Review: “Continuation-Passing Style”

All tail positions are continuations or recursive calls

```
(define witness-cps (p? xs succ fail)
  (if (null? xs)
      (fail)
      (let ([z (car xs)])
        (if (p? z)
            (succ z)
            (witness-cps p? (cdr xs) succ fail))))
```

Compiles to tight code
Homework: Solving Boolean formulas

A formula is one of these:

- Symbol (stands for a variable)
- Record (make-not \( f \)); \( f \) is a formula
- Record (make-or \( fs \)); \( fs \) is a list of formulas
- Record (make-and \( fs \)); \( fs \) is a list of formulas

In context of:

- (record not [arg])
- (record or [args])
- (record and [args])
Your turn: Find satisfying assignment!

(val f1 (make-and (list4 'x 'y 'z (make-not 'x))))
  ; x ∧ y ∧ z ∧ ¬x

(val f2 (make-not (make-or (list2 'x 'y))))
  ; ¬(x ∨ y)

(val f3 (make-not (make-and (list3 'x 'y 'z))))
  ; ¬(x ∧ y ∧ z)
Wait for it ...
Satisfying assignments

(val f1 (make-and (list4 'x 'y 'z (make-not 'x)))
  ; x \( y \setminus z \setminus \neg x \) ; NONE

(val f2 (make-not (make-or (list2 'x 'y)))
  ; \neg(x \lor y) ; \{x \rightarrow \text{#f}, y \rightarrow \text{#f} \}

(val f3 (make-not (make-and (list3 'x 'y 'z)))
  ; \neg(x \land y \land z) ; \{x \rightarrow \text{#f}, \ldots \}
Find assignment using continuations

start +----------+ succeed
--------->| |------------>
| solver |
<---------| |<-----------
fail +----------+ resume

start Gets partial solution, fail, succeed
(On homework, “solution” is assignment)

fail Partial solution won’t work (no params)

succeed Gets improved solution + resume

resume If improved solution won’t work, try another (no params)

A composable unit!
Continuations for the solver

A big box contains two smaller boxes A and B

There are two ways to wire them up (board)

Imagine A and B as formulas

Imagine A as a formula, B as a list of formulas!
Solving a literal

; (satisfy-literal-true x current succ fail) =
; (succ current fail), when x is bound to #t in cur
; (fail), when x is bound to #f in cur
; (succ (bind x #t current) fail), x unbound in cur

(define satisfy-literal-true (x current succ fail)
  (if (bound? x current)
      (if (find x current)
          (succ current fail)
          (fail))
      (succ (bind x #t current) fail))
Lisp and Scheme Retrospective
Five powerful questions

1. What is the abstract syntax?
   Syntactic categories? Terms in each category?
2. What are the values?
   What do expressions/terms evaluate to?
3. What environments are there?
   What can names stand for?
4. How are terms evaluated?
   Judgments? Evaluation rules?
5. What’s in the initial basis?
   Primitives and predefined, what is built in?
μScheme and the Five Questions

Abstract syntax: expressions and definitions
imperative core, let, lambda

Values: S-expressions
   (especially cons cells, function closures)

Environments: A name stands for a mutable location holding a value

Evaluation rules: lambda captures environment

Initial basis: yummy higher-order functions
A Scheme program is *just another S-expression*

- Function `define-syntax` manipulates syntax at compile time
- Macros are **hygienic**—name clashes impossible
- `let`, `&&`, `record`, others implemented as macros

(See book sections 2.16, 2.17.4)
Full Scheme: Conditionals

(cond [c1 e1] ; if c1 then e1
    [c2 e2] ; else if c2 then e2
    ...           ...  
    [cn en]) ; else if cn then en

; Syntactic sugar---‘if’ is a macro:
(if e1 e2 e3) == (cond [e1 e2]
                       [#t e3])

Full Scheme: Mutation

Not only variables can be mutated.

Mutate heap-allocated cons cell:

\[(\text{set-car!} \ ' (a b c) \ 'd) \Rightarrow (d b c)\]

Circular lists, sharing, avoids allocation
  • still for specialists only