Solution Summary

Approach:

The assignment involves finding the best connections between any two stations from the directed graph utilizing different cost functions such as stops, travel time, price and arrival time. In the directed graph, nodes represent different stations and edges in the graph are represented by various cost functions such as no. of stops, total time travel, price and arrival time. This assignment is solved in python utilizing various libraries such as pandas and NetworkX. Pandas' library is used for handling csv files whereas Networkx library is used for handling graph data structures and efficient graphs algorithms.

Key Insights

1. **Graph Representation**:
    - **Nodes and Edges**: In the graph, nodes stand for various stations, while edges indicate numerous cost functions, including the number of stops (islno_weight), total travel duration (time_weight), price (price_weight), and arrival time.
2. **Search Algorithm Selection**:
    - *A* Algorithm*: For some cost function that is related to time-constrained A* algorithm is found more suitable to work.
    - *Dijkstra Algorithm:* For the cost function stops, total time travel, price Dijkstra algorithm is used.
3. **Heuristic Selection**:
    - **Manhattan Distance**: The heuristic chosen for A* is simple and effective in calculating the shortest path in grid-like situations. Given the premise that stations are distributed uniformly over the network, this approach worked well to most of the problems but not all of them. I also tried Euclidian distance to calculate heuristic however it does not seem to work to most of the problem.
4. **Problems encountered and their solutions**:
    - **Problems**:
        1. While implementing this algorithm we found that it was not able to find the optimal path for the graph with nodes having arrival time or time-constrained graphs.
        2. High computational complexity with large graphs
        3. Selecting accurate heuristic for the cost function was very complex.

    - **Solutions:**
        1. To solve this problem, considered different algorithms, that is A* algorithm to find the optimal path. Since we require heuristic to compute path using this algorithm, we still needed to compute heuristic using Manhattan Distance. This solved most of the problems but a few of the problems still could not be solved using this algorithm.
        2. Different traversal techniques were utilized to manage complexity.

Conclusion

It successfully reconstructs the path and the total cost associated with forwarding packets from the source to the destination. This topic is addressed by using a variety of graph methods and search algorithms. Although the main issues were treated as how to optimize for performance and accuracy during the development of a solution, there are still some challenges we faced that simply had no perfect answer. So, most of the problems can be solved using these techniques and methodology; however, alternative ways may yield more precise solutions.