Internet of Things (IoT) for Intelligent Healthcare: Smart System to relieve pressure on hospitals during the Pandemic of Corona

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Abstract. Due to the spread of corona virus, healthcare systems are facing significant strain, with an increase in demand for medical supplies and healthcare professionals. Many solutions were proposed in that sense, especially with the emergence of the Internet of Things (IoT) as a powerful communication and information technology. This paper proposed one of the approaches targeting the environmental health as a whole. This is especially to decrease the pressure on health systems during crisis times. It is mainly about the creation of a real-time corona virus monitoring system. It is in the form of a wristband that measures the blood oxygen levels and the body's temperature. These measurements are essential in determining a patient's health status and the need for immediate ICU intervention. Additionally, the wristband has a tracker that can be used to monitor the patient's adherence to social distancing guidelines. Once the patient's parameters are above a certain threshold, the doctors and health professionals are notified instantly. This device is very optimal in terms of energy consumption. It is considered as a promising tool in handling the spread of the virus by providing patients and healthcare providers with instant access to healthcare services, regardless of their location.

Keywords. Smart System, Healthcare, IoT, monitoring

1 Introduction

The Internet of Things has become one of the most rapidly expanding industries in the world, transforming our daily lives through its development and implementation. Its primary application areas include health, smart cities, environment, defense, and energy. It has enabled companies to identify new business opportunities and envision innovative models centered around the data generated by smart objects. The central objective of this technology is to assist people in carrying out their daily tasks.

The Internet of Things comprises a vast network of connected physical objects that can be remotely controlled or monitored. These smart objects are connected to the internet and can communicate with one another. There are various types of devices within the Internet of

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Things that contain sensors, serving at automatically detecting the environmental changes or events and transmitting data via the network protocols [1].
In fact, IoT has improved productivity in three different areas that can be divided into three categories: monitoring devices, medical sensors, and household appliances. They can all interact and communicate with one another seamlessly in a global setting.
Regarding the health sector, research works presented in the following articles [2-4] contain IoT medical systems that were developed for the medical structure's hospitals. Their main objective was to assist the medical system and offer additional services to patients.
Given the numerous advantages of the Internet of Things, there has been considerable interest in exploiting this technology to aid the global environmental health systems during the current health crisis, especially the Corona virus pandemic. Hence, our article provides an overview of IoT-based systems in healthcare and presents one of the most practical solutions for the coronavirus pandemic, which could help alleviate the pressure on overstretched hospitals while containing the virus's spread.

2 Internet of Things

2.1 Definition

The term "Internet of Things" was first used by Kevin Ahstons, co-founder of MIT's Auto-ID Center, in 1999 during a presentation for Procter & Gamble (P&G). It refers to the interconnectedness of objects, devices, and sensors via the Internet. The CERP-IdO, defines IoT as a global network infrastructure with self-configuration capabilities, interoperable communication standards, and physical and virtual objects integrated seamlessly with intelligent interfaces and identities. This definition highlights the temporal and spatial aspects of IoT, allowing people to connect to the network from anywhere, anytime, through a range of connected objects such as smartphones, tablets, sensors, and video surveillance cameras. To avoid potential threats and risks, the Internet of Things needs to be designed for easy use and secure handling, while masking the underlying technological complexity.
The following (Figure 1) shows that the ability to connect to the Internet is valid for any object that surrounds us.

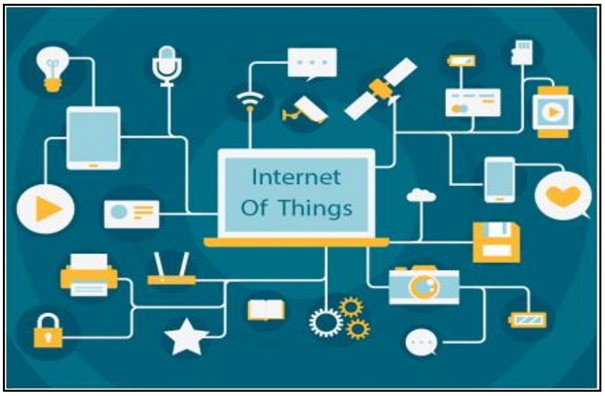

Fig. 1. Internet of Things (IoT)

2.2 The Architecture of the Internet of Things

The Internet of Things (IoT) is a network that connects all objects, and the data collected by these objects provide valuable insights for people who control them. It is also known as the

Industrial Internet, and it is a revolutionary concept in technology and communication that allows data transfer between human, animals, and objects through a network connection.

The Internet of Things consists of four key elements: 1) people-to-people, 2) machine-to-people, 3) people-to-machine or things, and 4) machine-to-machine interactions through the internet. The primary objective of IoT is to enable seamless connections between things, people, and places using a combination of hardware, software, and communication technologies to store, transfer and process data.

The Internet follows a standard architecture with three fundamental layers: Application layer, Perception layer and Network layer, as depicted in Figure 2. This architecture helps to organize and standardize the internet to ensure it remains stable, efficient, and secure.

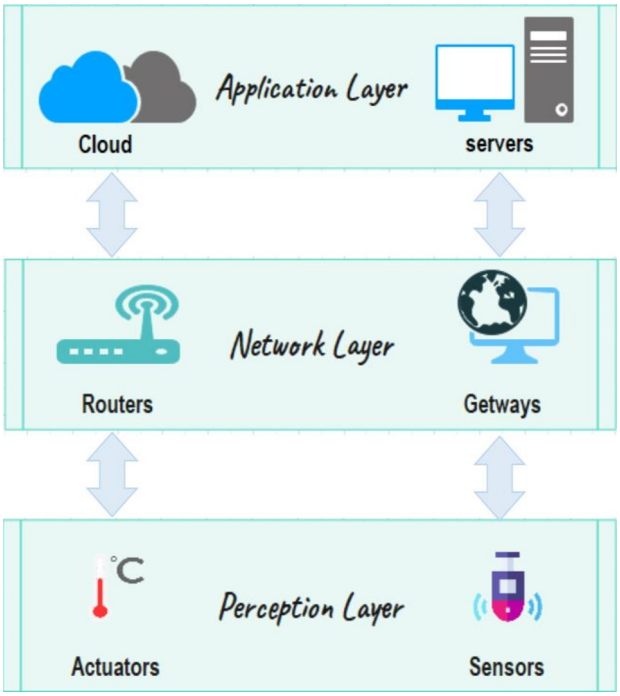

Fig.2. Architecture of IoT

The lowest layer of an IoT architecture, the perception layer (sometimes called the "device layer", "sensing layer," or "detection layer") is responsible for taking information from the physical world and presenting it digitally. This includes sensing (collecting data from the environment), identification (identifying objects), activation (realizing sensed data), and communication (establishing connections between disparate intelligent devices). Technology is included and human intervention is minimal.

The network layer (also known as the "transport layer") is responsible for sending data collected from sensor nodes over a network or network connection to an information processing device (or higher-level decision-making device). This layer enables the integration of various disparate networks, technologies and protocols.

At the top of the IoT architecture is the Application Layer, which is the layer that end-users interact with. Its purpose is to manage and deliver applications based on the information collected by the Awareness Layer. The Application Layer enables users to access customized services on the network, tailored to their specific needs, using a range of mobile devices and terminals.

3 Related works

The improvement of people's health and well-being is the ultimate objective of many nations where several studies and research works are conducted to achieve this golden goal.
Healthcare systems are primarily concerned with treating patients' conditions once a diagnosis is made. Hence, the trend of improving storage capacity, introducing more sophisticated algorithms, smart objects, and a willingness to integrate IoT-based solutions into healthcare, have increased. Thus, these solutions have shown significant impact on the health system. For instance, concerning home healthcare, the solutions in [5, 6] show IoT medical systems that were developed for home health monitoring. Finally, medical offices use intelligent systems to assist doctors in their daily tasks [7].
Numerous studies have demonstrated the importance of remote healthcare using IoT-based systems and the advantages it may offer in various situations. By monitoring and checking on non-critical patients' health, for instance, at home rather than in hospital, remote health monitoring can help the overburdened hospital ease the burden on its limited beds and medical supplies. This can be used to improve access to healthcare for people who live in remote areas and allow older people to take use of cutting-edge medical treatments wherever they are, whenever they choose.
Numerous Internet of Things (IoT) healthcare systems have been created using various technologies, including wireless sensor networks (WSN), wearable technology, smart mobile technologies, and radio frequency identification (RFID). The backbone of IoT-connected systems is RFID (Radio Frequency Identification), these microchips take the role of the printed labels and enable accurate object location. These identifying labels are among the most popular technologies used to create IoT health care-based systems because of the relationship between the cloud and connected items [8].
Wireless Sensor Networks (WSNs) are networks of autonomous, spatially dispersed devices that work together to jointly monitor various physical or environmental parameters, including sound, pressure, vibration, motion, temperature, and location. Normal WSN sensor nodes typically have a transceiver, microcontroller, memory, power source, and one or more sensors to detect physical events. The communication, power, sensing and processing units are the four main components that make up the sensor node's construction [9].
Mobile health (m-health) is the practice of collecting real-time patient health data using mobile devices and storing it on network servers that are connected to the internet. Using wearable body sensors and medical devices, the m-health data assist clinicians in diagnosing, monitoring, treating, and predicting health anomalies in their patients [10].
The main uses of wearable technology in healthcare are observation and tracking. One of its main components is sensors, which are mainly used in the data collection. In recent years, as semiconductor technology has advanced, sensors have brought a broad spectrum of parameter investigations closer to reality [11]. Each of these technologies has the capacity to gather information about patients, physicians, nurses, etc.

4 Design and Development

4.1 The proposed system

The Corona pandemic has resulted in several problems, including hospitals filled with patients because they do not have enough beds, as well as a lack of human resources working in them. To solve this crisis and provide a solution to the environmental health, we designed the following system, as shown in the figure below.

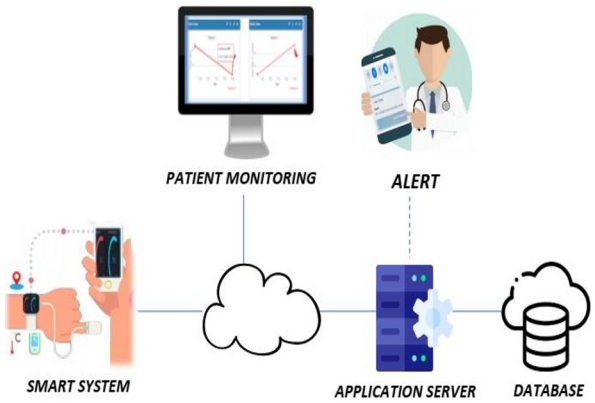

Fig.3.System architecture

The system consists of several important components, including a body temperature sensor that measures the patient's temperature, an oximetry sensor that measures the level of oxygen in the patient's blood, and a smart GPS that can locate patients and notify them if they are under quarantine within an approved facility. The electronic device is worn on the patient's wrist and uses wireless technology to send signals and data to a server via a cell phone.
The server stores the data in a database and provides real-time updates on the patient's status to the doctor's platform, allowing for easy monitoring and management of the patient's condition. If your blood oxygen level is low or your temperature is high, the medical staff will be alerted so they can react immediately.

4.2 The used tools

Our framework is mainly about a smart bracelet that can be developed using the following components:
- Arduino Nodemcu Esp8266: This is an open-source electronics platform that enables users to build interactive objects. The Arduino UNO inside the smart bracelet collects data from the body temperature and pulse oximetry sensors, and wirelessly transmits the data output to a server. In case the temperature recorded by the Arduino from the sensor is above 37°C and the blood oxygen level is below 90%, the Arduino sends an alert to the server.
-Pulse oximetry sensor: This sensor is small and clip-like, and it uses a beam of light to measure and monitor blood oxygen levels. It can detect respiratory dysfunction and help with diagnosing and monitoring Covid-19.
- Body temperature sensor: This sensor is a useful diagnostic tool that can detect if a patient's body temperature is abnormal. Thermistor sensors are often used in IoT applications to measure body temperature.

4.3 The implementation details

Concerning the implementation of the proposed solution, the very first step is to connect the body temperature and pulse oximetry sensors to the NodeMcu board, which is a firmware and development board based on the ESP8266-12E Wi-Fi module. After this, the board can be connected to the Arduino IDE, which contains specific code for collecting and analysing data in real-time. This is shown in Figure 4.

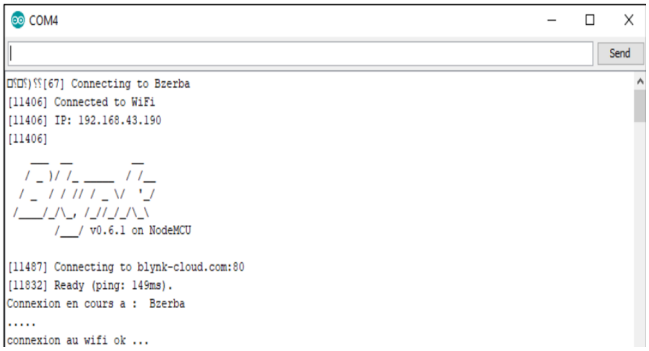

Fig.4. Connection of the NodeMcu to the Wifi

As shown in the following figure, after running this code, the strip was connected to the Wifi network in order to transmit the data, with respecting the programmed 10 seconds.

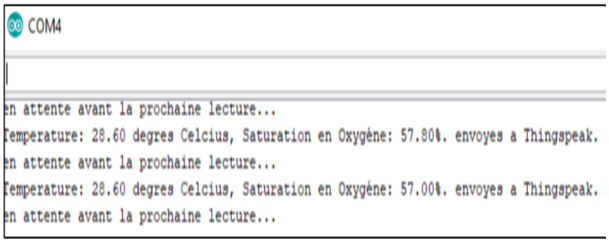

Fig.5. Sending the captured data to the Thingspeak Cloud

The data that is recorded in real-time is saved in the cloud service called ThingSpeak, which is an Internet of Things (IoT) analytics platform [12]. This platform not only consolidates and presents live data streams in a visual manner but also performs analytical operations on it. Additionally, the platform also stores the corresponding date and time of the recorded data. This is shown in Figure 6.

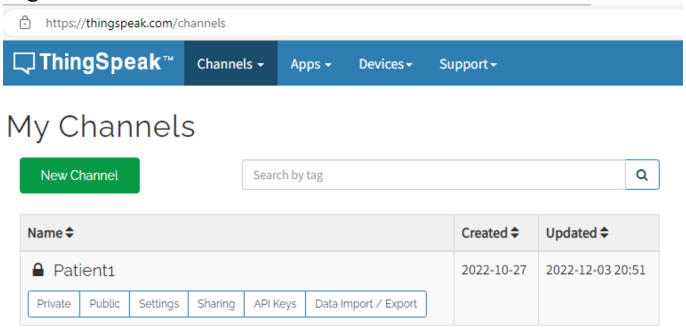

Fig.6. Data storage

There is also the possibility of exporting the recorded information to perform other analytics, graphs, maps... which can help in limiting the spread of the virus or improve the protection methods.

Fig.7. Export data

5 Results and Discussion

After the execution of this system, we obtain the following results:

The medical team will have access to the patients' status through the ThingSpeak platform, which provides a visual representation of the collected data in the form of graphs and charts.

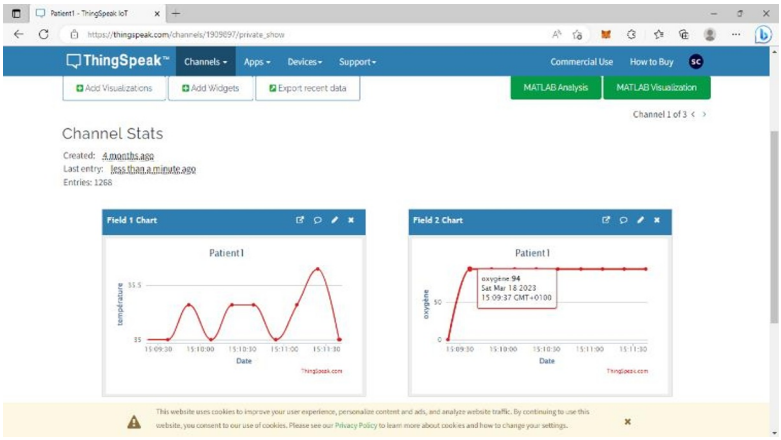

Fig.8. Patient Monitoring

As shown in Figure 9 (a), on the medical manager's smartphone, there exist the temperature status and oxygen saturation by sending the data from the cloud to the Blynk server in real time and find the patient's position [13].

Fig.9 (a). Real-time patient monitoring

For the localization, the purpose of this idea is to follow the movements of the patient and if he/she adheres to the quarantine, as well as to know the places he/she has crossed to identify the contacts, as shown in Figure 9 (b).

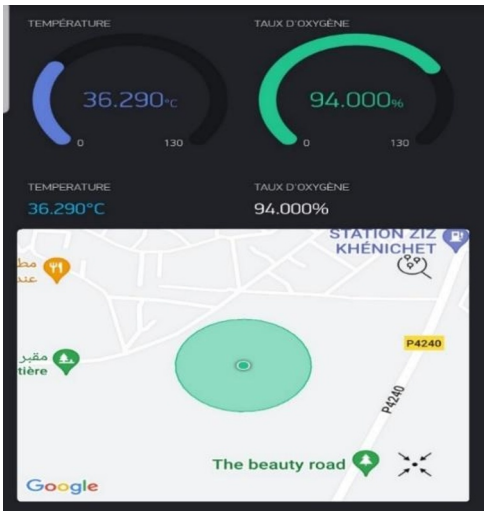

Fig.9 (b). Patient location

As shown in Figure 10, a Dashboard is used to monitor the patient's health status over time based on three main axes, the first for temperature, the second for oxygen saturation and the last for the date.

Fig.10. Monitoring the patient's condition over time

In case of deterioration in the patient's condition, the healthcare providers will receive a notification on their smartphones prompting them to transfer the patient to the intensive care unit. Two criteria have been set for this purpose: if the patient's body temperature is above 37 degrees Celsius or if the oxygen saturation level falls below 90%.

Fig.11 (a). Alert 1

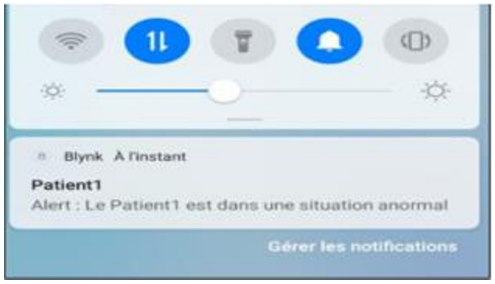

Fig.11 (b). Alert 2

This system may benefit us in the future if another pandemic appears, in order to avoid spreading rapidly, so that only the appropriate sensors can be modified according to each health crisis.

6 Conclusion

This paper presents a project proposal using an intelligent system for coronavirus patients who have improved to the point where they require regular monitoring by a doctor while respecting the procedures of the quarantine until full recovery. The cutting-edge internet of things technologies incorporated in the intelligent system enable it to identify elevated body temperature, low blood oxygen levels, and patient location. The gathered data is subsequently transmitted to health management applications for display and analysis. The proposed system is designed to be user-friendly and efficient in terms of energy consumption. It serves as a bridge between doctors and patients, ensuring the accuracy of medical procedures and offering medical resources to people in critical condition. With the current global health crisis, this innovative architecture offers a promising solution to help contain the spread of the virus. As researchers and computer scientists, we are motivated to continue developing smart solutions that benefit the medical field and contribute to the environmental health.

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