

# Study of IoT-Based Digital Technology to Combat COVID-19 Pandemic

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**Abstract:** The epidemic of coronavirus disease which is called COVID-19 is dispersing all over the world in a few months. The traditional health care systems face new challenges associated with the constant increase of infected persons with this disease. In the current time, the integration of smart medical sensors and devices of the Internet of Things (IoT) proposed the new health care domain which is called the Internet of Medical Things (IoMT). With this technology, accuracy, reliability, efficiency, and effectiveness are improved in the health domain. With the combination of cloud computing with IoT architecture, the smart healthcare system is designed which is able to support real-time applications when Artificial Intelligence (AI) processing on a vast data which is collected by wearable sensors network. The emergence of IoMT has initiated the vital change in assisting the management of diseases, improving the diagnosis of disease, treatment methods and also reducing the cost and errors in healthcare. The implementations of this technology in the health domain not only improve the healthcare quality for patients but also help the healthcare workers. This paper studies the use of IoT solutions throughout this pandemic period in a health care system, starting from early health monitoring solutions from wearable sensors up to a final recovery from COVID-19. IoMT can play an imperative role during this pandemic time and facilitate to stop the spread of the virus, recognize the patient who has been infected with this virus and also help to control the coronavirus infection in real-time.

**Keywords:** COVID-19, Internet of Medical Things (IoMT), Internet of Things (IoT), Ontology.

## I. INTRODUCTION

The pandemic of coronavirus disease which is called COVID-19 is spread globally in a few months. This novel virus and disease unknown before the outbreak initiate in Wuhan, China, in December 2019. But now COVID-19 is become a pandemic and affects a number of countries globally. This

pandemic has resulted in over 20 439 814 confirmed cases and over 744 385 deaths in 216 countries in the world [1]. COVID-19 infected people will show mild to moderate respiratory problems and these patients do not require any special treatment. Serious illnesses will show in older people and also those who have any respiratory disease and these patients are required special care. The COVID-19 is a communicable disease and it spread with droplets of saliva. Till now, no specific vaccine or treatment is found for this disease. The best method to avoid and minimize the spread of COVID-19 is only to be well knowledgeable of the COVID-19 virus, its causes, and how it spread. Save yourself and loved ones from its infections only by washing hands with soap and by the use of alcohol-based sanitizer. Social distancing is also the main precaution to save ourselves and others from this disease [2].

With the development of communication technology and sensor networks technology, portable and wearable devices have become more popular globally. Wearable devices mean the device that can easily wearable by the person in the form of necklaces, belts, watches, and many more. These devices have sensors with independent computing power and monitor the physiological information of the person like heartbeat, pressure, and breathing, etc., and also monitor the environment characteristics like temperature, humidity, and air quality. Sensors implemented devices are easily connected to smartphones, tablets, and computers with technologies like Bluetooth, Wi-Fi, and the internet. Nowadays IoT devices are widely used in various domains like the health sector, sports, and fitness to monitor the health of a person [3]. The integration of health devices with the other technology which is called the Internet of Things (IoT) develops the new emerging technology which is called the Internet of Medical Things (IoMT). Medical sensors are used to design wearable devices. With these devices, constantly monitor the health of patients in real-time instead of keeping the patients under surveillance in the hospital [4]. By using IoMT, numbers of activities are easily handled by patients, health workers like remotely medical assistance, data capture, and storage for analysis, drug management, in operation tasks, patients tracking, and many more [5]. The adaptation of IoMT is increased and gain popularity in the market. It is the emerging technology of IT in the healthcare area which is used to sense, auto collected data, intelligence, and internet-oriented [6].

IoMT technology is an IoT based solution which helps to design the healthcare systems based on IoT technology that helps to monitor the vital sign of health like ECG, Heart rate and blood pressure. By the implementation of IoMT technology, health domain become e-health which given the remarkable wellness health services globally to change the healthier lifestyle. Due to this technology, healthcare services become user centric and personalized services by provide private healthcare round the clock. The main motive of IoMT enabled healthcare system is to improve the health services and quality of life by avoiding the unpleasant hospitalization. Smartphone play a vital role and act as the gateway in the IoMT edge network. With the help of smartphone, data can be received and forward on the network over the internet to the healthcare service provider for data processing and storage [7]. The numbers of medical devices are connected to produce, store, analyze and also distribute user's health data. Wearable's, remote patients monitors, sensor enabled beds, infusion pumps and tracking devices are the some IoMT devices which are used to collect the data. The main motive of IoMT technology is to provide the satisfaction

of patient and also increase the quality of care which given healthcare providers [8]. IoMT technology is the amalgamation of data from medical devices that connect with healthcare IT systems through internet. The intention of IoMT technology is to combine people, data and processes with connected medical devices and mobile applications to improve patient outcomes. This technology allows patients to share health information with doctors for more accurate diagnoses with fewer errors and lower costs of care. In the current situation of COVID-19, this wireless technology plays an important role because of this no need for the patient's medical visit to hospitals which prevents the spread of coronavirus [9].

The infected patients are increasing daily globally and at that time its need to utilize the IoT in a robust, organized manner and in an efficient way to enhance the battle against the COVID-19 pandemic. This technology enables us to capture the real-time data of infected patients and locations remotely. The process involved in the implementation of IoT technology to fight COVID-19 is shown in Fig. 1 [10].

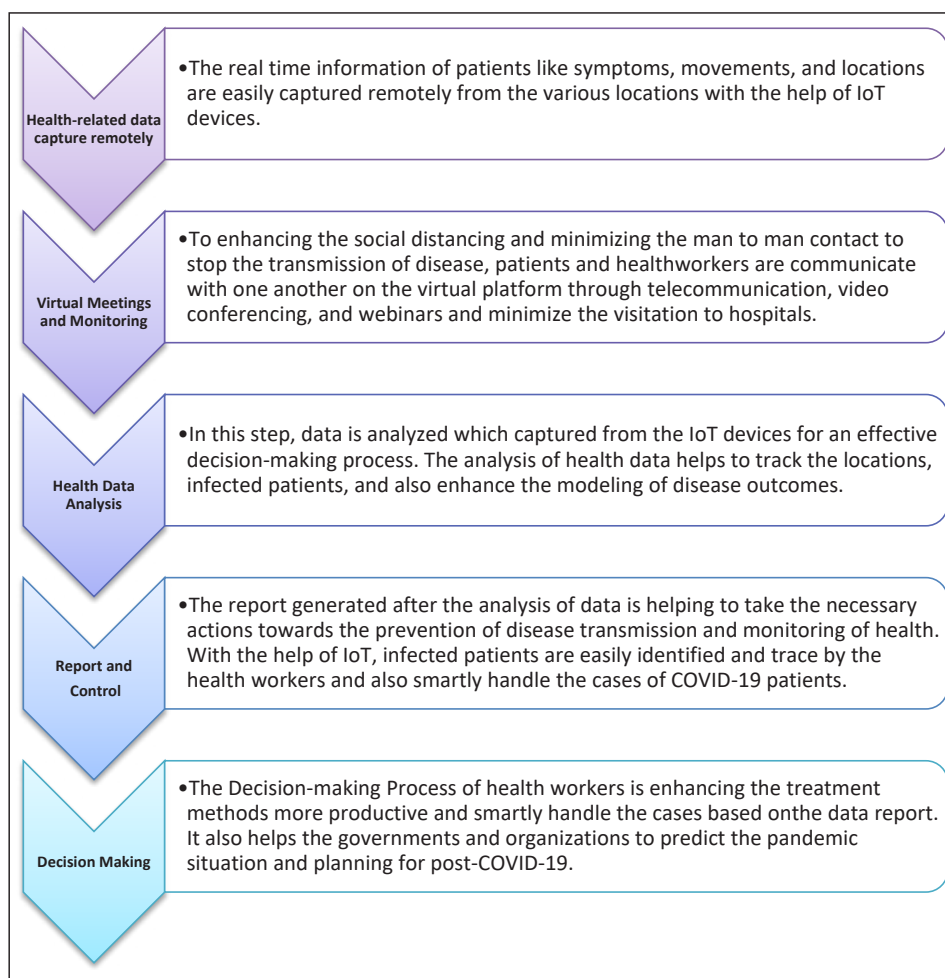


Fig. 1: Process in the Implementation of IoT to Fight with COVID-19

### Major Key-Merits of IoT to Battle with COVID-19 Pandemic [11]

The major key merits of IoT technology utilization in the COVID-19 pandemic are the highlight in Fig. 2.

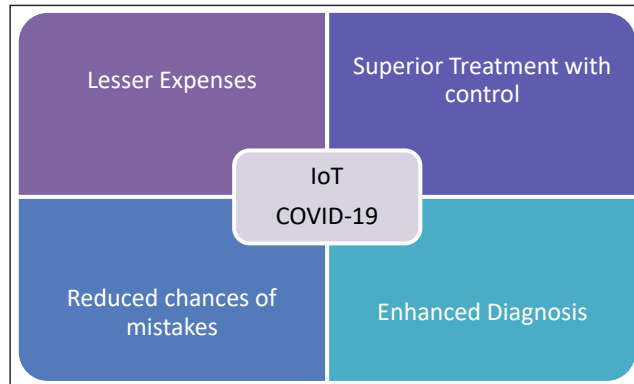


Fig. 2: The Major Key Merits of IoT to Battle with COVID-19 Pandemic

- *Lesser Expenses:* The cost of IoT implements devices is less means it is a one-time investment. The purchased devices are work for a number of years without any problem.
- *Superior Treatment with Control:* With the utilization of real data, IoT implanted devices take the right decision at the right time and increase the treatment process.
- *Reduced Chances of Mistakes:* The chances of mistakes are reduced due to the automation of IoT devices.
- *Enhanced Diagnosis:* By the utilization of IoT devices, the diagnosis process of the disease becomes easier and is able to be diagnosed in the early stage and at that time right treatment can be given to the patient.

## II. LITERATURE REVIEW

Sr. No.	Reference	Study
1	[12]	The correct prediction of protein complex plays an essential role to understand the principal mechanism of various cellular functions and elucidates the functionality of different un-annotated proteins. The basic topological properties of a protein are studied by several complex detection algorithms without using advance topological and biological properties and it can be implemented with the association rule learners such as PART and NNGE. These association rules provide better accuracy and low computational cost.
2	[12] [13]	The main aim of the IoMT platform is to provide a better life-tothe patient by providing personalized healthcare services into 24-hour services. Edge network of IoMT has a number of security threats like confidentiality, integrity, authentication, and authorization and they may cause a significant risk to patient's privacy and safety.
3	[14]	The advancement in IT and IoMT has encouraged extensive utilization of the smart system. 24*7 healthcare services are required for effective and reliable monitoring of a patient on the daily basis. To fulfill this requirement, edge computing and cloud platforms are needed for smart healthcare systems.
4	[15]	Proposed a deep learning solution for healthcare platform which automatically identify the type of food given to the patient on the basis of disease and other attributes such as age, gender, weight, calories, protein, fat, sodium, fiber, cholesterol by implementing deep learning algorithms like RNN, MLP, GRU, and LSTM.

Sr. No.	Reference	Study
5.	[8]	Monitoring and prediction systems in the health domain are essential for saving lives mainly when patients are remotely located. By using MSSO-ANFIS, an IoMT based healthcare monitoring system for heart disease prediction is proposed which presents higher values for precision, recall, F1-score, and accuracy with the lowest values for classification error when compared with the existing techniques.
6.	[16] [7]	The extended version of IoT is called IoMT in the healthcare domain. In the current COVID-19 situation, IoMT is used to create a medical platform to provide the proper healthcare at home and remotely without any movement. The novel security method is required to preserve the security of IoMT edge networks.
7.	[17]	Developed a CMMA for cluster head selection to give effective communication to sensors enabled devices of IoMT in the health domain. This technique not only minimizes the energy utilization of edge computing-based IoMT systems but also increases the network lifetime by uniformly distributes cluster heads in the network.
8.	[18] [19]	In today's situation, healthcare systems are digitized with interconnecting of medical devices. Data integration, Privacy, Security, Real-time processing Hardware implementation, and design optimization issues are faced by the developer while implementing IoT technology in the healthcare domain. IoMT systems play a vital role during this pandemic time to track and trace the infected patients.
9.	[20]	In the interconnected e-Health devices of the IoMT network, trust management plays an essential role to provide a smooth and reliable communication process. The trustworthy communications among the devices is a tedious task to handle in a large spread network but its control is based on fuzzy logic named FTM-IoMT.
10.	[5]	A web application named IoMT-SAF is based on novel ontological to ensure security in the IoMT platform. IoMT-SAF contains the assessment attributes list that covers the essential measures of security for the IoMT users to identify and implement security on the basis of user requirements.
11.	[21]	IoMT implementation helps in the identification of brain tumors at an early stage. An association rule learner like Partial Tree with advanced feature sets is adopted to detect brain tumors.
12.	[22]	Proposed a privacy-preserving-based data collection and analysis framework named P2DCA for IoMT applications. It collects the data with mobile nodes from WMSNs which are partitioned into multiple small clusters. Both data and location coordinates of nodes are aggregated on cluster head to hide data sources before share data with mobile nodes. The cloud server performs the analysis with the help of CP-ANN to differentiate the received video into the foreground and background area to identify the moving objects after collecting the data from the mobile nodes.

Sr. No.	Reference	Study
13.	[23]	A smart healthcare system is proposed by using IoMT, Big Data analytics, and by immersing ML algorithms. IoMT technology is used to connect the wearable sensors, patients, healthcare service providers through software and ICT.
14.	[24]	To predict the vertebral tumor in the early stage and for diagnosis treatment, HMRF is proposed. This technique is used the IoMT platform with MRI images to identify the tumor.
15.	[25]	A reliable, dynamic, flexible, faster, and secure network is needed for the IoMT platform. Paper presented the new Hybrid DL-driven SDN-enabled IoMT uncovering framework which is highly usable, capable, and cost-effective.
16.	[26]	For the early detection and classification of malignant cells in breast cancer, integrate the ML and CI-based techniques in E-Health care services on the IoMT platform. The identification of malignant cells is accomplished by extracting shapes and textured-based features. Well-known classification techniques like SVM, NB, and RF are used to classify tumor cells into malignant cells.
17.	[27]	New services in health sectors like remote sensing, assisting of elder people from home, and E-Visit improve the patient's health and convenience by reducing the per-patient cost by the utilization of IoMT. The study represents the main defense mechanism for proving end-to-end privacy and security by developing approaches that protect the patients from the variety of cyber attacks and threats and also provide safeguards to the healthcare domain.
18.	[28] [29]	Presented an IoMT enabled wearable device called iGLU 2.0 for continuous glucose monitoring for diabetic patients this is based on the principle of optical detection. The device is validated on pre-diabetic, diabetic, and healthy patients from persons aged 17-80 years by using real healthcare data. iGLU 2.0 device has a great capability to provide self-care monitoring solutions for smart healthcare.
19.	[30]	Introduced the new blockchain-enabled authentication protocol for IoMT platform called BAKMP-IoMT in the medical field. This protocol provides secure data transfer management between medical devices, personal servers, and cloud servers. Users can also easily access the healthcare data from the cloud server in a secure way because whole healthcare data is maintained by the cloud servers in the blockchain.
20.	[31] [32]	Paper presented that the IoMT enabled devices to help to monitor the elder's people, by in the monitoring of elderly creating digital medical records and generate the alert message for caregivers and family members when IoMT devices detect an unusual situation. The system also produces simple and secure access to real-time data.

Sr. No.	Reference	Study
21.	[33]	The integration of IoMT, cloud storage, and Blockchain technologies in the medical area is playing a vital role. It reduces the cost, increase speed to access data, automation, remove mediators, centralized data and also overcome the security of data issue by implementing the latest encryptions method. Introduced the new BC IoMT U6 HCS (BlockChain based Internet of Medical Things for Uninterrupted, Ubiquitous, User-friendly, Unflappable, Unblemished, Unlimited Health Care Services) layered architecture.
22.	[34]	IoMT and smart gadgets generated a large amount of data. Drift is the major challenge in the process of the huge volume of data streams. To solve this situation, the ERDDM method is introduced for the detection of drifts in data streams generated by sensors and smart devices in the medical domain. This method enhances the RDDM by minimizing the error rate.
23.	[35]	Introduced the MELINDIA architecture in the Intelligent Surveillance System, by deployed in a smart building or in a smart city with a number of cameras that generate vast valuable information. This architecture is used to produce useful data from the raw data stream by reducing the dimensions of data. It also achieves low latency by analyzing the data near the sensors and also prevents the redundant of data by reusing the data.
24.	[36]	Presented an E-ADS with the utilization of fog-cloud architecture to locate and mitigate malicious activities in the IoMT environment. It using two engines, like a traffic processing engine and an intrusion detection engine.
25.	[37]	Introduced the new real-time epileptic seizure detection model using the ordinary kriging method in an edge computing paradigm.
26.	[38]	IoMT technology is employed in the fast and safe detection of leukemia with the utilization of cloud computing. Clinical gadgets are connected with a network and the system provides real-time data for testing, diagnosis, and treatment of leukemia. It saves the time and efforts of patients and health-care professionals.
27.	[39]	The proposed iLog model provides the monitoring systems by analyzing the eating behavior of the user and differentiate the behavior into stress eating or normal eating. This model using the edge platform, a mobile and SBC platform. Foods items are automatically detected and classified from the images and then compared with a stored database of nutrition in Firebase.

### III. IoMT ARCHITECTURE

IoT is the new emerging technology that effectively works in various domains. In healthcare sectors, IoT is adopted and use for efficient diagnosis and treatment of health. Medical devices are integrated with IoT technology for effective treatment and

diagnosis processes in the healthcare environment. Services of IoT-based healthcare systems named IoMT are to assist the monitoring of patient data, taking decisions in emergency, reduce process cost, and increasing the facility in the medical field [40]. Fig. 3 explains the ontology-based architecture of IoMT.

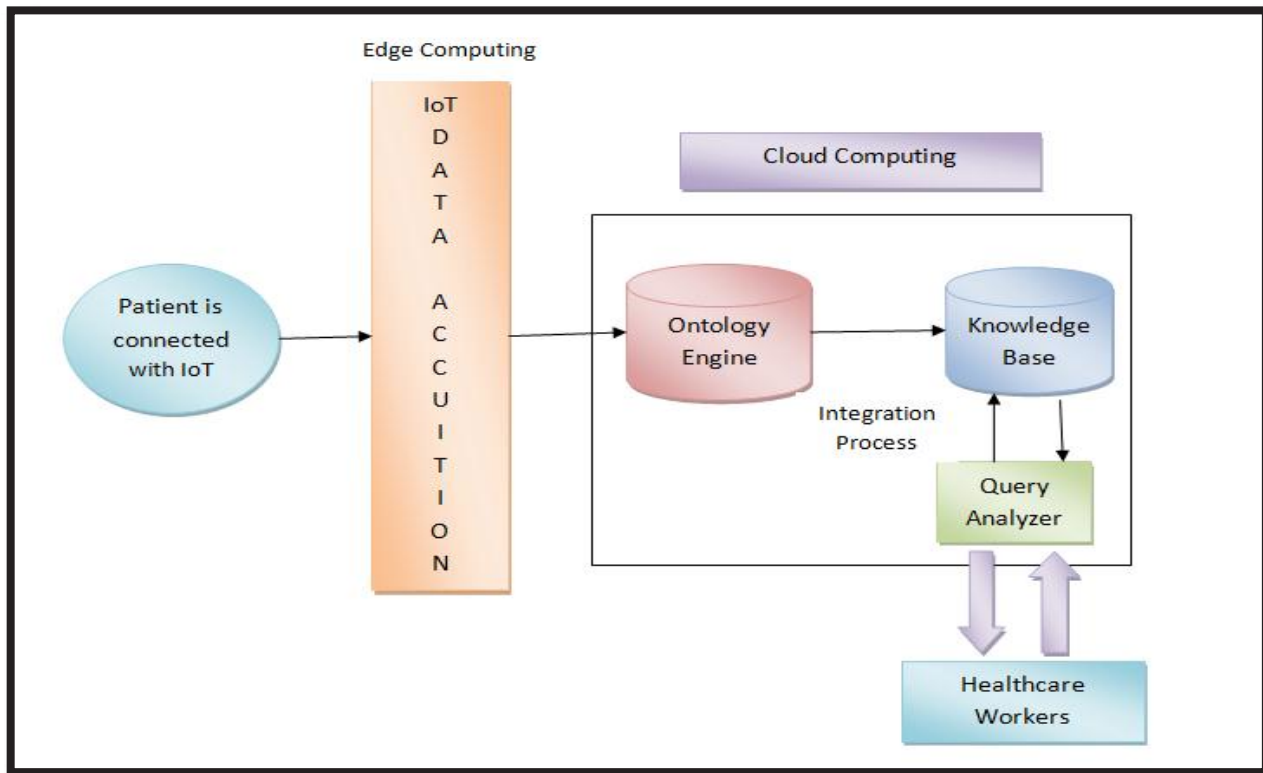


Fig. 3: IoMT Architecture with Ontology

- *Sensor Devices*: This layer consists of physical sensor devices such as medical equipment sensors based used during all activities involved in treatment and further assistance. All these equipment are capable of communicating through RFID, EPC, ZigBee, 4G-5G, Bluetooth, etc. for data transferring.
- *Edge Layer*: Edge computing has an important role in this architecture. After collecting information from the sensors, it will be stored on the cloud via the edge layer because the edge will reduce the amount of data in motion. Edge computing reducing

the dependency on a remote centralized server. Due to these healthcare workers would be able to have a more agile and responsive health care system from the IT network. Now health workers don't need to wait for their data to be sent to a central repository for processing and then returned to their hospital for use and patient treatment, which is a necessity for this pandemic period.

- *Storage Layer (Cloud)*: All reduced and preprocess data will be stored in a related database on servers located elsewhere. These servers are located on the

cloud and to realize the vision of the usage of IoT in medical services high-performance computing and Big Data analytics will play an important role.

- *Ontology*: During the pandemic time, fast and precise knowledge has an effective role in the management. Any kind of delay and imprecise knowledge may lead to a poor decision and detrimental action, resulting in increased mortality ratio as well as intensification. Ontology-based systems offer the advantage of flexibility and semantic interoperability for knowledge sharing in such conditions. Ontology is the framework for representing shareable and reusable knowledge across a domain. And due to this ontology have a great opportunity for performing productivity result in this pandemic time. At the

time creating ontology following phase is needed in the required area.

#### IV. UTILIZATION OF IoT DURING COVID-19 PANDEMIC

During this pandemic time, countries of the world are integrating their all resources and try to use the new technologies to minimize the effect of COVID-19. In this situation, AI and IoT technologies are used to stop the spread of the virus and also control the infection in real-time. In the present situation, healthcare technologies have pushed themselves to innovate new technologies which become more useful to handle that situation. The IoT technology plays an essential role to stop the spread of coronavirus and also assists healthcare workers in the treatment of patients. The major application of IoT during the COVID-19 pandemic is as follows [11] [10]:

Sr. No.	Application	Description
1	Virtual consultation	Patients get a consultation from health care workers remotely with the help of connected devices.
2	Internet-connected hospital	The whole hospital premises with the implementation of IoT devices become the integrated network to support the COVID-19 pandemic.
3	Inform the concerned medical staff during emergency	With the accomplishment of an integrated network, the patients and health workers easily communicate in less time and an effective manner.
4	Rapid screening of COVID-19	The proper diagnosis is implemented with smart integrated treatment devices. With this technology, the overall screening process becomes very fast.
5	Treatment of COVID-19 become transparent	Patients get the benefit without any partiality.
6	Treatment process becomes automated	With the help of this technology, treatment process selection become more productive and assists to easily handle the cases due to automation.
7	The smartphone app and smart tracing of an infected person through wireless healthcare network	Numbers of authentic applications are available on the digital platform. An application is easily installed on Smartphone and makes the identification process of an infected person smoother and fruitful.
8	Real-time update	With the interconnectivity of devices through the internet, real-time data will be shared and help to decide on that basis and cases can handle accurately.
9	Accurate forecasting of virus	Based on available data reports, predict the situation of things in the coming time with the help of some statistical method. It is also used in the proper decision-making process and also guides the governments, health workers, etc to plan for a better working environment.
10	Track quarantine	The critical step to control the spread of COVID-19 is effectively quarantined by the infected person. But it is easier to say than implementation. IoT and GPS enabled applications are used to track the movement of an infected person and also help to take the necessary actions to restrict the movement of such a person [41] [42].
11	Cleaning and disinfecting	Cleaning, sanitizing, and disinfecting of medical facilities and all around are essential and also destroy the infectious nature of the COVID-19 virus. To accomplish this task, self-driving robots are used which develop by several companies like TMiRob, UVD, and Xenex Disinfection Services. These robots are disinfecting the surfaces with high-intensity UV light and kill the virus by destroying their DNA. Robots are Wi-Fi based and easily controlled by apps [42].
12	Reducing in-home infections	With the increase of awareness among the people, they avoid touching the surfaces like doorknobs, switches, etc, instead of it, people use the IoT enabled devices like speakers, security system to open the doors and switch on the light [42].

## V. VARIOUS ISSUES AND FUTURE SCOPE OF THE STUDY

IoT technology has an essential role in the medical field but it faces a number of challenges that are listed below in Fig. 4.

But with these challenges, IoT technology is mostly used in this domain. In the future, IoT implementation and usage become more useful. Data storage in acceptable format and management of data are should be targeted in future work with the development of cost-effective and affordable applications.

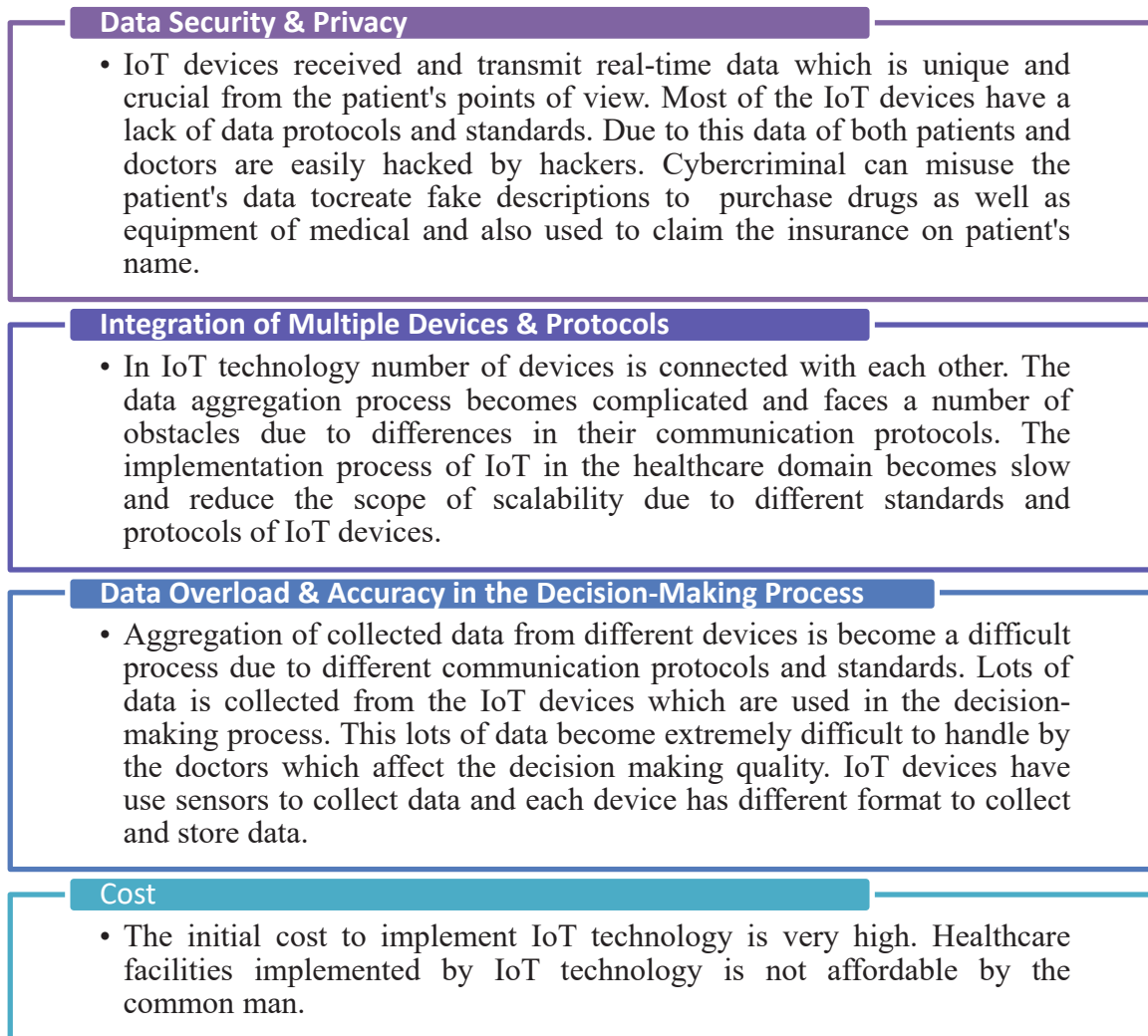


Fig. 4: Various Issues Faced by IoT during the Implementation in Health Domain [43] [44] [45]

## VI. CONCLUSION

The internet has changed our day-to-day activities and also modified the way of living. Now worldwide, the health domain has recognized the significance of ICTs in the functioning of healthcare. IoT technology makes our living easier and pleasant with virtual interactions. The innovative use of IoT in the healthcare sector not only brings benefits to doctors, nurses, and administrative staff of the hospital as well as patients during this COVID-19 pandemic. During this pandemic time, only social distancing and precautions. IoT devices help to maintain social distancing and help in the battle with COVID-19. In this paper;

we studied the influence of IoT in the health sector and act as the Internet of Medical Things (IoMT) because all the medical devices are connected with each other with the internet. Things are more and more integrated within the human body and they will communicate with healthcare and emergency services. We also represent the ontology-based architecture of IoMT. This technology plays a vital role in the health domain but it also faces challenges like accessing heterogeneous IoT data in the real environment and also creates the storage of a huge amount of IoT data accessing. We believe that IoT will greatly influence the health domain in the coming years by providing powerful applications.

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