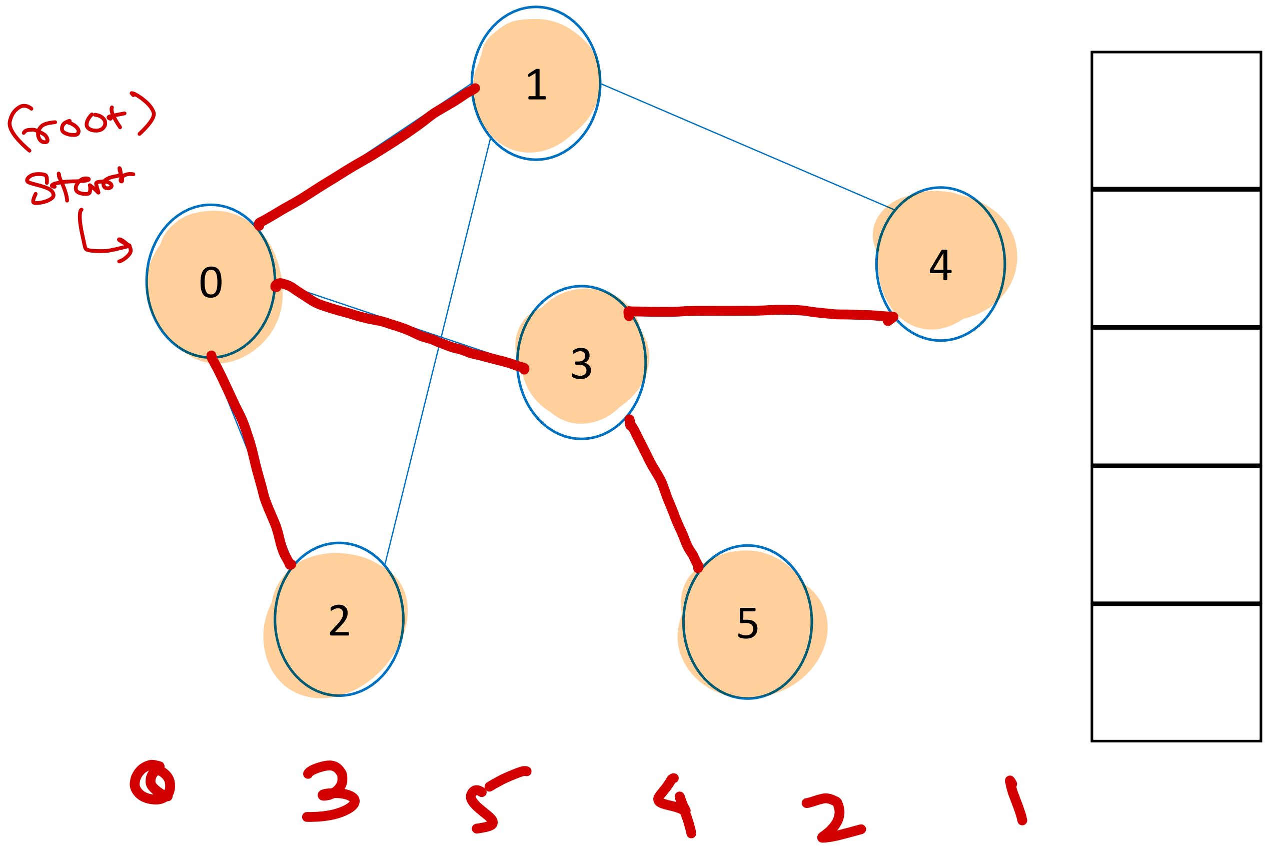
Data Structure & Algorithms

Nilesh Ghule

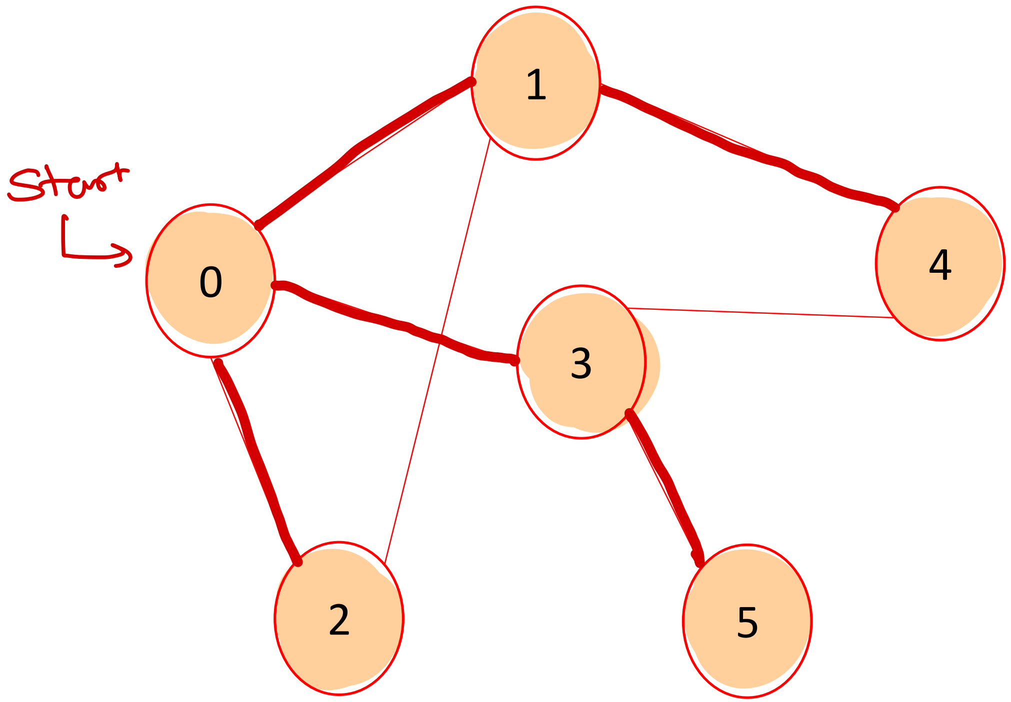
DFS Spanning Tree

1. push starting vertex on stack & mark it.
2. pop the vertex.
3. push all its non-marked neighbors on the stack, mark them. Also print the vertex to neighboring vertex edges.
4. repeat steps 2-3 until stack is empty.

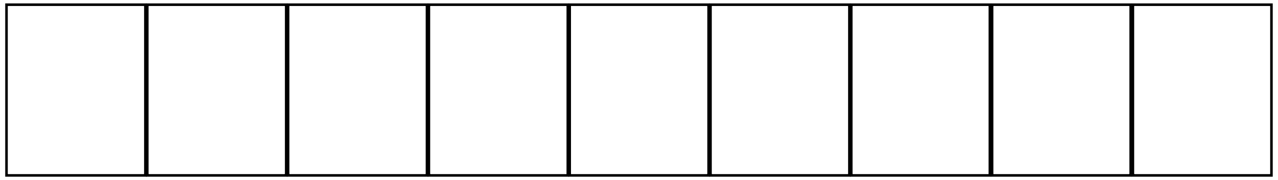


BFS Spanning Tree

1. push starting vertex on queue & mark it.
2. pop the vertex.
3. push all its non-marked neighbors on the queue, mark them. Also print the vertex to neighboring vertex edges.
4. repeat steps 2-3 until queue is empty.

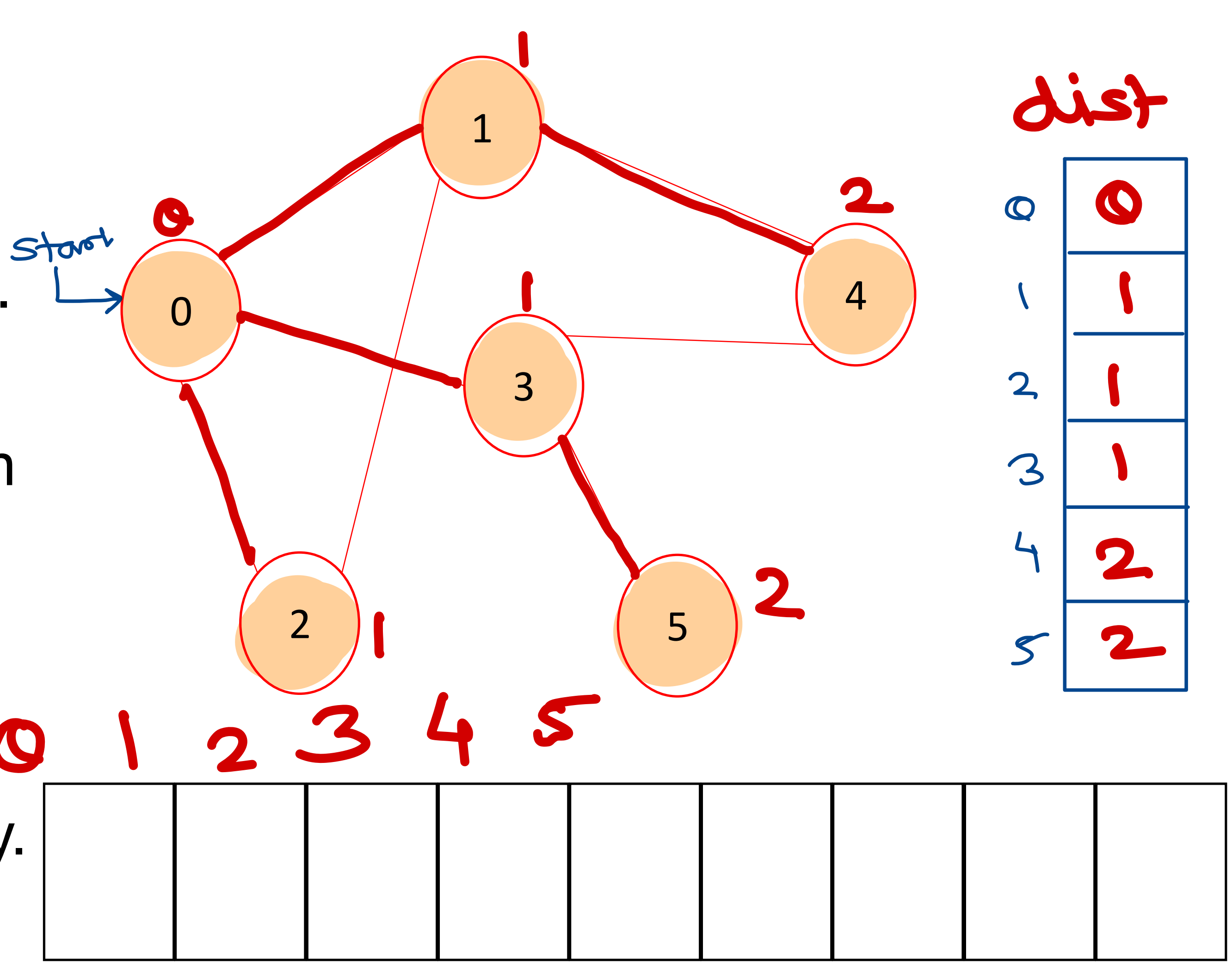


0 1 2 3 4 5



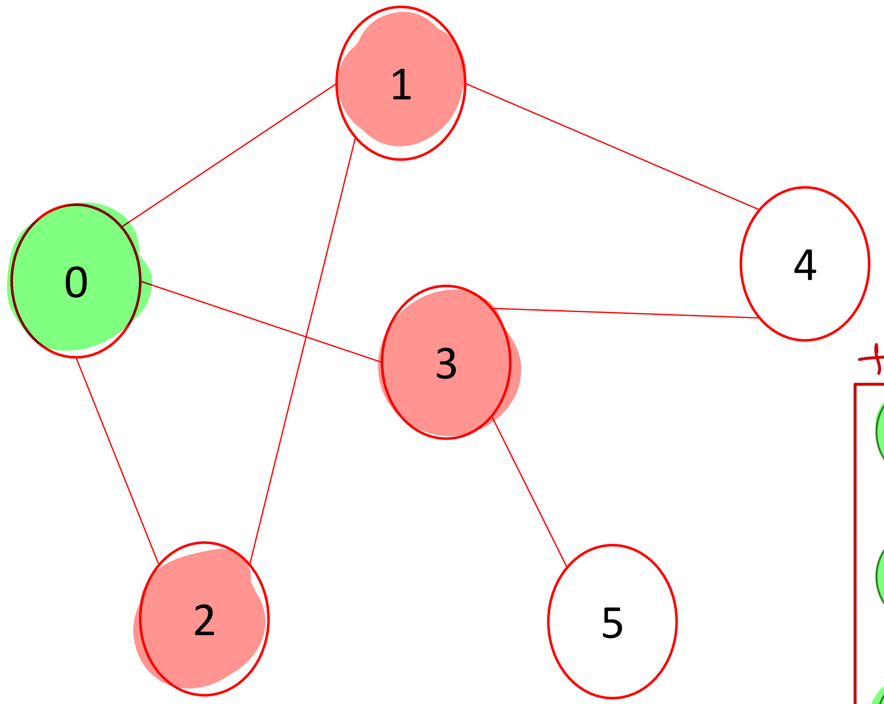
Single Source Path Length (Non-weighted graph)

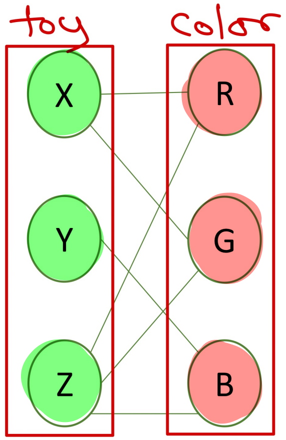
1. Create path length array to keep distance of vertex from start vertex.
2. Consider dist of start vertex as 0.
3. push start vertex on queue & mark it.
4. pop the vertex.
5. push all its non-marked neighbors on the queue, mark them.
6. For each such vertex calculate its distance as dist[neighbor] = dist[current] + 1
7. repeat steps 3-6 until queue is empty.
8. Print path length array.

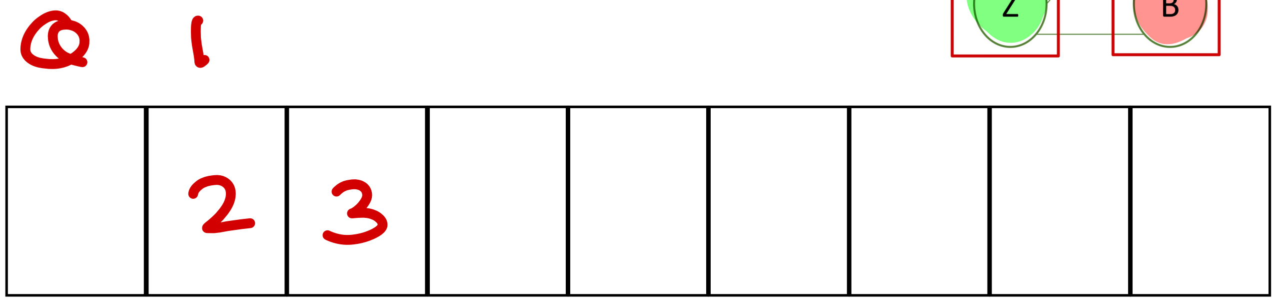


Check Bipartite-ness

1. keep colors of all vertices in an array. Initially vertices have no color.
2. push start on queue & mark it. Assign it color1.
3. pop the vertex.
4. push all its non-marked neighbors on the queue, mark them.
5. For each such vertex if no color is assigned yet, assign opposite color of current vertex (c1-c2, c2-c1).
6. If vertex is already colored with same of current vertex, graph is not bipartite (return).
7. repeat steps 3-6 until queue is empty.

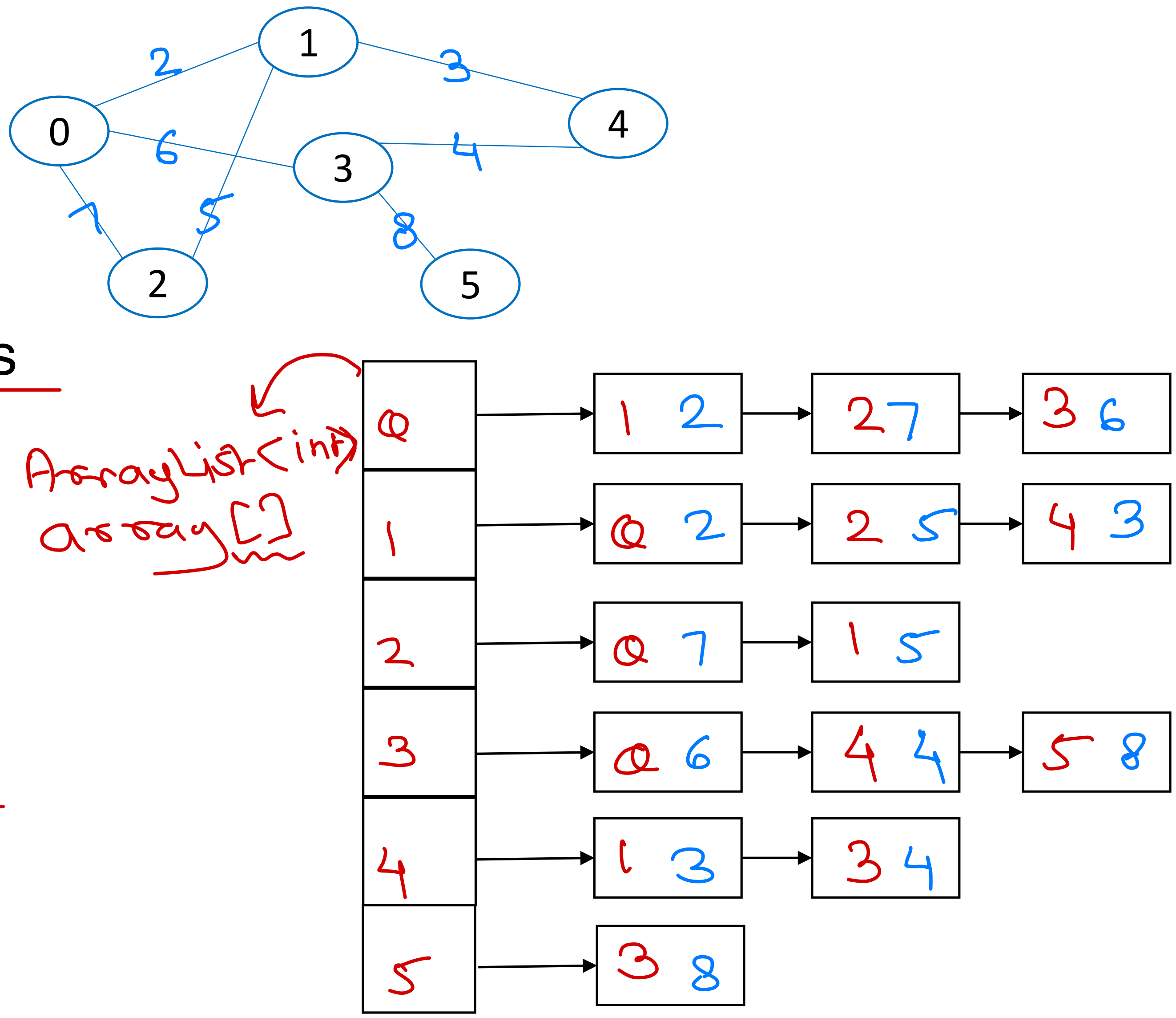






Graph Implementation – Adjacency List

- Each vertex holds list of its adjacent vertices.
- For non-weighted graphs only, neighbour vertices are stored.
- For weighted graph, neighbour vertices and weights of connecting edges are stored.
- Space complexity of this implementation is O(V+E).
- If graph is sparse graph (with fewer number of edges), this implementation is more efficient (as compared to adjacency matrix method).



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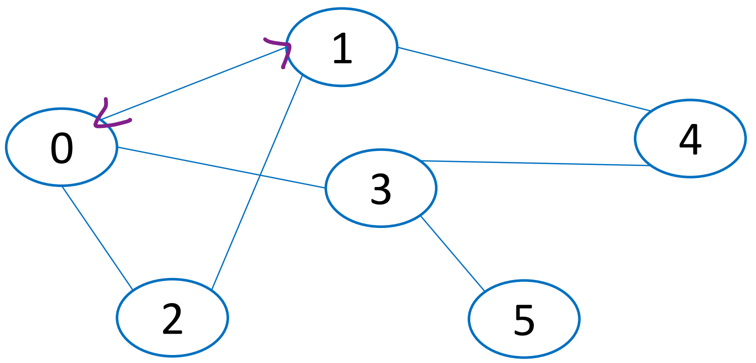
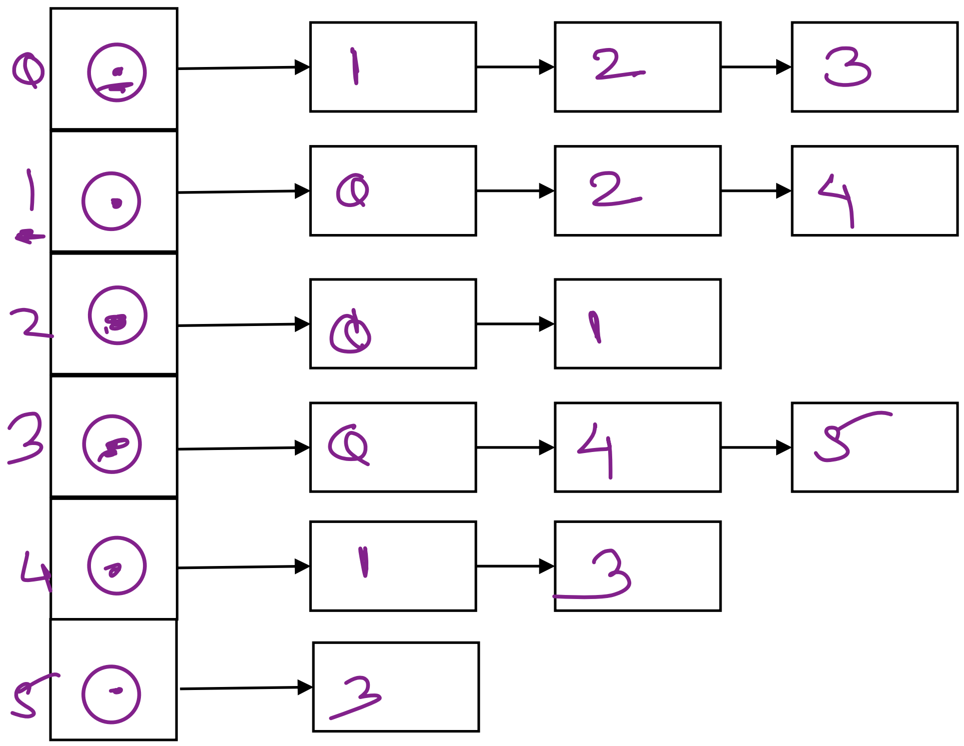


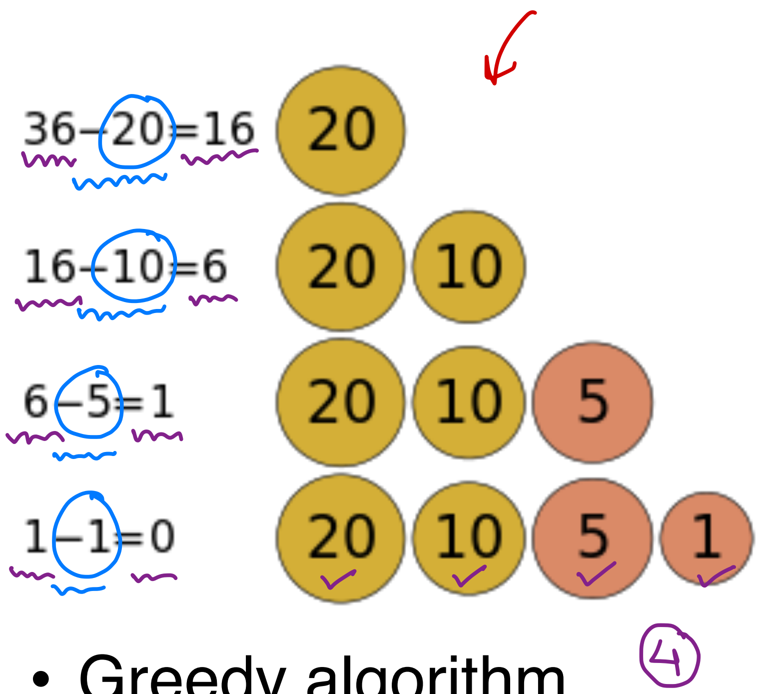
user input

src	dest
0	1
0	2
0	3
1	2
1	4
3	4
3	5



Problem solving technique: Greedy approach

- A greedy algorithm is any algorithm that follows the problem-solving heuristic of making the locally optimal choice at each stage with the intent of finding a global optimum.
- We can make choice that seems best at the moment and then solve the sub-problems that arise later.
- The choice made by a greedy algorithm may depend on choices made so far, but not on future choices or all the solutions to the sub-problem.
- It iteratively makes one greedy choice after another, reducing each given problem into a smaller one.
- A greedy algorithm never reconsiders its choices.
- A greedy strategy may not always produce an optimal solution.

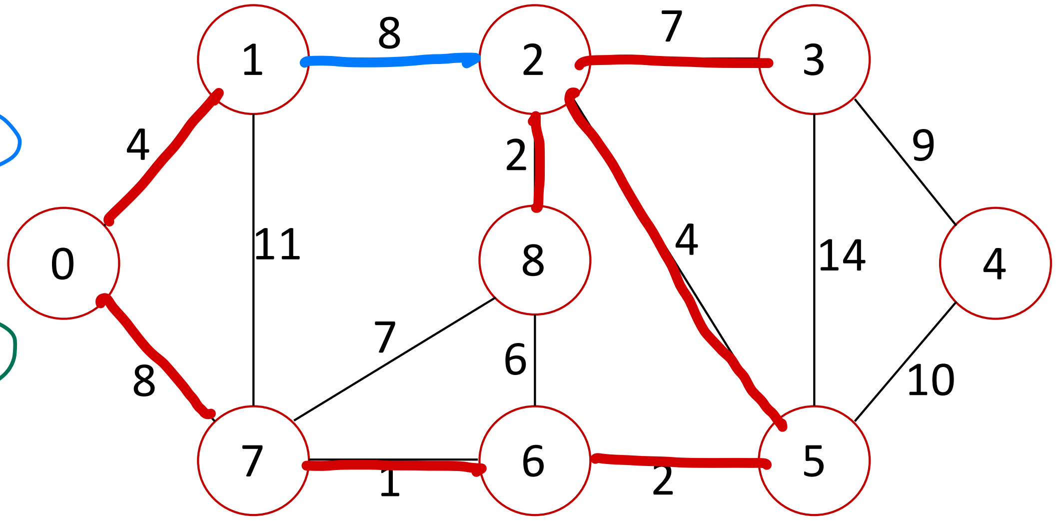


- Greedy algorithm decides minimum number of coins to give while making change.

Union Find Algorithm → check if graph contains a cycle.

1. Consider all vertices as disjoint sets (parent = -1).
2. For each edge in the graph
   1. Find set of first vertex. → sr → 3
   2. Find set of second vertex. → dr → 3
   3. If both are in same set, cycle is detected. sr == dr ✓
   4. Otherwise, merge both the sets i.e. add root of first set under second set

if (sr != dr)
  Parent[sr] = dr;



parent

0	1	2	3	4	5	6	7	8
1	3	5			3	5	6	2

src	des	wt
7	6	1
8	2	2
6	5	2
0	1	4
2	5	4
~~8~~	~~6~~	~~6~~
2	3	7
~~7~~	~~8~~	~~7~~
0	7	8
1	2	8
3	4	9
5	4	10
1	7	11
3	5	14

Kruskal's MST – Analysis

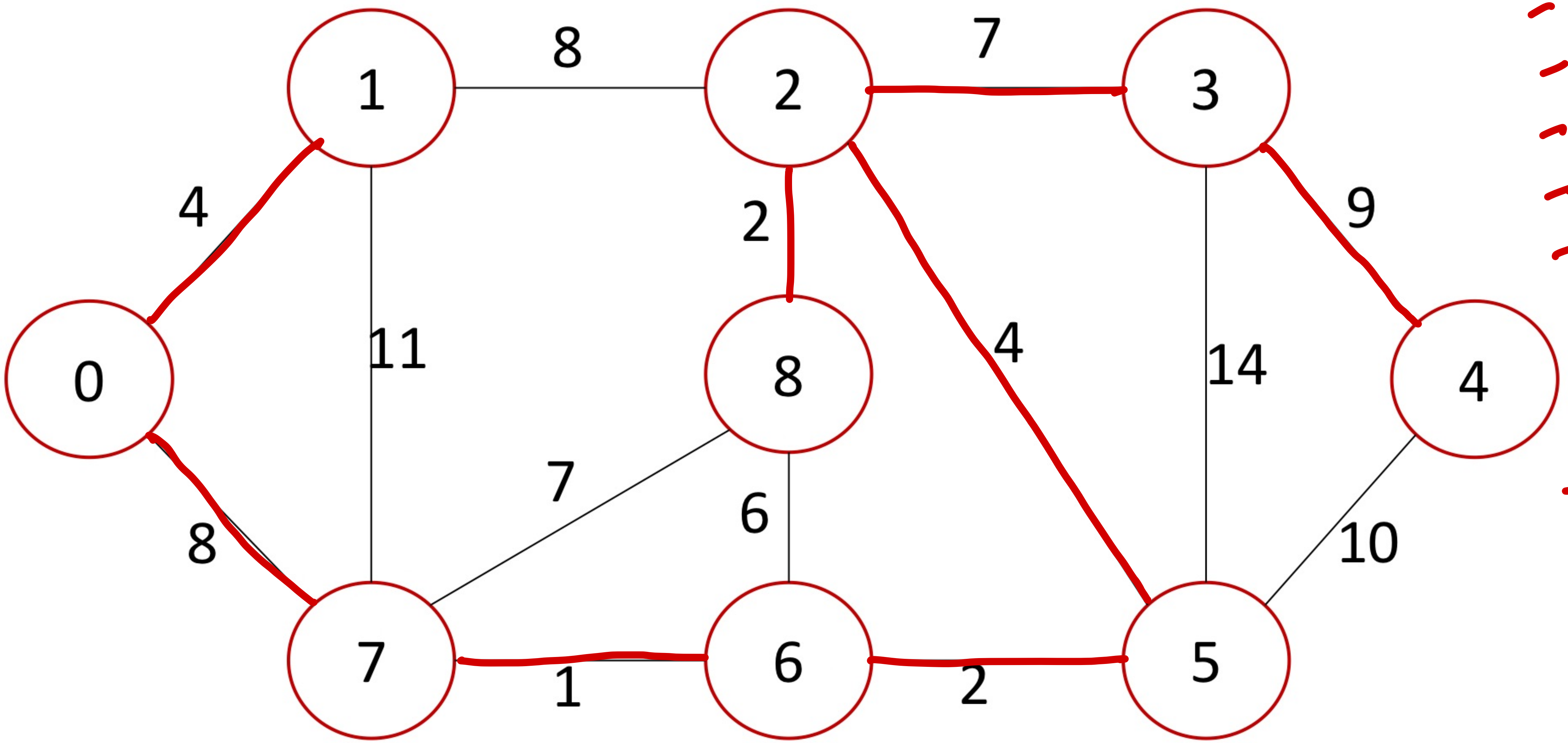
1. Sort all the edges in ascending order of their weight.
2. Pick the smallest edge. Check if it forms a cycle with the spanning tree formed so far. If cycle is not formed, include this edge. Else, discard it.
3. Repeat step 2 until there are (V-1) edges in the spanning tree.

union-find algo

- Time complexity
  - Sort edges: O(E log E)
  - Pick edges (E edges): O(E)
  - Union Find: O(log V)
- Time complexity
  - O(E log E + E log V)
  - E can max V^2.
  - So max time complexity: O(E log V).

Kruskal's MST – Analysis

9 vertices
14 edges

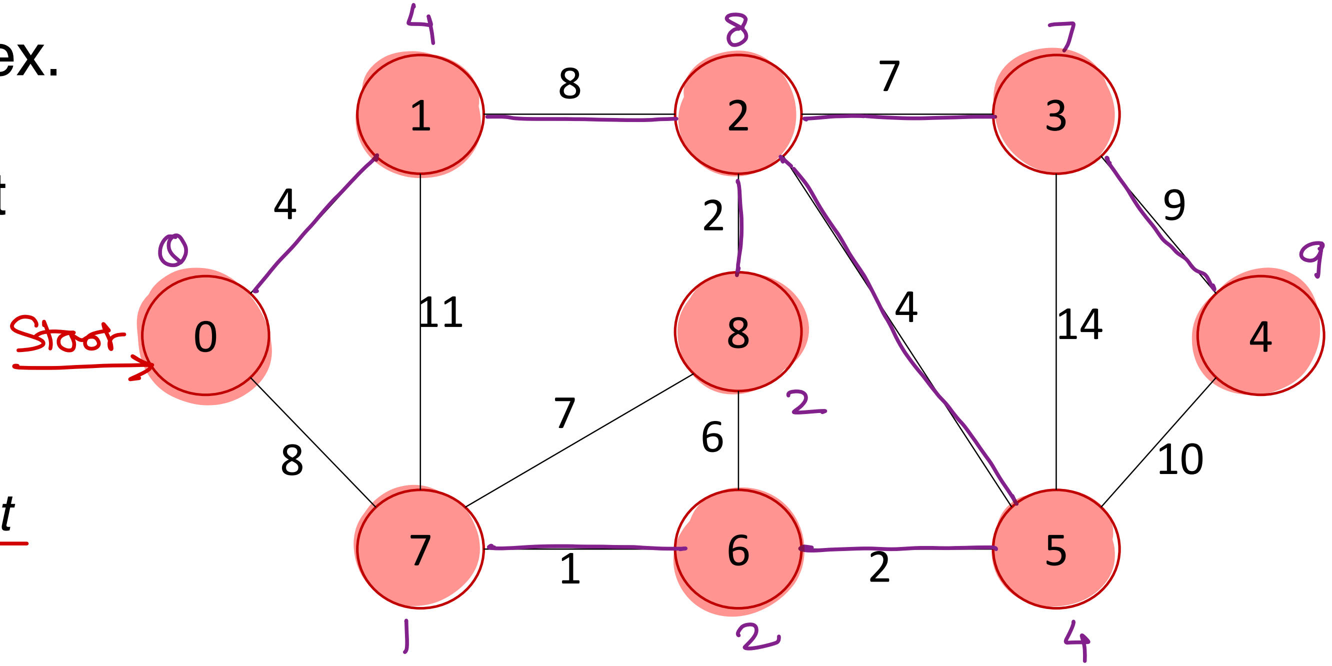


s	d	w
6	7	1
2	8	2
5	6	2
0	1	4
2	5	4
6	8	6
2	3	7
7	8	7
0	7	8
1	2	8
3	4	9
4	5	10
1	7	11
3	5	14

V).

Prim's MST

1. Create a set *mst* to keep track of vertices included in MST.
2. Also keep track of parent of each vertex. Initialize parent of each vertex -1.
3. Assign a key to all vertices in the input graph. Key for all vertices should be initialized to INF. The start vertex key should be 0.
4. While *mst* doesn't include all vertices
   i. Pick a vertex u which is not there in *mst* and has minimum key.
   ii. Include vertex u to *mst*.
   iii. Update key and parent of all adjacent vertices of u.
      a. For each adjacent vertex v, if weight of edge u-v is less than the current key of v, then update the key as weight of u-v.
      b. Record u as parent of v.



Thank you!

Nilesh Ghule <nilesh@sunbeaminfo.com>