CS61A Lecture 21
Scheme

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Computer Science in the News

http://spectrum.ieee.org/tech-talk/robotics/artificial-intelligence/a-texas-hold-em-tournament-for-ais

Today

- Review: Dispatch Dictionaries
- Review: OOP Implementation
- Scheme, a new language

Review: Dispatch Dictionaries

Idea: We will allow ourselves one kind of data structure. In particular, we will represent an object by a ***dispatch dictionary***, where the *messages* are the *keys*.

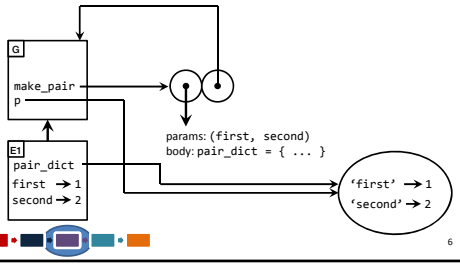
Review: Dispatch Dictionaries

```
def make_pair(first, second):
    pair_dict = { 'first' : first,
                  'second': second }
    return pair_dict
```

How do we create and use "pair objects" now?

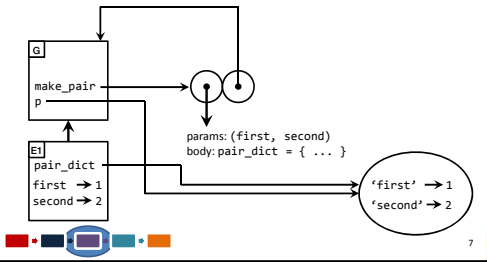
Dispatch Dictionaries

```
>>> def make_pair(first, second): ...
>>> p = make_pair(1, 2)
```



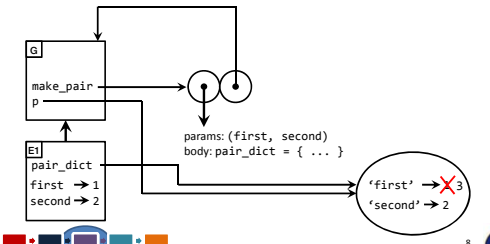
Dispatch Dictionaries

```
>>> p['first']
1
```



Dispatch Dictionaries

```
>>> p['first'] = 3
```



Review: OOP Implementation: Inheritance

Modified solution:

```
def make_class(attributes={}, base_class=None):

    def get_value(name):
        if name in attributes:
            return attributes[name]
        elif base_class is not None:
            return base_class['get'](name)

    def set_value(name, value):
        attributes[name] = value

    cls = {'get': get_value, 'set': set_value}
    return cls
```

To find the value of a class attribute...

... check if it is already in the dictionary of attributes.

Otherwise, if there is a parent class, check if the parent class has the class attribute.

A class is still a dictionary! The two new messages `get` and `set` allow us to use the general getter and setter functions.

Review: OOP Implementation: Objects

Just as we did with classes, we use dictionaries to represent *objects*:

```
def make_instance(cls):

    def get_value(name):
        if name in attributes:
            return attributes[name]
        else:
            return cls['get'](name)

    def set_value(name, value):
        attributes[name] = value

    attributes = {}
    instance = {'get': get_value, 'set': set_value}
    return instance
```

What class is this object an instance of?

To find the value of an instance attribute...

... check if it is already in the dictionary of attributes.

Otherwise, check if the class has a value for the attribute.

Dictionary of instance attributes

An instance is a dictionary! The two messages `get` and `set` allow us to use the general getter and setter functions.

Review: OOP Implementation: Objects

```
def make_instance(cls):
    def get_value(name):
        if name in attributes:
            return attributes[name]
        else:
            value = cls['get'](name)
            return bind_method(value, instance)
```

All the methods are defined in the class. We might get one of these: if we do, bind the first argument to the current instance to produce a bound method for the instance.

Review: OOP Implementation: Objects

```
def bind_method(value, instance):
    if callable(value):
        def method(*args):
            return value(instance, *args)
        return method
    else:
        return value
```

`callable` is a predicate that checks if the argument provided can be called with arguments.

If the value provided is callable (for example, a function), ...

... make the new bound method...

... where the first argument is bound to the instance given, and all the other arguments remain the same...

... and return this bound method.

If the value provided is not callable, return it as is.

Review: OOP Implementation: Instantiation and Initialization

We add an extra message that our classes can understand, which will allow us to create new objects:

```
def make_class(attributes={}, base_class=None):
    ...
    def new(*args):
        return init_instance(cls, *args)

    cls = {'get': get_value,
           'set': set_value,
           'new': new}
    return cls
```

Review: OOP Implementation: Usage

```
def make_pokemon_class():
    def __init__(self, name, owner, hp):
        self['set']('name', name)
        self['set']('owner', owner)
        self['set']('hp', hp)

    def increase_hp(self, amount):
        old_hp = self['get']('hp')
        self['set']('hp', old_hp + amount)

    ...

    return make_class({'__init__': __init__,
                       'increase_hp': increase_hp, ...})
```

Review: OOP Implementation: Usage

```
>>> Pokemon = make_pokemon_class()
>>> ashs_pikachu = Pokemon['new']('Pikachu',
                                  'Ash', 300)
>>> ashs_pikachu['get']('hp')
300
>>> ashs_pikachu['get']('owner')
'Ash'
>>> ashs_pikachu['get']('increase_hp')(50)
>>> ashs_pikachu['get']('hp')
350
```

Announcements: Midterm 2

- Midterm 2 is on **Wednesday, July 25**.
  - *Where*? 2050 VLSB.
  - *When*? 7PM to 9PM.
  - *How much*? Material covered until, and including, July 19.
- Closed book and closed electronic devices.
- One 8.5" x 11" 'cheat sheet' allowed.
- Group portion is 15 minutes long.
- If you have a conflict, please let us know by the end of **today, July 23**.

Announcements

- Homework 10 is due **Today**.
- Project 3 is due **Thursday, July 26**.
- Homework 11 is due **Friday, July 27**.
  - This will be released sometime tonight.

Please ***ask for help*** if you need to. There is a lot of work in the weeks ahead, so if you are ever confused, consult (in order of preference) your study group and Piazza, your TAs, and Jom.

Don't be clueless!

Scheme: A Dialect of Lisp

- The language you will implement for Project 4.
- One of the oldest languages still in use today!
- Easiest way to learn Scheme is to start by seeing some examples and then play with it, so that's what most of today will be.

http://www.lisperati.com/logo.html

SCHEME: SIMPLE EXAMPLES

```
STk> 5
5
STk> 'hello
hello
STk> '(hello tom)
(hello tom)
STk> (+ 5 7)
12
STk> (* 3 22)
66
```

```
STk> (= 3 22)
#f
STk> (= 3 3)
#t
STk> (equal? 'foo 'bar)
#f
STk> (equal? 'foo 'foo)
#t
```


SCHEME: SIMPLE EXAMPLES

```
STk> (if (= 3 3) 'true 'false)
true
STk> (if (= 3 4) 'true)
okay
STk> (first 'word)
w
STk> (butfirst 'word)
ord
STk> (last 'word)
d
STk> (butlast 'word)
wor
STk> (word 'race 'car)
racecar
```

STk evaluates Scheme expressions to okay if there is no value to the expression.

SCHEME: SIMPLE EXAMPLES

```
STk> (cond ((= 5 0) 'zero)
           ((= (remainder 5 2) 0) 'even)
           (else 'odd))
odd
STk>
```


Scheme: Prefix Notation

In Python:

```
4 + 7
```

In Scheme

```
(+ 4 7)
```

Notice that the parentheses go ***BEFORE*** the function or operation.

Scheme uses ***prefix notation*** where all operations appear before the expressions used by the operation. There is ***absolutely no exceptions*** to this notation.

This makes the language much simpler, since we don't have a bunch of different special cases for each type of operation.

SCHEME: VARIABLES

```
STk> (define toms-number 5)
toms-number
STk> toms-number
5
STk> y
*** Error:
    unbound variable: y
...
STk> (+ toms-number 66)
```

Variable names can have hyphens in Scheme

SCHEME: FUNCTIONS

```
STk> (define (square x)
           (* x x))
square
STk> (square 5)
25
STk> square
#[closure arglist=(x) 23a8a8]
```

Notice that we didn't have to say return or anything like that! In Scheme, every function MUST return a value. This is always the last expression of the body.

Scheme: Functions

```
STk> (lambda (x) (+ x 1))
#[closure arglist=(x) 23bbc8]
STk> ((lambda (x) (* x x)) 3)
9
STk> (define (call-with-2 fn)
           (fn 2))
call-with-2
STk> (call-with-2 (lambda (x) (+ x 1)))
3
STk> (lambda () 3)
#[closure arglist=() blahblahblah]
STk> ((lambda () 3))
3
```

Scheme has lambdas! Unlike Python, anything you can do in a named function you can also do in a lambda.

Scheme: Repetition

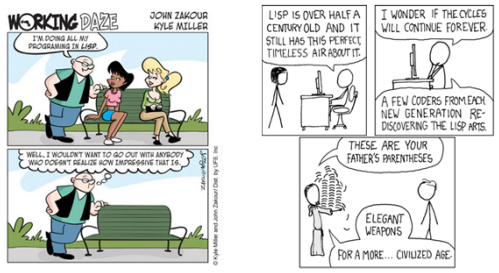
```
STk> (define (fact n)
         (if (<= n 1)
             1
             (* n (fact (- n 1)))))
fact
STk> (fact 5)
120
```

Traditionally, even if the version of Scheme you're running has loops, it's much more common to stick to recursion.

Scheme: More Examples

```
STk> (define (twice f)
           (lambda (x) (f (f x))))
twice
STk> (((twice (twice twice)) 1+) 0)
16
STk> (define (make-adder x)
           (lambda (y) (+ x y)))
make-adder
STk> ((make-adder 7) 22)
29
```


Break: Some Lisp Comics



Scheme: Pairs and Lists

```
STk> (cons 2 5)
(2 . 5)
STk> (list 1 2 3 4 5 6)
(1 2 3 4 5 6)
STk> (car '(1 2 3))
1
STk> (cdr '(1 2 3))
(2 3)
STk> (cons 1 '())
(1)
STk> (cons 1 (cons 2 (cons 3 '())))
(1 2 3)
```


Scheme: Lists

```
STk> (append '(1 2 3) '(4 5 6))
(1 2 3 4 5 6)
STk> (define (map fn lst)
           (if (null? lst)
               '()
               (cons (fn (car lst))
                     (map fn (cdr lst)))))
STk> (map (lambda (x) (* x 5)) '(1 2 3))
(5 10 15)
STk> (map (lambda (x) (* x 22)) '(1 2 3))
(22 44 66)
```

PRACTICE: SCHEME

What does each expression evaluate to?

```
STk> (square (square 5))
???
STk> '(square 5)
???
STk> (cons (car '(3 . 4))
           (cdr '(5 . 6)))
???
STk> (cons (car '(3 . 4))
           (cdr '(5 6)))
???
```

PRACTICE: SCHEME

What does each expression evaluate to?

```
STk> (square (square 5))
625
STk> '(square 5)
(square 5)
STk> (cons (car '(3 . 4))
           (cdr '(5 . 6)))
(3 . 6)
STk> (cons (car '(3 . 4))
           (cdr '(5 6)))
(3 5 6)
```

PRACTICE: SCHEME

Write the function `filter` which takes a predicate and a list and produces a new list only including the elements for which the predicate is true.

```
STk> (filter (lambda (x) (= (remainder x 2) 0))
             '(1 2 3 4 5 6 7 8 9 10))
(2 4 6 8 10)
STk> (filter (lambda (x) (< x 5))
             '(1 10 2 9 3 8))
(1 2 3)
```

CONCLUSION

Scheme: It's awesome, it's simple, it's what you're implementing in project 4.

Preview: We will start to talk about how we implement an interpreter.