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DESIGN AND IMPLEMENTATION OF A SYSTEM FOR OPTIMAL COLLECTION AND SUPPLY OF RICE PRODUCTS USING THE MODIFIED DIJKSTRA'S ALGORITHM

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Abstract

Analysis of the shortest path of a proposed system for optimal collection and supply of rice product using the modified Dijkstra's algorithm has been carried out. Imota Rice mill company used as a case study. It is designated as the starting point, which represents the initial node A on a weighted graph. The end point is taken to be the warehouse, which represents our target node G. From the results obtained, it can be concluded that the shortest distance between Imota Rice Mill Company, and the warehouse is 8km.

Keywords: Route, Rice Products, Optimal, Source and Destination Nodes

1.0 Introduction

Everyone desires to arrive at their destination on time. People who rely on public transit must obtain reliable bus information in order to decrease their waiting time at bus stops (Pradhan, 2013). Networks are required for the movement of people, the delivery of products, the communication of information, and the management of the flow of matter and energy. The scope of network application

is extremely broad. Roads, trains, cables, and pipelines are examples of phenomena that are represented and studied as networks. The expense, time, and complexity of networking (Mullai, 2012). The network's nature evolves in many types of network-based systems, such as television cable networks. Telephone networks, electricity supply networks, gas pipe networks, and water delivery systems are all examples of networks. As a result,

in order to solve networking difficulties, the cost, time, and complexity of the network are all taken into account. A graph is a mathematical abstraction that may be used to solve various networking issues. Locating the shortest routes plays a key part in the resolution of network-based systems.

A variety of algorithms can be used in graph theory. In a graph based network system, it is used to determine the shortest path. The complexity of the system is reduced as a result. The network path, the cost, and the time required to create and maintain network-based systems (Mullai, 2012).

This research work is on the Design and Implementation of a System for Optimal Collection and Supply of Rice Products. The aim of this research is to Design and Implement a system for optimal collection and supply of Rice products in Imota Rice mill, Lagos Company that will lead to the maximal utilization of time in accessing the warehouse from the Rice Mill, Ikorodu, Lagos. The objective is to obtain the shortest path of the network through which drivers can travel to enhance efficiency and possible links within the network which will reduce the following; waiting time, consumption of fuel, air pollution rate, and the wearing and tearing

of the mechanical components of the vehicle.

The methodology used in this research is the Object-Oriented Analysis and Design (OOAD) in simulating the land transportation network system in Ikorodu, Lagos. Java programming language will be used to simulate the algorithm. By developing a model to identify the shortest path for time efficiency in the transportation network system, the driver will know which path to follow to ensure the timely delivery of goods to its consumers; this problem will be addressed using the modified Dijkstra's algorithm. Therefore, the implementation of automated shortest path and use of modified Dijkstra's algorithm in land transportation network system will in no doubt improve and increase the efficiency and productivity and also reduce the waiting time.

The background of this research based on a case study of Design and Implementation of An Optimal Rice Distribution System in Ikorodu, Lagos. Using the Modified Dijkstra's Algorithm. The land transportation network system understudy consists of 7 nodes known as A, B, C, D, E, F and G. Each node here represents a bus stop.

Table 1: Bus stops in Ikorodu, Lagos and nodes

Ikorodu, Lagos	Node Number
Bus Stop A	1
Bus Stop B	2
Bus Stop C	3
Bus Stop D	4
Bus Stop E	5
Bus Stop F	6
Bus Stop G	7

Land transportation has proven to be the most popular and reliable mode of transporting people, commodities, and services from one location to another, both locally and globally, throughout human history. Food, mail, and other critical products dealers arrange resorts in land transportation platforms to beat time as a matter of urgency in delivery. The usage of land routes in a land transportation system entails the use of approved links termed edges paths, which connect all

nodes (bus stops) within a given geographical region of coverage. Lately, land transportation system has witnessed remarkable growth and improvement due to the emergence and rapid growth of information technology (IT) and the additional land safety measures put in place such as electronic devices to detect land turbulence, this way, enabling both drivers to avoid hazards and land users to patronize this means of transportation. In real life situations, the transportation

network is usually stochastic and time dependent (Thorup, 2014). In fact, a traveler traversing a link daily may experience different travel time on that link due, not only to the fluctuations in travel demand (source-destination matrix) but also due to such incidents as work zones, bad weather conditions, accidents and vehicle breakdowns. As a result, a stochastic time-dependent (STD) network is a more realistic representation of an actual road network compared with the deterministic one. In order to account for travel time reliability more accurately, two common alternative definitions for an optimal path under certainty have been suggested. Some have introduced the concept of the most reliable path, aiming at minimizing the probability of arriving on time or earlier than a given travel time budget. It is very necessary to note that computer scientist, engineers, network designers, programmers, road users, aviation industry should understand the rudiments and concepts used in land transportation network system as they constitute the shareholders in this sector. Such concepts range from understanding the ever-growing variety of components and strategies put together and master the approach in land transport networks and behavior (Thorup, 2014).

Reduction in waiting time is a major focus in this research which land transportation handlers seek to achieve. This research aims at the application of the modified Dijkstra's algorithm for optimal collection and supply of rice product, in Imota Rice mill company, which will lead to the minimal utilization of time in accessing the warehouse at Ikorodu, Lagos. Taking the shortest route will not only save time, but also reduce the consumption of fuel, air pollution rate, and the wearing and tearing of the mechanical components of the vehicles being used. A typical demonstration of a bird eye view of the land path of Imota Rice mill to its warehouse is shown in the table below.

Table 2: Representation of destination nodes

S/N	Nodes	Node Number
1	A-B	2KM
2	A-C	5KM
3	A-D	5KM
4	B-D	3KM
5	B-E	1KM
6	C-D	3KM
7	C-F	3KM
8	D-F	2KM
9	D-E	2KM
10	E-G	2KM
11	F-G	1KM

Node Description: In this network, node A is the source node, while G is the destination node or the sink node.

2.0 Related work

There are vast numbers of literatures on the application of Dijkstra's algorithm to the solution of real-life problems. Few among them are presented below:

Optimization of flight trajectory in order to minimize fuel consumption and timerelated cost by (Peyer et al., 2009). (Pradhan & Mahinthakumar,2013) conducted a comparative analysis of Dijkstra's algorithm and Floyd algorithm for the determination of shortest path between two cities in China using time and cost parameters. The study which was simulated on Microsoft Visual Studio established that Dijkstra's algorithm is more effective than Floyd algorithm. Determination of shortest path in very large-scale integration (VLSI) routing by (MG, 2015). (MG,2015) applied Dijkstra's algorithm to optimize the routes in a railway system so as to present the user with the shortest route. The proposed system provides users with regular and reliable information on rail system and serves as a framework for the development of future 'smart cities.

(Sabri et al., 2015) tackled the problem of evacuating a building during critical incidents and disasters by determining the shortest route an evacuee could take in order to exit the building in a shortest possible time. This was achieved through the application of Dijkstra's algorithm.

(Agarana et al., 2016) applied Dijkstra's algorithm simulated on a computer software called LINDO to the optimization of routes in a rail transit system among major stations in a proposed world-class university. The study which made use of Covenant University as a study case, predicted that the shortest path from the main entrance gate to the Electrical Engineering Department has a distance of 805meter. (Shivani & Bansal, 2017) proposed Vehicles Route Planning (VRP) for finding an optimal route from a car starting point to its destination. In this work, comparative analysis of Bellman-Ford and Dijkstra shortest path algorithms were conducted. Results from the simulation experiment confirmed that Dijkstra's algorithm perform best in terms of delay time and shortest travel path.

(Pushpalatha and Anuradha, 2019) proposed a Dijkstra's algorithm which use the network connectivity information and the estimated distance information among the sensor nodes to find out the shortest path between the source and destination nodes with low cost. Simulated results from the study showed that Dijkstra's algorithm is capable of producing position estimates with 4% error range. This paper presents the extension of the previous works through the design and implementation of a system for optimal collection and supply of rice product in Imota Rice mill.

2.1 Brief Description of the Study Area

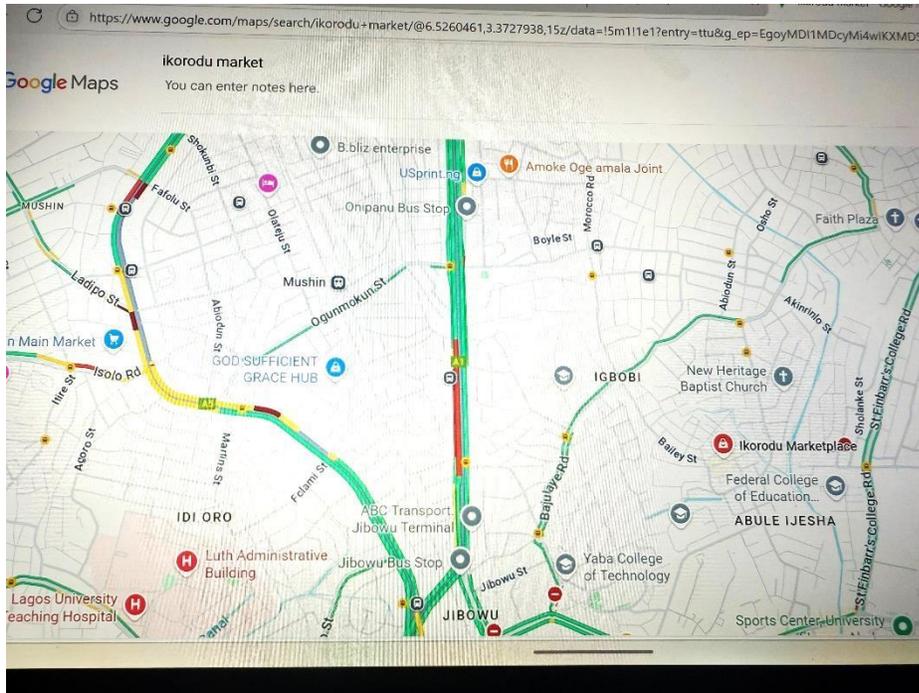


Figure 1 Map of the study area (Google map)

The locations used for this project work was obtained from Imota Rice mill and also the distance in kilometer (km) between each location in the graph was measured using Google maps location. Ikorodu, Lagos in located in the heart of the old Town Ikorodu in Lagos state. The market has been in existence for quite a while now.

3.0 Methodology

The specific data required for this study were collected from primary and secondary sources. The primary data were field survey data with global positioning system (GPS) to locate the locations of customers building. Secondary data was obtain from google earth data source to obtained Digitized Map of the study area and also the road and transportation routes in the study area. These data collections form our GIS. The comparison-addition model uses the hierarchical development methodology

(YWDM) propose by Ofem (2016), applied in designing and implementing the system because proposed system is a hierarchical. Web GIS project produced a hybrid product that has qualities of both traditional GIS and web applications. The collected data were represented within the database schema and web pages were coded using hypertext markup Language (XHTML), cascading style Sheet (CSS), Hypertext Pre-processor scripting language (PHP) and Java Scripting language (JS). The software packages use for the development of this application were RJ Text Editor, Adobe Fireworks, windows, apache, MySQL and PHP (WAMP Server). The analysis of the network was implemented using java Scripting Language.

These tools were chosen because of their level of integration and suitable Graphical User Interface (GUI) which makes the of the system easy to understand and manage. Unit

tested was done on the web pages to check for errors at individual functional points. The Location

Names and their Equivalent Node Numbers were recorded. This is presented in table 1

Table 1: Table of location names and their Equivalent node numbers

BUS STOP	NODE NUMBERS
A	1
B	2
C	3
D	4
E	5
F	6
G	7

3.1 Distances between nodes

Table 2: Table showing the nodes and the distances between the nodes

S/N	NODES	DISTANCE IN Kilometers (KM)
1	A-B	2
2	A-C	5
3	A-D	5
4	B-D	4
5	B-E	1
6	C-D	3
7	C-F	3
8	D-E	1

3.2 The physical topology of the network

The network topology is the arrangement and connectivity of nodes and links or routes in a network. In this paper the network topology was derived as shown in fig 1.0 after the nodes and distances between the nodes were obtained.

Analysis of the physical topology of the network

From FIG 1.0, steps were carried out to analyze the network in order to obtain the shortest route from a chosen source to a chosen destination.

In this paper, the chosen source was Node A and Node F was chosen as the destination. The following keynotes were also used to

represent the parameters used in the analysis of the network.

TL- Temporary label of a node/Upper bound which can be further updated to lower bound.

PL-Permanent label of a node/Permanent label which cannot be updated anymore further.

-Temporary label of a node *Permanent label of a node n- A node in a network dij- Distance cost between node i and j.

N/B. The moment a node in the network is given a PL outside the source, its reachable neighbor should be updated to get new TL for its neighbor.

3.3 Prototype model of the network

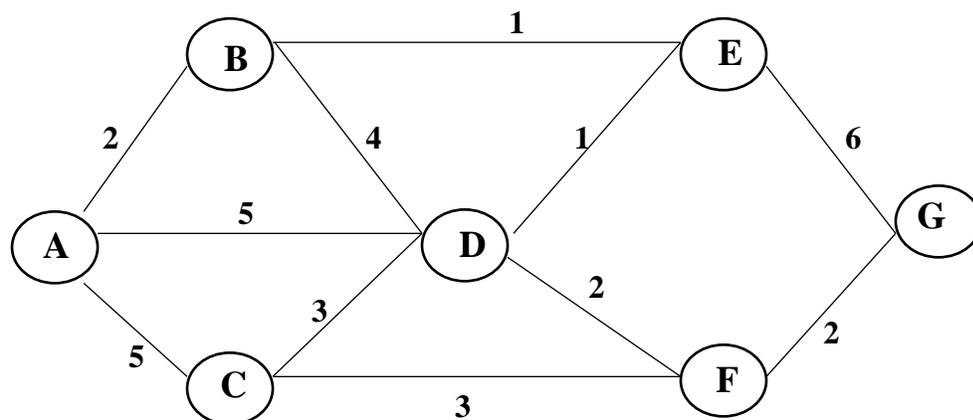


Fig. 2 a prototype model of the network

3.3.1 Network Analysis: At Level 1:

In Figure 3, the source node (A) is assigned a weight of 0, as well as all nodes directly reachable from A specifically nodes B, C, and D, which are labeled dij for their

temporary values. Nodes that are not reachable from A are assigned a temporary label of ∞ . Consequently, the node configuration at this stage appears as follows:

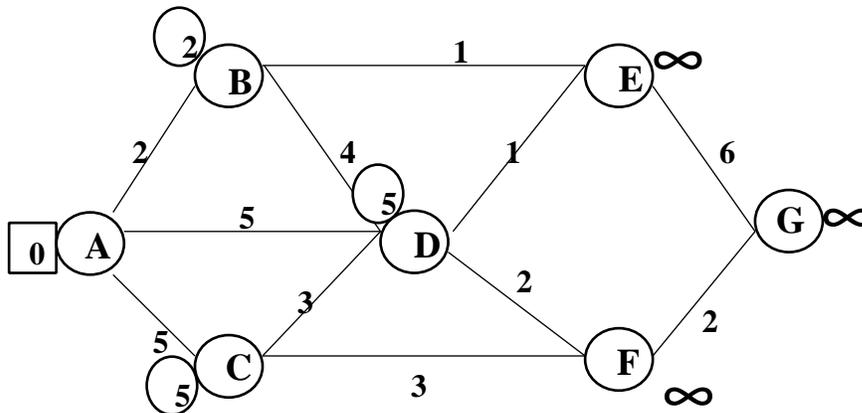


Figure 4: The Network at Iteration 1

The sequences of the node are as follows:

A	B	C	D	E	F	G
0	2	5	5	∞	∞	∞

*

At Level 2:

Next, evaluate the weight costs of all neighboring nodes accessible from A, as shown in Figure 4. The lowest cost among these will be designated as a permanent label (PL).

IF $TL(B) \leq TL(D)$ AND $TL(B) \leq TL(C)$
 THEN
 PL = Node B
 ELSE

PL ≠ Node B

Subject to further comparison.

Given that the logical condition is satisfied, the permanent label for node B is determined to be 2 km. The following outlines the network nodes and their sequence at Level 2:

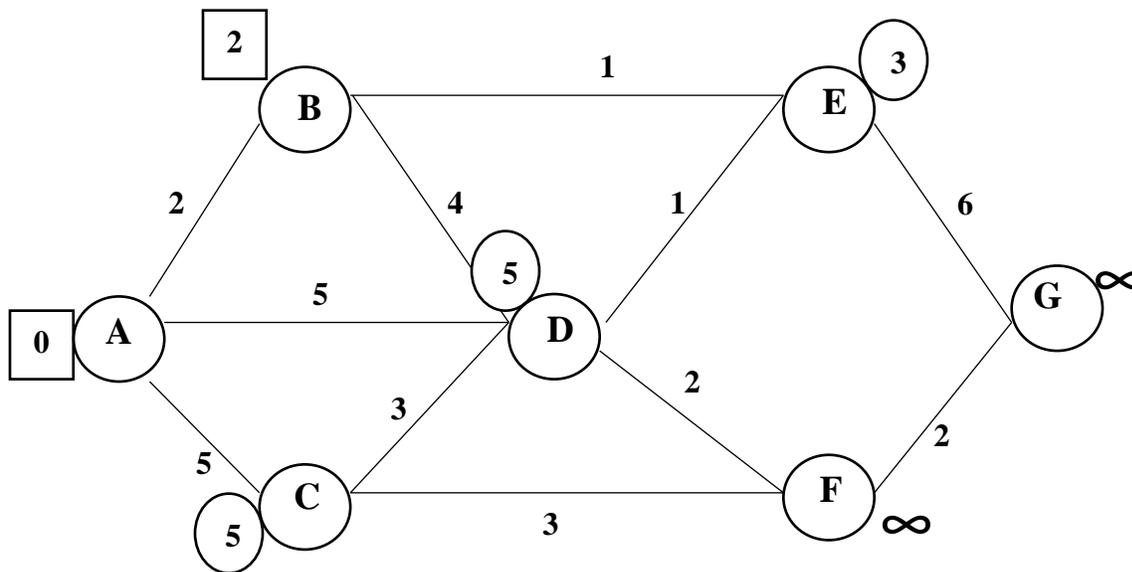


Figure 5: The Network Model at Iteration 2

With node B now assigned a permanent label, we will update the temporary labels (TLs) for its reachable neighbors. The sequences of the nodes at Level 2 are as follows:

A	B	C	D	E	F	G
0	2	5	5	3	∞	∞
*	*					

At level 3:

In Figure 5, assess the temporary labels (TLs) for nodes C, D, and E, selecting the smallest among them as the permanent label (PL).

If $TL(E) \leq TL(C)$ AND $TL(D)$
 THEN
 PL = Node E
 ELSE
 PL ≠ Node E

Pending further comparisons.

Given that the above logical condition is satisfied, the PL is confirmed as Node E with a distance of 3 km. Below is the network model and the sequence of nodes at Level 3:

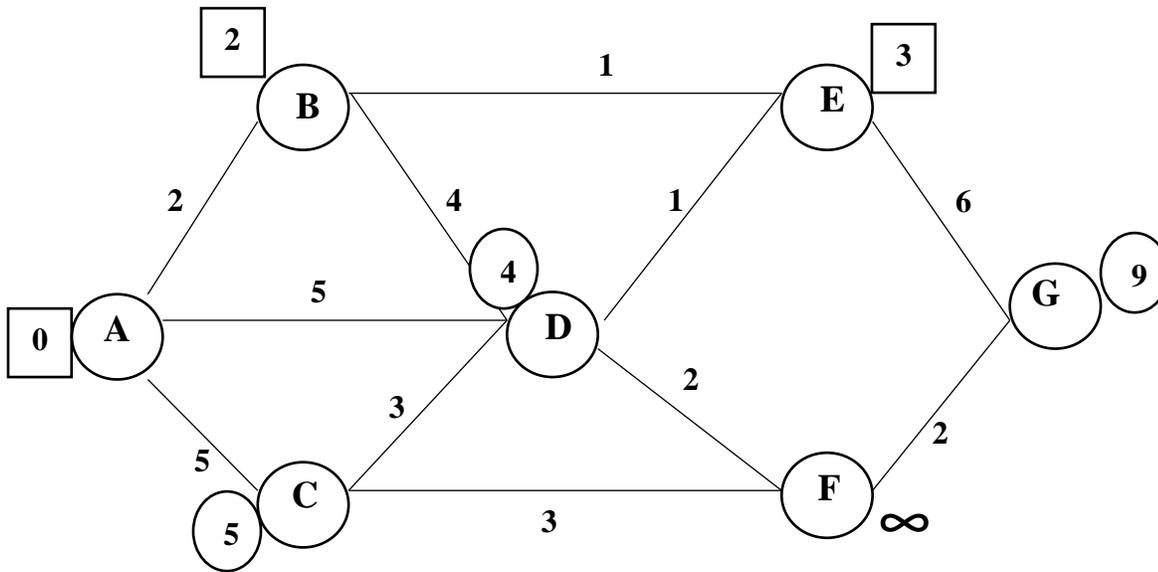


Figure 6: The network Model at Iteration 3

The sequences of the nodes at level 3 are as follows:

A	B	C	D	E	F	G
0	2	5	4	3	∞	9
*	*			*		

At Level 4:

Compare TLs for nodes D, C, and G in figure 6 and make the smallest of them PL

If $TL(D) \leq TL(G)$ AND $TL(C)$

THEN

PL \equiv Node D

ELSE

PL ≠ Node D

Subject to further comparison test.

Hence, since the above logical condition is true, the PL ≡ node D ≡ 4km.

See the network model and sequence of the node at level 4.

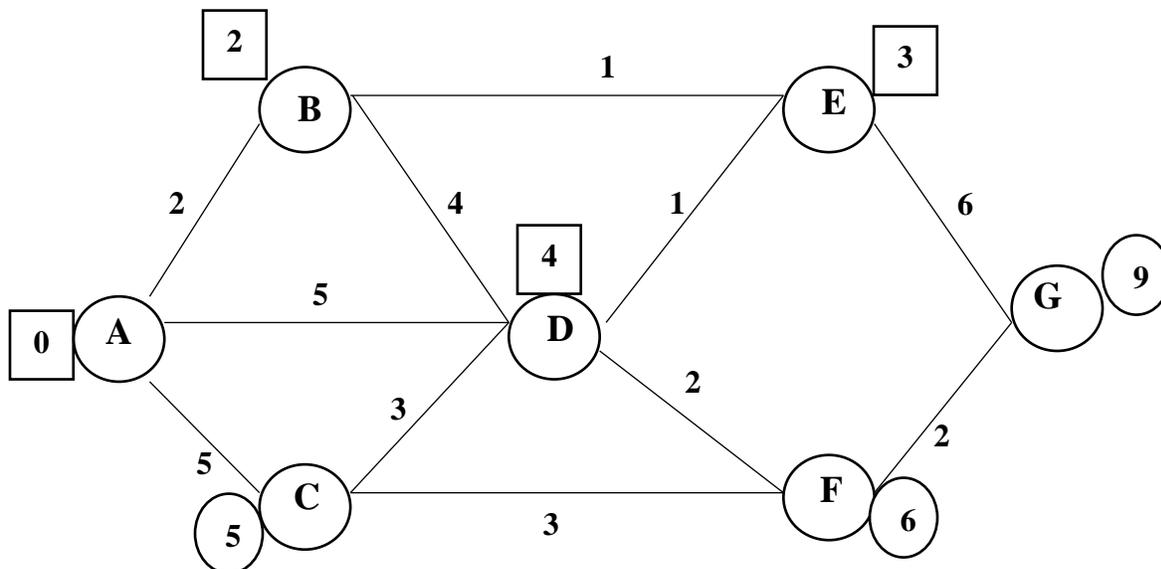


Figure 7: The network Model at Iteration 4

The sequences of the nodes at level 4 are as follows:

A	B	C	D	E	F	G
0	2	5	4	3	6	9
*	*		*	*		

At Level 5:

Compare TLs for nodes C, F, G and make the smallest of them a PL

Note:

If there is a tie, choose any path

If $TL(C) \leq TL(F)$ AND $TL(C) \leq TL(G)$

THEN

PL ≡ Node C

ELSE

PL ≠ Node C

Subject to further comparison test.

Hence, since the above logical condition is true, then PL ≡ node C ≡ 5km.

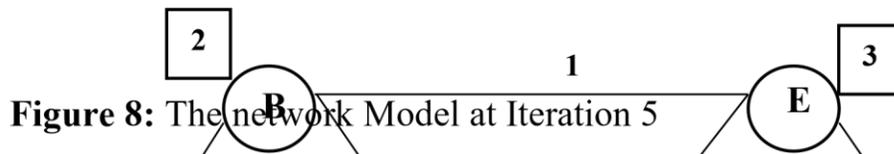
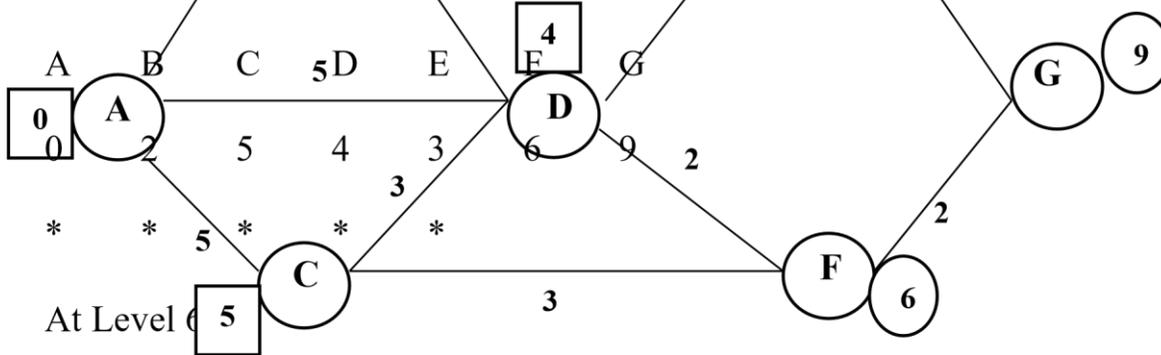


Figure 8: The network Model at Iteration 5

In figure 28, see the network model and sequences of the nodes at level 5:



Compare TLs for nodes F and G and make the smallest of them a PL

Note:

If $TL(F) \leq TL(G)$

THEN

PL ≡ Node F

ELSE

PL ≡ Node G

Hence, since the above logical condition is true, then $PL \equiv \text{node F} \equiv 6\text{km}$.

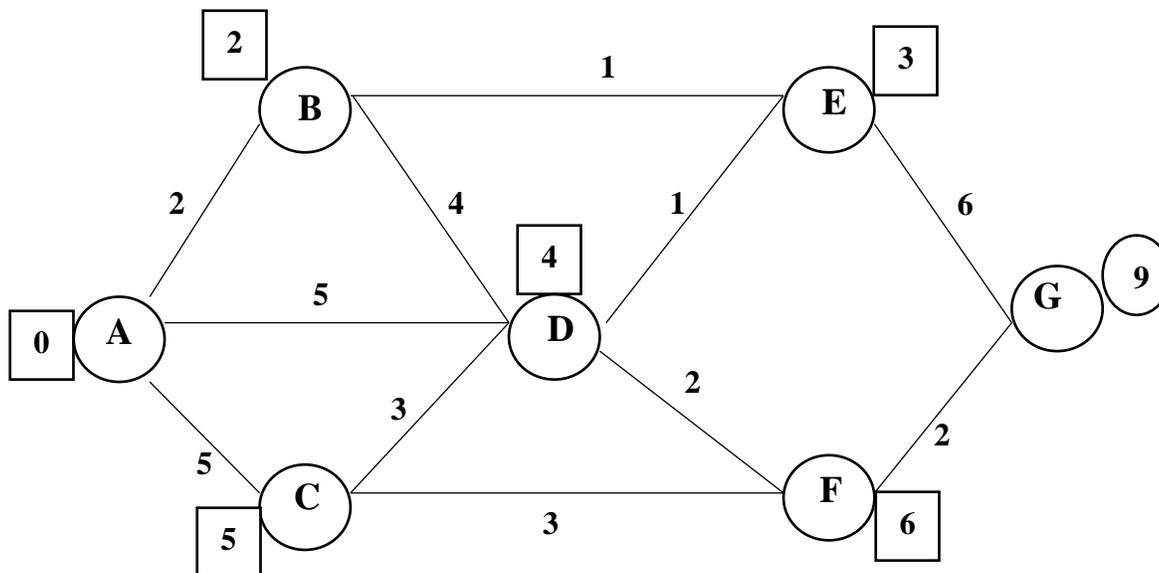


Figure 9: The network Model at Iteration 6

See the network model and sequences of the nodes at level 6:

A	B	C	D	E	F	G
0	2	5	4	3	6	9
*	*	*	*	*	*	

At Level 7:

Automatically update the permanent label (PL) for node G, signaling the conclusion of the algorithm. Below is the network model along with the sequence of nodes:

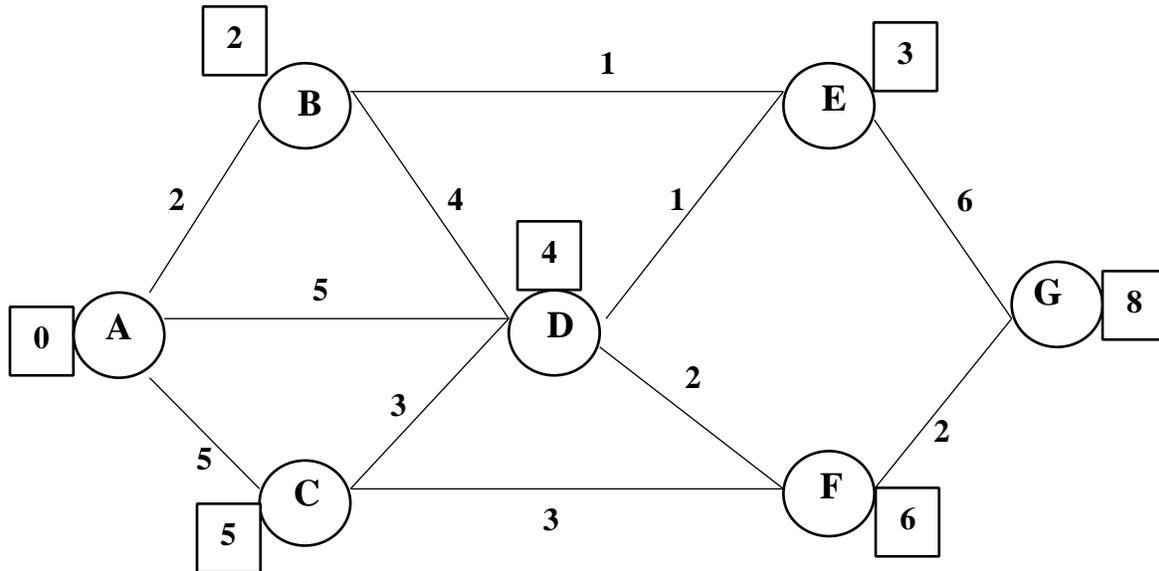


Figure 10: The Network Model at Iteration 7

See the sequence of nodes:

A	B	C	D	E	F	G
0	2	5	4	3	6	8
*	*	*	*	*	*	*

In this study, node A is designated as the source and node G as the destination. The objective is to identify the shortest path that minimizes travel time to the warehouse from the company, assuming a constant speed of 30 km/h through the interconnected nodes. Consequently, five alternative routes were selected for analysis.

Table 3: Alternative Routes from the network

R ₁ : A → B → E → D → F → G: 0+2+1+1+2+2 = 8 km
R ₂ : B → E → G: 0+2+1+6= 9km
R ₃ : A → C → F → G: 0+5+3+2 = 10 km
R ₄ : A → D → E → G: 0+5+1+6 = 12km

$$R_5: A \rightarrow D \rightarrow F \rightarrow G : 0+5+2+2 = 9 \text{ km}$$

Based on the evaluated routes, it is clear that Route 1 provides the shortest distance in the network, with a total weight cost of 8 km.

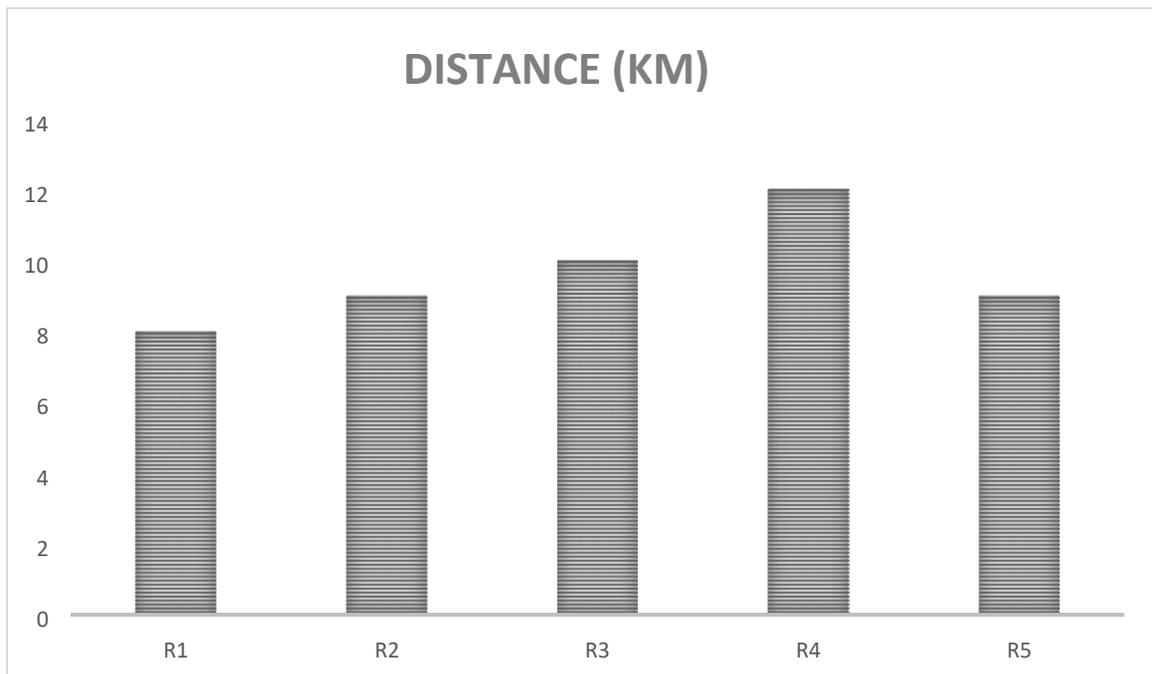


Figure 11: Graph of distance in kilometers against routes

Shortest Arrival Time

Average Speed = 30 km/hr

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

Table 4: Distance and time taken for each route from the network

Routes	Distance (km)	Time (hours)
R ₁	8	0.27
R ₂	9	0.30
R ₃	10	0.33
R ₄	12	0.40
R ₅	9	0.30

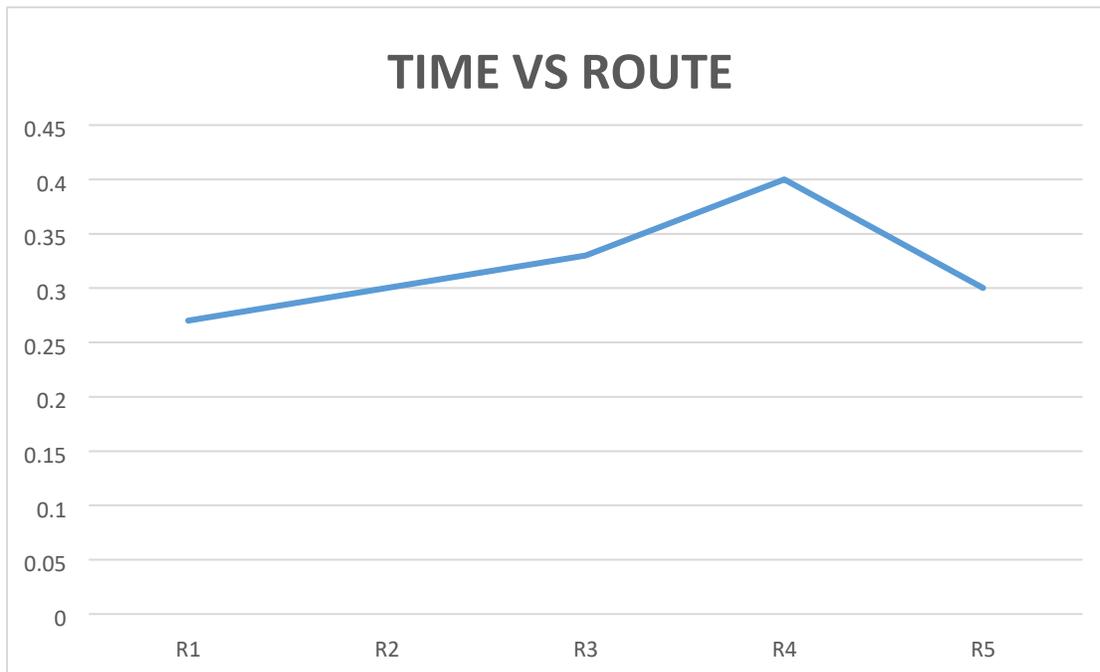


Figure 12: Graph of time in hours against routes

Based on the analyzed routes, it is evident that route 1 offers the shortest arrival time in the network, with a total of 0.27hr.

3.5 Advantages of the use of the modified Dijkstra's Algorithm:

Since time is a very important resource to both the distributor (the bus driver), the Management of the University of Calabar water factory, and the customer, efficient utilization of this modified algorithm will be of great importance both to the customer, the bus driver and the management of the water factory in the following sense:

- i. If the bus driver traversed through the shortest route in the network from the source node to access the destination node he will use less fuel consumption and will invariably reduce the wearing and tearing effect of the mechanical components of his bus (E.g. tyre, brake, lining, etc.) and will access his destination at the shortest possible time.
- ii. On the overall side of the management of the water factory, there will be an increase in the profit based of the business transaction via the supply of its products through the shortest route in the network.
- iii. Finally, on the side of the customer, time is money for their businesses, hence adequate utilization of this algorithm will increase their optimal time for receiving the water factory products

4.0 Conclusion

Analysis of the shortest path of a proposed system for optimal collection and supply of rice product was carried out in this paper using the modified Dijkstra's algorithm. Imota Rice mill company, which is the case study, is used as the starting point, which represents the initial node A on the weighted graph in figure 2. The end point is taken to be the warehouse, which represents our target node G. From the results obtained,

can be concluded that the shortest distance between Imota Rice Mill Company, and the warehouse is 8km. This has to be put into consideration by Imota Rice Mill Company so as to cut cost and save time of the customers, as a result of the shortest route identified in this study.

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