COS 333: Advanced Programming Techniques

- **how to find us**

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- **today**
  - course overview
  - project info
  - administrative stuff
  - regular expressions and grep

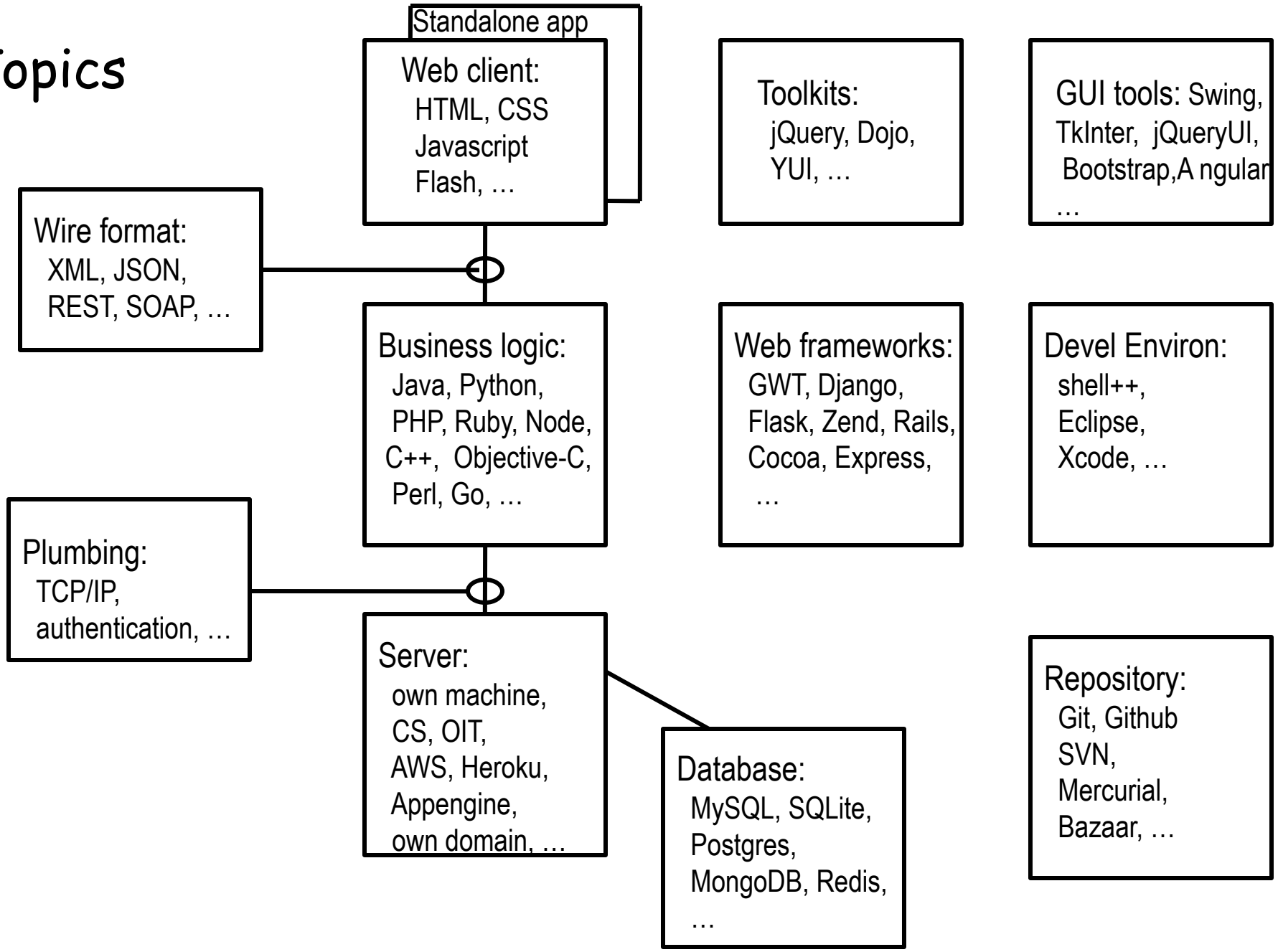
- **check out the course web page (CS, not Blackboard) and Piazza**
  - notes, readings and assignments posted only on the web page

    monitor the web page and Piazza every day
  - Assignment 1 is posted; due midnight Feb 8
  - initial project information is posted
- **do the survey if you haven't already**

Themes

- **languages and tools**
  - mainstream: C, C++, Java, C#, (Objective-C? Go?), ...
  - scripting: Awk, (Perl?), Python, (PHP?), Javascript, ...
  - programmable tools, application-specific languages
  - web frameworks, toolkits, development environments, interface builders
  - databases (MySQL, SQLite, MongoDB, …)
  - networks and plumbing
  - source code control (Git, SVN)
- **programming**
  - design, prototyping, reuse, components, interfaces, patterns
  - debugging, testing, performance, mechanization
  - portability, standards, style
  - tricks of the trade
- **reality**
  - tradeoffs, compromises, engineering
- **history and culture of programming**
- **guests**

Topics


Standalone app
Web client:
HTML, CSS
Javascript
Flash, …
Toolkits:
jQuery, Dojo,
YUI, …
GUI tools: Swing,
TkInter, jQueryUI,
Bootstrap,A ngular
…
Wire format:
XML, JSON,
REST, SOAP, …
Business logic:
Java, Python,
PHP, Ruby, Node,
C++, Objective-C,
Perl, Go, …
Web frameworks:
GWT, Django,
Flask, Zend, Rails,
Cocoa, Express,
…
Devel Environ:
shell++,
Eclipse,
Xcode, …
Plumbing:
TCP/IP,
authentication, …
Server:
own machine,
CS, OIT,
AWS, Heroku,
Appengine,
own domain, …
Database:
MySQL, SQLite,
Postgres,
MongoDB, Redis,
…
Repository:
Git, Github
SVN,
Mercurial,
Bazaar, …

Very Tentative Outline

week 1	**regular expressions, grep; project info**
week 2	**scripting: AWK, Python**
week 3	**web: HTTP, CGI; Javascript**
week 4	**DOM, Ajax; frameworks**
week 5	**databases; networks**
week 6	**Git, SVN; graphical user interfaces**
(spring break)	
week 7	**C++, Standard Template Library**
week 8	**Java, collections**
week 9	**C#, components: COM, .NET**
week 10	**APIs, DSLs, XML, JSON, REST**
week 11	**Go. Objective-C?**
week 12	**?**
May 5-8	**demo days: project presentations**
May 12	**Dean's date: project submission**

Some Mechanics

- **prerequisites**
  - C, Unix (COS 217); Java (COS 126, 226)
- **5 programming assignments in first half**
  - posted on course web page Thursday, due Sunday evening 10 days later
    but the first one is due this Sunday!
  - TAs will have office hours mostly Thursday and Friday
  - deadlines matter
- **project in second half (starts earlier!)**
  - groups of 3-5; start identifying potential teammates now
  - start thinking about possibilities right now
  - deadlines matter
- **monitor the web page**
  - readings for most weeks
  - notes generally posted ahead of time
  - use Piazza for discussion, assignment help, finding partners, ...
- **class attendance and participation <=> no midterm or final**
  - sporadic unannounced short quizzes are possible

Regular expressions and grep

- **regular expressions**
  - notation
  - mechanization
  - pervasive in Unix tools
  - in all scripting languages, often as part of the syntax
  - in general-purpose languages, as libraries
  - basic implementation is remarkably simple
  - efficient implementation requires good theory and good practice

- **grep is the prototypical tool**
  - people used to write programs for searching
    (or did it by hand)
  - tools became important
  - tools are not as much in fashion today

Grep regular expressions

`c` **any character matches itself, except for *metacharacters* `. [ ] ^ $ * \`**

$r_1 r_2$ **matches r_1 followed by r_2**

`.` **matches any single character**

`[...]` **matches one of the characters in set ...**

shorthand like a-z or 0-9 includes any character in the range

`[^...]` **matches one of the characters <u>not in</u> set**

[^0-9] matches non-digit

`^` **matches beginning of line when ^ begins pattern**

no special meaning elsewhere in pattern

`$` **matches end of line when $ ends pattern**

no special meaning elsewhere in pattern

`*` **any regular expression followed by * matches 0 or more**

`\c` **matches c unless c is ( ) or digit**

`\(...\)` **tagged regular expression that matches ...**

the matched strings are available as \1, \2, etc.

Examples of matching

`thing`	*thing* anywhere in string
`^thing`	*thing* at beginning of string
`thing$`	*thing* at end of string
`^thing$`	string that contains only *thing*
`^`	matches any string, even empty
`^$`	empty string
`.`	non-empty, i.e., at least 1 char
`thing.$`	*thing* plus any char at end of string
`thing\.$`	*thing*. at end of string
`\\thing\\`	*thing*\ anywhere in string
`[tT]hing`	*thing* or *Thing* anywhere in string
`thing[0-9]`	*thing* followed by one digit
`thing[^0-9]`	*thing* followed by a non-digit
`thing[0-9][^0-9]`	*thing* followed by digit, then non-digit
`thing1.*thing2`	*thing1* then any text then *thing2*
`^thing1.*thing2$`	*thing1* at beginning and *thing2* at end

egrep: fancier regular expressions

r+	one or more occurrences of r
r?	zero or one occurrences of r
$r_1|r_2$	r_1 or r_2
(r)	r (grouping)

grammar:

r: *c* . ^ $ [*ccc*] [^*ccc*]

r* r+ r?

r_1 r_2

$r_1|r_2$

(r)

precedence:

* + ? higher than concatenation, which is higher than |

```
([0-9]+\.?[0-9]*|\.[0-9]+)([Ee][-+]?[0-9]+)?
```

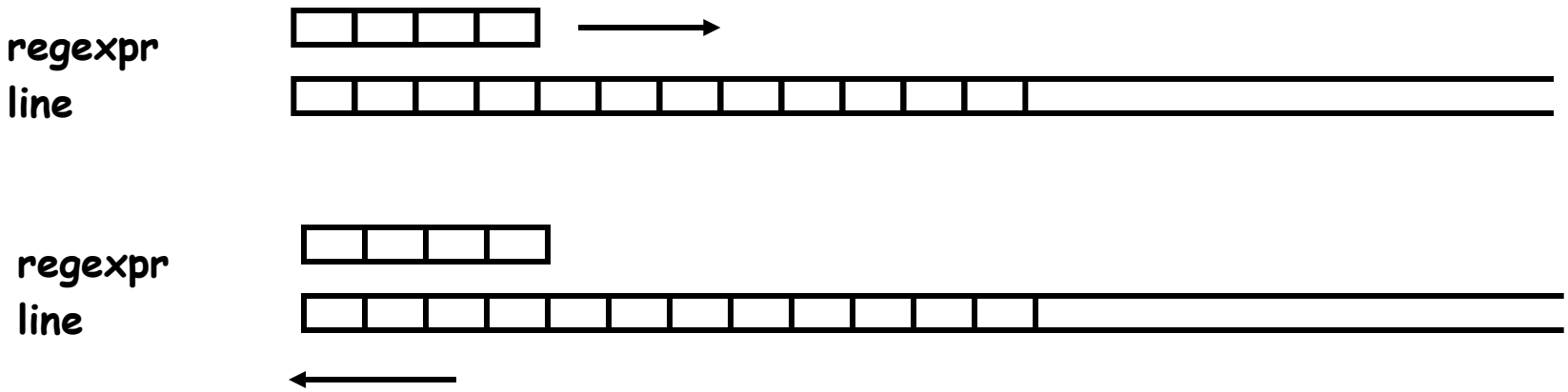
The grep family

- **grep**
- **egrep**
  - fancier regular expressions, trades compile time and space for run time
- **fgrep**
  - parallel search for many fixed strings
- **agrep**
  - "approximate" grep: search with errors permitted
- **relatives that use similar regular expressions**
  - ed original Unix editor
  - sed stream editor
  - vi, emacs, sam, ... editors
  - lex lexical analyzer generator
  - awk, perl, python, … all scripting languages
  - Java, C# ... libraries in mainstream languages
- **simpler variants**
  - filename "wild cards" in Unix and other shells
  - "LIKE" operator in SQL, Visual Basic, etc.

Basic grep algorithm

```
while (get a line)
    if match(regexpr, line)
        print line
```

- (perhaps) compile regexpr into an internal representation suitable for efficient matching
- match() slides the line past the regexpr (or vice versa),
  looking for a match at each point



Match anywhere on a line

- look for match at each position of text in turn

```
/* match: search for regexp anywhere in text */
int match(char *regexp, char *text)
{
     if (regexp[0] == '^')
          return matchhere(regexp+1, text);
     do {    /* must look even if string is empty */
          if (matchhere(regexp, text))
               return 1;
     } while (*text++ != '\0');
     return 0;
}
```

Match starting at current position

```
/* matchhere: search for regexp at beginning of text */
int matchhere(char *regexp, char *text)
{
    if (regexp[0] == '\0')
        return 1;
    if (regexp[1] == '*')
        return matchstar(regexp[0], regexp+2, text);
    if (regexp[0] == '$' && regexp[1] == '\0')
        return *text == '\0';
    if (*text!='\0' && (regexp[0]=='.' || regexp[0]==*text))
        return matchhere(regexp+1, text+1);
    return 0;
}
```

- **follow the easy case first: no metacharacters**
- **note that this is recursive**
  - maximum depth: one level for each regexpr character that matches

Simple grep algorithm

- **best for short simple patterns**
  - e.g., `grep printf *.[ch]`
  - most use is like this
  - reflects use in text editor for a small machine
- **limitations**
  - tries the pattern at each possible starting point
    e.g., look for aaaaab in aaaa….aaaab
    potentially O(mn) for pattern of length m
  - complicated patterns (.* .* .*) require backup
    potentially exponential
  - can't do some things, like alternation (OR)

- **this leads to extensions and new algorithms**
  - egrep — complicated patterns, alternation
  - fgrep — lots of simple patterns in parallel
  - boyer-moore — long simple patterns
  - agrep — approximate matches

Important ideas from regexprs & grep

- **tools: let the machine do the work**
  - good packaging matters
- **notation: makes it easy to say what to do**
  - may organize or define implementation
- **hacking can make a program faster, sometimes, usually at the price of more complexity**

- **a better algorithm can make a program go a lot faster**

- **don't worry about performance if it doesn't matter (and it often doesn't)**

- **when it does,**
  - use the right algorithm
  - use the compiler's optimization
  - code tune, as a last resort