Smart Home Technologies Toward SMART (Specific, Measurable, Achievable, Realistic, and Timely) Outlook

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Abstract Smart home and its associated concepts are familiar among home users and industries for a long known time. However, the lack of awareness and Specific, Measurable, Achievable, Realistic, and Timely (SMART) knowledge, the future for technology adoption in homes is still far away. The current research article provides a view on the state-of-the-art technologies of smart homes, how it impacts the daily life activities and SMART tool which is used to design, develop, construct, and achieve smart home goals. This research article enlists all the studies conducted in smart homes with different viewpoints followed by explaining the SMART tool that is used to set initial goal and plan to attain final goal. The authors compared and contrasted the role played by IoT in smart homes and how wireless protocols are deployed in smart home applications. The paper provides a summary on the significant applications on the basis of comfort, convenience, safety, and security.

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The paper also explains the sustainable nature of smart homes as zero net energy home and in connection with Leadership in Energy and Environmental Design (LEED). The review attained its SMART goal that is aimed at decoding the wireless protocol in order to suit the smart home applications.

Keywords Smart home · SMART · Wireless protocol · Leadership in Energy and Environmental Design (LEED) · Zero energy home

1 Introduction

Smart homes are interactive enough which bring both users and the home appliances together so that the latter can operate by it adapting to requirements and provide multifaceted functions to form Home Energy Management System (HEMS) [1].

HEMS applications, which are programmed Demand Side Management (DSM), enable the consumers to actively contribute in the improvisation of quality of power systems [2]. The energy consumption is regulated in smart homes, and the generation data is transferred to a gateway from smart meters which in turn performs energy optimization [3]. In the background that a smart home is equipped with renewable energy source, when a consumer utilizes an electric vehicle, then its battery can be charged with the surplus energy produced. This review work is developed with a flow on how to achieve the SMART goal with smart home appliances as the energy-efficient devices (Table 1).

In the second section, the paper details about the major smart home appliances as well as its functions. It also describes about the comfort, security, and how home users feel comfortable with these appliances. In the third section, the wireless protocols deployed in smart home applications are compared and contrasted so as to achieve the final SMART goal. This Sect. 3.2 discusses the role of IoT for sustainable environment and how smart home acts as a zero energy home. Section 3.3 discusses role of the Leadership in Energy and Environmental Design (LEED) in the smart home. Finally Sect. 4 concludes the section.

2 Smart Home Applications

The functioning of different home appliances with ICT at home eases the user's day-to-day functions and brings convenience to their life [10]. There is a distinctive feature associated with the functioning module of every smart home device with communication protocol usage as shown in Fig. 1.

The section deals with the smart home appliances other than heating and cooling system at home. The few appliances such as smart door bell, smart gardening rovers, smart fire system, smart plug, smart kitchen, and smart bathrooms are discussed and compared with references related to it in Table 2.

Table 1 Smart home in the view of SMART (specific, measurable, achievable, realistic, and timely)

SMART	How it is achieved?
Initial goal	The smart home's primary purpose, according to the participants, is making life at home more convenient (83% agree or strongly agree), providing security (71%), and enhancing entertainment and communication (60%) [4]. The first goal is to review the way how smart homes are able to protect, manage energy requirements, entertain, and provide comfort and convenience
Specific	The concept behind smart home is to accomplish energy efficiency, security, convenience, and comfort at homes. In order to accomplish this objective, a significant role is played by consumers upon the centralized automation that works by itself or pre-designed to increase savings and control energy consumption [5]
Measurable	One can measure the benefits attained by smart home users due to quick technological advancements, tremendous increase in digitization, and larger-than-life data streams. It also accomplishes the goals of smart home and also cut costs [6]
Achievable	One can easily set up the smart home concept by automating the control of all the electrical appliances in home or update the existing system with few smart devices. It is possible to control the home equipment using smart devices if those appliances are connected with suitable networks. According to the studies conducted earlier [4, 7], the Smart Home Technologies (SHTs) are easily adopted by markets since these technologies rely on the networked devices, appliances, monitors, and interfaces so as to achieve automation
Relevant	Wireless communication techniques and smartphone app are used to control and monitor home functions by embedding intelligence into sensors, interconnecting with smart devices and facilitating for easy access in different locations, increasing computation power, storage space, and improving data exchange efficiency by the integration of IoT services and cloud computing [7, 8]
Time-bound	A novel communication protocol is rendered by real-time scheduling strategy that keeps the home environment under control using switching functionality. The smart home is controlled by real-time scheduling approaches, for instance, Shortest Deadline First and Real-Time Task Scheduling [9]
Smart goal	The primary aim is to survey the way on how smart homes manage energy requirements, safeguard the home, entertain, and create comfort and convenience to home members. A detailed review was conducted upon smart home wireless communication systems and a wide range of home appliances. According to this review, the novel goal statement is that the smart home technologies can be utilized for smart monitoring at the time of critical situation

2.1 Smart Door Bell

The smart home users must be aware of the person who is entering their homes. Smart doorbell is loaded with image processing software since it is employed with camera to recognize and alert owner via voice or video response to their mobile phones. The homes are safeguarded with video cameras, microphones, and motion sensors to identify the person entering the home and also the animals that enter the user's farms. Various biometric techniques are available among which face recognition technique is unique and beneficial in case of smart doorbell at home. This technology is also

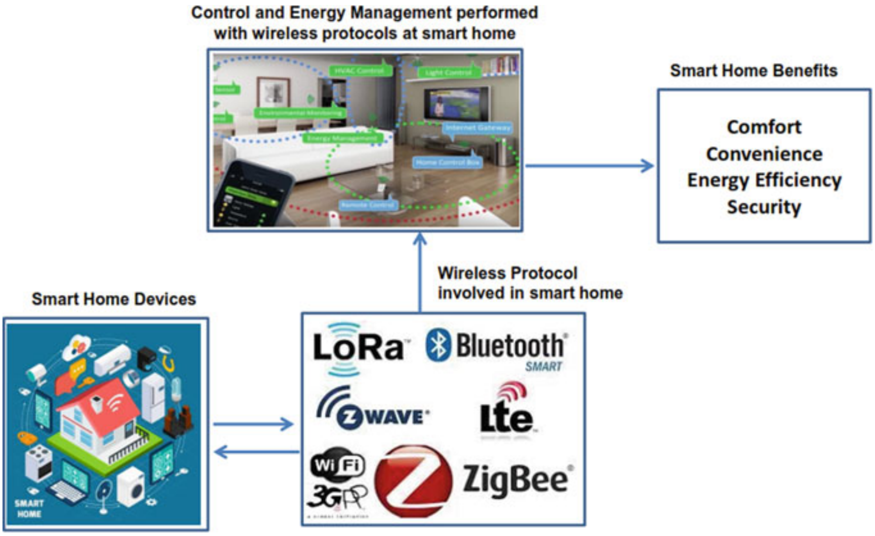

Fig. 1 Smart home toward achievement of comfort, convenience, security, and energy efficiency with communication protocols involved

used in other areas such as industries, businesses, and ports of entry, i.e., airports to identify the accused [11, 12].

2.2 Smart Gardening Rovers

Home gardeners forget to water their gardens, and at most of the times, they may not be aware of the nutrient requirements of the plants for its proper growth and production. The smart gardening rovers are fixed with sensors to determine the environmental conditions and fit with camera and arms that spray nutrients, fertilizers, etc., and measure various parameters of the environment such as heat intensity, wind speed, humidity, temperature, and soil moisture for gardening purposes [13]. The collected information is then shared via Internet to cloud database to ensure the proper amount of fertilizers and water delivered by rovers to plants for growth enhancement [14].

2.3 Smart Fire System

Smart fire alert system, a network of sensors, monitors and detects whenever there is an occurrence of gas leakage. Such identified leakages are updated to intelligent central processing systems. The occurrence of fire accidents is reduced by warning

Table 2 Table describes the performance, devices to be controlled, benefits, and zone of operation

Appliance	Performance	Device to be control	Benefits to home users	Zone of operation
Smart video doorbell [11, 12]	Control customized motion sensors that best fit your outdoor home activity	High-definition (HD) video camera	To recognize the person at door irrespective of the time and respond the visitors whether the intended person is available or not in home	Security and safety
Smart lawn mower [13, 14]	Control the lawnmower without stepping outdoors based on your grass growth	1. Control the motor for movement and blades 2. Timers to monitor the growth built-in LED to operate in the dark	1. Clippings of grass and easy disposal of waste 2. No weather constraints and maintain the proper grass optimum length 3. Easy control with less noise	Convenience
Smart fire system [15–18]	Detect the leakage of gas and operate the alarm	Control the alarm and fire safety devices	Whenever there is a fire outbreak in kitchen, the flame sensors warns the users through alarms	Security and safety
Smart plug [19, 20]	Automatically schedule the smart plug to turn ON and OFF using voice command	Control the power outlet of the plug to which devices connected	1. Reduction in the electricity bill amount through controlling the power of the output from remote areas 2. Mitigate the risks of electric fire accidents	Energy efficiency and comfort
Smart kitchen appliances [21, 22]	Control smart cooking equipment and check the ingredients to prepare the shopping list	Smart coffee makers, smart oven, cookers, smart refrigerators, etc.	1. Users can spend their time lavishly with family members with tasty and quality food 3. The screen notifies products to be purchased if it is out of stock	Convenience and safety

(continued)

Table 2 (continued)

Appliance	Performance	Device to be control	Benefits to home users	Zone of operation
Smart lock[23, 24]	Automatically unlock your door and connect to other smart devices	Virtual or physical key controlled with electromechanical system	Provides complete access control to specific area control based on the access to the property	Comfort and security
Smart bathrooms [25–27]	Improving health and hygiene by monitoring the blood pressure level and infections	Control shower heads, duration, music, and lightning to save water and energy	Futuristic flushing and reduced risk of overflowing Instant cleaning and health tracking	Convenience
Smart health care [28, 29, 29]	The hospitals that are connected with smart health care can increase the efficiency of the hospital by created priority lists on the basis of urgency and freed-up beds	Real-time location monitoring for medical supplies/healthcare equipment	Reduced healthcare costs and improved health outcomes, avoiding preventable harm Improved healthcare policies due to the round-the-clock patient data	Convenience and comfort

the people through alarm systems. Whenever there is a fire outbreak in kitchen, the flame sensors warn the users through alarms while the systems take appropriate actions instantly [15, 16]. The smart fire alarm system not only protects the building when there is a fire, but also communicates to other buildings' automation and security systems. This further ensures the residents of respective buildings to evacuate, preventing human loss and containing the spread of fire [17, 18].

2.4 Smart Plug

The smart plug enables the users to understand the power data for different loads through their smart gadgets so that they can manage their energy consumption patterns automatically. When smart plug is connected with the appliances which are continuously operated at home, the users can track the power consumption data of these appliances in their remote places using smart phones [19]. Communication occurs between smart plug and the home appliances leveraging wireless protocols like Wi-Fi and Zigbee can control and monitor the power [20].

2.5 Smart Kitchen

Smart kitchen, incorporated with sensing, control, and transmission modules, is able to identify the status of the equipment inside the kitchen and alert the user about the food's quality via email/SMS. Equipment, like smart refrigerators, is alerted for the expiration of their food products [21]. Smart kitchens are loaded with efficient exhaust system with sensors which automatically monitor the humidity, air temperature, quality, identify the fumes/strong smells in the kitchen, and enhance indoor air quality. With a coupled effect of automated kitchen and smart appliances equipped with smart devices, the result will be lower environmental impact and reduction in the energy loss [22].

2.6 Smart Locks

Smart lock systems find its application in various places in today's houses, cars, logistic solutions, storage, boxes for postal applications, lockers, etc. The smart lock system has tremendously increased its expertise after the induction of IoT. The door can be opened and closed using simple password or otherwise smart devices can also be used to control the doors. Bluetooth and Wi-Fi are enabled in this smart lock system to verify the physical condition of human beings and enhance the security and comfort of the users [23]. When an owner has too many keys to be managed such as car, apartment, gate or official systems or in case of large apartment complexes, fraternities, it becomes challenging to maintain the entry of authorized personals each and every time [24].

2.7 Smart Bathrooms

The IoT system advancements made today's bathrooms safe and secure place since it is installed with suitable sensors and connected with wireless local networks [25]. Water consumption, falling or slipping detection from impact, pressure distribution on a toilet cover, diagnostics of medical conditions from feces and urine samples, flushing sequence in a toilet, water temperature, and event sequence in showers must be monitored and kept under control [26]. The bathrooms are fixed with various sensors such as pressure sensors, positional sensors, and healthcare sensors to make it smarter. These smart bathrooms are intended to perform the timely events [27].

2.8 Smart Health Care

Healthcare monitoring system used has the capability to prioritize the needs of the patients based on the information collected regarding health parameters from senor nodes [28]. In this monitoring system, the smart devices collect a prism of information such as voice and electroglottographic EGG signals to be used in healthcare data analytics or signals. These signals are then transmitted as well as processed with appropriate wireless protocol so as to render quality care [29]. Smart healthcare monitoring systems help the patient especially elderly people, monitor their medical conditions through safe and proper diagnosis, and offer reliable care. This location detection system can be heavily relied during pandemics like COVID-19 since numerous patients are quarantined in different areas. In order to implement the real-time locating system, the BLE beacons are used as mobile Internet may fail to perform during indoor positioning [29].

3 Communication Protocols in Smart Home Applications

With the evolution of IoT, the focus has turned upon intelligent presence and communication that occurs between physical objects/things with human, i.e., $M2H$ or between machine and machine, i.e., $M2M$. The IoT devices are preferred for its diverse applications in various domains such as home/office automation, agriculture, health care, energy management, and industrial processes. This further increases the efficiency which in turn enhances the quality of life [30]. The next generation smart phones are interconnected with Internet of things which revolutionized the industry while to make the user feel comfortable, a more number of applications are being developed every day. Few prominent examples include Amazon's Alexa, Apple's Siri, and Google's Assistant. These applications ensure the user feels great comfort and ease, i.e., smart living. Nowadays, IoT, big data, and artificial intelligence act as the basis behind smart cities development and smart living concept [31]. Table 3 describes the smart home systems available in the market and the wireless protocol with which it is working. In Table 3, 6LowPAN / Thread, Zigbee, Z-Wave, Wi-Fi and Wi-Fi Direct, LTE-M, NB-IOT, LoRaWAN, and Sigfox communication protocol suitable for smart home systems are summarized with their working parameters, features, and applications of wireless protocols [32–61]. Table 3 provides clear insight on which wireless communication protocol can be selected on application of smart home.

6LoWPAN consumes low power and low bandwidth and supports star and mesh topologies [32] and connects to the cloud and enables industrial IoT. It supports asset tracking in industrial, agriculture, and automated factories with data monitoring, predictive maintenance, and analysis [33, 34]. Zigbee supports IEEE802.15.4 specification and is license-free and operates in the real home environment. Zigbee packets tend to experience improved latency under Wi-Fi interference; however,

Table 3 Summarize the working parameters, features, and applications of wireless protocols

Protocol	Frequency	Security	Range	Features	Application
6LowPAN/thread [32–34]	2.4 GHz	AES-128	100 m	Low power, low data	Smart home, automation, industrial monitoring, and smart grid
Zigbee [35–37]	915 MHz/2.4 GHz	AES-128	100 m	Primarily for home automation	Industrial automation, research, home automation, telecommunications, health care
Z-Wave [35, 38–41]	868/908 MHz	AES-128	150 m	Larger range than Zigbee, but slower. less crowded RF band	Home automation, wireless security sensors, and emergency alarms
Wi-Fi and Wi-Fi direct [41–44]	2.4 GHz/5 GHz	WEP, WPA, WPA-2 (AES)	100 m +	Wi-Fi direct is peer-to-peer similar to Bluetooth classic	Control smart home appliances
LTE-M[45–48]	1.4 MHz	3GPP (128–256 bit)	20 km +	Lower latency than NB-IoT. Double the module cost of NB-IoT. Latency = 50 to 100 ms	Machine-to-machine communication
NB-IOT [49–54]	180 kHz	3GPP (128–256 bit)	10 km +	narrowband cellular technology. Also called LTE-NB. Latency = 1.5 to 10 s	Public applications include event detectors, smart garbage bins, smart metering, etc. Industrial applications include asset tracking, smart agriculture, logistics tracking, etc.

(continued)

Table 3 (continued)

Protocol	Frequency	Security	Range	Features	Application
LoRaWAN [55–58]	868 MHz / 915 MHz	AES-128	5–20 km	Long-range/low-speed/low-power/longer battery life	Soil moisture sensor, water trough alarming, tracking, and monitoring of wildlife in a predefined area
Sigfox [59–61]	868 MHz/915 MHz	Not supports	10–40 km	Long-range/low-speed/low-power/longer battery life	Industry applications, industrial IoT (IIoT), smart cities, smart home, and asset tracking

delivery is not influenced [35–37]. Z-Wave is a complete IoT substrate implementation which contains communication model that is well defined, and networking and application layer protocols integrate actuators and sensors over RF to perform office and smart home automation services [38–41]. Wi-Fi connections are secured by the WPA-2 encryption mechanisms, and a constraint of Wi-Fi is its connectivity restrictions which is restricted to 50 m for homes and 100 m for other purposes. Wi-Fi direct is prone to several attacks such as impersonation, modification of messages, eaves dropping, service attach, and so on, and hence, cryptographic mechanisms are required to protect Wi-Fi direct-enabled communications [41–44]. LTE-M has strong connection with 3GPP 2G and 3G networks and less migration with respect to the 5G solution that is quite powerful. The same is similar to the NarrowBand-IoT (NB-IoT); however, there are advantages which are associated with the cost and complexity of the end devices. For applications with IoT that require low latency, high data rates, voice in typical coverage situations, and full mobility, LTE-M is deemed the best as it covers several IoT applications. The protocol functionalities in the LTE are reduced by NB-IoT to the minimum value after which it improves on the basis of requirement from IoT applications with small and infrequent data messages. It lessens the consumption of battery, thus making it economically feasible [45–48].

NB-IoT is used for monitoring the power consumption with management, healthcare assistance, and implementation of cost-effective automatic devices for smart homes. LoRaWAN is a perfect choice for industrial applications, especially factory-side automation as it ensures reliable communication, compared to Sigfox, at the time of moving at high speeds [49–54]. The farmers are equipped to do real-time monitoring of the state of crops consuming lower power with the help of Internet of things based on LoRaWAN technologies. This technology provides all the necessary information to the farmers so as to accomplish an efficient irrigation management of his farmlands [55–58]. Smart home applications, i.e., both commercial and health care, mandatorily need cheap sensors and long battery lifetime in order to track the asset and monitor the status. Sigfox ensures better suitability in these applications, because of the absence of constant communications [59–61]. The low data rate support pulls back the Sigfox from being implemented in high data rate applications used for status monitoring and asset tracking.

3.1 Role of IoT with Smart Home for Sustainable Environment

A smart city plays a major role in achievement of sustainable environment. Sensors, cloud computing, IoT sensor, and wireless technology are all required in smart cities with smart infrastructure. Among the different smart home equipment discussed, smart plugs consume the most energy in a smart home network due to an uninterrupted supply and home automation energy management that displays the balance of energy consumption among devices at regular intervals [62]. In order to accomplish efficient data management and energy conservation, this system involves lot of data and the handling of data can be decreased by merging cloud services with an efficient web framework [63, 64].

In the present pandemic situation, home-based healthcare system is gaining its importance for treatment. The IoT-based machine vision system provides the monitoring information from patients to transmit their condition to the healthcare network and solution to their health issues by mobile communication to assist them at the appropriate time [65]. Other than health care, providing emergency health care to accident cases is getting delayed due to lack of communication and selecting suitable location of hospitals based on the severity. The smart sensors and selecting suitable wireless protocols from Table 3 based on the range and application will offer the quick health solutions through the cloud via the IoT module using the GPS module. As a result, once the data is received and accepted, the crisis response team can quickly track the location using the GPS module. On Google Maps, the area is also visible. If this data reaches the control group in a timely manner, an important decision can be taken [66].

3.2 Smart Home with Communication Protocols as Zero Energy Home

Smart homes are incorporated with the communication protocols that offer sustainable lighting, real-time energy analytics, and programmable thermostat. The smart home users are able to track down their energy usage and decide accordingly so that the homes are sustainable and cost effective. Smart homes which are incorporated with renewable energy systems remain the best cost-effective option for the users with the smart meters [67, 68]. Further, the desire to build a net zero energy home at affordable costs also gets achieved with energy storage systems (ESS). It is slowly turning the smart homes into energy-independence mode with the incorporation of renewable energy generation systems. After taking into account the load usage patterns of a specific home with interfacing the communication protocols, the renewable energy generated in smart homes provides constant supply of electricity. In this scenario, the load takes up a specific amount of power under all the conditions which translates to low variability, low complexity, and uncertainty. The smart home technology with efficient communication protocol implements energy management in an efficient manner, which has all the potentials to promote sustainable living concept. The energy usage that occurs in residential and commercial sector must be focused in order to mitigate the GHG emission, create sustainable future, conserve energy, and finally maintain good quality of life [68].

3.3 LEED as Tool for Transforming Smart Homes Toward Sustainability

Going green is a phenomenon in which the energy-efficient methods are followed aiming at energy, cost, and environmental saving. With the mere installation of smart toilets and renewable energy sources, the homes cannot become smart homes. Those homes incorporated with energy-efficient techniques only are considered as green homes. LEED empowers the commercial and home users to find out and incorporate the measurable green building design, operations, construction, and maintenance solutions. The efficacy of the LEED buildings, with regard to occupant satisfaction, seems to be high in open spaces and small buildings rather than enclosed and large space buildings [69]. LEED ensures the occupants are satisfied with building and the workspace without any compromise on the rating level given. In the rating system followed by LEED, there is a voluntary program that exists with the objective to determine the level of sustainability in a building in different facets such as material selection, water efficiency, indoor environmental quality, location and site, and energy efficiency [70]. There is a total of nine evaluation categories listed in LEED for homes with a total score of 110 points. Those categories are integrative process, location and transportation, sustainable sites, water efficiency, energy and atmosphere, material and resources, indoor environmental quality, innovation, and regional priority [71].

In this way, LEED certification enables the smart homes to become zero net energy smart homes, thus leading a sustainable development. Across the globe, the governments must extend their support to comply with current standards. Further, they also must put efforts to fasten the future building energy code requirements and energy policies. The governments should bring certain building code regulations together so that better energy behavior can be promoted while the users and the building owners feel motivated to conserve the energy [72].

4 Conclusion

The current paper achieved its SMART goal by reviewing the accomplishments of wireless protocol to achieve sustainable environment and how these smart homes can be converted into zero energy buildings in the near future. The paper further introduced LEED and how it boosts the smart homes toward the development of sustainable environment. The different communication protocols have been compared with insights on the range, features, and the applications of smart home concept explained clearly in Table 2. From the survey, the smart home equipments and wireless protocols specific goal of achieving sustainable informatics is lacking. This would be enhanced with this SMART to plan and accomplish smart home sustainability. The first specific is achieved in this work by describing the smart home benefits and its significance in the viewpoint of comfort and convenience, security, and energy management. The paper is further reviewed to achieve the measurable with various smart home applications such as smart health care, smart lock, smart kitchen, smart bathrooms, smart lawn device, and smart doorbell to show how it reduces the energy cost. Table 1 lists the operations and functions of these smart devices in terms of its functioning. Achievable and relevant goal is obtained by the using the different wireless protocols as a suitable communication technology to achieve the automation.

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Health Monitoring of Critical Care Patients Using Internet of Things

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Abstract The Internet of Things is required for patient health monitoring. As many as 60% of human lives can be saved by detecting diseases at their earliest stages. The primary purpose of the device was to track vital signs in patients with a wide range of health conditions in real time. It is more appropriate to recognise the patient's status or health through the usage of GSM and IoT. Body temperature, coronary heart rate, eye movement, and oxygen saturation % can all be measured using sensors such as temperature, pulse metre, and blink sensors. The ESP32 microcontroller and the cloud computing idea are used in this system. The motion detection sensor is used to depict the coma patients' bodily movement. The patient's important factors are communicated to the legal individual's smart phones and laptops via a cloud server and GSM module. These recordings can be retained and evaluated for future comparisons and decisions.

Keywords Sensors · ESP32 · ThingSpeak · Health care · IoT monitoring system · Wearable devices

1 Introduction

Improved health is inextricably linked to a better quality of life. Many factors have contributed to the growing concern about the Global Health Issue, including: inadequate healthcare services, wide disparities between rural and urban areas, and a lack of doctors and caregivers at critical junctures. WHO defines health as "a condition of complete physical, mental, and social well-being, rather than the absence of diseases". Technology and medical research are merging at breakneck speed. As a result, medical professionals are utilising these technologies [1] to achieve that state. The Internet of Things (IoT) has arrived. Connecting things via sensors and a suitable platform is known as the Internet of Things. These microchips can be embedded in medical equipment. The data acquired by these microchips is then communicated via

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M2M. This is a more intelligent, flexible, and interoperable technique for monitoring any health concern that enhances therapy and responsiveness. This also aids in the tracking of data for each patient.

2 Literature Survey

In the field of medicine, IoT has been used to track patient health in several major ways. The works listed below are all relevant to this field.

According to the search scope, the microcontroller and gateway are used to upload data in IoT-based remote healthcare systems. There are two methods for storing data. One method is to store data in a Web-based database like MySQL or Google Firebase Database [2, 3].

In addition, a smart healthcare system dependent on the Internet of Things will be discussed, which will monitor the physical and environmental well-being of patients. This scheme's error proportion is within a particular range using sensors and the Internet [4].

Himadri et al. developed an alert system to notify loved ones if there is an issue with their loved one's health [4]. An IOT alert will be dispatched to the doctor if the system detects any variations in the patient's well-being that are not expected.

Heartbeat, SpO2, and eye blink sensors were used to measure a patient's heart rate, percentage of oxygen saturation (PO_2), body temperature, and eye movement, but no specific performance metrics were assigned to a patient. A prototype of Barger et al. smart's house facility, which use a sensor network to track and monitor the patient's movements at home, is now being tested. Their primary goal in their research is to discover if their system can outsmart behavioural patterns, which they have detailed in detail.

Lopes et al. [5] suggested an IoT framework for disabled individuals in order to research and uncover IoT innovations in the healthcare sector which benefits them as well as their community. In order to better understand the latest Internet of Things (IoT) technology and its applications, they examined two case studies.

Tamilselvi et al. [6] designed an Internet of Things health monitoring system that can measure basic symptoms including heart rate, oxygen saturation percentage, and body temperature. To capture the data from all of the sensors utilised in the experiment, an Arduino Uno was employed as a processing device. Despite the fact that it has been implemented, no precise performance measures for any of the patients have been defined.

Acharya et al. [7] proposed a healthcare monitoring kit [7] in the context of the Internet of Things. The system designed to keep tabs on vital signs like heart rate, ECG, body temperature, and respiration rate was able to keep track of these and other basic health indicators. An ECG sensor, a temperature sensor, a blood pressure sensor, and a Raspberry Pi are all present here. Using a Raspberry Pi, sensor data was gathered and processed before being sent back to the IoT network. The lack of data visualisation tools is the biggest problem with the system.

Banerjee et al. [8] proposed a non-invasive technique for detecting pulse rate. Real-time monitoring was achieved by using plethysmography and delivering results digitally. As with other intrusive therapies, the approach is safe for the patient. A smartphone-based heart rate monitoring system was developed by Gregoski et al. [9]. The technology tracked finger blood flow using a mobile light and camera and computed cardiac output based on blood flow. As a result of the system's development, people can now check their heart rate by merely by staring at their phones and receiving it wirelessly via a computer. As a beautiful concept, it is not possible to use this if continuous heart monitoring is necessary.

Mobile phone-based cardiovascular disease sensing was described by Oresko et al. [10] as a system that could be built if enough time and money were available. The prototype was only able to detect cardiovascular disease by monitoring heart rate in real time, rather than over a longer period of time.

An Arduino-based health factor controlling system controlled by a mobile device was proposed by Trivedi et al. [11]. The Arduino Uno board received the data from the analogue sensors. The built-in analogue to digital converter converts the collected analogue values into digital data. The physical characteristics of the gadget were transferred to it via Bluetooth. In order to use Bluetooth, the device had to rely on a small module.

Jennifers Raj et al. [12] established a model for developing a revolutionary information processing system in an IoT platform via a dependable healthcare monitoring system.

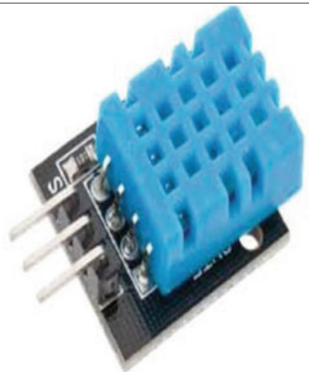
Proposed System: The major goal of this project is to develop a smart patient health monitoring system with a GSM module. Can we send an alert to the care taker or concerned doctor automatically, on the developing abnormal conditions of the patient, when the care taker is not near by the patient. Build an efficient system using low-cost sensors and record the sensor reading of the patient periodically in cloud for further analysis.

3 System Design

The IoT system makes use of the hardware components of some form. Table 1 describes the components that were used to create the proposed system.

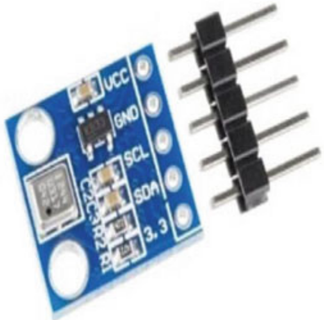
The project's primary goal is to develop and implement a patient health tracking system. The IoT sensor board for critical care of patients is shown in Fig. 1. Temperature, mobility, pulse monitoring, and eye blink are all sensed by the sensors inserted in the patient. These sensors are linked to a control unit that adds up the results from all four sensors. These determined values are then sent via the Internet of Things to the base station (IoT). The values from the base station can then be accessed by the doctor from any place. The patient's condition can be diagnosed and treated based on the patient's temperature, heart rate, and room sensor data. The kit can also be used at homes and can be embedded in the rooms of the patients who need constant monitoring. If the condition of the patient turns out to be abnormal, then the family

Table 1 System components

S. No.	Name	Image	Description
1	*ESP32 Processor*		One of the best-designed microcontrollers on the market today has an array of features that make it ideal for use in a wide range of applications. Sensors and controls can be connected to the ESP32's GPIO pins. Healthcare delivery could be transformed by ESP32 and the Internet of Things (IoT)
2	*Temperature sensor (DHT11)*		The DHT11 temperature and humidity sensor is widely used. Serial processing of temperature and humidity measurements is accomplished using an 8-bit CPU and a non-volatile memory (NVRAM). As a result, other microcontrollers can easily be connected to the sensor

(continued)

Table 1 (continued)

S. No.	Name	Image	Description
3	*Pulse monitoring sensor*		The heartbeat sensor was created using the plethysmography principle. Blood volume changes in any organ cause changes in the light intensity, which can be detected using this technique Pulse timing is critical in systems that monitor heart rate
4	*Motion sensor*		Any security system would be incomplete without motion detectors. When a motion sensor detects movement, it notifies your security system and, in some situations, your phone

(continued)

Table 1 (continued)

S. No.	Name	Image	Description
5	*Eye blink sensor*		In this eye blink sensor, infrared is employed to detect the eye blink. The variance throughout the eye will fluctuate when the eye blinks. There is a difference in output between blinks when the eye is closed and open

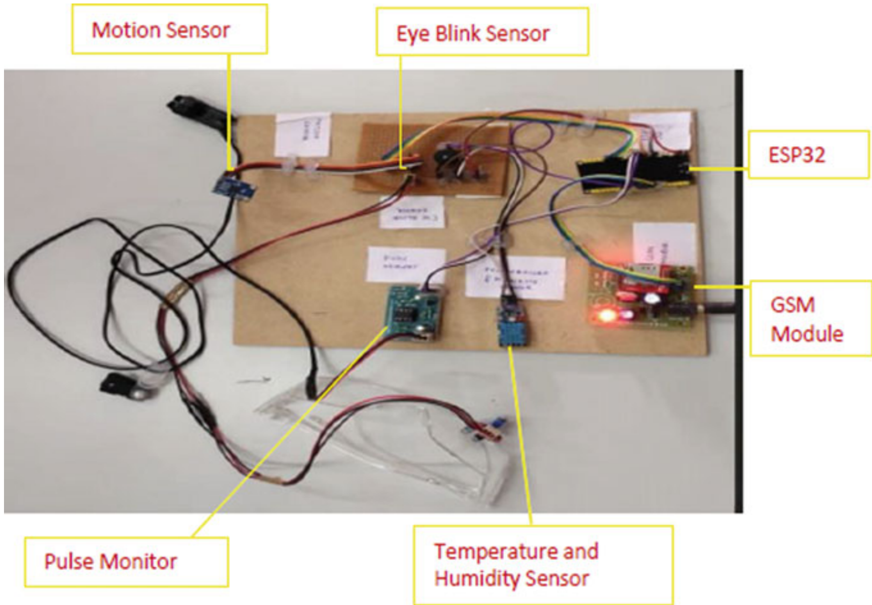


Fig. 1 IoT sensor board for critical care of patients

members of the patient will be informed immediately regarding the patient's health through a mobile message using GSM technology.

For all of the sensors and devices, ESP-32 serves as the main processing unit, which is connected to the sensors and devices via the ESP32. In order to retrieve data, perform analysis, and upload it to the cloud via a Wi-Fi module, the sensors are connected and controlled by an ESP32.

4 Methodology

The proposed system's fundamental premise is to continuously monitor the patient's condition. As a result, the healthcare monitoring system's three-stage architectural features are utilised, namely (1) sensor module, (2) sensor readings are relayed to the cloud server, (3) the buzzer sounds an alert to the user.

The sensors are wired and collect data from the patient's body using physiological indicators. The data is processed using an ESP32 module before being transmitted to the cloud server. ThingSpeak is used to provide a visual representation of data in an online user interface. The current status and procedure of transactions are displayed in ThingSpeak. Wi-Fi modules and Web servers can communicate more easily thanks to the HTTP protocol. With a refresh rate of every 15 s, the HTML user interface