Analysis of Order Delivery Route using Graph Theory

Indhu Sri Krishnaraj

*MS in Artificial Intelligence*

# 1. Introduction

With the great advancement in technology, e-commerce businesses have seen a tremendous growth in the recent years. People now-a-days tend to shop more on online stores as the system has become very convenient in its process. The businesses in e-commerce industry distribute their products globally to a wide range of customers. The convenience of shopping from anywhere and on any device along with the comfort delivery of products directly to home are some of the flexibilities that have led to the rise of online shopping.

The e-commerce companies offer a wide range of products to its customers. They have warehouses where the products are stored and when an order is received, these products are picked up from the warehouses and shipped to the customers’ addresses. But the process of order pickup from warehouse to delivery to customer has to be optimized [3]. The stores can receive multiple orders and there is a need to pick the optimal route for order delivery in order to save resources and manage to have an optimized delivery. This project aims to analyze the delivery network of a store with finding the best route and sequence of delivery of orders. To study and gain some important insights and solutions to this problem, we analyze the routing network using graph theory concepts.

# 2. Motivation

The most important reason for people doing online shopping is that it is the most convenient way to get any product that may or may not be available in offline stores. It also saves time to shop online rather than going to an offline store and spending time in the queue. In e-commerce stores, multiple customers place multiple orders. There is a need to transport these orders to the customers such that the route of the delivery is optimized [4]. Customers from different cities place orders and for all the orders received, it is important to identify a delivery sequence to deliver all the products efficiently on a large scale basis. The process of analyzing delivery routes requires extensive analysis. This motivates us to apply graph theory and its range of algorithms to solve the problem of delivering products from a warehouse to different locations by travelling the minimum distance. Therefore, our goal is to investigate this issue and find solutions for the order delivery network.

# 3. Objectives

As mentioned above, the objective of this project is to determine the most efficient path for delivering products for a delivery vehicle by analyzing the order delivery network. The following is a list of the project's primary goals:

1. Using visualization on the network of cities for viewing their connectedness.
2. Implementing and evaluating important graph theory concepts such as degree measure, centrality measure of cities, etc.
3. Finding the optimal or the shortest route for deliveries in different cities.
4. To apply additional graph algorithms, like community detection and graph coloring, to the network of cities.

In doing so, we utilize the data to apply some of the most practical graph theory algorithms and offer some insightful findings on the order delivery network and also find the optimal route of delivering products in multiple cities.

# 4. Implementation

To analyze this problem and carry out the project, a dataset is needed. Gathering order delivery data and city network data will be the first step. Certain features in the data we gather might not be relevant to our research. Location of the warehouse, the delivery addresses (cities) of all the orders and the distance between the cities in a network are the features that are essential in this study. In order to extract the data that was gathered and is relevant to our analysis, we look for these features in the data. After the data is processed, we start the implementation process to achieve the mentioned goals. The logical steps that for the implementation process are depicted in Fig. 1.

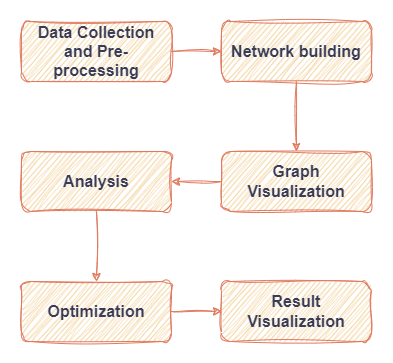


Figure 1: Implementation Design

The initial step of the project is to collect the order data and city network data and then to pre-process the data for further analysis. Subsequently, we create a network out of the data by depicting the cities as nodes and the paths connecting them as edges. The weights of the edges will be represented by the distance between the cities. The network will then be prepared for visualization. The visualization will offer a clear view of every node and the connections or edges between them. The visualization can be carried out using Python Libraries [1]. Next, we perform various analyses on the graph to gain insights into the delivery network. Some possible analyses include degree analysis [4] for identifying the cities where multiple routes originate from, centrality measure [4] for identifying the most important nodes in the network and the most important – finding the shortest path to deliver all the orders. Dijkstra’s Algorithm will find the shortest distance route between a given starting city to the destination city [2]. The Traveling Salesman Problem, which aims to deliver every product at the lowest possible cost and return it to the warehouse, and the Graph Coloring Problem [4], which draws conclusions about the network, are examples of optimization algorithms that we may apply to our network in the following step. Lastly, a visualization of the analysis' findings is possible. Our plan is to use Python programming language to implement the project.

# 5. Evaluation

To evaluate our project, we shall perform testing on how well the proposed routes optimize the delivery. This could involve analyzing certain metrics such as total delivery distance, distance per order, etc. This will also involve comparing the optimized delivery routes against basic delivery routes to check resource utilization before and after optimization.

# 6. Risks

Certain parts of the data are not taken into account. A few features like delivery deadline, vehicle capacity, weight of products and number of vehicles available for delivery are crucial factors for a delivery problem. But these factors are not considered. The only agenda here is to find the optimal or the shortest route to deliver all the orders to the customers by optimizing the distance travelled. This might only be optimal in the case of fuel efficiency.

# References

|  |  |
| --- | --- |
| [1] | A. Hagberg and D. Conway, ‘Networkx: Network analysis with python’, URL: https://networkx. github. io, 2020. |
| [2] | P. S. Rani and S. M. Owais, ‘Application of Graph Theory In Air-Transportation Network’, *Strad Research*, no. 8, p. 9, 2021. |
| [3] | A. D. Handayani, ‘Dijkstra Algorithm in Transportation Systems at Kediri’s Central Post Office’. |
| [4] | A. Majeed and I. Rauf, ‘Graph theory: A comprehensive survey about graph theory applications in computer science and social networks’, *Inventions*, vol. 5, no. 1, p. 10, 2020. |