UC Berkeley EECS
Lecturer
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Abstract Data Types & Dictionaries

Today's Lecture

- Abstract Data Types
  - More use of functions!
  - Value in documentation and clarity
- New Python Data Types
  - Dictionaries: a really useful tool!

Abstract Data Type

- Uses pure functions to encapsulate some logic as part of a program.
- We rely of built-in types (int, str, list, etc) to build ADTs
- This is a contrast to object-oriented programming
  - Which is coming soon!

Creating Abstractions

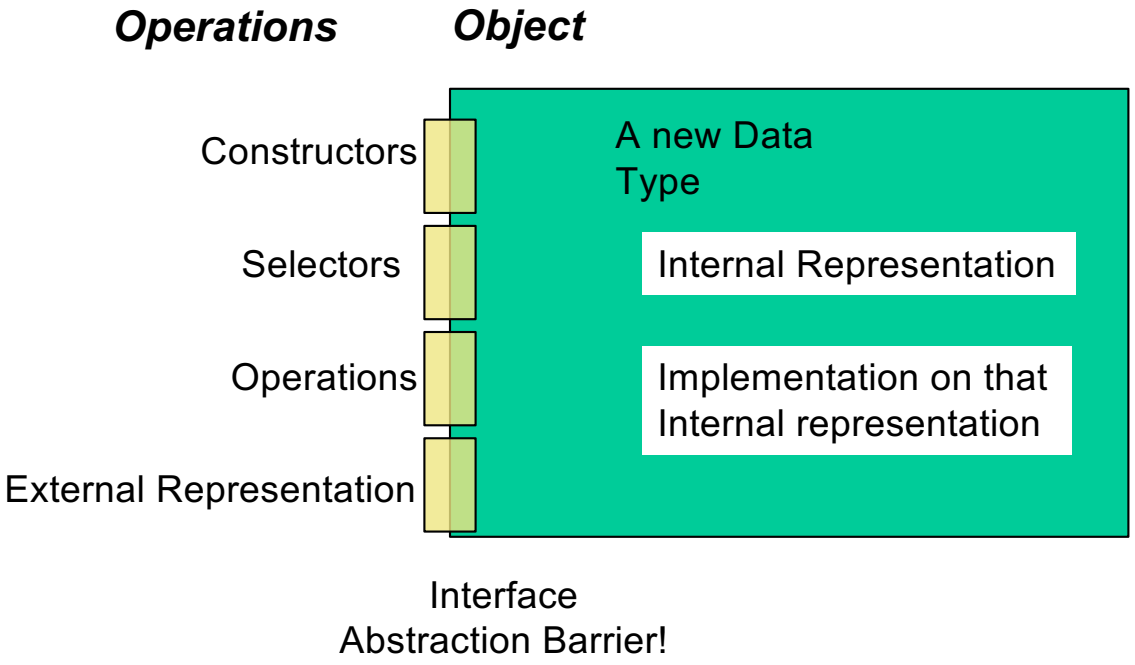
- Compound values combine other values together
  - date: a year, a month, and a day
  - geographic position: latitude and longitude
  - a game board

- Data abstraction lets us manipulate compound values as units
- Isolate two parts of any program that uses data:
  - How data are represented (as parts)
  - How data are manipulated (as units)
- Data abstraction: A methodology by which functions enforce an abstraction barrier between *representation* and *use*

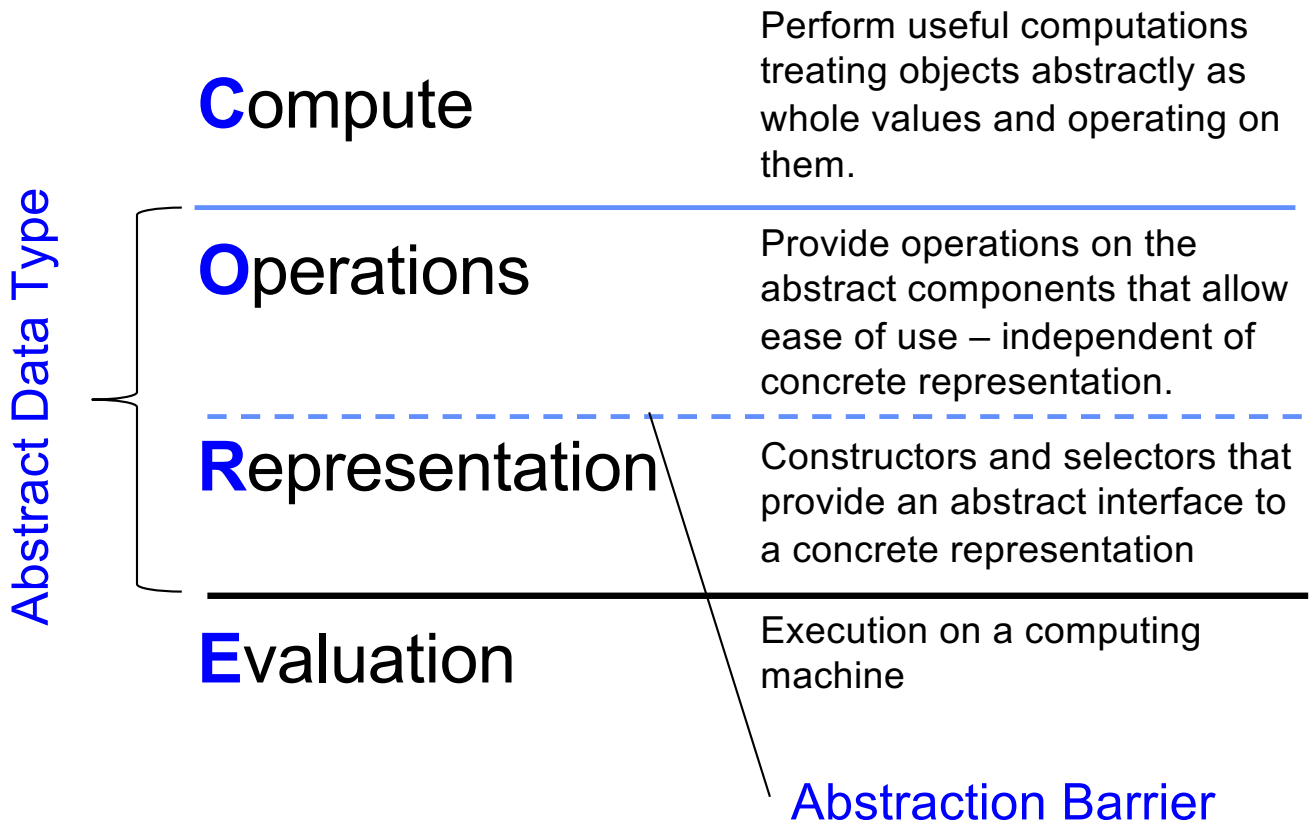
Why Abstract Data Types?

- "Self-Documenting"
  - contact_name(contact)
    - » vs contact[0]
  - "0" may seem clear now, but what about in a week? 3 months?
- Change your implementation
  - Maybe today it's just a Python List
  - Tomorrow: It could be a file on your computer; a database in web

Abstract Data Type



C.O.R.E concepts



Reminder: Lists

- Lists
  - Constructors:
    - » list(...)
    - » [<exps>,...]
    - » [<exp> for <var> in <list> [if <exp>]]
  - Selectors: <list> [<index or slice>]
  - Operations: in, not in, +, *, len, min, max
    - » Mutable ones too (but not yet
- Tuples
  - A lot like lists, but you cannot edit them. We'll revisit on Monday.

A Small ADT

```
def point(x, y): # constructor
      return [x, y]

x = lambda point: point[0] # selector
y = lambda point: point[1]

def distance(p1, p2): # Operator
      return ((x(p2) - x(p1)**2 + (y(p2) -
y(p1))**2) ** 0.5

origin = point(0, 0)
my_house = point(5, 5)
campus = point(25, 25)
distance_to_campus = distance(my_house, campus)
```

Creating an Abtract Data Type

- Constructors & Selectors
- Operations
  - Express the behavior of objects, invariants, etc
  - Implemented (abstractly) in terms of Constructors and Selectors for the object
- Representation
  - Implement the structure of the object

- An abstraction barrier violation occurs when a part of the program that can use the higher level functions uses lower level ones instead
  - At either layer of abstraction
- Abstraction barriers make programs easier to get right, maintain, and modify
  - Few changes when representation changes

Question: Changing Representations?

Question 2.1

Assuming we update our selectors, what are valid representations for our `point(x, y)` ADT?

Currently `point(1, 2)` is represented as `[1, 2]`

- A) `[y, x] # [2, 1]`
- B) `"X: " + str(x) + " Y: " + str(y)`
  `# "X: 1 Y: 2"`
- C) `str(x) + ' ' + str(y) # '1 2'`
- D) All of the above
- E) None of the above

A Layered Design Process

- **Build the application based entirely on the ADT interface**
  - **Operations, Constructors and Selectors**
- **Build the operations in ADT on Constructors and Selectors**
  - **Not the implementation representation**
  - This is the end of the abstraction barrier.
- **Build the constructors and selectors on some concrete representation**

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Dictionaries

Learning Objectives

- Dictionaries are a new type in Python
- Lists let us index a value by a number, or position.
- Dictionaries let us index data by other kinds of data.

Dictionaries

- Constructors:
  - » `dict( <list of 2-tuples> )`
  - » `dict( <key>=<val>, ...)`
  - » `{ <key exp>:<val exp>, … }`
  - » `{ <key>:<val> for <iteration expression> }`
    - `>>> {x:y for x,y in zip(["a","b"],[1,2])}`
    - `{'a': 1, 'b': 2}`
- Selectors: `<dict> [ <key> ]`
  - » `<dict>.keys(), .items(), .values()`
  - » `<dict>.get(key [, default] )`
- Operations:
  - » `key in dict, key not in, len(dict)`
  - » `<dict>[ <key> ] = <val>`

Dictionary Example

```
In [1]: text = "Once upon a time"
        d = {word : len(word) for word in text.split()}
        d
Out[1]: {'Once': 4, 'a': 1, 'time': 4, 'upon': 4}

In [2]: d['Once']
Out[2]: 4

In [3]: d.items()
Out[3]: [('a', 1), ('time', 4), ('upon', 4), ('Once', 4)]

In [4]: for (k,v) in d.items():
            print(k,"=>",v)
        ('a', '=>', 1)
        ('time', '=>', 4)
        ('upon', '=>', 4)
        ('Once', '=>', 4)

In [5]: d.keys()
Out[5]: ['a', 'time', 'upon', 'Once']

In [6]: d.values()
Out[6]: [1, 4, 4, 4]
```

Question: Dictionaries

What is the result of the final expression?

```
my_dict = { 'course': 'CS 88', semester = 'Fall' }
my_dict['semester'] = 'Spring'

my_dict['semester']
```

a) 'Fall'
b) 'Spring'
c) Error

Limitations of Dictionaries

- Dictionaries are unordered collections of key-value pairs
- Dictionary keys have two restrictions:
  - A key of a dictionary cannot be a list or a dictionary (or any *mutable type*)
  - Two keys cannot be equal; There can be at most one value for a given key

This first restriction is tied to Python's underlying implementation of dictionaries

The second restriction is part of the dictionary abstraction

If you want to associate multiple values with a key, store them all in a sequence value

Beware

- Built-in data type dict relies on mutation
  - Clobbers the object, rather than "functional" – creating a new one
- Throws an errors of key is not present
- We will learn about mutation shortly