Regular Expressions in Java Grammars

March 26–27, 2012

CS 60: Principles of Computer Science

Assignment 7 (Quantities) due tonight.

Assignment 8 (Full Unicalc) due next Monday.

Regular Expression Ingredients

Regular expressions are a formal way of describing simple patterns.
A regular expression can be:

- ✓ The empty string (sometimes written ϵ or λ)
- ✓ A single character (e.g., a or 0)
- ✓ Concatenation: $r_1\, r_2$
- ✓ Alternative: $r_1 \mid r_2$
- ✓ Repetition ("Kleene Star"): r_1^*.

In practice we use lots of abbreviations, e.g.,

$$\begin{array}{lcl} \texttt{[a-e]} & := & \texttt{(a|b|c|d|e)} \\ r? & := & r \mid \epsilon \\ r^+ & := & r\, r^* \end{array}$$

Application: Regular Expressions and Search

Unix's **egrep** *command does* line-by-line *search for* text *matching a* regular *expression.*

```
egrep   'hh'        /usr/share/dict/words
egrep   'y.*y'      /usr/share/dict/words
egrep   '(xq|hq)'   /usr/share/dict/words
egrep   '^y.*y$'    /usr/share/dict/words
```

Another Application of Regular Expressions

I have a Racket implementation of unicalc, with an extensive database:

```
(list 'km       (make-QL 1.0 '(kilometer) '()))
(list 'kph      (make-QL 1.0 '(kilometer) '(hour)))
(list 'kwh      (make-QL 1.0 '(hour kilowatt) '()))
(list 'l        (make-QL 1.0 '(liter) '()))
```

I wanted Java code to construct a database:

```
db.put("km", new Quantity(1.0, 0.0, Arrays.asList("kilometer"),
                          Collections.<String>emptyList()));
db.put("kph", new Quantity(1.0, 0.0, Arrays.asList("kilometer"),
                           Arrays.asList("hour")));
db.put("kwh", new Quantity(1.0, 0.0,
                           Arrays.asList("hour", "kilowatt"),
                           Collections.<String>emptyList()));
db.put("l", new Quantity(1.0, 0.0, Arrays.asList("liter"),
                         Collections.<String>emptyList()));
```

My Plan

Write Java code that loops over the lines of a file. For each line:

- ✓ Search for occurrences of the Racket pattern

```
(list 'joule   (make-QL 1.0 '(kg m m) '(s s)))
```

- ✓ For each occurrence, extract the four important parts, and generate appropriate Java code, e.g.,
  - Quotation marks and commas
  - `new Quantity`,
  - Calls to `db.put` and `Arrays.asList`

Reading Lines from a File

```
import java.util.Scanner;
import java.io.FileInputStream;
...
  try {
    FileInputStream fin = new FileInputStream(fileName);

    Scanner scan = new Scanner(fin);

    // Loop over the lines
    while ( scan.hasNextLine() ) {
        String line = scan.nextLine();
        ...
    }

  } catch (IOException e) {
    System.out.println("Could not open " + filename)
  }
```

Looping Over Pattern-Matches in a String

```
// importing java.util.* isn't enough
import java.util.regex.Pattern;
import java.util.regex.Matcher;

  Pattern p = Pattern.compile("[0-9]+"); // Only once
  ...

    // To loop over all matches of Pattern p in one string:
    // Step 1: Say which string we want to search
    Matcher m = p.matcher(myString);

    // Step 2: Loop over all matches.
    while (m.find()) {
      String matchedSubstring = m.group();
      ...
    }
```

Extracting Subparts of a Match

When you find a match (`m.find()`), rather than asking for the entire matched substring

```
m.group();
```

you can ask for the subpart matched by the k-th **parenthesized** part of the regular expression

```
m.group(k)
```

```
Pattern p2 = Pattern.compile("([A-Za-z]+) : ([0-9]+)");
Matcher m2 = p2.matcher("Student Pat : 42 units");

m2.find();
String match = m2.group();   // "Pat : 42"
String name  = m2.group(1);  // "Pat"
String num   = m2.group(2);  // "42"
```

Back to our Example

```
Pattern linePat = Pattern.compile(???);
    ...
    // Get ready to start searching this string
    Matcher m = linePat.matcher(line);

    // Loop over all pattern matches (database entries) i
    while (m.find()) {
      String unitName = m.group(1);
      String valueString = m.group(2);
      String numeratorSymbols = m.group(3);
      String denominatorSymbols = m.group(4);

      // ... print a line of Java...
    }
```

Exercise: Constructing A Regular Expression

What should my regular expression be, to match an entire Racket line with the correct 4 parts parenthesized?

```
(list 'joule    (make-QL 1.0 '(kg m m) '(s s)))
(list 'atomic_mass_unit (make-QL 1.0 '(dalton) '()))
```

Recall: `|` = "or," `...*` = "0 or more," `...+` = "1 or more", `.` = "any character except `\n`", `[abc]` = "a or b or c", `[^abc]` = "any single character except a or b or c".

Also in Java: `\d` = "any digit," `\s` = "any whitespace character (space, tab, ...)," `\S` = any "word" character (letter, number, underscore)

See `http://docs.oracle.com/javase/6/docs/api/java/util/regex/Pattern.html` for more.

Grammars and Parsing

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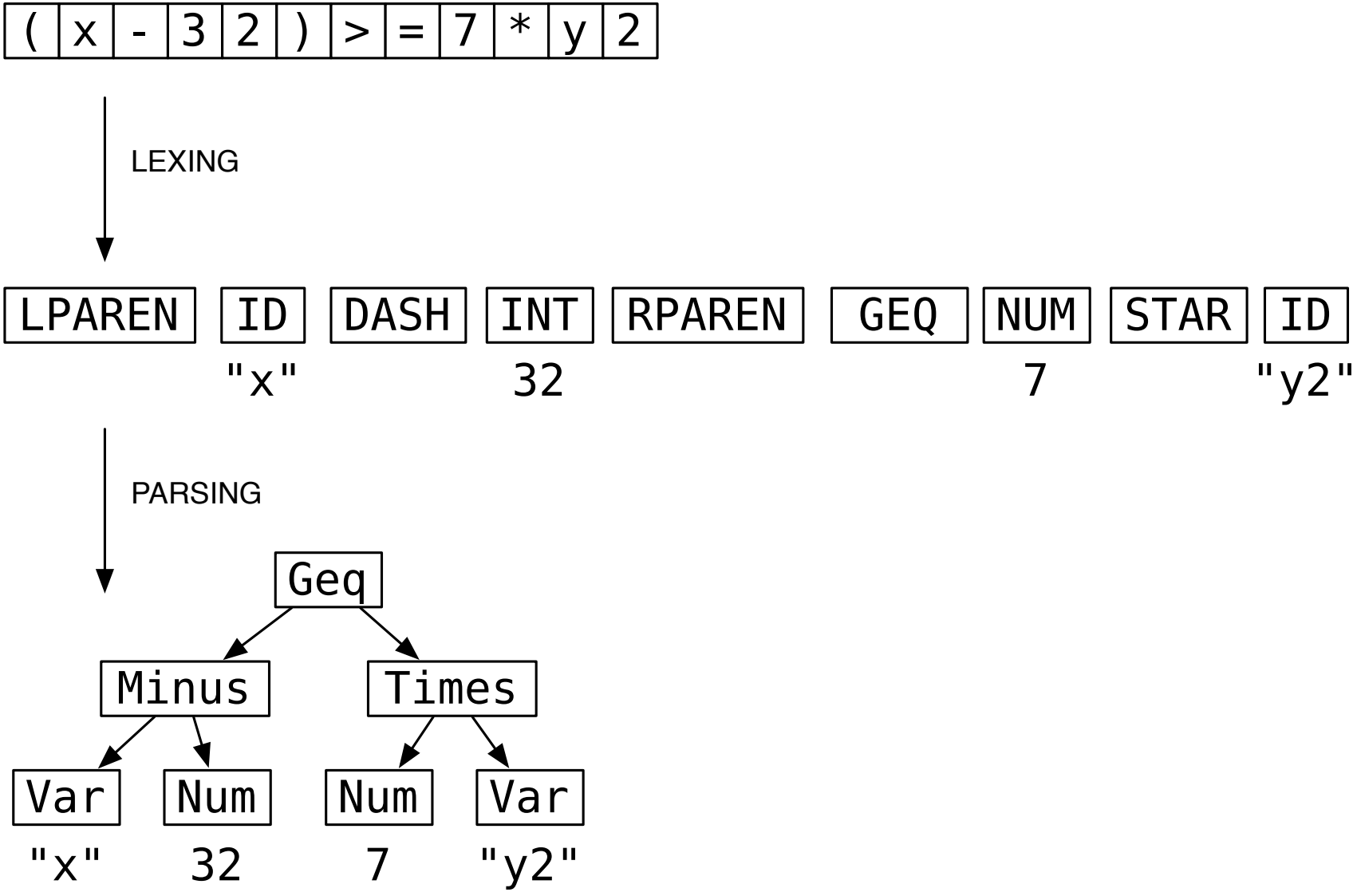
Traditional Lexing and Parsing



Specifying Syntax via CFGs

A *context-free grammar* is a set of rules for producing a set of strings (a *language*).

$$\begin{aligned} S &\rightarrow V + S \mid V \\ V &\rightarrow 0 \mid 1 \mid 2 \mid \cdots \mid 9 \end{aligned}$$

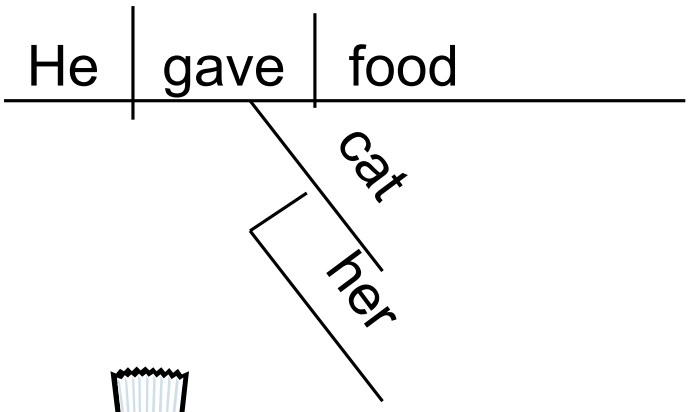
Ingredients:

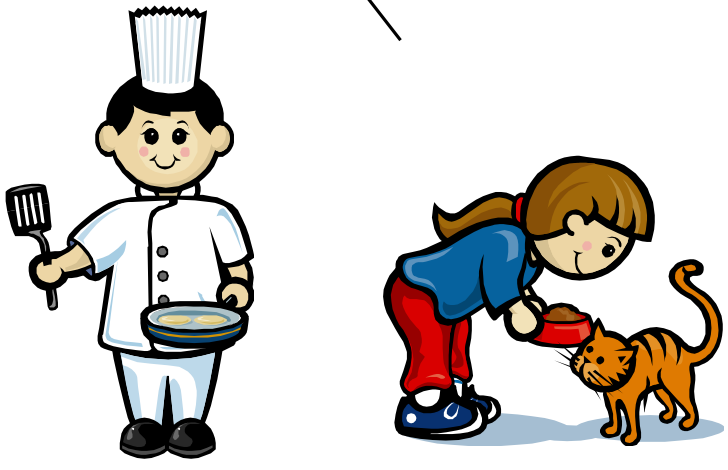
- ✓ Nonterminals: S, V
- ✓ Terminals: $+$, 0, 1, 2, …, 9
- ✓ Production rules: (*see above*)
- ✓ Where to start: S

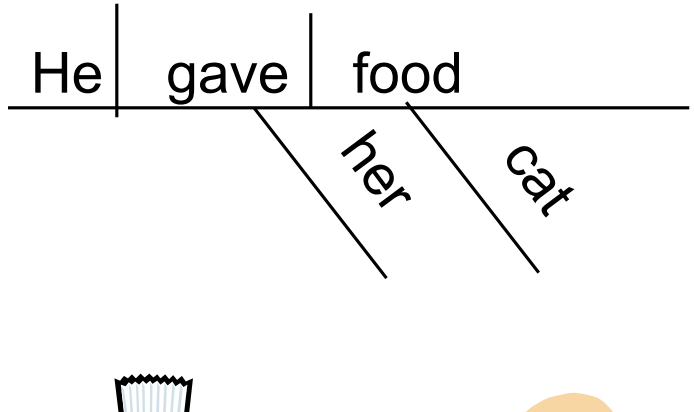
Show how to produce 4 starting from S.
Show how to produce 4 + 5 starting from S.
What other strings can we produce?

Using Structure to Clarify Meaning

He *gave* her cat food.







Parse Trees

The *parse tree* of a string makes explicit how a string was produced:

- ✓ Root is the start symbol
- ✓ When we apply a rule, items on the right-hand-side become children

Parse trees for **4** and 4+5?

$$
\begin{array}{lcl}
S & \rightarrow & V + S \mid V \\
V & \rightarrow & 0 \mid 1 \mid 2 \mid \cdots \mid 9
\end{array}
$$

Parse Trees

Show the parse tree for `9 - 3 + 2`

$$
\begin{aligned}
S &\rightarrow V + S \mid V - S \mid V \\
V &\rightarrow 0 \mid 1 \mid 2 \mid \cdots \mid 9
\end{aligned}
$$