CMSC 330: Organization of Programming Languages

Project 4 - Scheme Parser & Interpreter

Project 4 Overview

- Scheme programming
  - Write some functions in Scheme
- Scheme interpreter
  - Given Scheme AST
  - Evaluate AST
- Scheme parser
  - Write recursive descent parser
  - Build Scheme AST

Scheme

- Functional programming language
  - Steele & Sussman @ MIT, 1975
  - Based on LISP
    - Lots of Idiotic Stupid Parentheses
    - But uses lexical scoping
  - Resembles lambda calculus
- Features
  - Higher order functions – lambda (x) (…)
  - Builds lists using cons cells - cons, car, cdr

Scheme Examples

- Function evaluation
  - (+ 1 2) evaluates to 3
  - (+ 1 2 3 4 5) evaluates to 15
  - (- 3 4) evaluates to -1
  - (- 3 4 5) evaluates to -6

Scheme Examples

- Booleans
  - (= 1 2) evaluates to #f
  - (= 1 1) evaluates to #t
  - (bool? #t) evaluates to #t
  - (bool? 6) evaluates to #f

Scheme Examples

- Global bindings
  - (define three 3)
  - (+ three 4) evaluates to 7
- Creating functions
  - (define add-two (lambda (n) (+ n 2)))
  - (add-two 5) evaluates to 7

Scheme Examples

- Recursive functions
  - (define fact (lambda (n) (if (= n 0) 1
    (* n (fact (- n 1))))))
  - (fact 3) evaluates to 6
  - (fact 5) evaluates to 120

Scheme Examples

- Higher order functions
  - (define x 52)
  - (define foo (lambda (x) (lambda (y) (+ x y))))
  - (define x 25)
  - ((foo 3) 4) evaluates to 7

Note lexical scoping for x in foo

Scheme Examples

- Lists
  - (define x (cons 3 2))
  - (car x) evaluates to 3
  - (cdr x) evaluates to 2

  - (define y (cons 4 x))
  - (car y) evaluates to 4
  - (cdr y) evaluates to (3 2)

Use cons to build lists
Use car / cdr to deconstruct lists

Starting OCaml Code – scheme.ml

- Type ast
  - Represents Scheme abstract syntax tree
    - type ast =

```
      Id of string
    | Num of int
    | Bool of bool
    | String of string
    | List of ast list
```


Starting OCaml Code – scheme.ml

- Type value
  - Represents Scheme values
    - type value =

```
      Val_Num of int
    | Val_Bool of bool
    | Val_String of string
    | Val_Nil
    | Val_Cons of value * value
```

  - You will need to add new fields (e.g., closure)
    - But do not modify existing fields!

Starting OCaml Code – scheme.ml

- Type token
  - Represents Scheme tokens
    - type token =

```
      TId of string
    | TNum of int
    | TString of string
    | TTrue
    | TFalse
    | TLParen
    | TRParen
```

Project 4 – Part 1

- Scheme programming
  - Gain experience with Scheme programs
  - Write simple recursive functions
    - double x → two times x
    - powof2 x → true (#t) iff x is a power of 2
    - sum l → sum of the integer list l
    - map f l → list containing elements of l with f applied to them

Project 4 – Part 2

- Scheme interpreter
  - Given Scheme AST
    - Evaluate AST to produce value
      - define, values, lambda, identifiers, function calls, primitives
  - Can test interpreter without parser
    - Using manually constructed Scheme AST

Project 4 – Part 3

- Scheme parser
  - Given scanner
    - Converts input strings into sequence of tokens
  - Write recursive descent parser
    - Convert list of tokens into Scheme AST

Project 4 Notes

- Project files
  - basic.scm → your scheme code for part 1
  - scheme.ml → your code. Make all your edits here
  - main.ml → interpreter using code from scheme.ml
  - sample.output → example input / output (public test)
- Testing
  - ocaml scheme.ml → test for syntax / type errors
  - ocaml main.ml → run scheme interpreter
  - ocaml public_eval1.ml → run 1st eval public test
  - Etc…