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Smart Health care Monitoring System by application of IoT

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ABSTRACT: The recent decade had observed extensive research & developments in the field of healthcare services. To be specific, the Internet of Things (IoT) has shown potential applications in various medical devices & domains, sensors, and many. The Healthcare professionals are providing standard medical services to remote location also. This has improved patient safety, health care cost reduction, high accessibility of health care services, and enhanced operational efficiency in the health care sector. This study gives an up-to-date summary of the potential **Healthcare Applications of IoT (HIoT)** based technologies. Additionally, the application of the HIoT coupled with emerging technologies, healthcare services are solving various health care challenges. These potential challenges and tasks in HIoT system are also narrated. In a nutshell, the present study is a basis for a comprehensive source of information pertaining to the various fields of application of HIoT. This is a platform to future researchers, to work with commitment & advancements in this domain.

KEYWORDS: challenges, healthcare, Internet of Things, real time monitoring system

I. INTRODUCTION

As the world population, reaching to leaps and bounds, the healthcare industry has rapid growth and a major contributor to revenue and employment. In the past, the diagnosis of diseases & abnormality in a human body was done with physical analysis in the hospital. The patients had to stay in the hospital throughout their treatment period. This resulted in high healthcare cost and stress on the healthcare center at rural and remote locations. With the advent of technology, the disease diagnosis and health monitoring devices are miniaturized like smart-watches, rings. Technology has transformed a hospital-centric healthcare system to a patient-centric system. For instance, many clinical analyses (such as measuring blood pressure, blood glucose level, pO_2, level, and so on) can be performed at home without the help of a healthcare professional. Further, this data can be communicated to healthcare centers from remote areas with advanced telecommunication services. These communication services in association with new inventions (e.g., machine learning, big data analysis, Internet of things (IoT), wireless sensing, mobile computing, and cloud computing) have improved the accessibility of the healthcare facilities.

IoT has enhanced the technology besides diversified human interaction with the external environment. IoT, with futuristic protocol and algorithms, emerged as a major contributor to global communication. It connects a many number of devices, wireless sensors, home appliances, and electronic devices to the Internet. IoT can be applied to many fields of agriculture, automobiles, home and healthcare. The importance of IoT is due to its higher accuracy, lower cost, and accurate prediction in better way. Further, enriched knowledge of software and applications, coupled with the up gradation of mobile and computer technologies, simple wireless technology, and the improved digital economy yielded the rapid IoT revolution. The IoT devices (sensors, actuators, and so on) are integrated with other physical devices to monitor and exchange information utilizing different communication systems

II. LITERATURE SURVEY

The IoT- based Health care Monitoring System for War Soldiers by Gondaliaa, etal. in 2018, suggested a system to track the location of missing soldiers and wounded in due time and control their health. It reduces time of the exertion of the army control unit to find and rescue [5]. In his paper Durán-Vegaetal, in 2019, proposed an IoT System for Remote Health Monitoring to Elderly people by a Wearable Device and Mobile Application. It is a biometric bracelet connected to a mobile application, offering real-time observation of all collected data by the sensors in the bracelet

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(pulse rate, blood oxygen saturation and Body temperature). By this information, dectors can make decisions regarding their patients' welfare. This study explains the design and implementation of an IoT system for remote monitoring of elderly persons in nursing homes using a smartphone application and a wearable device. Further, it is low-cost and compatible with the IoT paradigm. The most essential features are: real-time monitoring of health status of the patients [6]. A smart health care monitoring system designed by Naik&Sudarshan in 2019. Their IoT platform system based on the Raspberry Pi. The system used Wi-Fi network technologies to identify human body parameters like body temperature, blood pressure,heartbeat, accelerometer,ECG, respiration, and other data on server of the internet of things [7].In their research paper Valsalan, et al. in 2020, suggested an IoT-based health tracking device with a mobile physiological screening mechanism that can continuously screen the patient's temperature, heartbeatand other specific necessary parameters. They suggested a continuous monitoring and control instrument to screen the patient status and archive the patient data in a server using a wi-fi based module remote communication [3].The research paper of D. Acharya & N.Patil in 2020, described IoT-based Health Care Monitoring Kit, the concept and deployment of an IoT-based smart doctor package for a vital medical situation that can provide robust access to IoT data to assist emergency health providers like Intensive Care Units. This system has developed to give the doctors the required history of patient health in real-time [8].In 2020, Godi et al. published an article in which they presented the E-Healthcare Monitoring System (EHMS), an IoT technology platform that they combined with machine learning (ML) techniques to create an advanced automated system. The patient's data is collected by an IoT wearable sensor. The data obtained from a variety of health monitoring devices is fed into an E-Health care management system. After that, EHMS analyzes the health status byusing machine learning techniques on raw data [9].Sangeethalakshmi, et al. in 2021, published an article in which they presented a patient health monitoring system using IoT, the suggested system included of mobile application and GSM for continuous monitoring of patients remotely. Sensors include a data acquisition unit, a microcontroller (ESP32), and a software system. The systemcontinuouslymonitors, shows, and savespatients' temperature, heartrate, ECG, blood pressure, and SPO2, and the same information was sent to doctors [10].

III. ARCHITECTURE OF HEALTHCARE IOT (HIOT)

The framework of the HIoT that is applied for healthcare system, to integrate the merits of HIoT technology and cloud computing in the field of medicine. It utilizes the protocols for the transmission of the patient data from various sensors and medical devices to a given healthcare network. The topology of a HIoT is the alignment of various components of an IoT healthcare system / network that are coherently connected in a health- care environment. A basic HIoT system consist of mainly three components (Figure 1) such as publisher, broker, and subscriber. The publisher represents a network of connected sensors and other medical devices that may work individually or simultaneously to record the patient's vital information. This information may include blood pressure, heart rate, temperature, oxygen saturation, ECG, EEG, EMG, and so on. The publisher can send this information continuously through a network to a broker.

IV. HIOT TECHNOLOGIES

The technologies applied to develop an HIoT system is vital. Since the utilization of specific technology can enhance the ability of an I oT system. Hence, to achieve various healthcare applications with an IoT system, many state-of-art technologies are adopted. These technologies can be categorized into three groups : identification technology, communication technology, and location technology (Figure 2).

4.1 Identification Technology : The main object of designing HIoT system is the acquisition of the patient data from the authorized node (sensor), present at remote locations. This can be done by identification of nodes & sensors, present in the healthcare network. The process of assigning a unique identifier (UID) to each authorized entity. Then it can be easily identified and unambiguous data exchange will be resulted.

4.2 Communication technology : Technology can connect among different entities in an HIoT network. They include both short-range and medium-range communication technology. The short-range communication technology is the protocols can establish a connection among the objects within a limited range or a body area network (BAN). Medium-range communication technology provides communication for a large distance, like communication between a base station and the central node of a BAN. Majority of HIoT applications prefer short-range communication technology. The most widely used communication techniques are RFID, Wi-Fi, Zigbee, Bluetooth and many.

4.3 Location Technology: The real-time location system (RTLS) or location technologies are utilized to identify and track the location of an object within the healthcare network. The treatment process can be tracked based on the distribution of available resources. The most widely used technology is the Global Positioning System (GPS), In this

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process, satellites are utilized for tracking purposes. This GPS provides a clear line of sight between the object and four different satellites. In HIoT, GPS is employed to detect the location of the ambulance, healthcare center, medical staff, patients and many

V. SERVICES AND APPLICATION OF HIOT

The latest advancements of IoT technology has supported the healthcare devices to do real-time analysis than in past. It supported the healthcare centers to reach more people in time and provide excellent healthcare service at minimum cost. The Role of big data and cloud computing made communication among patients and doctors more re- liable and simple. This resulted health care process into reduced financial burden on the patient. The present impact of IoT, is contributing to the evolution of HIoT. It includes disease diagnosis, personal care for pediatric and elderly patients, health and fitness management, and supervision of chronic diseases. This application of HIoT, is divided into two basic categories, known services and applications. The former includes the concepts of development of HIoT device, The latter includes the HIoT applications in diagnosis of a specific health condition besides measurements of health parameters. The following sections have a detailed description of the services and applications of HIoT.

VI. MOBILE IOT

Mobile IoT or m-IoT is a combination of mobile computing, sensors, communication technologies, & cloud computing to track patient health information and other physiological conditions (as shown in Figure 5). It provides a communication interface between the personal area networks and mobile networks (such as 4G and 5G) to provide an efficient Internet-based healthcare service. The application of mobile made the HIoT services more accessible to the healthcare practitioner. This has provided accessing the patient data, diagnose, and timely provide treatment. Many research papers have reports on the application of mobile computing in healthcare. They have developed an m-IoT based system to monitor the glucose level in diabetic patients that helped in hypoglycemia management. In another study, a mobile gateway-based HIoT system called “AMBRO” was designed in which many sensors were used for fall detection and heart beat control. .

VII. WEARABLE DEVICES

Wearable devices had supported healthcare professionals and patients to handle various issues at a reduced cost. They are noninvasive and developed by integrating various sensors with wearable accessories used by humans such as rings, watch, wristband, necklace, shirt, shoes, handbag, caps, and many. The attached sensor is to collect the environmental and patient’s health information. This information is then uploaded to the server/databases. Few wearable devices are also connected with mobile phones through health applications. Various studies are depicted in the literature indicating the application of these wearable devices (Figure 6) and mobile computing in real-time monitoring. They proposed a recognition method by integrating wearable devices in a wireless sensor network for monitoring of remote patients through an e-health mobile.

7.1 Community-Based Healthcare Services :

Community-based healthcare monitoring is a concept of developing a healthcare network with a local community such as a private hospital, in a small residential area, a hotel, corporate area, industry & so on, to monitor health conditions of resident people. In a community-based network, various networks are concatenated and work cooperatively to provide a collaborative service. A IoT-based cooperative health-care network was set up to provide healthcare monitoring in remote areas. To establish a secured connectivity among various networks, secured authentication and authorization mechanisms were employed.

VIII. APPLICATIONS

The HIoT services/concepts are utilized to develop various IoT-based applications. Re- searchers are working in many fields, with varied approaches to serve mankind. In simple words, these concepts are developer-centric and applications are user-centric. The rapid development in the IoT-technology has resulted in development of more affordable and user- friendly wearable sensors, portable gadgets and other medical devices. These systems collect patient information, diagnose diseases, monitor the health of the patients, and generate alerts in case of a medical emergency (Figure 8). In the following section, some of the most recent commercially available devices have been discussed. Further, various HIoT-based applications have been addressed including both single condition and multiple conditions (Figure 9).

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IX. CHALLENGES, LIMITATIONS, AND FUTURE SCOPE

In the recent past, the healthcare industry has witnessed outstanding technological development and its application to solve many healthcare-related issues. These significantly improved the healthcare services and devices has shown high efficiency. With the application of smartsensors, cloud computing, and communication technologies, IoT has successfully revolutionized the healthcare industry. Like other technologies, IoT also has certain challenges and issues that provide potential scope for future research. Some of the issues have been discussed in the subsequent section.

9.1 Servicing and Maintenance Cost : With rapid technological advancements and with continuous up gradation of the HIoT-based devices timely, this system involves connectivity of a large number of medical devices and sensors. This involves high maintenance, servicing, and up gradation costs. This may impact the financial burden to company and end-users. Hence, the inclusion of operating sensors with a lower maintenance cost is required.

9.2 Power Consumption: Most of the HIoT devices run on battery. Once a sensor starts functioning, the replacement of the battery is not simple. Hence, a high-power battery is required to power such a system. However, many professional are trying to design healthcare devices that can generate power for themselves with the integration of the IoT system with renewable energy systems. These systems will help in alleviating the global energy crisis to a certain extent.

9.3 Standardization: In the healthcare industry, a large number of varying range of products are available. Majority of these products claim to follow standard rules and protocols in the design process. However, it is lacking validity. Hence, a dedicated group is required to standardize these HIoT devices based on the communication protocols, data aggregation, and gate-way interfaces amd many. The validation and standardization of electronic medical records (EMRs), recorded by the HIoT devices are considered extensively. This can be achieved with collaboration of various organizations and standardization bodies such as Information Technology and Innovation Foundation (IETF), the European Telecommunications Standards In- stitute (ETSI), the Internet Protocol for Smart Objects (IPSO) and researchers to form working groups for the standardization of the devices.

9.4 Data Privacy and Security: The integration of cloud computing has transformed the idea of real-time monitoring. Due to this, healthcare networks has are vulnerable to cyber attacks. This may lead to error in patients' valuable information and may affect the process of treatment. To prevent HIoT system from this malicious attack, several preventive steps must be taken in designing the system. The medical and sensing devices of HIoT network must evaluate and employ identity authentication, secure booting, fault tolerance, authorization management, white- listing, password encryption, and secure pairing protocols to avoid an attack. Also the network protocols such as Wi-Fi, Bluetooth, Zigbee, and many must be integrated with secured routing mechanisms and message integrity verification technology. In IoT (connected network) every user is linked to the server. Any glitch in the security services of IoT may violate the privacy of the patient. This can be mitigated with the development of a more secure environment with the integration of advanced and protected algorithms and cryptographies.

9.5 Scalability: Scalability represents the flexibility of a healthcare device to change to any environment. A system with higher scalability functions better with efficient utilization of available resources. Hence, it is vital to design a device with higher scalability to work efficiently for present and future uses. A HIoT system is the interconnection of different medical devices, sensors, and actuators, to share information through the Internet. Due to lack of uniformity among the connected HIoT system devices, the scalability must be managed efficiently.

9.6 Identification: Healthcare professionals are associated with multiple patients and caretakers at the same time. Also, when a patient deals with multiple health issues, he interacts with many doctors. Hence, it is crucial to exchange the identity of the patient, caretaker and doctors among each other, during the treatment process. It helps to avoid confusion and maintain the smooth functioning of the healthcare system.

9.7 Self-Configuration: The IoT devices must be user-friendly to the users. It includes the feature like manual configuration. This will enable the users to change the system parameters according to the requirements and to change the environmental conditions.

9.8 Continuous Monitoring: Few healthcare issues demand long-term monitoring of the patient during treatment as in cases of chronic diseases, heart diseases, kidney failures, cancers and many. In such cases, the IoT device must be able to perform real- time monitoring efficiently.

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9.9 Exploration of New Diseases: With the rapid growth in technology, new healthcare apps are added with rolling of days. Though a large number of mobile apps are available for healthcare applications, the types of diseases for which, these apps were designed are still limited. Hence, it is necessary to include more diseases that were either neglected or got inadequate consideration in the past. This will add up to the diversity of the HIoT applications.

9.10 Environmental Impact: The development of anHIoT system requires the integration of various electronic equipments, activators, biomedical sensors, semiconductor-rich devices and many. The manufacturing & fabrication, require the utilization of earth metal and other toxic chemicals. This may result an adverse effect on the environment.

X. CONCLUSION

This paper investigated different aspects of the HIoT system. Comprehensive knowledge about the architecture of an HIoT system with components, protocols and the communication among these components are discussed. Also, this paper briefs about the present healthcare services with utilization of latest IoT technologies. By employing IoT-technology has helped healthcare professionals to monitor and diagnose several health issues, with many health parameters. This will provide health services and diagnostic facilities at remote locations. This has transformed the healthcare services from a hospital-centric to a more patient-centric system. This paper has discussed various applications of the HIoT system and their recent trends. Further, the challenges and issues associated with the design, manufacturing, and use of the HIoT system have been provided. These challenges will form a base for future advancement and research to focus on new trends. A comprehensive up-to-date knowledge on the HIoT devices is provided to the readers / researches. This will initiate their research and make advancements in this field.

Table:1 Reference range of SPO2, heart rate and body temperature

HealthParameters	NormalReferencerange	Note
Spo2	95%-100%	90%-94%Borderline
HeartRate	(60–100)bpm	10yearsandolder-adults
	(70–190)bpm	Neonate
	(80–160)bpm	Infant(1–11)months
	(70–130)bpm	Children(1–9)years
	(40–60)bpm	Athletes
BodyTemperature	36.4C–37.6C	11yearsandadultsbelow65years

Table: 2 Summery Table

SYSTEM	DEVICES USED	PROBLEM MONITORED	COMMUNICATION TECHNIQUE USED	DETAILS COMMUNICATED	USER INTERACTION WITH SYSTEM
Ingestible sensor	sensors, wearable patches, mobile device	medicalnonadherence	Electrical signal, bluetooth	Doses of medicine intake	No interaction
Ambient Assisted Living	Pebble smart watches, smart phones	Assistance for elderly people in AAL facilities	bluetooth, HTTP requests, google cloud messaging	Assistance request, request acceptance	2 way communication between user and caretakers.
Smart phone Medicine	Smart phones, smart bands, smart phone sensors	check vital readings of human body	Electrical signals, bluetooth	Medical records, action to be taken,	Allows interaction.
Interactive M-Health System for diabetics	GPRSBGM, smartphones	blood-glucose variations	GPRS, XML, HTTP	Abnormalities in reading, tips to patient and caretaker	2 way communication between user and caretakers.

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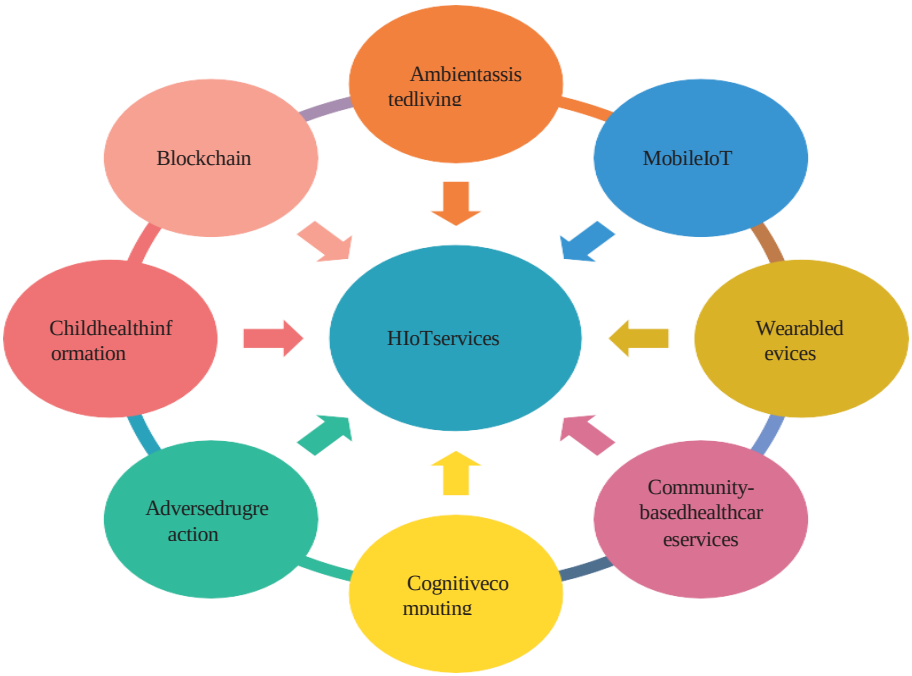

Fig: 1 widely used HIoT services

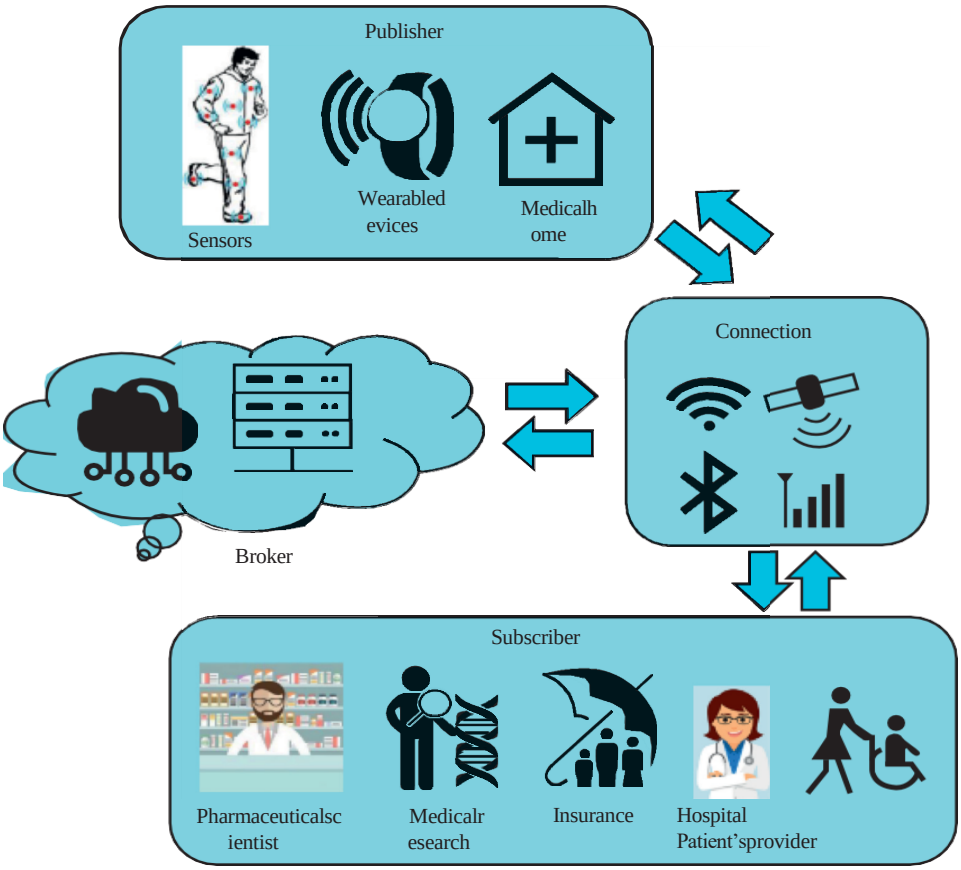

Fig: 2 Architecture of a HIoT framework

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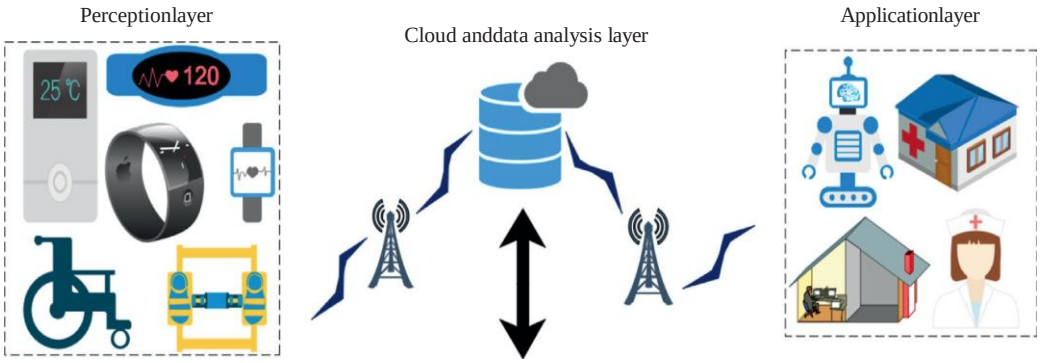
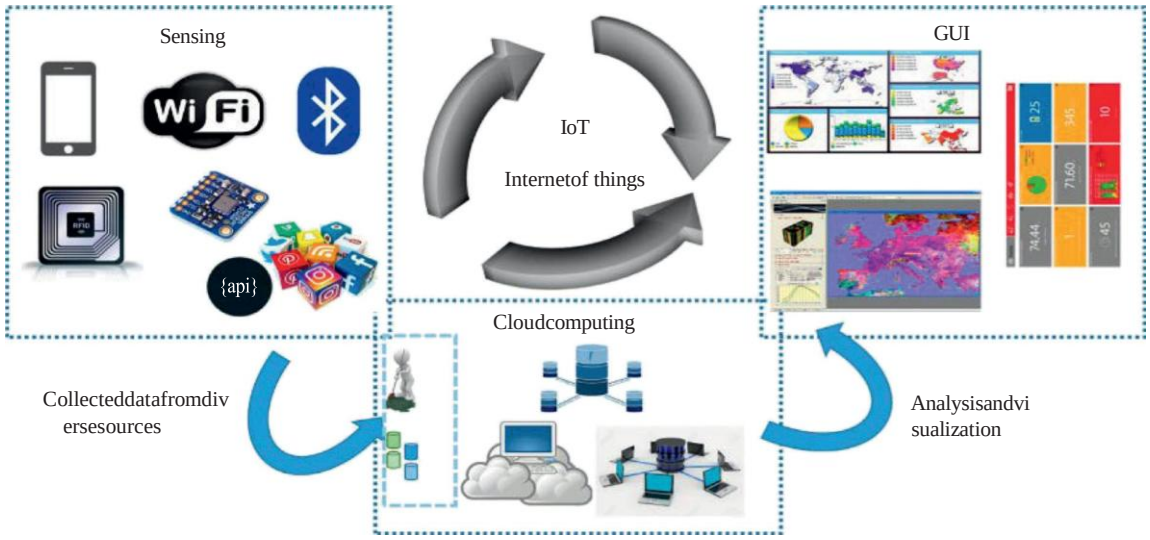
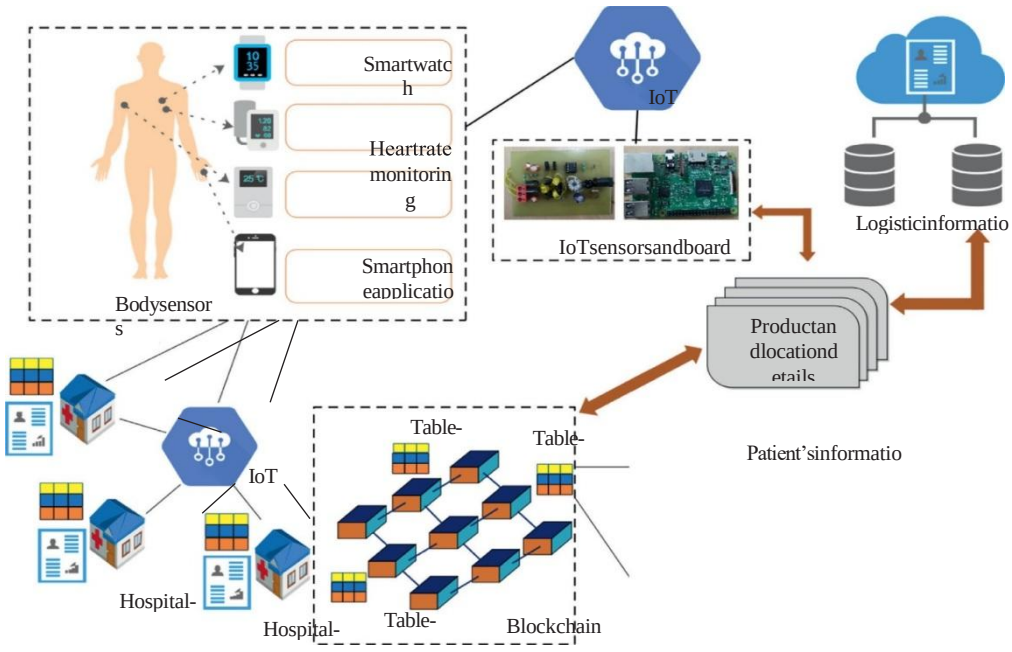


Fig: 3 A generalized m-IoT environment





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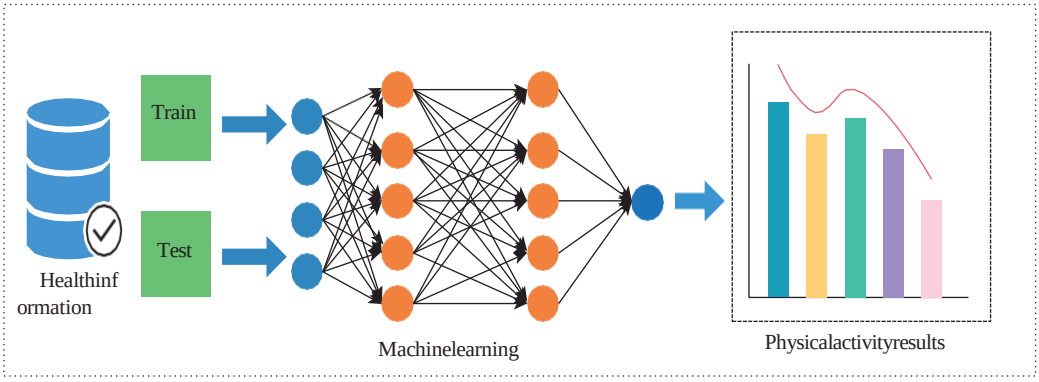

Fig:5 A block chain-based health monitoring system

Fig: 6 Wearable sensors

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