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CS 106B

Handout #51
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Parsing Strategies

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The Problem of Parsing

- The rules for forming an expression can be expressed in the form of a ***grammar***, as follows:

  E → *constant*
  E → *identifier*
  E → **E** *op* **E**
  E → **(E)**

- The process of translating an expression from a string to its internal form is called ***parsing***.

A Two-Level Grammar

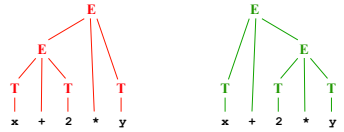
- The problem of parsing an expression can be simplified by changing the grammar to one that has two levels:
  - An ***expression*** is either a *term* or two expressions joined by an operator.
  - A ***term*** is either a constant, an identifier, or an expression enclosed in parentheses.
- This design is reflected in the following revised grammar.

  E → **T**
  E → **E** *op* **E**

  T → *constant*
  T → *identifier*
  T → **(E)**

Ambiguity in Parse Structures

- Although the two-level grammar from the preceding slide can recognize any expression, it is ***ambiguous*** because the same input string can generate more than one parse tree.



- Ambiguity in grammars is typically resolved by providing the parser with information about the ***precedence*** of the operators. The text describes two strategies: ***Iversonian precedence***, in which the operators all group to the right, and ***operator precedence***, in which each operator is associated with an integer that defines its place in the precedence hierarchy.

Exercise: Parsing an Expression

- Diagram the expression tree that results from the input string

```
odd = 2 * n + 1
```

The `parser.cpp` Implementation

```
/*
 * Implementation notes: readE
 * Usage: exp = readE(scanner, prec);
 * ----------------------------------
 * This function reads the next expression from the scanner by
 * matching the input to the following ambiguous grammar:
 *
 *       E -> T
 *       E -> E op E
 *
 * This version of the method uses precedence to resolve ambiguity.
 */

Expression *readE(TokenScanner & scanner, int prec) {
   Expression *exp = readT(scanner);
   string token;
   while (true) {
      token = scanner.nextToken();
      int tprec = precedence(token);
      if (tprec <= prec) break;
      Expression *rhs = readE(scanner, tprec);
      exp = new CompoundExp(token, exp, rhs);
   }
   scanner.saveToken(token);
   return exp;
}
```

The `parser.cpp` Implementation

```
/*
 * Function: readT
 * Usage: exp = readT(scanner);
 * ----------------------------
 * This function reads a single term from the scanner.
 */

Expression *readT(TokenScanner & scanner) {
   string token = scanner.nextToken();
   TokenType type = scanner.getTokenType(token);
   if (type == WORD) return new IdentifierExp(token);
   if (type == NUMBER) return new ConstantExp(stringToInteger(token));
   if (token != "(") error("Illegal term in expression");
   Expression *exp = readE(scanner, 0);
   if (scanner.nextToken() != ")") {
      error("Unbalanced parentheses in expression");
   }
   return exp;
}
```

The `parser.cpp` Implementation

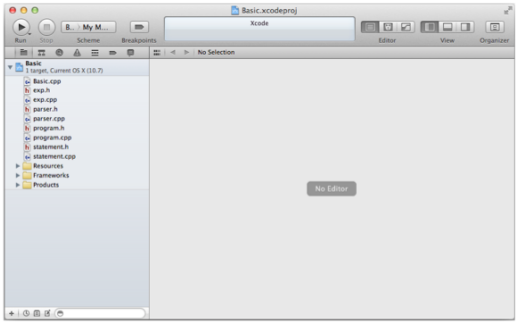
```
/*
 * Function: precedence
 * Usage: prec = precedence(token);
 * --------------------------------
 * This function returns the precedence of the specified operator
 * token.  If the token is not an operator, precedence returns 0.
 */

int precedence(string token) {
   if (token == "=") return 1;
   if (token == "+" || token == "-") return 2;
   if (token == "*" || token == "/") return 3;
   return 0;
}
```

Exercise: Coding a BASIC Program

- On the second practice midterm, one of the problems concerned the ***hailstone sequence***. For any positive integer *n*, you compute the terms in the hailstone sequence by repeatedly executing the following steps:
  - If *n* is equal to 1, you've reached the end of the sequence and can stop.
  - If *n* is even, divide it by two.
  - If *n* is odd, multiply it by three and add one.
- Write a BASIC program that reads in an integer and prints out its hailstone sequence.

The Basic Starter Project



Modules in the Starter Folder

`Basic.cpp`	*You write this one, but it's short.*
`exp.h` `exp.cpp`	*You need to remove the* `=` *operator and add a few things to* `EvaluationContext`.
`parser.h` `parser.cpp`	*You need to remove the* `=` *operator.*
`program.h` `program.cpp`	*You're given the interface, but need to write the private section and the implementation.*
`statement.h` `statement.cpp`	*You're given the interface and need to supply the implementation.*

Your Primary Tasks

1. Figure out how the pieces of the program go together and what you need to do.
2. Code the `Program` class, keeping in mind what methods need to run in constant time.
3. Implement the `Statement` class hierarchy: