IoMT-Based Smart Diagnostic/Therapeutic Kit for Pandemic Patients

M. Parimala Devi, G. Boopathi Raja, V. Gowrishankar, and T. Sathya

Abstract In the present situation, most of the patients suffered from pandemic diseases such as COVID-19, Ebola, etc. The infected people might have an incubation period of 1–14 days before creating any symptoms. The most widely recognized symptoms of coronavirus illness are high fever, breathing problem, and dry cough. Most of the patients (about 80%) recover from the illness without developing any major symptoms. This disease may be complicated rarely since it is more critical for aged people and even become fatal. The people with other major health problems, for example, asthma, diabetes, obesity, or heart disease might be progressively helpless against getting seriously sick. They lost their life before diagnosing specific medical problems. Since it requires huge investment in maintenance, diagnosis as well as treatment, and also it consumes time to provide a test as well as to investigate the patients' past clinical history. Numerous researches were undergone all over the world to smart kit the patients' past clinical records were stored in IoT cloud database. The security and privacy medical record of the patients is protected. This cloud access database provides the past medical history to the healthcare professionals to rescue the patient from a serious illness. Also, the current health status of the pandemic patients is continuously monitored through wireless telemetry technique Message Queue Telemetry Transport Protocol (MQTT). Based on the patient's live status, the health specialists suggest the medicine and/or recommend the precaution steps and provide the treatment effectively without direct contact with them.

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1 Introduction

Tragically, the elder aged population and the patients with constant health ailment is setting critical strain on present day patients' health monitoring frameworks [1, 2] and increasing demand rapidly on the assets and/or resources from patients' clinic beds to specialists and medical caretakers [3]. Rapidly increasing demand on healthcare frameworks may be reduced with the suitable way that gives highest consideration to the highly risk patients.

The Internet of medical things (IoMT) has been perceived as the most appreciable way to minimize the demand on healthcare monitoring frameworks [4–8]. A lot of this exploration takes more concentration in the monitoring of patients' health with most explicit conditions such as diabetes [6] or Parkinson's illness [7]. Further research would like to fill express needs, for instance, supporting recovery (aiding rehabilitation) through consistent checking of a patient's progression [8]. Crisis medicinal services administrations have furthermore been perceived as an opportunity by related works [9, 10], anyway has not yet been for the most part investigated.

A few similar existing works have recently introduced explicit zones and the modern advancements identified and studied with Internet of things (IoT) health care. A major research review has been introduced in [11, 12], which mainly focuses on commercially accessible frameworks, potential applications, and other associated issues. Each and every concept is considered individually, instead of as a feature of an overall design framework. Several sensor types such as pulse, temperature, pressure, and humidity are available in practice and are compared in [13], with some emphasis on communication. Finally, in [10], sensing the physical quantity and big data handling management is identified as the most essential for any network that supports communication.

In this way, this report makes a unique responsibility in that it recognizes every key components of end-to-end IoT healthcare monitoring framework and proposes a traditional model that could be applied to all IoT-based healthcare monitoring systems. This is most essential as there are still no known end-to-end IoT frameworks for constant remote monitoring of patients' health.

This work further gives a broad review of the cutting edge progressions that fall inside the proposed model. The primary objective is determined to sensors for monitoring distinctive clinical parameters, short-and-long-range communication measures, and cloud procedures. This work isolates itself from the past critical audit duties by considering every fundamental and essential part of an IoT-based healthcare monitoring system both separately and as a system.

Further, the significant commitment is made by setting target around low-power wide-area networks (LPWANs), including their intriguing suitability for use with regards to IoT structures. The upcoming approved band measures, for instance, narrowband IoT, are differentiated and the battling unlicensed-band standards, with explicit excitement for appropriateness to social insurance applications [14].

The remaining outline of this chapter is structured as follows. Section 1 explored the Internet of things (IoT) field in healthcare system and analyze the various concepts and techniques existing in the field of IoMT. Section 2 discusses the various pandemic diseases along with symptoms that arise in the world. Section 3 reviews the attractive features of existing healthcare systems available in market and also discuss the problem associated with it. Section 4 highlights the various types of telemetry techniques. Section 5 enhances the functionalities of proposed system in healthcare services and provides recommendations to enhance this research. Section 6 concludes the work, summarizing the important innovations and highlight the outline of IoMT areas where further research is needed.

2 Pandemic Diseases—Symptoms and Treatments

An outbreak is the case at which an ailment occurs in startling high numbers. It might remain in one zone or broaden all the more generally. An outbreak can occur within few days or it may take several days or sometimes years. In such case, specialists think about a solitary instance of an infectious disease to be an outbreak. This might be valid if it's an obscure illness, if it's new to a network, or if it's been missing from a populace for quite a while.

An epidemic is the situation at which an irresistible sickness spreads quickly to a greater number of people than pros would envision. It influences a greater zone than an outbreak.

A pandemic is a severe disease outbreak that spreads across several nations, probably entire world. It affects a larger number of peoples rapidly in a dense area and takes a greater number of lives than an epidemic. The World Health Organization (WHO) announced COVID-19 to be a pandemic when it turned out to be uncertain that the disease was serious and that it was spreading rapidly over a wide territory.

Figure 1 shows the different stage of disease outbreak along with their impact on economy and possibility of occurrences annually.

Figure 2 shows the comparison table of various pandemic outbreaks occurred in the world along with their mortality rate.

The WHO's pandemic prepared system ranges from Stage 1 (a for the most part protected) to Stage 6 (a full pandemic):

- **Stage 1**: An infection disease has caused to people with unknown infection from animals.
- **Stage 2**: The infection from animals has made people to sick.
- **Stage 3**: There is large number of affected patients from the infection. If the infection is spreading from human to human, it's not extensive enough to cause network level flare-up.

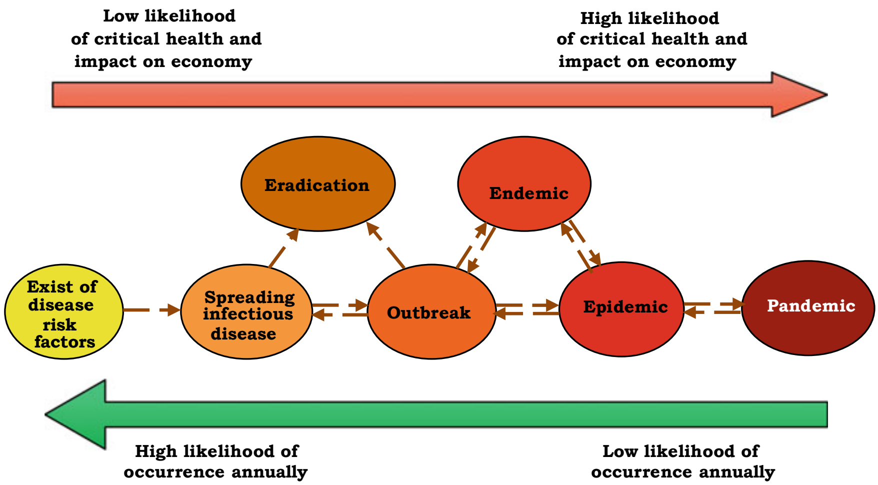


Fig. 1 Different stages of disease outbreak

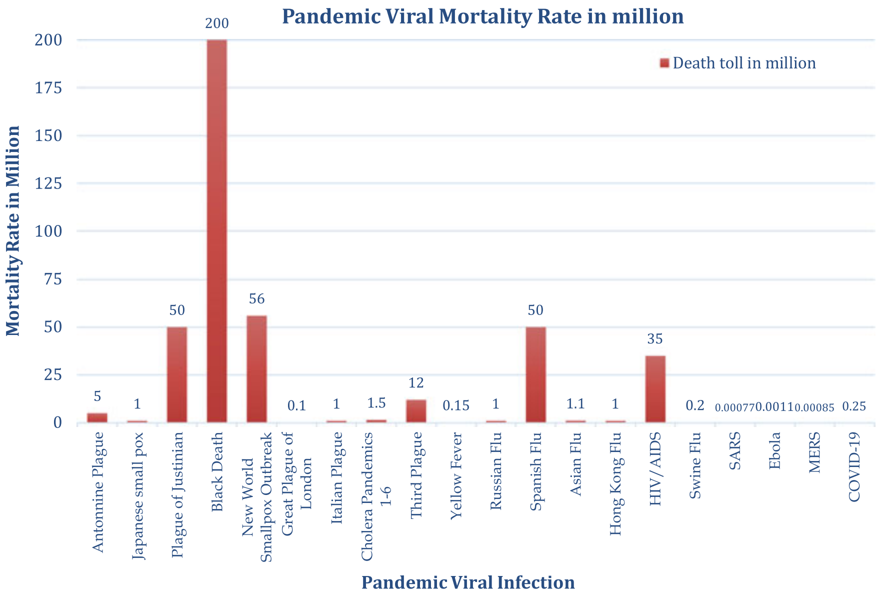


Fig. 2 Comparison of various pandemics with mortality rate

- **Stage 4**: The infection disease is effectively spreading from affected person to healthy person with affirmed flare-up which influences community level.
- **Stage 5**: The infectious disease is growing exponentially among people in more than one country.

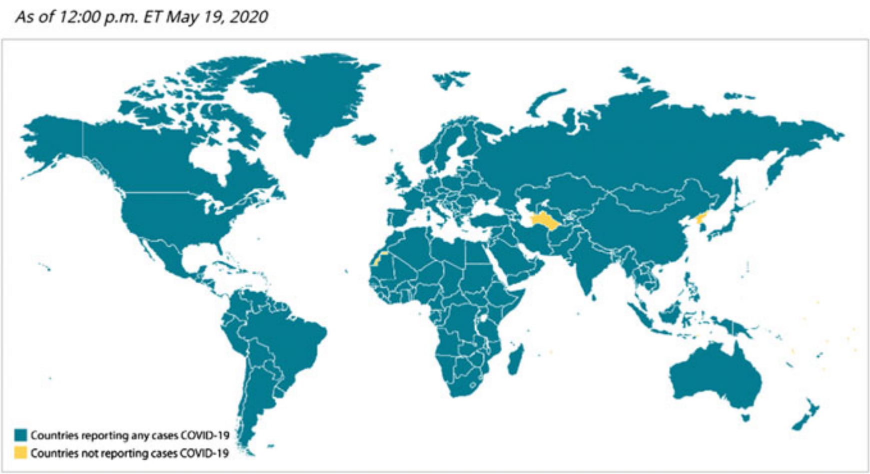


Fig. 3 Global case numbers reported by WHO and CDC (*data obtained from www.cdc.gov) [15]

- **Stage 6**: At least one more nation, in a substitute zone from Stage 5, has a community level outbreak.

2.1 Coronavirus Disease 2019 (COVID-19)

The region of corona affected and unaffected regions in the world are shown in Fig. 3. This global case number data can be reported by WHO and taken from official CDC Web site [15].

2.2 COVID Symptoms

Patients with corona infection may have mild symptoms to severe health illness. Elder peoples and adults who have extreme health ailments like heart or lung infection or diabetes appear to be at higher risk for COVID-19 illness.

The COVID-19 patients have larger possibilities of side effects detailed—going from mild indications to severe illness.

The symptoms may be noted visibly in the coronavirus affected patients even from second day and/or sometimes it takes up to 14 days after the corona infection. The most commonly observed side effects of COVID-19 patients are listed as follows, [16]:

- Dry cough
- Severe fever
- Shortness of breathing or breathing difficulty

- Body/muscle pain
- Chillness
- Lack of taste or smell
- Sore throat.

This is not all potential indications of corona patients. In few cases, some other different side effects have been observed including gastrointestinal side effects like nausea, vomiting, or diarrhea.

The Indian Council of Medical Research gave guidelines to begin fast antibody-based blood tests for COVID-19 in certain control zones and in enormous gathering center. Figure 4 shows the different phases of COVID-19 treatment.

The testing convention is portrayed in a given Fig. 5. That is, the individuals who have suspected for flu-like diseases could, after 14 days of being isolated, could be tested for an antibody-based test. If the test is negative, a hereditary test could be done to confirm or they could be isolated for 14 days more before another antibody-based test.

Serological tests can play an essential role during a lockdown since they can be utilized to recognize the individuals who do and don't have immunity to the new coronavirus. For instance, all health personnel as well as workers who perform essential functions (including police and fire-fighters) could be tested to allow those with immunity to get back to the frontlines.

The tests can distinguish forthcoming blood-plasma donors. Plasma is the one which is left over after separating the various cells in blood which contains antibodies and coagulant factors. The researchers identified and concluded that plasma from infected people containing neutralizing antibodies could improve the clinical illness of COVID-19 patients.

3 Application of IoT in Health care

Several efficient systems are available in practice nowadays in order to diagnosis and/or to provide treatment for pandemic patients [17]. Some of them are explained as below.

3.1 IoT-Based PCR for the Identification of Pandemic Disease

The block diagram of IoT-based PCR framework for pandemic disease detection is shown in Fig. 6 [18]. When the sample possibly containing the DENV is handled at focal point area, the results of diagnostic techniques as well as GPS directions of the patients' area are consequently moved by means of the client's cell phone interface through a worldwide system to a control community. The recovered information can

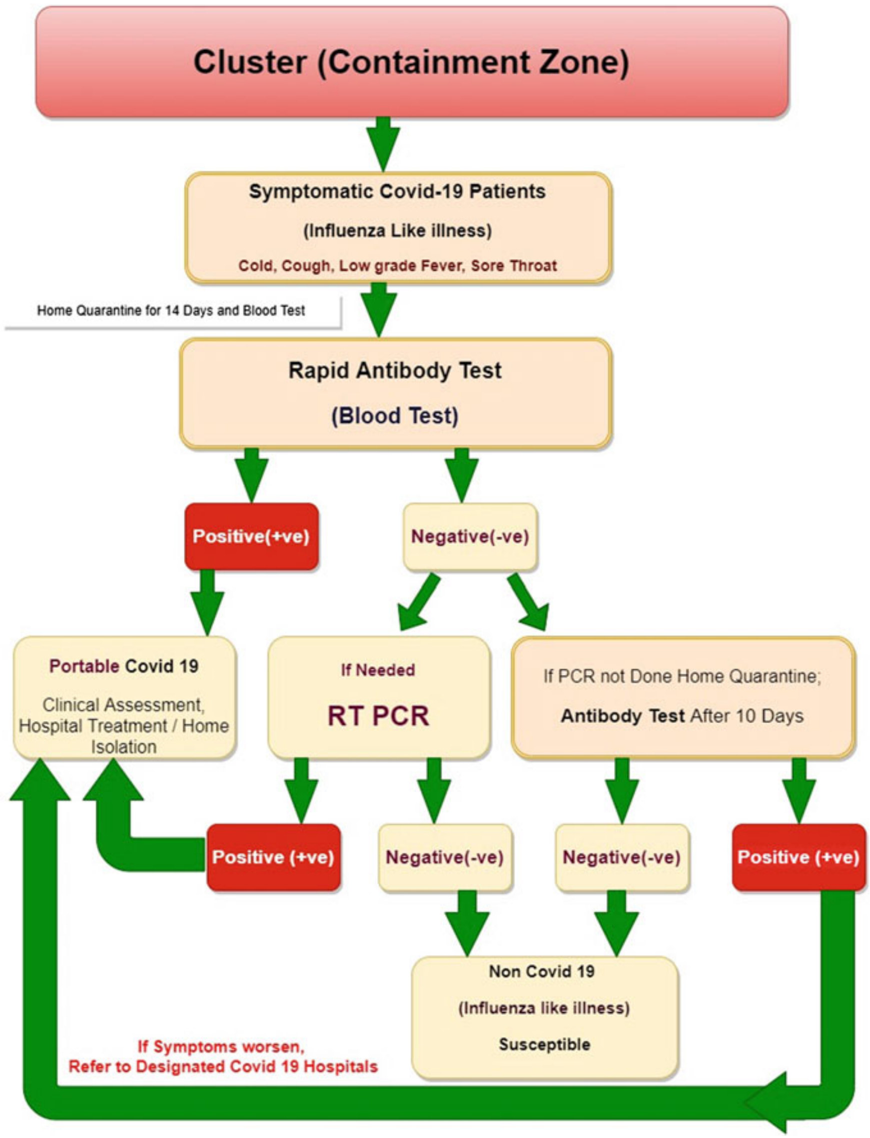


Fig. 4 Different phases of COVID-19 treatment

be prepared and put away in cloud. In light of this gathered data, infection flare-up guide can be created by indicating the illness episode zone and carry out regular monitoring.

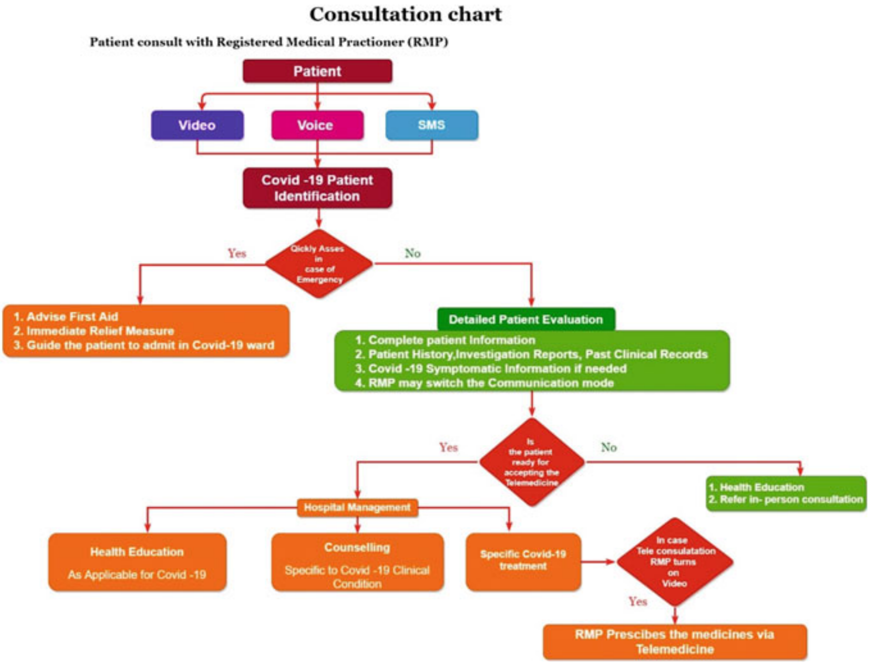


Fig. 5 Consultation flowchart for COVID-19 patients

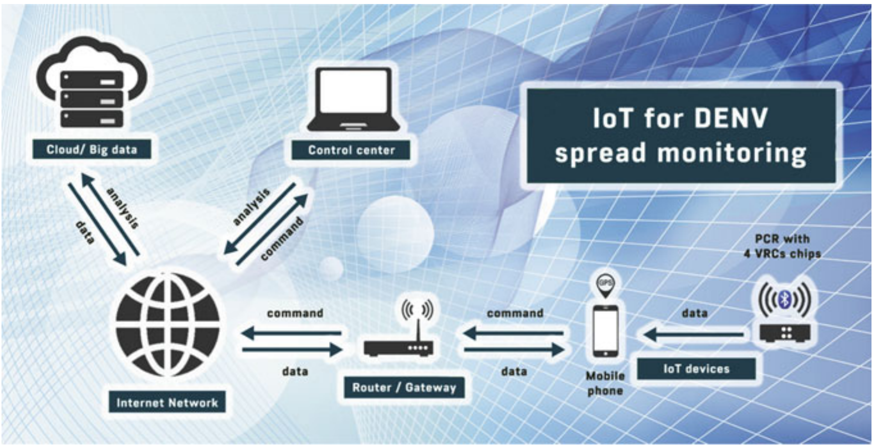


Fig. 6 Schematic diagram illustrates the IoT framework for the DENV spread monitoring [18]

3.2 IoT for Smart Health care

Figure 7 shows the concept of IoT-based smart healthcare setup for patient monitoring, [1]. The essential parameters such as respiratory rate, pulse rate, and body temperature are captured through sensors, processed and stored in the cloud as a patient database. Whenever need arises, these data can be accessed by specialist or other technicians effectively.

(1) Central node and wearable sensor

Wearable sensor nodes are only a devices or gadgets that can quantify physiological conditions. The recommended sensors are those that measure the imperative symptoms, for example, respiratory rate, pulse rate, and body temperature level. The each and every single sensor hubs gathers physiological information independently and moves altogether to the central node. It performs procedure on this information, in view of this, it might take some choice and afterward moves this data to an external environment.

(2) Communication over short-range

For sensors to communicate with the central node, this short-range communication technique is required. There are a couple of noteworthy necessities to consider while selecting a short-range communication standard, in view of the impacts on the human body, security, and latency.

(3) Communication for long-range

The sensed data collected by the central node is not valuable except if something should be conceivable with it. This data should be sent to a database where applicable gatherings, (for example, guardians or specialists) can safely access it. Also, there are a couple of considerations since quite a while ago run correspondences standard

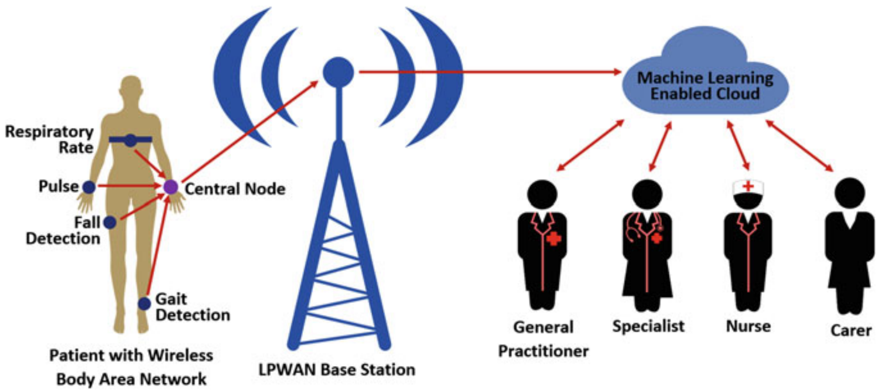


Fig. 7 Smart healthcare model for patient monitoring using IoT [1]

for use in a healthcare systems, including data security, error detecting and correcting capabilities, robustness, lower delay, latency and higher data accessibility. The error correcting capabilities and robustness are considered as more important in long-range communication against noise interference, as these guarantee that the data sent is equivalent to the data received.

(4) Secured architecture for cloud storage

The medical record and clinical data procured from patients must be taken care of securely for sometime later. Social insurance specialists benefit by knowing a patient's clinical history, machine learning (ML) and deep learning (DL) fruitful with the exception of if tremendous databases of information are available to it. The distributed cloud storage is the most useful practical method for putting away immense huge data. In any case, giving availability to social insurance experts without trading-off security is a key worry that ought to be tended to by specialists creating healthcare IoT devices. ML offers the likelihood to perceive inclines in clinical information that were beforehand dark, give treatment plans and diagnostics, and offer best proposals to social protection specialists that are express to individual patients.

3.3 IoT-Based Wearable Smart Health Monitoring System

Figure 8 describes the block diagram of smart health monitoring system with wearable sensors based on IoT concepts to monitor the status of patients' health, [19]. In this system, Arduino Pro Mini is utilized as microcontroller and the communication module is preferred as HC-06 Bluetooth module. Mostly, the physiological parameters can be measured by using pulse sensor and the body temperature can be continuously sensed with the help of smart thermometer or temperature sensor. The

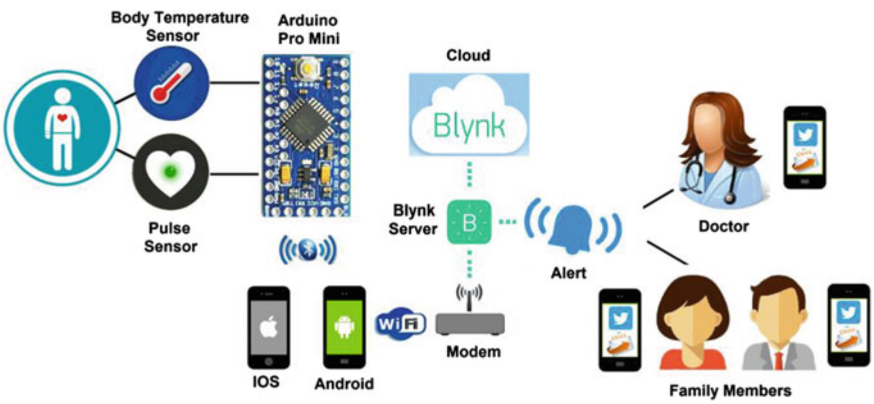


Fig. 8 IoT-based wearable smart health monitoring system [19]

basic idea of this efficient health monitoring system is shown in figure. This system consists of Arduino board (especially Arduino Pro Mini), Bluetooth module (HC-06), physiological sensors, and Blynk application with Wi-Fi/Internet connectivity.

4 Telemetry Principles

Telemetry is defined as the technique that collects measured parameters or other information at inaccessible or remote points and it allows sharing the sensed information to the desired persons/control unit or receiver for continuous monitoring, [20]. The word telemetry is arises from Greek word, where ‘tele’ means remote and ‘metry’ means measure.

A telemeter is a device used to measure any physical parameter remotely. It comprises of a sensor/actuator, a transmitting channel and a display unit, recording, or controlling gadget. Telemeters are the physical component utilized in telemetry. Telemetry techniques utilize several electronic gadgets and can be accessed remotely or hard-wired, it may be simple or computerized.

4.1 Wireless Radio Telemetry

Radio telemetry allows to analyze the physiological information of human under critical emergency conditions and in normal environmental factors with no inconvenience or deterrent to the individual or creature under scrutiny [20]. Elements impacting sound and wiped out people during the presentation of their every day errands may in this way be effortlessly perceived and assessed. Remote bio-telemetry has made conceivable the investigation of dynamic subjects under conditions that so far disallowed estimations. It is, along these lines, an imperative strategy in circumstances where no link association is plausible.

By bio-telemetry, the physiological signs can be acquired from swimmers, riders, competitors, pilots, or unskilled workers. Telemetric reconnaissance is generally helpful during transportation inside the medical clinic territory also for the consistent observing of patients sent to different wards or facilities for registration or treatment.

5 IoMT Framework for Pandemic Patients

The objective of the IoMT framework is to remotely monitoring the COVID-19 suspected and confirmed patients with primary symptoms and also those patients are allowed This framework not only monitor the key clinical data’s who are kept at self-quarantine safely in the home environment with least complications and with necessary safety guidelines and forward the time stamped sensor value of the patient

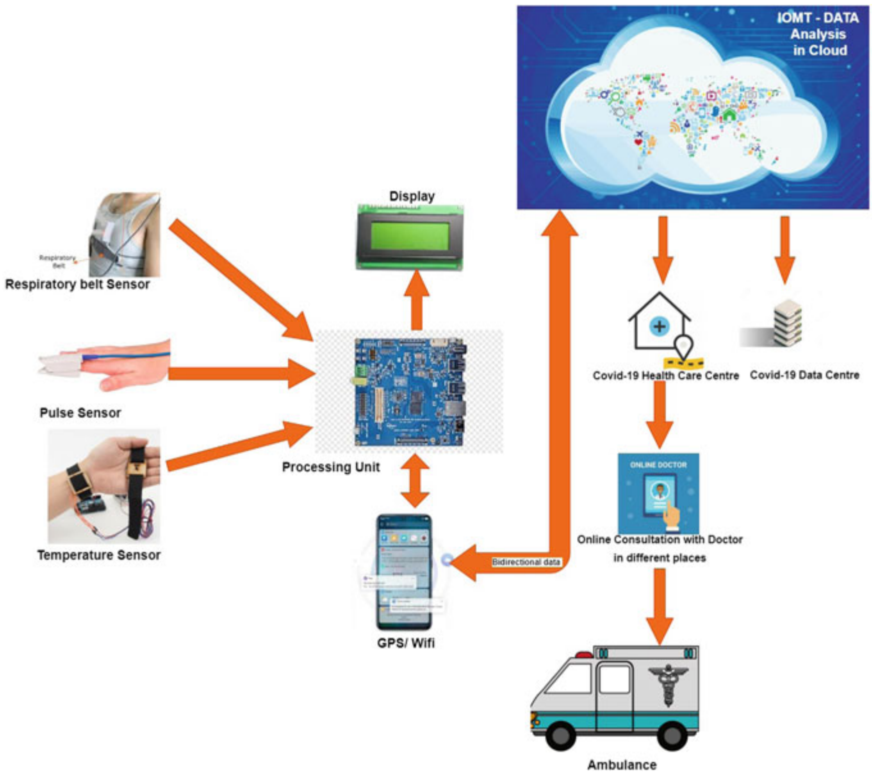


Fig. 9 Overall system architecture and communication

to IoT platform for data analysis and visualization. The patients' aggregate data is forward to healthcare center and alerts would be triggered based on the individual patient readings. Figure 9 shows overall IoMT framework for pandemic patients.

Because of implementing the proposed assisting and monitoring system, there exists a harmonious environment which is created between the family and friends of COVID-patients.

This kit helps the doctors and healthcare professionals to prefer the proper decision in due course. This system also helps the healthcare workers to monitor the clinical data of the COVID-19 patients with ease of time and the data of patients are collected without being contacted from the patients. These systems have four sensors to periodically get the patient data, mobile phones for monitoring and connectivity, IoT which enables cloud services and software to establish a connectivity.

Figure 10 shows the architecture of the smart healthcare kit for COVID-19 patients. The smart kit consists of different precision sensors to monitor breathing rate, fever, and heartbeat rate of a patient through data acquired by the processing unit which is connected to the patient mobile phones through inbuilt Wi-Fi. The patient data are post or published to IoT cloud platform using HTTP or MQTT protocol

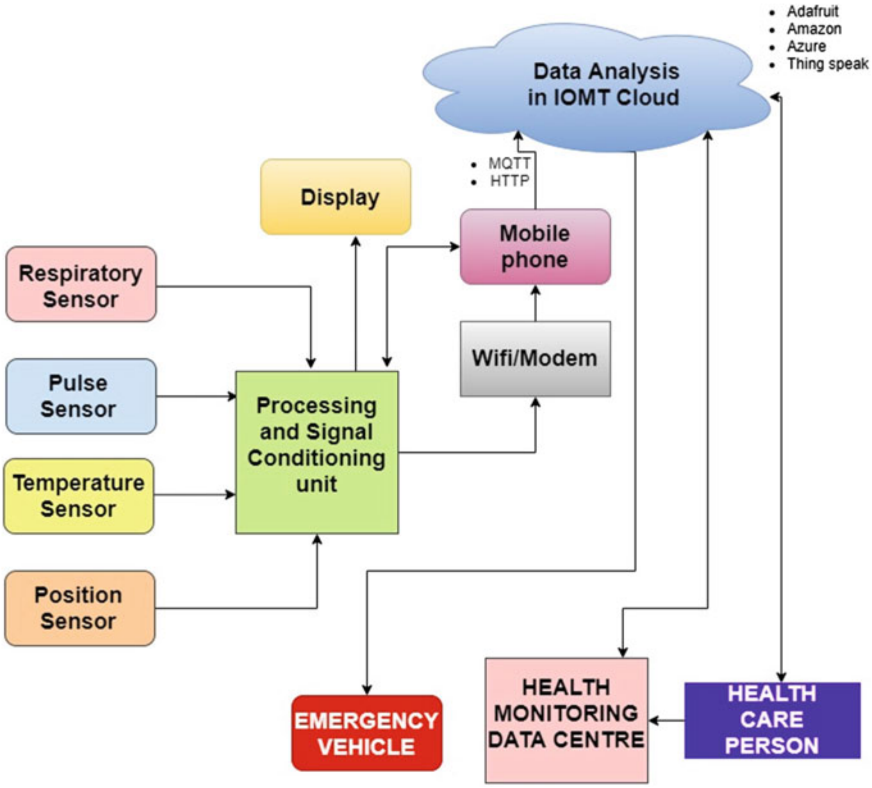


Fig. 10 Architecture of smart healthcare kit

for data analysis and management. The smart kit monitors COVID-19 patients in real time in the prescribed time stamp interval. The efficiency of this monitoring kit can be improved effectively by the data from the various sensors interfaced particularly with that system and the obtained data are stored in the cloud. The proposed healthcare system is providing highly reliable and it is convenient for the COVID-19 patients who are kept at quarantine and recommended to stay away for about 14 days to 28 days as mentioned by the guidelines of World Health Organization (WHO). These kits also help the suspected COVID-19 patients who wish follow the self-quarantine and also helps the patients and healthcare providers to monitor many patients at a time and improve the improve healthcare system of the country in the medical emergency period.

The vital importance of the proposed smart kits is not only monitored health status collected from patient's data through the IoMT frameworks but also allows the pandemic data center to save the critical illness of the patient continuously. The cloud storage of the patient's record helps the clinical data by authorized healthcare personals and doctors at any time across the country or world. The live status of the patients can be send to the family members through any of the services webhook, Twitter, SMS, email, and MQTT or REST-based mobile app.

5.1 Components in the Smart Kit Design

5.1.1 Heartbeat Measurement

The heartbeat rate of the individual patient can be measured by wearable biometric pulse sensor in the wrist or finger of the patient. This compact biometric sensor measures the number of beats per minute (BPM). The biometric pulse sensor is connected to processing unit to read out the heart rate of the COVID-19 patient in quarantine center or hospital. The analogously detected value changes, depending on the pulse beat. The analog values are converted into digital by ADC and the pulse is measured on the basis of the last measured values. Figure 11 shows the compact wrist pulse sensor for pandemic patients.

A small module which is connected to the processing unit Raspberry Pi, the pulse sensor will measures pulse of the patient and the health condition of COVID-19 patients is monitored. This sensor consumes low-power consumption and it could be operated by lithium–ion battery.

The Raspberry Pi the processing unit can read only digital information as they do not have inbuilt ADC module, thus an analog-to-digital converter is needed for taking measurements. High precision and high speed ADC module are needed for effective performance.

In order to convert the analog data of the pulse sensor 10 bit MCP3008 ADC is utilized. Figure 11 shows Raspberry Pi and heart rate monitor—connection setup. The positive pin of the biometric pulse sensor is connected to supply pin of the Raspberry Pi and negative is connected to ground. The signal which is to be measured is connected to Channel 0 of the ADC. The processing units aggregate the collected

Fig. 11 Wrist pulse sensor for patient

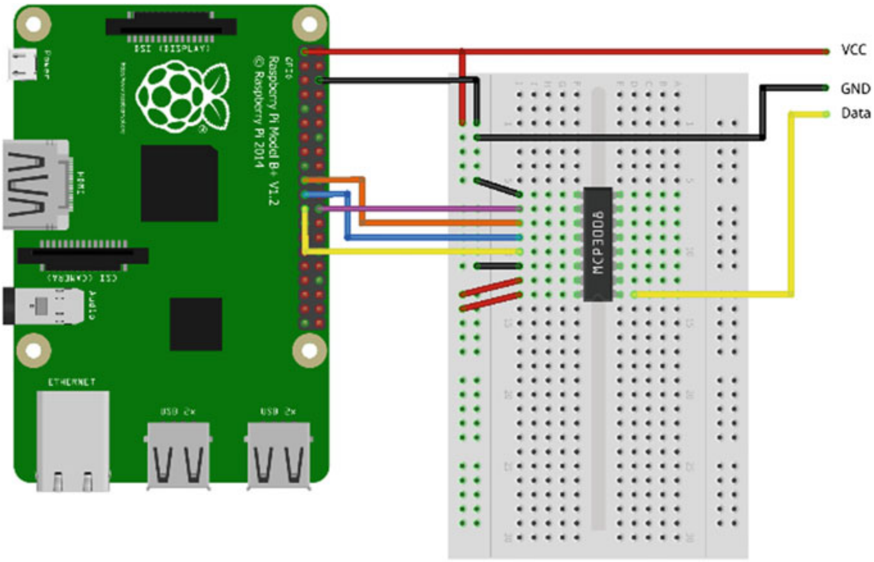


Fig. 12 Raspberry Pi and heart rate monitor—connection setup

data and publish it to the IoT cloud. The module would provide unobstructed heart health condition for individuals (Fig. 12).

Breathing Rate Sensor

For COVID-19 patient's serious symptoms is difficult in breathing and chest pain. It is very important to measure the breathing rate with heterogeneous wearable respiration belt sensor and ECG monitoring for COVID-19 patients with least patient contact. By precisely tracking respiratory rate, the abnormality can be detected in earlier stage without any indication of deterioration. This helps to identify the abnormalities due to COVID-19 for the suspected cases clearly.

From the literature survey, respiratory rate and ECG sensor technologies have evolved many different types for medical applications and use wide parameters to arrive at accurate readings.

The two sensors connected inside of a soft, flexible, and washable belt of the patient are ECG sensor and breathing sensor. The belt is strapped around the chest. When the chest of the patient expands and contracts regularly because of breathing the air in and out lungs. The analog signal received from the sensor is converted into digital by using appropriate ADC.

The on-body electrocardiogram (ECG) is diagnostic tool which is used to measure the bioelectrical and muscular functionality of the human heart. Hence, ECG bio-signal is recorded at regular interval for COVID-19 patients who are under quarantine and those who are suspected. The ECG is recorded to analyze and identify the myriad

Fig. 13 Fabric electrodes and leads for ECG monitoring

of cardiac pathologies diseases ranging from myocardial ischemia and infarction. The bio-ECG signal is taken with highest accuracy and the accuracy depends on the testing conditions also. Flexible electrodes are to measure multiple biomedical signals. Figure 13 shows fabric electrodes and leads for ECG monitoring.

ECG measurements are taken via leads that are placed on the patient body while the patient lies flat on any flat surface. The graph or a regular pattern of PQRST wave shows the abnormal electric activity if there are any abnormal cardiac rhythmic activities. The underlying heart beat and abnormal rhythm mechanism of the heart are measured effectively and passed to IoT cloud platform for further processing.

Mobile App

The mobile app using MQTT protocol subscribes the individual patient health status. Figure 14 shows the snapshot of the patient or healthcare professional mobile application. The application has feature to view individual sensor value and its graph.

GLCD

Figure 15 shows wrist GLCD displaying the ECG graph which had been sent by the processing unit of the smart kit.

Figure 16 shows the Microsoft Azure IoT dashboard with live ECG wave.

5.1.2 Respiration Rate Sensor

The essential and foremost symptoms of SARS are abnormal respiratory rate. The COVID-19 patients are severely affected by respiratory troubles and hence it is very important to measure the respiratory rate at the earliest as soon as possible. But it is not an easy thing to measure respiratory rate during critical stage as it is an indicator of patient live status. Respiration rate module not only can provide an early warning of breathing problem and tiredness but also the critical illness due to COVID-19.

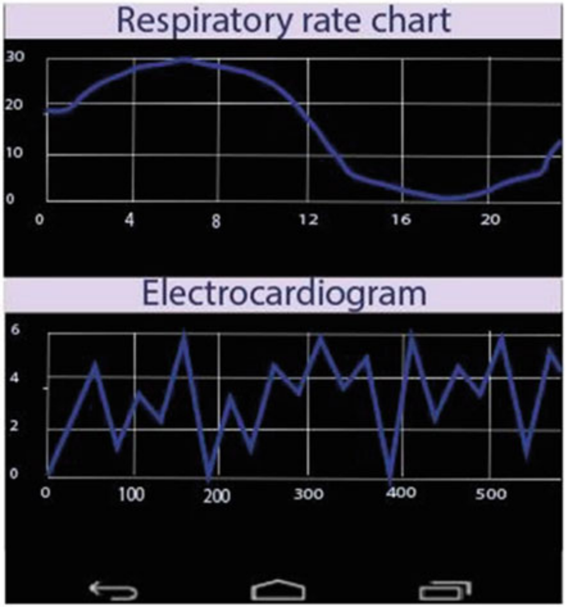


Fig. 14 Mobile app respiration and ECG status of the patient

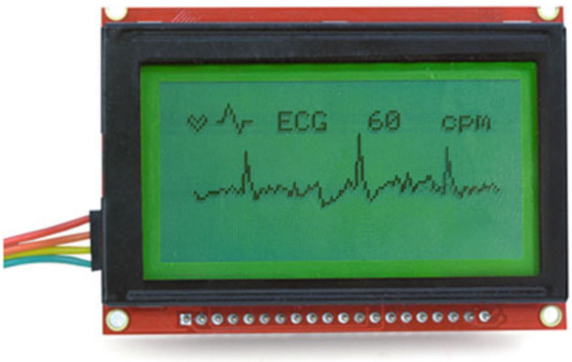


Fig. 15 Wrist GLCD ECG waveform of the patient

Nostril type sensor measures the breathing rate of the patient under critical condition and it indicates the abnormalities in continuous interval. This sensor module has a flexible hose which placed behind the ears, and a set of prongs which are placed under the human nostrils. Breathing rate is measured by these prong sensor module.

The thermocouple is placed in the compact small holder that allows the placement adjustment of sensor in the required position to accurately measure the airflow changes as well as the nasal air temperature. This sensor module is an easy to install and use. The healthy human has a breathing rate of 15–30 breaths per minute.

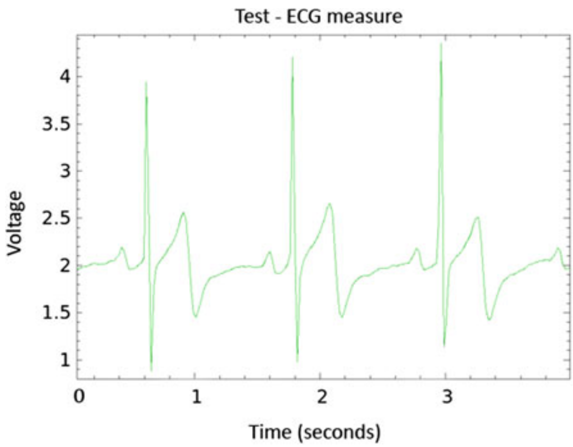


Fig. 16 Microsoft Azure IoT dashboard ECG measured graph

Figure 17 shows the mobile app showing the waveform of respiratory rate and electrocardiogram of the pandemic patients (Fig. 18).

Figure 19 shows the wrist GLCD of the pandemic patients connected to the processing unit. The live data is shown in patient wrist band.

Figure 20 shows the Microsoft Azure IoT dashboard respiration measured graph.

5.1.3 Temperature Sensor

The important symptom of pandemic disease COVID-19 is prolonged high fever. To measure temperature in different places of human body, the very high accurate thermometer sensor is utilized in the smart kit. More than one sensor unit is placed in different parts of the human body. The measured temperature would help the healthcare personals to identify the level illness of the patients in the quarantine. Figure 21 shows the body contact type thermometer module for Raspberry Pi.

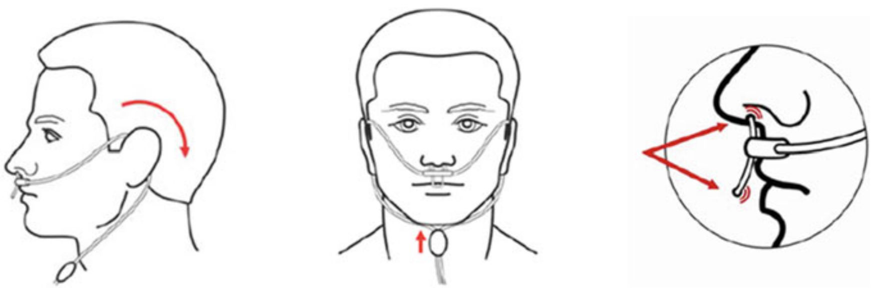


Fig. 17 Respiration measurement

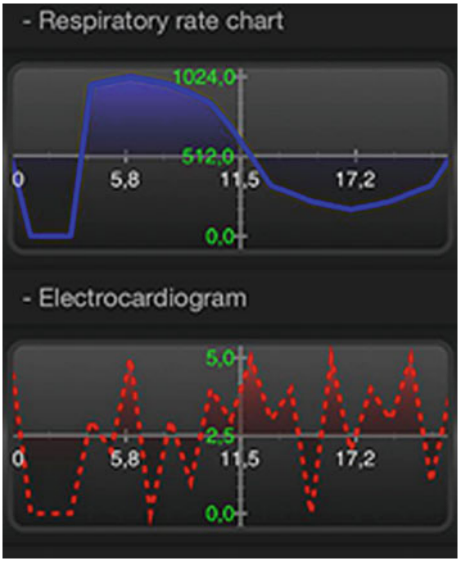


Fig. 18 Respiration live time stamp graph on mobile app

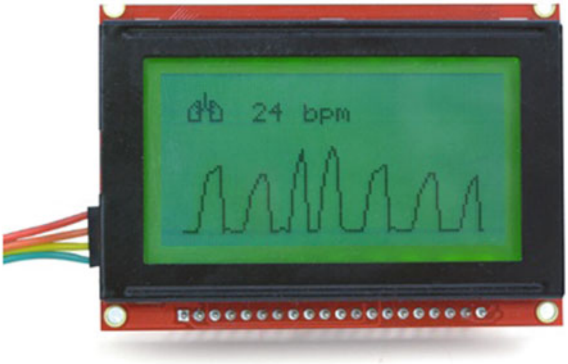


Fig. 19 Wrist GLCD respiration waveform of the patient

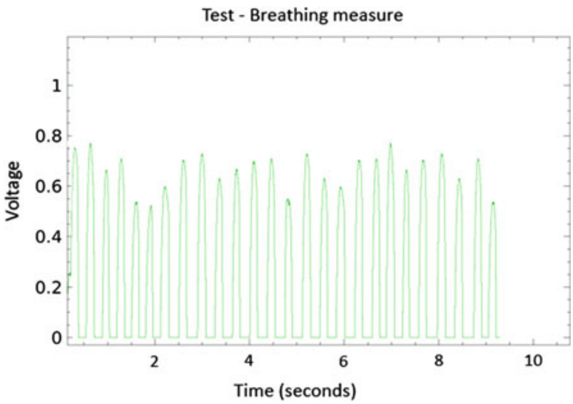


Fig. 20 Microsoft Azure IoT dashboard respiration measured graph

Fig. 21 Body contact type thermometer

A normal body temperature of a non-affected person is 37.0°C (98.6°F). The normal temperature of the adults may vary about 0.9°F in a day, and hence the continuous monitoring is needed.

Most of the pandemic diseases symptoms are fever that can be continuously monitored by the IoT cloud platform with thermometer sensor module attached to human body and the efficiency of evaluation and treatment done by the physician improves largely by this continuous monitoring technique. The smart kit utilizes the body contact type thermometer instead of contact-less infrared type as they could be easily sanitized after the use by the patient. Table 1 shows temperature range for various pandemic diseases.

For taking measures of temperature, the sensor is connected and there should be a contact between the metallic strip and skin of the human whose body temperature is to be monitored. Figure 22 shows thermometer connection with processing unit. Using adhesive tape or the wrist belt type sensor, it may be attached to the skin without causing inconvenience to the patient. After the patient recovers, the smart kit would be sanitized easily.

Table 1 Temperature range for various pandemic diseases

Disease	Temperature in °F
Hypothermia	< 95.0 °F
Normal	97.7–99.5 °F
Fever or hyperthermia	99.5–100.9 °F
Hyperpyrexia	104–106.8 °F

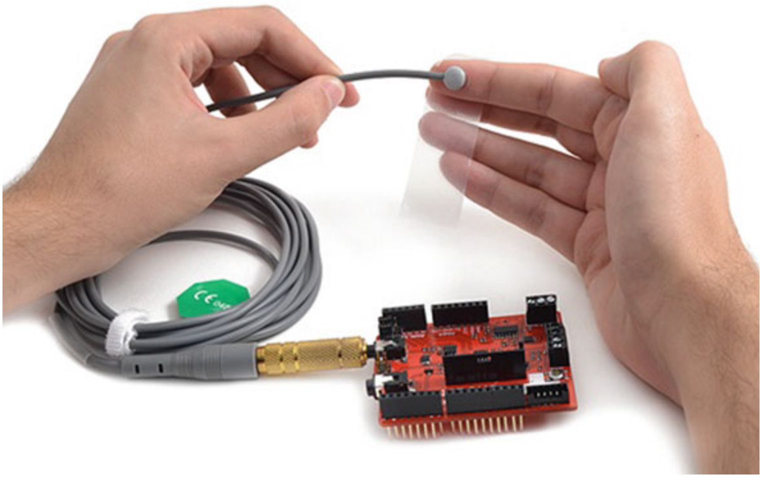


Fig. 22 Thermometer connection with processing unit

5.2 Processing Unit

The kit has processing unit for gathering, processing data from the sensor module. The various function of the unit is power management for sensors and communication between the IoT hub and kit. The processing unit has to be compact, low-power consumption, and high speed operation. The microcontroller or minicomputer is mostly used processing unit. The proposed smart kit utilizes Raspberry Pi minicomputer as it has inbuilt Wi-Fi and LAN capabilities. The Pi has interacts with 4G module and capabilities to utilize the full bandwidth.

5.2.1 Internet of Medical Things Platform

The IoT platform is responsible for integration of smart healthcare kit with healthcare professionals. The IoT platforms need to be configured based on the user requirement. They provide sensor data storage, analysis, visualization, and event processing of the pandemic patient. The IoT platforms also have to support 24 × 7 availability, scalability, and security. Today's market is flooded with lot of IoT middleware platforms. The most popular platforms are Amazon Web service IoT, Google Cloud Platform, Microsoft Azure IoT, and IBM Watson IoT. The designed IoMT framework utilize Microsoft **A**zure IoT platform as this hybrid services platform and able manage billions of the devices. Azure IoT supports large number of smart kits. They can analysis real-time stamp with patients past history of disease. The autonomous IoT framework for each district or hotspot can be created using Microsoft Azure. The healthcare professional, patient family, and district magistrate could subscribe the live health status. The patient kits connection and failure status could easily tracked by Azure IoT hub. The azure stream analytics would run live data analysis and evaluation on the stream of big data coming from kits in the district and automatically post the transformed set of information to healthcare center and pandemic crisis management center of the government. Figure 5.14 shows the Microsoft Azure monitor for patient health visualization. Based on the data analytics of patient's health, the azure IoT hub notify/alert if it detects any abnormal condition in the patients by email and webhook (Fig. 23).

Health Monitoring Mobile App

Figure 24 shows the android mobile app designed for pandemic patients and their doctors. The app continuously subscribe the pandemic patient health status through MQTT protocol from the IoT cloud database and trigger the alert through SMS and

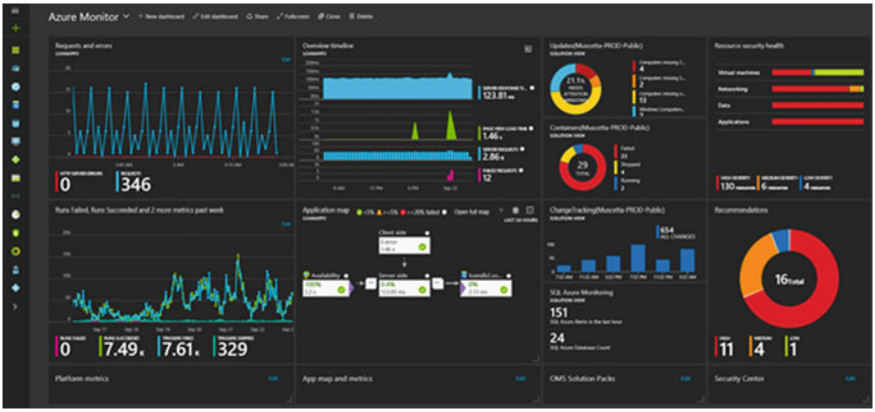
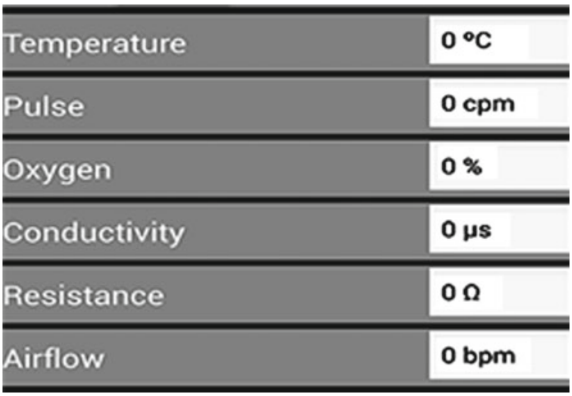


Fig. 23 Microsoft Azure monitor for patient health visualization

Fig. 24 Health monitoring mobile app



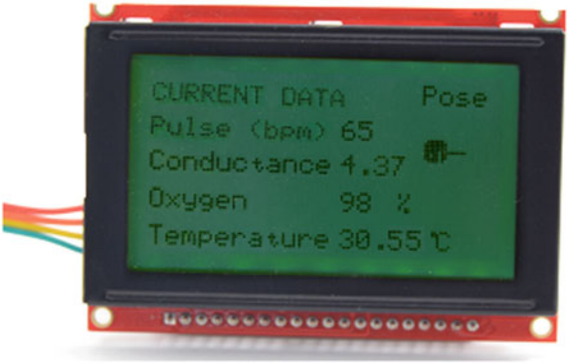


Fig. 25 GLCD for smart wrist band

email. The individual patients vital sign information are displayed in mobile app and also can be viewed through Web browser using webhook technique.

GLCD for the Wrist Band

The individual patient can know their current health status through GLCD of the smart wrist band. The wrist band alerts the patient if any vital signs are abnormal. Figure 25 shows the GLCD used in the kit prototype design and current sensors data information gathered by the kit processing unit.

6 Conclusion and Future Work

Today, numerous administrations can be reached with advancement in new technology and the quantity of utilizations that utilization this innovation is continually expanding. IoT innovation is extending step by step to incorporate various applications domains like smart cities, smart farming, and smart grid. The IoT-based smart health monitoring kits is one of them and this smart kits offers way to improve public health infrastructure of emerging countries like India. The consistent monitoring of pandemic patients in the emergency clinic condition is exceptionally troublesome with the current healthcare infrastructure and strategies. Patients under monitoring in medical clinics are in isolation ward and affect the mental health status. Numerous medical issues require early diagnose for better treatment since they cannot be treated effectively in later stages of the disease. The early testing is staggeringly significant for patients with coronary illness.

In this investigation, IoMT-based smart diagnostic/therapeutic kit for a patient monitoring system permits patients to be versatile in their quarantine zones. The created IoMT framework consistently gauges vital signs the pulse rate, fever, and rate of breathing of the pandemic patients and gives checking and following alerts various services like mobile app, SMS, email, and webhook. At the point, when the patient's essential information arrives at a foreordained cutoff esteem, the portable application cautions the patient and the individuals in the region. In the rare cases that there is no one in the hotspot region for the pandemic patient who can support him, the patient's pulse, heat level, and coordination data are sent to relatives and the healthcare professional as notices through the IoMT cloud platform. The primary motivation behind the smart kit is to make give that they get clinical guide as quickly as time permits, in the event of a potential inconvenience for heart sicknesses.

Our future work includes improving the trust in IoMT by providing the efficient security and privacy solution for the stakeholders (pandemic patients, healthcare professionals). The compactness of the smart kit can be enhanced by evolving sensor technologies and data processing techniques.

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