The application of graph theory for the networking of rural agriculture products marketing

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This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering

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APPROVAL

This Project titled "**The application of graph theory for the networking of rural agriculture products marketing**", submitted by Md. Shahed Hossen ID No:181-15-11221 and Ezzatun Nesa ID No:181-15-1967 to the Department of Computer Science and Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on 02 January 2022

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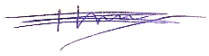

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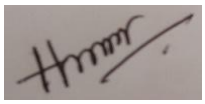

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We hereby declare that, this project has been done by us under the supervision of **Dr. Fizar Ahmed, Assistant Professor, Department of CSE** Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

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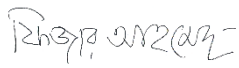

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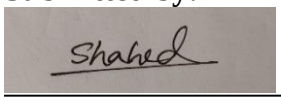

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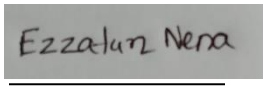

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ABSTRACT

Graph theory could be a major field of study at the present time. But so far research on graph theory is at an early stage. Graph theory plays a very effective role in creating a network mesh. A groundbreaking success is possible with the use of graph theory in Agriculture. In addition to marketing networks, it is possible to do some new research with graph theory, including fraud detection, recommendation system, among others. Large organizations like Facebook have built network networks among their customers using graph theory. They considered a graph whose vertices represent a collection of friends. And one edge is Facebook friends who will connect each of them. And graph theory plays a very effective role in creating such a network. In this paper, we have created a marketing network for marketing a rural agricultural product using graph theory. To build this network we apply various models and algorithms of graph theory of which the BFS algorithm was one of them. We use Python's networkx library to show you through this network visualization.

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CHAPTER-1

Introduction

1.1 Introduction

Graph theory is one of the largest fields of Discrete mathematics and it can be considered as a part of the branch coordination of mathematics. A graph is the sum of any vertex and vertices and the sum of the edges or lines that establish the relationship between different vertexes. Graphs can be used to model a Variegating of situations, such as football tournaments, social networks, and the Internet.

Graph theory can also be used in computer science research such as data mining, image capturing, image segmentation, networking, clustering, etc. Graphs can be used to efficiently plan routes for mail delivery, diagnose computer network errors, and plan to create a LAN using network topology [2]. The puzzle of bilateral institutions using the language of graph theory and the search for job seekers and employers was also a field of scientific research [17]. However, the report only deals with the creation of product marketing networks.

Graph theory can play an effective role in marketing business and agriculture development. Graph theory also plays an important role in creating a business model for the progress of a business, and in selecting a business area. According to graph theory, each point is called a vertex, and the line connecting one vertex to another is called an edge. Suppose, Figure:1 is a simple graph. Here we can see in the graph G consists of a no empty finite set. V(G) of segments called vertices (nodes) and a finite set E(G) of distinct unordered pairs of distinct elements of V(G) called edge. A graph is a join G = (V, E) of sets of fulfilment $E \subseteq [v]^2$; We will always take $V \cap E = \emptyset$ to avoid the ambiguity of notation. The Elements of v are the vertices or nodes of the graph. The elements of E are the edge. Here, the graph on V = {D, A, B, E, C} and E = {{D, A}, {D, E}, {D, C}, {E, C}, {A, E}, {A, B}, {B, E}}

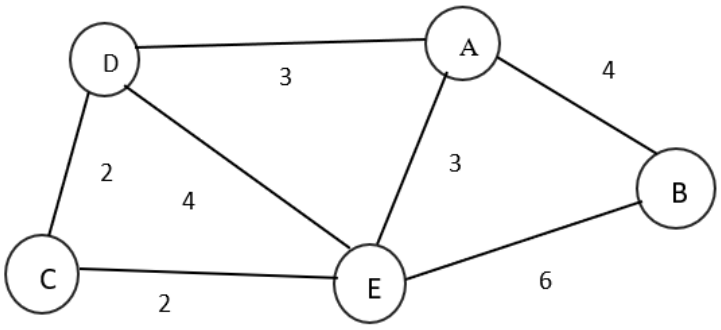

Figure: 1.1.1: Example of graph

Ensuring the success of the company by making reasonable decisions through constantly changing positions, setting responsible people in the management process. The decisions of the Board of Directors must be impartial and reasonable and the decision to be taken must be optimal. Graphs and networks are like a tool for decision support where graphical models reflect the structure of the decision problem, to apply and obtain specific mathematical solutions to specific rules. The theory of graphs and networks based on the field of knowledge is an important part of operation search [1].

The organization needs to increase the technological competitiveness of the use of information systems based on the graphs theory. Information plays an important role. It offers many benefits: to increase sales, increase production and shorten delivery times. Transformation of material products. Logistics systems in agribusiness are defined as systems that participate in the time-spatial transformation of material products, while the processes that take place in those objects are logistic. Logistical processes combine both the flow of the saturated material and the information of their users from the producer of productions, to process the waste in the result. The logistical process should be understood as an orderly chain of all activities involving the spacious movement of different elements [3].

Graph theory is at a very early stage of research, we think there is still a lot of research to be done on graph theory. Using this graph theory, we are trying to create a business marketing model and do business network analysis. We are trying to get our desired result based on this graph theory.

1.2 Motivation

In this present world, the importance of technology in the agricultural sector is enormous. During a pandemic, we have noticed technology is really important for agriculture. The marketing and circulation of agricultural products are done by networking. Through networking, we can collect a huge amount of data and information. And the implementation of that information can be done through graph theory. Such that we get our desired product very fast and know the details about it. Using networking we can take information from customers, buyers and farmers. This information is furthermore shared between them, which helps the farmers much to get their desired customer as well as help themselves to become successful.

1.3 Rationale of the study

The farmers of our country are really deprived of getting the actual price of their products. Thus, we want that the products are sold at optimum price. Using graph theory, we can create a data frame accurately. The mathematical implementation of graph theory is really helpful, comparable, and widely accepted. Network theory is a logical and realistic field. Using this we can get the actual result. Thus, it helps widely in the determination of actual agricultural products. Father more networking helps to create a connection between farmers and retailers.

1.4 Research Questions

- What is Graph Theory?
- How to use graph theory in computer science?
- How Graph Theory is used to create networks?
- What is the objective of your research?
- How did you create your dataset for research?
- How effective do you think graph theory is in building a network of agribusinesses?

1.5 Expected Output

There is a lot of good research going on in the world today related to data science, machine learning, and IoT. From business to agriculture, there is a wide range of machine learning in research. However, Graph Theory is still in its infancy in research work, but with the increasing scope of research on Graph Theory, it is possible to invent new things. We are trying to build a business marketing network in this study. We tried to connect a consumer directly with a farmer through a network. Several algorithms are used in this case, which will help to determine the sorted path between a farmer and a consumer. The main goal of our research is to create a network through graph theory, which will help us in the field of agricultural product marketing.

1.6 Research Objective

Our main goal is to create a network with Graph Theory that will help us in marketing our rural agricultural products, and the benefits of creating this network for rural agribusinesses are given below:

- ✓ The creation of this network will create a consumer's connectivity directly with rural farmers.
- ✓ Products can be supplied according to the demand of the product, which will protect the agricultural sector from unscrupulous traders.
- ✓ Connectivity of one farmer with another will be created.
- ✓ Rural farmers can be protected from the shadow of unscrupulous traders.

Finally, graph theory can play a pivotal role in product marketing in agriculture.

1.7 Report Layout

This report has five chapter in total.

- Chapter 1 discusses in detail about for research. For example, 1.1 Introduction of this research, 1.2 Motivation of our research, 1.3 Rationale of the study, 1.4 Research question, 1.5 Expectation outcome of our research, 1.6 Graph theory research objective, 1.7 Report Layout
- Chapter 2 discusses the Background of research. For example, 2.1 Introduction of this research background, 2.2 Related work in this research, 2.3 Research summery, 2.4 Scope of the problem, 2.5 Challenges of the research
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- Chapter 5 Conclusion and future work in this research. For example, 5.1 Summery of this Study, 5.2 Conclusion, 5.3 Limitation of this research, 5.4 Implication for future study.

CHAPTER 2

Background

2.1 Introduction

Graph theory is one of the main features of mathematical subsections, which is the geometric method of studying objects. It is believed that the founder was the famous mathematician Euler. The application of graph theory to the 19th century reduced interesting problem solving and attracted significant public attention. Starting in the 20th century, when graph theory was formed as an independent mathematical discipline, it was widely used in fields such as cybernetics, physics, supply, programming, biology, electronics, transportation, and communication systems. Leonard Euler's article on the problem of the seven bridges of Konigsberg was published in 1736 and is considered to be the first publication in the history of graph theory. This article and another article on Vander Mond's Knight's travel problems are researched and analyzed in the way Leibniz showed. Euler provided formulas on the number of faces of Edge, Vertex, and convex polyhedrons, and Koshy and Lhuillier gave general descriptions of the formulas by researching them. This is how topology is born.

At present, the use of graph theory has begun in research work around the world. Basically, Graph theory is more popular for network building. The study of graph theory is still in its infancy, with no very good quality research on it yet. The spread of graph theory is huge, so over time more and more new research on graph theory will begin.

2.2 Related Work

The field of research on graph theory is still in its infancy. Many researchers have already contributed to the study of graph theory through their work.

In this paper used the clustering-based strategy for customer service. In this case, they use Markov-based approach, and they are collected data from various websites for their research. The results of segmentation for various methodologies are also analyzed here for product creation. They are findings of the study have two important practical consequences. To begin, it is possible to link socio-demographic categories of customers with clusters of interests in order to establish and refine a product's target audience. Second, the resulting clusters can be utilized to build new items with cross-sell prospects by segmenting them based on their digital traces [4].

In this paper, the author recommends a system for a B2B business based on the temporary behavior of customers in the purchasing process. Initially, they use temporal graphs, providing clients with up-to-date knowledge of the purchasing process. Then they have developed a Low-rank graph reconstruction framework to determine the pattern of the common graph and find the missing edge. And eventually, they are trying to exploit the relationship between business customers. Also, to increase the effectiveness of the graph edge forecasts and marketing campaign suggestions, take use of the company customers' community ties. Finally, thorough empirical experiments on real-world B2B marketing data sets indicate that the suggested strategy may significantly increase the quality of campaign suggestions for difficult B2B marketing jobs [5].

The capacity of a mutant gene to take over a collection of structured populations is assessed using evolutionary graph theory in this research. The original evolutionary graph theory framework is employed here. The fixation probability is used in the computation. Fixation probability has taken over a population and is mostly concerned with game-theoretic applications. Data is gathered from social media and real-life instances in this study. The data working structure is shaped like a tree in this case. The paper's constraint is that we can't operate on several variables at once; instead, we need to concentrate on a single variable. The goal of EGT in this case is to allow us to work with a large amount of data. EGT may also be used to assess the quality and amount of product data [6].

The descriptive and comparative methodologies were employed in the study paper. The application of network theory to the subject of logistics is linked to organizations attempting to improve supply, manufacturing, and distribution, as well as the consequences of cross-company cooperation. By using graphical theory new entrepreneur can take an idea about the crisis he may face and get the solutions of these problems using mathematical terms and visualize by graphical representation. Authors' research, computations, and literature publications were used to gather information and data. The research's drawback is that it shows the variability of the organization's systems, as well as the difficulty of obtaining easy solution information for a stakeholder [1].

In this paper, the author focuses on finding the most influential members (node) of a social network, and they think that their research provides a better solution to find Top-K nodes with graph theory. Will solve their proposed methods: Finding the centrality based on several connections is solved using our technique, Determine the smallest number of nodes required to traverse the largest network, Calculate the maximum number of nodes required to cover a percentage of the region. Later, Kemp Kleinberg and Tardo offered a verifiable approximation guarantee for the algorithm by using the same problem. In this case, the greedy approximation theorem was applied. Solve both the top-k node and the – coverage at this point. Had presented a SPIN algorithm to provide a time and calculation speed efficient technique. In this case, the Coverage Diffusion method is applied [7].

In this research, marketing communication has been explained. Informal communication and formal communication are used in this research. Here word of mouth is used occurrence is used. Before we can generalize about the length of pathways, opinion leaders, search behavior, and other characteristics of referral network architectures, they must analyze a range of referral network forms. The validity of the weak-tie theory is also debatable because the available data only revealed one bridge between the subgroups. The tests of the strong-tie hypotheses, on the other hand, were based on intuitively logical reasoning and appear to be generally no there's reason to believe they're unique to the marketer in question. The research explains the referral process and methods. This research has the potential to be fruitful. Network analysis is tough and time-consuming, but the effort and money spent on it may pay off handsomely. The issue is that the referral process necessitates a large network and interaction [8].

This framework is made up of a conceptual framework that includes a risk mitigation environment variable. Interdependencies exist as well. The matrix technique and graph theory are employed. A single numerical index is used to quantify the risk mitigation environment. This approach allows for the addition of new factors that may have a larger influence. In this paper, the author has used the Delphi method to make predictions. And the Structural Equation Modelling (SEM) model has been used in this paper for the need to assign a priority to the inter-variable relationship by analyzing the data. A single numerical indicator is used to quantify and illustrate the risk mitigation environment. Using Delphi, AHP, ANP, SEM, or fuzzy logic, it is impossible to quantify inheritances and interactions. This paper's disadvantage is that manually processing such a large matrix is difficult [9].

The author of this work creates a demonstration based on the graph hypothesis to test the consistency of a money management system. The demonstration focuses on modifying the financial management framework, predicting future financial management systems, and determining techniques to obtain a solid financial management framework. Simultaneously, several scholarly recommendations are given to improve the financial management system. To keep a data table, the author employed a Directed graph. Under the circumstance that one element changes, the inventor examined exact solidity. The inventor will research multi-element impulse in the future. In this method, the author created a more realistic system [10].

They explore the fundamental data needs in this study and show numerous network measurements and theories using a large business-to-business communication network. A clustering technique for relational data with applications in social network analysis and multidimensional scaling comparison. The marketing research we looked at revealed the drawbacks of a purely structural approach. Characteristics of the characters, connections, and the circumstance should all be taken into account to guarantee a thorough inquiry.

Matrix analysis of group structure method. This aids in the investigation of social networks as well as multidimensional scaling [11].

The plan for cellular fabrication has been included in the article. The author employed the graph coloring approach in this case. In this case, the author also utilized a matrix. Dissimilarities between parts are taken into account by the author of this research, who arranges the generation framework in part-families and group machines. The author's comparison software was written in MATLAB and runs on a computer. The author's design seeks to reduce the frequency of inter-cell transfers by closely comparing manufacturing plans and separating components with different programs. This new strategy, known as MCF, is proving to be beneficial to many types of businesses [12].

This study applies network mathematics to the unique situation of corporate reporting of slavery in supply chains as a manner of meeting corporate human rights duties. Graph theory, which can sample affinity in databases, might 'value add' due diligence by measuring identity and honesty for organizations concerned about hazards like slavery in supply chains. This mathematical tool may be used to 'value add' to commercial and human rights analytical methodologies. Author things, graph theory random sampling approach has the potential to provide a better understanding of the networks in identity data as well as a valuable tool [13].

In this paper graph theory is used to find the matching nodes of the tourists that may help the tourists during traveling. Here network science is used to demonstrate travel mobility. Graph theory integrated the trajectory of different travelers and finds similarities across travelers. In this paper longest common subsequence algorithm, a recursive algorithm is used. The data sources are social media and mobile technology sensors. Data is manipulated through clustering. Data sparsity, selection bias, shortage of sources, and erroneous sources are all examples of data collecting limitations [14].

Xu, G., & Wu, J. (2016, October) has tried to rank Chinese products based on graphs. That's why they collect reviews of Chinese products. In this case, the author used as a model BaseNP and modified Co-ranking model. They also remove the wrong segmentation and opinion inclusion from the reviews. And they take the product features annotated from the corpus before doing word segmentation. The co-ranking model was created by combining HITS and PageRank. This model used mostly for Chinese product [15].

In this paper, the authors have tried to figure out the flexibility of the supply chain, and they think that their proposed framework will help the supply chain. They identified a total of 33 causes and divided them into six more groups. The authors use the matrix method of graph theory in this paper to evaluate the flexibility of these subjects. Here the digraph methodology was used to evaluate the agility of the index. Singh, R. K., & Kumar, P. (2019) used the matrix of rap theory to analyze the opposite logistical disposition [16].

2.3 Research Summary

In short, we can say that we have come close to our desired result. We think it is possible to build our business network and to build a business network with graph theory, we have been able to give everyone a reasonable idea about it. Since there has not been much research on graph theory yet, we think that a better study can be expected if more work is done on it.

2.4 Scope of the problem

Bangladesh has not done much with graph theory so far. This is a very important study for agribusinesses. We hope that this work will inspire future researchers to work on graph theory. We did not have enough datasets for research, yet we analyzed different markets and created a data set of districts of Bangladesh, which helped us to reach our desired results. Graph theory models are very effective in building networks. The importance of the network library function for visualizing a network is immense.

2.5 Challenges

As new researchers, we have faced many challenges in working with graph theory. Since Graph Theory is a new study, we have had to read a lot about it. As this study is new, not many resources have been found. Creating a marketing network with graph theory in agriculture has never been studied before, which raises a new challenge for us. Yet we think we have been able to give everyone a logical idea of graph theory.

CHAPTER 3

Research Methodology

3.1 Introduction:

We have used graph theory in our research work. Since we want to create a business marketing networking model, we need graph datasets. Creating new datasets and analysis makes research more meaningful. Below is a short explanation of our entire work through the graph:

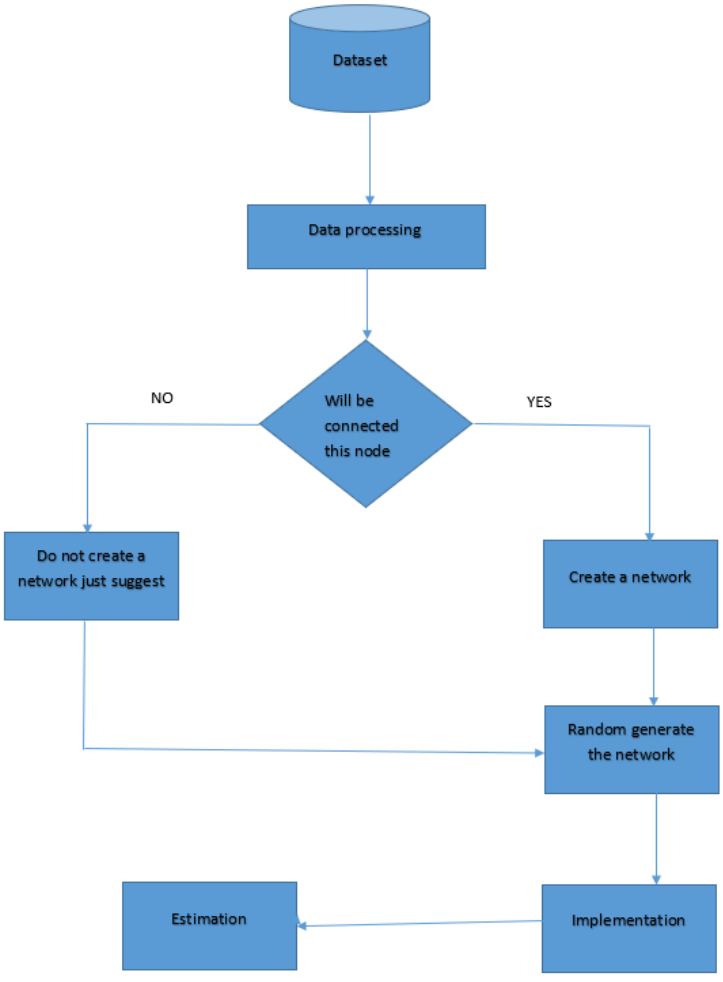


Figure 3.11: Explanation flow-chart

3.2 Research Subject and Instrumentation

Our research work is "**The application of graph theory for the networking of rural agriculture products marketing"**. We researched and tried to figure out how to build an agribusiness marketing network using village theory. For this whole task, we needed some high-class computers setups with Graphics Processing Unit (GPU). Below are the names of some of the Tools/Software required for this work.

Hardware & Software:

- Intel Core i5 including minimum 4GB RAM
- 1 TB HDD
- 120GB SSD
- Google Colab including 12GB GPU and 350 GB RAM

Developments Tools:

- Windows 10/ Windows 11
- Python 3.10
- Pandas
- Numpy
- Networkx
- Matplotlib

3.3 Data collection

Data is very important for good-quality research. Datasets can vary according to the type of study, some of which are very important.

- ✓ Recorded
- ✓ Ordered
- ✓ Graph

Since we wanted to create a marketing network with graph theory, so our dataset was built in the form of a graph dataset.

We build our dataset by targeting different market strategies. In this case, we follow the B2B Business Strategy of Bangladesh and different countries of the world and finally create a data set of B2B business based on the production and marketing of agricultural products in the districts of Bangladesh. We use several important websites to create this dataset [19] [20], which helps us build a business network.

Table 3.2.1: Our simple dataset

Zone_of_production	Product_amount	Zone_of_consumer	Consumer_demand
Dhaka	12	Chandpur	6
Bagerhat	10	Dhaka	9
Barguna	12	Chandpur	11
Rajshahi	14	Dhaka	13
Chittagong	12	Dhaka	9
Dinajpur	9	Natore	7
Rajshahi	10	Bugra	10
Rajshahi	12	Dhaka	6
Rajshahi	15	Bagerhat	9
Habiganj	10	chandpur	10

3.4 Described of Graph Data:

Graph data is a graph that is defined by as a graph. It's defined by nodes, which are our vertices in our graph. Graph datasets are primarily intended to establish and navigate relationships. To save data using graph datasets, and to establish relationships between edges. There is no limit to the number and type relationship of a node. Graph datasets have advantages, such as social networking, recommendation engines, and fraud detection. The graph Figure-3.3.1 below is shown as a network.

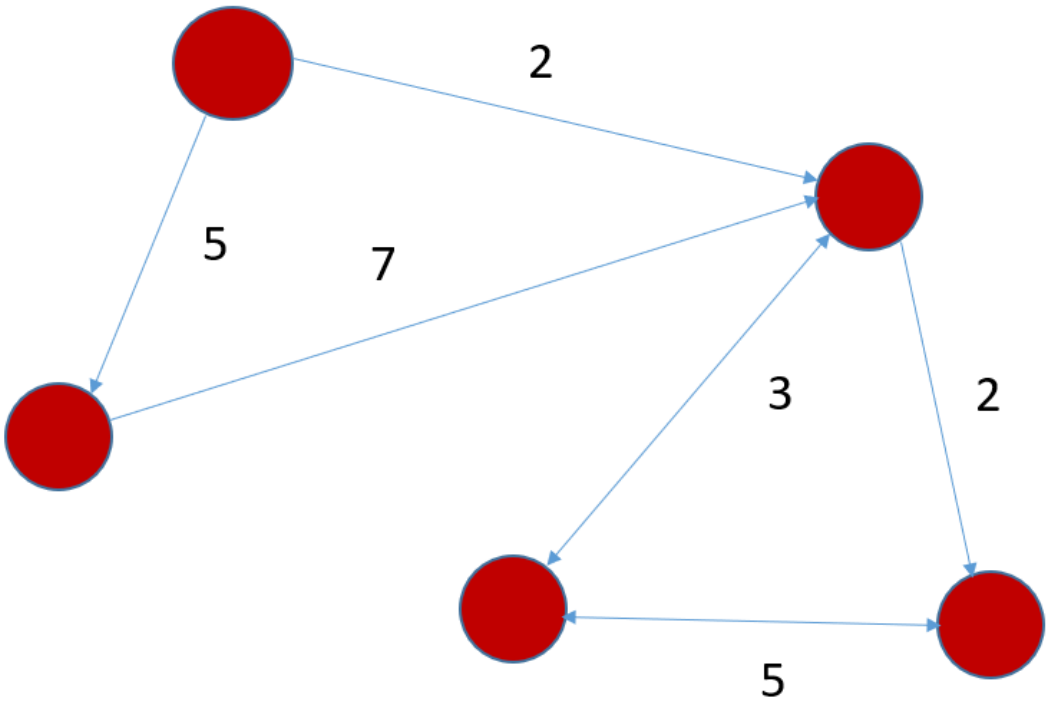


Figure 3.4.1: Example Graph Data

3.5 Data Preprocessing

Data preprocessing is a big part of research after data collection. We try to give a strategic form to the product quantity and product demand of a district by collecting data according to the product demand of different districts, which helps us to build a business network using graph theory.

	Zone_of_production	Product_amount	Zone_of_consumer	Consumer_demand
0	Dhaka	12	Chandpur	6
1	Bagerhat	10	Dhaka	9
2	Barguna	12	Chandpur	11
3	Rajshahi	14	Dhaka	13
4	Chittagong	12	Dhaka	9
5	Dinajpur	9	Nator	7
6	Rajshahi	10	Bugra	10
7	Rajshahi	12	Dhaka	6
8	Rajshahi	15	Bagerhat	9
9	Habiganj	10	chandpur	10

Figure 3.5.1: Sample of prepossessing dataset

3.6 Implementation and Requirements

3.6.i Problem discussion

We group our desired datasets based on district and product demand and marketing. And we use some models and algorithms according to different logics of graph theory, among which BFS and DFS are important. To visualize the graphs, we use Python's **NetworkX** library which leads us to the desired result.

3.6.ii NetworkX library

Networkx is one of the most widely used networks or graph programming packages in python. Network X is the reference library for Python's network algorithms. It was created

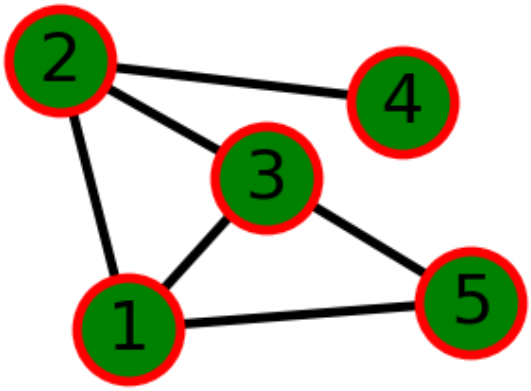
and developed, driven by research applications such as measuring the spread of disease, cyber security, and the impact of scholars. It is currently a mature package with a wide range of algorithms, low access bar, and the ability to convert many data formats.
Install in networkx with pip: **$ pip install network**

Creating Networkx:

```
import networkx as nx
import matplotlib.pyplot as plt
import random
```

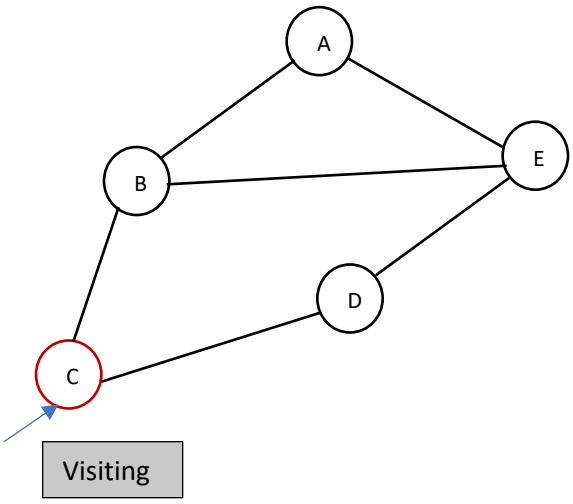
Example of network and creating graph:

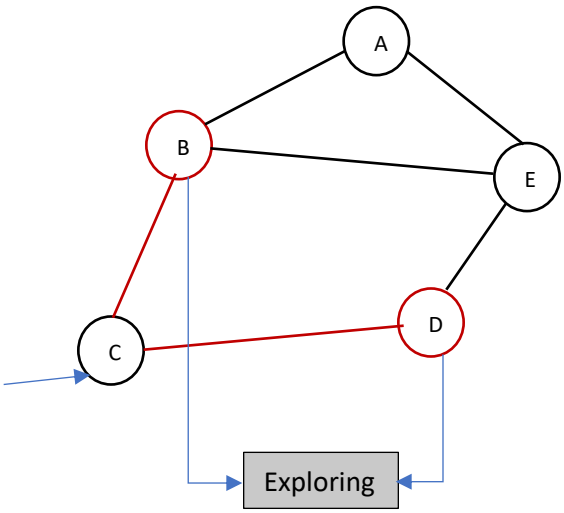
```
import networkx as nx
import matplotlib.pyplot as plt
G = nx.Graph()
G.add_edge(1, 2)
G.add_edge(1, 3)
G.add_edge(1, 5)
G.add_edge(2, 3)
G.add_edge(3, 5)
G.add_edge(4, 2)
pos = {1: (0, 0), 2: (-1, 0.3), 3: (2, 0.17),
       4: (4, 0.255), 5: (5, 0.03)}

options = {
    "font_size": 36,
    "node_size": 3000,
    "node_color": "green",
    "edgecolors": "Red",
    "linewidths": 5,
    "width": 5,
}
nx.draw_networkx(G, pos, **options)
# Set margins
ax = plt.gca()
ax.margins(0.20)
plt.axis("off")
plt.show()
```



3.6.iii BFS Algorithm

Another basic search strategy for exploring nodes and edges in a network is the Breadth-First Search (BFS). It has an O(V+E) time complexity and is frequently used as a building component in other algorithms. One thing that the BFS algorithm is particularly good for is: On an unweighted graph, find the shortest path. In the sense that a breadth-first search investigates nodes in layers, it starts at a node in the graph and explores its neighbors first before going on to the next level of neighbors. Two important graph traversals are given below:





BFS Algorithm Pseudocode:

```
Input: n as the source node

BFS (G, n)
let X be queue.
X.enqueue( n )

mark s as visited
while ( X is not empty)
v = X.dequeue( )

for all neighbors i of v in Graph G
if i is not visited
X.enqueue( i )
mark id as visited
```

Bello is a map of the BFS algorithm and the shortest path:

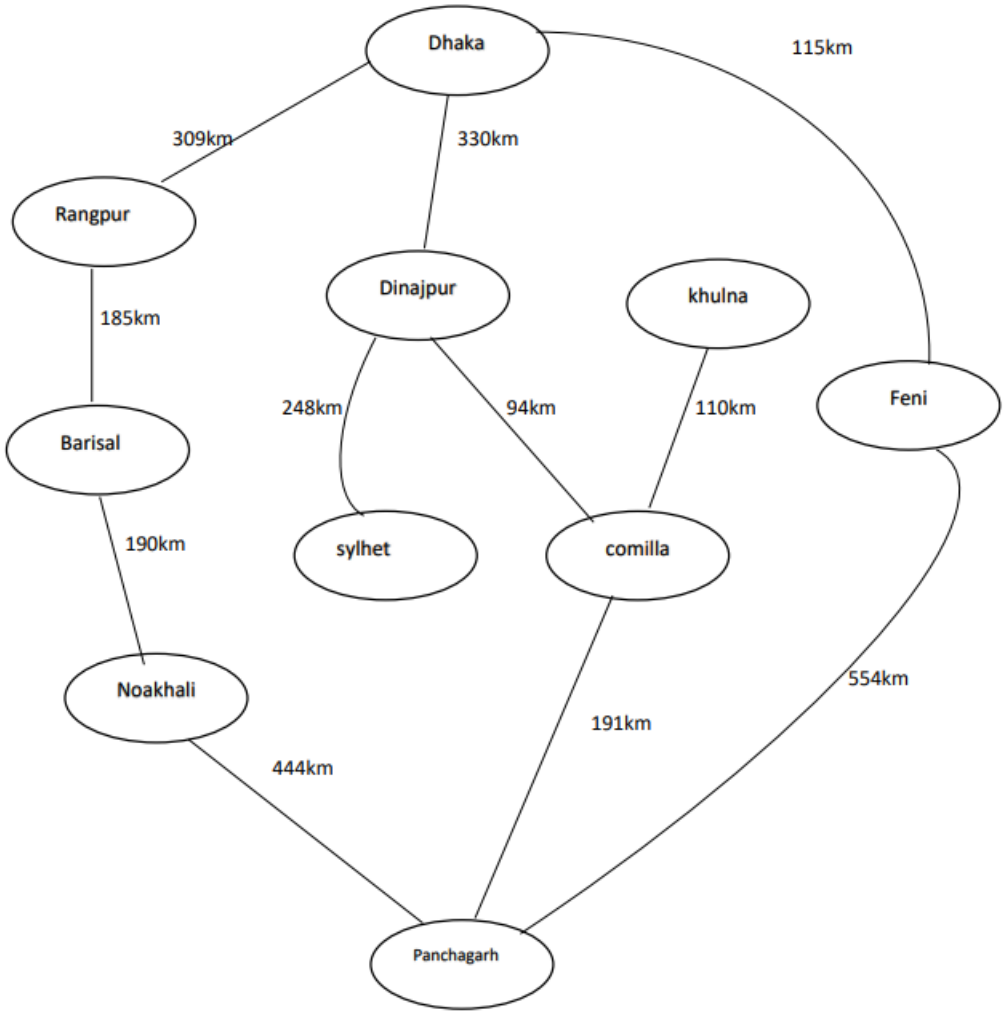


Figure 3.6(iii).1: BFS graph Example

The correct way to go from one city to another is shown in the picture:

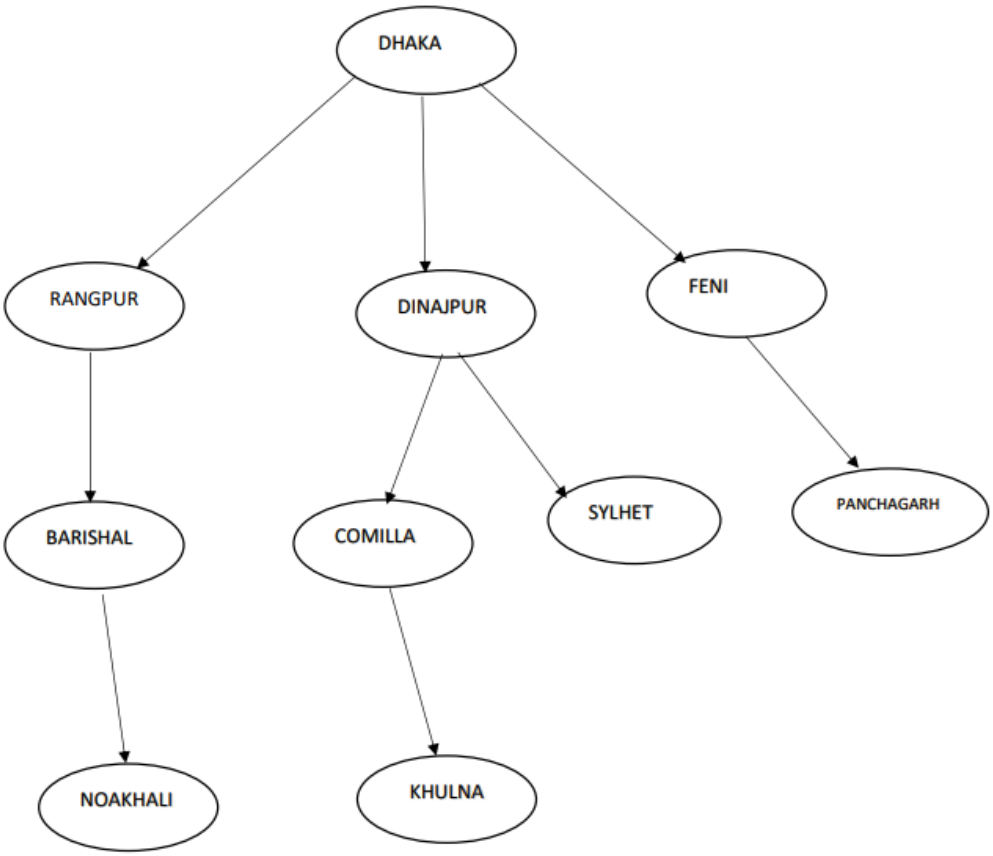


Figure 3.6(iii).2: Best path from city to city

3.6.iv Randomly Generate graph

Consider the case when v is a finite collection of n items. Currently, we write v={0,…….,n-1}. G of all graphs on v into a probability space is our goal. G= Randomly follow for each $l \in [v]^2$. Its own probability space $\Omega_e \coloneqq \{0_e, 1e\}$ choosing $d_e(\{1e\}) \coloneqq d$ and $d_e(\{1e\}) \coloneqq c$.

So, the Product space $\prod_{e\in[v]^2} \Omega_e$.

Let us determine the anticipated number of some given length k ≥ 3 in random graph G ∈ g (n, d). so, let $X \coloneqq g(n,d) \rightarrow \mathbb{N}$ be a random variable that assigns to every random graph G its number of K-cycle the number of subgraphs isomorphic to C^k. Let we begin by writing,

$$(n)_k : n(n-1)\ (n-2)\ \ldots\ \ldots\ \ldots (n-k+1)$$

For the number of sequences of k distinct element of a given n-set.

3.7 Clustering

Clustering is the process of grouping a collection of things in such a way that the objects in this group (referred to as clusters) are more similar to one another than the objects in other groups (clusters). It's used as a fundamental function of exploratory data mining and a general strategy for statistical data analysis in machine learning, pattern recognition, image analysis, data retrieval, bioinformatics, data compression, and computer graphics.

Cluster analysis is not a specific algorithm, but it may be used to address a variety of problems. This may be accomplished using a variety of algorithms that construct a cluster and varies greatly in their grasp of how to effectively locate them. Cluster members, dense regions of data space, groups with small distances between distances, and specialized statistical distributions are all popular cluster notions. As a result, clustering may be viewed as a general-purpose optimization problem. The unique data set and the intended application of the findings decide the appropriate clustering algorithms and parameter settings (such as distance functions for use as a density threshold or anticipated cluster parameters). Cluster analysis is a repeated process of information discovery or interactive multi-purpose optimization requiring judgment and failure, rather than an automated operation. The data propulsion and model parameters must be modified regularly until the results meet the default criteria. The network clustering is shown below through an image:

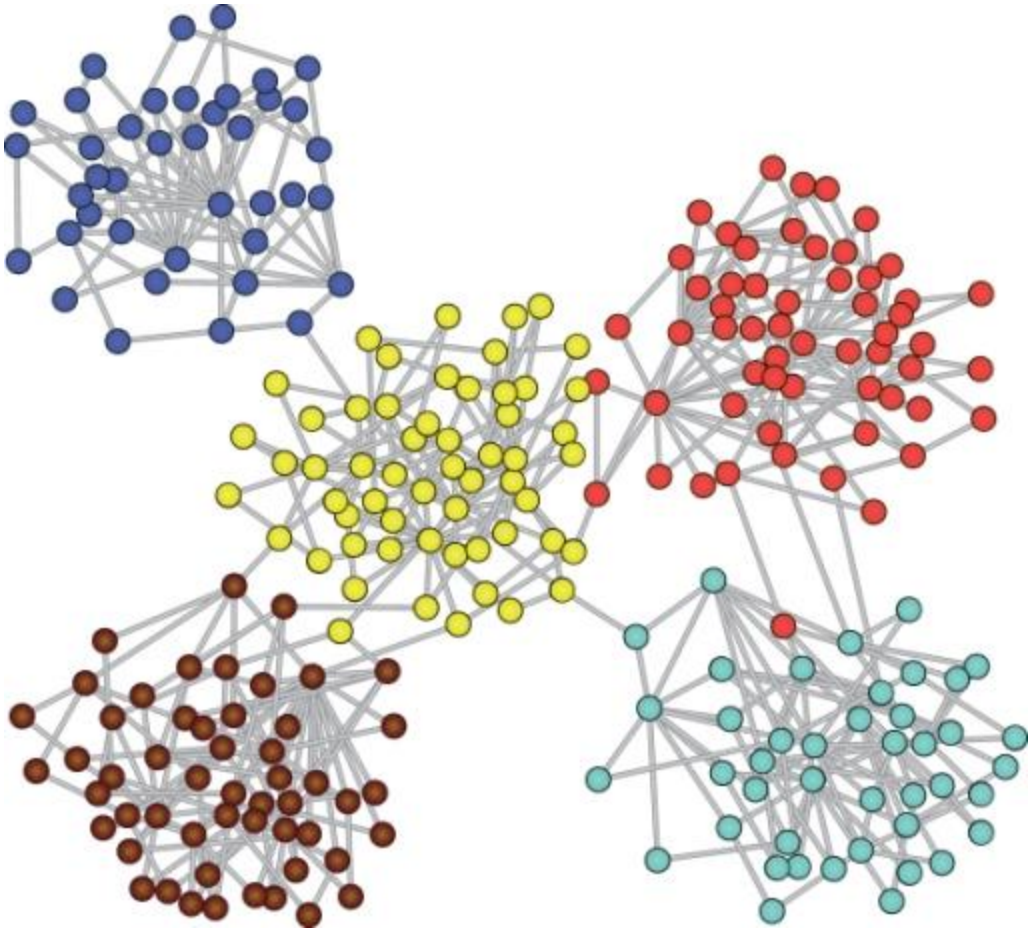


Figure-3.7.1: Network clustering example

CHAPTER 4

Experimental Results & Discussion

4.1 Overview:

In this chapter, we will discuss our experimental results, which we got after applying various models and algorithms of graph theory. First of all, we will discuss the experimental setup and then we will review the results.

4.2 Connectivity with districts-based distance

First of all, we convert our desired dataset into a Python dictionary method. We then create a short dataset according to the distance of each district, resulting in a network within each district according to the distance. This will make product marketing accessible from one district to another, and we use Python **NetworkX** to visualize this network.

Create a dictionary:

```
dic={}
```

```
[56] for i in range(len(nodes)):
       dic[nodes['Zone_of_production'][i]]= nodes['Consumer_demand'][i]
```

```
[43] dic
```

```
{'Bagerhat': 14,
 'Barguna': 6,
 'Bhola': 16,
 'Bogra': 9,
 'Brahmanbaria': 11,
```

Now, we have to set the distance attribute for each of the nodes:

```
# We have to set the distance attribute for each of the nodes
for i in list(G.nodes()):
    G.nodes[i]['dic'] = dic[i]

nx.draw_networkx(G)
# This line allows us to visualize the Graph
```

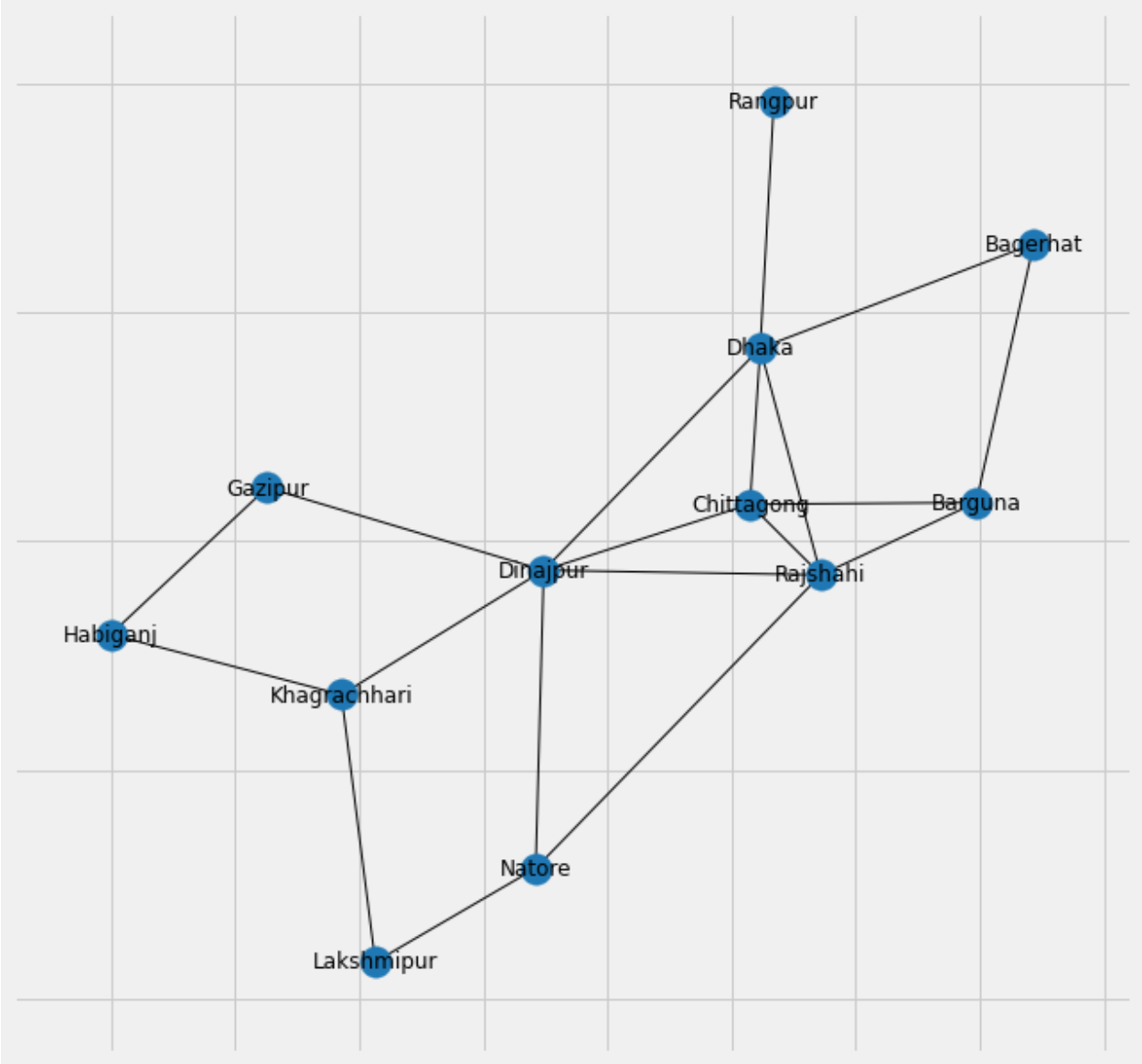


Figure 4.1.1: districts-based distance

4.3 Grouping by Production Zone and Consumer Zone

For grouping, we use Python group by function. It helps us to differentiate between the production area and consumer area. And helps determine the amount of production and marketing demand in an area.

```
df = pd.DataFrame(nodes)
```

```
gb=df.groupby(['Zone_of_production','Product_amount','Zone_of_consumer','Consumer_demand']).sum()
```

```
gb
```

Zone_of_production	Product_amount	Zone_of_consumer	Consumer_demand
Bagerhat	10	Dhaka	9
Barguna	12	Chandpur	11
Bhola	12	Rangpur	6
	25	Munshiganj	22
Bogra	10	Natore	9
...	...	...	...
Shariatpur	14	Madaripur	14
Sherpur	18	Magura	18
Sirajganj	29	Manikganj	26
Sunamganj	16	Meherpur	14
Sylhet	20	Moulvibazar	20

```
grp = df.groupby('Zone_of_production')
grp.filter(lambda x: len(x) >= 2)
new=grp.sum()
new
```

```
('Bagerhat', 'Dhaka')
  Zone_of_production  Product_amount Zone_of_consumer  Consumer_demand
1           Bagerhat              10            Dhaka                9

('Barguna', 'Chandpur')
  Zone_of_production  Product_amount Zone_of_consumer  Consumer_demand
2            Barguna              12         Chandpur               11

('Bhola', 'Munshiganj')
   Zone_of_production  Product_amount Zone_of_consumer  Consumer_demand
74              Bhola              25       Munshiganj               22

('Bhola', 'Rangpur')
   Zone_of_production  Product_amount Zone_of_consumer  Consumer_demand
21              Bhola              12          Rangpur                6

('Bogra', 'Natore')
   Zone_of_production  Product_amount Zone_of_consumer  Consumer_demand
22              Bogra              10           Natore                9
```

Zone_of_production	Product_amount	Consumer_demand
Bagerhat	10	9
Barguna	12	11
Bhola	37	28
Bogra	10	9
Brahmanbaria	12	11
Chandpur	14	13
Chittagong	24	18
Comilla	9	7
Cox's_Bazar	10	10
Dhaka	12	6
Dinajpur	28	22
Faridpur	12	6
Gazipur	11	10

4.4 Marketing network with Visualization

The purpose of our study was to create a product marketing network for the rural agricultural sector. For this, we try to build a business model using graph theory. Below is a visualization of our marketing network.

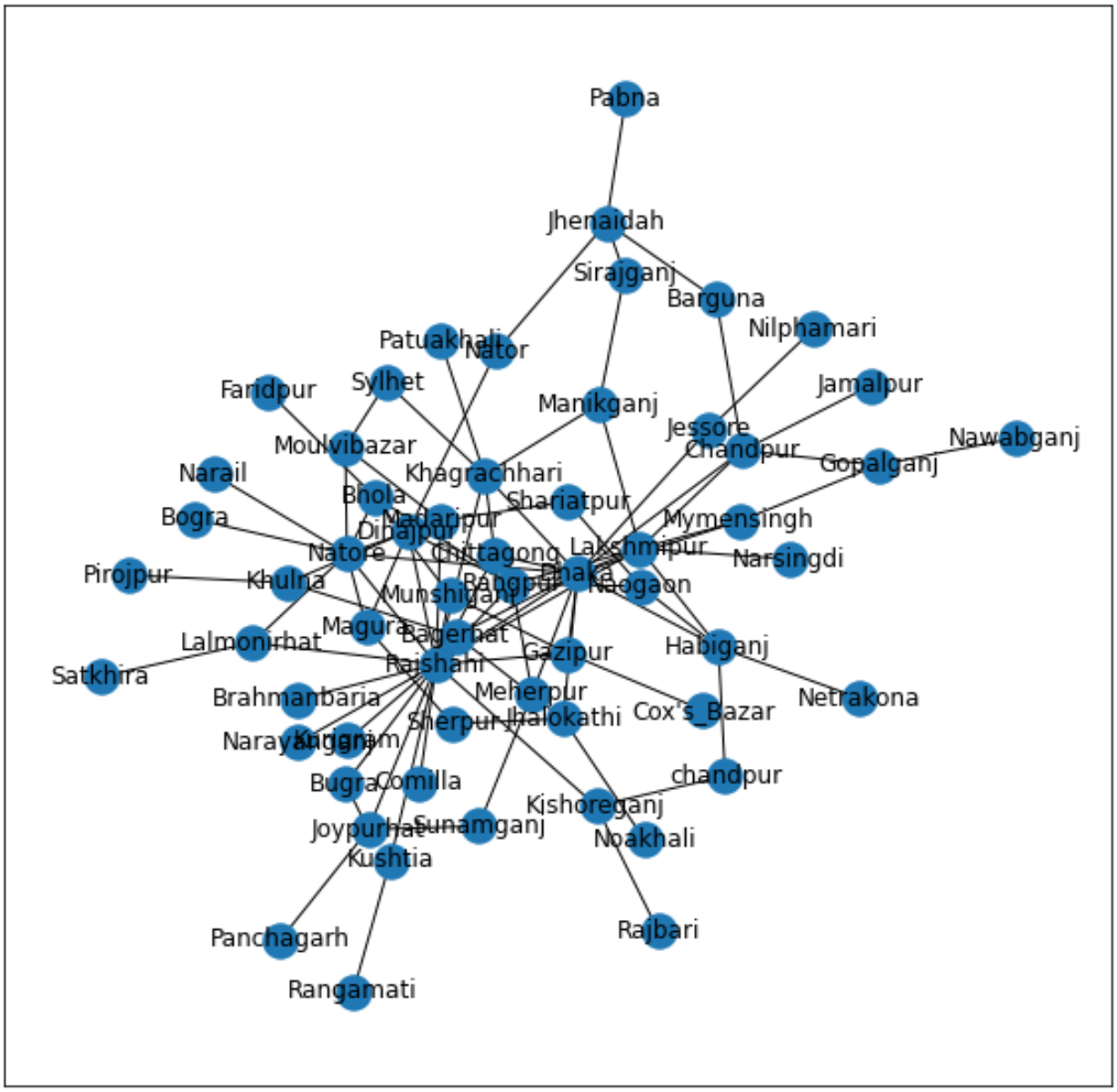


Figure 4.3.1: Product marketing network with visualization

4.5 Network Analysis with BFS Algorithm

At this stage, we have identified some important things from our dataset. Which has helped us to do network analysis.

- The degree of centrality
- Most substantial
- District wise most important network connection is one of them.

A district is identified as the apex for considering such a graph, and that district will help each district to be connected. Thus, some districts have been grouped separately and those districts will help to connect other districts. Finally, through BFS Algorithm apply we build our Final Product Marketing Network. The BFS algorithm apply makes it easier to find the shortest path between a consumer and a farmer. As a result, it will be easier to determine which agricultural product is readily available at the nearest distance from a consumer, and perishable agricultural products can be easily marketed. Following the application of the BFS algorithm, the marketing network is given below:

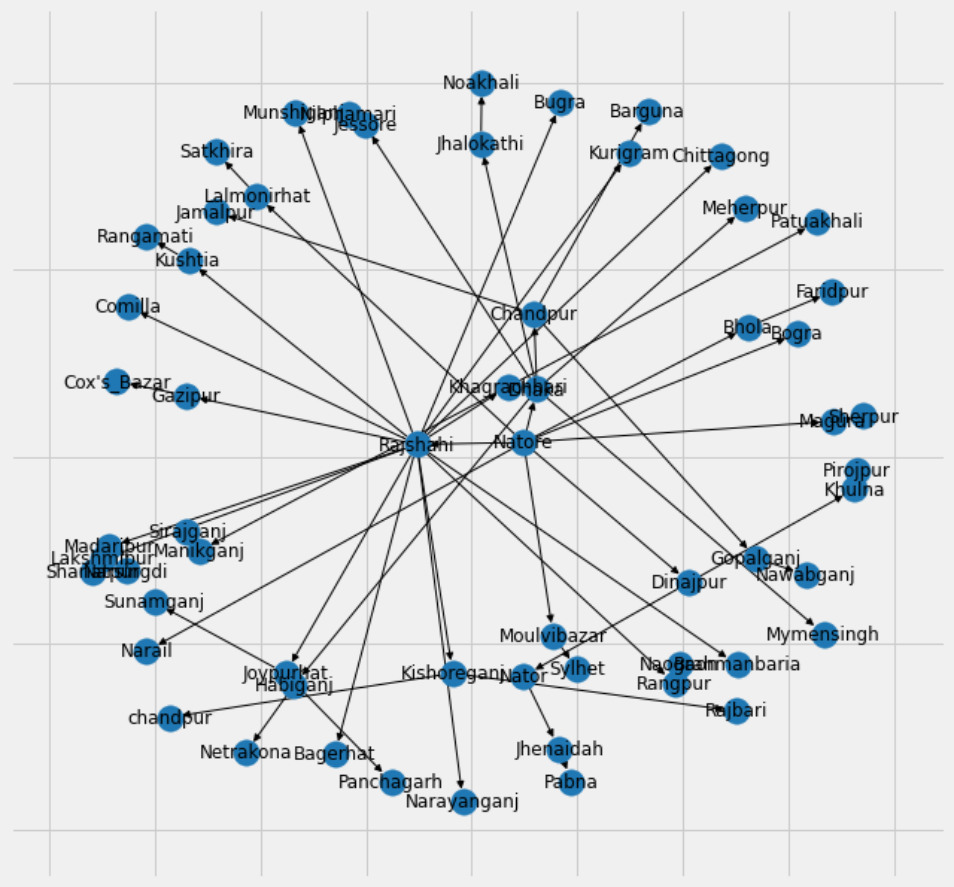


Figure 4.4.1: Marketing network with BFS Algorithm

4.6 Network Clustering

After applying BFS Algorithm the clustering of the network is shown in Figure-4.6.1.

```
'Bhola': 0.09820602781855253,
'Bogra': 0.04182155431287786,
'Brahmanbaria': 0.08381903099187905,
'Bugra': 0.10156654742827413,
'Chandpur': 0.11764952883496355,
'Chittagong': 0.17963920587235205,
'Comilla': 0.08381903099187905,
"Cox's_Bazar": 0.028083481720806835,
'Dhaka': 0.3864914159021986,
'Dinajpur': 0.21008813047182834,
'Faridpur': 0.01601040992790512,
'Gazipur': 0.17226066285240543,
'Gopalganj': 0.03830789436632053,
'Habiganj': 0.12331019040110013,
'Jamalpur': 0.019180764063374545,
'Jessore': 0.06473030798091467,
'Jhalokathi': 0.09867069932212824,
'Jhenaidah': 0.012037665969751043,
'Joypurhat': 0.10886212478285609,
'Khagrachhari': 0.201254122230712,
'Khulna': 0.06422444769127178,
'Kishoreganj': 0.09198620640243349,
'Kurigram': 0.08381903099187905,
'Kushtia': 0.08610757642762158,
'Lakshmipur': 0.2565137121478088,
```

Figure: 4.6.1: District wise Network Clustering

4.7 Descriptive Analysis

Before we build a product marketing network with Graph Theory, we try to understand the different uses of Graph Theory. Although the scope of research on graph theory is very limited, due to which we have to face many challenges in researching it, the creation of a graph theory dataset was one of them. However, we are able to create a dataset in terms of Bangladesh by analyzing the marketing data of different countries. In the end, we think

that our results are quite satisfactory. Given these results, we hope that future researchers will be interested in working on it.

4.8 Summary

In short, we can say that since research on graph theory is still in its infancy, we think we are fairly successful in the concepts we have tried to convey. And we think we've been able to get to the threshold of realizing the dream we had.

CHAPTER 5

Conclusion and Future Work

5.1 Summary of this Study

Our completed research is based on graph theory. The purpose of this study is to create a network with graph theory and to use it in rural agricultural product marketing. We have been trying to work with this graph theory for a long time. Below is a summary of the research step by step:

Step 1: Plan to work with graph theory

Step 2: Problem analysis and try to understand the problem

Step 3: Graph theory network model design

Step 4: Data collection from Bangladesh and another country marketing strategy

Step 5: Making the dataset suitable for use in graph theory

Step 6: Data preposing for applying graph theory model

Step 7: Apply Graph theory model, Network visualization function

Step 8: Check our desired outcome

Our research on graph theory will help in the development of rural agriculture. Protect rural farmers from the shadow of unscrupulous traders. Now I will talk about future work and completion work with Graph Theory.

5.2 Conclusion

We have created a network for rural agricultural product marketing, through which a consumer will have direct connectivity with a farmer based on the production and marketing of agricultural products. So far, no product marketing network has been created using Graph Theory, hopefully we have been able to give everyone an idea about Graph Theory through our work. We think this research will help other researchers in the future to create marketing networks. And we think we'll see more new research on graph theory in the future.

5.3 Limitation

There are some limitations in each study. The biggest limitation we had in this study was that it was not a conventional study like all other studies. As a result, we haven't been able to get enough of the researchers' ideas on graph theory. As research on graph theory is at an early stage, we also face a big challenge in creating datasets. Since this was a new work, it was a big challenge for us to know which model we could use to get better results. But hopefully, there will be more research on graph theory in the future.

5.4 The Implication for Future Research

Since creating a marketing network with graph theory was a new study, we need more research. In the future, we will do more market analysis to create datasets, and try to make our marketing network model more efficient. And we will try to gather some new information in the future.

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The application of graph theory for the networking of rural agriculture products marketing

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