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# Optimizing the network of the distribution of petroleum products for pipelines mating company (PPMC) from refinery to depots using MS-MD pathfinder

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**Abstract**
In this research work, the Multiple Sources – Multiple Destinations pathfinder (MSMD-pathfinder) was used to obtain the shortest route from the three Nigerian refineries at Port Harcourt, Warri, Kaduna, and the Apapa atlas cove jetty in Lagos to the sixteen deports located outside the refinery towns. The Optimal routes of the refineries and the Apapa atlasCove Jetty to the sixteen deport by road were obtained. The distance of the various roads in the Nigeria road networks was obtained using Google map from Google GPSand Nigeria Atlas map. The shortest routes obtained compare favorably with the actual ones and were found to be the best.

**Keywords:** Shortest route, petroleum, road network, network model, pipeline, products

## Introduction
The Pipeline and Product Marketing Company (PPMC) receives crude oil from the Nigeria National Petroleum Corporation (NNPC) unit called the National Petroleum Investments Management Services (NAPIMS). The PPMC then supplies the crude oil to the NNPC local refineries. However, petroleum products are sometimes imported to supplement local production when the local refineries are unable to process enough for the country's needs. Petroleum products, either imported or refined locally, are received by the PPMC through import jetties and pipelines and distributed through pipelines to depot strategically located all over the country from where petroleum tankers lift the products to designated retail outlets. There is also a provision for using the rail system to move from some of the PPMC depots to designated retail outlets. Over the past years the cost of transporting these products through the pipeline network annually has amounted to billions of dollars. The production and distribution of petroleum products in Nigeria downstream sector is an important factor in her domestic economy. From 1970 to date, the nation has invested substantially in refineries, storage depots and pipelines. The total pipeline network is about 4500km (PPMC, 1994a) [7]. Unfortunately, within the past few years, the supply of these petroleum blends to storage depots and then to consumers has not been enough to meet the increasing demand, which includes: Domestic sector, Industrial sector, Transport and Agricultural sectors (PPMC, 1994b) [6].

The influences underlying the consumption of major petroleum products, both for transport and domestic activities, have received a great deal of attention since the first oil crisis in the early 1970s (Espey, 1996) [4]. In addition to determining the key influences on the consumption of petrol and other products like House Hold Kerosene (HHK) and Automatic Gas Oil (AGO), many studies examining fuel demand have been undertaken to predict future demand (Banaszak et al., 1999 and Ediger and Akar, 2007) [1, 2]. Proper scheduling of the distribution through pipeline networks can facilitate the economic integration of refinery locations and storage depots for easy shipments of the products from refineries to depot locations and then to consumers at minimum delivery cost (Eke and Enibe, 2007) [3].

The Nigerian refineries with their locations are as follows:

- Port Harcourt Refinery Company limited (PHRC) situated in Port Harcourt, Rivers State.
- Warri Refinery and Petrochemical Company Limited (WRPC) situated in Warri, Delta State.

- Kaduna Refinery and Petrochemical Company Limited (KRPC) situated in Kaduna, Kaduna State.
- Apapa, Atlas core jetty, Lagos where imported refined petroleum products are stored.

The storage depots are located in Aba, Enugu, Makurdi, Yola, Benin, Ore, Mosimi, Atlas-cove and Satellite both in Lagos, Ibadan, Ilorin, Suleje, Minna, Kaduna, Jos, Gombo, Maiduguri, Kano, Port Harcourt, Warri, Calabar and Gusau. As shown in Figure 1: below:

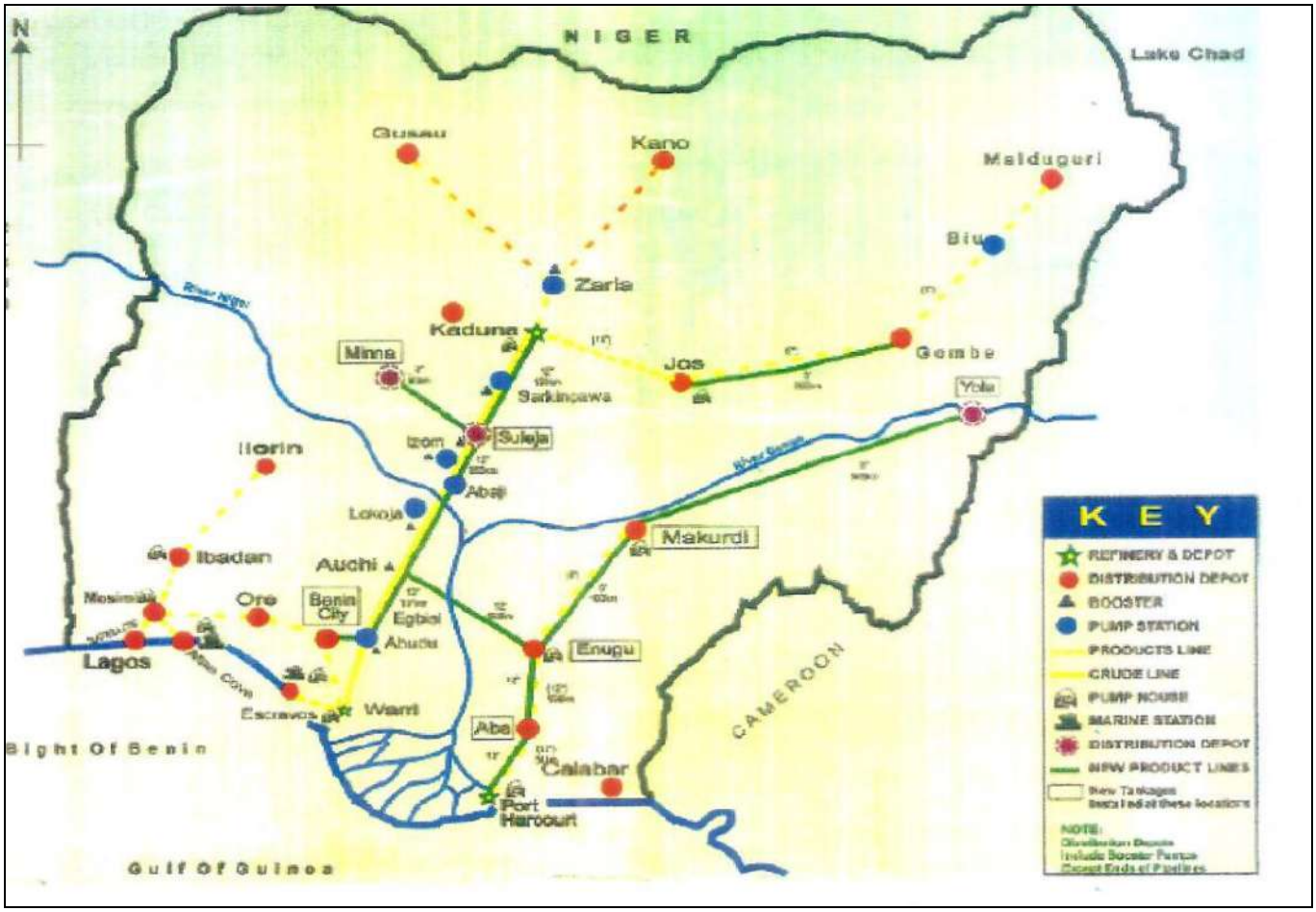


**Fig 1:** NNPC-PPMC Crude Oil and Products Pipeline Network (Source: PPMC, 1994a) [7]

To enhance the distribution of crude oil products from the oil rich of the Niger delta to other parts of the country, a grid of oil pipeline was constructed to link some of the states at strategic locations. The network consists of multi-product pipelines and crude oil pipelines that crisscross the country and from a grid that links 23 petroleum storage depots to the four refineries at Port Harcourt (I and II), Kaduna and warri, the off-short terminal Bonny and Escravos and the jetties at Atlas cove, Calabar, Okirika and Warri. However, the vandalization of oil pipeline installations has assumed worrisome dimensions and a variety of forms in Nigeria. Variousterms, 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 both lead to the severe shortages of the products which,in turn, lead to loss of billions of naira and loss of innocent lives by fire incidents caused by pipeline vandalization. This act of pipeline vandalization leaves NNPC with almost one potion of distributing refined products to the 23 storage depots. This option is nothing but trucking (i.e. transporting by road). Hence in this research work, we examine road network in Nigeria with the possibility of obtaining the shortest routes from each of the four sources to the 16 depots outside the refinery town, in order to optimize the cost of transporting such products within Nigeria using the computer package designed by Ikpotokin and Tamber. (2017) [5].

**Formulation of the Problem**

The KRPC, WRPC, PHRC and the Apapa Atlas cove jetty road network in Figure 2, Figure 3, Figure 4, and Figure 5 respectively where modeled out of Figure1. Which is the NNPC and PPMC crude oil, and products pipeline networks.

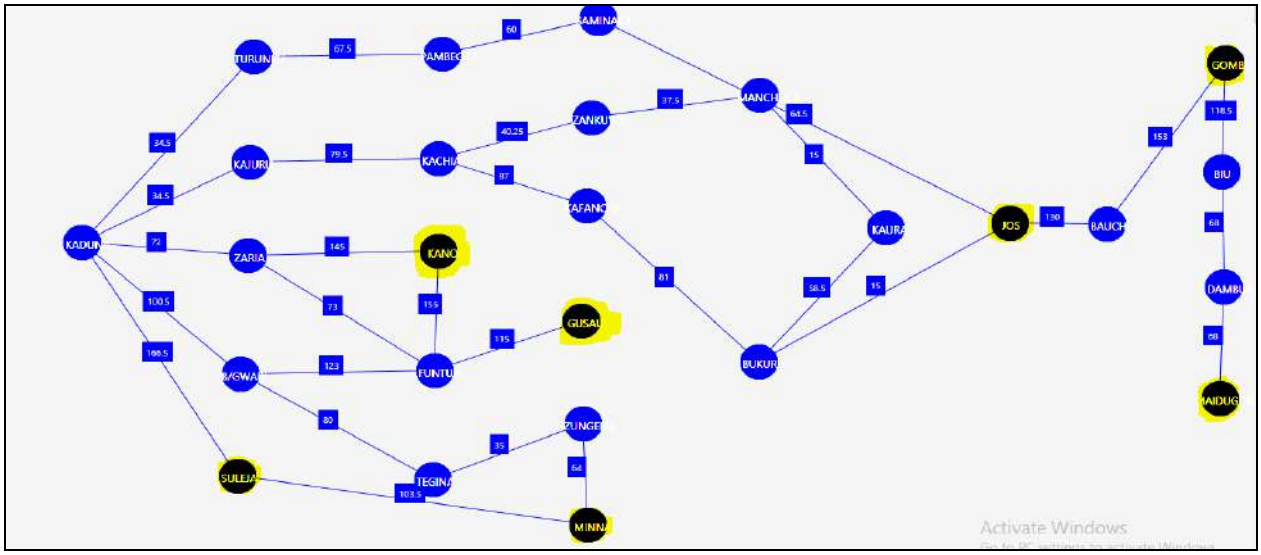


**Fig 2:** The Road Network from KRPC to the Depots

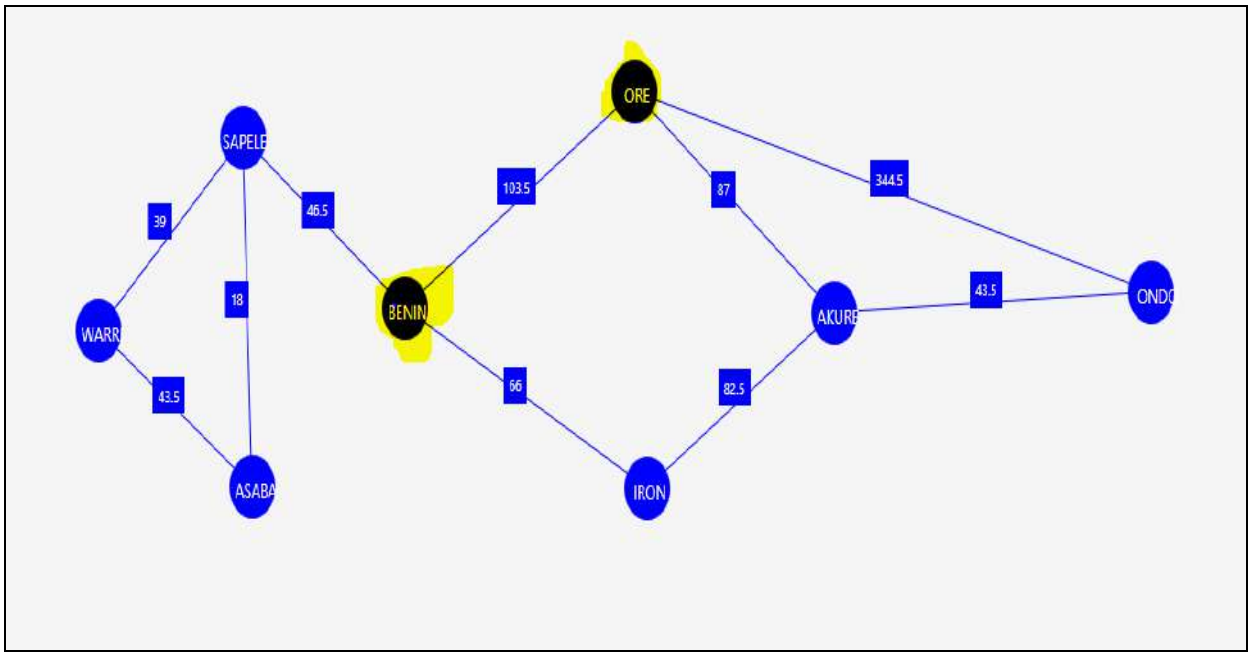


**Fig 3:** The Road Network from WRPC to the Depots.

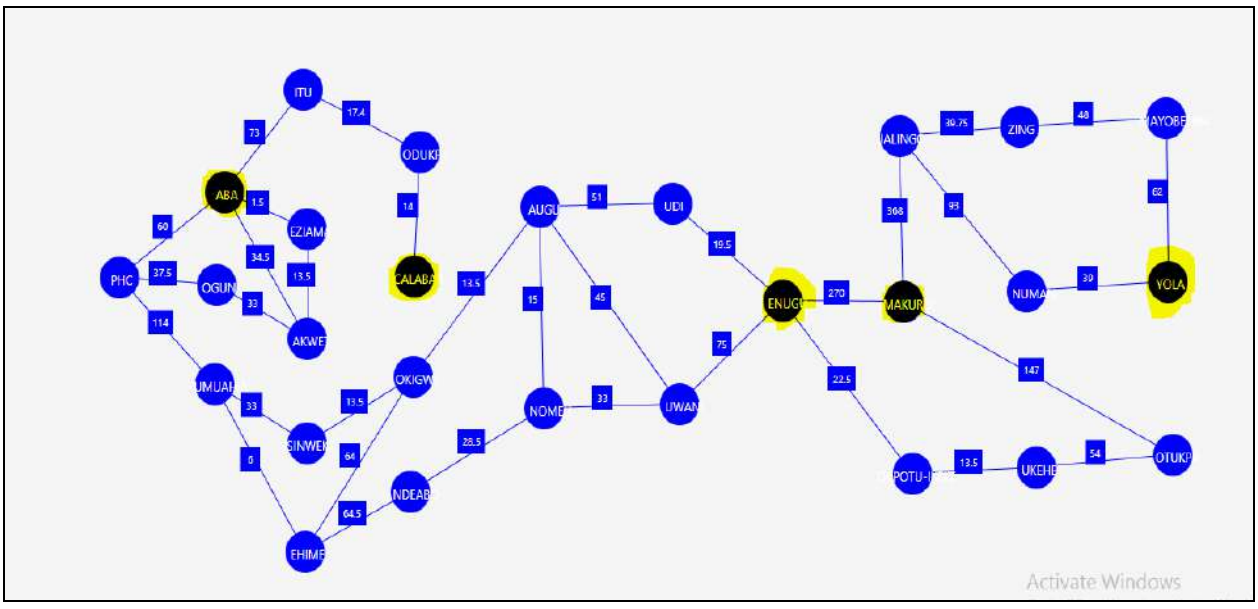


**Fig 4:** The Road Network from PHRC to the Depots.

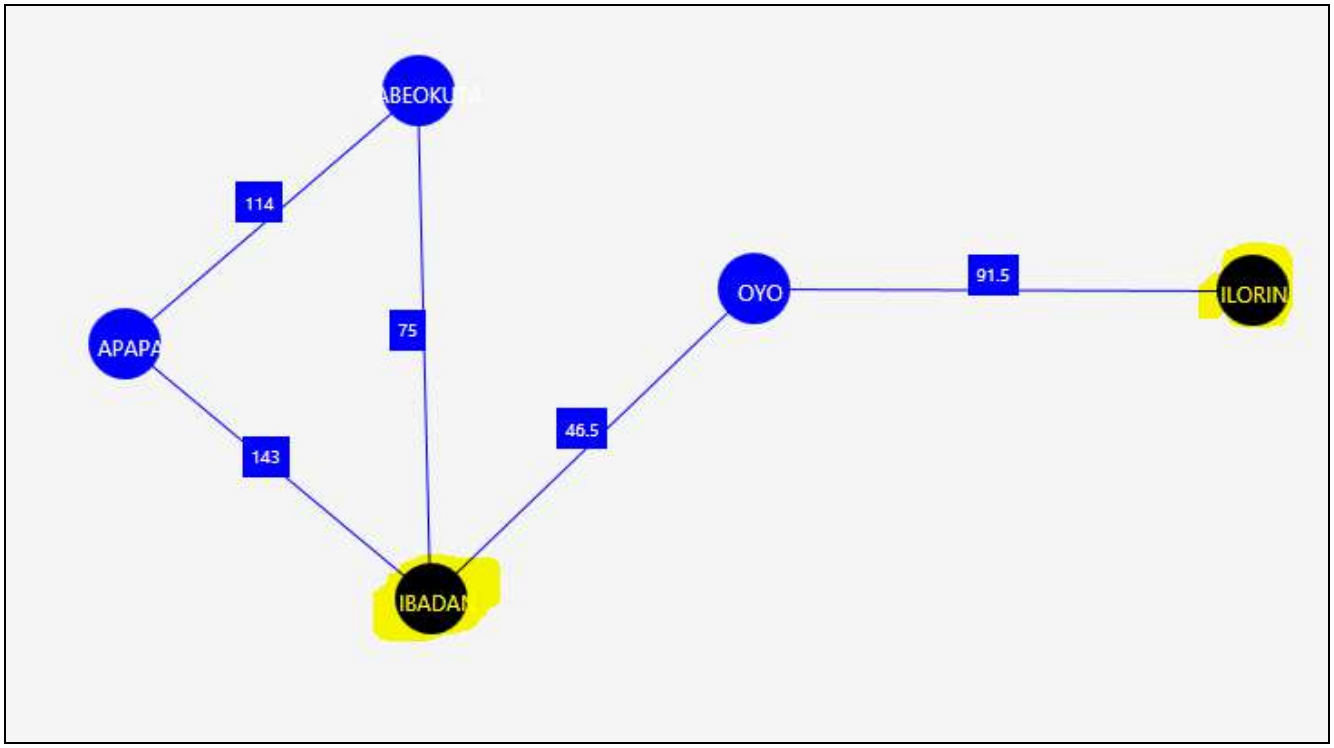


**Fig 5:** The Road Network from Apapa Atlas cove Jetty to the Depots.

**Solution**

Subjecting the models in Figure 2, Figure 3, Figure 4, and Figure 5 above to the MS-MD pathfinder computer package the following results were obtained.

**Results**

The results of the Figure 2, Figure 3, Figure 4,and Figure 5 are shown in Figure 6, Figure 7, Figure 8 and Figure 9 on respectively which are the shortest routes from the three(3) refries and Apapa Atlas cove Jetty road networks.

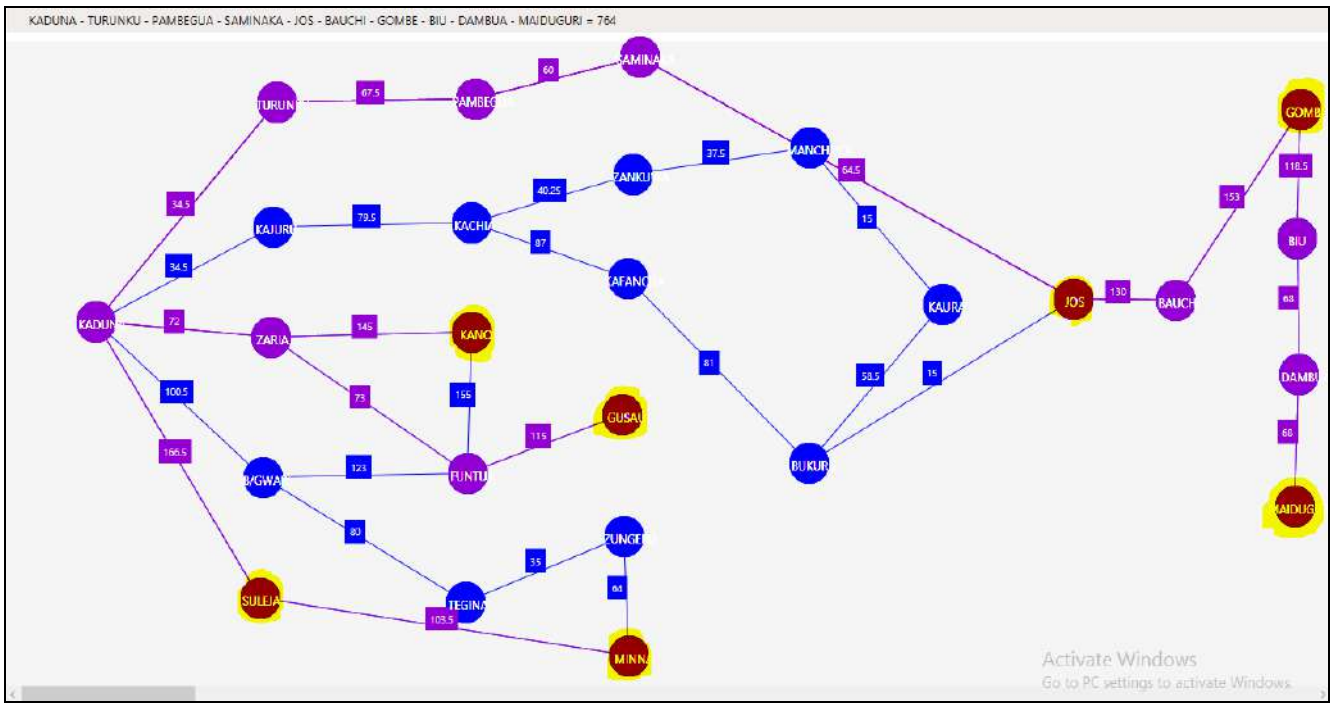


**Fig 6:** The Shortest Path of KRPC to the Destinations Depots.

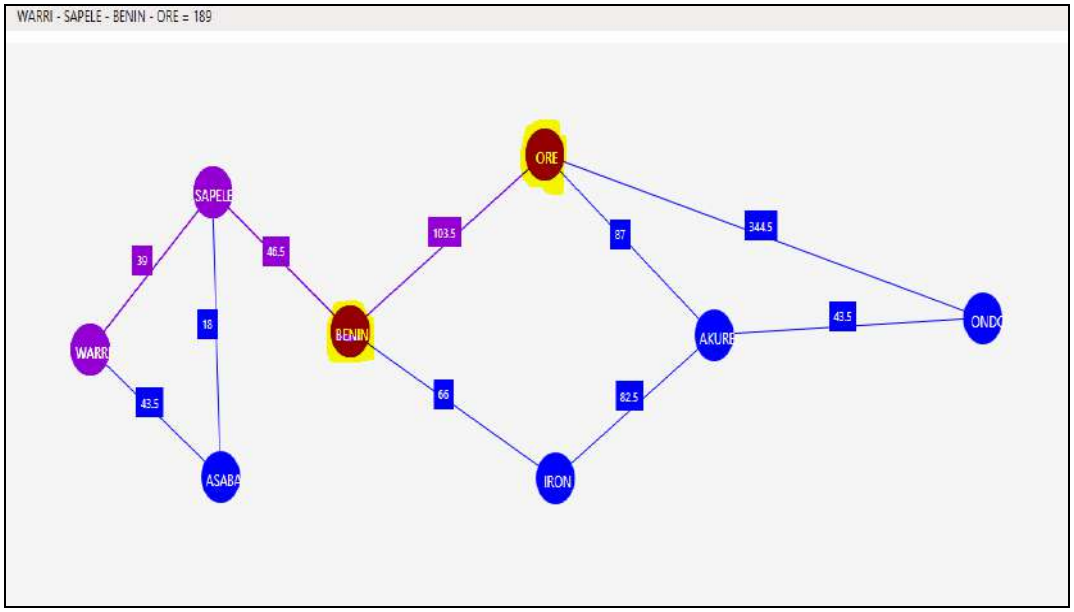


**Fig 7:** The Shortest Path of WRPC to the Destinations Depots.

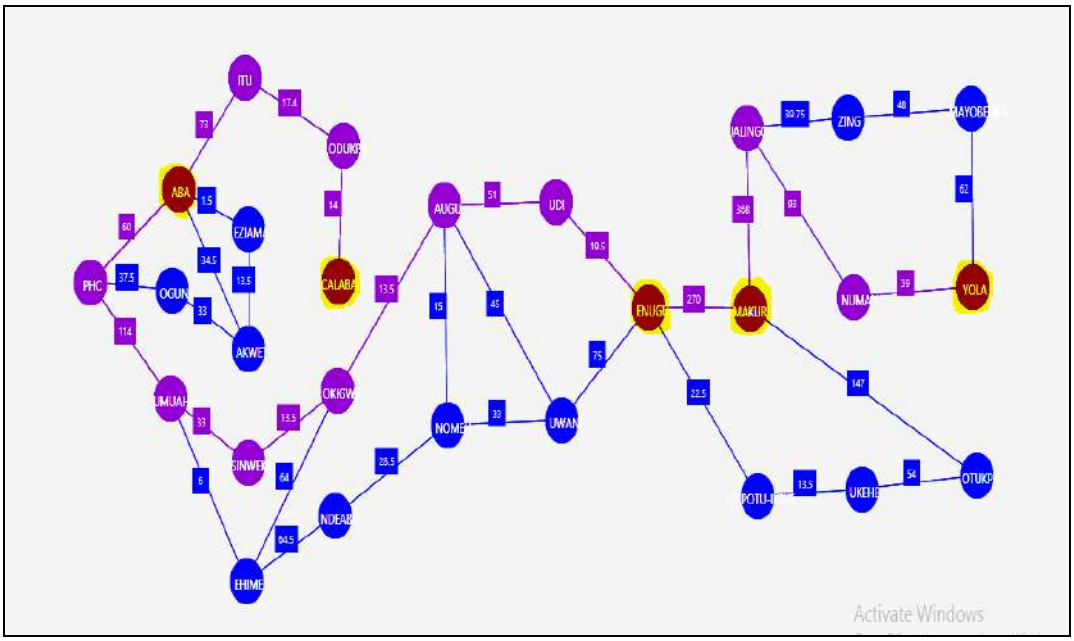


**Fig 8:** The Shortest Path of PHRC to the Destinations Depots.

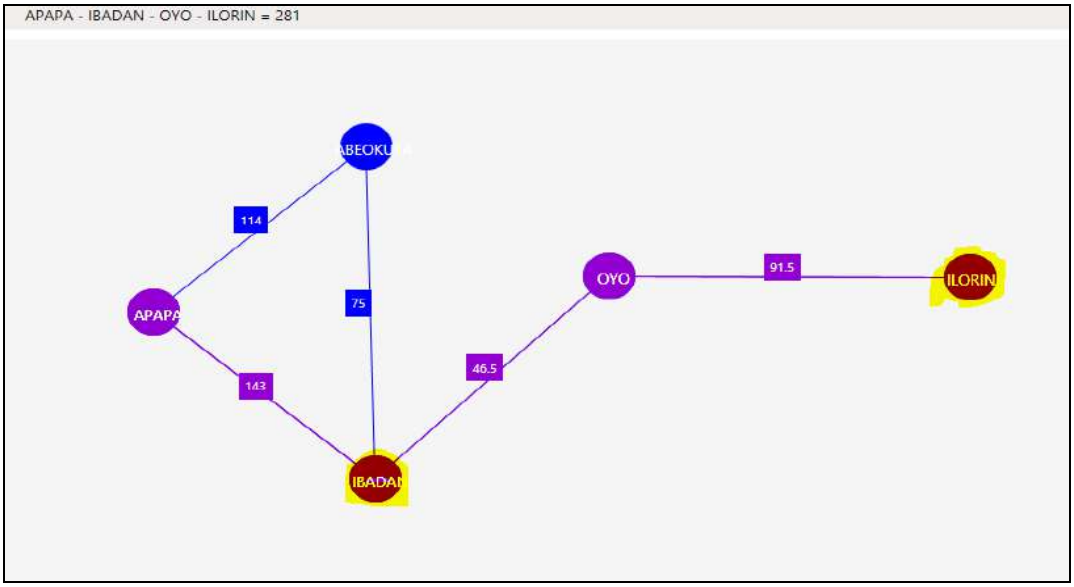


**Fig 9:** The Shortest Path of Apapa Atlas cove Jetty road network to the Destinations Depots.

**Discussion**

From figure6, the shortest routes are:

i. Kaduna to Kana = Kaduna→Zaria→Kano . = 217km
ii. Kaduna to Suleja = Kaduna →Suleja. = 166.5km
iii. Kaduna to Gusau = Kaduna →Zaria →Funtua→ Gusua =260km
iv. Kaduna to Minna =Kaduna →Suleja→ Minna =270km
v. Kaduna to Jos = Kaduna →Turunku→pambegua →Saminaka→Jos Bauchi→ Gombe =502.5km
vi. Kaduna to Maiduguni = Kaduna →Turunku →Pambegua→Samiralca→Jos →Bauchi→ Gombe→Biu→DamBua→Maiduguri= 764km

**From Figure7: the shortest routes are:**

i. Warri to Benin→ Warri→ Sapele→Benin = 85.5km
ii. Warri to Ore → Warri→ Sapele → Benin → Ore = 189km

**From figure 8: the shortest routes are:**

1. Port Harcourt to Aba = Port Harcourt →Aba=60km
2. Port Harcourt to Calabar = PHC → Aba → Itu →Oduka→ Calabar = 164.4km
3. Port Harcourt to Enugu = PHC→Umuahi→Sinweke→Okigwe→Augu→Udi→ Enugu = 244.5km
4. Port Harcourt to Makurdi = PHC → Umuahia → Sinweke→Okigwe→Augu→ Udi →Enugu→Makurdi= 514.5km
5. Port Harcourt to Maiduguri = PHC →Umuahia → Sinweke →Okigwe → Augu→Udi→Enugu→Makurdi→Jalnigo→Numan→Yola= 1014.5km
6. From figure9. The sheet routes are:
    1. Apapa to Ibadan = Apapa→Ibadan = 143km
    2. Apapa to Ilonin = Apapa→Ibadan→Oyo→Ilonin = 281km

**Conclusion**

Objectively, this study has applied some laid-down procedures to collect, analysis and interpret road-network data of the stage coach problem. The outcome of the analysis has produced four (4) separate results of the network using the MSMD-pathfinder. In conclusion, the MSMD-pathfinder should be used for determination of the optimal path (shortest route) involving many sources (multiple sources) and multiple destinations, multiple sources and single destinations, single sources and single destination and single source of multiple destinations. Unlike the existing computer packages where only the numerical part of the network model is extracted before inputting which destroys the network model beauty, the MSMD-pathfinder inputs the network models directly and the results are also presented in network tree.

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