

## Fundamental Algorithms 10

### Exercise 1: Modified Depth/Breadth-First Traversal

Consider the following, modified traversal algorithm for graphs and trees:

```
ModTraversal(V:Node) {
    // assume Mark[V.key]=1 at entry
    // init (local!) list for "active" nodes
    Queue active = {};
    // visit all (non-visited) nodes connected to V
    forall (V,W) in V.edges do {
        if Mark[W.key] = 0 then [
            // visit node W and mark as visited:
            Visit(W);
            Mark[W.key] := 1;
            // append node W to "active" nodes
            append(active,W);
        ];
    };
    // perform traversal from all "active" nodes connected to V
    forall W in active do {
        ModTraversal(W);
    };
}
```

#### Exercise 1a:

Consider the graph given in Figure 1: in what order are the nodes "visited" by the modified traversal? (Number the nodes in the graph accordingly.) The traversal shall be called by

```
Mark[S.key] := 1;
ModTraversal(S);
```

(S being the start node for the traversal).

**Solution:**

Due to the recursive call of the function ModTraversal, the traversal is similar to a depth-first traversal. However, the approach to first mark the nodes adjacent to the current node and append them to a list of active nodes is similar to breadth-first traversal. Hence, the traversal is a mixture between DFT and BFT: first, all nodes adjacent to the current node are visited, but the traversal then proceeds in depth-first manner. See Figure 1 for the resulting order.

**Exercise 1b:**

In the same graph, mark the edges that are part of the spanning tree computed by ModTraversal.

**Solution:**

See Figure 1.

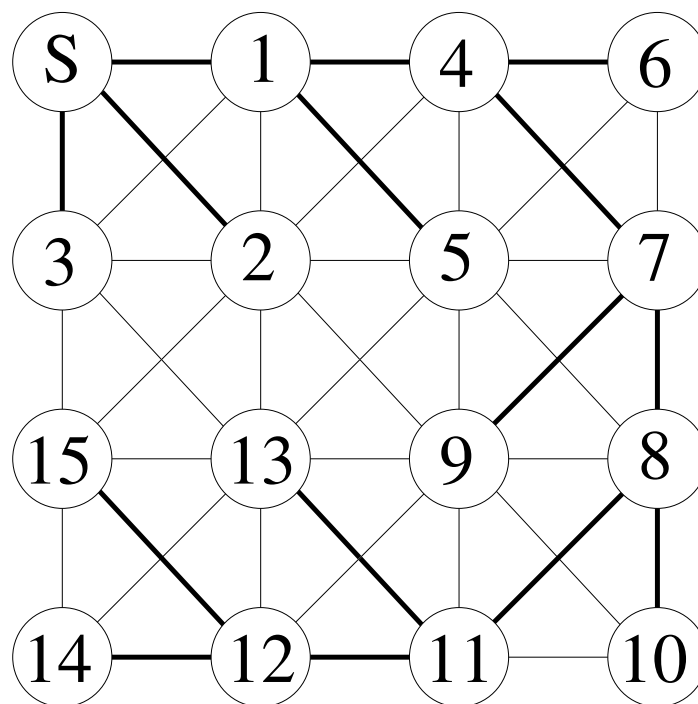


Figure 1: Graph for Exercise 1a) and 1b). It is not specified, in which order edges outgoing from a node V are stored in the list V.edges – you may assume any order you like.

**Exercise 1c:**

Now assume that the second forall-loop is changed into a parallel loop:

```
// perform traversal from all (non-visited) nodes connected to V
forall W in active do in parallel {
  ModTraversal(W);
};
```

Discuss whether there can be concurrent read or write access to the elements of the array Mark. Discriminate between the two cases that the traversed graph is a tree and that it is not a tree.

**Solution:**

**For an arbitrary graph (not a tree):** Here, concurrent access are possible. Consider nodes 2 and 3 in Fig. 1: they will trigger concurrent accesses to the nodes 13 and 15, for example.

**For a tree:** In that case, no concurrent accesses can happen – subtrees are traversed in parallel, but as the subtrees are not allowed to share nodes (this would violate the tree property!), parallel accesses are exclusive.