S1

**CX1107 Data Structures and Algorithms** **2020/21 Semester 2**

# Solution 6: Graph

*School of Computer Science and Engineering* *Nanyang Technological University*

**Q1** Manually execute breadth-first search on the undirected graph in Figure 6.1, starting from vertex $s$. Then, use it as an example to illustrate the following properties:

**(a)** The results of breadth-first search may depend on the order in which the neighbours of a given vertex are visited.

**(b)** With different orders of visiting the neighbours, although the BFS tree may be different, the distance from starting vertex $s$ to each vertex will be the same.

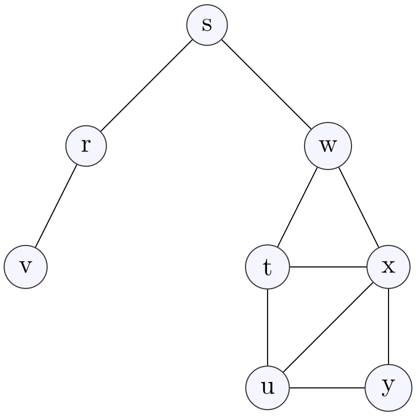


Figure 6.1: Graph for Q1

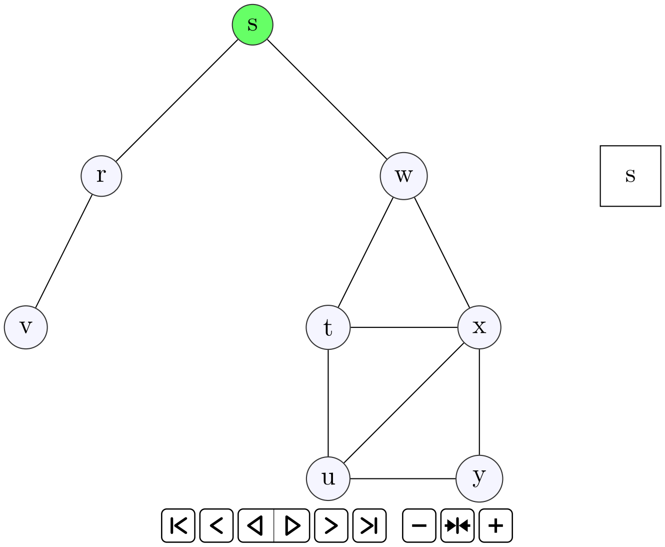


Figure 6.2: Graph for S1

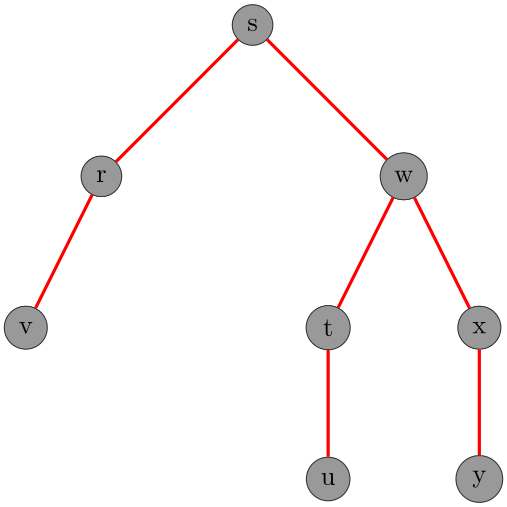


Figure 6.3: Visiting neighbors in alphabetical order

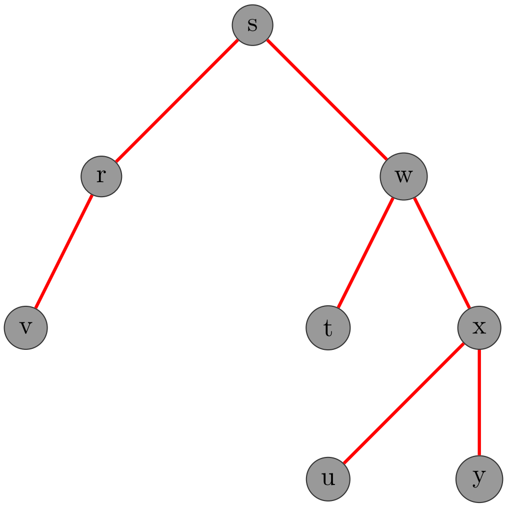


Figure 6.4: Visiting neighbors in reverse alphabetical order

- When the queue is empty, the BFS is finished.
- The edges of BFS tree are shown in red.
- Likewise, a BFS tree can be constructed if the neighbors are visited in the reverse alphabetical order (an exercise for the students).
- The two trees differ in that vertex u is adjacent with t in the left tree, but adjacent with x in the right tree.
- The distance from starting vertex s to each other vertex is equal in the two trees.

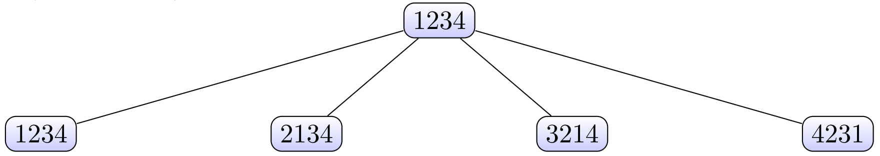
**Q2** Give a pseudocode of finding a simple path connecting two given vertices in an undirected graph in linear time.

**Algorithm 1** Depth First Search (DFS)

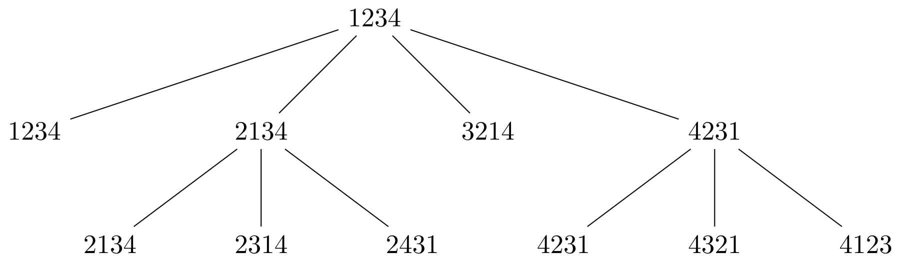
```
S2 function SimplePath(Graph $G$, Vertex $v$,Vertex $w$)
        create a Stack, $S$
        push $v$ into $S$
        mark $v$ as visited
        while $S$ is not empty do
            peek the stack and denote the vertex as $x$
            if $x == w$ then
                while $S$ is not empty do
                    pop a vertex from $S$
                    peek the stack
                    print the link
                end while
                return Found
            end if
            if no unvisited vertices are adjacent to $x$ then
                pop a vertex from $S$
            else
                push an unvisited vertex $u$ adjacent to $x$
                mark $u$ as visited
            end if
        end while
    return Not Found
    end function
```

**Q3** Give a pseudocode of a backtracking algorithm to print out all possible permutation of a given sequence. For example, input is given as "1234". The 24 output permutations are printed out from "1234" to " 4321".

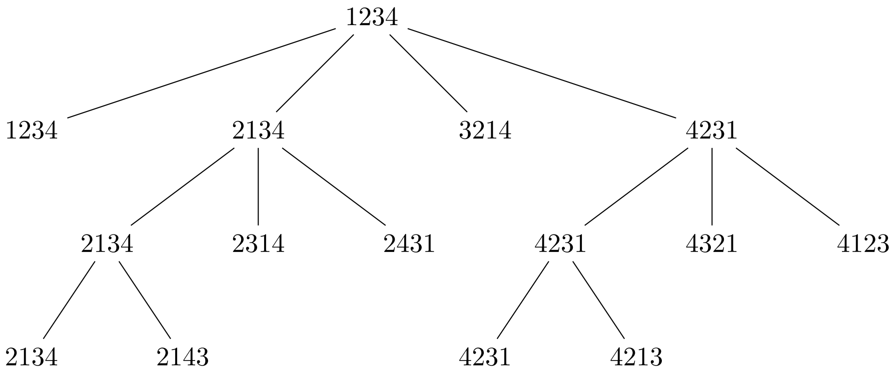
**S3** To systematically print out all the permutations, we first swap the first element with each other element.



Next we need to swap the second element with each other element (except the element in the first position). Here we only case the second and the fourth cases.



Next we need to swap the third element with the following element (in the example, we only leave the last element to swap).



You can observe that printing out all the permutation we need to iterative swap one element with each other element and recursively do so on its smaller sequence (reduce by one element) until we reach the last element. The pseudocode is as following:

**Algorithm 2** Backtracking algorithm for Permutation

```
function PERMUTATION($char[]seq$, $sInx$, $eIdx$)
    if $sInx == eIdx$ then
        print $seq$
    else
        for $i \leftarrow$ sInx to eInx do
            swap the sInx$^{th}$ character and the $i^{th}$ character in $seq$
            Permutation(seq,sInx+1,eIdx)
            swap the sInx$^{th}$ character and the $i^{th}$ character in $seq$        ▷ backtracking
        end for
    end if
end function
```