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A Measurement Approach Using Smart-IoT Based Architecture for Detecting the COVID-19

Poongodi M.[1] · **Tu N. Nguyen**[2] · **Mounir Hamdi**[1] · **Korhan Cengiz**[3]

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Abstract
The corona virus has infected the entire world in the most severe ways. Many countries found the situation is very difficult to deal with and their health support infrastructure is not sufficient to manage the spread. People are locked in their homes and the whole world economy is in danger. That final vaccine has not yet reached the masses to deal with the epidemic. The corona virus, also known as COVID-19, can be spread by touching or coming close contact with an affected person, which is why the risk becomes so significant. However, the emergence of new emerging innovative technology such as blockchain and the Internet of Things (IoT) has changed the healthcare sector, especially in preventive measures. Different devices have ushered in a new era in the field of symptom-based diagnosis where doctors can most easily identify a person with a corona infection. This article presents a robust health-based IoT systems that can strengthen the COVID-19 administration and achieve greater results with available resources. The simulation results confirm the effectiveness of the proposed infection detection system.

Keywords COVID-19 · Infection tracing · Corona virus · Monitoring and tracing · Smart IoT

✉ Korhan Cengiz
kcengiz@trakya.edu.tr

Poongodi M.
dr.m.poongodi@gmail.com

Tu N. Nguyen
tu.nguyen@kennesaw.edu

Mounir Hamdi
mhamdi@hbku.edu.qa

[1] College of Science of Engineering, Hamad Bin Khalifa University, Doha, Qatar

[2] Department of Computer Science, Kennesaw State University, Marietta, GA 30060, USA

[3] Department of Electrical - Electronics Engineering, Trakya University, 22030 Edirne, Turkey

1 Introduction

Over the past centuries, it has been estimated that the world has faced a variety of epidemics and pandemics. By the end of 2019, it is estimated that a new virus called COVID-19 has developed in China, where millions of people are continue to be infected until now. In the year, 2015 there were several news reports TED Talk by Bill Gates, on the title "The next outbreak? We are not ready", maybe he mentioned on this future disruption of COVID-19 and the suffering faced by nations and economies in-prior. COVID-19 infection exposed in the month of December 2019 at Wuhan, China. The World Health Organization (WHO), has announced COVID-19 as pandemic because the disease has effectively spread around the world within a few months. Severe conditions were observed worldwide from March 2020 till now [1]. From different researchers, this is estimated till now, the number of cases recovered worldwide includes 21 million. In this situation, hospitals in some developed countries of the world have experienced overloading of healthcare systems. The worst situation was experience in underdeveloped countries. Therefore, it can be estimated that this pandemic situation has effectively triggered the worst economic situation in many countries. On the other hand, all the nations are under severe lockdown situation and also due to this individuals suffer from depression. In this pandemic situation, various economic projects and events were postponed by different countries.

Cancellation of different events causes more inconvenience and economic disruptions, all these are carried out aiming to cope up through reducing the spread. In the recent environment, it has been considered by the dense of population to accept to maintain the physical proximity as the process to reduce the infection as shown in Fig 1. Furthermore, in recent research studies, the virus can be confined in the environment for more than 10 minutes [2].

It is confined that COVID-19 has become airborne transmission-like in the indoor space. Medically it also examined that COVID-19 is very contagious in the first three days after the onset process. The common indicators of COVID-19 which includes cold, fatigue, breathing issues, Severe throat pain etc. However, in the later period, it can be assessed that several common treatments are provided in terms of curing the virus integration [3].

On the other hand, in different researches, have addressed that the spread of the virus is both symptomatic and asymptomatic. COVID-19 in the time of exposure of onset problem is raised from two to fourteen days [4]. To the present date, vaccine is not reached the people to avoid the infection rapidly; instead the prevention policy is maintained in the society. In terms of controlling and protect us from the infection of COVID-19, it can be highlighted that preventive measures are required to be used by the population. According to different researchers, the usage of masks, hand sanitizer, and soap usage is considered significant to be followed as important criteria for preventive measures. Social distancing is also addressed to be effective in terms of protecting an individual from the COVID-19 virus. However, in this pandemic situation, there were various types testing methods is established [5]. An individual found positive in COVID-19 needs to be isolated in terms of reducing the chances of spread of the virus to their close ones. The condition in the mid of 2020, was considered to be vulnerable and a contact tracing process was required in terms of reducing the possibilities. On the other hand, the business infrastructure has also changed in the year 2020, and a drastic shift is determined towards the current digital age [6].

The most concerning question that emerges out of this understanding is the case of strategizing the best practice to imply efficient utilization of the developing solutions to communication techniques and the integration of internet or online-based technologies, concerning adapting to the current pandemic. In this case, the initial process towards constructing

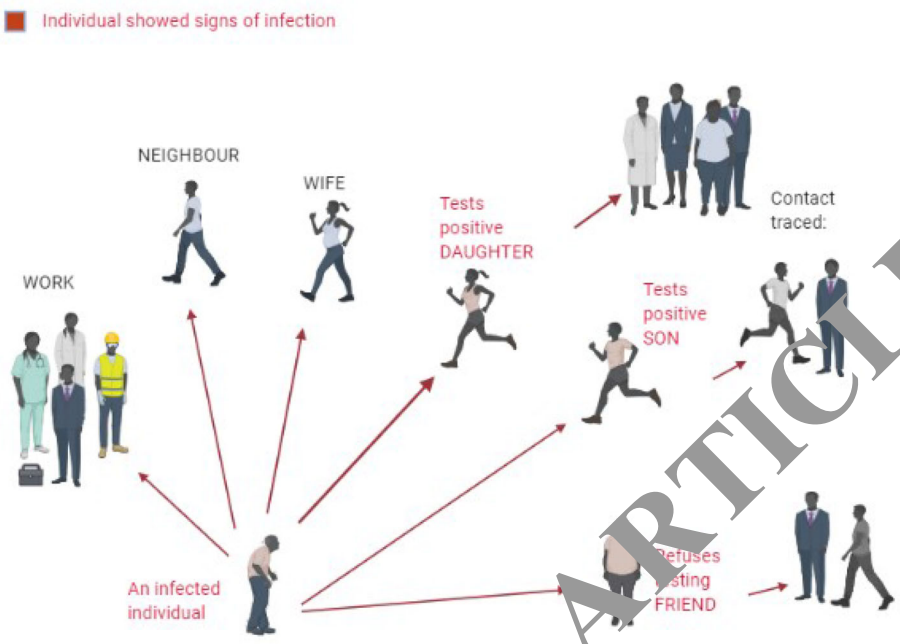

Fig. 1 Contact tracing

a suitable communications process related to the association of effective monitoring, tracking, and wireless application to make immediate reports about identified infections. This is presented as a beneficial approach to construct a detailed and precise overview of how the infection is metastasizing within the area. In this case, the organizations are significantly benefited from the application and introduction of the Internet of Things (IoT) into the business environment [7,8].

The internet of things can be outlined as a composition of relatively physical objects, which are systematically networked with each other to imply operation of sensing mechanisms and further enabled in developing software optimization that can effectively contribute to processing information autonomously. Furthermore, there are clear indications of the second wave of industrial revolutions that are estimated to be majorly heralded and led by the prevalent IoT applications, such as 5G wireless services and developing WiFi equipment which has been extensively penetrating the global business markets. These applications have gained significance within the field of healthcare, with primary involvement in the practices of monitoring the health of patients and provisioning telehealth procedures. This has been a major contribution whereby the healthcare professional can now carry out services from hospital premises to private environments. As such, the Healthcare Internet of Things aims at defining a wider variety of beneficial attributes to healthcare servicing through technology [9]. Furthermore, the Internet of Medical Things also proposes various advances in the maintenance of health care devices [10].

In this research paper, we proposed the IoT based preventive measures for individuals who have been potentially infected due to COVID-19 . The proposed IoT based system gives the contribution highlights as stated below:

1. Contract tracing can be effective based on wireless technology networks integrated with portable IoT devices. These will apply a graph theoretic mechanism to assess infections and thereby can effectively eliminate the need for physical contact for conducting contact tracing.
2. By assimilating the data received with the contact tracing graph can be established to originate a healthcare server particularly for COVID-19 cases. Besides, an infection tracing graph can be produced by merging details about patients with a confirmed infection along with the outcomes of the infection detection graph. This can be applied to visualize the pattern by which the infection is spreading within a community.
3. The most beneficial aspect of this approach is the access to portable and wearable healthcare equipment to communicate patient information. Successful communication can be developed by creating a device to device links and provisioning 5G wireless connections for information sharing.
4. The infection tracing procedures conducted over the people closer to the individuals reflecting intense symptoms or confirmed as a virus carriers is implied as the best practice to prevent infection spreading as well as issuing effective quarantine procedures.
5. The proposed method further outlines a symbiotic relationship between the data received about infection symptoms and the contact as well as the infection detection graphs. Thereby, it illustrates striking deviations from the previous and current evidence on contract tracing mechanisms, primarily dedicated to the introduction of IoT networking [11–13]. In this case, previous works reveal information related to just use contact and infection and fail to derive symptomatic details.

The research paper is organized as Section II describes details about the Role of IoT in Healthcare, Section III , gives a complete research details on proposed work using IoT , Section IV shows the result ourcomes with simulation Experiments. Sections V, Conclusion and future direction of the research.

2 Role of IoT in Healthcare

In the era of globalization and the modern technological world, it seems that healthcare systems are making a abrupt change in various nations. Implementation of telemedicine in healthcare and medical systems seems to be helping people suffering from chronic diseases so that their life expectancy rate can increase. Besides this, the burden of healthcare infrastructure can also be managed if the focus is made to the in-home telemedicine system that seems to be gaining importance and popularity among the customers or patients along with the health care and medical system. The telemedicine system is mainly designed for meeting up some more objectives of the clinical and medical world that further helps to know the significance of the IoT in healthcare. Followed by the significance of telemedicine and IoT, it can be combinable and further can be called IoMT(Internet of Medical things) [10] that further state the connection between traditional medical equipments with the attractive and advanced attributes of IoT. The emergence of wireless communication systems has showcased the advanced technological use along with knowing the importance of IoT that can become a remedy for the old-aged healthcare systems[14–16].

It has been viewed that customers always seek for the product and service that are high in quality and affordable. For this reason, the demands and availability of IoT have increased [17–21], which seems to be an affordable, proactive, and personalized one. However, the IoT has complemented the use of telemedicine among a huge mass and has further taken care of the

health management system effectively. This kind of idea has given rise to HIoT (Healthcare Internet of Things) [9] that can be further classified into two broad types that include personal IoT devices and Clinical HIoT devices. In the case of personal HIoT, smartwatches seem to gain importance among a huge mass, whereas clinical IoT devices include glucose monitors that further help the healthcare professional to manage the health of the patients since it consumer lesser time. The healthcare and medical system are developing with each passing day that is showcasing the popularity of internet connectivity. The high internet use is making the healthcare system get developed and focus on the 5G wireless, and cloud technologies that further help to analyse the health-based data effectively and thus provides an affordable healthcare service to the care seekers [22,23]. Due to the sudden emergence of a pandemic situation, it has created a problem for the new adoption of IoT that seeks a possible solution. It has been found that people in lockdown suffer from severe acute respiratory syndrome that needs the help of tracing models (eg., [13]. In this situation, it seems that accurate data needs to be collected from the patients by making effective communication with them, the health physician, which is the responsibility of the health administration, and researchers. However, in this crisis, it is important to collect real-time data from the patients that can be possible with the help of IoT devices. It has been found that how the IoT has played a significant role in tracking down and monitoring the people, who are infected with COVID-19.

However, followed by the result gained from the monitoring and tracking session, it can be said that the people will get to know the exact situation of their health and could be able to know how the infection has taken a pandemic turn that devastated the lives of the people comprehensively.

The collected health-based data can be further merged up with the medical record of the infected and ill-health patients so that further possible infection tracking solutions can be received. Besides connecting with the healthcare system, it has been found that IoT has a link with the social networking system. The significance on the application of IoT along with D2D communication that further introduces the IoT and D2D for social events [24]. For this reason, social relationships and communication got enhanced and that has helped to take control of the pandemic situation. It became possible as wireless contact has been done with the patients, co-workers, relatives, and many such that also gave rise to developing new contact tracing tools so that an accurate control can be made to the pandemic situation.

3 Proposed IoT Based Solution

It is important to detect the core reason behind the emergence of COVID-19 along with searching for the possible solution to reduce the negative impact of this infection at a worldwide level. However, before describing the solution for the proposed concept, it is important to know that there are various kinds of sensors [25] that can help to manage the pandemic situation effectively. It can be assumed that IoT devices can be taken as the solution to the problem such as in the case of wearable, which can help to monitor vital information like the temperature of the owners. However, after the monitoring process, the gathered data is sent to the Intelligent server holds information of medical data for further infection tracing and to make contact effectively. Besides this kind of infection tracing, information regarding the result can be transferred to the mobile phone of the user followed by the D2D and 4G/5G wireless relay. This kind of process helps in collecting information from the IoT devices along with sending those collected data to the healthcare server. It has been found that if the wearable IoT fails to make an effective D2D connection with mobile phones then it can rely

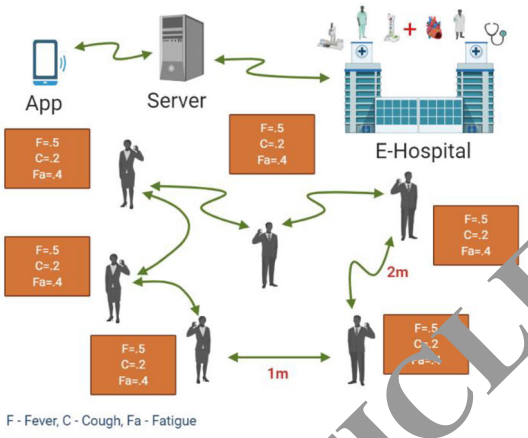

Fig. 2 Contact tracing using IoT and D2D communications: Stage 1

on various kinds of capillary communication methods that include Wifi, Zigbee, Bluetooth, and any such. It will help to make effective communication with mobile phones that can further help in complementing the total tracing process of the infectious process, which is COVID-19.

Besides this, it has been found that social media also plays an important role in establishing effective technological-based communication and thus making a connection with the social groups for a long period. The social networking system helps in complementing the tracing devices that too help in making fast communication along with establishing a social relationship effectively. Besides this, the knowledge of the social groups provides support to the contact tracing system or devices. However, it has been found that the communication process can be managed effectively among the devices belonging to the same owner, which can be categorized on a device level. In the case of a network level, the server and the network operator need to manage and take care of the privacy and integrity of all the individuals. However, in Figs. 2,3,4 and it has been found that a contract tracing and infection tracing framework has been introduced that consists of four different stages that can be termed as S_1, S_2, S_3, and S_4, which can be further explained in respective ways. In the case of stage 1 that is S_1, an individual faces problems like fever, cough, fatigue that are taken as the initial stage of COVID-19. In the case of S_2, confirmed infection cases are identified through tracking control devices and doing effective monitoring with the help of IoT, in this stage, the individual is announced as infected. Besides this, S_3 is taken as one of the crucial stages, where an individual is taken as the infected patient if that person has symptoms to S_1.

However, in the last stage that is the S_4, the infected patient is kept quarantined and remain isolated for some days. In this case, wearable IoT devices help to make fast and efficient communication using the D2D technique, 4G/5G, and Wifi by having the intention of data integrity. Identifying an individual with symptoms is the only way to complement the proposed approach by focusing on the state of art contact with the tracing methods. As outlined in Algorithm 1, IoT-based prevention framework has been established effectively. It has been found that the proposed scheme has effectively explored the contact followed by the Contact Tracing Graph $G_1(V_1, E_1)$. In this case, every single node of G_1 represents a individual by relating to the mobile or any kind of wearable device that is further linked with the associated data or information. The data include mobility that is presented in the form of geo-spatial and dealing with the dynamics of symptoms in an overtime way by using wearable or handheld devices along with some accurate medical equipment. Besides this, every single edge of

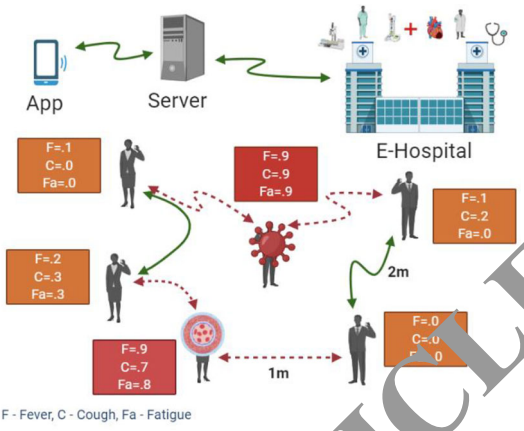

Fig. 3 Contact tracing : Stage 2 with IoT

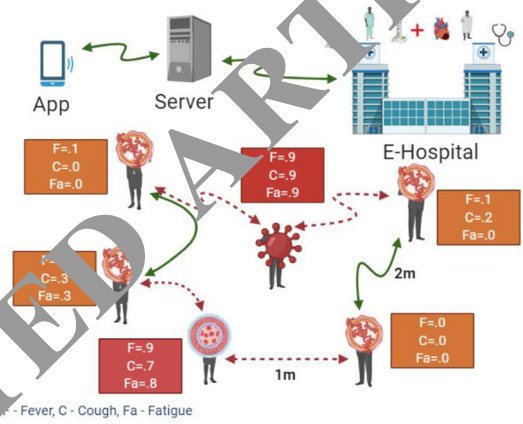

Fig. 4 Contact tracing : Stage 3 with IoT

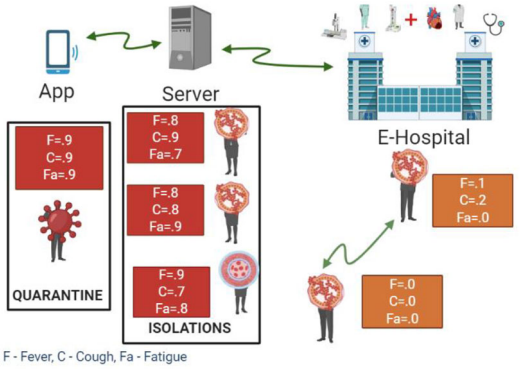

Fig. 5 Contact tracing : Stage 4 with IoT

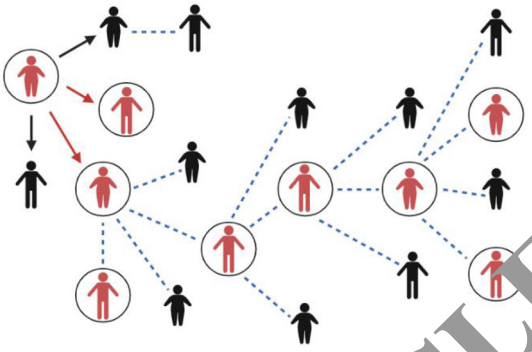

Fig. 6 Graph-based contact tracing model

G_1 represents the contact between two humans, where it seems that effective information is transferred between two individuals, where major help is provided by the 2D, and 5G/4G that can help to establish an effective wireless communication process. The whole process can be further indicated to a centralized server, where the usage of mobile phones or any handheld devices seems to be the core one that can help to track the contact followed by each node presented in the network process. In the process of V_1, it can be estimated how a person can be identified and which person has made contact with whom. The node that will be given will be considered as the confirmed case, where after that the server can mark and create a form that will further include the Infection Detection Graph $G_2(V_2, E_2)$. All these will include the needed information, which is significant to conduct a further operation that includes Contact Tracing graph $G_1(V_1, E_1)$ and the confirmed infection detection, where information is collected from hospitals or testing centers. It will be prominent to note that the edges mentioned in the graph of detecting infection to mainly deal with the basic facts of human-to-human contact where information is transferred between two individuals. All these can be traced in the Contact Tracing Graph that is G_1. However, when the server has information on whole about the nodes and the current service cases, then only it seems that potential victims can be identified accurately. Among these, the simple approach is all about checking at time t a node concerning V_x from a distance, where there is a presence of a positive COVID-19 patient that can be further taken as a node for a certain duration [26,27]. However, in the case of the Information Tracing Graph, it has been found that every infected person is colored or marked based on his or her specific disease. In this case, two different patterns or colors can be used, where one color such as black can be used to mark the confirmed cases of COVID-19 that can be identified further in Figs. 2, 3, 4 and 5. On the other hand, the white color has helped to identify the people, who have the potential to get infected. Besides this, it has been found that the set of edges represents the transmission of infection that further helps to investigate the potential rate of the coronavirus patient, which has been presented and marked in the form of a red and white pattern. Furthermore, the natural key parameters have also been analyzed in an accurate way that includes distance threshold, contact duration, infection rate, and many such that further include symptoms regarding induced dynamics along with stating its solution.

By focusing on the physical and mobility contacts, it can be assured that tracing and infection detection can be done in an effective way that can be further updated periodically. It is because it represents the dynamic connection between the users that has further been cleared up for the presentation of random graph models. In this case, the probability and

proximity that took place between two users have been represented in a dynamic way, which can further be appeared and disappeared followed by the corresponding edges.

Algorithm 1: Operating Procedure

Data: Initialize DT_{th}, SIM_{th}, T_{th1}, T_{th2}
/* DT_{th}: Threshold of social distance; */
/* SYM_F_{th}: Symptoms threshold; */
/* T_{th1}: Min. duration of contact with high symptom human; */
/* T_{th2}: Min. duration of contact from infected individual; */

Result: Standard operating protocol (SOP)
initialization;
if *distance* ***is less than*** DT_{th} *and Infected Individual* **then**
  Rapid announcement of Isolation;
  Inform healthcare authorities;
if SYM_F ***is greater than*** SIM_{th} **then**
  Indicate the carriers on symptoms;
  Self-quarantine;
if *distance* ***is less than*** DT_{th} **then**
  for *all persons in context* **do**
    read current;
    if *Individual have symptoms* ***is greater than*** SIM_{th} **then**
      if *contact duration* ***is greater than*** $Time_{th1}$ **then**
        Indication of statistics of person infected with or not wearing mask;
    if *Confirmed Infected person* **then**
      if *Duration of contact* ***is greater than*** T_{th2} **then**
        Indication of statistics of person infected with or not wearing mask;

Besides this, the graph-theoretical model helps to collect the abstract of the history of the users continually in an efficient manner as shown in Fig. 6. It has been assumed that the communication process between two users mainly depends on the contacts and proximity they had once followed by the previous time instances. It has been found that the contact tracing graph can be analysed with the help of the Markov process followed by a particular order. However, it has been found that contacts and proximity can be updated followed by some specific rates that further result in the occurrence of the non-occurrence of edges. Besides this, it has been found that the accurate model mainly based on the previous result or bundle of data along with considering the time and complexities of the applied model in comparison to the high-order models with the low-order models.

It seems that the IoT devices are mainly used for the contract tracing calls and are considered as the low-power that results in giving results without consuming high time. Besides this, it helps in making a suitable compromise between the above-explained models so that an effective implementation can be made of IoT devices. It is because it will help in tracking down the COVID-19 result along with monitoring it in an effective way that will enhance the feasibility and flexibility rate of the whole process [28].

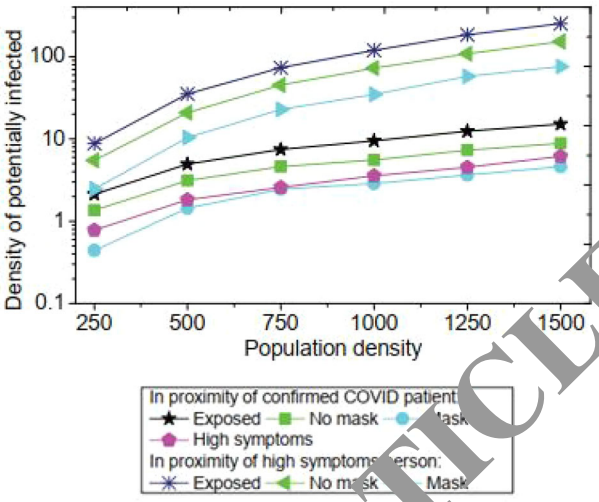

Fig. 7 Dense populated function with infection

It can be assumed that by the use of various kinds of models the Contact Tracing Graph can be analyzed effectively so that accurate knowledge and ideas can be gained on the density and degree of distribution of results. However, the result is all about dealing with the COVID-19 result that has further been gathered with the help of contact tracking devices that includes IoT. However, the rate of changes will be focused on user specific contacts by further following the edges of the Contact tracing graph followed by appearance and disappearance factors. All these can be evaluated as low compared to the rate of models and observation of it followed by its instances that include dealing with the snapshots of the graph. For instance, it has been found that there is a strong effect followed by the previous contact made by the users with the future proximity that will be held in the coming years. Besides this, an independent analysis has been made by taking into consideration the core features of the memory-less model. This type of model can be applied followed by individual time along with the instances of it that further seems to be ignoring the internal factors and dependencies. For this reason, the whole process fails to understand the important correlation between the essential features of the models concerning IoT devices. However, it has been found that the graph-theoretic model can be further related to many other existing models that can be understood by the use of suitable graphs. It is because suitable graphs can help to track and represent the person who got infected from COVID-19. The process includes updating the edges in an effective way that further represents the transmission of infection among the potential people. Hence, it has been found that the important aspects of the model are taken as the possible ways of tracing the contact effectively those people who are infected with the virus.

4 Simulation Experiments

Representative simulation experiments have been conducted to demonstrate the COVID-19 virus infection out using Python. A total dense of people about 250 to 1500 per sq. kms is generated with the help of this stimulation. Every individual has a particular property such as a tool to identify the present location, a symptom flag (SYM_F), and a disease flag (DIS_F). It has been identified that the exact position is produced with the help of using the binomial

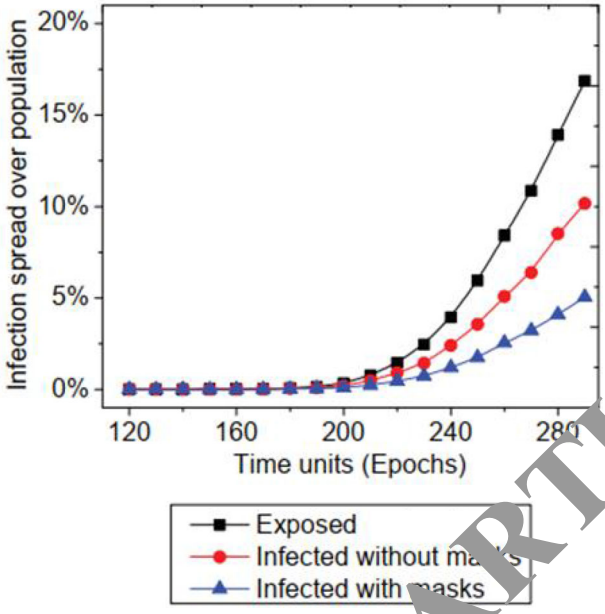

Fig. 8 Demonstration on spread of infection w.r.t time

point procedure. Here the intense and sparse population density is simulated by using 200 and 1600 points per square kilometer. The ultimate interest of it is to understand the trends and the unconditional value is not that much interesting. The find out the COVID status of a person, there is a binary method called DIS_F [0, 1] as established by the chosen health center. On the other hand, SYM_F [0, 1] is the distribution that is evaluated by using a total of the symptoms. A symptom for a specific individual is forecasted by making use of smart wearable instruments and diagnostic tools by the health machinery. The matter of exposing a person is taken into consideration for an affected person; the possibilities of infection with and no mask and gloves are given as 0.2 and 0.5. Certainly the fact, that the possibility of completely understanding the infection is still rigorous. As these are sensible choices to examine the performance of the latest technologies. Research has shown that the COVID virus is not infected on the interactions that take place momentarily but it needs some extra time to infect the other person. As the survey was conducted, the researchers found that the time is 10 times units to get infected by the virus remaining in constant touch with the infected person. The complete time unit is not that essential due to the reason of interest in the technologies. The symptoms of the COVID virus are checked constantly without any time gap. The warning signal triggers whenever there is an increase of symptoms than the actual symptoms is more than 65 times units. From research studies, it is observed by the simulation that every movement and health of an individual is infected up to 250-time units. As a result, the whole simulation is repeated 120 times with various speed units and according to that, the average consequences are reported. Researchers studying this aspect have declared that the procedure of contact tracing is produced by following three steps. This includes:

1. Violation of social distancing: the inter-device distance is used for constantly checking the distancing. The device shows the signal when two or more devices come together

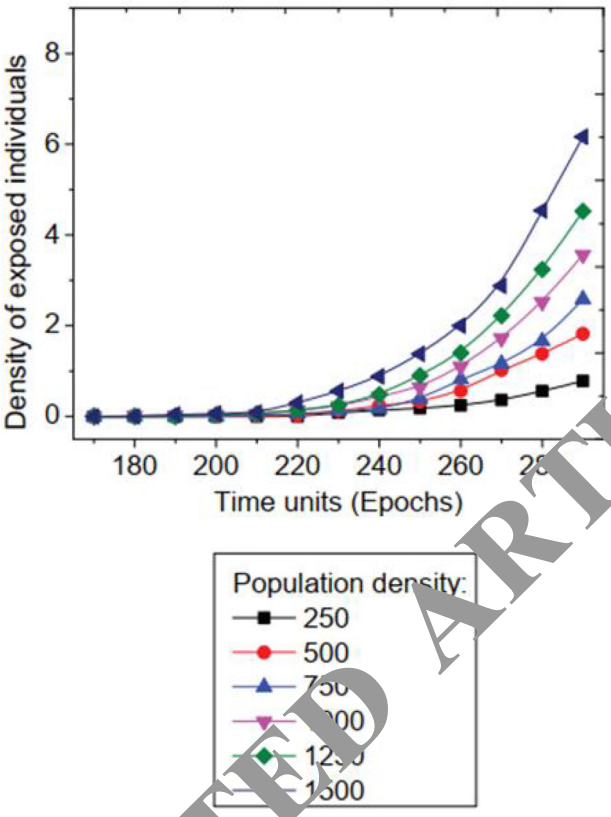

Fig. 9 Population dense got exposed w.r.t Time

to each other. The instant detecting the distance violation is done by following the next monitoring process.

2. Possible infected case based on the symptoms: if the owner of the device has the higher symptoms ($SYM\_F > SIM_{th}$), or the owner has got directly contacted with the disease ($DIS_F = 1$), in this case, an instant alert is rised and sent it to the health-care authorized persons as well as the affected individual without sending the actual identity.
3. Probable disease spread infection: when the devices are close to each other, then the DIS_F and SYM_F are evaluated to find out the possible owner of the device.

Researchers analyzing these aspects have identified that the evaluation of the solutions is done by following the metrics given below:

1. The whole dense of population who got exposed to the infected COVID-19 patients.
2. Possibly infected patients in 2 different cases: can be every individual is wearing masks or without mask.
3. The whole number of people having greater level symptoms after contacting directly to the infected people.

Figure 7 above illustrates the population dense who got closer to the COVID affected person in recent times or a person with maximum signs of infection. The whole dense of population depicted to the affected human rises when the number of the population rises.

With the total depicted individual, it is assumed that every individual is wearing the mask. Then the density of the possible infected population increases to three. On the other hand, it is observed that people with no mask increase to five. Researchers evaluating this issue have identified that the framework finds out that the person with more symptoms can transmit the infection to the person got recently being exposed to that individuals. As a result, it is observed that the number of depicted people number high-rocketed beyond 324 per Sq.Km for the population dense of about 1650 per Sq. km. As per the observation is done, it is found that 120 people per square kilometer could be possibly get affected by the COVID virus even if they wear a mask. However, it is found that without wearing a mask this number will rise to 240 people.

With the help of an observation window of a 300-time unit, researchers have found out the percentage of the possible infected and possible people with as well as without wearing a mask, by the matter of people having the highest number of symptoms are taken into consideration. It is also observed that the percentage of people infected by the COVID rises to 15 percentage as shown in Figs. 8 and 9. As a result, it is significant to isolate every infected people to diminish the spread of the virus. On the other hand, it is better to implement lockdowns and decrease activities that are carried out in the outdoor environment. As a result, the proposed policy not only finds out and traces the infected people but also traces every individual who got exposed to the disease.

5 Conclusion and Discussion

From the above discussion, it can be summed up by saying that 2020 will be remembered always for COVID-19. It has been found that how the smart IoT-based framework has helped to improve the monitoring and contact tracing process that has provided a solution to the healthcare and medical system. It seems that IoT has made its presence in a worldwide way that has allowed it to showcase its potentiality in the technological world. With the help of COVID-specific sensors, the key symptoms of the infection can be detected in an effective way followed by the IoT devices. All these can be further connected with the contact tracing graphs that will help to gather information regarding COVID-19 along with knowing the potentiality of the infected individual. However, this article has helped to know the importance of IoT that has played a crucial role in collecting real-time data of the infected individual, which is a vital task. Besides this, it has been found that IoT devices have helped to manage the health care and medical system infrastructure effectively. All the relevant models, graphs that have been identified in this study have helped to know the importance of IoT in the modern technological world that further helped handle the infected people effectively. This kind of technological advancement aids in the decision-making process that further helps to identify infection clusters and in the process of searching health care resources like the COVID-19 kits [29].

The important information provided in the article seems to be extending in various kinds of location that further provides essential details on the incorporation of indoor location information along with maintaining the privacy and protecting the health care data of the care seekers effectively. In this study, it has been found that usage has been done on simple mobility and symptom evolution models. These could help in the simulation process by focusing on providing proof of the concept of advanced technology use in the health and medical care systems. These frameworks are simple that can help to obtain accurate results regarding the COVID-19, where the main focus can be made to the mobility tracing process. However, all

these details have been presented as the proposed scheme that can be further known in a more detailed way through simulation-based experiments. Hence, it can be assumed that the next step to this concept will be a natural step that will give the development to the prototypes and will thugs accurately refine them so that all these can be turned into effective products, which will be used at a large scale in the coming future.

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