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Solving MTSP (Geocode) for E-commerce Delivery using K-Medoids and Dynamic Programming

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Abstract:- With the increased demand for speedy and same-day deliveries, various e-commerce businesses are looking into new ways to move items in a cost-effective, time-efficient, and sustainable manner. This can be achieved by having a robust execution of delivery. Considering the difference in journey, time, cost factors and number of salespersons the recommended system delivers the best solution in terms of three criteria: cost, time, and sustainability. So, the goal is to reduce the overall distance travelled by all salesperson. Our designed Application will take locations, number of salespersons & vehicle and showcase the optimized sequence of locations. This will save not only Time but Money and Fuel too, which is a win-win situation for both customers and logistics organization. The application was much more needed for since it will be saving the valuable resources of environment.

Keywords:- *MTSP, TSP, K-Medoid, Dynamic Programming, Graph Partitioning, Geocode.*

I. INTRODUCTION

There has been a huge increase in orders placed in recent years, particularly in online shopping. Fast or same-day delivery is a major concern for merchants; according to a survey, the majority of customers will not shop at a store or online shopping site that does not offer this service. According to another study, the majority of customers would be ready to pay more for same-day or faster delivery.

There are both advantages and obstacles for businesses that use the notion of SDD (Same-day delivery). The increased production level in the organization is one of the primary advantages. The organization's productivity is expected to expand significantly as a result of increased supply turnover. As the demand for speedy delivery methods grows, so will the shipping prices to deliver buyers' orders. Consider that delivery expenditures accounted for $28 billion (12 percent) of Amazon's overall earnings in 2018. With the rise in online orders, businesses are under pressure to provide customers with prompt and dependable product delivery.

Aside from huge, traditional stores that offer a wide range of quick delivery services, non-traditional courier organizations also strive to offer quick delivery services. For example, Insta cart, Incoperates without a warehouse or permanent shippers, instead relying on freelancers to deliver things ordered from stores to its clients. From a technical standpoint, most e-commerce delivery services are plagued by the Multiple Traveling Salesperson Problem (MTSP). These organizations with multiple delivery agents must deliver to multiple locations, so it's crucial to discover the best optimal path so that all of these agents may deliver products at the lowest possible cost.

Traditional modes of transportation, such as trucks, have a large vehicle capacity yet deliver products very slowly owing to traffic. As a result, many organizations and businesses have begun to adopt new technology and different modes of transportation in order to meet urgent delivery commitments. For example, because of its appealing delivery network, Amazon Inc. can now give same-day or next-day delivery to the majority of the US population, which has been at its pinnacle for the previous four years. Amazon has debuted PrimeAir, which uses an airborne aircraft to deliver packages weighing less than five pounds in thirty minutes or less. We support a solution for courier delivery service firms that delivers the merchandise promptly in this process.

II. LITERATURE REVIEW

- Mohammad Sedighpoura, Majid Youse fikhoshbakhtb, Narges Mahmoodi Darani "An Effective Genetic Algorithm for Solving the Multiple Traveling Salesman Problem", here They used GA2OPT, a modified hybrid metaheuristic algorithm, to solve the MTSP problem.
- Prof Ratna Nayak, Vedank Vekhande, Bhavya Sheth, Rohan Dhumal2, Prashant Patra2 "Product Delivery Optimization", In this paper product delivery is solved using Dijkstra's algorithm. However, they are not concerned multiple salesmen & vehicle type.
- Suchithra Rajendran, Aidan Harper, "Simulation-based algorithm for identifying best package delivery alternatives under three criteria: Time, cost and sustainability". It is important to consider mode of transport, this paper speaks about time, cost by considering the mode of transport which can be implemented to improve speed of product delivery.
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III. CURRENT SYSTEM

Most e-commerce organizations rely on traditional text address format which is tedious for delivery agents to search for the correct location. Google has already started implementing Plus Codes in their maps which can faster the delivery rate if MTSP is solved using Geo Coordinates or Plus Codes.

Most of the Applications software and API are obtainable on the Internet for Planning and Managing the Routes commercially. There are currently no API's that deal with the MTSP problem. When you only have a few deliveries to make, Google Maps is ideal. It's completely free, quick, reliable, and simple to use. When using Google Maps as a route planner, we don't need to look any farther than Google's comprehensive tutorial. However, when it comes to planning transportation routes, there are some limits.

- The routes need to be 10 stops or less
- We can only plan for one driver not more than one at a time
- We need to manually decide a structured order for your stops

IV. PROPOSED METHOD

MTSP can be used for effective and efficient delivery of products for e-commerce and other delivery containing multiple delivery agents from one source to multiple destination whose Geographic Coordinates or Plus Codes (Open Location Code) are known.

A. Working

The proposed method is divided into 2 categories, namely graph partitioning and finding the best optimized path for each partitioned graph, here we are implementing "K-Medoids Algorithm" for finding the clusters and partitioning them and creating k new graphs which starts from the same source or same node and "Dynamic Programming" for finding the optimized travelling salesperson path for each of the partitioned graph.

B. Graph Partitioning

Every place has its own geographic coordinates or plus code; hence, every address can be mapped to a unique geographic coordinate. It is possible to find the geographic coordinates of the plus code as well. To find the clusters and partition them K-Medoids algorithm is used. Firstly, the value of k is assigned, where k is the number of clusters required or number of delivery agents. Select k random geographic coordinates of the given places called medoids. For each medoid find the Manhattan Distance for each of the geographic coordinate (place).

Manhattan Distance = $|x1 - x2| + |y1 - y2|$

For each point select the smallest Manhattan Distance of the out of all the k medoid. The smallest value belongs to that particular medoid cluster. For k medoids, form k general clusters.

Find the total cost of the k clusters combined, which is the sum of the Manhattan Distance between the point and the medoid from which the cluster is defined. Experiment with taking other medoids into consideration as well. If the cost is lower than the current existing cost then take these new clusters into consideration for the partition.

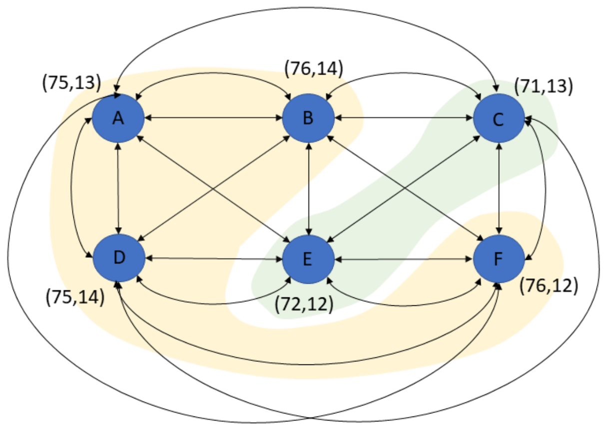

Fig. 4.1: Geo-Coordinates graph with clusters to be used for partitioning.

C. Dynamic Programming Approach for TSP

For the k clusters formed in the previous stage by using the K-Medoids algorithm, form k different graphs by making sure that the source is same for all the k graphs, consider the source to be the warehouse where all the products to be delivered are collected and the products which needs to returned back to the seller.

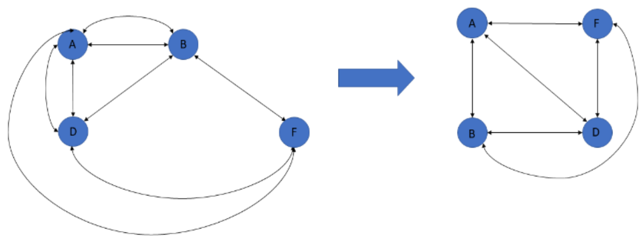

Fig. 4.2: Cluster-1 Partition with source A

Fig. 4.3: Cluster-2 Partition with source A

By using this algorithm, we can find the best and optimal path for delivering the products. The time complexity of the Dynamic Programming is $O(N^2 * 2^N)$ which is much better when compared to the Brute-Force method which has the time complexity of *O(N!)*.

V. RESULTS AND DISCUSSION

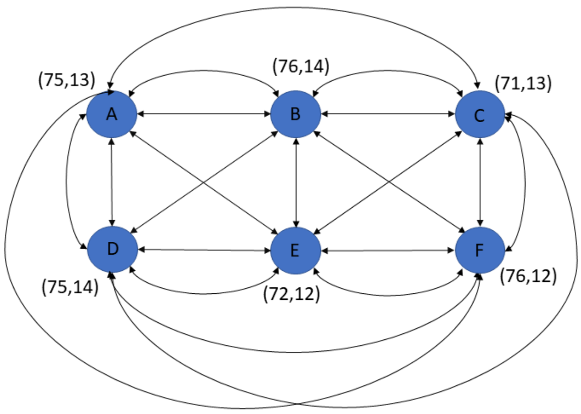

Fig. 5.1: Geo-Coordinate graph

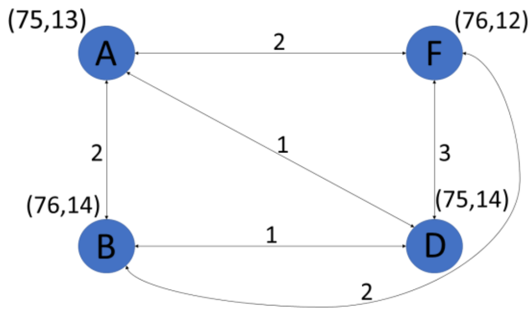

Fig. 5.2: Partition-1 with Geo-coordinates & Manhattan distance.

By applying Dynamic programming to solve TSP to the above graph, the best optimal path possible is A-F-B-D-A

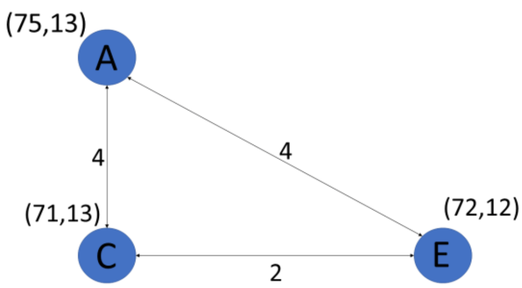

Fig. 5.3: Partition-2 with Geo-coordinates & Manhattan distance.

By applying Dynamic programming to solve TSP to the above graph, the best optimal path possible is A-C-E-A

VI. CONCLUSION

This approach of solving MTSP helps to deal with the real-world problem of e-commerce delivery. The proposed system is effective when the addresses are in the form of geocode data (GCS, OLC), which we believe will be the norm in the future rather than the text address format that is being used currently. The proposed system is done with K-Medoids Algorithm and Dynamic Programming.

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