Discrete Structures: CMPSC 102

Oliver BONHAM-CARTER

Fall 2018

Week 7

Quiz

- Given on Wednesday 17th during LAB time (2:30pm)
- Online format
- Two hours to complete
- Ten questions: Multi-choice, True/False, Matching and Short Essay
- Picking out bugs of code or determining output

What to study

Same as during the quiz

- **Slides, notes, with chapters to add detail to class material**
- Main ideas behind mathematical subjects in class (again, study your slides)
- Python basics and code
  - Study the code from the practicals and covered in class to understand the how programs worked.
  - Mathematical operators: using doing calculations on in the interpreter with Python
  - `for` loops using `range()`
  - Iterations over sequences
  - Strings, characters, integers, floats
  - Sequences, sets, lists, dictionaries, tuples
  - Conditional statements

What to study

New material

- Monoids
- `AND` statements
- `OR` statments
- Properties of Sequences: (i.e., Associativity, Commutative and others)
- Tautologies and Contradictions
- Truth tables:
  - What are they?, How used?, How to determine decisions using them?
- Conditional Implications (A $\rightarrow$ B) and (A $\leftrightarrow$B)
  - Dynamic vs. Static Data Structures (Python code)
  - Streams, Iterators and generator functions (Python code)

Streams: Static variables

What is "Static"?

- A *static* data structure is an organized container or collection of data in memory of a fixed size
- A "static" sequence may be mutable like a `list` but at any one time, it exists as a complete data structure.
- Static lists and Actively created lists

Create a static `list`

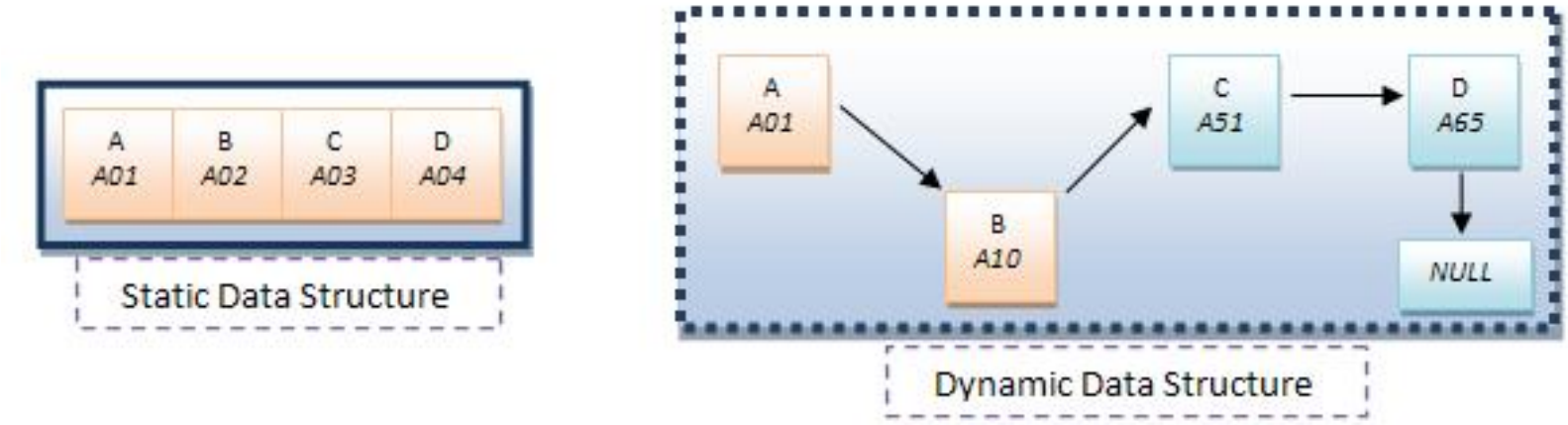
```
stringList = ['count_'+str(i+1) for i in range(4)]
```

Create a active `list`

```
a = 2
b = 3
myList_list = [a+b, b+a, len(["a","b"])]
```

The `lists` are still of a set size.

Dynamic vs. Static Data Structures



The difference between the dynamic and static data structures

- Static data structures are ideal for storing a fixed number of data items, lack the dynamic data structures flexibility to consume additional memory if needed or to free up memory when possible for improved efficiency.

Other Ways to Make Static Lists

https://en.wikibooks.org/wiki/Python_Programming/Lists


```
listOfWords = ["this","is","a","list","of","words"]
items = [ word[0] for word in listOfWords ]
print(items) # ['t', 'i', 'a', 'l', 'o', 'w']
```

```
print([x+y for x in 'tea' for y in 'pot'])
# ['tp', 'tt', 'ep', ..., 'at']

print([x+y for x in 'tea' for y in 'pot' if x != 't' and y != 'o' ])
# ['ep', 'et', 'ap', 'at']

print ([x+y for x in 'tea' for y in 'pot' if x != 't' or y != 'o' ])
# ['tp', 'tt', 'ep', ..., 'at']
```

```
zeros_list=[0]*5
print(zeros_list)
```

```
item_list=['item']*3
print(item_list)
#['item', 'item', 'item']
```

Dynamically-Generated Sequences

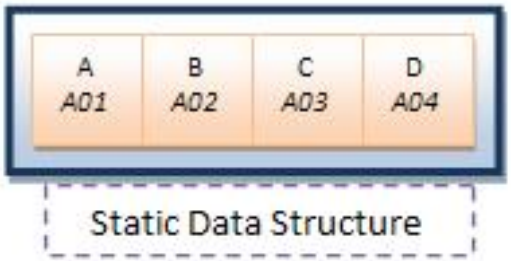
- The size of the list was settled at the time of the creation of the list
- The list could be printed to the screen item-by-item or all-at-once
- Enter dynamically generated sequences: Items are created, printed, consumed as needed.

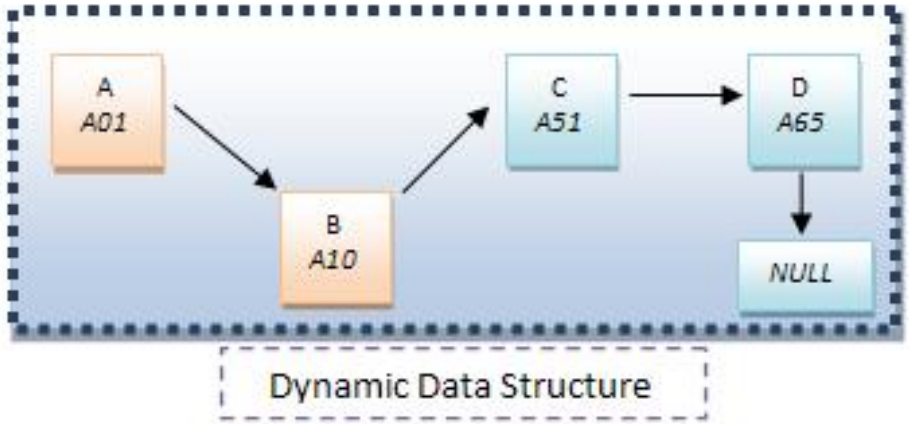
In Chapter 7.1, Stavely Says...

An input stream, for example, appears to a program to be a sequence of values - lines, characters, numbers from sensors, whatever they may be - that are not present all at once, but appear dynamically over time. Some input streams don't even have an end: the data keeps coming indefinitely.

Dynamic vs. Static Data Structures

Let's see that graphic again!





The difference between the dynamic and static data structures

Streams and Iterators

- The term *stream* denotes any dynamically-generated sequence of values
- Two kinds of sequences:
  - Static sequences (similar to any other list that we have already seen)
  - Streams: *generated* data structures using iterators and range objects

Streams by Invoking an iterator with a `for`-statement

```
#for i in iterator:
#   statements
l_list = ["Apples", "Oranges", "Apricots",
"Avocado", "Ananas (pineapple)", "Asparagus"]
print(" Starting with 'A' ")
for line in l_list:
   if line.startswith("A"): print(line)
```

Using Iterators as Defined By Others

Generator data type: *names*

Another Stream Invoking an iterator

```
l_list = ["Apples", "Oranges", "Apricots",
"Avocado", "Ananas (pineapple)", "Asparagus"]
names = (line[:2] for line in l_list)
for i in names:
   if i =="Ap": print(" Found: ",i)
   else: print(i)
print(names)  # no usable output?
for i in names: print(i) # item-by-item
```

- The generator expression is evaluated, creating an iterator, and the *name* variable is bound to that iterator.
- The `for`-statement invokes names for values one after the next

The Yield Keyword

Create another generator

```
def createGenerator():
   mylist = range(3)
   for i in mylist:
   # find the square of the value as needed
      yield i*i
# end of createGenerator()
######################
# Initiation: create a generator
myGenerator = createGenerator()
# Where is this generator in memory?
print(myGenerator)
for i in myGenerator:
   print(i)
```

YAY: *Yet Another Yield*

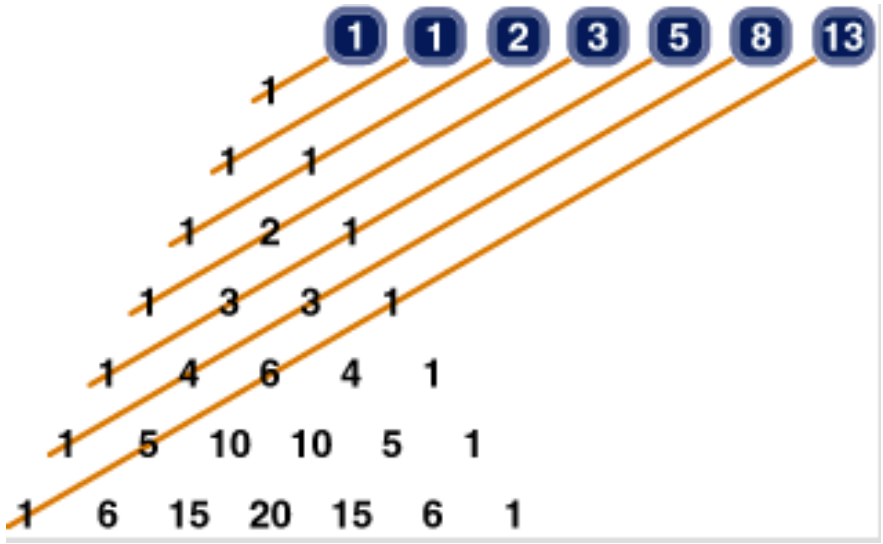
yay.py

{ Let's Code! }

Sequences of Fibonacci

Sequence

- $F_n = F_{n-1} + F_{n-2}$
- For $n = 1, 2, \cdots, 8$
- The sequence follows as: 1, 1, 2, 3, 5, 8, 13, 21



Pascal's Triangle to find the sequence

Interesting reference:

`http://mathworld.wolfram.com/FibonacciNumber.html`

Static Function

The n_{th} term of the Fibonacci sequence

Binet's Formula

$$F_n = \frac{1}{\sqrt{5}}\left(\left(\frac{1+\sqrt{5}}{2}\right)^n - \left(\frac{1-\sqrt{5}}{2}\right)^n\right)$$

- Static equation using Binet's formula

A static function for the Fibonacci sequence

```
import math
def fibsBinet(n):
    a = (1/math.sqrt(5))
    b = ((1 + math.sqrt(5))/2)**n
    c = ((1 - math.sqrt(5))/2)**n
    return a * (b - c)
#end of fibsBinet()
for i in range(8):
    print(fibsBinet(i)) # calculate each value as needed
```

Tuple-Maker Functions For Fibonacci Sequences

Not a Generator: Return elements of the sequence all at once in a structure

Make a tuple containing the results

```
def fibsTuple(n):
    result = ( )
    a=1
    b=1
    for i in range(n):
        result += (a,)
        a, b = b, a + b
    return result
print("  My type is: ",type(fibsTuple))
print(fibsTuple(5)) #(1, 1, 2, 3, 5)
```

- Every time around the loop, the function creates a new tuple, a copy of result with another value concatenated onto the end. Each tuple but the last is never used again.
- Result is returned in one structure

List-Maker Functions For Fibonacci Sequences

Not a Generator: Return elements of the sequence all at once in a structure

A list maker

```
def fibsList(n):
    result = [ ]
    a=1
    b=1
    for i in range(n):
        result.append(a)
        a, b = b, a + b
    return result

print("  My type is: ",type(fibsList))
print(fibsList(4)) #[1, 1, 2, 3]
```

- More efficient function than `fibsTuple()`: as a result is modified in place rather than creating a whole new data structure during each iteration
- When n is large the difference may be significant
- Result is returned in one data structure

Generator Functions For Fibonacci Sequences

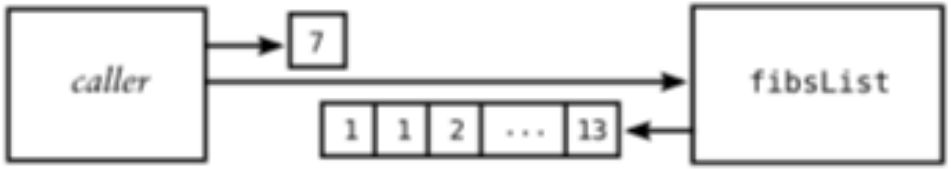
Creating sequences dynamically with *yield*

- Functions having *yield*-statement are generator
- This function works as a generator or otherwise

A generator function for the Fibonacci sequence

```
def fibs(n):
    a=1
    b=1
    for i in range(n):
        yield a
        a, b = b, a + b
print([x for x in fibs(6)])
print("  My type is:",type(fibs))
f = fibs(6)
for i in f: print(i)
print("  My type is: ",type(fibs(6)))
```

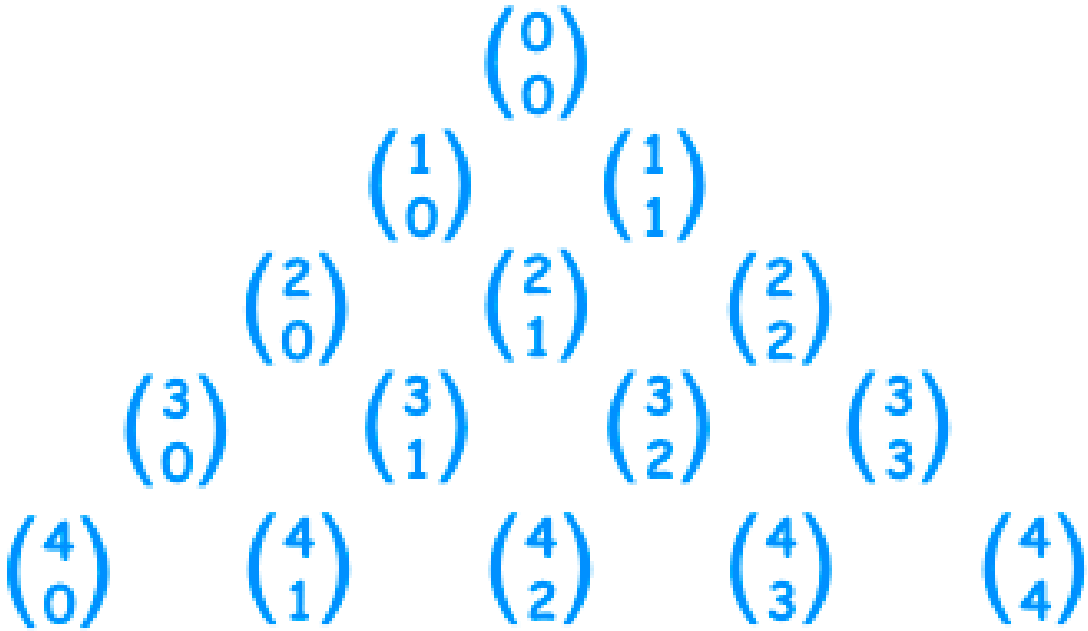
Call versus List Maker



- Non-Generator function: WIth `fibsTuple()` or `fibsList()`, the code that calls the function "pushes" a value of n to the function and the function "pushes" a sequence object back (Click to see Tuples)
- Generator function: With `fibs()`, the caller pushes a value of n to the function and then "pulls" values from the function (or, more precisely, from the iterator returned by the function) as it needs them. (Click to see fibs)

Combinations *(to make another generator function)*

- How many ways are there to choose k things from a set of n?
- Said: *n choose k*
- $Choose(n, k) = \frac{n!}{k!(n-k!)}$



Finding Combinations using a Generator

combinations.py

{ Let's Code! }