IFERP connecting engineers... developing research

ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Vol 8, Issue 10, October 2021

Telemedicine-Assisted Contact Tracing: The Role of contactless IOT e-Thermometer in the proactive prevention of COVID-19 contamination

[1] Maitanmi O. Stephen, [2]Akinniran Oluwagbohun. Oke [3]Deborah Aleburu [4]Racheal Olufunmilayo Ajiboye [5] Otuneme Nzechukwu C. [6]Somefun Olawale Mufutau [7]Oluwatosin Ajiboye
[1][5][7] Babcock University, Software Engineering Department, Ilisan Remo, Ogun State, Nigeria
[2]Akinniran Oluwagbohun Oke, Hremsoft OES Limited, Nigeria
[3] Mountain Top University, Computer Science and Mathematics Department, Ibafo, Ogun State, Nigeria.
[4] Lagos State College of Nursing, Igando, Lagos State.
[6]Babcock University, Computer Science Department, Ilisan Remo, Ogun State, Nigeria
[1] maitanmio@babcock.edu.ng [2]oakinniran@hremsoft.com
[3]ddaleburu@mtu.edu.ng [4]braaf5@yahoo.co.uk [5] otunemech@babcock.edu.ng [6]somefuno@babcock.edu.ng
[7]ajiboyeoluw@babcock.edu.ng

Abstract: This study reviews the need to invest in tracing and monitoring of pandemic disease for the purpose of tracking and isolation of SARS-CoV-2 carrier for effective removal of the disease within the nation so that eventual increase mortality and poor health services in the country can be reduced. In addition, delay in adequate contact-tracing can lead to ineffective process of keeping the disease under control among the populace and the outcome can be disastrous to the people and the economy in general. Provision of a technological contact tracing can be done automatically with available contact-less thermometer devices linked to adequate telemedicine portal in different locations and this is essential and key to reduction in challenges faced in tracking and monitoring by governmental public health agencies. Therefore the paper has developed a graph-based contact-tracing mobile application for effective tracing and monitoring of COVID -19 patients which is aimed at reviewing existing architectural framework patterns on contact-tracing, designing of virtual thermometers, and the creation of telemedicine portal based on semantic graph architecture.

Keywords: Telemedicine, IOT, COVID-19, contactless, thermometer

I. INTRODUCTION

On the eve of this decade, the world was greeted with the news that a highly infectious viral microbe with pandemic-causing potential was detected in Wuhan, China. The virus, a type of coronavirus, now known as SARS-CoV-2, has reached every nation of the world, leaving in its trail overflowing hospitals, oxygen-dependent people suffering from COVID-19, rising death tolls, and depressed economies. These led many nations to institute various degrees of lockdown measures to curb the spread of the virus.

Unfortunately, after prolonged shutdown of businesses and national economies, re-opening and galvanizing the generation of income led to a second wave of the viral infection, leading to more deaths and further financial collapse. This was due, in part, to the inability of nations to identify and completely map out locations already contaminated by SARS-CoV-2. This concept, known in public health parlance, as touch monitoring, has been instituted in previous large scale infections to mitigate their spread. It is one of the pillars of preventive medicine. This well-established process of epidemiological communication tracing, if instituted early, has been found to minimize the extent and geographical complexities of epidemics [1]. Its major limitation is that it is strenuous and time-consuming, making the development of alternative contact tracing tools both desirable and mandatory.

The coronavirus has been shown to remain highly infectious even after being exposed to various surfaces. This is worsened by the complexities of accurately identifying these contaminated surfaces, thus creating challenges for public health managers. Re-opening of borders, schools, tourist centres and other public places will bring people into contact with previously unidentified contaminated surfaces, causing a possible resurgence of the virus and further lockdown measures.

Many individuals and businesses that are already impoverished will be tilted into starvation, extreme poverty and even collapse. It is obvious that the coronavirus pandemic has led to colossal losses for billions of individuals and millions of businesses [2].

In other to avoid these, processes that will aid the rapid and accurate detection of virus-contaminated locations and human carriers are urgently needed. The development of a tool that will facilitate effective viral contact tracing in both private and public locations in Nigeria formed the basis of this paper.

Strategies that will lead to the final eradication of the coronavirus scourge will include contact tracing and identification of contaminated surfaces. However, more efficient and less cumbersome approaches need to be adopted. To this end, technologically-advanced contact tracing tools using telemedicine solution has been conceptualized. This will involve a contactless e-thermometer that generates information and relays it to a remote server. Since it is contactless, it has no risk of spreading infection, and can obviate the challenges faced by individuals seeking health care during a lockdown. Furthermore, it can be deployed in both public and private locations in order to identify contaminated surfaces and infected people, so that these can be isolated/disinfected and/or treated to further control the spread of the virus.

To achieve this, a model was constructed to create an automated IoT temperature capturing device procedure integrated with a USSD module coordinated in a web portal that has a telemedicine process with video conferencing architecture. This web portal has the capability to integrate block chain and semantic knowledge graph in tracking contacts. This involves the use of World Wide Web (www), an neo4j db, mysql, restful API, OES LMS application, OES Health Portal, semantic web technologies and Java 2 Enterprise Edition (J2EE) architectural design, python, django in the implementation of the model design.

A. Statement of the Problem

The poor health statistics in many developing nations of the world, including Nigeria, have been worsened by the coronavirus scourge. Governments and non-governmental bodies have been grappling with the problems associated with contact tracing of carriers and persons infected with the virus, including accurately mapping the surfaces already contaminated by the germ. Delayed identification of infected individuals has led to the introduction and escalation of the disease among hitherto uninfected communities, with devastating outcomes to businesses and individuals. The need for tracing and monitoring of the disease cannot be over-emphasized. Therefore, investing in a thermometric device that applies telemedicine solutions without coming in contact with the surfaces or individuals, while generating information automatically to a remote server, will be a step in the right direction. Currently, the world is a standstill on of the tracking coronavirus. According to [3] over 5 million have been confirmed worldwide and 27% was able to recover while 5% death rate was obtained. The remaining 68% is still cases that is being observed. The confirmed cases are still on the increase though three brands of vaccines have already been approved for use namely Astra Zeneca, Johnson & Johnson (J&J) and Moderna.

B. Objectives of the study

The aim of this paper is to develop a graph-based contact-tracing mobile application for effective tracing and monitoring of COVID -19 patients.

Specific objectives are to review existing architectural framework patterns on contact-tracing, designing of virtual thermometers, and the creation of telemedicine portal based on semantic graph architecture.

II. LITERATURE REVIEW

A. Internet of Things (IoT)

The term Internet of Things was coined by Kevin Ashton, the cofounder and Executive Director of AutoID Center at MIT in 1999; it refers to uniquely identifiable objects and their virtual representations in an "internet-like" structure. As there is no universal definition for the IoT, the main concept is that everyday objects be equipped with identifying, sensing, networking and processing capabilities that will allow them to communicate with one another and with other devices and services over the Internet to be able to accomplish some objective [4]

'Things' in this context refers to devices and everyday objects, ranging from small ones (such as wrist watches and medical sensors) to larger ones (such as robots, cars and buildings). Each and every one of these contains devices that communicate with the users by generating and retrieving information about and from their environment. They also contain hardware that allows them to control outputs (such as relay switches or digital ports) [5]. For a device to be a member of an IoT network it has to be able to perform the following functions [5].

Collection and transmission of data: The device should be able to sense its environment (e.g. the home or a person's body), collect information related to it (e.g., temperature and lighting conditions) and then transmit it to a different device (such as a mobile phone or laptop) or to the Internet.

Actuate devices based on triggers: It should be programmed to actuate other devices (for example turn on the lights or turn off the heating) based on conditions set by its user. For example, a device can be programmed to switch on the lights when it gets dark in the room.

Receive information: One of the features of IoT devices is that they can receive information from the network they belong to (i.e. other devices) or through the Internet (e.g., information such as new triggers, new status of operation and in sometimes new functionality).

Communication assistance: IoT devices that are members of a device network should be able to communicate (i.e. forward data) with other nodes of the same network. They can act as messengers for devices (nodes) that are not very close to an endpoint (e.g., your router) in order to get direct information from.

B. IoT for Healthcare

Telemedicine

Telemedicine is referred to by the World Health Organization (WHO) as "healing from a distance . It involves the use of telecommunications and information technologies technology to provide patients with remote healthcare services. Also, medical personnel uses telemedicine for digital imaging delivery, video consultations, and remote medical diagnosis.

C. Types of Telemedicine

Telemedicine is broken down into three types of solutions: store-and-forward, remote patient monitoring, and real-time encounters [6].

Store-and-Forward Telemedicine: Store-and-forward telemedicine is often referred to as "asynchronous telemedicine." It is a system through which health care professionals exchange and interpret or react to patient medical information such as laboratory results, imaging studies, images, and other documents with a doctor, radiologist, or specialist at another place. It's not unlike email, but to maintain patient c onfidentiality, it is achieved using a solution that has built-in, advanced security features. Store-and-forward is especially common with certain specialties, including dermatology, ophthalmology, and radiology, for diagnosis and treatment.

Real-time telemedicine: Real telemedicine is also referred to as "synchronous telemedicine." It's possible that real-time video visits will come to mind when one thinks about telemedicine. Patients and clinicians use video conferencing tools during a real-time telemedicine experience to hear and see each other. Although, other forms of telemedicine are used to boost conventional in-person appointments, in some cases, real-time telemedicine can be used instead of avoidable trips to the hospital. It is commonly used for primary care, urgent care, follow-up visits, and drug and chronic disease management.

Remote Patient Monitoring: Remote patient monitoring, or telemonitoring, is a technique that enables healthcare professionals to monitor the vital signs and behaviors of a patient at a distance. This form of monitoring is also used to treat patients at high risk, such as those with heart disease and people newly released from the hospital. For the management of a variety of chronic disorders, remote monitoring is often extremely useful. Diabetics may use it to monitor their glucose levels, for example, and send the data to their doctor.

D. The Rising Surge for the Use of Tele-medical Tracing Due to COVID-19

The 2019 coronavirus disease (COVID-19) pandemic and the subsequent social distance orders have prompted health care providers to tackle patient access and their own financial security by improving how they provide care [7].

During the COVID-19 pandemic, there have been improvements in the way health care is provided to reduce personnel and patient exposure to ill patients, retain personal protective equipment (PPE), and mitigate the effects of patient spikes on hospitals. Healthcare services will need to change the way they screen, assess, and treat patients using approaches that do not rely on in-person experiences. Telemedicine systems help provide patients with the required treatments while reducing the risk of spread of SARS-CoV-2, the virus that causes COVID-19, to other healthcare workers and patients (CDC, 2020).

Potential Uses of Telemedicine in respect to COVID-19 [8].

1. Screening for signs of COVID-19: Telemedicine can be used to screen for signs of COVID-19 and determine possible exposure in patients. To assess patients for COVID-19 symptoms, to evaluate the severity of their symptoms, and to decide if the patient needs to be seen for treatment, admitted to the hospital, or can be treated at home, phone screening, online screening software, smartphone applications, or virtual telemedicine visits can be used. Cell phones and tablets or other telemedicine technology may be used by mobile home health care units, community health volunteers/workers, or emergency responders to connect with healthcare professionals at a health center for patients who may need to be hospitalized.

2. Contact tracing: Telemedicine can be used, in particular by telephone, to interview COVID-19 patients in order to decide who they were in contact with during the timeframe in which they were possibly contagious, and to follow up on their contacts in order to warn them of the need for quarantine, to ascertain whether they have any symptoms, and to advise them what to do if they develop symptoms.

3. Monitoring COVID-19 symptoms: In order to reduce overcrowding in health care facilities and to save hospital beds for more serious situations, patients with mild or moderate COVID-19 symptoms will also be isolated and monitored at home. Healthcare providers can check in with patients regularly using telemedicine devices, such as phones or apps, to track their condition, offer advice, and decide whether the condition of the patient is worsening and they need to be treated for in-person care, such as hospitalization.

4. Providing advanced treatment for patients with COVID-19 in hospitals: A diverse team such as nurses, respiratory therapists and physicians may need treatment for patients who are hospitalized with COVID-19. Using telemedicine technology (tablets, phones), one member of the team will access the patient's room and communicate with the rest of the team to determine the patient's condition, adjust respiratory and other therapy, adjust the care plan, and handle complications. Moreover, telemedicine can be used by health facilities to communicate with doctors who have advanced training or experience in respiratory infections such as COVID-19.

5. Providing non-COVID-19 patients with access to vital healthcare: To the extent practicable, telemedicine should be used as a tool to ensure quality of treatment to reduce adverse effects from preventive, chronic, or routine care that may otherwise be postponed due to concerns regarding COVID-19. Usage of telemedicine will help decide when deferment of an in-patient visit or service is appropriate. In order to minimize the amount of in-patient visits and overcrowding in outpatient settings, follow-up visits may be done by phone or internet. In order to further minimize the need for contacts and meetings with ill-patients. Providers can use internet-based prescription drugs to provide multi-month dispensing of drugs.

III. METHODOLOGY ADOPTED

For the achievement of the above set objectives, the following methodology will be utilized.

1. Existing literatures on mobile application network design concept and enterprise application development using design patterns will be reviewed. This is to give an overview of existing design architecture with the software design models. Gaps identified and areas of improvements will be noted in the usage of the technology.

2. In developing the model, the formal methods approach will be adopted. The specifications of the model will be designed firstly, thereafter the verification phase where the proofing of the defined specifications will be carried out to ascertain the correctness and feasibility of the specifications. Two things will be focus on namely; firstly, choosing of relevancy mobile network architecture design and working with manufacturing of contactless thermometer with QR Code. This architecture will involve leveraging on an existing Java Persistence Architecture (JPA) with strut Modal View Controller design (MVC), Modal Controller Template (MCT) in connecting to main office backend. The application on the phone will be in synchronized with the Firebase.

3. This will be achieved by developing a mobile interface using android servlet development tools such as Java programming language and the MVC framework via the NetBeans Integrated Development Environment (IDE), for the client side. The admin part will be developed with the Hyper Text Markup Language (HTML), JavaScript, and Cascaded Style Sheet (CSS). Firebase, Neo4j and MySQL will be used as the database management system layer. This will be a four-tier architecture application layer on top of the LMS. This means a whole 4-tier architecture model will be adopted for the semantic web architecture. A sample diagram of the proposed model is presented in figure 1.

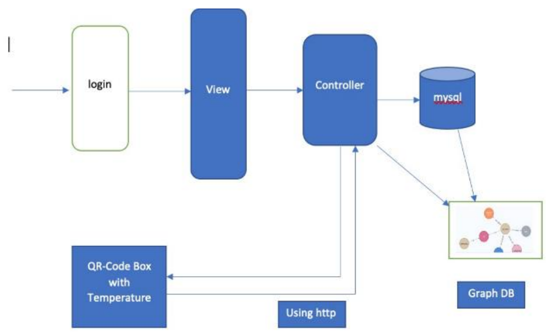

Figure 1. Semantic analysis of the graph

IV. RESEARCH JUSTIFICATION

Implementation of this research work will drastically assist in bringing the spread of Covid-19 into control with less funding, through the enhancement of contact-tracing procedures and workflow through the use of telecommunication devices with a video conferencing web portal architecture based on block-chain for safe keeping of records with integrated secured database tracking capabilities. This will also aid in generating data that can be used to know the direction of focus of the pandemic. It will further contribute to the reduction of additional confirmed cases within the country in which the product is adopted.

CONCLUSION

The successful completion of this study will contribute to the improvement of good health, adequate contact-tracing in people irrespective of their location and financial status. It will reduce community infections that occur during contact with isolated persons. This will aid and further address the health challenges and complexity of Nigeria using Internet of Things devices (IoT) and it can be further extended to other African Countries.

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