CS1010S Tutorial 8

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Year 2 QF

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March 26, 2017

Today's Agenda

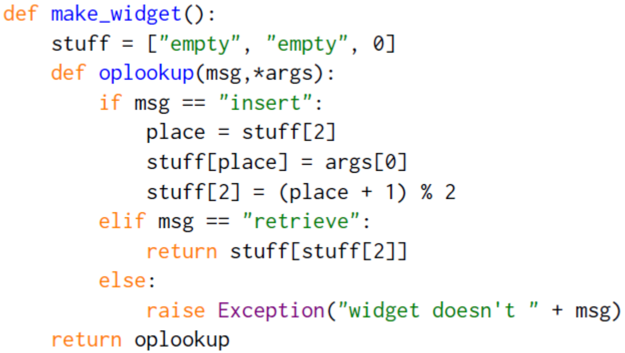
1. Recap
2. Question One
   - Discussion
3. Question 2
   - Standard solutions
4. Question 3
5. Question 4
6. Question 5
7. Extra stuff: Another final question

Recap - Message Passing & Stateful Objects

- A function
- A higher order function
- A higher order function object
  - can accept parameters like message
  - and other number also
- What you want is basically
- $A = make\_something()$
- A('add', 10)
- A('subtract', 20)
- A recipe of making such object
  - An internal storage object outside the helper function
  - If - elif - else statement to check message
  - return a helper function

Recap - Message Passing & Stateful Objects

A more in-depth explanation using example.
Where are all the ingredients for the recipe?



```
def make_widget():
    stuff = ["empty", "empty", 0]
    def oplookup(msg,*args):
        if msg == "insert":
            place = stuff[2]
            stuff[place] = args[0]
            stuff[2] = (place + 1) % 2
        elif msg == "retrieve":
            return stuff[stuff[2]]
        else:
            raise Exception("widget doesn't " + msg)
    return oplookup
```

Recap - VarArgs

A technique to take unknown number of arguments

- Use '*' to denote the input parameter
- Removing '*' will give a list of the arguments
- Use '*' against when passing these arguments to another function

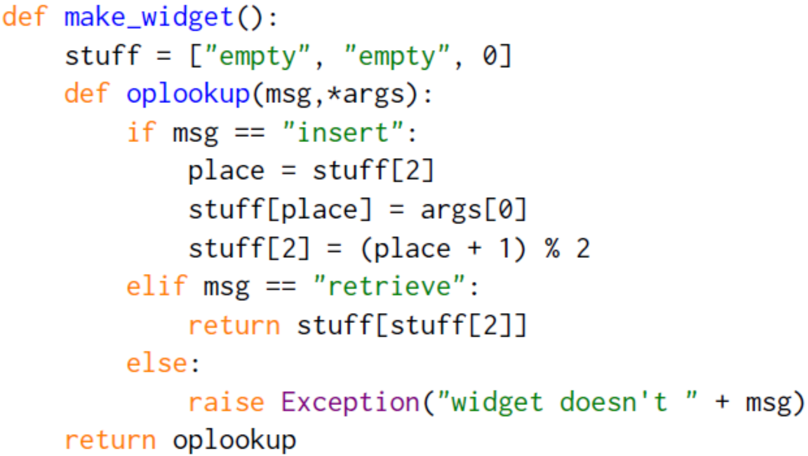
Recap - Dictionary

A new data structure

- keys and values - iterable objects in **order**
- construct a dictionary
  - dict([(1,2),(2,4),(3,6)])
  - dict()
  - {‘a’:1, ‘b’:2}
- check for a key in dictionary:
  - d.get(key) - None if no such key
  - if d[key]: - may have key error
  - if key in d:
  - if key in d.keys():
- del d[key]
- d.clear()

Question 1 Part A

Describe in simple English how a widget behaves. Your explanation should be comprehensible to a layman who does not understand programming.

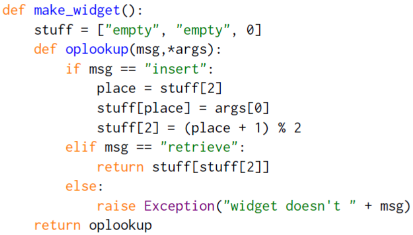


```
def make_widget():
    stuff = [”empty”, ”empty”, 0]
    def oplookup(msg,*args):
        if msg == ”insert”:
            place = stuff[2]
            stuff[place] = args[0]
            stuff[2] = (place + 1) % 2
        elif msg == ”retrieve”:
            return stuff[stuff[2]]
        else:
            raise Exception(”widget doesn't ” + msg)
    return oplookup
```

Question 1 Part A Discussion

How this widget behaves?

- A widget is made by *make_widget*()
- It can only store a maximum number of 2 objects inside.
- You can use a statement to insert: w('insert', object1)
- You can use a statement to retrieve : w('retrieve')
- When you try to insert into an already full widget, the one inserted first will be removed.



```python
def make_widget():
    stuff = ["empty", "empty", 0]
    def oplookup(msg,*args):
        if msg == "insert":
            place = stuff[2]
            stuff[place] = args[0]
            stuff[2] = (place + 1) % 2
        elif msg == "retrieve":
            return stuff[stuff[2]]
        else:
            raise Exception("widget doesn't " + msg)
    return oplookup
```

Question 1 Part B

Write the code required to insert the following objects into the widget: 1, 2, 3.

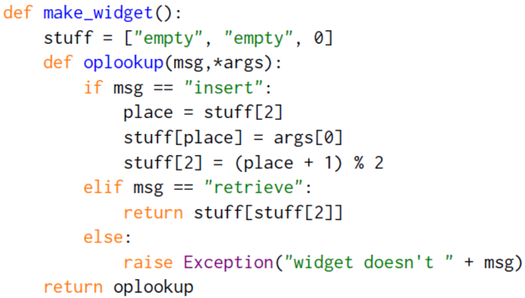
- w = *make_widget*()
- w('insert', 3)
- w('insert', 2)
- w('insert', 1)

```
def make_widget():
    stuff = ["empty", "empty", 0]
    def oplookup(msg,*args):
        if msg == "insert":
            place = stuff[2]
            stuff[place] = args[0]
            stuff[2] = (place + 1) % 2
        elif msg == "retrieve":
            return stuff[stuff[2]]
        else:
            raise Exception("widget doesn't " + msg)
    return oplookup
```

Question 1 Part C

Suppose we perform a retrieval 3 times. What is returned in each time?

- w('retrieve')
- w('retrieve')
- w('retrieve')



```python
def make_widget():
    stuff = ["empty", "empty", 0]
    def oplookup(msg,*args):
        if msg == "insert":
            place = stuff[2]
            stuff[place] = args[0]
            stuff[2] = (place + 1) % 2
        elif msg == "retrieve":
            return stuff[stuff[2]]
        else:
            raise Exception("widget doesn't " + msg)
    return oplookup
```

Does the value of the widget ever change?

Question 2

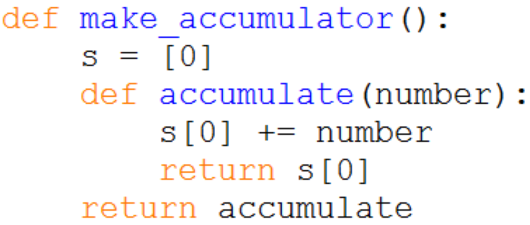
An accumulator is a function that is called repeatedly with a single numeric argument and accumulates its arguments into a sum. Each time it is called, it returns the currently accumulated sum. Write a function *make_accumulator* that generates accumulators, each maintaining an independent sum.

Question 2 Discussion

Your *make_accumulator* should returns:

- A function
- which manages an internal value
- stored in an internal object
- with its internal value changes
- everytime it is called

Question 2 Zexin's solution



```
def make_accumulator():
    s = [0]
    def accumulate(number):
        s[0] += number
        return s[0]
    return accumulate
```

Note that for the recipe:

- *s* is the internal storage object
- *accumulate* is the helper function returned
- and there is no if statement to check the message

Question 3 Part A

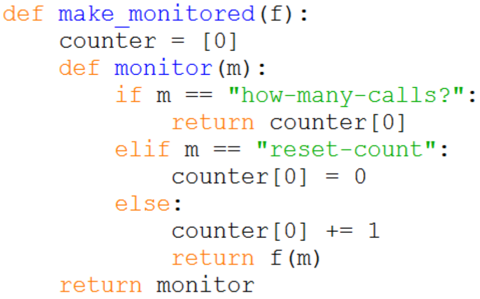
Write a function *make_monitored* that takes as input a function, *f*, that itself takes one input. The result returned by *make_monitored* is a third function, say *mf*, that keeps track of the number of times it has been called by maintaining an internal counter. If the input to *mf* is the special string 'how-many-calls?', then *mf* returns the value of the counter. If the input is the special string 'reset-count', then *mf* resets the counter to zero. For any other input, *mf* returns the result of calling *f* on that input and increments the counter.

Question 3 Part A Discussion

Your object should do these:

- Take note of how many times *f* is called
- Return the number of calls when 'how-many-calls' is entered
- Set the counter in internal object to 0 when 'reset-count' is entered
- Otherwise, pass the input to *f*
- Assume that there is only one input for *f* !

Question 3 Part A Zexin's Solution



```
def make_monitored(f):
    counter = [0]
    def monitor(m):
        if m == "how-many-calls?":
            return counter[0]
        elif m == "reset-count":
            counter[0] = 0
        else:
            counter[0] += 1
            return f(m)
    return monitor
```

Question 3 Part B

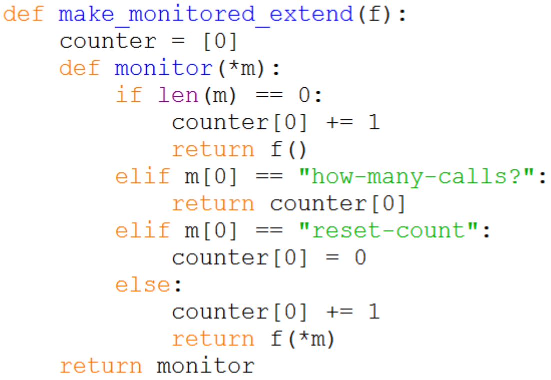
Extend *make_monitored* so that it works for functions that take an arbitrary number of parameters.

Question 3 Part B Discussion

The difficulty lies in that

- You need to know how to take in VarArgs
- You need to know how to pass VarArgs to f
- Does VarArgs work for the case when there is no parameter?
- What if there is no parameter passed in?

Question 3 Part B Zexin's Solution



```
def make_monitored_extend(f):
    counter = [0]
    def monitor(*m):
        if len(m) == 0:
            counter[0] += 1
            return f()
        elif m[0] == "how-many-calls?":
            return counter[0]
        elif m[0] == "reset-count":
            counter[0] = 0
        else:
            counter[0] += 1
            return f(*m)
    return monitor
```

Question 4

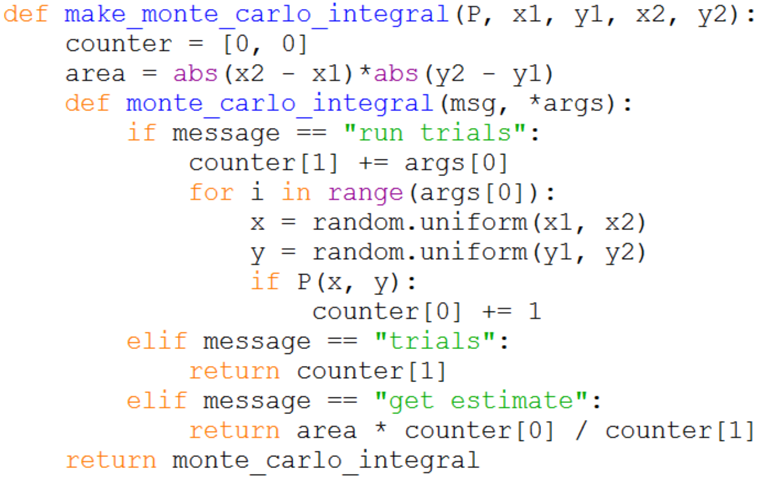
Implement Monte Carlo integration as a function *make_monte_carlo_integral* that takes as arguments a predicate *P*, lower and upper bounds *x1*, *y1*, *x2*, and *y2* for the rectangle and returns a new function.

Question 4 Discussion

How to tackle this?

- Listen to Zexin on what is Monte Carlo integration first
- You will need to record down the number of success and trials
- You will calculate the probability of the random point being P
- You will estimate the area using the total area and probability
- Is Monte Carlo integration unbiased? Try to prove it

Question 4 Zexin's solution



```python
def make_monte_carlo_integral(P, x1, y1, x2, y2):
    counter = [0, 0]
    area = abs(x2 - x1)*abs(y2 - y1)
    def monte_carlo_integral(msg, *args):
        if message == "run trials":
            counter[1] += args[0]
            for i in range(args[0]):
                x = random.uniform(x1, x2)
                y = random.uniform(y1, y2)
                if P(x, y):
                    counter[0] += 1
        elif message == "trials":
            return counter[1]
        elif message == "get estimate":
            return area * counter[0] / counter[1]
    return monte_carlo_integral
```

Question 5 Part A

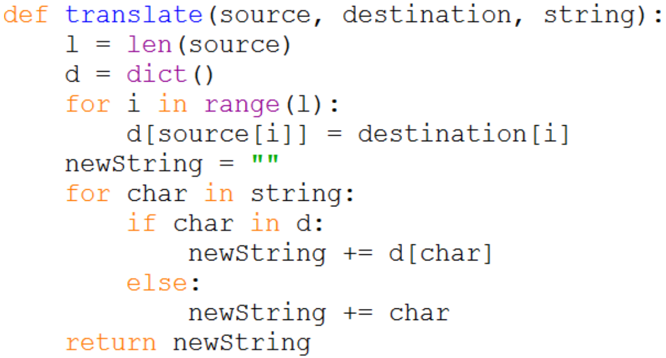
Make use of dictionary to create a character translator function *translate*. It takes 3 strings as arguments: *translate(source, destination, string)*. *source* contains the set of characters you want "translated", *destination* contains the set of characters to translate to, and *string* is the string to perform the translation on.

Question 5 Part A Discussion

Recall the usage of dictionary

- You should be storing *source* as the keys
- And *destination* as the values
- What should you use to check key-value pair?
- Make sure no key error will happen =p

Question 5 Part A Zexin's solution



```python
def translate(source, destination, string):
    l = len(source)
    d = dict()
    for i in range(l):
        d[source[i]] = destination[i]
    newString = ""
    for char in string:
        if char in d:
            newString += d[char]
        else:
            newString += char
    return newString
```

Question 5 Part B

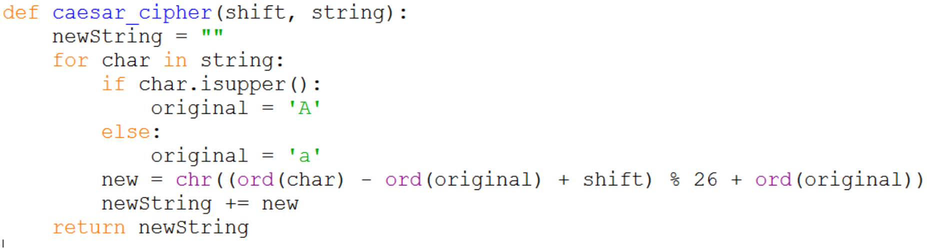
Create a function *caesar_cipher(shift, string)*, where shift is the number of positions to shift, and string is the string to encrypt.

Question 5 Part B Discussion

You are not restricted to only use Dictionary now

- You are instead encouraged to use *chr* and *ord*
- Take note of what is ASCII code
- Take note how to check uppercase or lowercase

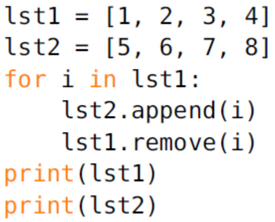
Question 5 Part B Zexin's solution



```
def caesar_cipher(shift, string):
    newString = ""
    for char in string:
        if char.isupper():
            original = 'A'
        else:
            original = 'a'
        new = chr((ord(char) - ord(original) + shift) % 26 + ord(original))
        newString += new
    return newString
```

Extra stuff: Another final question

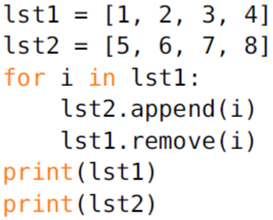
If time permits, we will go through this.



```
lst1 = [1, 2, 3, 4]
lst2 = [5, 6, 7, 8]
for i in lst1:
    lst2.append(i)
    lst1.remove(i)
print(lst1)
print(lst2)
```

- This is a problem for which you need to know mechanism of for loop.

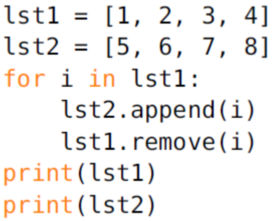
Extra stuff: Another final question



```
lst1 = [1, 2, 3, 4]
lst2 = [5, 6, 7, 8]
for i in lst1:
    lst2.append(i)
    lst1.remove(i)
print(lst1)
print(lst2)
```

- *i* will loop from 1 to 4?
- Or does it go to where it **should** stop?
- Let us use a demo to find out!

Extra stuff: One final question



```
lst1 = [1, 2, 3, 4]
lst2 = [5, 6, 7, 8]
for i in lst1:
    lst2.append(i)
    lst1.remove(i)
print(lst1)
print(lst2)
```

Hence the solution is:

$$[2, 4]$$

$$[5, 6, 7, 8, 1, 3]$$

Feedback & more

- Slides + relevant material available at:

  `https://github.com/wangzexin/Teaching`

- After the tutorial, if you have further questions:

  `wang.zexin@u.nus.edu`

Thank You

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