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Viral Control Using a Block chain and Internet of Things Model Based on the Cloud

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ABSTRACT

The rising number of COVID-19 infections and fatalities makes it tough to find a drastic solution to halt the virus's worldwide spread. Essential measures include prompt diagnosis, isolating patients, and monitoring their contact information. By connecting hospitals/laboratories, people who test negative for COVID-19, those who test positive for the virus, and contact persons to a consortium blockchain system housed in the cloud, this research offers a unified method for regulating the spread of the virus. As a result of the results of the execution of the rules of the blockchain smart contract, the proposed method guarantees that the status of COVID-19 cases is monitored and updated in real time, with the relevant modifications made to the blockchain. Network of Things (IoT) devices track the duration and distance of interaction between infected individuals and others they come into touch with. Utilizing GPS, Bluetooth, and Ultra-Wideband (UWB) Internet of Things (IoT) sensor technologies, we determined the distances between the impacted individuals and their connections. This suggested smart contract for the Ethereum network was built using the solidity programming language and the Remix integrated development environment. Testing revealed that the proposed approach correctly identified contact circumstances and managed people's different statuses utilizing the blockchain system in the cloud, all while adhering to the smart contract rules. Since the proposed model produces an error rate of 11 cm or lower when used for distances of one meter or less.

Key words

Internet of Things (IoT), cloud computing, blockchain technology, and smart contracts are all included within the acronym COVID-19.

INTRODUCTION

Near the end of the year, a novel coronavirus epidemic hit Wuhan, China, infecting more than 70,000 individuals in only 50 days and killing more than 1800. It was found that this virus is a member of the coronavirus family. The new virus has been named 2019 novel coronavirus (2019- nCov) by the Chinese researchers who found it. International Committee on the Taxonomy of Viruses (ICTV) [1] assigned the virus the designation SARS-CoV-2 and the illness the designation COVID-19. When an infected person coughs, sneezes, or releases their respiratory fluids or aerosols out into the air, it may easily spread to other people. Because of their microscopic size, aerosols may be inhaled via the nasal passages and deposited in the lungs. When infected droplets land on surfaces, they may infect anybody who touches their face, particularly their eyes, nose, or mouth. Surfaces made of plastic or stainless steel may allow the virus to survive for days, while those made of copper or cardboard may only allow it to exist for a few hours. But the amount of active virus decreases with time, and there may not always be enough to cause infection [2]. The current best estimate for the incubation time of COVID-19 is one to fourteen days [3]. The Internet of Things (IoT) is now indispensable in the healthcare industry, and it has a profound effect on people of all ages due to its ability to monitor their health in real time [4]. The COVID-19 pandemic has had a profound impact on the Internet of Things (IoT) ecosystem. Direct usage in preventing the spread of the virus is possible (e.g., via temperature screenings and contact tracing). (such as temperature screening, contact tracking, and so on). Recognizing early cases, tracking ill individuals, and isolating them are critical capabilities to have during pandemics.

RELATED WORK

Numerous medical research have shown the IoT's general use in combating the COVID-19 pandemic and in the early detection of zoonotic illnesses [7-9]. But many of them were missing the technical details needed to fight COVID-19 using the IoT. However, there were a plethora of academics who made significant contributions in many ways to the use of IoT in tackling COVID-19; this topic will be examined from five main angles, namely:

• Survey articles on Internet of Things (IoT) technology for COVID-19 prevention.

• The models, frameworks, structures, methods, systems, and applications of the Internet of Things (IoT) to deal with COVID-19. Combating COVID-19 with the integration of IoT and artificial intelligence.• Incorporating blockchain technology and the Internet of Things to combat the COVID-19 pandemic.

• Examining the acquired data from the Internet of Things environment.

The next sections will elaborate on each of these rules. First things first: many researchers looked over what was already written on COVID-19-related Internet of Things (IoT) applications. K. Kumar et al. [10] reviewed the tracking methods and suggested an Internet of Things (IoT)-based architecture that might be used to control the COVID-19 epidemic. Musa Ndiaye et al. [11] presented an explanation of the IoT and its possible advantages at the COVID-19 conference. Also included in the study were problems with the method for deploying sensors and how the COVID-19 epidemic affected the progress of IoT network development. Twelve IoT-based applications were investigated by Ravi Pratap Singh et al. [12] for their possible role in the fight against the COVID-19 pandemic. Researchers AwishkarGhimire et al. [13] looked into and examined a bunch of models that use AI and the Internet of Things to assess how well they work. Mohammad Nasajpour et al. [14] assessed the COVID-19-fighting IoT apps and systems using the TRIAD framework of early diagnosis, quarantine, and post-recovery.

MOTIVATION AND CHALLENGES FACING THE PROPOSED MODEL

In this part, rationale of the suggested model and the primary issues confronting the proposed approach are described.

Motivation of The Proposed Model

Worldwide, the number of COVID-19 infections and deaths is rising daily, according to data compiled by the World Health Organization. There were 25,425,432 confirmed cases and 5,112,461 deaths as of 17 November 2021 [38]. Our primary driving force was the daily rise in numbers, which was mostly caused by close personal contact with sick individuals. In February 2021, the World Health Organization (WHO) updated its definition of "contact person" [39]. A person was considered exposed if they were within one meter and had direct physical contact with the offender for at least fifteen minutes. According to this research, the contact person poses the most risk when it comes to spreading COVID-19. The use of Internet of Things (IoT) sensors, including global positioning systems (GPS), Bluetooth, and ultra-wideband (UWB) radios, is crucial in determining how far apart people are [40]. That way, we can find out who was impacted and who was in contact with them.

Challenges Facing the Proposed Model

There are various obstacles confronting the suggested model, the most prominent of which being the following:

• The main technological barrier to monitoring infected or contact cases is to detect the specific position of the individual and hence the capacity to estimate distances between people in distance less than one metre.

• Storing the infection history for each individual as the system will react with situations differently via an alerting module.

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• Ensure the secrecy and privacy for infected or contact patients.

THE PROPOSED IOT AND CLOUD BLOCKCHAIN MODEL FOR COVID-19 INFECTION SPREAD CONTROL

The suggested technique is based on three categories of cases:

• Normal case: uninfected or non-contact case, as depicted in figure 1 in green with the letter "A".

• Contact case: a case that contact with an infected case at a distance of less than one metre and for more than 15 minutes, as depicted in figure 1 in orange with the letter "B".

• Infected case: a verified case in which it has been proved by chest CT or laboratory test (such as PCR and D-dimer [41]) as depicted in figure 1 in red with the letter "C".

The Proposed IoT and Cloud based Blockchain Model

Controlling the Spread of COVID-19: An Architectural Framework As shown in figure 1, the proposed model architecture is made up of four main parts: an IoT environment, an alerting module, a blockchain management system, and a blockchain that is hosted by a cloud-based consortium. For location tracking, the IoT ecosystem makes use of a wide variety of sensors, including GPS, Bluetooth, and UWB. In environments with an error rate greater than 1 meter, such as inside or in restricted spaces, relying only on GPS sensors to determine positions is not feasible. However, although the World Health Organization (WHO) reports that the infection distance is less than or equal to 1 meter, the other two sensors can identify the location with a better rate of error of 10 cm in indoor or closed environments. Consequently, the location database in the cloud is updated in real-time with all data. To aid in the containment of infectious diseases, the alerting module notifies the blockchain management system of the contact persons' details (case B) and simultaneously disseminates all relevant procedures and case-specific information (case C) based on its type.

MODEL IMPLEMENTATION AND RESULTS DISCUSSION

There are numerous subtleties in the implementation process for the suggested model, but the emphasis will be on two key elements which are, smart contracts implementation and outdoor/indoor tracking.

Smart contracts implementation

Smart contract built using solidity programming language utilising one of the most frequent tools for implementing contracts to the Ethereum network which is the Remix IDE. Figure 5 displays the emented code to execute the rules of smart contracts. As illustrated in figure 5, there are five rules was evaluated to define the kind of case.

```
pragma solidity ^0.8.5;
contract Covid19_Infection_Spread_Control{
  uint256 public createTime= block.timestamp;
  enum Person1_Statelist{ A, B, C }
    Person1_Statelist Person1S_choice;
  enum Person2_Statelist{ A, B, C }
    Person2_Statelist Person2S_choice;
  enum MedicalReportlist{ P, N }
    MedicalReportlist MedicalReport_choice=MedicalReportlist.N;
  constructor() public {}
  function getCurrentState() public view returns(Person1_Statelist){
    return Person1S_choice; }
  function SetNewState(uint256 Distance,uint256 ContactTime,uint256
InfectionDate) public{
    //Distance in centimeter, Date and Time in seconds
    uint256 QuarantineDays=createTime-InfectionDate;
    if(Person1S_choice==Person1_Statelist.A && Distance < 100 &&
Person2S_choice == Person2_Statelist.C && ContactTime>900) {
      Person1S_choice=Person1_Statelist.B;
    } else if (Person1S_choice==Person1_Statelist.A &&
MedicalReport_choice==MedicalReportlist.P){
      Person1S_choice=Person1_Statelist.C;
    } else if (Person1S_choice==Person1_Statelist.B && QuarantineDays>1209600){
      Person1S_choice=Person1_Statelist.A;
      //14 days quarantine in seconds=1209600
    } else if (Person1S_choice==Person1_Statelist.B &&
MedicalReport_choice==MedicalReportlist.P){
      Person1S_choice=Person1_Statelist.C;
    } else if (Person1S_choice==Person1_Statelist.C &&
MedicalReport_choice==MedicalReportlist.N){
      Person1S_choice=Person1_Statelist.A; }}
  function getNewState() public view returns(Person1_Statelist){
    return Person1S_choice; }}
```

Figure 1: Smart contracts implemented code

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A brief description of the smart contracts rules is as follows:

•Checking the contact case which is within 1 meter with (CASE C) for at least 15 minutes. Figure 1 shows the test results for a contact case that its type changed from A represented as zero to B represented as one. Note that the distance is measured in centimeters and time in seconds.

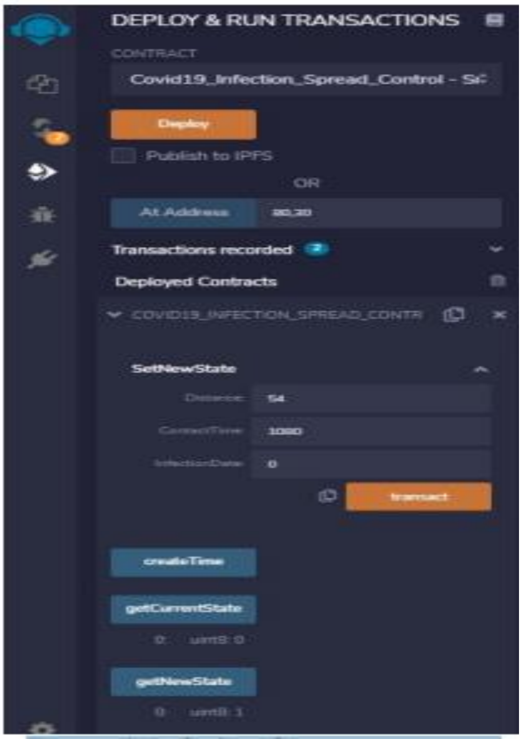

Figure 2: Rule 1 in the smart contracts

•Checking normal cases that are infected and confirmed according to positive reports from hospitals and laboratories. Figure 7 shows the test results for a case that its type changed from case A (0) to case C (2).

Figure 3: Rule 2 in the smart contracts

• Checking contact cases after 14 days quarantine without any symptoms.Figure 8 shows the test results for a case that its type changed from case B (1) to A (0). Note that the assumed currentdate/time (Unix epoch time): 1623584270 which is Sunday, June 13, 2021 11:37:50 AM and infection date/time (Unix epoch time): 1621398914 which is Wednesday, May 19, 2021 4:35:14 AM.

Figure 4: Rule 3 in the smart contracts

•Checking contact cases that were confirmed as infected cases according to positive reports from hospitals and laboratories. Figure 9 shows the test results for a case that its type changed from case B (1) to case C (2).

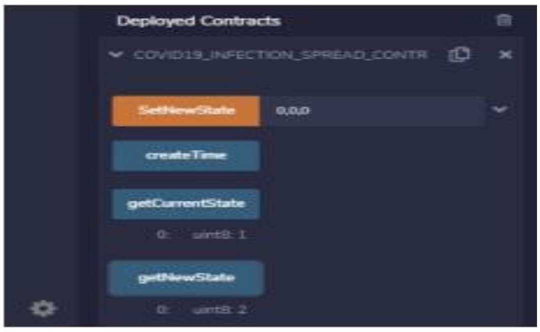

Figure 5 : Rule 4 in the smart contracts

• Checking confirmed infected cases which are recovered according to negative reports from hospitals and laboratories. Figure 10 shows the test results for a case that its type changed from case C (2) to case A (0).

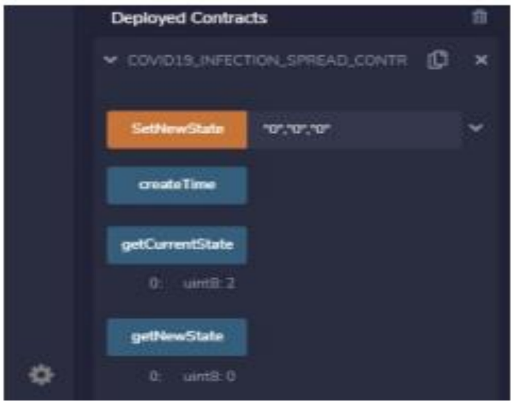

Figure 6: Rule 5 in the smart contracts

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Outdoor/Indoor

Tracking To calculate accurate values of distances between people, cloud-based location DB is used to store locations every moment, and thus the ability to determine the distances between people. Figure 7 shows the database model of cloud-based location DB which shows the integration between indoor and outdoor technologies. GPS used for outdoor tracking, and on the other side Bluetooth and UWB used for indoor tracking.

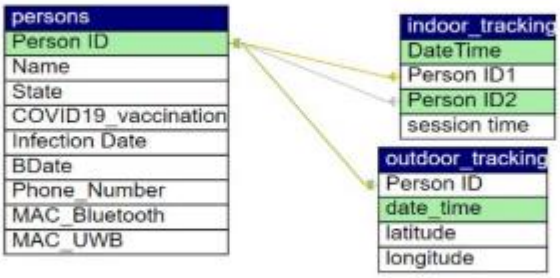

Figure 7: The database model of cloud-based location DB

Outdoor tracking in the proposed model is based on GPS technology, GPS location captured through IoT sensors and manipulated in model code by Geolocation.getCurrentPosition() function. Figure 12 shows a part of the code that explains how to determine the current position of the device.

```
var options = {
    enableHighAccuracy: true,
    timeout: 5000,
    maximumAge: 0
};
function position(pos) {
    var crd = pos.coords;
    console.log('current position:');
    console.log(`Latitude : ${crd.latitude}`);
    console.log(`Longitude: ${crd.longitude}`);
    console.log(`More or less ${crd.accuracy} meters.`);
}
function ErrorHandler(err) {
    console.warn(`ERROR(${err.code}): ${err.message}`);
}
navigator.geolocation.getCurrentPosition(position,
ErrorHandler, options);
```

Figure 8: Determining the current position.

Then the distances are calculated between two coordinates by latitude and longitude which are generated by GPS sensors. The distance is calculated based on the “haversine” function:

$$a = \sin^2(\Delta\varphi/2) + \cos\varphi 1 \cdot \cos\varphi 2 \cdot \sin^2(\Delta\lambda/2) \quad (1)$$

$$c = 2 \cdot \operatorname{atan2}(\sqrt{a}, \sqrt{(1-a)}) \quad (2)$$

$$d = R \cdot c \quad (3)$$

where φ is latitude, λ is longitude, R is earth’s radius (mean radius = 6,371km). Figure 13 shows a part of the code that explains how to determine the distances based on GPS.

```
function distance(lat1, lon1, lat2, lon2) {
    var p = 0.017453292519943295;
    // Math.PI / 180 = 3.141592653589793 / 180
    var c = Math.cos;
    var a = 0.5 - c((lat2 - lat1) * p)/2 +
            c(lat1 * p) * c(lat2 * p) *
            (1 - c((lon2 - lon1) * p))/2;

    return 12742000000 * Math.asin(Math.sqrt(a));
     //  R = 6371 radius of earth in KM ;
    2*1000*100*6371 to convert it to centimeters
}
```

Figure 9: Determining the distances based on GPS

Indoor tracking in the proposed model is based on two technologies which are Bluetooth and UWB. The distance is calculated based on received signal strength indicator RSSI because the signal strength depends on distance and broadcasting power value. Figure 9 shows a part of the code that explains how to determine the distances based on Bluetooth and UWB.

```
protected static double calculateDistance
(int txCalibratedPower, double rssi) {
    if (rssi == 0) {
        return -1.0;
    }

    double ratio = rssi*1.0/
    txCalibratedPower;
    if (ratio < 1.0) {
        return Math.pow(ratio,10);
    }
    else {
        double distance =  (0.89976)*Math
        .pow(ratio,7.7095) + 0.111;
        return distance*100;
    }
}
```

Figure 10: Determining the distances based on RSSI

Figure 10 shows an example that applied in the real environment to verify that the calculated distances between two points are equal to the real distance in the real environment.

Figure 11: An example to determine

the distance In the applied example, Bluetooth and UWB can measure distances with a maximum coverage level of up to 50 meters and the GPS can measure distances with an unlimited maximum coverage. The results can be shown in figure 11.

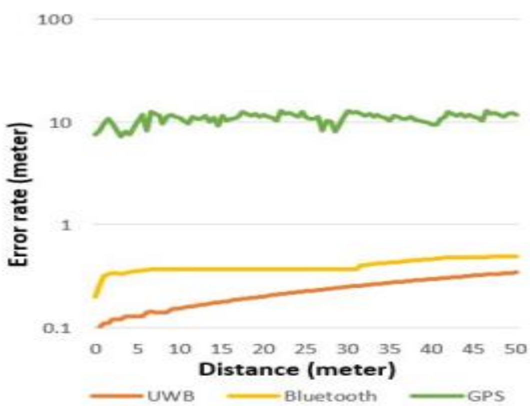

Figure 12: Distance error rate in GPS/Bluetooth/UWB

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According to testing results as shown in figure 12, there are error rates in the calculated distances using the proposed model as following:

• In a distance of less than or equal 1 m (using Bluetooth and UWB only), the error rate does not exceed 11 cm.

• In a distance between 1 m to 50 m (using Bluetooth, UWB, GPS), the error rate does not exceed the values between 11 cm and 35 cm.

CONCLUSIONS

This study introduced a new model for infection control using the Internet of Things (IoT) and blockchain technology in the cloud. It allows for reliable, secure, and efficient cooperation and monitoring of COVID-19 patients, contacts, and normal cases, as well as authorized hospitals and labs. By integrating preexisting indoor and outdoor IoT monitoring technologies with a cloud-hosted blockchain system, the idea suggests a new way to manage and restrict the spread of COVID-19. The created model successfully identified COVID-19 patients and determined contact persons using IoT outside GPS-based sensors and interior UWB/Bluetooth-based sensor technologies, with a distance calculation error rate of less than 11 cm/m. In order to calculate distances, data is transmitted from IoT sensors to a cloud-based consortium blockchain system. There, it is processed by a pre-programmed smart contract that identifies whether a user is normal, a contact, or a patient. If it detects a COVID-19 infected case or contact, a location-based warning is sent out.

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