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A Cloud Mobile-based Information Retrieval and Optimal Route Service Delivery System for Aiding the Treatment of Diabetic Patients in Nigeria

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Keywords: *cloud, mobile, diabetes, solution, type1. type 2.*

GJCST-B Classification: *C.2.4*

ACLOUDMOBILEBASEDINFORMATIONRETRIEVALANDOPTIMALROUTESERVICEDELIVERYSYSTEMFORAIDINGTHETREATMENTOFDIABETICPATIENTSINNIGERIA

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I. Introduction

Diabetes is considered as one of the most incurable diseases in the world, and once a patient gets infected, it remains forever [1]. Early research on diabetes mellitus such as in [2], defined the disease as a genetically determined disorder of metabolism which in its fully developed clinical expression, is characterized by fasting hyperglycemia, atherosclerotic vascular disease, and neuropathy. Studies in [3] showed that in 180 million Nigerians, the estimated occurrence of diabetes is 1% in rural areas, and ranges from 5% to 7% in urban areas. That is; at least fourteen million, four hundred and six thousand (14,406,000) Nigerians are currently living with the incurable disease. The continuous and organized management of the diabetes is the only way to avoid the impact of such incurable disease. Earlier methods of treatment of diabetes was based on paper and pen work. The pictorial evaluation of patients' healthcare was not possible [4]. The past record of patient record is only on the desk of the medical expert who treated the patient. With the introduction of computer in early sixties, most doctors use the desktop to store data or information. This has some shortcomings; one of these is the concept of information sharebility within and outside the medical doctor's domain. Various research works have tried to solve this problem through the use of technology over the physical one on one treatments, see for example [5] and [6].

In [7], the use of web based was introduced. Also, the idea of using mobile health technology for solving diabetes issues was introduced in [8] and [9]. These works serve as the foundation on which other mobile health improvement was built. While these ideas have achieved great success in solving diabetes related issues. However, accessibility of diabetic information by doctors from other domains where such patient is visiting probably for the first time is a challenge. There have been over 180,000 recorded deaths of diabetic patients in Africa where Nigeria tops the list. One basic cause was because they were unable to connect their doctors from remote areas therefore making it difficult to receive treatment as soon as possible due to elongated time taken to attend to patients [10]. For example, if a patient is travelling from Lagos to Kano, and on getting to Abuja the blood sugar increases, He needs to visit any closest diabetic centre within Abuja domain. Getting

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to the hospital the patient information is not there but in Federal Medical Lagos Island where he lives. Therefore, the doctor will need to start all over to get accurate Information that will lead to proper prediction. This may take time and sometime the patient may be unconscious and much information may not be gathered. The second issue is that of getting the optimal route to the closest hospital from the patient position. If a wrong route is taken it may lead to delay and this may lead to death. Therefore, two challenges of timely information availability and optimal route selection problems are the issues this research aim at tackling in the context on Nigeria Mobile health system. To achieve this, the research proposes a cloud mobile-based Information retrieval and optimal route service delivery system for aiding the treatment of diabetic patients in Nigeria. This system will aid the minimization of the time taken by physicians to treat diabetic patients and recommend the shortest route to the available hospital.

The rest of this paper is organized as follows: Section II introduces the literature review. Section III demonstrates the design and the implementation of the system. In section IV the results are discussed and ended with the conclusion in Section V.

II. Literature Review

Cloud computing is an information technology service model that allows computing services to be provided on-demand to customers over a network in a self-service fashion and independent of devices and location. These services include Software, Infrastructure and a Platform [11]. The main idea of cloud computing is to have rapid and uninterrupted access to various services. With cloud technology, cloud service providers and consumers can interact without necessarily coming into contact [12]. Recently, several services are being deployed in cloud; examples of such services include cloud market, toys, and more importantly health services. The need to deploy health services on the cloud is numerous. The work of [13] highlighted few of the benefits of deploying health services in cloud. Furthermore, in [14], the author emphasized on the effects of deploying severe and chronic health related issues in cloud. Example of such severe health issues is Diabetes mellitus. This is a genetically determined disorder of metabolism which in its fully developed clinical expression is characterized by fasting hyperglycemia, atherosclerotic and micro-angiopathic vascular disease, and neuropathy [2]. However, in [15], the authors defined Diabetes mellitus (DM) as a glucose metabolism disease characterized by chronic hyperglycemia resulting from defects in insulin secretion, insulin action, or both. Diabetes happens because the body can't use glucose correctly either the pancreas not producing enough insulin or the cells of the body not reacting rightly to the insulin produced. This disease has three main types; type I, type II and Gestational diabetes [16]. With the evolution of technology, management of diabetes has become easy and uncomplicated. A home blood glucose test was a major leap ahead for diabetics, after the patient tests his blood glucose levels, the management system records and stores the test results and other detailed data like, date and time of tests, the type and dosage of insulin, type of exercise, diet [16]. DM poses a great threat to human health as well as a huge socioeconomic burden for governments. According to the updated data from the international diabetes federation (IDF), the estimated global prevalence of DM reached 8.8% in 2015 and 12% of global health expenditure was due to DM in the same year [1].

Advancement in ICT provides a variety of options for developing hardware and software deployment platforms for new test and sensor technologies. However, many of these products have not been optimized for usability or evaluated for their effectiveness in motivating or changing users' self-management behaviors [17]. For example, The work of [18] and [19] developed new ideas in the area of mobile technology for diabetes management, However, there are few published studies addressing which specific elements of mobile diabetes applications offers the greatest potential to benefit users effectively. Many mobile decision support software apps for smartphones are now available for diabetes and are intended to assist patients to make decisions in real time without having to contact their HCP. For example in Rao *et al.,*(2010), The author reported that they had visited the Apple iTunes store on October 9, 2009, and selected the 12 diabetes apps with the highest ratings. They found that these apps contained 22 types of data management features. The work of [20] identified and reviewed 71 commercial mobile diabetes applications available at the Apple applications store as well as 16 mobile diabetes applications from the medical literature. They found that these applications has incorporated inputted data from up to six monitoring tasks and provided up to seven support tasks. Future mobile decision support applications are expected to also incorporate information guided by global positioning systems, such as where to find nearby healthy restaurant foods. Patients with diabetes can use the information presented by apps to help guide their choices of medication doses, foods, or exercises.

Though ICT has contributed to the positive growth of health care delivery systems in major hospitals in Nigeria, however, most healthcare providers believe that improvement in telecommunication within the hospitals will also improve the quality of healthcare. For example, up to 68% of post-surgical patients have been effectively followed up using their GSM phone contacts [21]. This observation beams a ray of hope as it appears that with increasing availability of mobile phones and extension of connectivity to the rural areas, the problem t patient follow-up which has been the bane of longitudinal study design in Nigeria may be over soon. The use of telephone to schedule clinic appointments is also emerging, particularly more prominently in University College Hospital, Ibadan (UCH).

In [22], the authors emphasized that People saddled with chronic diseases need recommendations or facts regarding disease management. These include dosage adjustment of medication and other general information that highlights correction of life styles, changes in diet and physical exercise. The ubiquity of mobile phones and its current integration in health care has made it a worthy tool to this effect. The need to evolve from regular GSM call monitoring of sick patients led to e-Health. By definition, e-Health, or digital health, is the use of emerging communication and information technologies, especially the internet, to improve health management [23]. M-Health is a sub segment of e-Health, and it is the use of mobile computing and communication technologies (eg, mobile phones, wearable sensors) for health services and information [24]. Mobile health technology uses techniques and advanced concepts from an array of disciplines, for example, computer science, electrical and biomedical engineering, medicine and health-related sciences [25].

Recently, mobile phone has become the main sources of information for users. In fact, a huge number of applications were developed in different mobile operating systems to respond to the user's requirements [16]. Several applications have been created to manage diabetes. In [25], the authors designed a Framework for a Mobile-Based Alert System for patient Adherence in Nigeria. The system works by sending mobile medical alerts through SMS to patients, prompting them to take their drugs. However, the real life system wasn't implemented. The authors in [13] developed a Mobile Based Patient Compliance System for Chronic illness care in Nigeria. The phone based Patient Compliance System (MPCS) works by reducing the time-consuming and error-prone processes of existing self-regulation practice to facilitate self-reporting, non-compliance detection, and compliance reminder among patients in Nigeria. The work in [26] carried out a study on the effects of Mobile Phone Short Message Service on Antiretroviral Treatment adherence in Kenya. The study showed that several researchers have applied wireless technology in ensuring patient adherence to antiretroviral treatments. In [22], the authors designed and implemented a Voice-based Mobile Prescription Application (VBMOPA) to improve health care services. The application can be accessed anyplace anytime, anywhere through a mobile phone by dialing an appropriate number, this connects users to an e-prescription application that is resident on a web server. This system could lead to costs and life savings in healthcare centres across the world especially in developing countries where treatment processes are usually cumbersome and paper based. In [27], a system that sends Diabetes Educative materials via Mobile Text Messaging SMS messages to educate parents with Type 1 diabetic children was developed. In Norway, SMS messages were sent to educate parents with Type 1 diabetic children. Wedjat which is a mobile medication reminder and monitoring system was developed in [28]. It is a smart phone application designed to help remind its users to take the correct medication on time and record the in-take schedules for later review by healthcare professionals. Also, In [29], developed a mobile based medicine in-take reminder and monitor system. Research in [30] developed a Wireless Technology for social change was developed. It works by collecting patient information using mobile phones during home based care visits for HIV/AIDS patients. Also, BGluMon (Blood Glucose Monitor) a mobile application that permits the patient to see clearly his/her blood glucose level on daily basis was developed in [31].

The contributions of all these authors is well appreciated; however the shortcomings observed allow the research to contribute. One observation is that most of these works focus on treatment of diabetes without considering the previous Information of patients. However, experience based on past history of patient is the best method to be used or study by medical experts before prescribing any drugs, Sometime there is the need to change patient's drug and this can only be done based on the past history. The second is that of deterring the optimal route based on the current patient's position. Getting the optimal route was never explained by any of these authors. Two things that differentiated this work from others are:

a) Provisioning of Cloud based Information Retrieval system of every registered diabetic patient to be available anywhere across Nigeria through Alibaba cloud.
b) Provisioning of optimal route for diabetic patient from its current location to the available hospital where this treatment will take place. This is achieved through the use of Djisktra Algorithm.

These to the best of the researcher's knowledge is yet to appear in the literature

III. Information Retrieval and Optimal Route System (irors) Design

The Information Retrieval and Optimal route system is design are in two phases. The first phase is in the Information gathering which has to do with the registration of diabetic Information of patients in any of the 36 states of the Federal and State hospitals across the country in Nigeria. The registration allows patients with a unique key with biometric proof which serves as the primary key for proper identification and also guide against double registration. This was achieved using Java API to run on Android OS. As soon as the registration is done, the Information is recorded in Alibaba cloud as shown in Fig. 1. Whenever a diabetic's patient has a rise in glucose level such patient can visit any of the available hospital closer to where he or she is positioned. All that the doctor will need is to retrieve the current Information of the patient from the Alibaba cloud for usage. Once the Doctor has finished attending to the patient, then the patient Information is updated and return to the cloud for future use across the states. Apart from this, other Information were gathered and put in the cloud for patients to and can be retrieved anytime. These includes the:

- Method of diagnosing a patient with Diabetes Miletus
- Information of symptoms associated with Diabetes Miletus
- Information pertaining to the treatment and management of Diabetes Miletus Patient.
- Feeding Plan and type of food a Diabetes Miletus Patient should eat so as to manage his/her health.

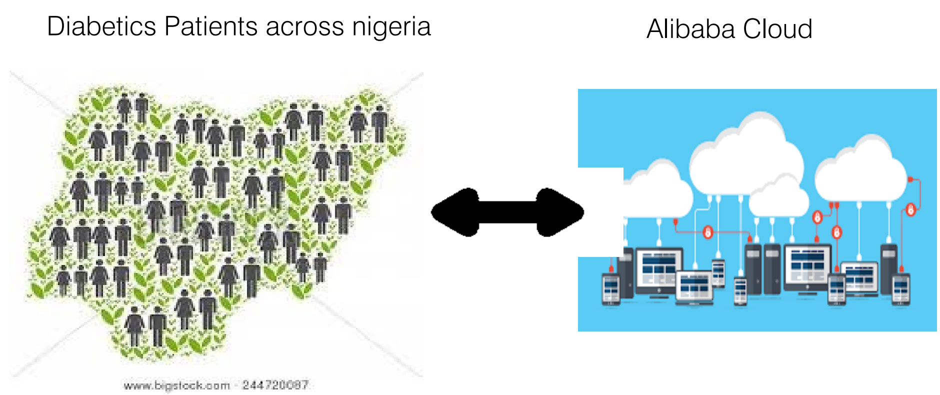

Figure 1: Cloud based Information Retrieval System

On the issue of the optimal route selection, 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. The full algorithm is in Table 1. The Djisktra Algorithm used six cities within Abuja as a prototype demonstration. These are A,B,C,,D,E and F having 2,4,1,7.3.1,2 and 5kms respectively as the distances from one location to another on the graph. This undirected graph is depicted in Figure **2** as a means of recommending the nearest hospital to patient in transit.

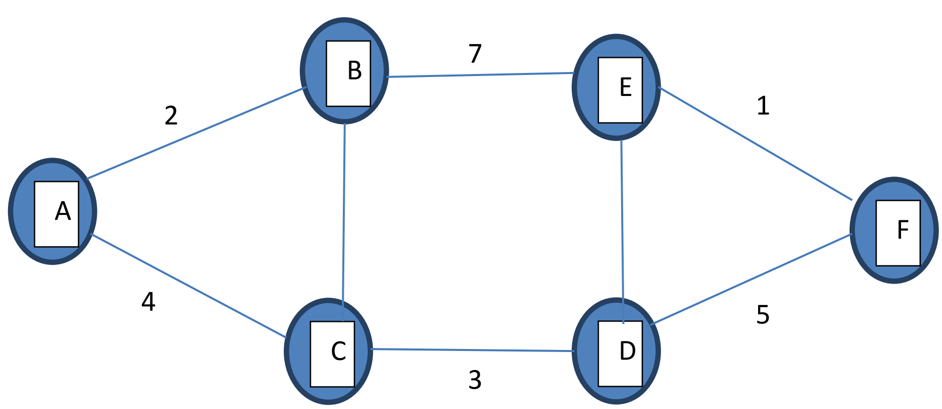

Figure 2: Shortest Path for Patient

Table 1: The Djisktra Algorithm

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

IV. Results and Discussion

Figure 3 shows part of the registration interface phase of diabetic patients during early registration. The results obtained from our experiment are in two phases. The first is into retrieval of Information of patient while the second is into getting the shortest distance and path from source that is, patient's position to destination (shortest hospital route). Table 2 to Table 8 and Figure 3 to Figure 4 attended to the first phase and Table 9 attended to the second phase. The full discussion is given under the discussion section.

V. Discussion

The mobile application has a lot of interfaces to aid diabetic patients in their treatment. One of these is the Registration page which is shown in Figure 3. This allows patients to fill their information and register as a new user, all the information is uploaded to the Alibaba cloud.

Figure 3: Registration Interface

The developed model was tested with thirty (30) patients with the use of six (6) hospitals designated by A,B,C,D,E and F and eighteen (18) physicians. Five (5) patients were assigned to hospital A, and Physicians A1 – A3 attended to the patients. Physician A1 spent twenty (20) minutes, Physician A2 spent fifteen (15) minutes, and Physician A3 spent eighteen (18) minutes on Patient 1. This is shown in Table 3. The average time spent on the patients was calculated and recorded. This is repeated for Patients 2 – 5.

The entire process was repeated in the other hospitals B, C, D, E and F, and the average time taken to attend to patients in each hospital is calculated and recorded. This is shown in Table 2 to Table 7.

Table 2: Hospital A's READINGS

Patient	Physician A_1	Physician A_2	Physician A_ 3	Average
1	20	15	18	17.67
2	15	17	22	18.00
3	17	19	23	19.67
4	16	17	17	16.67
5	15	17	19	17.00
	Average = 16.60	Average = 17.00	Average = 19.8	

Table 3: Hospital B's READINGS

Patient	Physician B_1	Physician B_2	Physician B_3	Average
1	24	12	15	17.00
2	22	17	21	20.00
3	18	24	18	20.00
4	17	18	19	18.00
5	14	13	16	14.33
	Average = 19.00	Average = 16.80	Average = 17.80	

Table 4: Hospital C's READINGS

PATIENT	PHYSICIAN C_1	PHYSICIAN C_2	PHYSICIAN C_3	AVERAGE
1	19	15	23	19.00
2	17	17	22	18.67
3	19	15	25	19.67
4	18	17	16	17.00
5	16	15	14	15.00
	Average = 17.80	Average = 15.80	Average = 20.00	

Table 5: Hospital D's Readings

Patient	Physician D_1	Physician D_2	Physician D_3	Average
1	20	15	18	17.67
2	15	17	22	18.00
3	17	19	23	19.67
4	15	19	25	19.67
5	17	16	16	16.33
	Average = 16.80	Average = 17.20	Average = 20.80	

Table 6: Hospital E's Readings

Patient	Physician E_1	Physician E_2	Physician E_3	Average
1	20	15	18	17.67
2	15	17	22	18.00
3	17	19	20	18.67
4	13	15	18	15.33
5	15	17	17	16.33
	Average = 16.00	Average = 16.60	Average = 19.00	

Table 7: Hospital F Readings

PATIENT	PHYSICIAN F_1	PHYSICIAN F_ 2	PHYSICIAN F_3	AVERAGE
1	20	15	18	17.67
2	15	17	22	18.00
3	17	19	23	19.67
4	16	22	24	20.67
5	18	23	21	20.67
	Average = 17.2	Average = 19.20	Average =21.60	

The overall reading of the developed model is shown in Figure 3. It shows the average response time recorded in the six (6) hospitals. The existing method was also tested with five (5) patients and three (3) physicians, and the time taken by physicians to attend to the patients is recorded, and the average was calculated. This is shown in Table 8. The comparison of the average time taken by physician in each hospital to attend to their patients using cloud based system was 18.05 minutes as depicted in Figure. This was compared to the current existing system that recorded 39.66 minutes as shown in Table 8 and Figure 4.

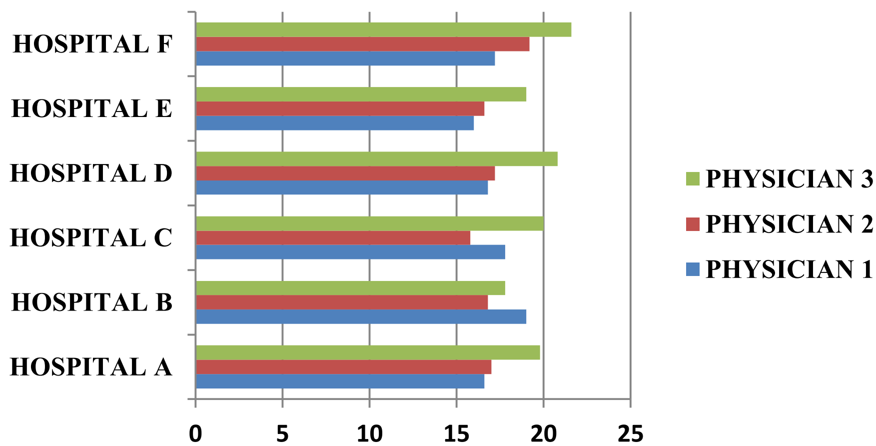

Figure 3: Overall Reading of Cloud Based Model

Table 8: Time taken (Mins.) by Physicians to attends to patients using existing system

Patient	Physician 1	Physician 2	Physician 3	Average
Patient 1	35	39	41	38.33
Patient 2	32	36	37	35.00
Patient 3	40	42	43	41.67
Patient 4	41	45	41	42.33
Patient 5	42	43	38	41.00

Average = 39.66 Minutes

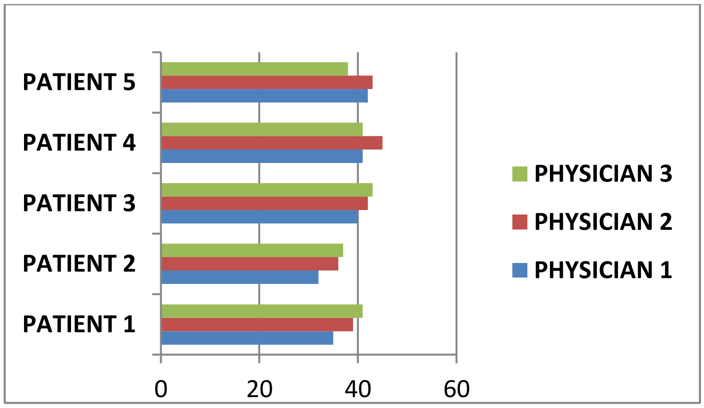

Figure 4: Readings of Existing Model

On the issue of the shortest distance and paths, the source of patient was chosen from location A and the best hospital for the treatment is location F via different paths as depicted in Figure 2 in section three earlier. The result is shown in Table 9, where the initial location was A= 0 and all other locations become ∞. Now the direct paths to A are B and C with C(u,v) to be 2 and 4 respectively. But 2 is less than∞ and less than 4. Therefore the new d(v) = 2 and is selected. Ones it has been selected the next direct paths to B is C and E with C(u,v) to be 1 and 7 respectively. This gives 3 as the minimum distance as against the former 4 in location C and 9 in E. The minimum out of 4 in C and 9 is selected. The new minimum (d(v) = 4). Once a location has been selected it will not be selected again. This process continues until it reaches F. Based on the Dikjstra Algorithm of Table 1 the minimum distance obtained was 9kms. The shortest path to location F is indicated by the arrow in Table 3.9. This is given as F (9) →(8)→(6)→(3)→(2)→(0) in reserve order. This becomes A→B→C→E→D→F.

Table 9: Shortest Path of Hospitals (A,B,C,D,E and F)

	A	B	C	D	E	F
A	0 ←	∞	∞	∞	∞	∞
B		2 ←	4	∞	∞	∞
C			3 ←	9	∞	∞
E				9	6 ←	∞
D				8 ←		11
F						9 ←

9

VI. Conclusion

Diabetes is one of the killer diseases in the world. Although this cannot be cured but it can be managed as revealed by scholars. The management of this disease is a function of early retrieval of patient Information when the sugar level rises. This is because late retrieval of Patients' Information by Doctors may lead to death of such patient. It is also a function of getting the good hospital that will handle the involved patient. In addition, getting the shortest distance from the source (Patient location) to the available hospital is also an important issue to be addressed. This work has addressed these challenges by designing a cloud mobile-based Information retrieval and optimal route service delivery system for aiding the treatment of diabetic patients in Nigeria. This system will aid the minimization of the time taken by physicians to treat diabetic patients and recommend the shortest route to the available hospital. This was achieved using Java API to run on Android OS. Each user registers and fills necessary information on this application once. This information is uploaded directly to Alibaba cloud, which serves as the repository. The prototype demonstration was carried out with thirty patients with a total of eighteen physicians across six hospitals. Three physicians in each designated hospital attended to 5 patients, and the time taken to attend to each patient using our developed model was recorded and compared with existing method. The Djisktra algorithm was adopted as the solution to achieve the optimal path problem. The reason for the adoption of this algorithm is based on the fact that it is a one source shortest path algorithm. The algorithm made use of six hospitals; A,B,C,D,E and F having 2,4,1,7,3,2,1 and 5 kms as the distances from one location to another on the graph.

The prototype demonstration recorded an average of 17.802, 17.866, 17.868, 18.268, 17.200, and 19.336 Minutes across the six hospitals, the existing system was also demonstrated using same conditions, and an overall average time of 39.66 Minutes was recorded. Based on the six hospitals within Abuja metropolitan city used in the experiment, and with the use of relaxation approach of the Djikstra algorithm. The result obtained from Source A (Patient) to destination F (Shortest Distance to the patient's location) was 9km.

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