UE5 Fundamentals of Algorithms

Lecture 9: Binary trees traversals

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In [24]:
```
import sys
import os
from graphviz import Digraph
```

```python
from IPython.display import display
from utils import draw_binary_tree
```

Outline

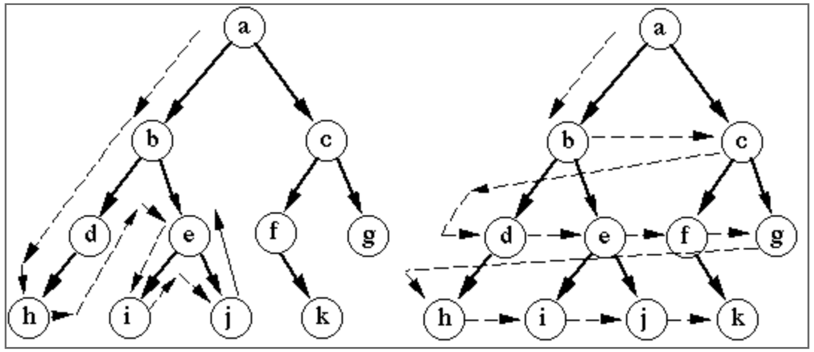
- Traversal methods
- Depth first
- Breadth first

Binary trees traversal methods

> *Methods to explore and process nodes in a tree (or a graph).*

- Because Trees are non-linear, there are multiple possible paths
- Can be applied to the whole tree or until a certain condition is met
- Traversals methods will provide very different results

Two main traversal strategies:



1. **Depth-First search (DFS):**
    - visiting a node (sarting with the root)
    - then recursively traversing as deep as possible
    - then explore another branch.
2. **Breadth-First search (BFS):**
    - visiting a node (with the root)
    - explore all its neighbors (children)

- then mode move to the children.

Depth-first search (or traversal)

> ***Depth-first search (DFS)*** *is a traversal method that visits all the leaves first in a tree (or a graph).*

1. Place the source node in a **stack**.
2. Remove the node from the top of the stack for processing.
3. Add all unexplored neighbors to the stack (at the top).
4. If the stack is not empty, go back to step 2.

Depth-first search (or traversal)

In [25]:
```
def dfs(tree, start):
        stack = [start]
  while stack:
      vertex = stack.pop()
      print(vertex, end = ' ') # traitement
      stack.extend(tree[vertex])
```

In [26]:
```
tree = {'A': set(['B', 'C']),
                 'B': set(['D', 'E', 'F']),
         'C': set([]),
         'D': set([]),
         'E': set([]),
         'F': set([])
        }
```

In [27]:
```
dfs(tree, 'A') # A B D F E C
```

```
A B F E D C
```

Depth-first search: pre-order, in-order, and post-order.

For **depth-first search**, there are different types of processing: *pre-order*, *in-order*, and *post-order*, based on when the processing is done (before/after exploring the root or the children). Notation :

- R = Root
- D = Right subtree
- G = Left subtree

There are three (main) types of traversal:

- **Pre-order**: R G D
- **In-order**: G R D
- **Post-order**: G D R

Depth-first traversal: pre-order, in-order, and post-order.

Implementation of the strategies:

```
def preorder(R):
  if not empty(R):
    process(R)          # Root
    preorder(left(R))   # Left
    preorder(right(R))  # Right

def inorder(R):
  if not empty(R):
    inorder(left(R))    # Left
    process(R)          # Root
    inorder(right(R))   # Right

def postorder(R):
  if not empty(R):
    postorder(left(R))  # Left
    postorder(right(R)) # Right
    postorder(R)        # Rooot
```

Example

We will use this data structure

In [28]:
```
class Node:
        def __init__(self, value):
        self.value = value
        self.left = None
        self.right = None

    def get_value(self):
        return self.value

    def set_value(self, v = None):
        self.value = v
```

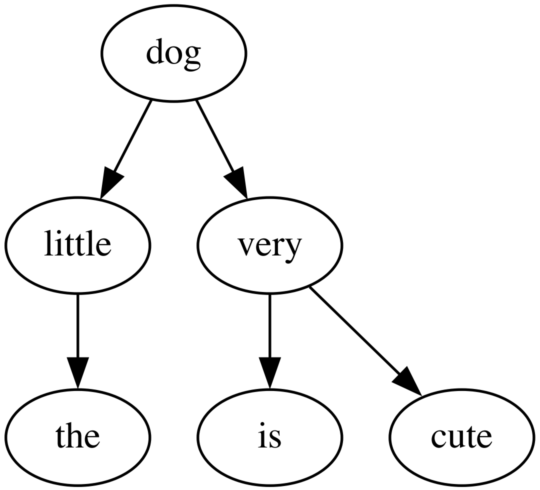
In [29]:
```
root = Node("dog")
        root.left = Node("little")
root.left.left = Node("the")
root.right = Node("very")
```

```python
root.right.left = Node("is")
root.right.right = Node("cute")
```

Example

How to get the sentence in the correct order?

```
In [30]: draw_binary_tree(root)
```



Depth-first traversal pre-order (OOP + iterative)

In [31]:
```
    def iterative_inorder_traversal(node):
        stack = [node]
while stack:
    current_node = stack.pop()
    print(current_node.value)
    if current_node.right:
        stack.append(current_node.right)
    if current_node.left:
        stack.append(current_node.left)
```

In [32]:
```
iterative_inorder_traversal(root)
```

```
dog
little
the
very
is
cute
```

Depth-first traversal pre-order (dict + recursive)

Recursive implementation using a dictionnary data structure.

In [33]:
```
TT = {"dog": ["little", "very"],
          "little": ["the"],
    "the": [],
      "very": ["is", "cute"],
      "is": [],
      "cute": []
    }
```

In [34]:
```
def preorder(T, node):
        if node is not None:
    print(node)
    if len(T[node]) > 0:
        preorder(T, T[node][0])
    if len(T[node]) > 1:
        preorder(T, T[node][1])
```

In [35]:
```
preorder(TT, "dog")
```

dog
little
the
very
is
cute

Iterative version.

```
In [36]: def preorder_traversal(T, node):
             stack = [node]

             while stack:
                 current_node = stack.pop()
                 print(current_node)

                 if len(T[current_node]) > 1:
                     stack.append(T[current_node][1])

                 if len(T[current_node]) > 0:
                     stack.append(T[current_node][0])
```

```
In [37]: preorder_traversal(TT, "dog")
```

```
dog
little
the
very
is
cute
```

Solution: inorder traversal

```
In [38]: def inorder(T, node):
             if node is not None:
         if len(T[node]) > 0:
             inorder(T, T[node][0])
         print(node)
         if len(T[node]) > 1:
             inorder(T, T[node][1])
```

```
In [39]: inorder(TT, "dog")
```

```
the
little
dog
is
very
cute
```

Breadth-first search (or traversal)

> ***Breadth-first search (BFS)** is a traversal method that visits all the nodes in a tree (or a graph) level by level.*

```
      1
     / \
    2   3
   / \
  4   5
```

The main difference will be that we use a Queue instead of a Stack

In [40]:
```python
def bfs_print(node):
    if node is None:
        return

    queue = [node]

    while queue:
        current_node = queue.pop(0)
        print(current_node.value, end=' ')
```

```
        if current_node.left:
            queue.append(current_node.left)

        if current_node.right:
            queue.append(current_node.right)
```

In [41]:
```
root = Node(1)
root.left = Node(2)
root.right = Node(3)
root.left.left = Node(4)
root.left.right = Node(5)
```

In [42]:
```
bfs_print(root)
```

```
1 2 3 4 5
```