z_]

Some are not recognized by some commands

Examples

Regular expression	Meaning
ABCDEF	String "ABCDEF"
a*b	Any number of 'a' followed by a single 'b'
ab?	a or ab
a{5,15}	5 to 15 repetitions of 'a'
(fred){3,9}	3 to 9 repetitions of string "fred"
.+	Any, non empty, sequence (entire line)
myfunc.*(.*)	A function with name beginning by "myfunc"
^ABC.*	A line beginning by "ABC"
.*h$	A line ending by "h"
hello\>	Word ending by "hello"
a+b+	One or more 'a' followed by one or more 'b'

Examples

Regular expression	Meaning
.*b.*3	Matches string "./fbar3"
[a-zA-Z0-9]	A letter or a digit
A|b	A or b
\w{8}	A 8 character word
((4\.[0-2])| (2\.[0-2]))	Numbers 4.0, 4.1, 4.2 or 2.0, 2.1, 2.2
(.)\1	Two times the same character (ex. "aa")
(.)(.).\2\1	Any 5 character palindrome string (e.g., radar, civic, 12321, etc.)

Basic RE: \(.\)\1 and \(.\)\(.\).\2\1
Extended RE: (.)\1 and (.)(.).\2\1

\1, \2
Backward Reference

Exercise

- Write a RE to match
  - All the lines containing an integer number between 1 and 50 (extremes included)

```
^[1-9]$ | ^[1-4][0-9]$ | ^50$
```

  - Any date with format yyyy/mm/dd
    - A year can be expressed on 2, 3 or 4 digits. Assume that the number of days of each month is 31.

```
\d{2,4} \/ (0[1-0] | 1[0-2]) \/ (0[1-9] | [1-2][0-9] | 3[01])
```

\d{2,4} equal to [0-9]{2,4}

find

- Allows
  - Searching and listing the file, directories or links that match a given criterion
  - Possibly executes a shell command on every listed file
- Notice that
  - Find outputs the relative path of the matching files, not their basenames
  - This is important for writing the REs to match a give path and the actions to be performed

find

- Format
  - find directory options actions
- In details, the find command
  - Visits the **directory** subtree
  - Outputs the list of pathnames satisfying the **options**
  - Possibly performs the **actions** on every file of the list
- We need to analyze how to specify directory, options and actions

find: specify directory

- Specifies the search directory tree in which execute the command
  - .
  - /usr/bin
  - ./subDirA/subDirB

```
find directory options actions
```

find: specify options

Option	Meaning
-name pattern	Match with the file name. The initial path (basename) is removed. In some versions it is possible to place the pattern between double quotes to specify regular expression. **-iname** is equal but case insensitive
-path pattern	Like the previous one, but you need to specify path+filename **-ipath** is equal but case insensitive

```
find directory options actions
```

find: specify options

Option	Meaning
-regex expr	Specifies a regular expression that matches the found relative path (full path) **-iregex** is equal but case insensitive
-regextype type	Indicates the type of regular expressions used: posix-basic, posix-egrep, posix-extended, etc. You must specify the type before the regular expression (**regextype** must precede **regex**)
-atime [+,-]n -ctime [+,-]n -mtime [+,-]n	Last access, status or modification time n=1 specifies from 0 to 24 hours back n value with sign : + means ≤, - means ≥

```
find directory options actions
```

find: specify options

Option	Meaning
-size [+,-]n[bckwMG]	File dimension Sign + means ≥, - means ≤ Next character indicates the size : • b blocks (of 512 bytes) • c bytes • k kbytes • w word (2 bytes) • M Mbytes • G Gbytes
-type type	File type **f** per regular file (i.e., text files, executable, etc.), **d** for directories, **p** for pipes, **l** for symbolic links, **s** for sockets

```
find directory options actions
```

find: specify options

Option	Meaning
-user name -group name	File owner identifier (**user** name) File group identifier (**group** name)
-readable -writable -executable	File access permissions
-mindepth n -maxdepth n -quit	Search limited to a subtree section: **mindepth** and **maxdepth** indicate the minimum and maximum depth from **directory** (-maxdepth 1 means search only on **directory**) Quit the search after the first match

```
find directory options actions
```

Examples: find & options

```
find . -name "*.c"

find . -regex "*.c"

find . -regex ".*\.c"

find /usr/bin -iname "a.*"
```

File with `".c"` extension

Wrong: `"*.c"` is not a RE

Correct equivalent RE

All files starting with 'a' or 'A' that do have any extension

All files with dimension >500 bytes

All readable files in the current directory (.) with name beginning by ab, aab, aaab,etc., and any extension

```
find . -size +500c

find . -readable \
  -regex "\./a+b.*\..*"
```

Examples: find & options

```
find /usr/bin \
  -regextype posix-extended \
  -regex ".*\/..(.)(.).\2\1.*"

find /usr/bin -regex \
  ".*\/..\(.\)\(.\).\2\1.*"
```

All files in directory `/usr/bin` starting with two characters, followed by a palindrome word with 5 characters, and followed by other characters in indefinite number

The same but with standard RE

All files with extension `exe` in directory `/home/usr` from level 2 to 4 (included)

```
find /home/usr/ \
  -mindepth 2 -maxdepth 4 \
  -name "*.exe"
```

find: specify actions

- The default action of **find** is to output the list of matching files
  - The default action is equivalent to the **print** command
    - find directory options **`-print`**
- It is possible to execute
  - any shell command
  - on every pathname of the matching list

```
find directory options actions
```

find: specify actions

Option	Meaning
-print	Default action. Print a name for each line
-fprint	Like the previous one, but it performs the output on a file
-print0	Like -print, but without going in the next line
-execdir command	Executes command
-exec command	Secure POSIX version of the previous one. Expands the command by including the path and the name
-delete	Deletes the founded filename

```
find directory options actions
```

find: specify actions

- The execution of a command is performed by means of the option **`exec`** (or **`execdir`**)
  - Format
    - **`find directory options -exec command '{}' ';'`**
    - **`find directory options -exec command \{} \;`**
  - Where
    - The **command** is executed in the directory
      - in which the pathname has been found by using **`execdir`**
      - in the current directory if **`exec`** has been used
    - find substitutes string `'{}'` (or `\{}`) with the current pathname of the list
    - String `';'` (or \;) terminates the command executed by find

```
find directory options actions
```

Examples: find & actions

```
find . -name "*.c" -print
```

-print is the default action

```
find / -type f -print0
find / -type l -print0
```

Searches all the regular files or the symbolic links

```
find . -name "*.c" -print -quit
```

Prints the first entry that has a match and then it exits (**-print** has to be inserted)

Cancels all the matching files (both commands are equivalent)

```
find . -name "*.old" -type f -exec rm -f \{} \;
find . -name "*.old" -type f -exec rm -f '{}' ';'
```

Examples: find & actions

```
find / -user root -exec cat \{} \;
```

Outputs the content of each file of the root filesystem belonging to user **root**, and concatenates their content

```
find / -user root -exec cat '{}' >> file.txt ';'
```

Like the previous one, but the concatenation is redirected in the file file.txt

```
find . -name "*.txt" -exec head -n 2 \{} \;
```

Outputs the first two lines of each **.txt** file

Examples: find & actions

```
find /home/usr/ \
  -mindepth 2 -maxdepth 2 \
  -name "*.exe" \
  -type f \
  -exec chmod +x \{} \;
```

Adds the execution permissions of the `".exe"` files in the second level directories of "/home/usr/"

Exercise

- Report the UNIX commands to do what indicated, possibly using redirections and pipes
  - Search how many files with extension ".txt" are present in current working directory
  - Display how many lines are present in all founded files with extension ".txt"

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- Report the UNIX commands to do what indicated, possibly using redirections and pipes
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```
find . -name "*.txt" | wc

find . -name "*.txt" -exec wc \{} \;
```

Pipe: applies wc (word count) **to the list** of files found by find (list of all files with extension ".txt")

-exec: applies wc (word count) **to the content of each file** (\{}) found by find