# Algolab Exam

Scientific Programming Module 2
Algorithms and Data Structures

Thusday 26th, Jan 2017

## Introduction

- Taking part to this exam erases any vote you had before, both lab and theory
- If you don't ship or you don't pass this lab part, you lose also the theory part.

- Log into your computer in *exam mode*, it should start Ubuntu
- To edit the files, you can use any editor of your choice: *Editra* seems easy to use, you can find it under *Applications->Programming->Editra*. Others could be *GEdit* (simpler), or *PyCharm* (more complex).

### Allowed material

There won't be any internet access. You will only be able to access:

- Sciprog Algolab worksheets (index.html)
- Alberto Montresor slides (../montresor/Montresor%20sciprog/cricca.disi.unitn.it/montresor/teaching/scientific-programming/slides/index.html)
- Stefano Teso docs (../teso/disi.unitn.it/_teso/courses/sciprog/index.html)
- Python 2.7 documentation : html (../python-docs/html/index.html) pdf (../python-docs/pdf)
  - In particular, Unittest docs (../python-docs/html/library/unittest.html)
- The course book *Problem Solving with Algorithms and Data Structures using Python* html (../pythonds/index.html) pdf (../pythonds/ProblemSolvingwithAlgorithmsandDataStructures.pdf)

### Grading

- The grade of this lab part will range from 0 to 30. Total grade for the module will be given by the average with the theory part of Alberto Montresor.
- Correct implementations with the required complexity grant you full grade.
- Partial implementations *might* still give you a few points. If you just can't solve an exercise, try to solve it at least for some subcase (i.e. array of fixed size 2) commenting why you did so.
- One bonus point can be earned by writing stylish code. You got style if you:
  - do not infringe the Commandments (../algolab/index.html#Commandments)
  - write pythonic code (http://docs.python-guide.org/en/latest/writing/style)
  - avoid convoluted code like i.e.

```
if x > 5:
    return True
else:
    return False
```

  when you could write just

```
return x > 5
```

> **!!!!!!!!! WARNING !!!!!!!!!**
>
> **!!!!!!!!! **ONLY** IMPLEMENTATIONS OF THE PROVIDED FUNCTION SIGNATURES WILL BE EVALUATED !!!!!!!!!**

For example, if you are given to implement:

```
def cool_fun(x):
        raise Exception("TODO implement me")
```

and you ship this code:

```
def cool_fun_non_working_trial(x):
    # do some absurdity

def cool_fun_a_perfectly_working_trial(x):
    # a super fast, correct and stylish implementation

def cool_fun(x):
    raise Exception("TODO implement me")
```

We will assess only the latter one `cool_fun(x)`, and conclude it doesn't work at all :P !!!!!!!

Still, you are allowed to define any extra helper function you might need. If your `cool_fun(x)` implementation calls some other function you defined like `my_helper` here, it is ok:

```
def my_helper(y,z):
    # do something useful

def cool_fun(x):
    my_helper(x,5)

# this will get ignored:
def some_trial(x):
    # do some absurdity
```

## What to do

In /usr/local/esame (/usr/local/esame) you should find a file named `algolab-17-01-26.zip`. Download it and extract it on your desktop. The content should be like this:

```
algolab-17-01-26
    |- FIRSTNAME-LASTNAME-ID
        |- exercise1.py
        |- exercise2.py
        |- exercise3.py
```

2) Check this folder also shows under `/var/exam`.

3) Rename `FIRSTNAME-LASTNAME-ID` folder: put your name, lastname an id number, like `john-doe-432432`

From now on, you will be editing the files in that folder. At the end of the exam, that is what will be evaluated.

4) Edit the files following the instructions in this worksheet for each exercise.

> **WARNING: *DON'T* modify function signatures! Just provide the implementation.**

> **WARNING: *DON'T* change the existing test methods, just add new ones !!! You can add as many as you want.**

> **WARNING: *DON'T* create other files. If you still do it, they won't be evaluated.**

> **IMPORTANT: Pay close attention to the comments of the functions.**

> **IMPORTANT: if you need to print some debugging information, you *are allowed* to put extra `print` statements in the function bodies.**

> **WARNING: even if `print` statements are allowed, be careful with prints that might break your function, i.e. avoid stuff like this: `print 1/0`**

3) Every exercise should take max 25 mins. If it takes longer, leave it and try another exercise.

> **WARNING: MAKE SURE ALL EXERCISE FILES AT LEAST COMPILE !!!**
> **10 MINS BEFORE THE END OF THE EXAM I WILL ASK YOU TO DO A FINAL CLEAN UP OF THE CODE**

# Exercises

## 1) SwapArray

You are given a class `SwapArray` that models an array where the only modification you can do is to swap an element with the successive one.

In [5]:

```
from exercise1_solution import *
```

To create a `SwapArray`, just call it passing a python list:

In [6]:

```
sarr = SwapArray([7,8,6])
print sarr
```

```
SwapArray: [7, 8, 6]
```

Then you can query in $O(1)$ it by calling `get()` and `get_last()`

In [7]:

```
print sarr.get(0)
```

```
7
```

In [8]:

```
print sarr.get(1)
```

```
8
```

In [9]:

```
print sarr.get_last()
```

```
6
```

You can know the size in $O(1)$ with `size()` method:

In [10]:

```
print sarr.size()
```

```
3
```

As we said, the only modification you can do to the internal array is to call `swap_next` method:

```
    def swap_next(self, i):
    """ Swaps the elements at indeces i and i + 1

                If index is negative or greater or equal of the last index, raises
                an IndexError

            """
```

For example:

In [11]:

```
sarr = SwapArray([7,8,6,3])
print sarr
```

```
SwapArray: [7, 8, 6, 3]
```

In [12]:

```
sarr.swap_next(2)
print sarr
```

```
SwapArray: [7, 8, 3, 6]
```

In [13]:

```
sarr.swap_next(0)
print sarr
```

```
SwapArray: [8, 7, 3, 6]
```

Now start editing the file `exercise1.py`:

### 1.0) test swap

To check your environment is working fine, try to run the tests for the sole `swap` method. You don't need to implement it, the tests are in `SwapTest` class and should all pass:

**Notice that *`exercise1`*** is followed by a dot and test class name: *`.SwapTest`*

```
python -m unittest exercise1.SwapTest
```

### 1.1) is_sorted

Implement the `is_sorted` function, which is a function *external* to the class `SwapArray`:

```
def is_sorted(sarr):
    """ Returns True if the provided SwapArray sarr is sorted, False otherwise

        NOTE: Here you are a user of SwapArray, so you *MUST NOT* access
              directly the field _arr.
    """
    raise Exception("TODO IMPLEMENT ME !")
```

Once done, running this will run only the tests in `IsSortedTest` class and hopefully they will pass.

**Notice that *`exercise1`*** is followed by a dot and test class name: *`.IsSortedTest`*

```
python -m unittest exercise1.IsSortedTest
```

**Example usage:**

In [14]:

```
print is_sorted(SwapArray([8,5,6]))
```

```
False
```

In [15]:

```
print is_sorted(SwapArray([5,6,6,8]))
```

```
True
```

### 1.2) max_to_right

Implement `max_to_right` function, which is a function *external* to the class `SwapArray`. There are two ways to implement it, try to minimize the reads from the SwapArray.

```
def max_to_right(sarr):
    """ Modifies the provided SwapArray sarr so that its biggest element is
        moved to the last index. The order in which the other elements will be
        after a call to this function is left unspecified (so it could be any).

        NOTE: Here you are a user of SwapArray, so you *MUST NOT* access
              directly the field _arr. To do changes, you can only use
              the method swap(self, i).
    """
    raise Exception("TODO IMPLEMENT ME !")
```

**Testing** : `python -m unittest exercise1.MaxToRightTest`

**Example usage:**

In [16]:

```
sarr = SwapArray([8, 7, 6])
print sarr
```

```
SwapArray: [8, 7, 6]
```

In [17]:

```
max_to_right(sarr)
print sarr
```

```
SwapArray: [7, 6, 8]
```

In [18]:

```
sarr = SwapArray([6,8,6])
print sarr
```

```
SwapArray: [6, 8, 6]
```

In [19]:

```
max_to_right(sarr)
print sarr
```

```
SwapArray: [6, 6, 8]
```

## 2) DiGraph

Now you are going to build some `DiGraph`, by defining functions *external* to class `DiGraph`.

> **WARNING: To build the graphs, just use the methods you find inside `DiGraph` class, like `add_vertex`, `add_edge`, etc.**

Start editing file `exercise2.py`

In [21]:

```
from exercise2_solution import *
```

### 2.1) odd_line

Implement the function `odd_line`. Note the function is defined *outside* `DiGraph` class.

```
def odd_line(n):
    """ Returns a DiGraph with n verteces, displaced like a line of odd numbers

        Each vertex is an odd number i, for  1 <= i < 2n. For example, for
        n=4 verteces are displaced like this:

        1 -> 3 -> 5 -> 7

        For n = 0, return the empty graph

    """
    raise Exception("TODO IMPLEMENT ME !")
```

**Testing:** `python -m unittest exercise2.OddLineTest`

**Example usage** :

In [22]:

```
print odd_line(0)
```

```
DiGraph()
```

In [23]:

```
print odd_line(1)
```

```
1: []
```

In [24]:

```
print odd_line(2)
```

```
1: [3]
3: []
```

In [25]:

```
print odd_line(3)
```

```
1: [3]
3: [5]
5: []
```

In [26]:

```
print odd_line(4)
```

```
1: [3]
3: [5]
5: [7]
7: []
```

### 2.2) even_line

Implement the function `even_line`. Note the function is defined *outside* `DiGraph` class.

```
    def even_line(n):
        """ Returns a DiGraph with n verteces, displaced like a line of even numbers

            Each vertex is an even number i, for  2 <= i <= 2n. For example, for
            n=4 verteces are displaced like this:

            2 <- 4 <- 6 <- 8

            For n = 0, return the empty graph

        """

        raise Exception("TODO IMPLEMENT ME !")
```

**Testing:** `python -m unittest exercise2.EvenLineTest`

**Example usage:**

In [27]:

```
print even_line(0)
```

```
DiGraph()
```

In [28]:

```
print even_line(1)
```

```
2: []
```

In [29]:

```
print even_line(2)
```

```
2: []
4: [2]
```

In [30]:

```
print even_line(3)
```

```
2: []
4: [2]
6: [4]
```

In [31]:

```
print even_line(4)
```

```
2: []
4: [2]
6: [4]
8: [6]
```

### 2.3) quads

Implement the quads function. Note the function is defined *outside* `DiGraph` class.

```
    def quads(n):
        """ Returns a DiGraph with 2n verteces, displaced like a strip of quads.

            Each vertex is a number i,  1 <= i <= 2n.
            For example, for n = 4, verteces are displaced like this:

            1 -> 3 -> 5 -> 7
            ^    |    ^    |
            |    ;    |    ;
            2 <- 4 <- 6 <- 8

            where

              ^                                        |
              |  represents an upward arrow,   while    ;  represents a downward arrow


        """
        raise Exception("TODO IMPLEMENT ME !")
```

**Testing:** `python -m unittest exercise2.QuadsTest`

**Example usage:**

In [32]:

```
print quads(0)
```

```
DiGraph()
```

In [33]:

```
print quads(1)
```

```
1: []
2: [1]
```

In [34]:

```
print quads(2)
```

```
1: [3]
2: [1]
3: [4]
4: [2]
```

In [35]:

```
print quads(3)
```

```
1: [3]
2: [1]
3: [5, 4]
4: [2]
5: []
6: [4, 5]
```

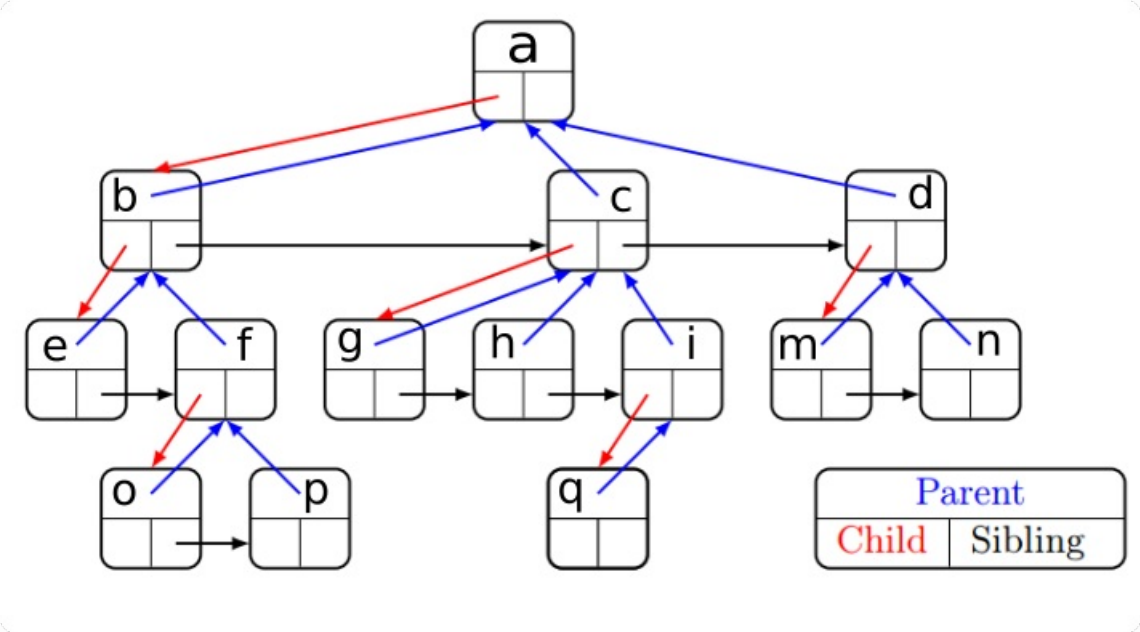
In [36]:

```
print quads(4)
```

```
1: [3]
2: [1]
3: [5, 4]
4: [2]
5: [7]
6: [4, 5]
7: [8]
8: [6]
```

## 3) GenericTree

In this exercise you will deal with family matters, using the `GenericTree` we saw during labs:




Now start editing the file `exercise3.py`:

### 3.1) grandchildren

Implement the `grandchildren` method:

```
    def grandchildren(self):
            """ Returns a python list containing the data of all the grandchildren of this
                node.

                - Data must be from left to right order in the tree horizontal representatio
    n
                  (or up to down in the vertical representation).
                - If there are no grandchildren, returns an empty array.

                For example, for this tree:

                a
                |-b
                | |-c
                | \-d
                |   \-g
                |-e
                \-f
                  \-h

                Returns ['c','d','h']
            """
            raise Exception("TODO IMPLEMENT ME !")
```

**Testing:** `python -m unittest exercise3.GrandChildrenTest`

**Usage examples:**

In [37]:

```
from exercise3_solution import *
```

In [38]:

```
ta = gt('a', gt('b', gt('c')))
print ta
```

```
a
\-b
  \-c
```

In [39]:

```
print ta.grandchildren()
```

```
['c']
```

In [40]:

```
ta = gt('a', gt('b'))
print ta
```

```
a
\-b
```

In [41]:

```
print ta.grandchildren()
```

```
[]
```

In [42]:

```
ta = gt('a', gt('b', gt('c'), gt('d')), gt('e', gt('f')) )
print ta
```

```
a
|-b
| |-c
| \-d
\-e
  \-f
```

In [43]:

```
print ta.grandchildren()
```

```
['c', 'd', 'f']
```

### 3.2) uncles

Implement the `uncles` method:

```
   def uncles(self):
           """ Returns a python list containing the data of all the uncles of this
               node (that is, *all* the siblings of its parent).

               NOTE: returns also the father siblings which are *BEFORE* the father !!

               - Data must be from left to right order in the tree horizontal representatio
   n
                 (or up to down in the vertical representation).
               - If there are no uncles, returns an empty array.

               For example, for this tree:

               a
               |-b
               | |-c
               | \-d
               |   \-g
               |-e
                 \-h
               \-f


               calling this method on 'h' returns ['b','f']
           """
```

**Testing:** `python -m unittest exercise3.UnclesTest`

**Example usages:**

In [44]:

```
td = gt('d')
tb = gt('b')
ta = gt('a', tb,  gt('c', td), gt('e'))
print ta
```

```
a
|-b
|-c
| \-d
\-e
```

In [45]:

```
print td.uncles()
```

```
['b', 'e']
```

In [46]:

```
print tb.uncles()
```

```
[]
```