



香港中文大學(深圳)

The Chinese University of Hong Kong, Shenzhen

***INTRODUCTION TO COMPUTER SCIENCE:
PROGRAMMING METHODOLOGY***

**TUTORIAL 14
TREE**

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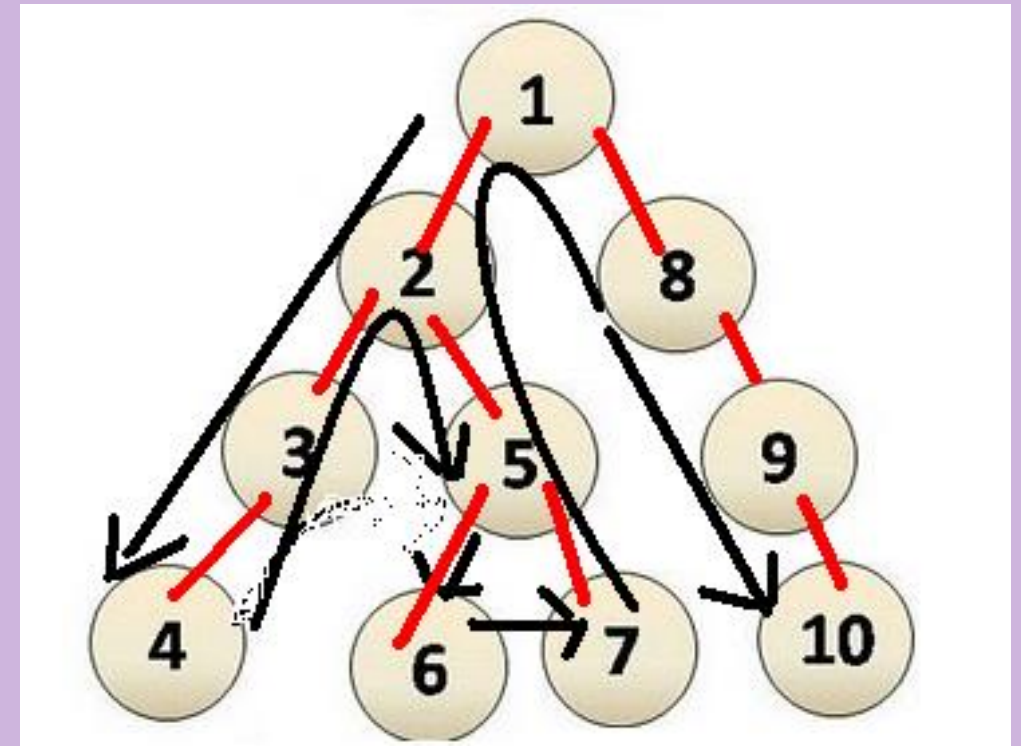
Definition of Binary Tree Class

- Refer to the *LBTree.py* file.
- The nodes in the binary tree you define is of **Node** class defined by yourselves. Node class has four data fields, one(element) store the value of the node and three references(or pointers) store parent, left child and right child node respectively(or equivalently their addresses).
- The binary tree has two data fields, its root and its size(the total number of nodes).

Depth First Search

- **Depth-first search (DFS)** is a fundamental algorithm for traversing or searching tree data structures.
- One starts at the **root** and explores **as deep as possible** along each branch **before backtracking**.

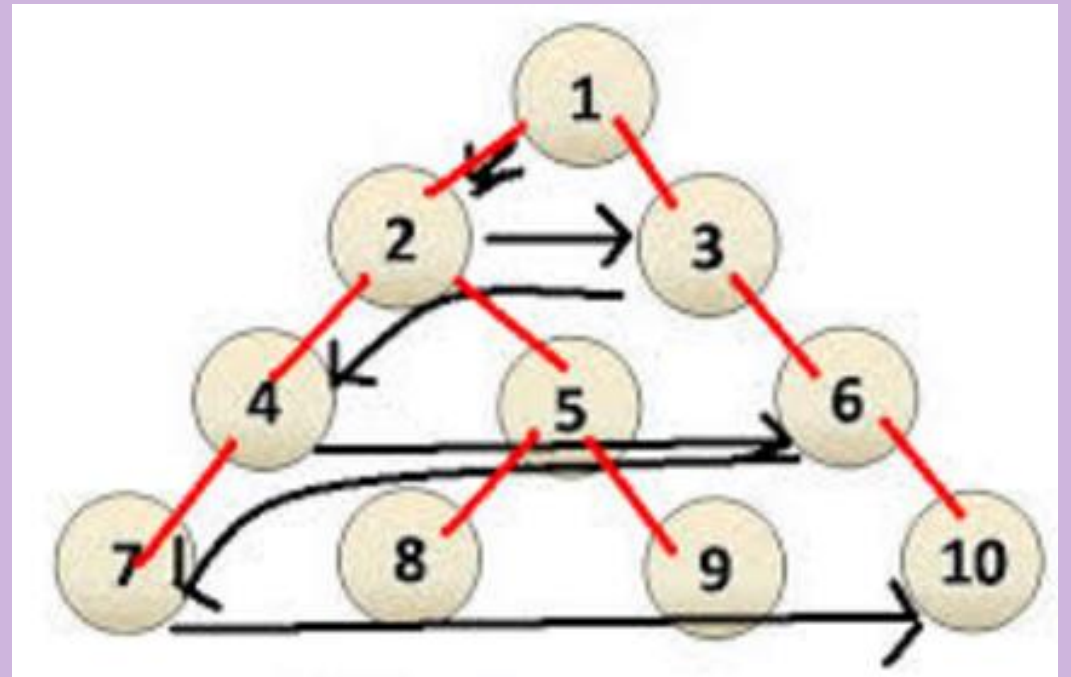
➤ Refer to the *DFS.py* file.



Breadth First Search

- **Breadth-first search (BFS)** is another very important algorithm for traversing or searching tree data structures.
- Starts at the **root** and we visit all the positions at depth **d** before we visit the positions at depth **d + 1**.

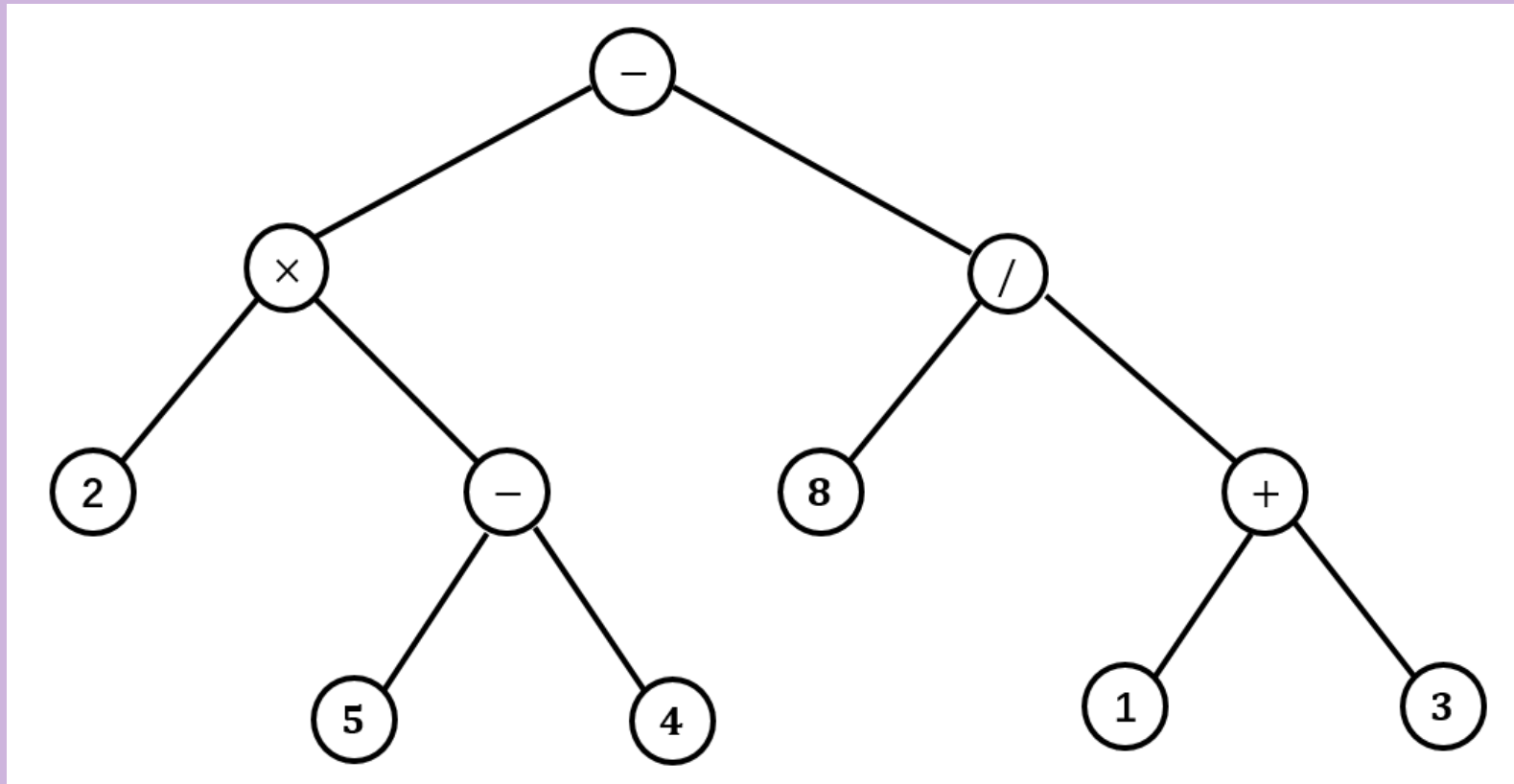
➤ Refer to the *BFS.py* file.



Q1: Represent an Expression

- An arithmetic expression can be represented using a binary tree, with each node being a number or an operator. Try to draw a tree to represent an expression $2 \times (5 - 4) - (8 / (1 + 3))$.

Q1: Answer



Q2: Create a Tree Object

- **Using the definition of binary tree class, create an object of that class, with value of each node equal to that in the binary tree you draw in Q1.**

Q3: Depth First Search

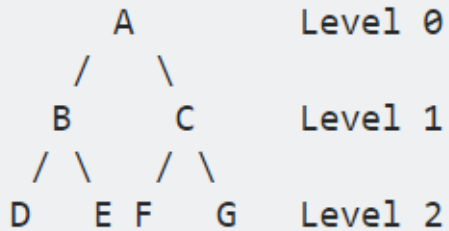
- i) Apply the **Depth First Search** algorithm to the tree you create in Q2, and check the order of elements in the tree printed out.
- ii) Modify the **Depth First Search** program a little bit, define a function that is able to evaluate an expression represented by a binary tree.
- iii) You can try i) ii) using **Breadth First Search** algorithm.

Q4: Path Length of a Tree-I

- **The path length of a tree T is the sum of the depths of all positions in T . Describe a linear time method for computing the path length of a tree T .**

Q4: Path Length of a Tree-II

Counting Nodes



We start with a path length of 0:

- Node **A** is the root, which is always on level 0. It does not contribute to the path length. (You don't need to follow any paths to reach it, hence 0)
 - $0 + (0) = 0$
- On level 1, you have two nodes: **B** and **C**:
 - $0 + (1 + 1) = 2$
- On level 2, you have four nodes: **D**, **E**, **F** and **G**:
 - $2 + (2 + 2 + 2 + 2) = 10$

FINAL REVIEW!

- Try to answer these questions and test yourself!

SINGLE-CHOICE QUESTIONS

1. Which of the following is NOT a high-level programming language?
 - a. Java language
 - ☒ b. Assembly language
 - c. Python
 - d. C++ language
2. Binary number **11001101.001** and hexadecimal number **45E.8** equal to decimal numbers:
 - ☒ a. 205.125 and 1118.5
 - b. 205.125 and 1119.5
 - c. 153.25 and 1118.5
 - d. 153.25 and 1119.5

SINGLE-CHOICE QUESTIONS

3. Order the following time complexities from fast to slow:

I. 2^n

II. $\log(n)$

III. $n\log(n)$

IV. n^3

V. n

VI. n^2

a. I, II, III, IV, V, VI

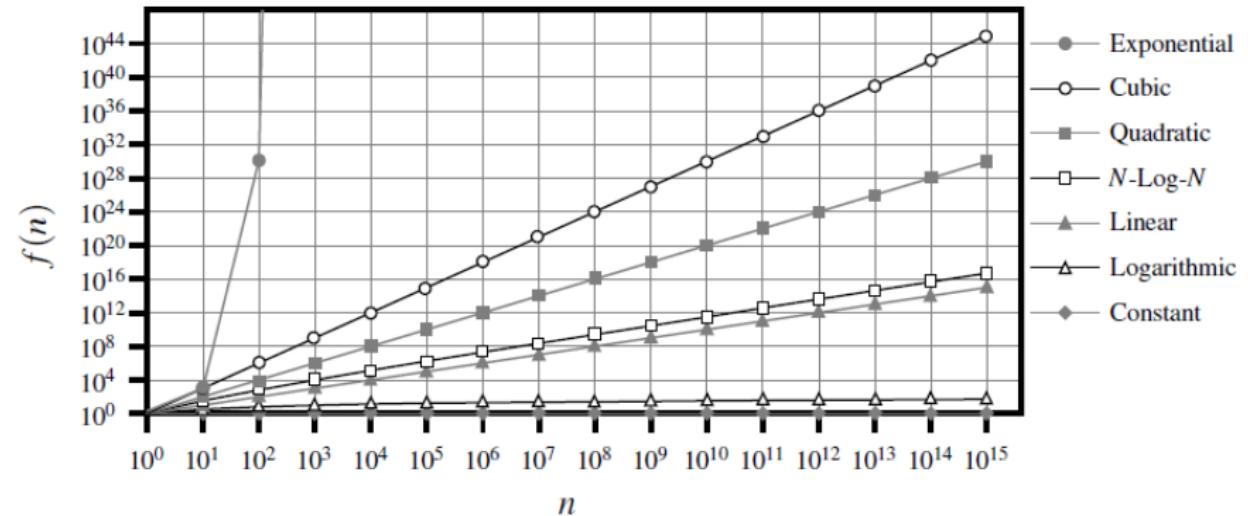
b. V, II, III, I VI, IV

c. III, II, V, VI, IV, I

d. II, V, III, VI, IV, I

The 7 functions used in algorithm analysis

- We may use the following 7 functions to measure the time complexity of an algorithm: **constant**, **logarithm**, **linear**, **N-log-N**, **quadratic**, **cubic** and **other polynomials**, **exponential**



SINGLE-CHOICE QUESTIONS

4. Concerning the following program, which of the following statements is incorrect?

```
if x<10:  
    print('Below 10')  
elif x<15:  
    print('Below 15')  
elif x<7:  
    print('Below 7')  
else:  
    print('Something')  
print('Done')
```

- a. print('Below 10') will be executed when x = 8.
- ☒ b. print('Below 7') will be executed when x = 1.
- c. print('Below 15') will be executed when x = 12.
- d. print('Something') will be executed when x = 20.

MULTIPLE-CHOICE QUESTIONS

5. Which of the following is/are the python reserved word?

- ☒ a. True
- ☒ b. del
- c. assertation
- ☒ d. break

False	None	True	and	as	assert	break
class	continue	def	del	elif	else	except
finally	for	from	global	if	import	in
is	lambda	nonlocal	not	or	pass	raise
return	try	while	with	yield		

6. Which of the following is/are a legal variable name/s?

- ☒ a. Myvar
- ☒ b. _myvar
- ☒ c. My_var
- d. My-var

Rules for defining variables in Python

- Must start with a letter or underscore _
- Can **only** contain letters, numbers and underscore
- Case **sensitive**

MULTIPLE-CHOICE QUESTIONS

7. Concerning algorithm analysis, which of the following statement/s is/are correct?

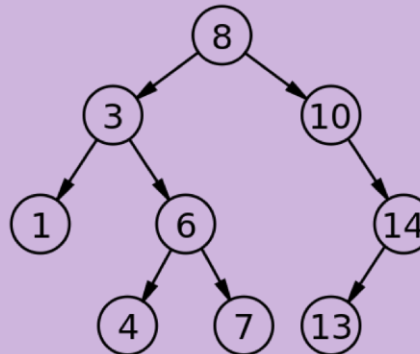
- a. Function $5n^4 + 6n^3 + 2n\log(n) + 2n + 2$ is $O(n\log(n))$.
- ☒ b. The big-Oh notation allows us to say that a function $f(n)$ is less than or equal to another function $g(n)$ up to a constant factor when n is large enough.
- c. When we analyze an algorithm, we are usually interested at its average performance regardless of the input size.
- ☒ d. The big-Oh notation can be used to characterize the running time of an algorithm in the asymptotic sense.

OPEN QUESTIONS

8. Concerning the following program, and assume that input t will be a reference pointing to the root of a binary tree.

```
def Search(t):  
    if t:  
        print(t.element)  
        if (t.left is None) and (t.right is None):  
            return  
        else:  
            if t.right is not None:  
                Search(t.right)  
            if t.left is not None:  
                Search(t.left)
```

- Which algorithm is implemented in this function? **DFS**
- If input t is referencing to the root of the following tree, what would be the output of this function?



8
3
1
6
4
7
10
14
13

GOOD LUCK!

Congratulations on finishing the CSC100I course

Hope you can do well in all exams!

加油

See you in another opportunity!

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