# CS 241: Systems Programming
# Lecture 24. Regular Expressions I

Fall 2019

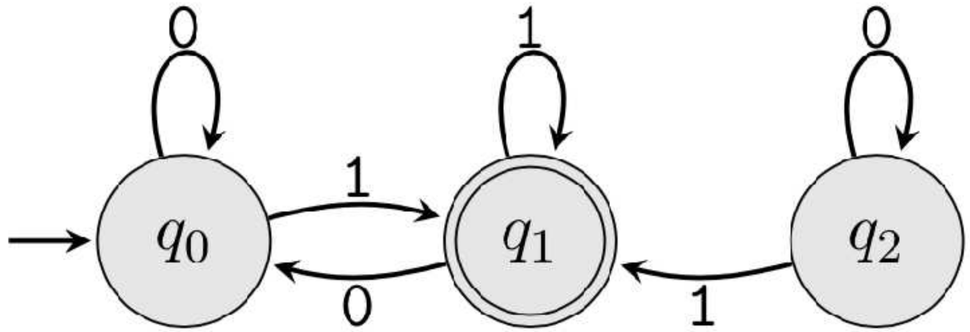
Prof. Stephen Checkoway

# Theory of regular languages

Mathematical theory of sets of strings

- You'll see this in CS 383

Connection to finite state machines



# Theory of regular languages

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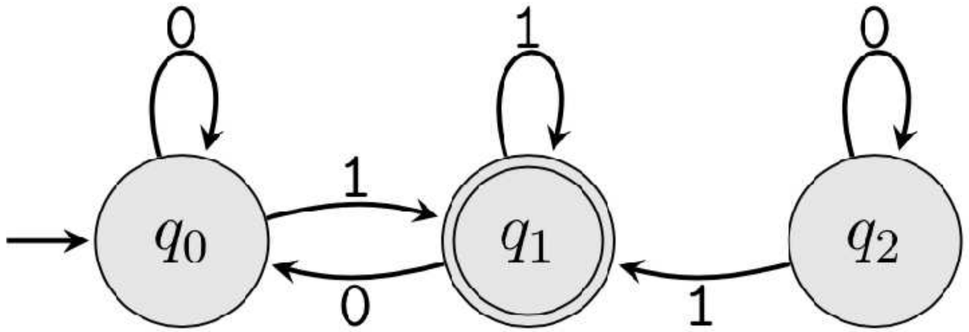


**We're going to skip all of this for this course!**

# Problem we want to solve

Identify and/or extract text that matches a given pattern

Examples

- Find all lines of text in a file containing a given word
- Extract all phone numbers from a file
- Extract fields from structured text
- Classify types of text (e.g., compilers need to determine if some text is a number like 0x7D2 or symbols like == or keywords like double)
- Find all of the tags in an HTML file

# grep(1)

grep matches lines of input against a given regular expression, printing each line that matches (or does not match)

```
$ grep 'Computer Science' file
```

- prints each line of `file` that contains the string "`Computer Science`"

More generally,

```
$ grep regex file
```

will print each line of `file` that matches the regular expression `regex`

# What is a regular expression?

Text that describes a search pattern

Comes in a variety of "flavors"

- Basic Regular Expression (BRE)
- Extended Regular Expression (ERE)
- Perl-Compatible Regular Expressions (PCRE)

Be careful not to confuse with file globbing

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Every other character just matches itself; precede any of the above with \ to treat as normal

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- `\1` the first saved match
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- `\1` the first saved match
- `\5` the fifth saved match
- Using such "back references" makes it not a real regular expression and should be avoided

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# Extended regex (modern)

`{m,n}` match previous item at least `m` times, but at most `n` times

`( )` group and save enclosed pattern match

`+` match 1 or more of the previous `{1,}`

`?` match previous 0 or 1 time `{0,1}`

`|` match RE either before or after

- `apple|banana`

# POSIX character classes

Within brackets [ ], we can use character classes corresponding to those in ctype.h by surrounding the name with [: and :]

- `alnum`, `digit`, `punct`, `alpha`, `graph`, `space`, `blank`, `lower`, `upper`, `cntrl`, `print`, `xdigit`
- E.g., `[[:digit:][:blank:]]`

Shortcuts (needs "enhanced" regular expressions):

- `\d` is `[[:digit:]]` `\D` is `[^[:digit:]]`
- `\s` is `[[:space:]]` `\S` is `[^[:space:]]`
- `\w` is `[[:alnum:]_]` `\W` is `[^[:alnum:]_]`

# Examples

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| **a** | Anything with the letter 'a' |

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| `[abc]` | One of 'a', 'b', or 'c' |

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| `a.*b` | 'a' then anything else, then 'b' (includes 'ab') |
| `[abc]` | One of 'a', 'b', or 'c' |
| `(ab\|c){2}` | 'abab', 'abc', 'cab', 'cc' (ERE) |

Which string does the ERE

```
\(\d{3}\) \d{3}-\d{4}
```

match?

A. ddd ddd-dddd

B. (ddd) ddd-dddd

C. 123 456-7890

D. (123) 456-7890

E. \(123\) 456-7890

Which of the following is an ERE for matching the syntax for an integer literal in C?

E.g., it should match all of `0`, `5`, `023`, `0xFeedFace`, `0XA1f`, but not `1x2` or `0789`

A. `(0|0x|0X)[[:digit:]]+`

B. `(0[0-7]*)|[1-9][[:digit:]]*|0[xX][[:xdigit:]]+`

C. `([0-7]*)|[[:digit:]]*|(0x|0X)[[:xdigit:]]*`

D. `\d`

E. This cannot be matched with a regular expression

# grep(1)

Name comes from ed(1) program command `g/re/p`

```
 grep –E re files
egrep –l re files
egrep –c re files
egrep –n re files
egrep –i re files
egrep –v re files
```

use extended regex (or use egrep)

just list file names

just list count of matches

just list line numbers

ignore case

show non-matching lines

# awk(1)

Named after the developers

- A. Aho
- P. Weinberger
- B. Kernighan

Programming language for working on files

Consists of a sequence of pattern-action statements of the form

- `pattern { action }`
- Each line of the input is matched compared to each `pattern` in order; each matching pattern has its associated `action` run

# Running AWK

Running

- `$ awk -f foo.awk files` # foo.awk contains the program
- `$ awk prog files` # pattern-action separated by `;`

Understands whitespace separated fields (can change this via `-F` option)

- `$1`, `$2`, `$3`
- `$0` is the whole line

Other variables, just use their names

# Patterns

| | |
|---|---|
| `/re/` | matches the regular expression `re` |
| `BEGIN` | matches before any input is used (can be used to set variables) |
| `END` | matches after all input is used (e.g., can print things) |
| `expr` | matches if the expression is nonzero |
| `p1,p2` | matches all lines between the line matching p1 and the line matching p2 (including those lines) |
| | (empty pattern) matches every line |

# Actions

An action is a sequence of statements inside `{ }` separated by `;`

- assignment statements var = value
- conditionals/loops: **`if`**, **`while`**, **`for`**, **`do-while`**, **`break`**, **`continue`**,
- **`for`** `(var` **`in`** `array) stmt`
- **`print`** `expr-list`
- **`printf`** `format, expr-list`

A missing action means to print the line

# Simple AWK program

Prints the lines of a file with START and END

```
BEGIN { print "START" }
      { print }
END   { print "END"}
```

# Simple AWK program

Prints lines longer than 72 characters

```
length($0) > 72 { print }
```

Missing action block means print

```
length($0) > 72
```

# Sum up a list of numbers

```
BEGIN { SUM = 0 }
      { SUM += $1 }
END   { print "Total is", SUM }
```

# Print size and owner from ls -l

```
$ ls -l | awk '{ print $5, "\t", $3 }'
```

Given pop.txt with lines containing zip code, county, population, e.g.,

```
44001, Lorain, 20769
44011, Lorain, 21193
```

what is the awk command to print out the population of Oberlin (zip code 44074)?

A.
```
$ awk -F ', ' '/44074/ { print $3 }'
```

B.
```
$ awk -F ', ' '$0 == 44074 { print $2 }'
```

C.
```
$ awk -F ', ' '$1 == 44074 { print $3 }'
```

D.
```
$ awk -F ', ' '44074 { print $2 }'
```

# In-class exercise

https://regex.sketchengine.co.uk Do the four interactive exercises

Grab a laptop and a partner and try to get as much of that done as you can!