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The Use of Dijkstra Algorithm in an Ad-Hoc African Mobile Market to Determine the Optimal Route Selection.

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ABSTRACT

Tackling Network Problem in Africa market for SMMEs (TNPA) is a project currently ongoing by Adekunle Ajasin University, Akungba-Akoko. The basic goal of the project is to look into how SMME African markets can benefit from the cloud or other technology through Information gathering and Sharing. This may be attributed to the role they play in most economies in reducing unemployment and their contribution towards gross domestic product in Nigeria. With the emergence of cloud technology, most African markets have not fully benefited from Cloud services. Literature reveals that Cloud Infrastructure is costly and not available in some rural areas in Africa. Even where it exists, they experience network failure sometimes. With the increase in numbers of people using mobile equipment, the idea of mobile cloud was introduced, Unfortunately, SMMEs in rural areas cannot afford this huge subscription coupled with Internet failure. This has made most SMMEs not getting optimum price when price negotiation is ongoing. The challenge which is the crux of this work is to determine the optimum cost between the cow buyers and the cow sellers when price tie occurs from various cow sellers. A typical seven African markets were chosen in South West Nigeria and an Ad-Hoc system is set up for buying and selling of products. The use of Dijkstra algorithm in the context of solving SSME African market is novel. In addition, the use of two options which are the distance and time of determining the optimal root and optimum price when price tie occurs is another contribution,

Keywords: Cloud, Mobile Cloud, Ad-hoc Mobile Cloud, Cow buyer, Cow seller:

1. **NTRODUCTION**

The Cloud e-marketplace is a market where goods are being exchanged for services.Two major objects are important in this market. These are the consumers and the providers. Sometimes an intermediary or middleman can participate in this market. The goods may be inform of monetary cost being provided by the consumers (Clients) while the services are being provided by the service providers(Akingbesote, Adigun, Xu, et al., 2014; Ayotuyi T Akinola et al., 2015),(Akingbesote, Adigun, Xulu, Sanjay, et al., 2014). These services may be in the form of Software as a Service (SaaS), Platform as a Service (PaaS), Infrastructure as a Service (IaaS) and Everything as a Service (EaaS). One major benefit of the cloud market is the option of pay per go(R. Buyya, C. S. Yeo, 2008).Today, the number of people using the cloud services have grown from 2.4 billion in 2013to 4.6 billion in 2018 (Statisca, n.d.).

When the cloud service started, it was based on static connection. That is, the concept of mobility was never addressed. However, in 2009, Mobile Cloud Computing (MCC) took over the major topic of discussion in the IT sector(N. Sinha, S. B. Sharma, 2017).This project was fully launched in November 2012 for the period of 36 months. The project was coordinated by SAP Research and the ICC Lab at the Zurich University of Applied Science. With the advancement of mobile technology, over one billion users are gaining from the mobile technology based on the 2014 projection in (Kim & Kim, 2018). Mobile Cloud is the technology that is based on the concept of mobility where users can make use of any mobile device like laptop, hand set to communicate with each other through the cloud. They can also have their information stored in the cloud or use any cloud Infrastructure across the Globe. With the Mobile Cloud Computing, users view their devices such as personal digital assistance (PDA), tablets, mini-tops, palm-tops etc as a medium of "computing in the pocket" through which various (mobile) transactions can be carried out.

One important thing that has made Mobile cloud computing to become popular is the concept of the wireless technology(L. Fangming, S. Peng, J. Hai, D. Linjie, 2013). This has improved the seamless integration of very fast wireless Internet connectivity. It is now possible for resource impoverish mobile devices to be able to offload enormous data storage and tasking computation processing to a more powerful and centralized cloud platform(H. Wu, Q. Wang, 2012). MCC has numerous benefits, among which are ease of integration, multi-tenancy, scalability and dynamic provisioning of services in an on demand manner. In the same vein, MCC has some challenges which has affected African SMME markets. This includes poor network connectivity and long WAN latency (L. Fangming, S. Peng, J. Hai, D. Linjie, 2013). These negative factors brought the concept of Ad-Hoc Technology (D. Kovachev, Y. Cao, 2011).

Ad hoc market is a group of mobile devices that serve as a cloud computing provider by exposing and sharing their computing resource(s)/services with other mobile devices, at the same time could request for a service. It is a collection of wireless hosts that creates a temporary network without the help of any centralized support. And there is no support for network re-configuration. Ad-hoc network has the advantage of being dynamic therefore a node can enter and leave the network anytime. In addition, it is an infrastructure-less mobile platform that enables a mobile node to source for services from other peer mobile nodes within a community of devices. Apart from these, the system allows mobile members to provide services in general to other mobile peers(G. Huerta-canepa, 2010),(Baishnab, 2014).

Despite the introduction of these various technologies, literature reveals that Africa is yet to have full benefit from these technologies. The most affected people are those in the rural area especially, people operating Small, Medium and Micro Enterprises (SMMEs). The course of this challenge may be attributed to energy, network failure, cost of setting up Infrastructures and others as earlier discussed. To solve this challenge, Adekunle Ajasin University, Akungba-Akoko, Nigeria has embarked on a project tag "Tackling Network Problem in Africa for SMME (TNPA-SMME). The basic goal is to look into how SMMEs can benefit from these technologies". The idea is to leverage on the Ad-Hoc Technology to provide services for SMMEs in African markets.

In this paper, an Ad-Hoc network is proposed for a local community in Nigeria, however the challenge is on how to determine the optimum cost for the product based on buyer preference especially where tie occurs. We tackled this challenge by the use of Dijkstra algorithm. The remaining paper is organized as follow: section II discusses the literature review. In Section III, the scenario, the formulation of the data set and the use of Dijskstra algorithm are discussed. Section IV discusses the results and discussion section and the paper ends in section V with the conclusion.

2. LITERATURE REVIEW

Many works have been done in the context of cloud markets. See(Wang & Ng, 2010)(Balamurugan & Ajay, 2013),(Alvi et al., 2012), (Xiong & Perros, 2009), . For example in (Xiong & Perros, 2009), the author viewed the cloud as single central point of entry. However, based on the works of other authors(Khazaei et al., 2012)(M et al., 2012)(Mustafa & Elmaleeh, 2013)(Akingbesote, Adigun, Jembere, et al., 2014)the generalized modeling could not reflect the current real cloud e-marketplaces. In the opinion of these authors like(Khazaei et al., 2012)(M et al., 2012)(Mustafa & Elmaleeh, 2013),(Chen & Li, 2010)(Member, 2012)(Guo et al., 2014), they viewed the cloud as series of queues service stations for optimal resource allocation. For example, in the opinion of(Mustafa & Elmaleeh, 2013)(M et al., 2012), the authors' submission is that cloud computing comprises of various servers in data centres. in proving the concept, the authors used the queue theory with M/G/m/m+ r approach to conclude that today's cloud requires the use of multiple servers for effective operation.

Unlike (Mustafa & Elmaleeh, 2013)(M et al., 2012), the focus of(Akingbesote et al., 2015) about this market is that of prioritizing urgent jobs. Based on this focus, the authors proposed the use of a non-preemptive priority policy. To further addressed this in (A.O. Akingbesote, 2015), the author believed that the cloud could be modeled dynamically. This is done by setting two service centers. The first is the working center and the other as the reservoir. When the number of clients on the queue in the working center reaches certain threshold, then control switches to the reservoir center. The author uses the molder principle as the proof of concept in terms of cost. Though, this market has been so favourable in terms of saving cost and others as earlier discussed, the issue of service provisioning to rural community especially African markets as a result of energy and network failure problems have been a great challenge. In addition, the issue of mobility of rural people that are most time on transit is another challenge.

All these have made SMMEsin Africa to face tremendous challenges that threaten their growth and survival. In (Mutoko, 2014), the author attributed the challenges being faced by Botswana SMMEs to include lack of or limited access to markets due to poor and expensive cloud Infrastructure, financial inadequacies, limited management skills, poor work ethics and lack of competitiveness. Based on these and other reasons, the authors proposed the use Mobile cloud market. The work of(Matandela, 2017)(Olawale & Garwe, 2010) investigated the obstacles to the growth of new SMMEs in South Africa using the principal component approach. The most important ones were Economic, Markets, Management and Infrastructure (external).

However, in (Matandela, 2017), the author used the concept of duality of structures (DoS) of Giddens' Structuration Theory. The theory was used in South African to see if cloud services can be a lens to innovate their businesses and become competitive in the face of global economic slowdown, high cost of IT services and inadequate e-competency. In addition, the theory was to understand and interpret the factors influencing the readiness of SMEs to adopt cloud computing. . Still on the African context, the work of (Akingbesote, Adigun, Xulu, & Jembere, 2014) proposes a cloud based mechanism that provides utility services for Small, Medium, and Macro Enterprises (SMMEs) in the context of mobile e-services. The queuing theory and the simulation model were the tools for the proof of concept. From the evaluation, African SMMEs could benefit from this mechanism especially in a prioritized e-health services.

The issue of health services was further addressed in cloud African market in (Akingbesote, 2019). authors use cloud mobile based technology to address the issue of Information Retrieval and Optimal Route Service Delivery System for Aiding the Treatment of Diabetic Patients in Nigeria. The wok faces the challenge of time taken for physicians to attend to patients due to unavailable Information and problems associated with location of hospitals. While all these authors have various contributions on how African SSMME can benefit from the cloud market and MCC services, However, the issue of Network/Internet failure and the cost of setting up the cloud infrastructure in local community have been a great set back to SMMEs growth in Africa.

The use of Mobile Ad-hoc came in to compliment these two technologies. In(A.T. Akinola et al., 2015), the authors uses analytical hierarchy model to select the Optimal QoS service in Ad-hoc mobile African market in the context of emergency service provisioning. The contribution of this work is centered on the reduction of the complexity involved by the usage of other algorithm. The issue of determine the optimal root was further addressed in (Gangwar & Krishan Kumar, 2011).

The works of all these authors are highly appreciated. For example (Mutoko, 2014)(Matandela, 2017)(Olawale & Garwe, 2010)(A.T. Akinola et al., 2015)and (Gangwar & Krishan Kumar, 2011)]. These authors have given the reseacher the basic and the fundamentl concept of understanding the Ad-hoc market. However, the short fall observed from some of these works has given the researcher the opportunity to add value to the body of knowledge. Foremost, all these works have centered on e-health, energy services and Bandwidth. However, the issue of how farmers and local apprentice can fully benefit from the Infrastructure less market has not been fully addressed. In addition, the challenge of when the service requested by the decision maker (Client) produces more than one alternative (Solution) has not also been fully addressed.

This challenge is the crux of this work. This is addressed by setting up an Ad-hoc African cow market for buying and selling of cows in typical African SMMEs in Nigeria. A search mechanism is put in place that allows consumers to providers' prices of cow. Another mechanism which is the Dijiktrar algorithm is set in place to determine the optimum root to the location of the provider in case more than one provider proffer the same solution (Price tie occurs) to further reduced cost. Two things differentiate this work from others.

- The use of Dijkstra's algorithm in the context of solving SSME African market is novel.
- The use of two options which are the distance and time for determining the optimal root when price tie occurs is another contribution

All these to the best of the researcher's knowledge is yet to appear in the literature.

3. PROBLEM FORMUATION AND SOLUTION USING AD-HOC MOBILE MARKET

3.1 Problem Formulation

There are five major cities in South West Nigeria that serve as cow markets as depicted in Figure 1. These are Oke-Agbe (Cs 1),Oka- Akoko (Cs 2), Oba-Akoko (Cs 3), Auchi (Cs 4) and Okene (Cs 5). Each of these cow sellers offer the same services but different prices. The services they offer are to provide Busty, Medium, Small, intestine and cow head with leg services. The survey of the prices of cow sellers are depicted in Table 1 and Figure 2 respectively. When a cow buyer wants to buy a cow, he needs to first make a survey of prices in the whole markets to get the optimum price. Some times the price may be the same with different cow seller. For example, the price of busty cow may be the same for cow seller 1 and cow seller 3 in two different cities or communities. In that situation, one needs to further look for other parameters that could further optimized cost. This paper addresses this using distance or the time taking from the buyer's location. The distance is represented using D 16,D20 and others while the time is represented using T2,T6 and others as shown in Figure 1.

The distance is measures in Kilometers while the time is in minutes. In this work, the decision is given by decision maker (Cow buyer) for this options. The choice of selecting distance and time is based on the fact that most road in Nigeria are bad. Therefore, some distance location to the market may be short but with bad road which invariably takes much time and costly. Also, some may be long with less time and less costly. In addition, some cow trucks based their charges on distance covered while some charge on time basis. Creating infrastructure facility to cater for this market is a challenge. This is because the only thing these farmers can afford are handsets. Therefore, an Ad-hoc mobile is needed for easy information sharing among the buyers and suppliers.

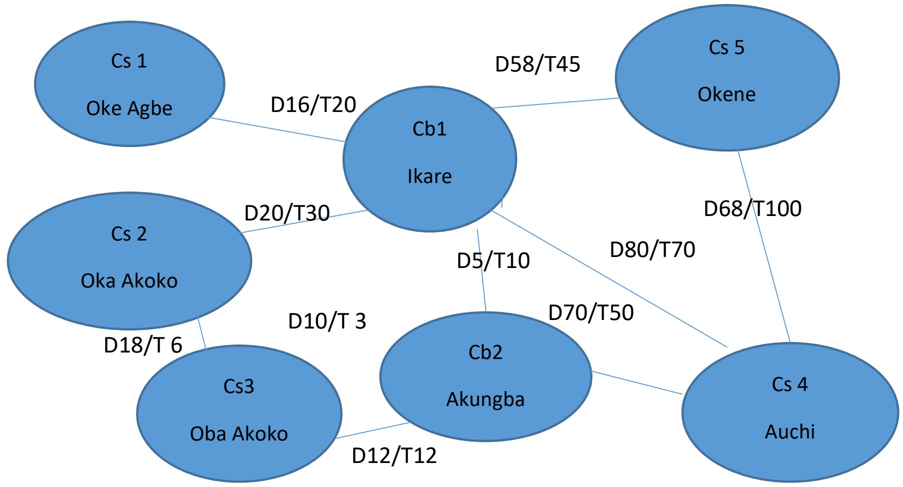

Figure 1: Cow seller location with distance and time in South West Nigeria

Table 3: Cow Price Table Survey

Services	Cs 1 (Oke-Agbe)	Cs 2 (Oka Akoko)	Cs 3 (Oba Akoko)	Cs 4 (Auchi)	Cs 5(Okene)
Busty >= 100kg	142000	160000	142000	156000	142000
99<=Medium <= 71	130000	134000	128000	130000	132200
70<=Small <=21kg	98000	94000	100000	110000	94000
Intestine <= 20 kg	67000	67000	69000	69000	67000
Cow leg with Head < 15kg	25000	24000	24000	25000	23000

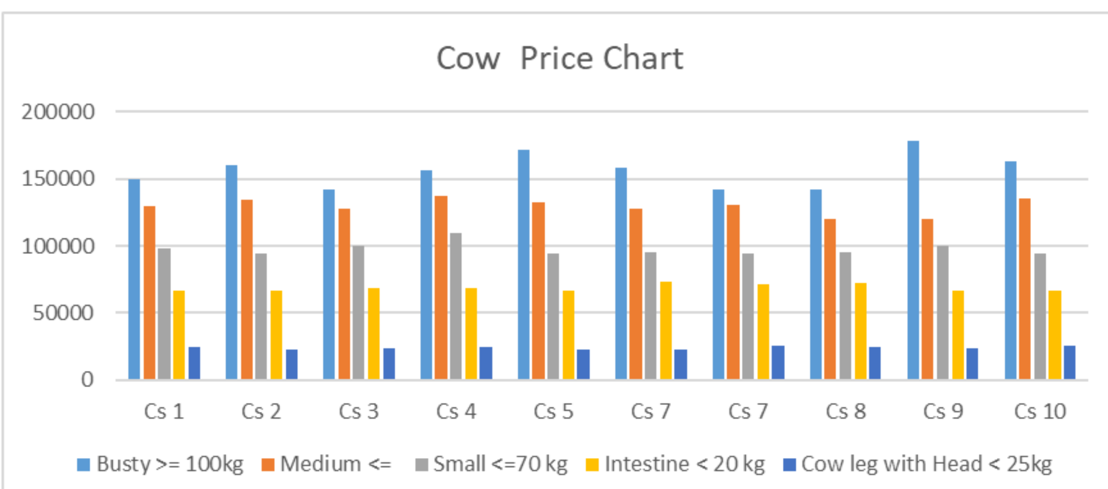

Figure 2: Cow Price Chart

3.2 Proposed Solution Approach

The proposed solution approach to solving this problem is to set up an Ad-hoc mobile market for this SMME. This market consists of various communities of cow sellers (Cs) and the other communities where cow buyers(Cb) resident. The proposed market is shown in Figure 2 and Figure 3. It consists of five Cow sellers (Cs….C5) and three Cow buyers (Cb1 …Cb3). The Algorithm in Table 2 is then proposed. The proposed algorithm is made up of three section. The normalization and the search based on decision maker preference. The second section is that which calls the Dijkstra algorithm that uses the distance or time to rank the cow sellers when the answer to user's preference is more than one (Price tie occur). The last section gives the decision maker the car seller with the minimum price based on the preference of the decision maker. The normalisation algorithm only function in the environment where the unit of the payooff are not the same. For example, some parameter are benefitial when the value or the payoff are decreasing and some are benefial when the value is going up. To have a common unit, then their need for normalization. The normalization is depicted in Table 3. In this context, the unit are the same therefore require no normalization. For further study, see our work in (A.T. Akinola et al., 2015)(Akingbesote et al., 2013). The next is the use of decision making analysis search mechanism to get the best price. The decision tree algorthm is shown in Table 4. The idea of Minmax and Maxmin is used to determine the best price based on minimum cost. The crux of this work is centered on the use of two options where the decision maker has more than one solution(Price tie occurs) and he needs to use other parameter(s) (Distance or Time) to determine the best option. This will enable the decision maker to have the optimal route selection.

The Dijkstra algorithm is depicted in Table 4. The use of relaxation approach of the Dijkstra algorithm given by d[v]=d[u]+c[v] was used to get the shortest paths and distance. This is an undirected graph as shown in Figure 3**.** The Djisktra Algorithm used five cow sellers'communities, These are Oke-Agbe,Oka- Akoko, Oba-Akoko, Auchi and Okene. and two cow buyers' communities which are Akungb-Akoko(Cb1) and Ikare(Cb2) in South West Nigeria. The distance/time are shown in Figure 1. To demonstrate this algorithms, a cow buyer from Akungba-Akoko wants to buy a busty cow from cow seller. Currently, there are five cities and five cow sellers who sell cow. He needs to know the prices of each of the cow seller to determine the best price (Minimum cost). On receiving the best, he was able to have three cow sellers with the same price tag (Price tie occurs). For further optimization of cost, he needs to know the distance/time taken to get to each of the communities to minimize cost. For this buyer to use the traditional method of going up and down will be costly and risky. All he needs is to join the Ad-hoc Mobile cow community group and launch his preference.

The optimum price (Op) is calculated using this formula.

Let
Mp = Minimum price
x = price per unit distance travelled
y = price per unit time travelled and
z = Distance covered
k = Time spent

Opd = Mp + xz ……………………………………………………………………………………………(1)
Opt = Mp + yk and …………………………………………………………………………………………(2)
Op = Min[Opd, Opt] ………………………………………………………………………………………..(3)

Where Opd = Optimun price based on distance and
Opt = Optimum based on time

The detail after launching his preference is under the discussion section.

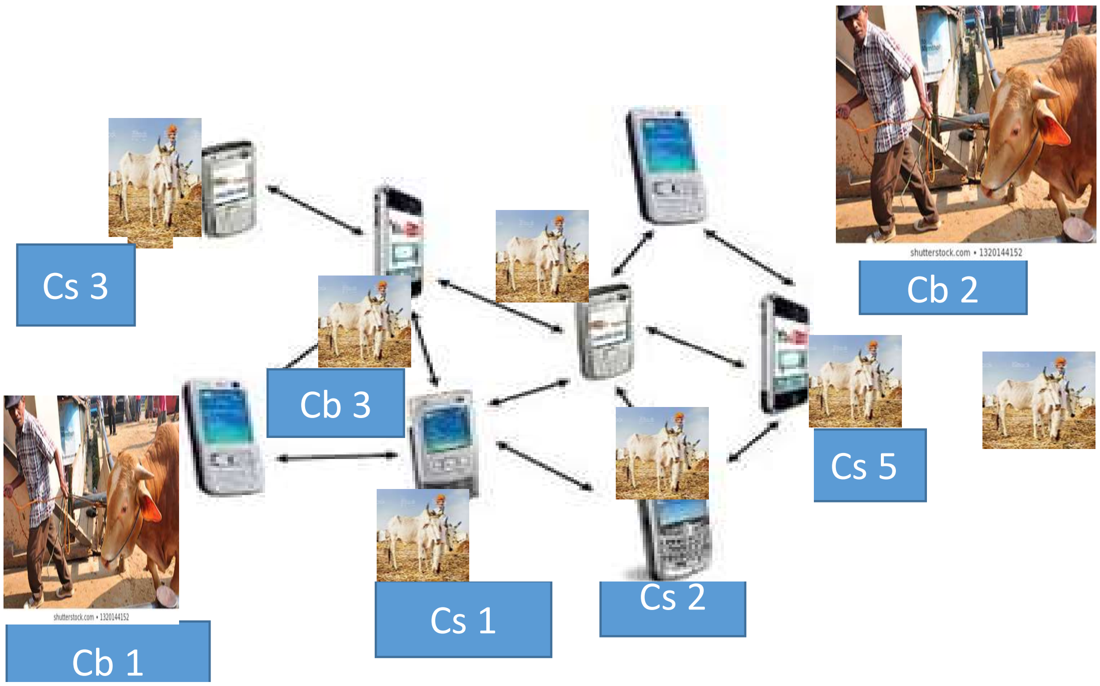

Figure 3: Proposed Ad-Mobile Market

Table 4: Proposed Ad-hoc Mobile Cow Market Algorithm

```
Set parameters (p, rt,r)
Input the decision maker QoS preference
Call normalization where different units exist
Call decision making analysis search mechanismto determine the minimum price
If minimum price is given by more than one Cs then
    Get option(DistanceorTime)
     If DistanceorTime = distance then
vertex set Q = distance
      else
vertex set Q = time
Array  TimeorDistance
     Repeat
         Call Djistral Algorithm
TimeorDistance [i] = dist
     Until the root of all Cs with minimum price is calculated
Sort  TimeorDistance [i]
     Minimum = Min [TimeorDistance [i]]
     Min(Cs) = Cs[Minimum]
Else
Min(Cs) = maxmin[]
Endif
Print Min(Cs)
```

Table 5: Normalized Algorithm

$$P = P_{ij}\,; 1 \leq I \leq n\,; 1 \leq j \leq m;$$

```
for (i = 0; i < m; i++) do
    for (j = 0; j < n; j++) do
      if(qf[j]eq 0)
            if (diffqos[j]! = 0)
          v[i][j] ← ((qmax[j] − p[i][j])/ iffqos[j]);
    else
          v[i][j] ← 1;
    end
    else  if(qf[j] eq 1)
          if (diffqos[j]! = 0)
          v[i][j] ← ((p[i][j] − qmin[j])/ iffqos[j]);
    else
          v[i][j] ← 1
    endif
      endif
```

$$V = \left(V_{i,j}; 1 \leq i \leq n, 1 \leq j \leq m;\right)$$

Table 6: Proposed Cow Market DijkstraAlgorithm

function Djiskstra (Graph, source): create vertex set Q **repeat** **for each** vertex v in Graph: distortime [v] ←INFINITY prev [v] ←UNDEFINED distortime[source] ←0 **while** Q is not empty: u ←vertex in Q with min distor time[u] remove u from Q **for each** neighbor v of u: alt ←distortime [u] +cost (u, v) **if** alt <distortime[v]: distortime[v] ←alt prev[v] ←u **return** distortime [], prev [] **until all root covered**	*// Initialization* *// Unknown distance from source to v* *// Previous node in optimal path from source* *// Distance from source to source* *// Source node will be selected first* *// Where v is still in Q* *// A shorter path to v has been found*

4. RESULTS AND DISCUSSION

Under the previous section, some algorithms were proposed to solve the problem in Table 2. In this context, the normalization algorithm is not needed because all the parameters involved have the same unit. The solution outcome of the problem is shown under the Best, Worst column of Table 5. The best is the Maximin based on minimum cost and the Minimax based on the maximum price is the worst price. From the columns, if a decision maker (Cb 2) makes a request for busty cow, the best price is #142,000 provided by Cs 1, Cs 3 and Cs5 . The worst price is from Cs 2. For the best seller of Medium cow, it is #128,000 produced by Cs 3 only. All others are depicted in Table5 and Figure 4. Under the busty cow condition, there are more than one seller with the best price (Price tie occurs). Therefore, the Dijkstra algorithm is then called to choose the minimum distance or the time taken depending on the decision maker preference from Cb 2 to Cs1, Cs 3 and Cs 5. For example, we have three roots from Cb 2 to Cs 5. These are Cb 2 →Cb 1 →Cs 5, Cb 2 → Cs 4 →Cs 5,Cb 2 → Cs 5, Using the distance as decision maker preference, the results are 5+58 (63 Km), 80 Km and 78+68 (146 Km). The shortest to Cs 5 from Cb 2 is 63 Km. The shortest to Cs 1 from Cb 2 is calculated to be 16Km and that of Cb 2 to Cs 3 is 12 Km. Based on Distance, the minimum distance is 12 kilometers from Akungba to Oba-Akoko. Using time, we have Cb 2 →Cb 1 →Cs 5 to be 55, Cb 2 → Cs 4 →Cs 5 to be 165 and Cb 2 → Cs 5 is 70 minutes. The other shortest roots to Cs 1 and Cs 3 are 30 minutes and 9 minutes respectively. Therefore, the minimum based on time is 9 which is from Akungba to Oka Akoko -Oba-Akoko.

If the cost per distance (x) is #20 and the cost per minute is #15 (y) as discussed in equation 1 and 2, then
Opd = Mp +xz = 142000 +(12*20) =142240 (from Akungba to Oba-Akoko)
Opt = Mp + yz = 142000 +(9*15) = 142135 (from Akungba to Oka Akoko -Oba-Akoko)
Op = Min[Opd, Opt] = [142240, 142135] → 142135 (from Akungba to Oka Akoko -Oba-Akoko)

The price per distance and the price per time determine the optimum price when price tie occurs. From the analysis, it is observed that Cs 3 is the best option. However, the best root that optimizes cost is from Akungba to Oka Akoko -Oba-Akoko. Though Akungba to Oba has short distance however, certain parameters like bad road, accident along the root, Police extortion, many check points and many others may be attributed to the high price. The root along Akungba to Oka Akoko -Oba-Akoko seems to be faster because of no much hindrance(s)as experienced in the other one which invariably reduces the time and the price.

Table 7: Minimum and Maximum Price Table

Services	Cs 1 (Oke-Agbe)	Cs 2 (Oka Akoko)	Cs 3 (Oba Akoko)	Cs 4 (Auchi)	Cs 4(Okene)	Maximin Min. Price	Minimax Max. Price
Busty >= 100kg	142000	160000	142000	156000	142000	142000	160000
Medium <= 100	130000	134000	128000	130000	132200	128000	134000
Small <=70 kg	98000	94000	100000	110000	94000	94000	110000
Intestine < 20 kg	67000	67000	69000	69000	67000	67000	69000
Cow leg with Head < 25kg	25000	24000	24000	25000	23000	23000	25000

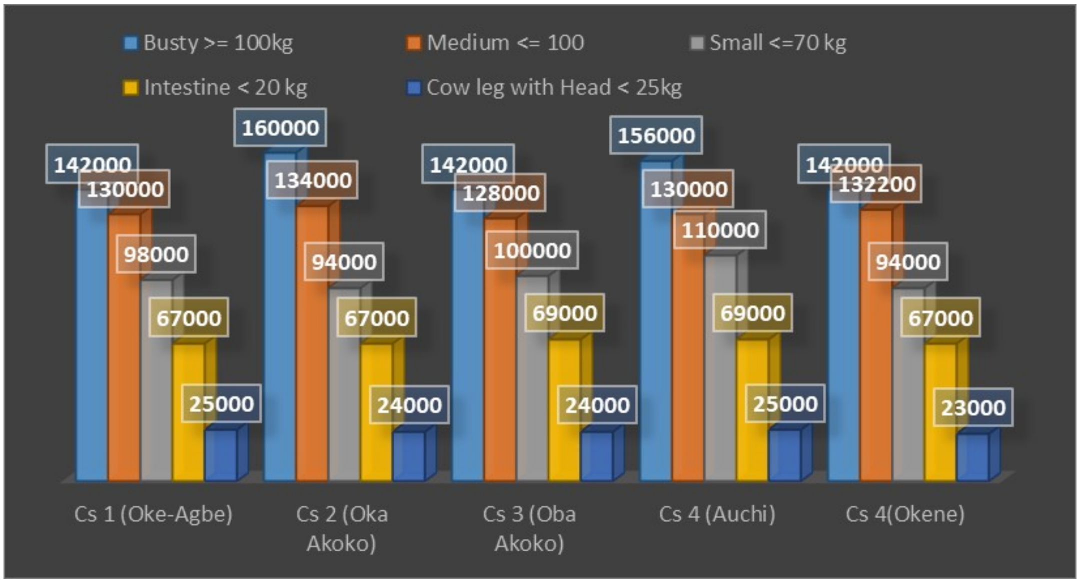

Figure 4: Minimum and Maximum price chart

5. CONCLUSION

The cloud market has come into place to provide various services to consumers by providers. The idea behind this is to reduce cost, consumers' time and others. While this market has proofed worthy to be patronized, however, setting the Infrastructures and coupled with network or Internet failure have not made it possible for African SMMEs to patronize and have the good gain of the market. With the concept of mobile services, the Mobile Cloud Computing opened the African markets to see how they can participate and benefits from this technology. This is hope to boost the economies in reducing unemployment and improve African gross domestic product in Africa especially Nigeria. The issue of network and cost of Infrastructures are also challenges to African SMMEs. Tackling Network Problem in Africa market for SMMEs (TNPA) is a project currently on going by Adekunle Ajasin University, Akungba-Akoko.

The idea behind this project is on how African SMMEs can leverage on the current technologies for Information gathering and Sharing. This paper examined an optimized infrastructure less market that could be used by African SMMEs. A typical cow market is used as the case study for buying and selling of cows. The challenge on how to optimized cost for a buyer especially when there is price tie among sellers is the crux of this work. The use Djiskstra Algorithm is proposed to determine the Optimal Root based on price tie. Seven cities are chosen as African cow markets in South West Nigeria and an Ad-hoc system is set up for buying and selling of products. The decision making analysis search mechanismis first applied to get minimum price and the Dijkstra algorithm is then applied to determine the optimum price by using distance and time where price tie occurs.

From the experiment, it is observed that optimization of cost is a function of distance and also of time. Sometimes, the distance may be short and the time may be long because of certain parameters like bad road, accident along the root, Police extortion, many check points and many others. This will invariably cause high price. Therefore, if optima price is needed for the purchase of cow, then longer road with shorter time will be the best. In the experiment conducted, though Akungba to Oba has short distance however, it has cost of #142240 while from Akungba to Oka Akoko -Oba-Akoko with long distance and shorter time has #142135. This may be attributed to the aforementioned causes. Two things this work has added to the body of knowledge. The first is the use of Dijkstra algorithm in the context of solving SMMEs African market problem.

The second is the use of two options which are the distance and time of determining the optimal root and optimum price where price tie occurs. While this market has the advantages of being used without access point and also faster than the infrastructure market being an infrastructure less market, it must be noted that challenges like bandwidth, limitation of battery life span and multi hop still need to be further addressed for the expansion of the market.

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