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Integration of IoT and Cloud Computing to Manage the Patient E- Prescription

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Abstract: Data management is crucial to the functioning of healthcare systems and affects how well software programmes operate. The most recent equipment offers facilities that current healthcare systems do not use to allow their stakeholders to communicate with the system. The existing systems do not allow for as much freedom for chemists to collaborate as they should. Apart from this, we propose a system based on android and a web application by which a doctor has the ability to prescribe patients through an android application using stylus pen and other users such as patients, receptionists, pharmacists and admins interact with the system via their web accessibility. The suggested solution is based on combining cloud computing and Internet of Things technologies with the system. The Cloud IoT technology often finds application in remote healthcare monitoring and dispenses feasible solutions to patients with severe heath conditions and disabilities. Employing remote monitoring through Cloud and IoT aids in proactive and prior detection of diseases and as such, suitable healthcare solutions could be provided to ensure patient convenience and comfort.

Keywords: Internet of things, Healthcare, E-prescription, Cloud of Things, Arduino.

I.INTRODUCTION

The use of electronic prescriptions is a crucial measure to advance the healthcare sector. The use of electronic prescriptions enables systems for providing healthcare should be more aware of and anticipatory of the patient. As many patients as possible follow the same process to learn their test results or their health status, as is well known. Only if the prescriptions are made online accessible to the registered healthcare systems and are recorded in full, including all prescriptions, medication intake, patient states over time, billing information, and other details, are cross-border prescriptions possible.

By consolidating all of these patient inputs, the time it takes for a patient to be cured will be shortened. Another advantage of these kinds of systems is that the pharmaceutical sector. This will enable the chemists to verify the prescriptions, enabling a correct check and balance of the patient's system-acquired medication dosage. Additionally, pharmacies have the option to reserve their data in a computer-based system rather than a file-based one, making the system more adaptable. It greatly simplifies the management process and lowers the cost of maintaining inventory data.

In some circumstances, preserving healthcare system data in this manner lowers the likelihood of data loss. Finding the specific When electronic health records are implemented, managing patient or employee data becomes much simpler. Maintaining the integrity, security, and confidentiality of patient data is one issue in this domain. Different systems have been developed to address and resolve this problem. The advanced healthcare system will require some expertise on the part of both the staff and the patients to operate. This area of ubiquitous healthcare could support a variety of sophisticated applications. The applications could be based on the pharmacy inventory system, the receptionist token system, the doctor's dashboard patient forecasts, or training applications for recent graduates to be trained in the healthcare industry.

Overall, the system will have humungous benefits through the proper management and usage of healthcare data, electronically. The systems based on healthcare provide great flexibility to the administrative operators as well. The electronic prescriptions could be encrypted end-to-end to secure the prescription as well as to ensure the integrity of the user data too. The interaction of doctors with the applications is quite easy when it comes to the prescriptions. The latest equipment used in the healthcare systems for treating the patient could be integrated with the system’s central data repository. From those repositories of data, applications could predict or suggest some diagnostics, medicines, patient’s health-state to the doctor, via exposed API interfaces to the data. This way the secrecy and privacy could also be tackled in the form of electronic agreements made between the healthcare institutions and federal/government institutions. This mechanism allows the healthcare systems to evolve in dynamic directions which needs to be controlled by proper

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legislations and regulations. One way of such approach is through he blockchain networks, which is currently the hottest topic in IT industry.

Interoperability is the key to integrate and provide a flexible healthcare system. Using such mechanisms such as APIs, blockchain networks, IoT devices and much more of 5G network services will evolve the healthcare sector in dynamic and versatile environments. Usage of IoT devices in healthcare will bring innovation with it and provide efficient and less error prone interactions to the healthcare stakeholders. The intelligent devices will be able to provide faster processing for the repetitive tasks that the healthcare employees had to manually before.

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II. LITERATURE SURVEY

The IoTHeF The IoT-enabled remote patient surveillance efficiency reported by the author Jatin Arora was met in his analysis to fulfill all requirements for a standard use case. The new framework is economic and suitable for rural patients with no established health services in the area and expenditure constraints for the presence of experts in the city center. The system introduced was applied and run for two weeks. Different sensors, embedded systems, and wireless networking systems have been researched and the best-fit components have been used. The sensors were optimized to deliver clinical precision. Math Works' with the GPS based IoT framework was chosen because it is a powerful and easy to use, open-source framework. It provides the choices for private or public networks which can be accomplished only by entering the accepted login ID and the registered patient user password.

In brief, the author is sincerely agree it is beneficial for the sample community to incorporate such a structure. [7] The author Alex Page examined the current scenario of this text and forecast potential directions for the application to clinical practices of virtual health monitoring technologies. Wearable sensors, especially IoT-based ones, provide attractive data observation and controlled data observing and monitoring for a longer period in personal and office environments than is typically the case for visitors to the workplace or laboratory. This treasure-chair of data can significantly improve healthcare and minimize costs when processed and distributed in easy visualizations to physicians. The author also highlighted several challenges in sensing, interpretation, and visualization before software to effectively incorporate into clinical functional practice can be optimized [8]. This paper specifically aimed to build an Android ecosystem in the field of healthcare with the IoT and cloud computing model.

IoT is a technology in which multiple industries are involved. This advancement would immensely support future healthcare. The paper is focused on the implementation of the Android ECG waves platform. This article is aimed at developing an Android-based healthcare app platform using the IoT and cloud computing principles. We also developed a programme for "ECG Android Software," allowing end users to contextually view their ECG waves with data logging features. Logged information can be sent to a confidential person, a private storage system or a medical system which includes all the information tracked by medical practitioners for review. The information can be tracked. The idea of using IoT and cloud technology to create a medical application is not inherently new, but experimental research is insufficient for the development of such a device. The key principles of IoT are protected by this article. The paper also explains the design of the different technologies in the healthcare context, including IOIO microcontrollers, signal processing, network protocols, secure and cost effective file-sharing networks, information management systems, and virtual cloud. This paper illustrates the device and application setup and architecture vital to general IoT and cloud-based medicine.

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Other health aspects which include the facilities described in the report. This ends with guidelines for the health system and extensibilities. [9]. Currently, in hospitals, they need to monitor regularly depending on patient health status. When the patient's health status improves abruptly, the healthcare provider is not immediately aware of it. So, to transcend the use of health monitors, and with the aid of these monitors, changes in patient behavior are expected to occur progressively. These electrodes are connected to the human body and electrodes track the health of patients from time to time. In this article, the author suggest how patients are tracked by health care providers who are closer to the patient and who are still further from the patient by progressively shifting health conditions [10].

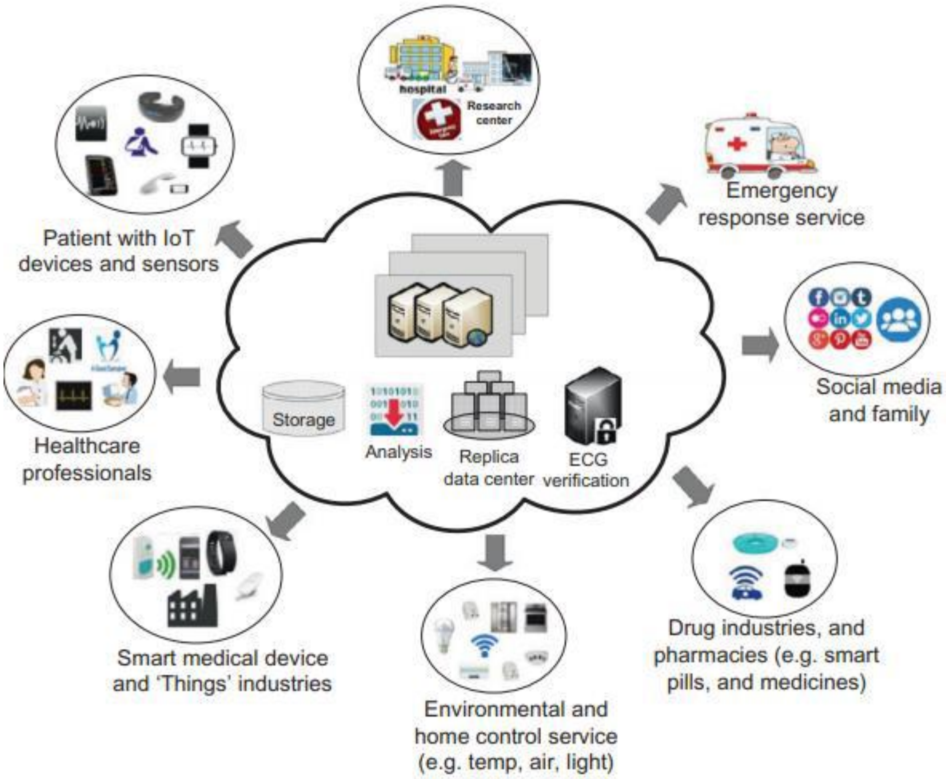

Fig 1. Health IIoT Framework structure

III. METHODOLOGY

Figure 1 illustrates how our proposed framework workflows. Procurement of data from patients by various instruments, such as heart rate, temperature, and pulse, etc. Mostly with a built-in WIFI ESP8266 module, the collected data is further submitted to the AWS (Amazon Web Services) cloud through the We Mos Board. Further use will be offered for AWS features such as AWS Lambda (an event-driven, server-less computing platform), Amazon Dynamo DB (a fully controlled NoSQL database proprietary database framework that supports key-value and document data structures), AWS IoT (a cloud network that allows embedded devices to communicate efficiently and safely with cloud applications and other software) and AWS Data Analytics. AWS functions can be carried out on the cloud, such as data collection, data management, and data analysis. The visualized details can be viewed from the dashboard of the Smartphone-based program by physicians, patients, and caregivers. The suggested framework would also give the stakeholders a warning note if irregular or vital conditions happen. Lambda function is used, Lambda is a server less and an event based computing platform. Simply put it is a processing service that runs the code remotely in response to events and automatically manages the resources that are required by the code.

IV. DATA COLLECTION AND THREE FUNCTIONAL LAYERS

In short, the author fully believe that the new approach will be useful for the intended population. The demands first obvious in the cloud computing environment (IaaS); a software vendor is being pursued to preserve total performance, high scaling capacity, and openness to the hardware requirements of the solution. The transmission of small quantities of data from many channels from a coordination perspective characterizes the virtual medical observation of patients in real-time. A contact protocol between a computer and a network is more helpful in this case than the regular HTTP (Hypertext

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Transfer Protocol) protocol. The new protocol MQTT (Message Queuing Telemetry Transport) has proven very successful in this field, thanks to its light-weight and its ability to handle large numbers of deployed IoT devices, as well as its efficient networking and low power operation. Data treatment is another essential aspect; in particular, data collected must first undergo precise review to verify if there are serious conditions involving urgent medical care; alternatively, the data is then fed a database directly for subsequent data processing. Finally, SaaS systems, such as several cloud platform APIs, may be used to upgrade and manage the systems, but also to incorporate the used apps for the end-user in a familiar manner.There are several vendors on the industry, such as AWS, Aruba, Google, Microsoft Azure, Cloud Sigma, and 1&1. Table 1.2 displays the list of services (reported by their trade names) provided by these cloud service providers.

	AWS	Microsoft Azure	Google	CloudSigma	Aruba	1&1
Files	S3	File storage	Storage	-	-	-
NoSQL	DynamoDB	Cosmo	Datastore	-	-	-
IOT	aws iot	IOT Suite	Cloud IOT	-	-	-
			Core			
Data Analytics	EMR	HDInsight	Cloud Machine Learning	-	-	-
Notifications	SNS	Notification	FireBase	-	-	-
Monitoring	Cloud Watch	Monitor	Stack Driver	Sigma Monitoring	Aruba Monitoring	monitorin g Option
archiving files	Glacier	storage	NearLine	-	-	-
Multi-zone	14	3	13	10	-	-

Table 1. Services Available for Patient Monitoring System

A three-layer arrangement comprising various systems working to meet the system objective would be active in the design of the proposed system. Consumer tier, cloud layer and physician / specialist tier are the layers of the structure proposed. Figure 1 demonstrates the device architecture of the three layers planned method. The following is defined.

Patient Layer

The layer of the patient contains a patient and an IoT node. The IoT module comprises of a variety of biomedical sensors that calculate key data (i.e. cardiac rate, saturation of blood oxygen and corpse temperature), and a wifi microcontrovertibly handles these important data, encrypts and automatically transmits them via the Wi-Fi AES algorithm to the Cloud database. MAX30102 is an extremely adaptive, heart rate and oxygen saturation pulse oximeter. These sensors are attached to the microcontroller ESP8266 NodeMCU which controls the entire device and provides transmitting and processing functions Fig. ESP8266 NodeMCU is an IoT computer built with a lightweight, inexpensive, self-contained Wi-Fi module and a high speed, which can also run autonomous applications.

Cloud Layer

The cloud layer guarantees that private health data are kept secure. Cloud accepts patient layers of confidential data in an encrypted manner that enhances the robustness of the device against not just external threats but also internal attacks, where the cloud service provider will execute itself. In any data collection, the Cloud layer is not paid nor supplies data to the next layer.

Doctor/Specialist Layer

This capable of recording and managing patient data in real time through experts in trusted medical centers. This helps professionals to forecast suspicious events and to take measures to deter the case of an emergency. A back-end system is used for capturing and decrypting and transmitting data to the dashboard for tracking. In order to authenticate and avoid fraud, specialists must first be logged into the system via a web interface and then led to surveillance. AWS is used to create the web interface.

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There are different IoT devices available in the market such as Arduino and Raspberry Pi [11]. Arduino is a small microcontroller motherboard whereas Raspberry pi is small computer used for general purpose, usually with the Linux operating system, and the ability to run multiple programs.
Arduino board has its own programming language known as Arduino similar to C language. Different sensors and actuators can be attached with Arduino or Raspberry pi for specific tasks. E-health v2.0 consists of 16 different sensors related to healthcare. These sensors are used to monitor the patient's health. E-health can be used with Arduino or Raspberry Pi. There are different protocols used for IoT communication such as Constrained Application Protocol (CoAP), Message
Queuing Telemetry Transport (MQTT) protocol, Advanced Message Queuing Protocol (AMQP) [12]. CoAP is mainly restricted for small gadgets. Just like Hyper Text Transfer Protocol (HTTP), it also uses the restful architecture. MQTT is a lightweight protocol which is based on publish/subscribe technique. There are two types MQTT client and MQTT broker. The client publishes messages to the broker against a unique topic. The broker distributes the message and publish to the corresponding client. The corresponding client is subscribed to the unique topic. AMQP is an application layer protocol, specifically designed for supporting messaging applications and communication patterns [13].

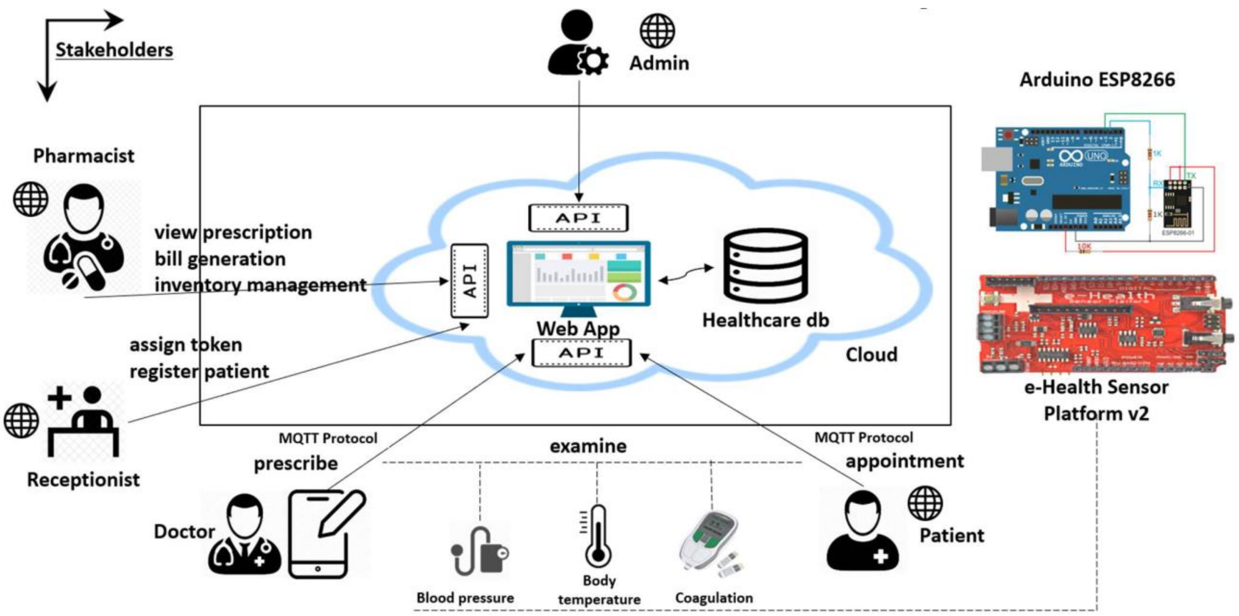

Fig. 2. Overall System Overview of Healthcare System with IoT devices

Fig. 2. Represents the overall system overview. The system includes 5 types of users which are admin, doctors, pharmacists, receptionists and patients. Doctor interacts with the android interface provided in the form of an android application. Four of the remaining users interact with the
system using our web-application. As each of the users has its own role in the different processes to be followed in the daily routine of healthcare systems, we define each of these activities in the form of activity, sequence, data-flow diagrams. All of the stakeholder requests communicate with the system either through a web-interface or a smart phone interface. Also, the streaming analytics for the IoT devices as well. The point that needs to be highlighted here is that the all requests are passed through well-defined API interfaces. These requests could either be the GET or POST requests. The backend, database and IoT-platform are deployed onto Amazon cloud.

Before going into much details, I would like to highlight some of the use case that a patient can perform. Patient needs to be registered into the system with the help of a receptionist. Patient has the option to access information related to prescriptions and billing. He can get appointed online and has to reconfirm about the patient's appointment with the doctor. For that purpose, patient needs to visit the receptionist so that he/she may generate a token through the system via a registered IoT token-generation device. This device is registered onto the IoT platform used on the Amazon cloud services. The service receives a request to generate a token via communicating through MQTT protocol. The streaming analytics is responsible to stream the data to our hospital
management database, which then generates a token receipt for the patient via an authenticated channel. Another use case is that the patient can take an offline appointment from the doctor. The receptionist can call the patients in a specific sequence, generated by the system. So, the point here is that when the doctor prescribes one patient, he has the option to call the next patient and he can retrieve the historical-information of the patient instantly on the android tablet or a smartphone device. The doctor can prescribe the patient via checking him up via the IoT devices registered in the clinic

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e.g. the blood-pressure IoT device, temperature device. This process makes sure the automation of data inputs into the prescription instantly when the doctor uses the device with the patient. This reduces the effort for a doctor to focus more on the patient's health rather than consuming his/her time on entering the patient-data manually. Once, the prescription is done. It is submitted to the system via API exposed interface which are responsible to store patient-data in the form of a prescription. The patient, as usual needs to visit the pharmacy and get the treatment-dose from any of the pharmacy inside the healthcare systems. If the pharmacy does not have the dose for that patient or in any other case, it would be permissible to print the prescription. This process saves the cost of paper and reduces the chances of getting the prescription stored on a central repository. Which could then be streamed to other government healthcare systems. This hierarchy allows the patient to get treatment from any of the healthcare systems and the doctor would be able to fetch the previous information of the patient. The pharmacy has the facility to generate bills for the patients as well as the hospitals for the imported drugs. Managing all of the information on cloud allows the government to downstream the rules and regulation instantly on the healthcare industrial systems. The pharmacy has two types of inventories. One is for the raw-material imported for the hospital so that the experts/scientists could make the inhouse medicines. Once the raw-material is store into the system. It can be consumed in the making of medicine which makes the admin to perform an operation of converting the number of raw-material used to create a final product.

The e-prescription has been implemented in many ways as the image stored (i.e. e-prescription) via doctor's android application is online and accessible. The pharmaceutical information such as the storage of medical records in the form of prescriptions as well as the inventory is also an e-prescription. The e-bills generated in the form of ingredients are also shown to the end user as well as the doctor to get more insights of the historical medical dose used by the patient. The conversion of internal raw material for the inventory is also an innovative step that could allow the instant medical provision in case of urgency. This allows the faster and immediate delivery of medicine to the healthcare system, without the cost of goods-transport. Conversion of all these e-prescription data or information collectively will bring responsive healthcare systems which will have immediate effect on the treatment process of the patient as the doctor will have more insights in the form of a digital prescription.

V. IMPLEMETNATION

We have three parts in our system. For the web application, we require a web-server (WAMP) installed on a server or a machine that is accessible on a local-network environment. We also require the database (MySQL, part of WAMP) to be configured with it. The languages used in order to develop the web-application are PHP, html, CSS, JavaScript etc. The plugins or libraries we used were jQuery, bootstrap etc. For the smartphone application, we developed an android as interface to the doctor through which he/she could use the stylus pen to prescribe the patient. We used Java as a language for the development of this application.
Third part is related to the IoT platform, in which we have registered IoT devices on the cloud (Amazon). The IoT devices that are usable with our system are token-generator, blood-pressure and body-temperature devices.

Fig. 3. Arduino setup with blood pressure sensor device.

We can further enhance our system to increase performance of the hospital system to achieve the goals of efficiency, user-friendliness and less-error-proneness. The physical view of the Arduino setup with the sensor can be seen in Fig. 4, which is registered on the IoT platform and is publishing the patient's data on the cloud where the streaming analytics service is streaming it into the healthcare center's database. Which is then ready to be used by the doctor on his android smartphone-based application.

We performed several tests for publishing the blood pressure readings to the server and observed the response time in measures to check the performance of the system. Moving onto the next section, we plan

Evaluation

This section covers the evaluation of proposed system. In Fig. 3, we can see response times for e-prescription system where the doctor prescribes the patients. The unit we use for presenting the statistics of response time is millisecond. The minimum value of the response time for our system is about 800 milliseconds whereas the maximum response time is 1,400 milliseconds. This figure shows the result of 100 e-prescriptions.

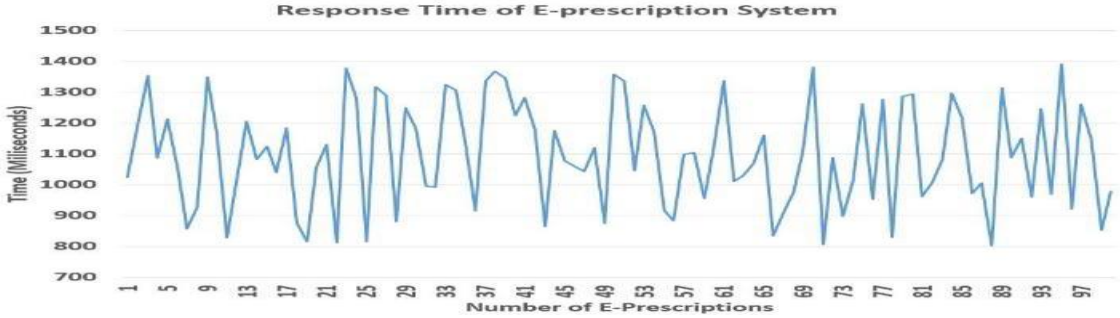

Fig. 4. Response time of e-prescription management system.

Fig. 4 shows the statistics for a specific patient. The data includes body-temperature in Celsius, heart-rate in beats-per minute and blood-pressure in millimeter of mercury.

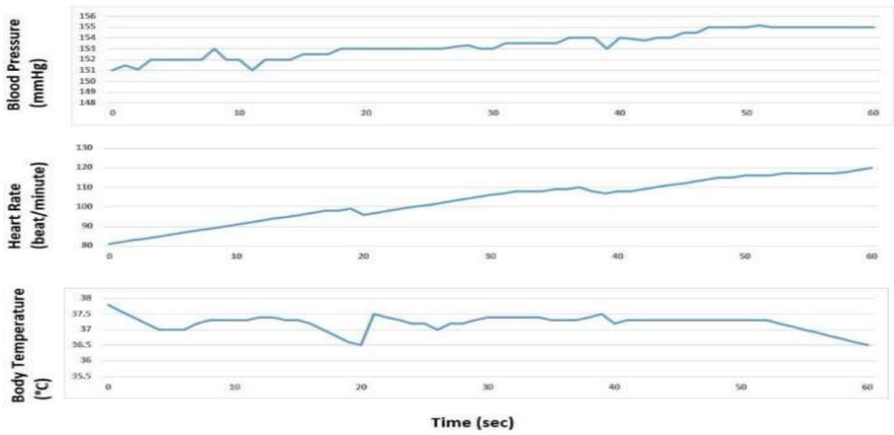

Fig. 5. Analysis of patient's medical statistics

VI. CONCLUSION

The IoT module is attached to patient in order to collect patient's temperature and pulse information with the assistance of sensors. Board takes 10 readings every minute. Each board has a unique id (i.e. board ID) which uniquely identifies the board and in turn identifies the patient to which the board is assigned. The IoT module (board) collects and sends the patient's health data to cloud along with the unique board id using the API call. The effect of IoT-enabled patient surveillance, which fulfilled all the specifications of a standard use case, was demonstrated in this paper. The new scheme is cost-efficient and suitable for rural patients with no established health services in the area and with financial limits on participation by specialists in the city center. The scheduled system was commissioned and lasted 2 weeks. Several sensors and integrated systems have been studied and wireless networking systems are used to better suit the devices. Clinical performance was configured in the sensors. Notices were checked during the activity of the system but no warning signal was sent because no such specifications were identified following implementation. Math Works with GPS based IoT

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network, as it is an efficient and clear open-source system. Although healthcare systems have been improved but a lot of systems still use the process of scanning the prescriptions manually and convert them into e-prescriptions.

We've made this possible by letting the doctor prescribe through an android application either on a tablet/smartphone. Another accomplishment made in our system is the usage of IoT healthcare devices which are authenticated and stream and fetch the healthcare data through proper licensed and secure channels. The performance of system has been improved with the usage of these IoT devices in terms of response-times as well as automation. This provides an easier way to the users
to interact with the system smartly. We evaluated our system which provides a direction to the automation and possibilities inside the healthcare industry via the use of multiple IoT devices. In future, we extend this work by introducing artificial intelligence in the proposed system. If the doctor is not available on site, the patient can receive e-prescription based on previous medical history in case of emergency. This can be provided as a first aid treatment to the patients.

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