6.090
Building Programming Experience

Lecture 3

1/12/2007

More Procedures and lists

- Iterative vs Recursive Procedures
- Syntactic sugar and shortcuts
- Lists

Recursive Procedures

- Let’s look at this one again:
- ```
  (define (sumto n)
    (if (= n 1)
        1
        (+ n (sumto (- n 1)))))
  ```
  ```

Recursive Procedures

- What happens when n is very large?

```
(define (sumto n)
  (if (= n 1)
      1
      (+ n (sumto (- n 1)))))
```

- (+ 100 (+ 99 (+ 98 (+ 97 ….

Recursive Process

- (+ 100 (+ 99 (+ 98 (+ 97 (sumto 96)))))
- Each addition is a pending operation
- Intrepreter has to store it, wait to evaluate it
- Try it for a really large n -- should slow down fast

Newer Version

- Old

```
(define (sumto n)
  (if (= n 1)
      1
      (+ n (sumto (- n 1)
```

New

```
(define (sumto n ans)
  (if (= n 1)
      (+ ans 1)
      (sumto (- n 1)
             (+ ans n))))
```

Are there any more pending operations?

Iterative vs Recursive

- Two types of processes:
  - Iterative: no pending operations
  - Recursive: pending operations
- Hint: look for the point where the procedure is called again:
  - (op (call-again ….)) -- recursive
  - (call-again …) -- iterative

Friendlier Iterative Procedures

- Extra arguments are annoying
- Use a helper function instead
-
```
(define (sumto-helper n ans)
  (if (= n 1)
      (+ ans 1)
      (sumto-helper (- n 1) (+ ans n))))
(define (sumto n)
  (sumto-helper n 0))
```

Iterative versions

- Factorial:
  - (define (fact-iter n) …
- Exponentiation:
  - (define (expt-iter x n) …

Syntactic Sugar

- Syntax:
  - How to correctly arrange the language to describe computation
- Syntactic Sugar “sweetens” language to make it more convenient
  - No new capabilities

First example: **let**

- **(let** ((*name1 val1*)
          (*name2 val2*))
      expr)
- Binds the value of val1 to name1 when evaluating *expr*
  - No changes elsewhere

Let example

- ```
  (let ((a 3)
        (b 5))
    (+ a b))
  ```
  ```

Let example

- ```
  (let ((a 3)
        (b 5))
    (+ a b))
  ```
- Equivalent to:
- ```
  ((lambda (a b) (+ a b))
   3 5)
  ```

Let “practice”

- ```
  (let ((+ *)
         (* +))
     (+ 3 (* 4 5)))
  ```
  ```

Let practice

- ```
  (define m 3)
  (let ((m (+ m 1)))
    (+ m 1))
  (define n 4)
  (let ((n 12)
          (o (+ n 2)))
    (* n o))
  ```
  ```

More Syntactic Sugar

- This one appears quite often:

```
(define new-function
      (lambda (a b c) exprs)
```

- Shortcut version:

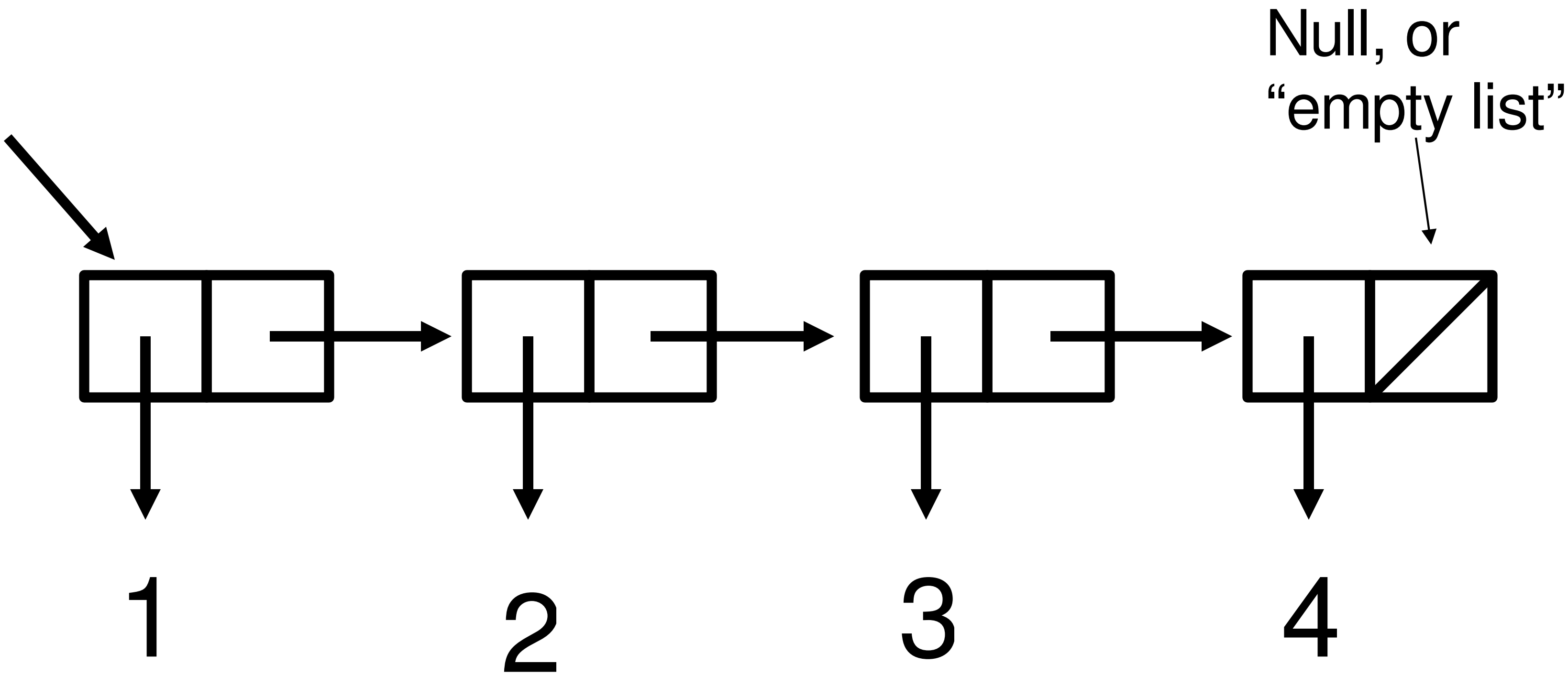
```
(define (new-fuction a b c) exprs)
```

Lists

- Basic data structure in Scheme
- Create a list using **list**
  - (**list** 1 2 3 4 5 6)
- (define lst (list 1 2 3 4 5))

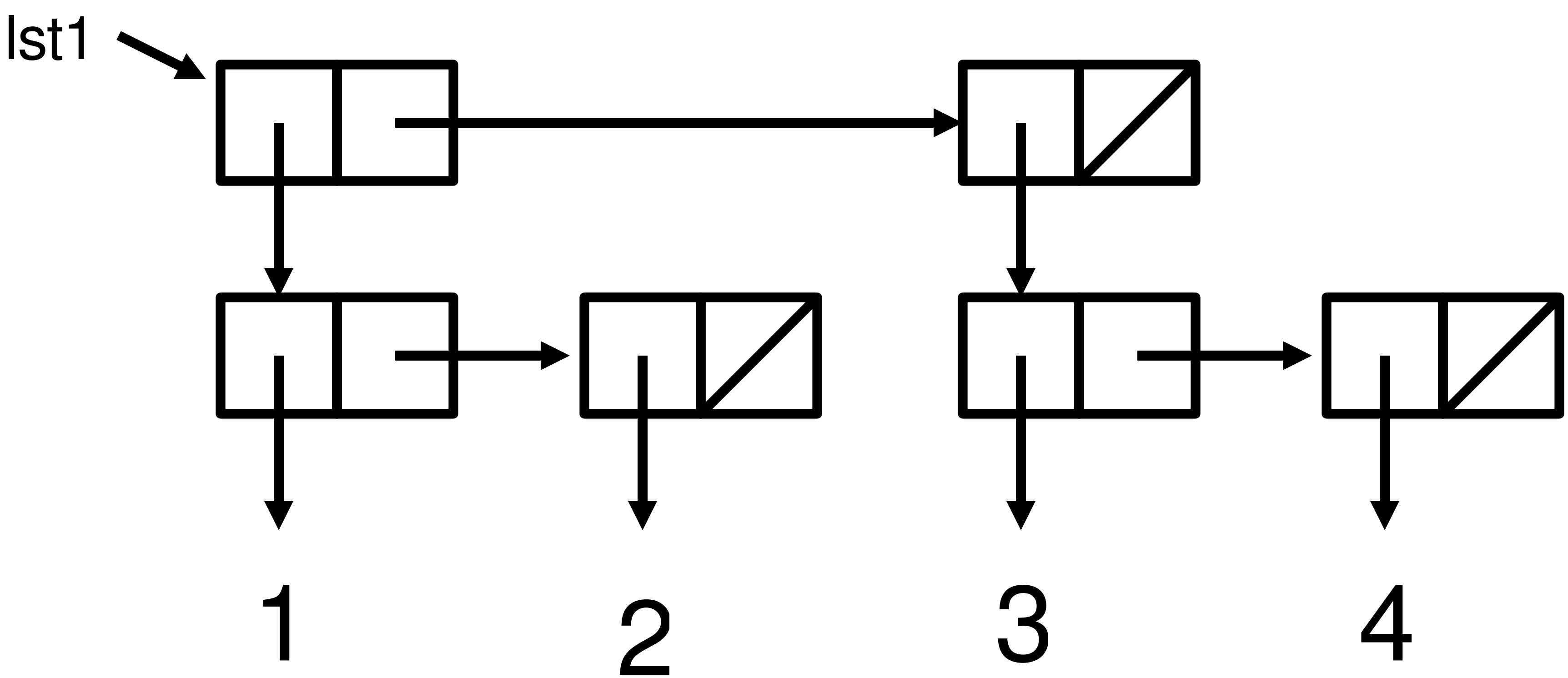
How are lists represented

- (list 1 2 3 4)



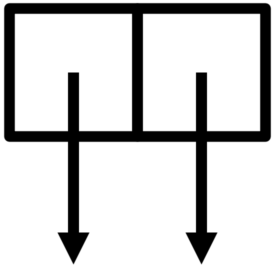
Lists

- Anything can be in a list
- (define lst1 (**list** (**list** 1 2) (**list** 3 4)))



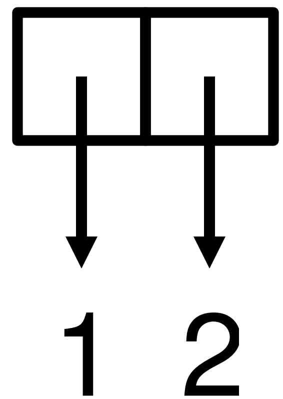
Pairs

- A list is built out of pairs
- A pair is a basic type
- Box with two pointers
- To create a pair use **cons**
- Also known as a “cons cell”

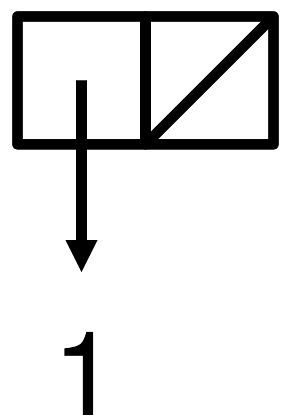


Pairs

- (**cons** 1 2)



- (**cons** 1 null)

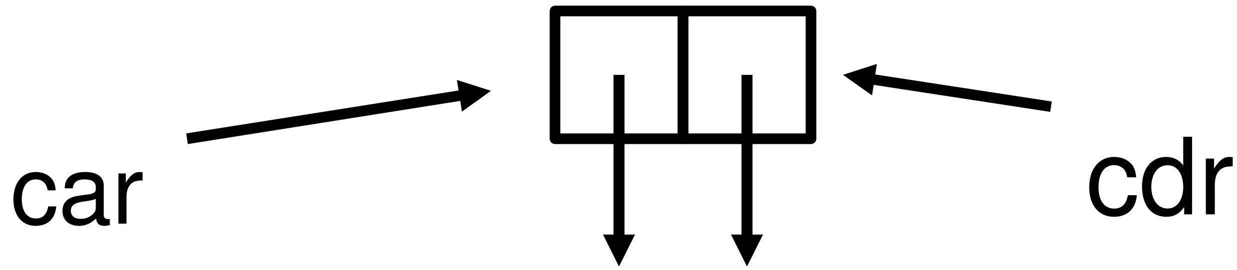


Building lists

- We can use **cons** to build up lists
- Draw a box and pointer diagram for
- (cons 1 (cons 2 (cons 3 (cons 4 null))))

Getting stuff out of pairs

- We can put things in a cons object, but how do get them back?



Examples

```
(car (cons 1 2))
(cdr (cons 1 2))

(define lst (list 1 2))

(car lst)
(cdr lst
(cdr (cdr lst))
```

Finding the length of a list

- Define a procedure length
- What’s the recursive case?
- What’s the base case?

Checking for the empty list

- Base case is an empty list
- Check for it using the **null?** Predicate

- (null? lst) returns #t if lst is the empty list, and #f otherwise

length

- Plan
  - Base Case: Empty list -> 0
  - Recursive Case: 1 + lenth of “rest of list”

length

- (define (length list)