Optimal Routes for Distributing Refined Products for Port Harcourt Refining Company Limited (PHRC), Port Harcourt, Rivers state, Nigeria

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Abstract

In this study, the dynamic programming Method was coded in Micro-Soft excel to determine the optimal routes from Port Harcourt refinery to its five distribution depots located outside the refinery town. The distances of all the possible routes from the Refinery to the five destinations in the Nigerian road network was obtained using map reading from the Nigerian atlas map. Also, the data of Nigerian roads was collected from Cross Country Limited.

Keywords - *Shortest Route, Microsoft Excel, Optimal Route*

I. INTRODUCTION

The movement of people, goods and services is an important aspect of economic development of towns and cities all over the world. Land values tend to increase in areas with expanding transportation networks and increase less rapidly in areas without such improvement. Rapid and continue rise in housing and land prices are expected in cities with transportation improvement and rapid economic and population growth as stated in [2].

Reference [1] noted that transportation in Nigeria started as far back as the pre-colonial era. The first form of transportation was shanks pony (i.e. human foot). During that period, transportation facilities such as roads, railways, and air transport systems were really not in existence. The emphasis then was on bush path. However, [7] states that, people eventually, learn to use animals such as donkeys, horses, camels, among others, for transportation. As years went by, different modes of transportation were invented, Cargo movement by trucks, trains, planes and boats are the most essential part of a business. Therefore, for businesses to be able to sell their products locally, nationally or internationally to make profit and grow larger, they must also be able to receive shipment of raw products which they need to make their items. Just like in any part of the world, transportation play a Significant role in the economic growth and development of Nigeria both directly and indirectly, [7] estimated that losses in the Nigerian economy arising from the poor state of roads is about N450 billion yearly.

Reference [3] used dynamic programming to find the optimal route (shortest path) from the sea port sources (Lagos, Warri, Port Harcourt and Calabar) to Maiduguri, Nigeria. The researcher consider only the roads linking the state capitals from the four sources to the destination. Reference [5] used Floyd Warshal’s Algorithm to find the shortest route for 21 major cities in Nigeria considering Calabar, Cross River state as the origin and Kaduna, Kaduna state as the sink node. He considered only the major roads connecting the 21 cities.

The two authors above, used the Nigerian distance matrix as their source of data. Moreover, they used dynamic programming method (classical and/or TORA software) to find the optimal routes from a source to a destination.

In this study, the idea of map reading was used to obtain the distances (in kilometers) of all the possible routes from the source to the 5 destinations outside the refinery town for greater reliability. And then coded the Dynamic programming algorithm in Microsoft Excel to find the optimal routes of transporting refined products from Port Harcourt Refining Company Limited (PHRC) situated in Port Harcourt, Rivers state, Nigeria to the 5 storage depots outside the refinery town situated at Aba, Enugu, Calabar, Makurdi and Yola all in Nigeria.

Even though there are pipe lines from the refinery to all the 5 depots, the vandalization of oil pipelines installations has assumed worrisome dimensions and a variety of forms in Nigeria. Various terms, such as oil bunkering, oil theft, pipeline vandalization,fuel scooping, and oil terrorism, have been used to describe the various forms of theft of crude oil and its refined products in Nigeria which has leads to the severe shortages of the product which in turn lead to loss of billions of Naira and loss of innocent lives by fire incidents cause by pipeline vandalization. This act of pipeline vandalization leaves PHRC with almost one option of distributing refined products to the 5 storage depots. This option is nothing but trucking (i.e. road transport). Hence in this work, we examine road network of the company with the possibility of determining the optimal routes from the source to the 5 Storage depots outside the refinery town, in order to minimize the cost of transporting such products within Nigeria.

Reference[6] noted that "it is difficult to trace back the history of the shortest path problem. One can imagine that even in very primitive (even animal) societies, finding short paths (for instance, to food) is essential. Compared with other combinatorial optimization problems, like shortest spanning tree, assignment and transportation, the mathematical research in the shortest path problem started relatively late. This might be due to the fact that the problem is elementary and relatively easy, which is also illustrated by the fact that at the moment that the problem came into the focus of interest, several researchers independently developed similar methods". He further stated that path Problems were also studied at the beginning of the 1950s context of "alternate routing", that is, finding a second shortest route if the shortest route is blocked. The author further stated that, there are two well- known methods of shortest-length paths: the Bellman-Ford method and Dijkstra's methods. Reference [4] redesigned Floyd's algorithm to handle the case in which most of the parameters in a network are single valued neutrosophic sets and are uncertain. However, in this work we used Microsoft Excel to find the optimal routes from the refinery to the 5 destinations.

II. METHODOLOGY

For greater reliability, the idea of map reading was used to find the distances (in kilometers) between the nodes from the Nigerian atlas map that shows all the 36 states, 774 Local Government Areas and all the roads linking the entire Local Government Areas. Also, the data of Nigerian roads was collected from Cross Country Limited.

In this study, the modeled network developed consist of twenty-seven (27) nodes with thirty-five (35) arcs.

A. Procedure for Solving Shortest Route Problem using Microsoft Excel

Consider the network in figure 1 below where node A is the source node and node F is the destination node, the network was modeled in Microsoft Excel as shown in figure 2 below.

Step1: Model the problem in Excel as shown in figure 2 below. It is important to name each column, for easy identification when imputing the formulas. Under the Demand/Supply column, the source node and the destination node are assign the values 1 and -1 respectively and every other node zero meaning they are neither sources nor destinations.

Step 2: Impute the first formula as =sumif(from,h3,on-route)-sumif(to,h3,on-route) under the Net Flow column.

Step 3: Depress the enter key and then copy the formula in step 2 to every cell under the Net Flow column, stop when the destination node in the Nodes' column is reached. Zeros will appear in every cell under the column if the formula is imputed correctly.

Step 4: Impute the second formula as =sumproduct(on-route,distance) in cell F19

Step 5: Depress the enter key, zero will appear in cell F19 because there is no any value in the on-route column at this stage.

Step 6: Click on DATA at the top of your computer screen, solver box will appear at the top right hand side of the screen, click on solver, solver parameter box will open.

Step 7: Set objective as the total cell, i.e, select the cell that has zero value under the distance column, select minimize, select the entire on-route column as the variable cell you want to change.

Step 8: Click on add to add the constraint net flow = supply/demand by selecting the entire net flow column, equal to and then the entire supply/demand column.

Step 9: Click ok, the solver parameter box will display accordingly all the cells you selected in steps 7 and 8.

Step 10: Select make Unconstraint variable Non-Negative, select simplex LP as the solving method, click solve. The Excel solver will display the result. Under the net flow column, cells I13 and I18 will change from zeros to 1 and -1 respectively and every other cell in that column will remain zero satisfying the constraint net flow = supply/demand. Also, the on-route column contains zeros and ones. 1 on a path means the path is on the shortest route and zero on a path means the path is NOT on the shortest route. Moreover, the cell in step 4 will change from zero to the total optimal distance. Select keep solver solution and close the window to save your solution.

III. RESULTS

The PHRC road network with the distances in kilometers is shown below in figure 3 where the red node is the source node (refinery town), the blue nodes are the destinations (depot towns). After the implementation of the above procedure, the result is obtained and shown in figures 4 to 8.

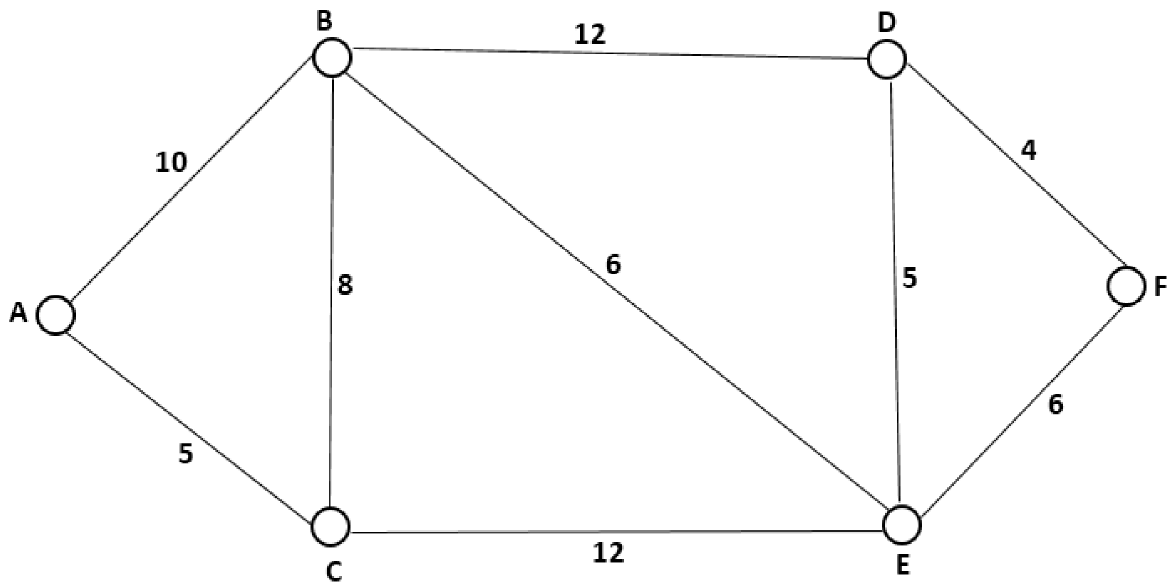
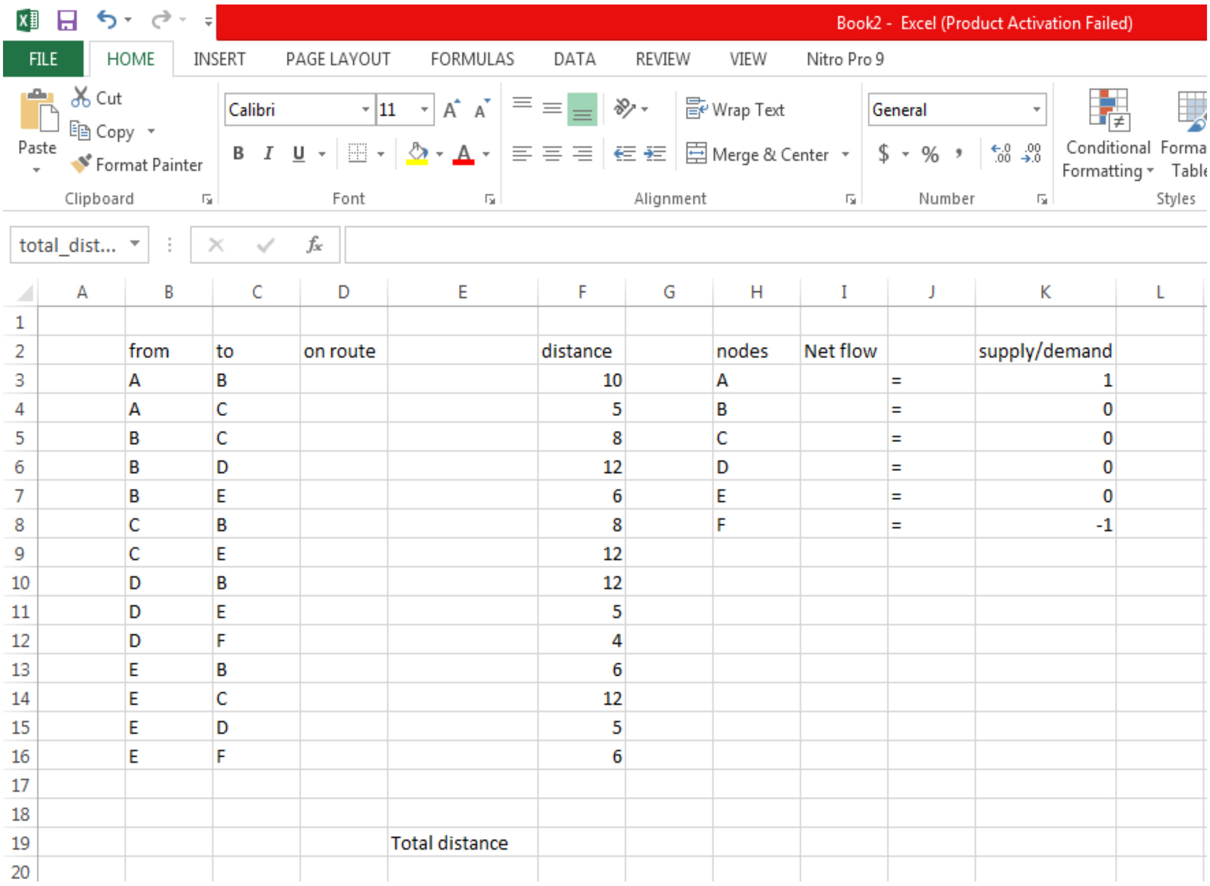


Fig. 1 An arbitrary network.



	A	B	C	D	E	F	G	H	I	J	K	L
1												
2		from	to	on route		distance		nodes	Net flow		supply/demand	
3		A	B			10		A		=	1	
4		A	C			5		B		=	0	
5		B	C			8		C		=	0	
6		B	D			12		D		=	0	
7		B	E			6		E		=	0	
8		C	B			8		F		=	-1	
9		C	E			12						
10		D	B			12						
11		D	E			5						
12		D	F			4						
13		E	B			6						
14		E	C			12						
15		E	D			5						
16		E	F			6						
17												
18												
19					Total distance							
20												

Fig. 2Model of the network in figure 1 in Microsoft Excel.

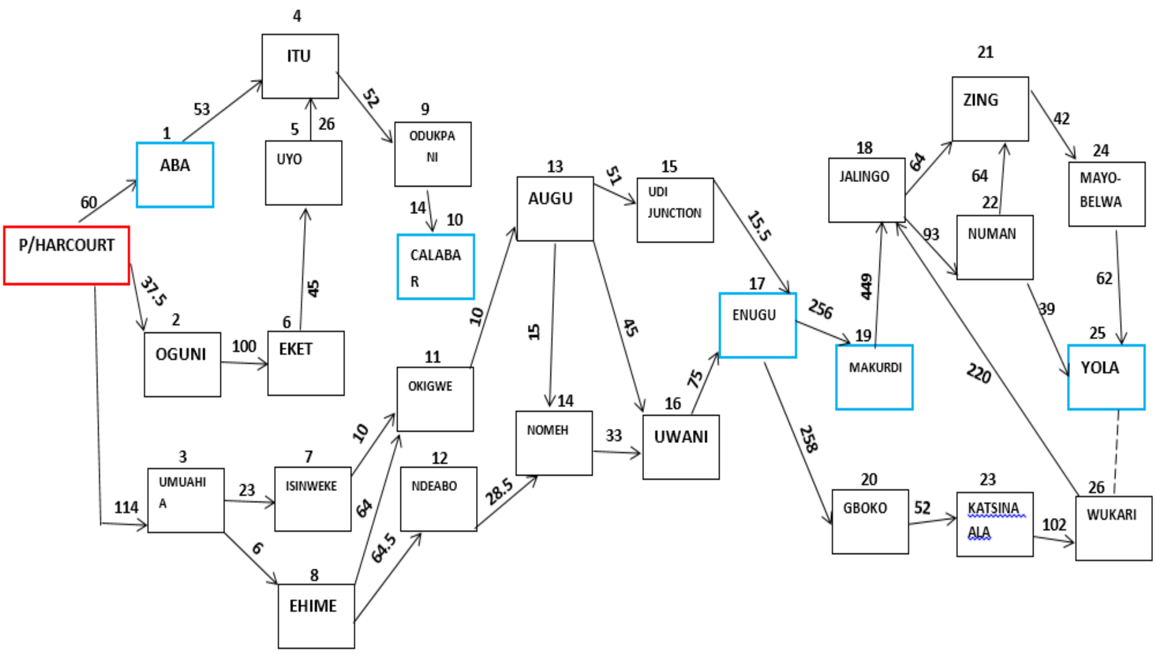
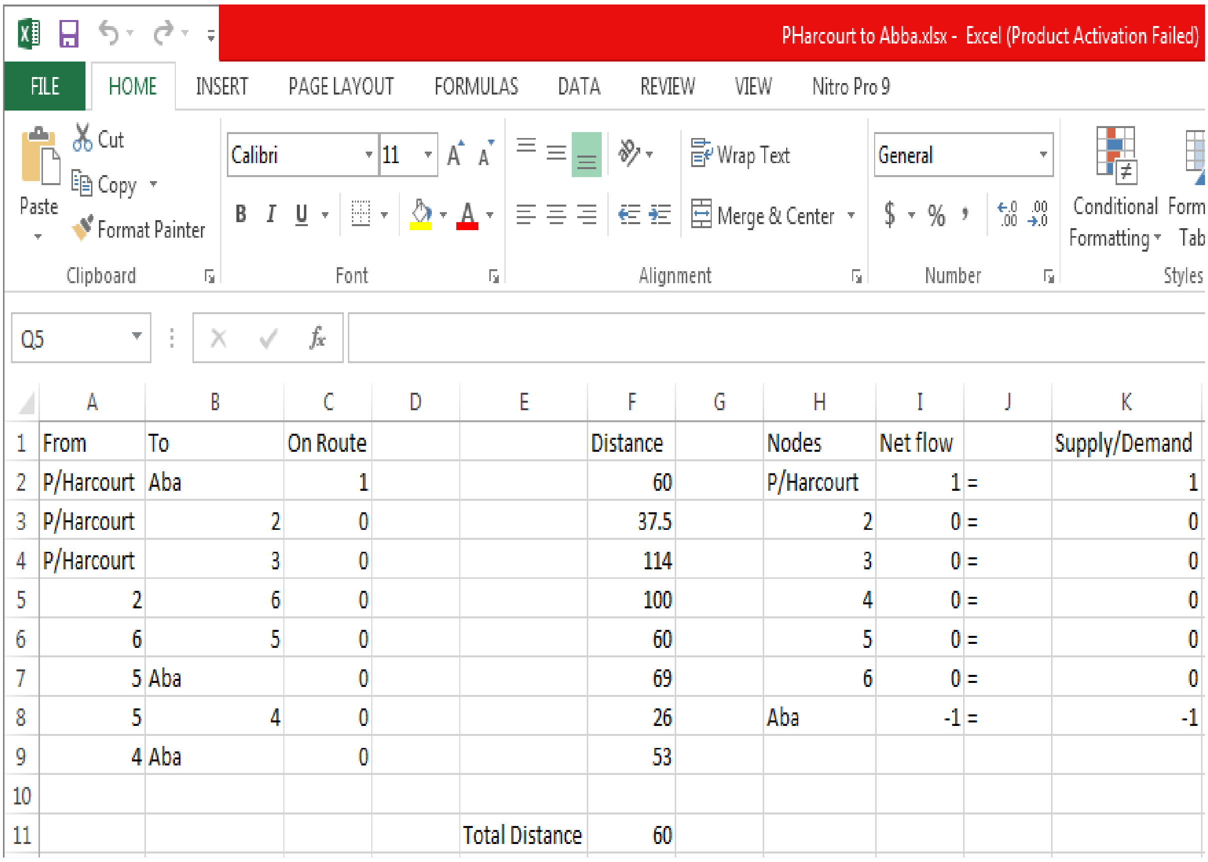
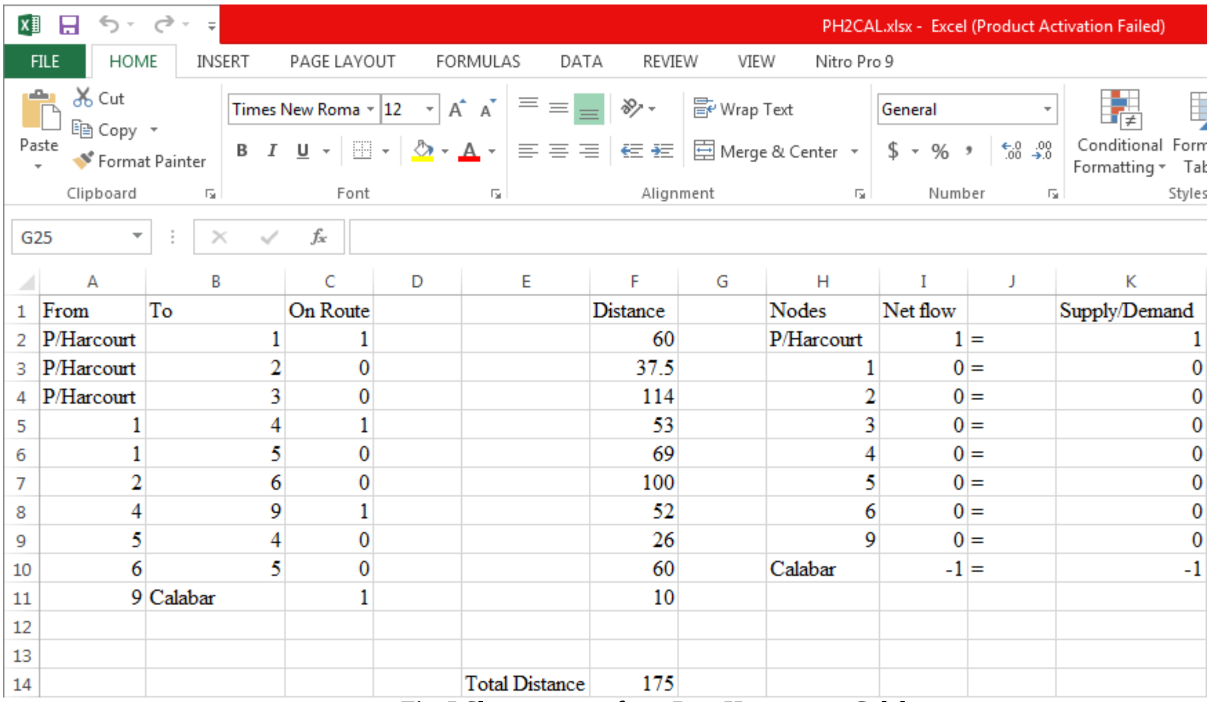


Fig. 3PHRC Road Network.



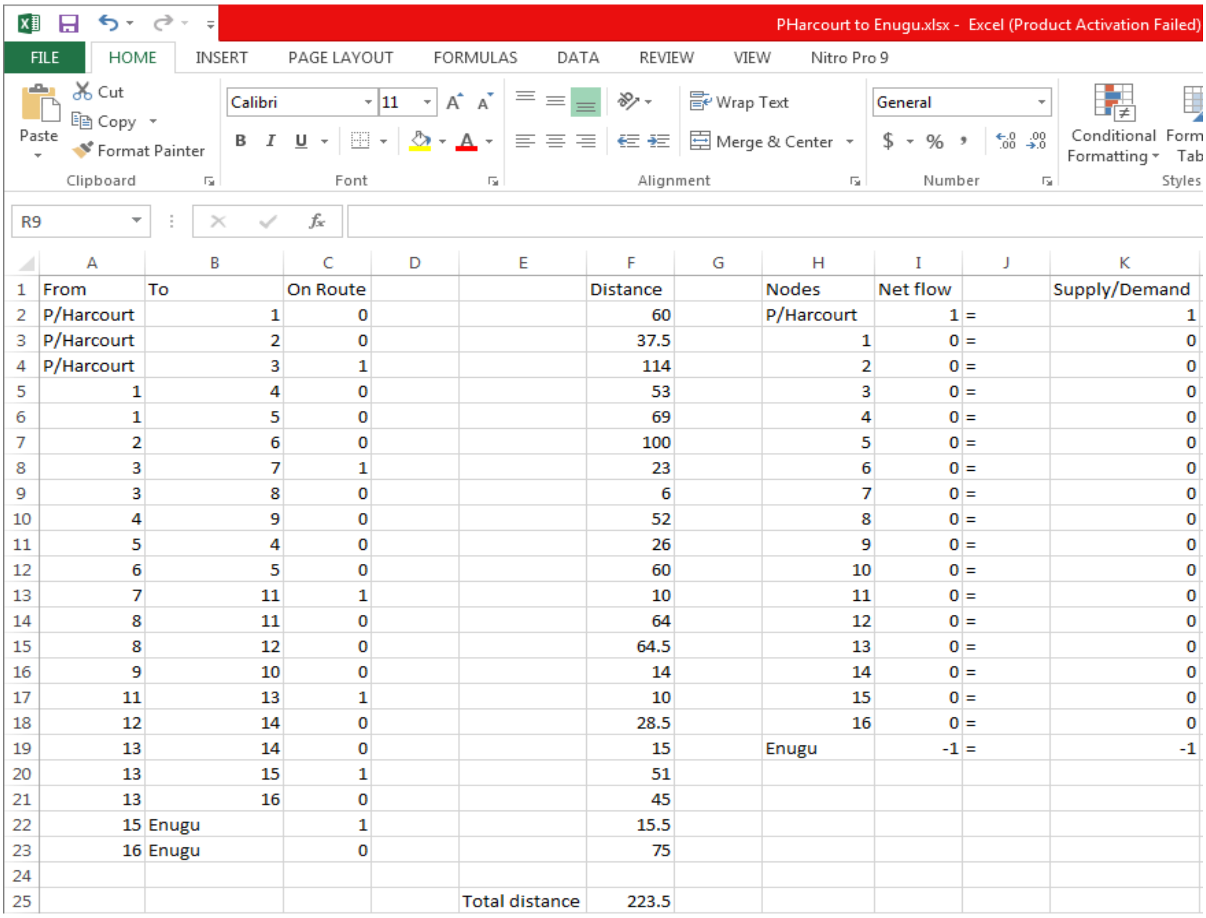
	A	B	C	D	E	F	G	H	I	J	K
1	From	To	On Route			Distance		Nodes	Net flow		Supply/Demand
2	P/Harcourt	Aba	1			60		P/Harcourt	1	=	1
3	P/Harcourt	2	0			37.5		2	0	=	0
4	P/Harcourt	3	0			114		3	0	=	0
5	2	6	0			100		4	0	=	0
6	6	5	0			60		5	0	=	0
7	5	Aba	0			69		6	0	=	0
8	5	4	0			26		Aba	-1	=	-1
9	4	Aba	0			53					
10											
11					Total Distance	60					

Fig. 4 Shortest route from Port Harcourt to Aba.



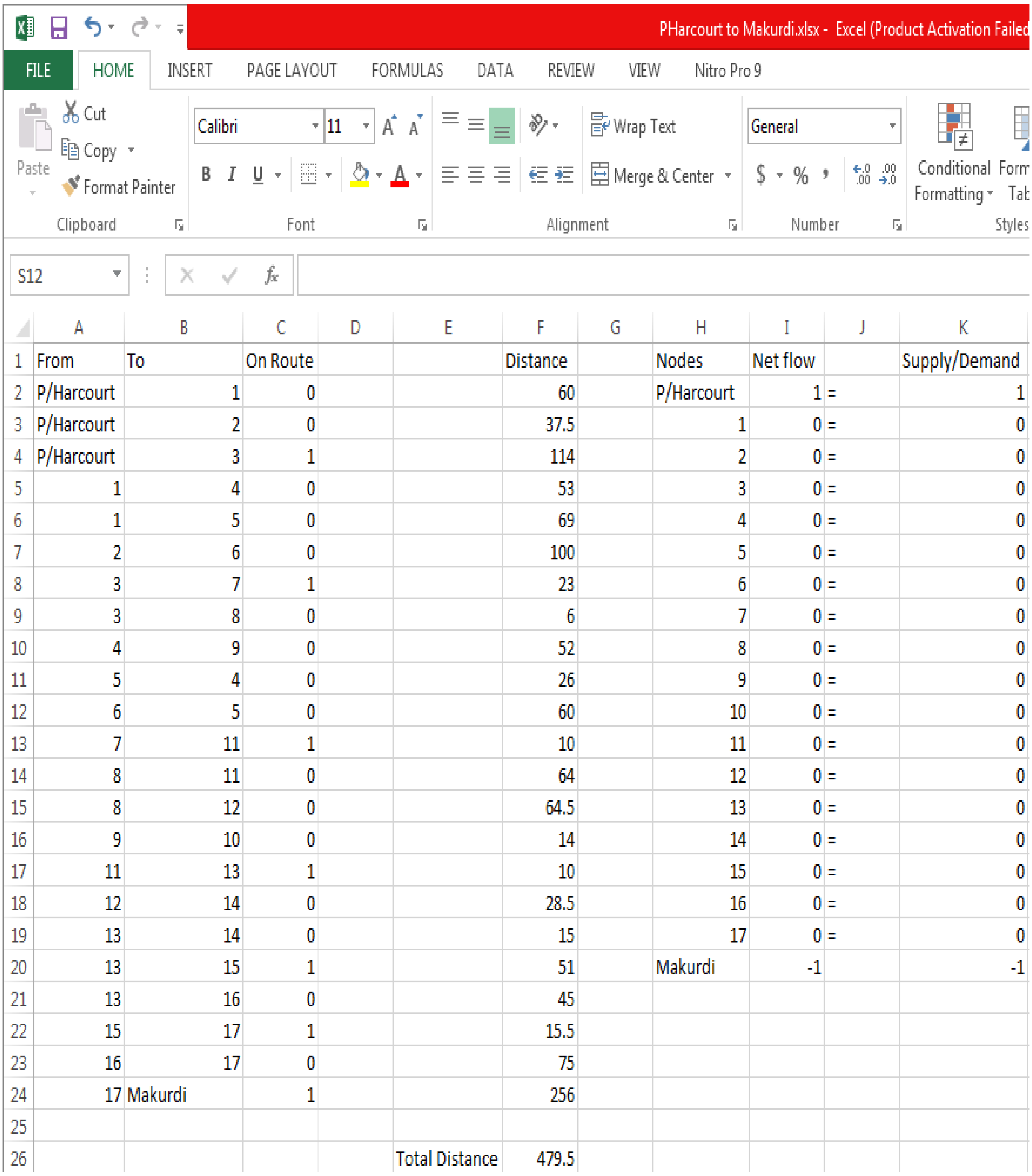
	A	B	C	D	E	F	G	H	I	J	K
1	From	To	On Route			Distance		Nodes	Net flow		Supply/Demand
2	P/Harcourt	1	1			60		P/Harcourt	1	=	1
3	P/Harcourt	2	0			37.5		1	0	=	0
4	P/Harcourt	3	0			114		2	0	=	0
5	1	4	1			53		3	0	=	0
6	1	5	0			69		4	0	=	0
7	2	6	0			100		5	0	=	0
8	4	9	1			52		6	0	=	0
9	5	4	0			26		9	0	=	0
10	6	5	0			60		Calabar	-1	=	-1
11	9	Calabar	1			10					
12											
13											
14					Total Distance	175					

Fig. 5 Shortest route from Port Harcourt to Calabar.



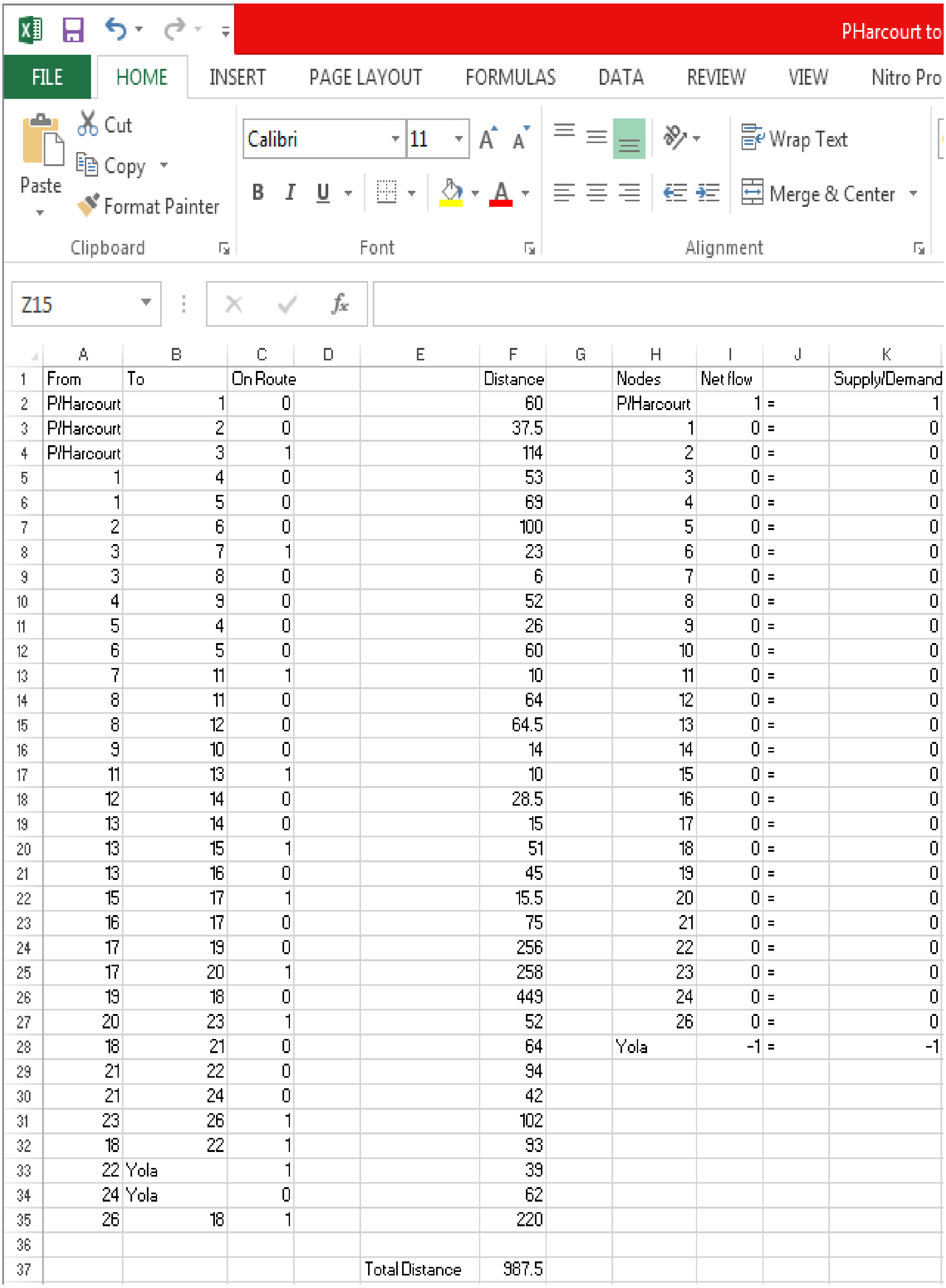
	A	B	C	D	E	F	G	H	I	J	K
1	From	To	On Route			Distance		Nodes	Net flow		Supply/Demand
2	P/Harcourt	1	0			60		P/Harcourt	1	=	1
3	P/Harcourt	2	0			37.5		1	0	=	0
4	P/Harcourt	3	1			114		2	0	=	0
5	1	4	0			53		3	0	=	0
6	1	5	0			69		4	0	=	0
7	2	6	0			100		5	0	=	0
8	3	7	1			23		6	0	=	0
9	3	8	0			6		7	0	=	0
10	4	9	0			52		8	0	=	0
11	5	4	0			26		9	0	=	0
12	6	5	0			60		10	0	=	0
13	7	11	1			10		11	0	=	0
14	8	11	0			64		12	0	=	0
15	8	12	0			64.5		13	0	=	0
16	9	10	0			14		14	0	=	0
17	11	13	1			10		15	0	=	0
18	12	14	0			28.5		16	0	=	0
19	13	14	0			15		Enugu	-1	=	-1
20	13	15	1			51					
21	13	16	0			45					
22	15	Enugu	1			15.5					
23	16	Enugu	0			75					
24											
25					Total distance	223.5					

Fig. 6 Shortest route from Port Harcourt to Enugu.



	A	B	C	D	E	F	G	H	I	J	K
1	From	To	On Route			Distance		Nodes	Net flow		Supply/Demand
2	P/Harcourt	1	0			60		P/Harcourt	1	=	1
3	P/Harcourt	2	0			37.5		1	0	=	0
4	P/Harcourt	3	1			114		2	0	=	0
5	1	4	0			53		3	0	=	0
6	1	5	0			69		4	0	=	0
7	2	6	0			100		5	0	=	0
8	3	7	1			23		6	0	=	0
9	3	8	0			6		7	0	=	0
10	4	9	0			52		8	0	=	0
11	5	4	0			26		9	0	=	0
12	6	5	0			60		10	0	=	0
13	7	11	1			10		11	0	=	0
14	8	11	0			64		12	0	=	0
15	8	12	0			64.5		13	0	=	0
16	9	10	0			14		14	0	=	0
17	11	13	1			10		15	0	=	0
18	12	14	0			28.5		16	0	=	0
19	13	14	0			15		17	0	=	0
20	13	15	1			51		Makurdi	-1		-1
21	13	16	0			45					
22	15	17	1			15.5					
23	16	17	0			75					
24	17	Makurdi	1			256					
25											
26					Total Distance	479.5					

Fig. 7 Shortest route from Port Harcourt to Makurdi.



	A	B	C	D	E	F	G	H	I	J	K
1	From	To	On Route			Distance		Nodes	Net flow		Supply/Demand
2	P/Harcourt	1	0			60		P/Harcourt	1	=	1
3	P/Harcourt	2	0			37.5		1	0	=	0
4	P/Harcourt	3	1			114		2	0	=	0
5	1	4	0			53		3	0	=	0
6	1	5	0			69		4	0	=	0
7	2	6	0			100		5	0	=	0
8	3	7	1			23		6	0	=	0
9	3	8	0			6		7	0	=	0
10	4	9	0			52		8	0	=	0
11	5	4	0			26		9	0	=	0
12	6	5	0			60		10	0	=	0
13	7	11	1			10		11	0	=	0
14	8	11	0			64		12	0	=	0
15	8	12	0			64.5		13	0	=	0
16	9	10	0			14		14	0	=	0
17	11	13	1			10		15	0	=	0
18	12	14	0			28.5		16	0	=	0
19	13	14	0			15		17	0	=	0
20	13	15	1			51		18	0	=	0
21	13	16	0			45		19	0	=	0
22	15	17	1			15.5		20	0	=	0
23	16	17	0			75		21	0	=	0
24	17	19	0			256		22	0	=	0
25	17	20	1			258		23	0	=	0
26	19	18	0			449		24	0	=	0
27	20	23	1			52		26	0	=	0
28	18	21	0			64		Yola	-1	=	-1
29	21	22	0			94					
30	21	24	0			42					
31	23	26	1			102					
32	18	22	1			93					
33	22	Yola	1			39					
34	24	Yola	0			62					
35	26	18	1			220					
36											
37					Total Distance	987.5					

Fig. 8 Shortest route from Port Harcourt to Yola.

IV. DISCUSSION

From figure 4, the shortest route from Port Harcourt refinery to Aba depot is Port Harcourt refinery → Aba depot with the total distance of 60km. But from the data collected from Cross Country Limited, the route is very bad and the finest route is Port Harcourt → Oguni → Eket → Uyo →Itu→ Aba = 167km.

From figure 5, the shortest route from Port Harcourt to Calabar is Port Harcourt → 1 → 4→ 9 →Calabar, where from figure 3, 1 represents Aba, 4 represents Itu, 9 represents Odukpani. Hence, the shortest route from Port Harcourt to Calabar is: Port Harcourt → Aba → Itu → Odukpani → Calabar with the total distance of 179km. Similarly from the data collected from Cross Country Limited, from Port Harcourt to Aba is not good, making the route not the finest even though shortest. The finest route is Port Harcourt → Oguni → Eket → Uyo → Itu → Odukpani → Calabar = 2 74.5km.

From figure 6, the shortest route from Port Harcourt to Enugu is Port Harcourt → 3 → 7 →11 → 13 →15 → Enugu, where from figure 3, 3 presents Umuahia, 7 represents Isinweke, 11 represents Okigwe, 13 represents Augu and 15 represents Udi. Hence, the shortest route from Port Harcourt refinery to Enugu depot is: Port Harcourt refinery → Umuahia → Isinweke → Okigwe → Augu → Udi → Enugu depot with the total distance of 223.5km. And this coincide with the data collected from Cross Country Limited. Thus, the route is optimal.

From figure 7, the shortest route from Port Harcourt to Makurdi is Port Harcourt → 3 → 7 → 11 → 13 →15 → 17 → Makurdi, where from figure 3, 3 presents Umuahia, 7 represents Isinweke, 13 represents Okigwe, J represents Augu and 17 represents Enugu. Hence, the shortest route from Port Harcourt refinery to Makurdi depot is: Port Harcourt refinery → Umuahia → Isinweke → Okigwe → Augu → Udi → Enugu → Makurdi depot with the total distance of 479.5km. And this coincide with the data collected from Cross Country Limited. Thus, the route is optimal.

From figure 8, the shortest route from Port Harcourt to Yola is Port Harcourt → 3 → 7 → 11 → 13 →15 → 17 → 20 → 23 → 26 → 18 → 22 → Yola, where from figure 3, 3 present Umuahia, 7 represents Isinweke, 11 represents Okigwe, 13 represents Augu, 15 represents Udi, 17 represents Enugu, 20 represents Gboko, 23 represents Katsina Ala, 26 represents Wukari, 18 represents Jalingo and 22 represents Numan. Hence, the shortest route from Port Harcourt refinery to Yola depot is: Port Harcourt refinery → Umuahia → Isinweke → Okigwe → Augu → Udi → Enugu → Gboko → Katsina Ala → Wukari → Jalingo → Numan → Yola depot with the total distance of 987.5km. And this coincide with the data collected from Cross Country Limited. Thus, the route is optimal.

V. SUMMARY

In this work, data of the PHRC road network was collected using map reading, a network was developed and solved. Optimal routes from the refinery to the five depots outside the refinerytown was obtained. All possible routes from the refinery to the 5 depots outside the refinery towns was established. Also, the summary of the result is:

1. Port Harcourt refinery → Aba depot = 60km.
2. Port Harcourt refinery → Aba → Itu → Odukpani → Calabar depot = 179km
3. Port Harcourt refinery → Umuahia → Isinweke → Okigwe → Augu → Udi junction → Enugu depot = 223.5km.
4. Port Harcourt refinery → Umuahia → Isinweke → Okigwe → Augu → Udi junction → Enugu → Makurdi depot = 479.5km.
5. Port Harcourt refinery → Umuahia → Isinweke → Okigwe → Augu → Udi junction → Enugu → Gboko → Katsina Ala → Wukari → Jalingo → Numan → Yola depot = 987.5km.

VI. CONCLUSION

We have successfully developed and analyzed the road network for transporting refined products from the source (Port Harcourt) to the 5 destinations outside the refinery town.

In addition, an Excel solver was used to speedily analyze the network and the solution confirm to the real life situation. Figure 9 below is the network showing the critical paths where red node is the refinery town and blue nodes are the depot towns.

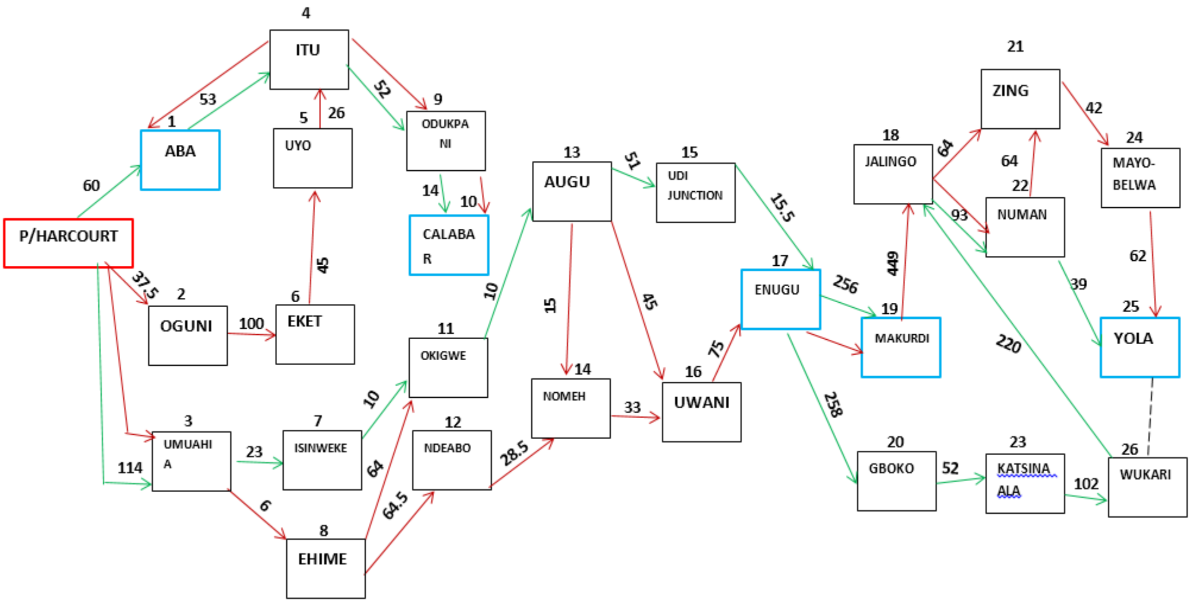


Fig. 9 PHRC Road Network. Where Red node is refinery town and the blue node is a depot town.

Optimal Route (shortest, safest and good Good routes but longer.

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