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Applications of the IoT and blockchain for COVID-19 containment

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ABSTRACT: The entire world got affected by the unprecedented spread of the COVID-19 virus. The news reports and video clippings emanating from different parts of the world are really appalling. Governments across the globe are working overtime to somehow stop this killer pandemic in the budding stage. As on this date, nearly 2.5 laths people succumbed to this virus. IT specialists are skillfully leveraging a bevy of proven and potential digital technologies and tools to support the universal goal of surmounting this dangerous endemic. Specially, electronics engineers are instrumenting IoT sensors and actuators to provide non contact and non invasive means of detecting the presence of virus in individuals. Security engineers are working to ensure how security can be enforces in systems that are being used for COVID-19 because data is vulnerable to security attacks by hackers. In this paper, the applications of the IoT and blockchain technologies for resolving COVID-19 issues are presented with a review of recent literature.

KEYWORDS: COVID-19 – The Internet of Things (IoT), Blockchain, research problems with COVID-19

I INTRODUCTION

In December 2019, many people got infected with a new corona virus which was initially named as 2019-nCov and later named as SARS-CoV-2 by International Committee of Taxonomy of Virus (ICTV). This could cause the disease called COronaVirus Disease 2019 (COVID-19). World Health Organization (WHO) refers to SARS-CoV-S virus as COVID-19 virus in its documentation [1]. According to Dadax Worldometer, from its epicenter, COVID-19 has spread to infect 22, 52, 366 people in 210 countries and territories around the world as on April 18, 2020, 06:52 GMT. COVID-19 is a pandemic as declared by World Health Organization (WHO) [2], which is transmitted through respiratory droplets and contact routes. Since the number of infected persons grows rapidly all over the world and there is no specific medicine or treatment to cure the infection, it is crucial to analyze the spread pattern of the disease and take necessary control actions. The primary testing procedure for detecting the presence of COVID-19 virus is the Reverse Transcription Polymerase Chain Reaction (RT-PCR), a nucleic acid testing method. It is a laboratory based testing and it takes around 24 to 72 hours between sample collection and generation of results. More important is the cost involved is RT-PCR testing is very high. Utilizing such testing kits to all the individuals is not an effective approach. Alternate methods such as Point of Care (POC) tests which detect the presence of antibodies such as IgG and IgM indirectly imply that the individual may get infected by the virus [3].

This is the most crucial time to sagaciously apply some of the existing and emerging computational methods such as the IoT, artificial intelligence, big and fast data analytics platforms, blockchain, etc., to bring forth competent solutions for surveillance, detection and prevention of COVID-19 and mitigation of the impact to healthcare. In this paper, we review the recent literature to study the applications of IoT and blockchain for resolving COVID-19 issues.



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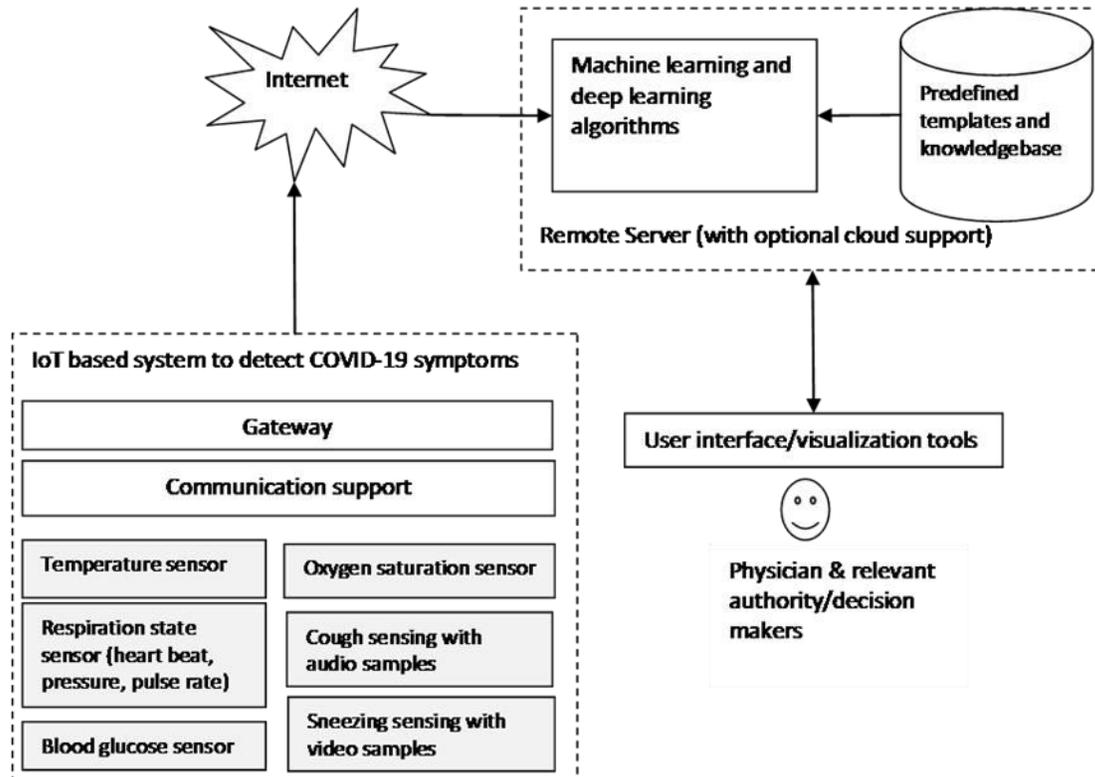
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II. LITERATURE REVIEW

Applications of the IoT

The Internet of Things is a collection of devices and sensors connected to the Internet and the devices in the network can share data with one another. With the IoT, not simply computers and smart phone can get connected to the Internet, but any sensor or device such as washing machine, refrigerator, fan, light, etc can be connected to the Internet. With rapid growth of COVID-19, the IoT has emerged into mainstream applications to fight against the infection. Timely surveillance systems are typically used to collect information on epidemic prone diseases and give early alerts to public. The IoT based platforms can provide country-wise real time update on the total number of infected cases. Advances in wireless sensors, the Internet, Radio Frequency Identification (RFID) and AI techniques are the key drivers for enabling the IoT to extend its applications to respiratory disease management [4]. For example, IoT based smart helmet proposed in [5] can automatically detect COVID-19 virus using facial recognition facility mounted with the thermal imaging system. This system requires only less human intervention. Facial recognition systems are being developed to find whether people are wearing masks or not. Due to rapid spread of COVID-19, recent face recognition cameras are able to identify masked faces. The artificial algorithms are trained with huge dataset of masked faces in order to predict masked faces with sufficient accuracy. Some facial recognition companies employ thermal imaging enabled facial recognition to identify people having elevated temperature. Nowadays, facial recognition technology becomes essential to verify the identity of employees in government offices, hospitals, business organizations, etc to provide non contact means of identity verification whereas the other biometrics based identity checking such as fingerprints use touch based sensors. In [6], a portable non-contact system which acquires both temperature and respiration state of a person by capturing the thermal video of his/her face which provides screening result about COVID-19 within 15 seconds. AI enabled infrared sensor systems help in identifying people who might be unknowingly infected with COVID-19 by monitoring the temperature of people in proximity. Mobile phones with embedded sensors can identify COVID-19 symptoms [7]. Phone based surveys can help in distinguishing high-risk persons from low-risk patients [8]. Wearable devices equipped with medical sensors that are capable of measuring vital parameters such as temperature, respiration rate, heart rate, pulse, pressure and blood glucose, oxygen saturation [61]. These wearable devices enable physician to monitor the people without human touch which is more essential in the case of COVID-19. The crucial role played by the IoT and artificial intelligence can be realized with a hypothetical use case for COVID-19 as shown in the Fig. 1.



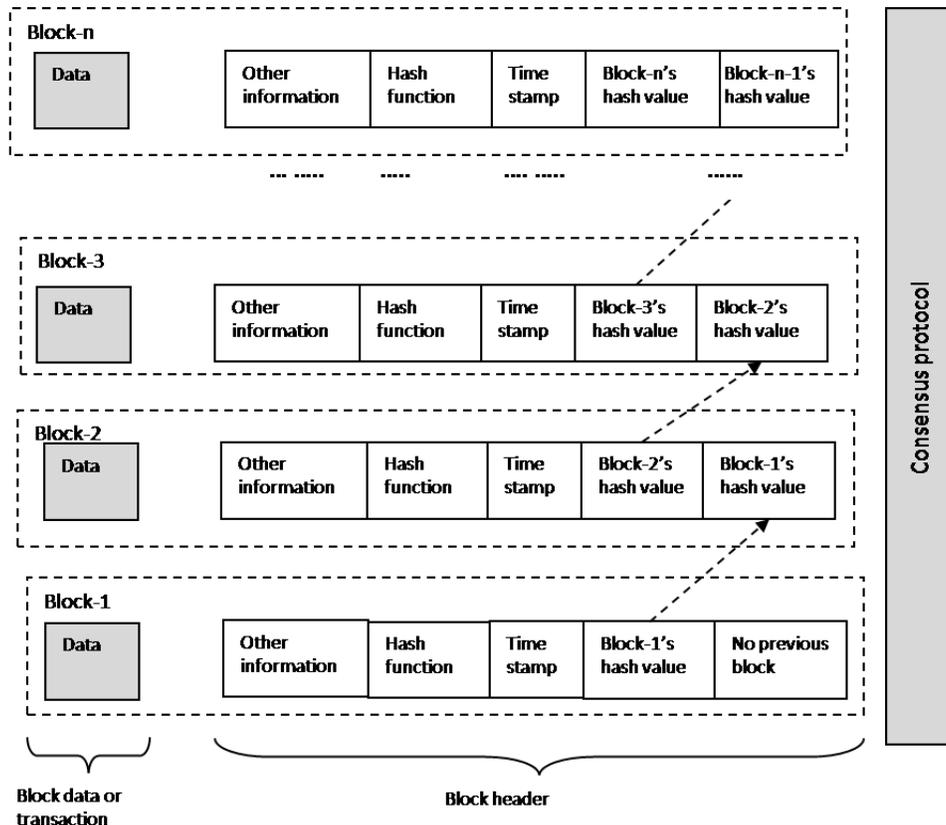
As in Fig. 1, different IoT sensors such as temperature sensor, blood glucose sensor, respiration state sensors, oxygen saturation sensor acquire vital parameters/symptoms for COVID-19. In addition audio samples and video samples collected from an individual can be analyzed to detect the presence of cough and sneeze respectively. The acquired data is communicated after required preprocessing at gateway via Internet to remote server where analysis is done using machine and deep learning algorithms. The server may be backed up with cloud services to have the infrastructure like storage and high performance CPUs. The algorithms are guided with relevant domain knowledge to get more accurate and meaningful insight which enables a physician to take appropriate decision in real time.

Another important identification technology, Radio Frequency Identification (RFID) tags can be used to identify people or things where it is tagged from a distance up to hundreds of meters without human intervention and it does not require line of sight [10]. RFID based bracelets can be used in Real Time Location Systems (RTLS) to track the location of patients, nurses, ventilators, etc during crisis such as COVID-19 with the incorporated infrastructure. IoT based Chatbots can help people in identifying symptoms based on a conversation and suggests whether people really need to go for hospital consultation or not

Applications of Blockchain

Blockchain is a combination of computers which are connected with one another in a decentralized fashion where a time stamped series of immutable records of data is maintained and shared (i.e. any block of data entered is distributed to all nodes by consensus algorithm after verifying the validity of the data) among the participants with three unique characteristics, namely, (i) decentralized architecture for data storage (ii) transparency and (iii) immutability. In a blockchain, once the data is put, it cannot be changed, but a node can append the data which in turn gets distributed to all the participants in the network after approval. Blockchain architectures are of two types, public and private. Public blockchain is one which can be accessed by anyone whereas a private blockchain maintained by a group of organization

with authorized users. In the case of private blockchain, only one organization holds the central authority which is more responsible for the validating the data during its appendment. From the research works[11-12], the typical architecture of blockchain can be realized as shown in Fig. 2. Structure of blockchain



From Fig. 2, the very first block of the chain is genesis block which does not have its previous block. The major components of blockchain include node, block, miners(authorized nodes to approve data change occurs in any block), consensus protocol, hash function. In addition, there are other components such as time stamp(to record the time of block creation), digital signature(private key of the concerned node in confidential format and public key of other nodes of the network), nonce value(random value) and nBit(refers to the encoded target of a block header where target is the threshold value of the block header).

Security related concept in blockchain is as follows. Whenever, a node enters data, miner nodes(there can be any number of miner nodes in network) which will verify the logical validity and consistency of the data using different consensus algorithms such as Proof of Work(PoW), Proof of Stake(PoS), etc[12] and then permit the data entry. Whenever a data is entered, the hash value of the entire transactions of the concerned block is computed and updated throughout the network. Further, the consensus protocol appends the data with time stamp and distributes the data to all nodes. Thus the distributed data is upto date in all nodes. More important aspect is that, once the data is put into a block, it cannot be modified but any further data can be appended. So, the data cannot be tampered. The unique feature of blockchain is that each node stores the hash value of its previous block. Any change in data will reflect in hash value of the concerned node which in turn gets updated to its successive node. This continues till the end of the chain. Unless all miners(very frequently all the nodes in a network will serve as miners) accept a change as valid one, it can never gets appended. This kind of immutability and consensus rules of blockchain makes the data secure and safe within network. In healthcare domain, sharing of data in a secure manner is crucial as medical data of patients are sensitive information. Consider a hypothetical blockchain for

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Blockchain for COVID-19

Blockchain technology, as a secure, decentralized technology facilitates storage and sharing of data among different stakeholders/participants in healthcare domain without compromising security and privacy [13]. In [14], the first blockchain based framework is proposed to automatically detect the unknown infected individuals and places of COVID-19 and further to estimate the associated risks. Blockchain network deployed on mobile phones facilitates the tracking of COVID-19 spread while preventing the exposure of user information [15]. Blockchain and AI technology also help in distribution of medicine and donations to the respective destinations according to the computational laws and cryptography [16]. A low cost POC diagnostic testing platform which combines the use of blockchain, and artificial intelligence proposed in [17] enables the collection of high-quality data from federated blockchain platforms with high confidence & speed and facilitates the analysis of deep insights. Blockchain can be designed for providing surveillance data to local and national healthcare agencies such as WHO, Health Ministry and relevant nodal hospitals.

III. CONCLUSION

Researchers from various scientific domains ranging from genetic engineering, molecular biology, virology, etc. are sagaciously and sincerely working on myriads of multifaceted tasks to come out with workable and winnable solutions to combat this virus. Medical researchers are exploring and experimenting with an array of techniques to produce powerful vaccines. Immunity-enhancing mechanisms are being widely published to educate people. Medical electronics professionals are instrumenting versatile and resilient IoT devices to detect the virus at an early stage. IoT data gets aggregated from different sources and subjected to a variety of investigations in order to accurately predict the existence of the virus on someone. The full history of affected people is getting stored in blockchain ledgers to ensure data security. A dazzling array of mobile applications is being built and released in order to empower and educate common people to be on the safer side. Thus, on various fronts, purpose-specific efforts are underway.

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