

Computer Science I

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Lecture 2

Computation

- It's more than just number crunching!
- Manipulation of symbols.
- Logical reasoning.
- Artificial Intelligence.

Types of Values in Scheme

- Numbers: 1, 2, 17, 3.14159.
- Symbols: bill, hillary, al, tipper.
- Lists: (bill hillary al tipper), (bill hillary chelsea).
- Booleans: #t, #f.
- Strings: "To be or not to be.", "Vassar College".
- Procedures: #<primitive:+>, #<primitive:*>

How Scheme Evaluates Composite Expressions

(<operator> <operand> <operand> ... <operand>)

- Evaluate <operator> to get a procedure.
- Evaluate each <operand> to get a value.
- Apply the procedure to the values.

Evaluating: (+ 8 7)

- Evaluate + to get #<primitive:+>.
- Evaluate 7 to get 7.
- Evaluate 8 to get 8.
- Apply #<primitive:+> to 8 and 7 to get 15.

Welcome to DrScheme

```
> +  
#<primitive:+>  
> 7  
7  
> 8  
8  
> (+ 8 7)  
15
```

Welcome to DrScheme

```
> (define eight 8)
```

```
> (define seven 7)
```

```
> (define two 2)
```

Evaluating: (+ eight seven)

- Evaluate + to get #<primitive:+>.
- Evaluate seven to get 7.
- Evaluate eight to get 8.
- Apply #<primitive:+> to 8 and 7 to get 15.

Welcome to DrScheme

```
> +
```

```
#<primitive:+>
```

```
> seven
```

```
7
```

```
> eight
```

```
8
```

```
> (+ eight seven)
```

```
15
```

Evaluating: (* 2 (+ 8 7))

- Evaluate * to get #<primitive:*>.
- Evaluate (+ 8 7) to get 15.
- Evaluate 2 to get 2.
- Apply #<primitive:*> to 2 and 15 to get 30.

Welcome to DrScheme

```
> *
```

```
#<primitive:*>
```

```
> (+ 8 7)
```

```
15
```

```
> 2
```

```
2
```

```
> (* 2 (+ 8 7))
```

```
30
```

Scheme Synonyms

- Operator, procedure, function.
- Operand, argument, parameter.

How Scheme Processes Variable Definitions

```
(define <variable> <expression>)  
  
(define graduation (+ 2000 4))
```

- Scheme does NOT evaluate the keyword “define”.
- Scheme does NOT evaluate the <variable>.
- Scheme DOES evaluate the <expression>.

Defining Variables whose Values are Symbols

Welcome to DrScheme

```
> (define president bill)
```

reference to undefined identifier: bill

What went wrong?

- Scheme tried to evaluate the variable “bill”.
- We had not previously defined “bill”.
- How can we talk about the symbol “bill”, rather than the variable “bill”?

Quote

- Inhibits evaluation.
- General form: (quote <expression>).
- Example: (quote bill).
- Shorthand form: '<expression>.
- Example: 'bill.

Defining Variables Whose Values are Symbols

```
Welcome to DrScheme  
> (define president 'bill)  
> president  
bill  
> (define first-lady 'hillary)  
> first-lady  
hillary
```

Constructing Lists in Scheme

```
Welcome to DrScheme  
> '()  
()  
> '(superman)  
(superman)  
> '(batman superman)  
(batman superman)  
> '(hulk batman superman)  
(hulk batman superman)
```

Constructing Lists in Scheme

```
Welcome to DrScheme
> '()
()
> (cons 'superman '())
(superman)
> (cons 'batman (cons 'superman '()))
(batman superman)
> (cons 'hulk (cons 'batman (cons 'superman '())))
(hulk batman superman)
```

The CONS Procedure

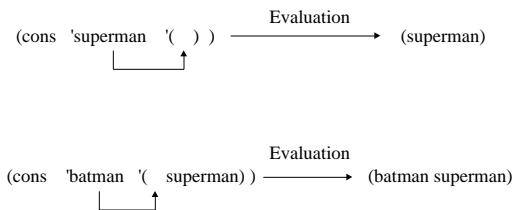
(cons <item> <list>)

- Constructs lists of values.
- First argument can be anything.
- Second argument is normally a list.
- CONS will construct a new list by inserting <item> at the beginning of <list>.

The Empty List

- A list with nothing on it.
- User types '() to Scheme.
- Scheme evaluates '() to get ().
- Scheme displays “()” as the value of '().

An Illustration of CONS



Constructing Lists in Scheme

```
Welcome to DrScheme
> (define first-couple (cons 'bill (cons 'hillary '())))
> first-couple
(bill hillary)
> (define second-couple (cons 'al (cons 'tipper '())))
> second-couple
(al tipper)
> (define leaders (cons first-couple (cons second-couple '())))
> leaders
((bill hillary) (al tipper))
```

Constructing Lists in Scheme

```
Welcome to DrScheme
> (define heroes (hulk batman superman))
reference to undefined identifier: hulk
```

What went wrong?

- Scheme tried to evaluate the variable “hulk”.
- We had not previously defined a variable called “hulk”.
- Nor had we defined “batman” or “superman”.

Quote Inhibits Evaluation of Composite Expressions

```
Welcome to DrScheme
> (quote (hulk batman superman))
(hulk batman superman)
> '(hulk batman superman)
(hulk batman superman)
> (define heroes '(hulk batman superman))
> heroes
(hulk batman superman)
```

Taking Lists Apart in Scheme

```
Welcome to DrScheme
>(define heroes '(hulk batman superman))
> heroes
(hulk batman superman)
> (car heroes)
hulk
> (cdr heroes)
(batman superman)
```

The CAR and CDR Procedures

(car <non-empty-list>) (cdr <non-empty-list>)

- The argument to CAR should be a non-empty list.
- CAR returns the first item on the list.
- The argument to CDR should be a non-empty list.
- CDR returns the new list that results from deleting the first thing on the given list.

```
Welcome to DrScheme
> (define heroes '(hulk batman superman))
> heroes
(hulk batman superman)
> (car heroes)
hulk
> (cdr heroes)
(batman superman)
> (car (cdr heroes))
batman
>(cdr (cdr heroes))
(superman)
>(car (cdr (cdr heroes)))
superman
> (cdr (cdr (cdr heroes)))
()
```

CAR and CDR are Inverses of CONS

```
Welcome to DrScheme
> (define two-things (cons '<thing1>'<thing2>))
> (car two-things)
<thing1>
> (cdr two-things)
<thing2>
```

CONS is Inverse of CAR and CDR

```
Welcome to DrScheme
> (cons (car '<thing>) (cdr '<thing>))
<thing>
```

Abbreviations for Combinations of CAR and CDR

(car (car X)) is the same as (caar X)

(car (cdr X)) is the same as (cadr X)

(cdr (car X)) is the same as (cdar X)

(cdr (cdr X)) is the same as (cddr X)

The “LIST” Procedure

- Takes any number of arguments.
- Forms a list out of them.

```
Welcome to DrScheme
> (list 1 2)
(1 2)
> (list 'a 'b 'c)
(a b c)
> (list (list 1 2) (list 'a 'b 'c))
((1 2) (a b c))
> (list)
()
```

How to construct this MENU using CONS, quoted symbols and '() ?

```
Welcome to DrScheme
> (define menu
  '( (eggs cereal pancakes)
    (burger soup salad)
    (spaghetti steak casserole)
    (ice-cream pie cake)
    (coffee tea milk soda)))
```

How to get EGGS from the MENU?

```
Welcome to DrScheme
> (define menu
  '( (eggs cereal pancakes)
    (burger soup salad)
    (spaghetti steak casserole)
    (ice-cream pie cake)
    (coffee tea milk soda)))
```

How to get the list of desserts from the MENU?

```
Welcome to DrScheme
> (define menu
  '( (eggs cereal pancakes)
    (burger soup salad)
    (spaghetti steak casserole)
    (ice-cream pie cake)
    (coffee tea milk soda)))
```

How to add SANDWICH to the lunch section of the MENU?

```
Welcome to DrScheme
> (define menu
  '( (eggs cereal pancakes)
    (burger soup salad)
    (spaghetti steak casserole)
    (ice-cream pie cake)
    (coffee tea milk soda)))
```