Shortest Path Algorithm for Unweighted Graphs using BFS

* Description
  + Unweighted graph is a special case of the weighted shortest-path problem, with all edges a weight of 1
  + Shortest path using BFS only works for unweighted graphs
* Required data
  + A distance table with three columns (each row corresponds to a vertex)
    - Vertex
    - Previous vertex
    - Distance from the source vertex
  + Queue: (to, from, distance)
    - Vertex we came from (from)
    - Vertex we reached (to)
    - Total cost of the path to the vertex (distance)
* Algorithm
  + Create the distance table with all the vertices
    - Initialize the distance of the source to 0
    - Initialize the distance of all the other vertices to -1
    - Code: distanceTable = {vertex:(None, 0 if vertex == source else -1) for vertex in graph}
    - Initial State 
      Path and Cost Arrays 
      Queue 
      From 
      To 
      Cost 
  + Add all the neighboring vertices of the source vertex to the queue
    - Queue format: (from = source, to = source.neighbors, distance = 1)
    - Adding the source node to the queue: queue.append((from=None, to=source, distance=-1))
    - Queue 
      A 
      From 
      To 
      Cost 
      A 
      1 
      A 
  + While queue is not empty
    - Current = queue.pop() which will give (from, to, distance)
    - If that vertex we reached is not in the distance table which is if the distance is == -1:
      * distance+1
      * Update the distance table with the vertex we reached
      * For each neighbor of that vertex AND they are not in the distance table:
        + Add the neighbor with distance+1 to the queue
  + To get the path from A to B
    - Find B in distance table
      * If the previous vertex is empty, then there is no path from A to B
      * If it has a previous vertex, go to that vertex
    - Repeat the process until the path is A
    - Now we have a path from B to A, just reverse to get the path from A to B
* Big O Analysis
  + Running time: (|E|+ IVI), if adjacency lists are used. In for loop, we are checking the outgoing edges for a given vertex and the sum of all examined edges in the while loop is equal to the number of edges which gives O(IEI).
  + If we use matrix representation the complexity is O(|V|^2), because we need to read an entire row in the matrix of length IVI in order to find the adjacent vertices for a given vertex.
* Problems/Issues
  + BFS to find the shortest path cannot be used in weighted graphs because it does not guarantee to find the shortest path
  + Therefore, we need to use Dijkstra’s Algorithm which is used for finding the shortest path in weighted graphs
* Resources
  + <https://www.youtube.com/watch?v=T_m27bhVQQQ>
  + Data Structure and Algorithmic Thinking with Python (Pg 258)