J. Inst. Eng. India Ser. B (February 2022) 103(1):245–257
https://doi.org/10.1007/s40031-021-00632-3

REVIEW PAPER

# A Review on existing IoT Architecture and Communication Protocols used in Healthcare Monitoring System

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Received: 28 February 2021 / Accepted: 31 May 2021 / Published online: 9 June 2021


**Abstract** Nowadays, due to modernization or advancement in the Internet of Things (IoT) especially in the Healthcare area, we want to take care of our elders with some monitoring equipment, and the Internet of Things can play a significant role in it. The motivation of writing this paper is to collect the information of various existing Internet of Things Architecture and Communication Techniques used in Healthcare Monitoring System to observe that how efficiently, different researchers have used it. So we have studied different real-time health monitoring system based on diseases which are common in elderly people like diabetes, blood pressure, heart disease, sleep apnea, and cancer, etc. In this real-time health monitoring system, researchers introduced many new measures, communication techniques like ZigBee, Long-Range Wide Area Network (LoRawan), Radio Frequency Identification (RFID). Apart from this, it was also observed that remote monitoring system in Healthcare is incomplete without data processing and early prediction in such diseases. Though, Machine learning provides efficient techniques to extract knowledge from diagnostic medical datasets collected from the patients. That is why we highlighted the current role of various Machine Learning algorithms like Support Vector Machine, K-Nearest Neighbor, Random Forest, etc., for processing of Healthcare data and also helpful to predict the output more precisely.

**Keywords** HealthCare · IoT · LoRaWan · ZigBee · RFID · Machine learning

## Introduction

Internet of Things (IoT) is regarding the development of the internet ahead of computers and smartphones to an entire series of environments, procedures, and other things. It has been many years since IoT came into existence, but still, we have not entirely understood it, and this is the reason why we have not been able to use it efficiently in the healthcare area. It means to say that it is yet to be known well so that we can use it properly in our daily life. As IoT is entering into healthcare, the expectation of getting new facilities is also increasing especially for the elderly. In today's modern era, we all have a shortage of time to take care of our parents who are very old, due to which they depend more on IoT-based new wearable sensors. Elderly people need more health monitoring so that we can quickly identify and cure, whatever side effects they have such as increased blood pressure, body temperature, heart disease, etc., by the doctors within the time. So in such a situation, by sensing the data from the body of the elderly people, with the help of sensors and communication techniques we can forward it for further processing. The size and weight of these sensor nodes are so small that they are very easy to carry and they can automatically sense the data [1]. To operate them, the patient does not even have to do the manual effort from outside. However, these sensors are more sensitive which sometimes stops working on the power shortage or environmental hazards and the result is

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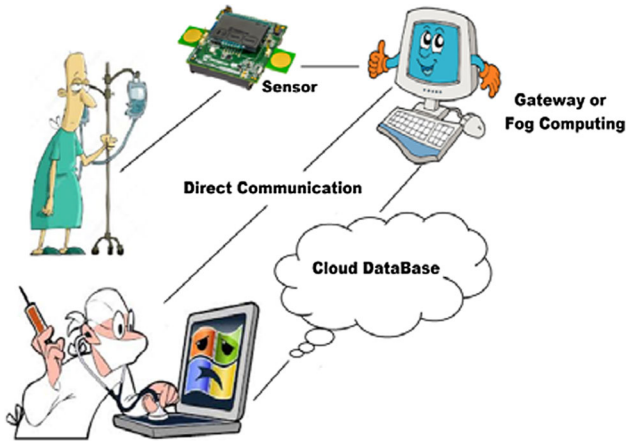


**Fig. 1** IoT in HealthCare

system failure [2]. In Fig. 1, it was demonstrated that how IoT sensors and technology are working in the HealthCare area.

Smart Healthcare is an intelligent infrastructure that transfers information with the help of an IoT system and also implements processing from cloud and fog computing. In various applications, we can use HealthCare with IoT like, diagnosis and elderly treatment, health management and managing chronic diseases, disease avoidance and risk monitoring, smart hospitals, virtual assistants, reducing urgent situation waiting times, assisting drug research, etc. IBM is the first to introduce the Smart Healthcare concept [3] in 2009. No doubt the Internet of Things (IoT) among the wide stimulating areas of investigation for the engineering society and device manufacturing business. Whereas with the help of established internet, we can connect two devices to communicate and that too with the help of the intervention of a human. While IoT connects all sorts of devices "Things" into a broad network of interrelated computing intellect without the involvement of a human. The growth of the IoT industry is demonstrated in Fig. 2, and various IoT elements with technology are present in Fig. 3.

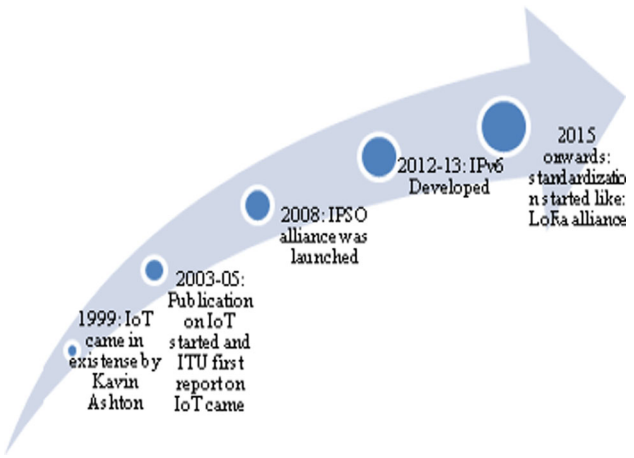


**Fig. 2** Growth of IoT

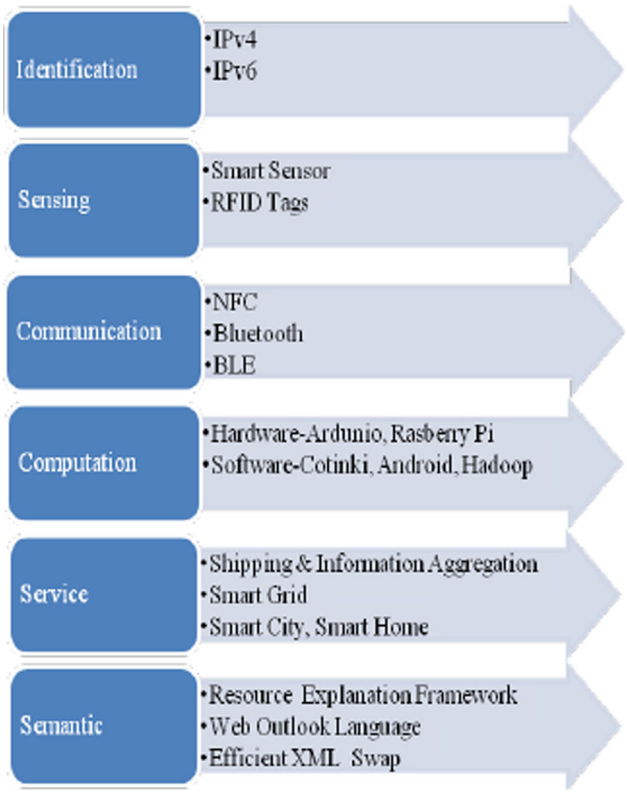


**Fig. 3** IoT Elements with Technology

## Overview of IoT Protocols and Architecture

Today, we are using internet TCP/IP protocol suite for network communication and billions of IoT devices can work because it is connected through the internet. IoT protocols are an essential element of the IoT technology stack and without them, the hardware connected to it is useless. Because the IoT protocols only tell data exchange in a structured and meaningful way. Whatever IoT is today is due to its essential characteristics like communication between sensors, equipment, servers, gateways, and end user's applications. Although the IoT protocols enable this all smart stuff to talk and interact. Though the availability of present Internet communications is free and the biggest constraint for any IoT device even today is that it is too heavy and a power-consuming process for any *IoT* use case. The application layer works as an association between the user and sensor that is needed for the application. "Constrained Application Protocol (CoAP) was designed to translate the HTTP model so that it could be used in restrictive devices and network environments. CoAP relies on the User Datagram Protocol (UDP) for

establishing secure communication between endpoints. Apart from transferring IoT data, CoAP leverages Datagram Transport Layer Security (DTLS) for the secure exchange of messages in the transport layer"[4, 5]. CoAP is more efficient when used in arrangement with 6LoWPAN, a lighter version of the traditional HTTP protocol. "Message Queuing Telemetry Transport-(MQTT)" is a lightweight publication/subscription type messaging protocol. MQTT's design is simple and lightweight, and it is specially designed for battery-powered devices, providing small power consumption for devices. It works over TCP, and it cannot be used with all types of IoT applications. Moreover, it uses text for topic names, which increases its overhead. Once there is physical connectivity done, then with a unique method, all the devices can be separated from operating in their range. The network address has a critical role to identify each computer that is associated with the same router. Each alliance in IoT has its network address; for occurrence, ZigBee is one alliance with its network addresses. Like this, "BLE and Z-Wave" are having their network addresses according to their environments. "6LoWPAN (IPv6 Low Power Wireless Personal Area Network)" devices also function on IEEE 802.15.4, but their network stack is with IP connectivity (IPv6). With effective physical layer standards, we can achieve all this like more devices in a single environment and low power consumption, longer battery life, lower bandwidth consumption, the ability to connect smaller and lighter devices. "Near Field Communication (NFC), IEEE 802.15.1 (Bluetooth Low Energy (BLE) – Bluetooth 4.0), IEEE 802.15.4 (ZigBee, 6LoWPAN, WirelessHART, MiWi)," etc., are the standards set by definite bodies such as proprietary vendors (Z-Wave by SIGMA DESIGNS) and IEEE (Institute of Electrical and Electronics Engineers).

IoT architecture is divided into five layers [6] as shown in Fig. 4, and the architecture of IoT in HealthCare is demonstrated in Fig. 5. The responsibilities of different layers in IoT architecture are:

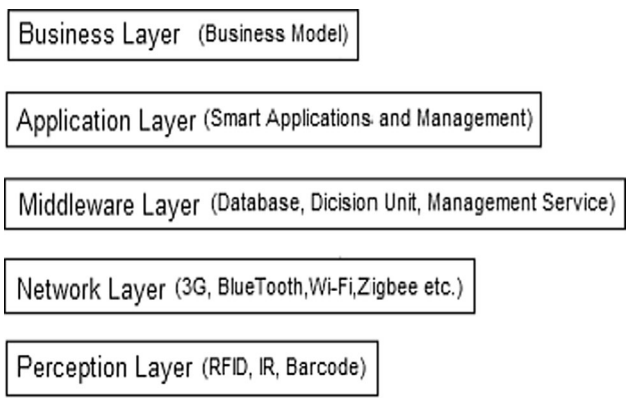


**Fig. 4** IoT Architecture

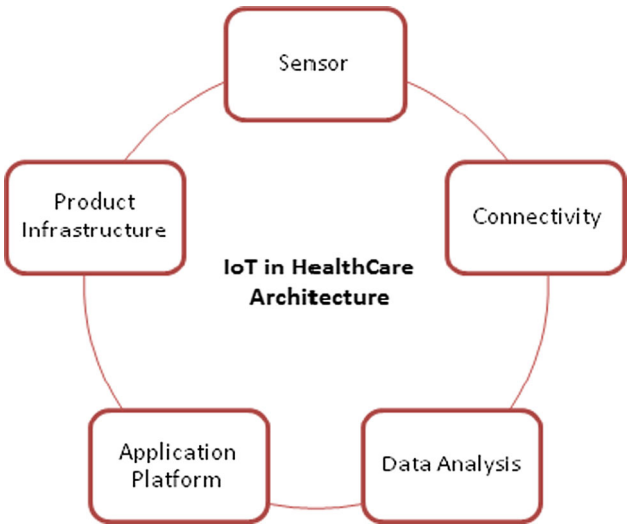


**Fig. 5** The architecture of IoT in HealthCare

I. *Perception layer* The perception layer is like a physical layer, or we can also call it the device layer. On this layer, all sensors like RFID, infrared sensors. barcode is scanned and collect data from the sensor node to forward it to the network layer further.
II. *Network layer* In IoT architecture, the network layer is also called as transmission layer. It works by sending the data received from the perception layer to the processing unit securely. The transmission standard can be wired and wireless to send data securely and this layer use 3G, wi-fi, Bluetooth, and Zigbee technology. Thus, the data are then forwarded to the middleware layer.
III. *Middleware layer* One device of IoT connects to the other device only when both provide the same type of services. The middleware layer has the responsibility to connect it to the database by keeping in mind the service management. Further, computation and decision-making are also done by the same middleware layer.
IV. *Application layer* This layer comes up with the global management service. As per the device applications like it can be smart farming, smart health, smart home, intelligent transportation, smart city, etc.
V. *Business layer* The business layer helps in creating a business model, graph, flowchart, etc., for different business models from the output received from this layer, which is useful in determining the further business strategies.

## Applications of IoT in HealthCare

IoT in the HealthCare field provides applications that can be separated into two sections [7, 8];

I. Single condition observation, e.g., Glucose level monitoring, electrocardiogram sensing, blood pressure sensing, body temperature sensing, oxygen value sensing ii) Clustered condition observation, e.g., Rehabilitation management, medication system, wheelchair system, imminent healthcare, smartphone healthcare solutions.

Further for general HealthCare, lots of apps are available like;

*Google Fit*

It is a health-tracking application. It is the only set of application programming interfaces (API) that combine data from multiple devices and apps. API is a computing edge that defines exchanges of data between multiple software. Google fit uses sensors of a user's mobile devices to witness our physical fitness behavior for an instance running, walking, cycling, and many more. As per the user's fitness objective, they measured against a widespread view of their fitness level.

*ECG Self Monitoring*

The Electrocardiogram (ECG) sensors calculate the biopotential that is caused by electrical signals, and it controls the expansion and contraction of the heart chambers. It is implemented in a health checkup procedure.

*Pedometer*

This device counts every step of a person by detecting the movement of the person's hands and hips. The movement of a body is observed by attaching a enclose of reference which consists of an intangible coordinate system, to a viewer and measuring the change in position of the body relative to the enclose with the change in time. The technology for a pedometer includes a mechanical sensor and software to count the number of steps. Today, Micro-electro-mechanical systems (MEMS) sensors and complicated software are to be used for the same purpose.

*Noom-Walk*

Noom Walk is similar to a pedometer as it counts steps all over the day. It does not use GPS technology, so the app uses less battery and after counting steps for 24 h, Noom Walk uses around the equal battery life as a GPS-enabled app just for few minutes.

*Water Your Body*

This app is created to remind a person to drink a certain amount of water every day. This app is based on a lot of predefined algorithms that take some related information from a user for instance weight, height, etc., to set reminders for the users. Some of them are also used some tracking components to track the temperature of a body and as well as energy is being exhausted from a body.

*Instant Heart Rate*

Basically, this application and technology are quite similar to the technology which is being used in Heart rate monitoring. For instance, some predefined algorithms and software are used in this. The main quality of this application is to measure heart rate instantly or in a fraction of a second.

*Finger Print Thermometer*

It is a sensor-based application that takes a user's finger to detect body temperature and pressure. It recognizes the finger which we press on the display panel. These sensors can permit users to just place their finger on the screen and recognize the print, rather than on a button. Random networks of a hybrid nanostructure stand on ultra-long silver nanofibers, and fine silver nanowires are used to produce clear, flexible electrodes of this multitasking sensor array.

*On track Diabetes*

This application connects to Dexcom-glucometer to track the level of blood sugar. A person can also give related information based on steps, exercise levels, meals, etc.

## Motivation

When a device is associated with the internet, it means that can send and/or receive information. This ability to send and/or receive information makes devices smarter. IoT in HealthCare is gaining more attention due to the advancement in the development of IoT devices. Fortune Business Insight says that the market will go up to USD 176.82 billion by 2026 and it was USD 30.96 in 2018. The market is predicted to rise at a CAGR of 33% in the estimated period (2019–2026). The integration of AI with IoT is the vital feature driving the IoT in HealthCare market extension. Asia Pacific area is probable to grasp the maximum market share. As per our knowledge, in this paper, we describe the existing IoT structural design and communication techniques in HealthCare Monitoring. Application area of IoT devices is going to be increased in our daily life

like SmartHome, HealthCare, Remote Monitoring, etc., and various types of technology platforms are being used for the architecture of IoT along with this various communication protocols. As our focused area is Smart HealthCare, hence, this field needs to be optimized. If communication technique challenges and accurate data transmission are not addressed, then we will fail to recognize the disease at the right time. These points motivated us to bring forward this review work taking into consideration various parameters like Coverage area, transmission range, accurate data as futuristic solutions. To make available the readers through an explanation of the dissimilar work available in this field of HealthCare in IoT which helps to adapt these methods in solving communication and accuracy of data problems in future. In this COVID-19 situation, today when we cannot physically take care of our elders and near dear ones, then such remote monitory system can be most effective, just the high-speed internet should be facilitated. Researchers will get the help to explore more to address solutions in approaching days. As per the report of Deloitte and NASSCOM, Fig. 6 exhibits the number of IoT-enabled devices growth per year and the CAGR growth rate which is almost 33%.

## Literature Survey

### Bluetooth Low Energy (BLE)

BLE is an energy-efficient and low latency protocol because of its single-hop transmission feature. In this paper [9], the author has compared some microcontrollers for the gateway node and has chosen the MCU node based on its specification. Sensed data from patient's body stored on an android app with the help of Bluetooth Low Energy (BLE). BLE also provides Cyclic Redundancy Check (CRC) for data security, and this same app forwarded the collected data on the cloud for further reference. In this paper, the author proposed a reliable system at a low cost. In another experiment [10], the author has sent patient data from three different methods like BLE, Wi-Fi, GSM to the mobile app by making RPi3 a gateway node, so that if one data is lost from one method, the data from the remaining method could be received. And finally, web application software has been proposed to provide an interface for cloud databases. In this work [11], we observed that the working of the BLE protocol is better in the case of latency and energy parameters.

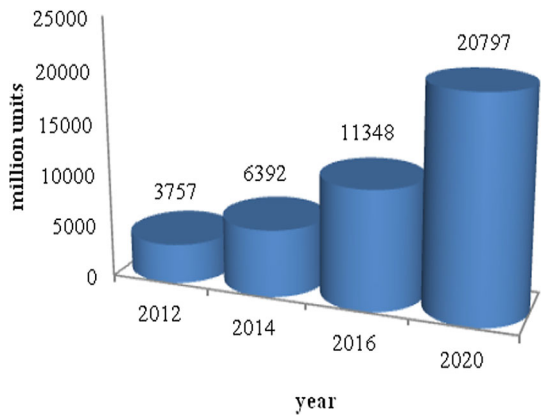


**Fig. 6** Number of connected device per year

*Drawbacks*

The early-stage disease prediction method is not present in the above work, and all patients' complete sensed data are stored on the cloud without any data analysis which may increase the big data problem on the cloud in the future. Also, BLE supports single-hop transmission which is not so much reliable, as an end-to-end transmission depends upon the working of intermediate nodes.

### Bluetooth (IEEE 802.15.1)

This paper [12]shows, that IoT helps a lot to reduce deaths due to heart attack, here the entire patient monitoring system is separated into two steps which are data acquisition and data transmission. In the data acquisition part, data forwarded into four different modules by checking the patient's Electrocardiogram (ECG), pulse rate, heart rate, blood fat, blood pressure, patient location, and blood glucose. These modules are synchronous uninterrupted communication for all data, uninterrupted communication in special slots, transmission on patient demand, and event-triggered transmission. At last, the implementation was performed on a prototype, in which the monitoring work was done with the help of Java application in Android smartphone on sensed data which was sent via Bluetooth and data were left on the server-side for monitoring of doctors.

*Drawbacks*

It has also been observed that Bluetooth is not adaptable for long-range transmission [13]. BLE and Bluetooth work on the same frequency and range, but the transmission rate in the case of Bluetooth (IEEE 802.15.1) is up to 1- 3 Mbit/s, whereas in BLE it is 1 Mbit/s.

### ZigBee (IEEE 802.15.4)

The contribution of master–slave architecture [14], in IoT, plays a significant task. The slave node passes on the different data readings to the sub-master node with the help of

ZigBee, which is a good protocol for small distance communication, followed by the sub-master node, send the data which was received from the slave node to the master node, which is at a much greater distance and here sometimes due to lack of cellular network, therefore, LoRawan protocol has been used. The accuracy of the ZigBee protocol explained in this paper [15], during communication, such as accurate location detection by ZigBee terminal when it passes through ZigBee router area. When sensed data of patients are compared with manual reading, almost 99 percent of the matches took place. On a similar standard, one more technology is used for communication [16], the author has proposed an IoT-based biomedical kit which is very cheap. As well as it can be implemented on a lot of people simultaneously. The basic platform in this system is Raspberry Pi 3, and it was connected to a wireless transceiver "nRF24L01 (IEEE 802.15.4)" and microcontroller MSP430G2553 for data sensing and transmission. The author has also stated in this paper that cost, power consumption, standby mode, and data transmission rate wise nRF is best instead of ZigBee and BLE. So when we talk about data accuracy, we found that ZigBee performance is good, and based on power consumption, standby mode, and data transmission rate parameters- nRF is good.

*Drawbacks*

Here, we can see that both Zigbee and nRF are designed for small-distance communication and the data rate of ZigBee is 250 kbit/s.

**Sigfox/LoRa/NB-IoT under LPWAN**

Benefits of Sigfox, LoRa, and NB-IoT protocols [13] such as battery life, cost, and range of radio communication, under the low power wide area networks (LPWAN) category. LoRaWan uses AES 128b for encryption and NB-IoT uses LTE encryption, but Sigfox has no authentication or encryption. A new architecture [17] has been proposed for Smart HealthCare, in which communication takes place with the help of LoRa connectivity to Fog Computing. It has been observed that the monitoring of remote area patients can be forwarded to several kilometers away also; this system does not allow too much burden of data on the cloud and is also a good example of energy efficiency. In this research work [18], a channel access mechanism solution is provided to reduce the collisions, and the focus area of this work is to analyze the scalability of LoRa technology. No doubt the Sigfox/LoRa/NB-IoT protocols under the LPWAN category are good.

*Drawbacks*

Since the NB-IoT commercial deployment is very less in HealthCare, so its lifetime and performance are not sure whether it is good or not. Another challenge is internet connectivity in a remote area, and it is expected that 5G communication will be able to solve this. The common drawback in the above-cited papers is that they are just working on the communication part there is no mechanism to detect the disease in the early stage.

**MQTT**

In this work [19], throughput and end-to-end delay parameters were taken for a comparison between Message Queue Telemetry Transport (MQTT) and HTTP. To build the simulation environment, OMNET + + network simulation was used and it described that MQTT protocol performs better as compared to HTTP. Again in this related paper [20], MQTTT has been used for health monitoring. Firstly, a wearable device receives the health-related data from the sensors and then by customizing the data, forward it to the cloud because of the MQTT protocol. In addition to this, a fuzzy classifier [21] is used to receive the continued data from the sensor as well as for the data filtering task, so that only a calculated amount of data is to be sent on the cloud.

*Drawbacks*

More power consumption is required by MQTT and another issue is that it uses text to topic name which increases its message overhead.

**CoAP**

The Constrained Application Protocol (CoAP) is a web transfer protocol that is used for constrained nodes within constrained networks, which is having low bandwidth and low availability. It is similar to HTTP protocol. The author [22] has given an example of a hybrid system in this paper. This hybrid system is made up using both 6LoWPan and CoAP protocols, due to which the efficiency of this hybrid system has increased up to a great extent. Similarly [23], the author has used CoAP as the protocol of an application layer and implementing it under 6LoWPan network on Contiki OS. Here, the performance is quite satisfactory and it was concluded that CoAP is a reliable and effective application protocol.

*Drawbacks*

CoAP is not good in congestion control mechanism and having poor interoperability with other devices.

### Miscellaneous

In this system [24], the author has mainly explained the role of IoT in the health care monitoring of elderly people. The process of sensing the heart rate and body temperature of the elderly by making an Arduino do it yourself (DIY) board is the base. Besides, sensed data have been stored on the cloud for further graph plotting and emergency notification. In this research, it has also been said to create a future model in which the decision-making algorithm of machine learning will be used.

In the same way, the Raspberry Pi platform has been used [25], the author has given the proposal of an IoT-based system keeping in mind the elderly and disabled people who speak a very low sound. To create this system, Raspberry Pi is connected with a GPIO interface, which patients can access from their smartphone. With the help of the internet, this system sends pre-recorded audio messages to hospital staff or relatives, so that help can be delivered in time.

In this work [26, 27], hybrid system is made up using both 6LoWPAN and MQTT protocols, where 6LoWPAN is used for framing and for internal communication MQTT is used. In this work [28], a new protocol was proposed and its performance was checked on the NS-2 simulator and results show that it is good in energy-saving and network lifetime parameters.

### ML in HealthCare

In this paper [31], the author has focused on how to use sensed data from the cloud efficiently. For example, here only the database of patients with diabetes has been researched to indicate that the dataset is a severe disease of diabetes and which data set tells it to be early-stage of diabetes. Here, the author has used various classifier schemes of ML-like decision tree, K-NN, SVM and finally propose a Fuzzy Rule-Based Neural Classifier.

Random forest classifier and IoT [34] can perform well in the healthcare system. It has been demonstrated that how to improve the interactivity between the patients and the doctors. For the reliability of this process, the author has performed experiments on datasets of various diseases, like diabetes, breast cancer, surgery, thyroid, spect-heart, heart disease, liver disorder, and dermatology. The author has used different algorithms of machine learning over different datasets such as Support Vector Machine, K-NN, Decision Trees, MLP, and Random Forest. The best results that we have come across are through the random forest technique of machine learning and the average results are also good on different disease data sets. In the future, if we use a large data set, then maybe some other algorithm of machine learning can give better results.

In heart care disease [35], Fog-based HealthCare with deep learning technique is a unique Health Fog system, especially for heart patients, in which the Ensemble method of deep learning has been used on edge computing devices. For high precision, tremendous compute resources (CPU and GPU) are used for instruction and forecast. In the future, this architecture could be used for other fog computing applications such as weather forecasting, agriculture, smart city, traffic management, and other HealthCare issues such as cancer, diabetes, and hepatitis, which can supply skillful results.

A multi-agent system [36] has been described as flexible, reliable, and energy-efficient. Here, the focus is on the data reduction algorithm, so that a reduced set of data is prepared, which is very similar to the original data set. By using this above-said method, we will not have the requirement of separate external memory. For the implementation of this system, Java language has been used in the JADE environment and the data reduction ratio has been calculated up to 80 percent.

ANN-based IoT-enabled HealthCare system framework is demonstrated [37], and the accuracy of the developed model is 90.54% for a healthy person and 87.88% for a patient with diabetes and kidney disease. ANN Technique of Machine Learning especially focused on Sleep Apnea disease [38], which is an event detection system also a good idea. Different sensors are used for data collection purposes like MEMS-based accelerometers and Industrial Spiro-meter. Only ACC data are used to train the system, and for good results, the author has suggested that more sensors can be used for monitoring purposes in the future.

In this work [39], the Deep Neural Network technique was used here to extract the features from EEG, ECG, Temperature, and Pulse Rate, and the accuracy of the model was found at 97.5%. To find the abnormality in the Kidney [40], FPGA-based IoT-enabled ultrasound images were used along with a Support Vector Machine classifier to know the accuracy of the system. Similarly, k-means algorithm of machine learning is used to predict the upcoming situation [14].

In Table 3, we demonstrated various ML algorithms and application areas.

In the comparison graph shown below in Fig. 7, we have compared the accuracy value of the diabetes dataset [41–45] given in different papers by various classification methods of machine learning like SVM, K-NN, Decision Tree, Naive–Bayes, Logistic Regression, and Random Forest.

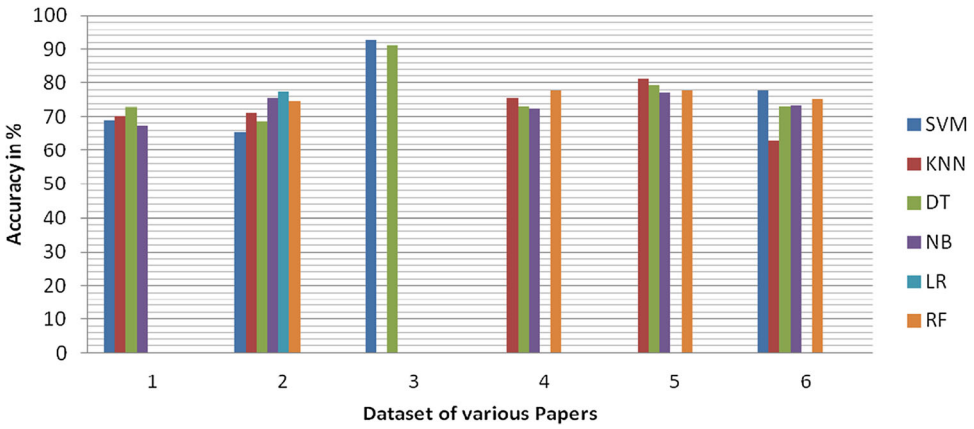


**Fig. 7** Accuracy comparison

## Challenges with IoT in Healthcare

I. Data security and isolation
II. Integration: various devices and protocols
III. Network lifetime
IV. Data overload and accuracy
V. Cost

These three checks are very important for data security and Privacy, i.e., authentication, confidentiality, and integrity. For Data security [34, 46, 47], either we talk about Fog Computing, Cloud computing, and Direct transmission, such algorithms do necessitate large storage capacity levels where cloud computing up to an extent can solve this large memory requirement [48]. Sometimes the data are much classified, and it might become a big difficulty if stolen or compromised. Most security depends upon the developers of the devices, but we also need some new security methods [49, 50]. IoT networks in hospitals are extensively using 6LoWPAN with "RPL (IPv6 Routing Protocol for Low Power and Lossy Networks)". Storage requirements can be met by using motes ROM. But still using more capacity memory, we can control a few more attacks and can reduce the issue of security further. Other solutions could be private cloud and data aggregation techniques. In other words, it should be in the practice and process of all of us that we confirm that the data cannot be used and accessed by any unauthorized individual and parties. Security of data guarantees that the data are reliable and accurate whenever it is needed by authorized access. A data security plan involves aspects such as gathering only the necessary data, safe maintenance and demolishes any data that is no longer needed. These steps will assist any business to meet the legal commitment of possessing responsive data. Appropriate use of data is defined by data privacy in an appropriate approach [51]. The IoT system can function and convey information via an online approach only when devices are securely connected to a communication network. Some of them as given below [52]:

- *Bluetooth* The IEEE 802.15.1 standard is an exclusive open wireless technology standard for exchanging data over a short distance. Bluetooth radio adopts the Frequency Hopping Spread Spectrum—FHSS. The transmit distance of this technology is directly proportional to the transmit power.
- *Wi-Fi* The IEEE 802.11 network is an arrangement of the Wireless Local Area Network (WLAN). In low band mode, three variables of IEEE 802.11(b, g, n) are present, which can transmit data from 11 Mbps and up to 54 M bps and goes up to 32 m indoors and 95 m outdoor.
- *Cellular* Cellular networks have become more popular in recent years. It uses radio waves for transferring information. In the 1980's, it was started by the name of 1G which was an analog system, then the 2G-Digital system comes into existence, then 3G and after that 4G cellular network generation came which is based on LTE and Wi-Max network standards.

Some of the reasons behind the data overload are given below:

- A lot of new information is created continuously.
- The pressure to create and compete in information provision leading to a quantity over quality effect in many industries
- The simplicity in online information sharing, creating and duplicating.
- The exponential rise in channels to collect information by; print media, radio, websites, television, e-mail, RSS feeds, mobile telephony, etc.
- Increasing in the weight of historical data available to us.
- High volumes of contradictory, conflicting, and plain old erroneous information.

- No simple methodologies for comparing, quickly processing, and evaluating information sources.
- To fall short in clear structure in groups of information and poor or bad clues as to the associations between those groups.

A node in an IoT network requires a lot of energy as well as a storage area to make it so capable. In this work [53], for energy efficiency especially for wearable devices ATTINY85 sensor is used which results in the long life of a 220 mAh battery. Samsung Exynos 5422, a smart Gateway, has also been used, which is energy efficient as well as fast [54] due to the processor installed in it. This system can understand only FHIR datasets files, so in the future, it can be made compatible with CSV datasets, and the working of Gateway can also be made more accurate by associating it with Artificial Intelligence. This can be done by reducing the computational task and simultaneously without losing the accuracy of the information [55], and this can also be achieved by traveling the shortest path by data packets with the help of FUZZY rules [56]. Data overload will occur when the input data will be larger than its processing capacity. When data overloads, then the reduction in data started to occur. As data accuracy is one of the important features of data quality. This tells us that the data values that have been stored for the object are also correct. To be correct, data values must be true values and must be represented in a steady and explicit form. The accuracy will always be if the data values are correct. Since 100% of data accuracy is not possible anyhow. There will always be some amount of data in the inaccurate database. The application area of all protocols is also different from the perspective of these parameters like coverage area, transmission range, and operational bandwidth. A global standard can also be made to resolve this issue. Overload of data and lack of accurate data on the cloud, fog, and gateway devices is also a challenge for IoT in healthcare. For data quality and accuracy issues, Machine Learning Technology can be a good solution. Although work has been started in this direction, it can be improved further. Whenever we talk about advancement in the IoT field, it directly affects the cost of the system. Whether we argue on a new protocol design, a new IoT wearable device, on a sensor that fulfills multiple purposes; these are all cost-dependent areas. Device developers should also pay special attention to this direction.

So IoT networks require these characteristics [57] such as:

- *The capacity to connect a large number of heterogeneous elements* Thousands to millions of devices will be needed to build a large IoT system, and all these devices must also be entirely diverse from each other. Most of the IoT devices are diverse depends upon the input and output layout of particulars and the communication protocols. So to make a reliable IoT system, inter-device communication, interoperable devices, and analysis of the data from all diverse devices is a big challenge.
- *High reliability* On each layer of IoT, reliability is required because of the proper working of the system and aims toward the achievement of service delivery ensured by it.
- *Real-time data transmission with minimum delays* These devices transmit real-time data to the base station (BS), which can further be used in different applications and that too with a minimum delay such as abnormality discovery. Under adequate power accessibility, wireless transmissions from sensors can be scheduled at regular time intervals to maintain real-time data acquisition.
- *The ability to protect all data flows* Diverse security methods are involved in all layers of IoT because data security is a big concern for IoT.
- *The ability to configure applications* Sensors get outdated from time to time, and there are chances of malfunction, so it is better to configure them from time to time according to the application.
- *Device-level monitoring and traffic management* Monitoring all activates of connected devices and managing all traffic or we can say proper routing should be there.
- *Cost-effectiveness for a large number of connected objects* As we add more new devices to the network, the cost of the system will also increase. That is why either these devices support multiple applications or they do not cost much.

Well, these are the consequences by which it becomes more complex.

## Problems in existing System

Various factors affect the IoT in HealthCare applications like it requires continuous research in every field of healthcare to offer a fast and better competence for patients for example manufacturing smart devices, fast communication techniques, etc. IoT has a heterogeneous network and due to a lack of standard architecture, sometimes it becomes a difficult task to use communication techniques according to the applications. Without analytics power, IoT is useless which is now becoming the biggest source of Big Data. Deep learning, Artificial Intelligence, Machine Learning, and Big data analytics can be used for some value-added applications in IoT. As we can see from Table 1, that the professionals working in the HealthCare department are getting massive data of the patients with the

**Table 1** Comparison between various Technologies used for Healthcare architecture

| Ref. work | Published by | IoT interoperability | Data on cloud or server | Technique for prediction | Single/Multiple parameters | Technologies |
|---|---|---|---|---|---|---|
| [29] | Springer | RPi | Yes | No | Multiple | GSM |
| [30] | Scientific Research | RPi | Yes | No | Single | SMS/Alarm |
| [31] | Elsevier | Android | Yes | No | Multiple | Bluetooth |
| [20] | SPC | RPi | Yes | No | Multiple | MQTT |
| [14] | Ubiquity | Arduino | Yes | k-means | Multiple | ZigBee & LoRawan |
| [31] | Elsevier | Java | Yes | Fuzzy Rules | Multiple | 5G mobile network |
| [21] | Elsevier | Android | Yes | Fuzzy Rules | Multiple | MQTT |
| [26] | MDPI | RPi | Yes | No | Multiple | MQTT on 6LoWPAN |
| [24] | Elsevier | Arduino | Yes | No | Multiple | LED & LDR |
| [10] | Elsevier | Rpi3 | Yes | No | Multiple | BLE |
| [32] | Elsevier | Android | Yes | No | Multiple | BLE |
| [33] | Elsevier | Weka/Matlab | Yes | HOBDBNN | Multiple | Bluetooth |
| [23] | IEEE | Contiki | Yes | NO | Multiple | CoAP on 6LoWPAN |

help of IoT technology either on cloud or server, which is creating a data surplus and accuracy problem. As well as it is wastage of time to deal with irrelevant datasets or values at the time of diagnosis. Before sending the whole data to the cloud or diagnosis the whole dataset, analysis of datasets or data mining can assist better care to the patient. As we found in the literature review that the patient's data are either getting from the direct patient's sensor device or from cloud storage to diagnose by the doctors. If doctors are working on a cloud storage data set, then it cannot be a real-time health monitoring system. Sometimes, it is very difficult for those who live in remote areas where doctors are far away from their reach to consult. In those cases, if symptoms arise for some serious and common diseases, so without a doctor's intervention, the machine learning approach will be helpful to detect the severity level of the disease. So, IoT technology with ML can build precision of the information and disseminate more correct and real-time information to patients. This leads to fewer accidents from misperception, better protective concern, and superior patient satisfaction. So with this feature, we can use IoT in a well-planned manner in healthcare and take it to a new level. This is the best use of it in healthcare, that we should do it for elderly patients with some serious and common diseases. In a healthcare monitoring system, the patient simply has to attach the IoT-based sensor to their body and the sensor does the rest of the monitoring work itself and keeps the report to the doctor and family as well. But remote monitoring facilities can benefit those people who live in remote areas and doctors are far away from their reach.

## Conclusion and Future Scope

So far the utility of IoT-enabled technology in Healthcare is facing many challenges such as heterogeneity of IoT devices, lack of cost-effective smart and accurate medical sensor, lack of a standard architecture of IoT system, high handling volume data and challenge of interoperability, etc. Though to prepare IoT for healthcare it is necessary to support IoT interoperability, for this IoT system will have to be compatible with all devices, which will require a standard IoT architecture, which could do decision-making task itself. When all these challenges are well explored, then the researcher can do some new work in it by using new methods and technologies, we can increase "the applications of IoT in the HealthCare field." People who reside in remote regions and doctors are far away from their reach in that case remote monitoring facilities can be benefitted for those. So the selection of a communication standard for HealthCare purpose, especially remote monitoring, will be our first important factor in our further research. It is an important factor, and we have shown through Table 2 the comparison between various technologies which we are using currently for Healthcare Monitoring. Different authors have used different communication techniques according to the application and area of the problem, such as BLE, Bluetooth, and ZigBee

**Table 2** Comparison of short- & long-range communication protocols

| | SigFox | LoRawan | NB-IoT | BLE | ZigBee | MQTT |
|---|---|---|---|---|---|---|
| Aptness for healthcare | Low | Moderate | High | High | Moderate | Moderate |
| Coverage area | 9.5 km | 7.2 km | 15 km | 150 m | 30 m | M2M |
| Transmission rate | 100bps | 0.25–5.5kpbs | 250kbps | 1Mbps | 250kbps | 2Mbps |
| Authentication and Encryption | Private key signature Encryption and scrambling Technique | distinctive key distribution, recognized only by the node and base station using the unique key Data encryption | 3GPP S3 security, which includes user and device identity, entity authentication, confidentiality, and data integrity | Secure pairing before the key exchange, Two keys used to provide authentication and identity protection, AES-128b encryption | AES-128b, Network key shared across network, Optional link key to secure Application layer communications | TLS/SSL |
| Operational Bandwidth | 868 MHz (Eu) 915 MHz (US) | 868 MHz(Eu) 915 MHz(US) 433 MHz(Asia) | LTE bands, in the guard bands of LTE (guard-band mode), or re-farmed GSM bands | 2.4 GHz | 2.4 GHz | 2.4 GHz |

**Table 3** Various ML algorithms and their application area

| ML algorithms | Applications |
|---|---|
| Naive–Bayes | Categorize news, e-mail spam recognition, face detection, emotion study, medical diagnosis, number identification, and weather forecast. On the whole, it is useful for big data set and efficient on a big range of difficult issues |
| Decision tree | It helps us in finding inconsistent collection, assessing the comparative importance of variables, handling of values, forecast and data management |
| Linear regression | It tells us about the association between the input explanatory variable and the output dependent variable |
| Logistic Regression | There are many real-world applications such as measuring the success rates of the promotion campaign, credit scoring, predicting the revenues of a certain product |
| K-NN | Used in search where we are looking for similar data set |
| Learning VECTOR Quantization | It is used in data reduction or reduced data set |
| SVM | It is used for text and hypertext classification, classification of images, bioinformatics, etc |
| Apriori | Healthcare |
| Boosting with AdaBoost | It is useful where we are having ample data to make a prediction and we look for extremely high predictive results. It is used for reducing bias and variance in supervised learning |
| Random forest | Banking & Finance, Medicine, Stock Market, E-commerce |

for small coverage areas, and some authors have described sigfox/LoRa/NB-IoT techniques are good for low power wide area networks as demonstrated in Table 1. There is very little focus on Machine Learning for early-stage disease prediction, which is a very important area, without which we could not be able to predict the disease at the early stage. So this will be our second important factor in our further research like which ML technique can predict the disease more accurately. Machine learning techniques as demonstrated in Table 3 and IoT together can do a miracle in today's modern technology and especially in the HealthCare area; if both of them are used with good understanding, then it can create a new benchmark in the HealthCare field, which can be a boon for the HealthCare of elder people.

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