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

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

- 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

- **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`

- **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!
Project 4 – Part 1

• Scheme programming
  – Gain experience with Scheme programs
  – Write simple recursive functions
    • double x → two times x
    • powof2 x → true (#t) if 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…