Indian Institute Of Technology Delhi

OPTIMAL LOCATION POLICY OF DARK STORES FOR QUICK COMMERCE COMPANIES

MCL 865
PROJECT PRESENTATION

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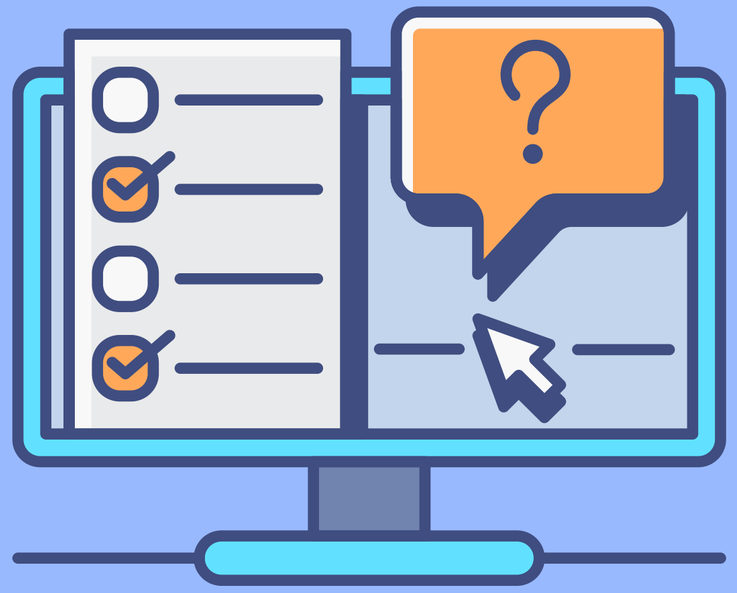

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OVERVIEW

SUPPLY CHAINS FOR QUICK COMMERCE COMPANIES CAN BE VERY TRICKY AND CHALLENGING IN NATURE

- PURCHASING
- CONTRACTS
- PROCUREMENT
- WAREHOUSING
- DELIVERY
- PACKAGING
- TRANSPORTATION
- DEMANDS

ONE OF THE MAIN PROBLEMS IS SETTING UP OF DARK STORES FOR OPTIMUM COVERAGE OF ALL DEMAND POINTS

OPTIMISE THE LOCATION FOR DARK STORES

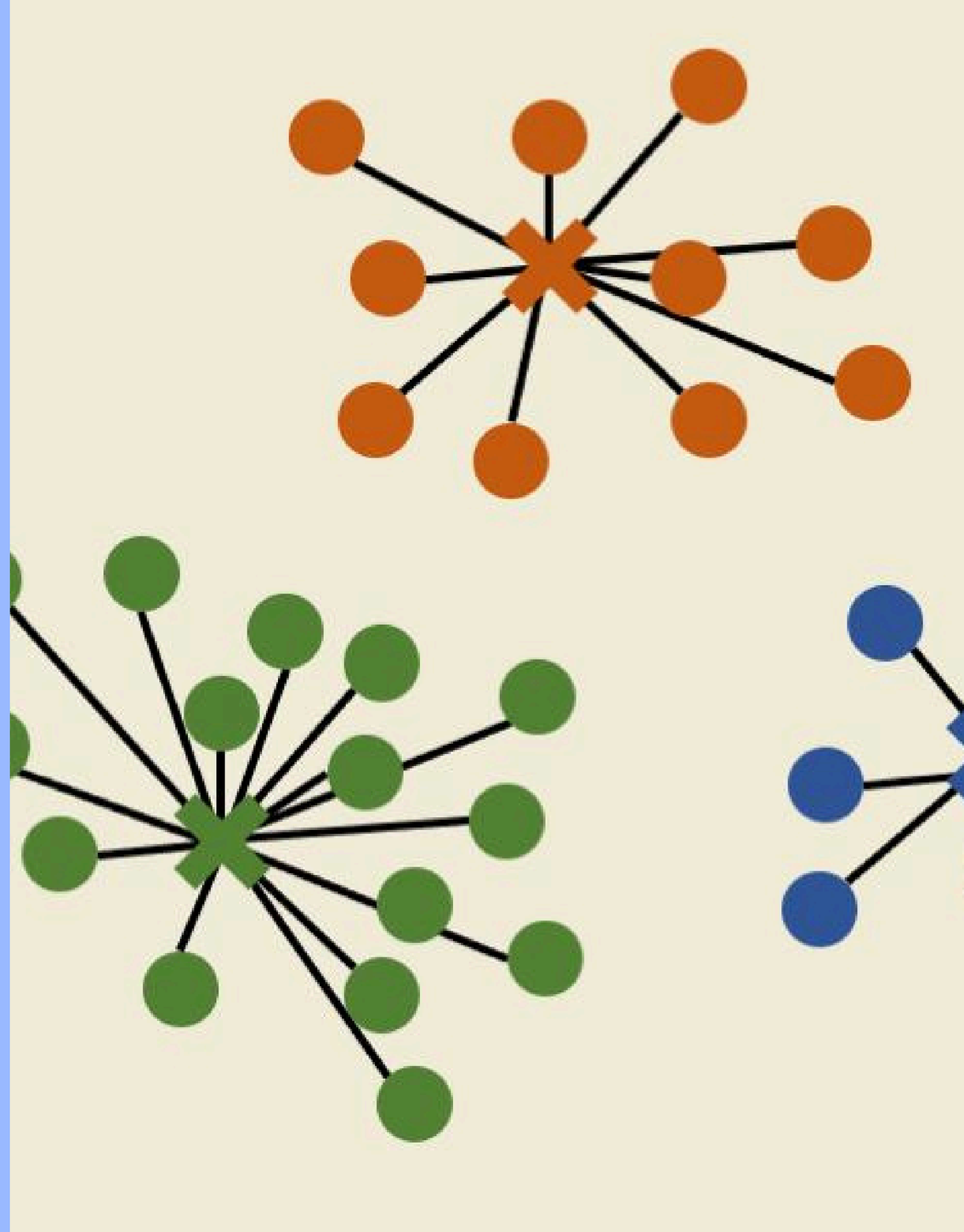
- Fast Delivery
- Strategic Dark Store Placements
- Enhance Satisfaction
- Improve Scalability
- Optimize Resources

- Minimize Cost
- Adaptability
- Efficient Delivery Network
- Maximize Service Levels
- Coverage Of All Demand Points

HOW WE WILL BUILD THE MODEL?

Employing Mixed Integer Linear Programming (MILP), we strategically determine dark store numbers and locations by analyzing demand patterns and operational constraints, tackling the NP-hard clustering problem and offering a versatile solution for optimal distribution networks and generating globally optimal solutions.[1]

Drawing from Nascimento et al.'s[2] insights, originally focused on biological data, we adapt their clustering model for logistics. This adaptation efficiently identifies demand clusters, minimizing intra-cluster distances for optimized warehouse placement. Using centroid identification, we pinpoint optimal dark store locations, ensuring optimal service to each cluster.



TWO PART PROCESS

CLUSTERING ALGORITHM

Minimize intra-cluster distance by forming clusters . Ensure each object is in one cluster, prevent empty clusters, and link variables linearly. Binary variables denote cluster membership and object presence.

Tech used:

PULP Python Framework

NUMPY Performing Calculation

CENTROID PLACEMENT

From the clusters we find a centroid for each one of them which will be at optimum distance from all the nodes

Tech Used:

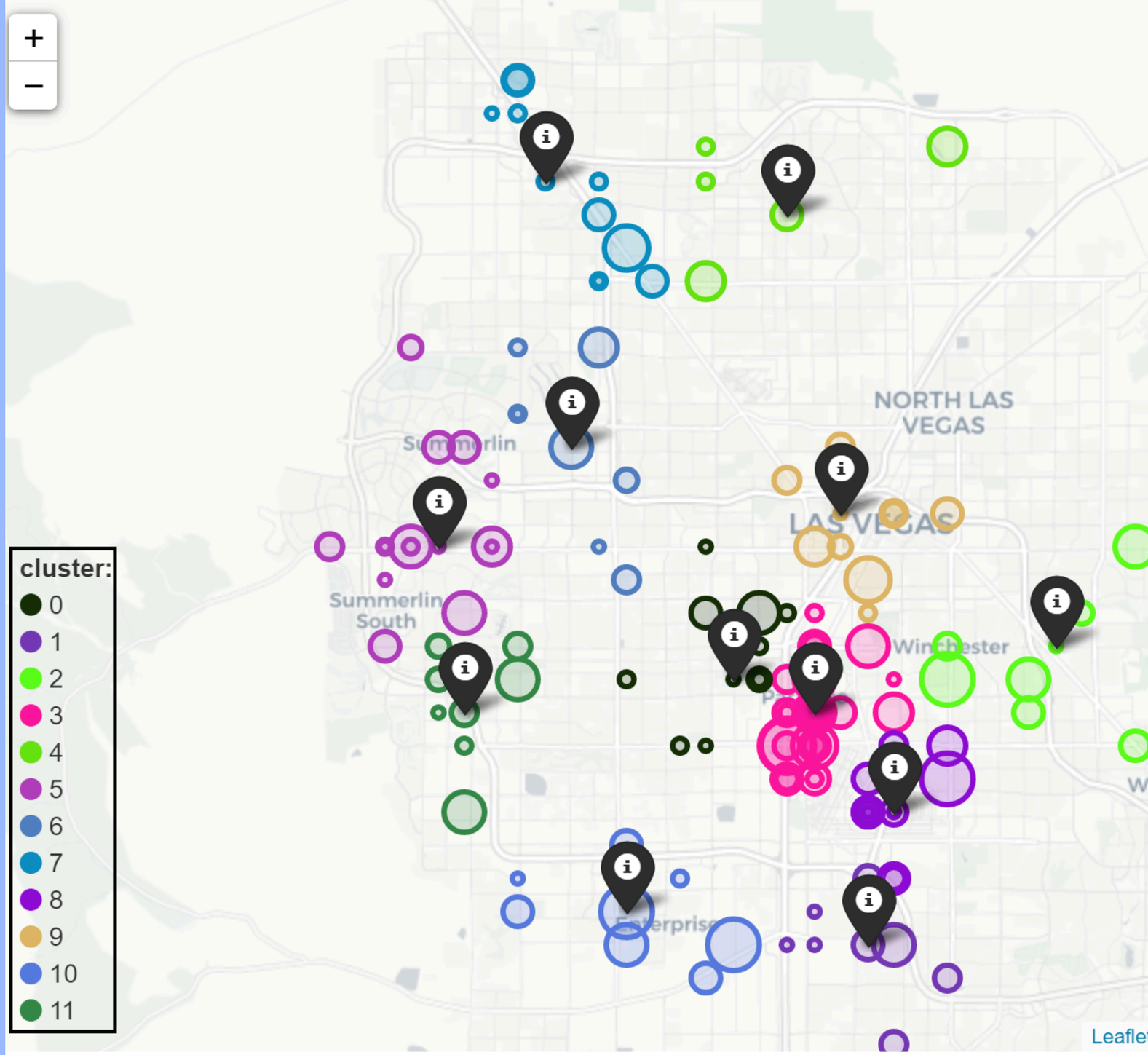
PULP Python Framework

NUMPY Performing Calculation

MATPLOTLIB Graphical Representation

APPLICATIONS

- Warehouse Placement Optimization
- Retail Store Placement
- Healthcare Facility Planning
- City Planning and Infrastructure Development
- Resource Allocation in Disaster Response



MATHEMATICAL FORMULATION

CLUSTERING ALGORITHM

1. The method aims to minimize the total distance within the cluster when a set of data points and the number of clusters is provided.

$$\min \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} d_{ij} y_{ij} \tag{1}$$

subject to

$$\sum_{c=1}^{k} x_{ic} = 1, \qquad \forall i \in V \tag{2}$$

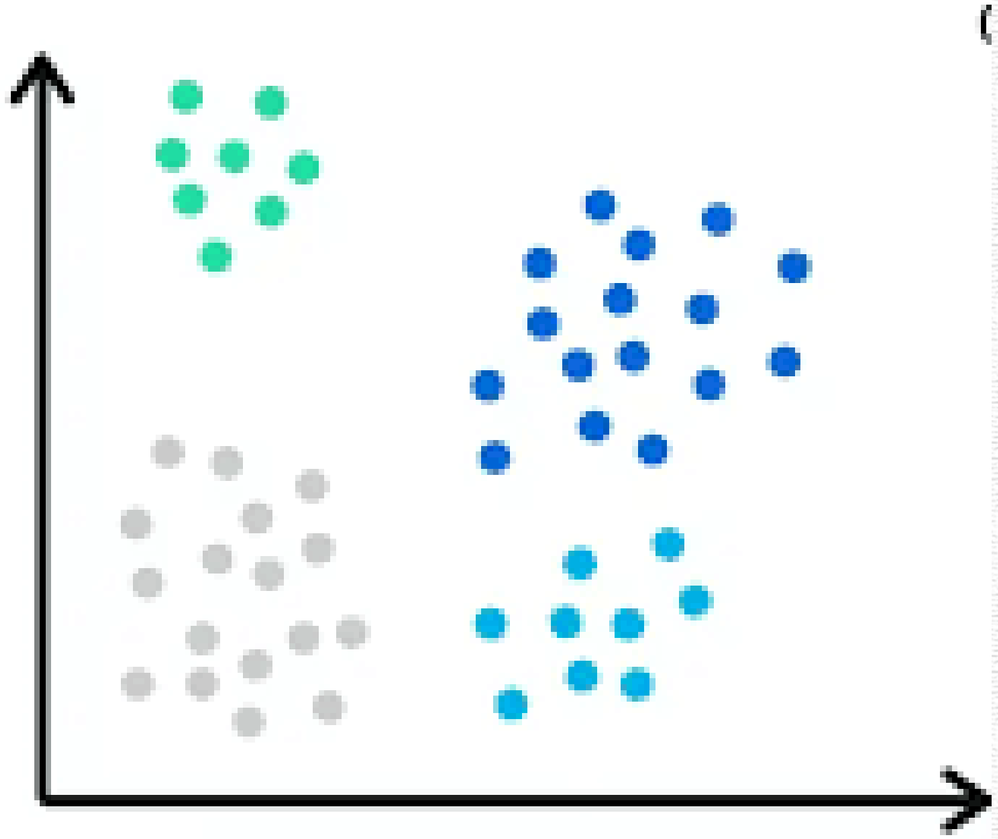
$$\sum_{i=1}^{N} x_{ic} \geq 1, \qquad \forall c \in C \tag{3}$$

$$y_{ij} \geq x_{ic} + x_{jc} - 1, \quad i = 1, \ldots, N-1; j = i+1, \ldots, N; \forall c \in C \tag{4}$$

$$y_{ij} \in \{0, 1\}, \qquad i = 1, \ldots, N-1; j = i+1, \ldots, N \tag{5}$$

$$x_{ic} \in \{0, 1\}, \qquad \forall i \in V, \forall c \in C \tag{6}$$

N is the number of objects to cluster. k is the number of clusters, a user-defined parameter. y_{ij} are binary variables taking value 1 if members i, j are in the same cluster, 0 otherwise. d_{ij} are the distance values between members i, j. The first constraints (2) makes sure that each object is found in exactly one cluster. The second set of constraints avoids empty clusters (3). The third set of constraints (4) is to relate variables to each other in a linear fashion. The last two sets of constraints (5, 6) restrict the domains of variables.



Centroid Placement

2. Since, now we have the nodes divided into the clusters, we can now find the optimal location of the dark stores within each cluster by finding the centroid of all the available points.

Let $(x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)$ be n points in a given cluster.

The coordinates of the centroid $(\bar{x}, \bar{y})$ of these points are calculated as:

$$\bar{x} = \frac{1}{n} \sum_{i=1}^{n} x_i$$

$$\bar{y} = \frac{1}{n} \sum_{i=1}^{n} y_i$$

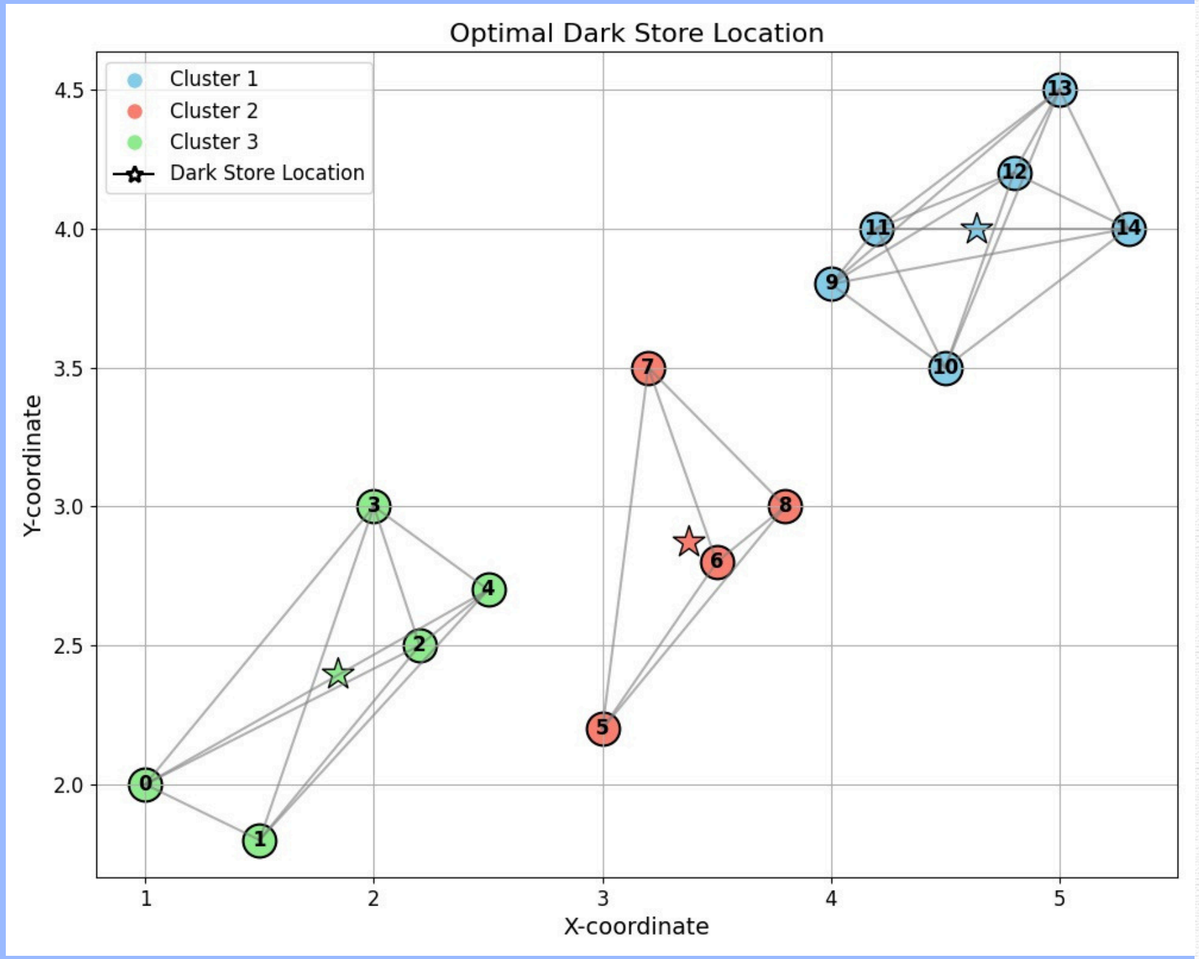
The centroid $(\bar{x}, \bar{y})$ represents the optimal location for a dark store within the cluster, as it minimizes the average distance to all points in that cluster. By integrating cluster formation with centroid calculation, this approach enables the strategic placement of dark stores to efficiently serve customer demand while minimizing operational costs.

Python Code

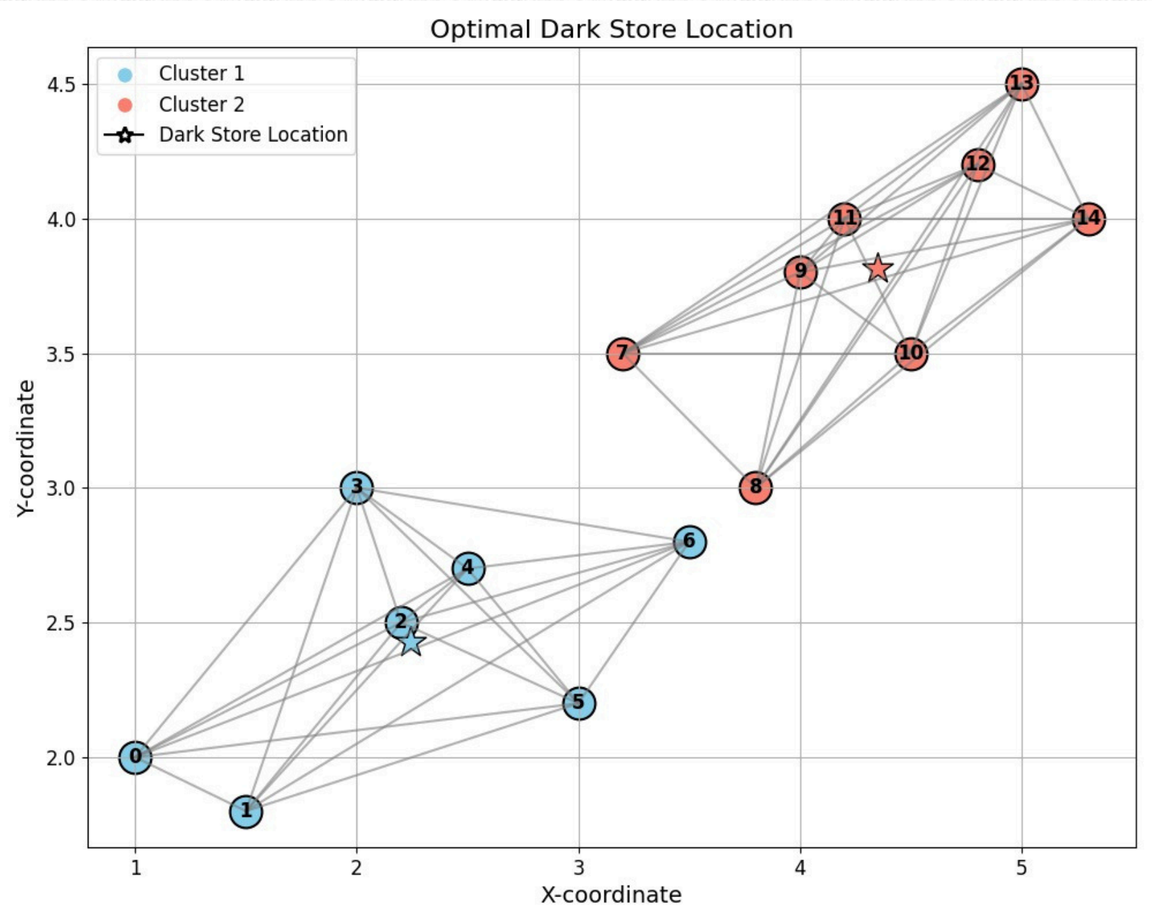
```python

# Compute distances between nodes
d = [[0]*N for _ in range(N)]
for i in range(N):
    for j in range(N):
        dist = np.sqrt((coordi[i][0] - coordi[j][0])**2 + (coordi[i][1] - coordi[j][1])**2)
        d[i][j] = dist

# Define the number of clusters
k = 3

# Initialize decision variables
x = pulp.LpVariable.dicts("x", ((i, j) for i in range(N) for j in range(k)), cat="Binary")
y = pulp.LpVariable.dicts("y", ((i, j) for i in range(N) for j in range(i + 1, N)), cat="Bi

# Define the objective function
prob += sum(d[i][j] * y[i, j] for i in range(N) for j in range(i + 1, N))

# Define constraints
for i in range(N):
    prob += sum(x[i, j] for j in range(k)) == 1

for c in range(k):
    prob += sum(x[i, c] for i in range(N)) >= 1

for i in range(N - 1):
    for j in range(i + 1, N):
        for c in range(k):
            prob += y[i, j] >= x[i, c] + x[j, c] - 1

# Solve the problem
prob.solve()
```

RESULTS

Using the before mentioned python code some results of data points with k clusters and centroid where the warehouse can be located.

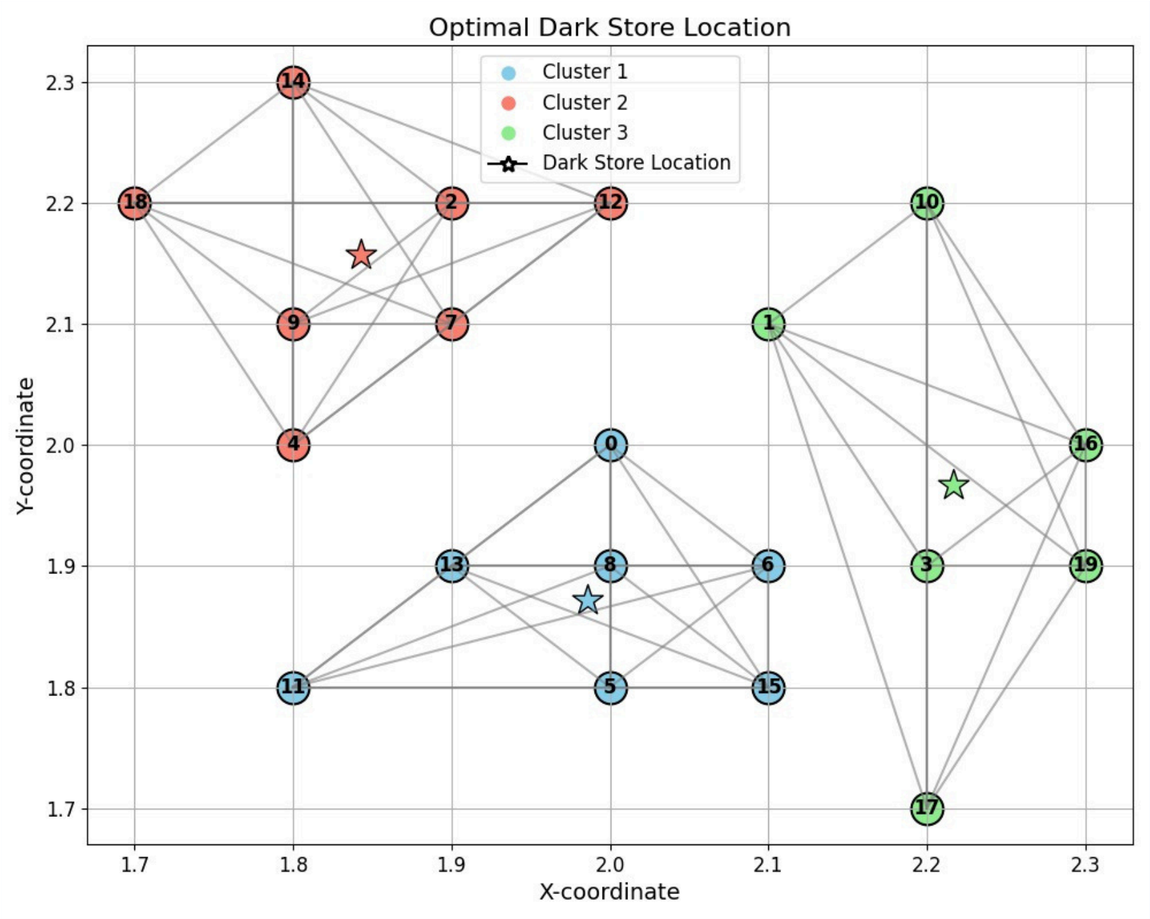


15 NODES
3 CLUSTERS

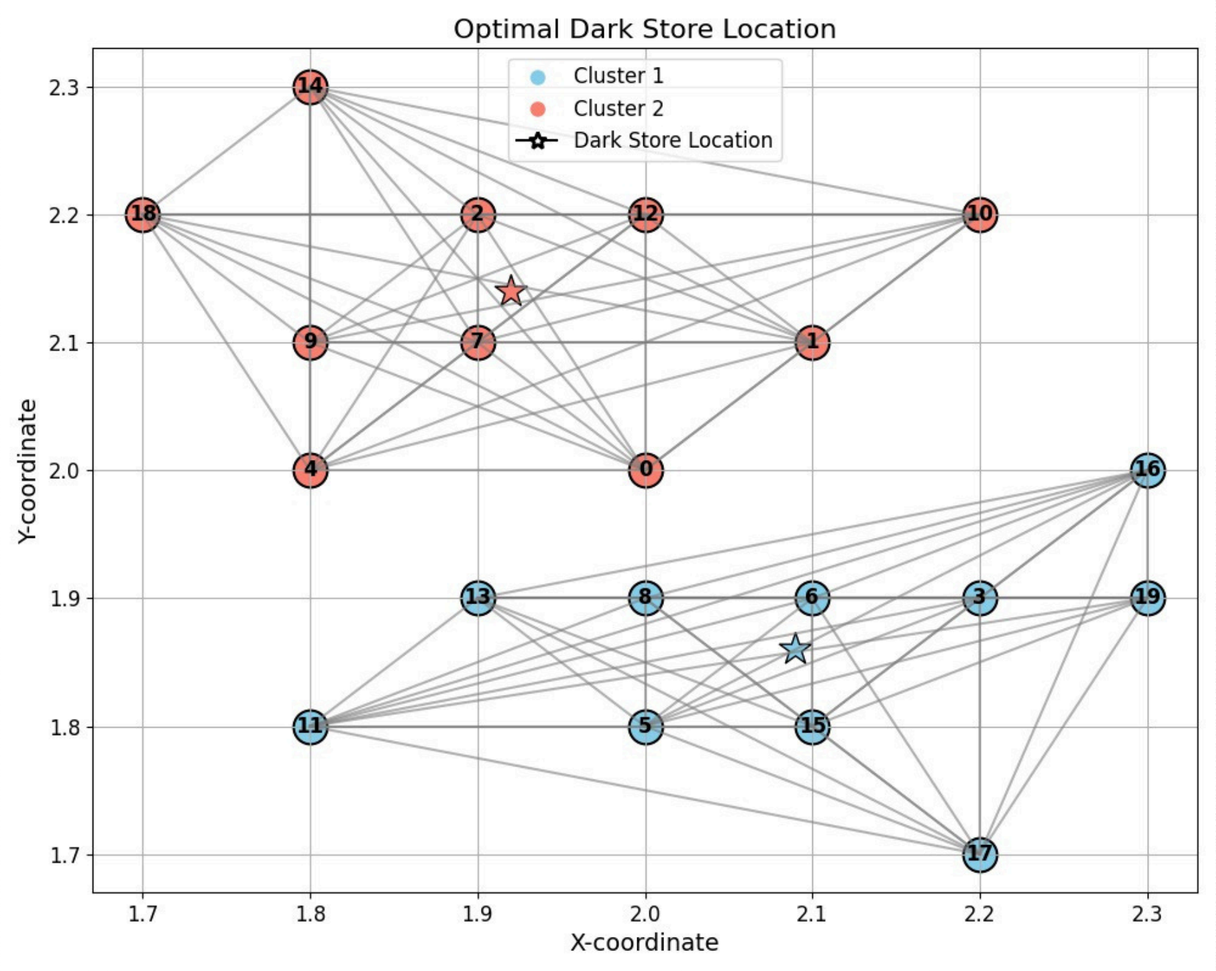


15 NODES
2 CLUSTERS

20 NODES
3 CLUSTERS



20 NODES
2 CLUSTERS



CONCLUSION

Our study aimed to optimize dark store locations for quick commerce by employing a combined approach of cluster formation using Mixed Integer Linear Programming (MILP) and centroid calculation.

Key findings and contributions include:

- **Optimal Cluster Formation**: Successful clustering of demand points for efecient resource allocation and operational planning.
- **Ecient Dark Store Placement**: Centroid-based placement of dark stores minimizes delivery distances and operational costs.
- **Operational Eficiency**: Strategic dark store placement reduces delivery times, enhancing overall supply chain eciency

Thank You