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# Cloud Networking based Patient Risk Detection Monitoring System

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***Abstract***-Recent increase in elder population due to seriously low birth rate and development of medical technology, aging rate in Korea is rapidly accelerating. A sudden increase in the elderly population result in problems such as medical finance burden and lack of medical beds, such as medical insurance deficit. In order to prepare for this situation, this paper proposes a cloud based patient information monitoring system for home-based medical beds. Arduino is used to implement the model, and heart rate, temperature, and humidity information from sensors is stored in a cloud server-based, firebase database in real time to send a notification alarms from smartphone app in case of danger. Cloud-based services will enable 'home-based medical beds', and can also be used to monitor patients in nursing hospitals or clinics without ability to build and maintain pirvate servers.

***Keywords:*** Cloud, Database, Biometric information, IOT Sensor, Home based medical beds, Patient monitoring.

## 1. Introduction

With remarkable development of science and medical technology in 21st century, human life expectancy continues rise, and in this situation, Korea is facing serious social problems such as low birth rates and aging population. This aging phenomenon can cause serious problems like growing medical insurance deficit due to nursing costs, and growth of elder population may cause shortage of medical beds, collision of community medical care and eventually "medical refugees." Japan, with largest aging population so far, shows that about 30% of the money earned by Japanese citizens is used for medical care and pensions, and its growing trend intensifies labor shortage and medical care burden[1][2]. This aging issue is not limited to Japan and can soon become reality in Korea. In addition, rapid increase of COVID-19 cases in Seoul metropolitan area has forced the government to allow home quarantine for COVID-19 patients. To prepare for these social problems, this paper proposes a 'cloud-based patient monitoring system' for home-type medical beds. Home-type medical beds focus on using a sensor to identify patients' body information, monitor their condition around the clock in case of emergency and provide telemedicine. Efficient use of medical beds through this model could be a solution for medical insurance deficit and bed shortages by minimizing actual hospitalization which will make clear room for emergency patients. However, to construct and maintain private servers and databases for such patient monitoring will be costly. Not only could these costs prevent establishment of home medical services but can also increase medical expenses for patients. A huge, integrated cloud server for medical information in each of the regions could solve this problem, making monitoring service possible for even facilities without budget[4]. For the model presented in this paper, Arduino and heart rate, temperature, and humidity sensors are used to store and monitor patient's data in a 'firebase', which is a cloud-based server. In addition, to prepare for possible risk situations for patients, measurement beyond threshold triggers the model to identify the risk situation and inform it to medical staff.

## 2. Patient Monitoring System Design

### 2.1 System Configuration

The purpose of this system is to store and monitor patient's

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biorhythm on a cloud server for home-type medical beds, and to notify patients so that medical staff can quickly respond in case of emergency. The proposed 'cloud-based patient monitoring system' stores patient-related information measured by heart rate, temperature, and humidity sensors in database provided by the firebase, and displays measurements on smartphone applications for monitoring purpose, which all happens simultaneously. When measurements exceed the predetermined threshold, it is identified as an emergency and alerts medical staff through notification in smartphone app with brief summary of situation. Figure 1 is an overall configuration of the proposed cloud-based patient monitoring system[5][6].

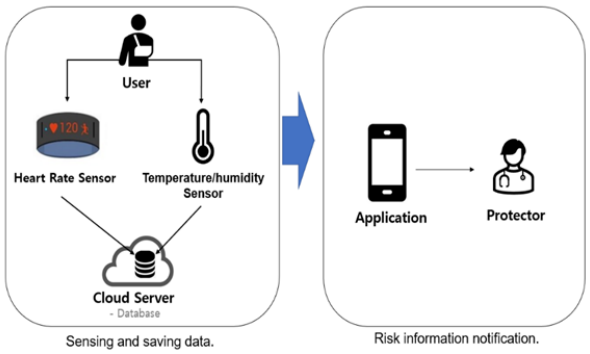


**Figure 1-** Cloud-based Patient Monitoring System Diagram

### 2.2 System Design

Arduino measures heart rate of a patient, and temperat ure and humidity of a patient's residence using heart r ate sensor and a DHT11 sensor. In this case, measure ments are simultaneously transmitted to database of th e firebase using ESP8266 module. Heart rate and tem perature data are stored in database, classified by pati ent. Since these are personal data and has to be confi dential, real-time database designed as private model a nd operated as lock mode. The patient's data is synch ronized in the database, and uploaded data could be v iewed through application. When transmitted patient da ta exceeds the threshold, application installed in guardi an or medical staff's device will send push alarms of the dangerous situation. Figure 2 shows architecture of cloud-based patient monitoring system.

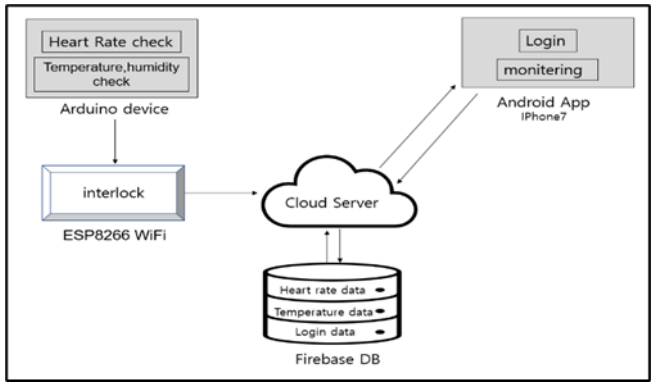


**Figure 2-** Cloud-based Patient Motoring System Architecture

### 2.3 Standard Threshold Reference Value

Usually, the average heart rate of an adult male or female at ease is 60 to 100 times. If they measure out of normal threshold, over 100 heart rates (tachycardia symptoms) or under 50 (brachycardia symptoms), the patient's heart rate is judged as unstable and notified to guardians or medical staff. In addition, heart rate may not be measurable due to cardiac arrest. So, if BPM is zero because heart rate cannot be measured, it is designed to send a notification about the patient's risk through application. Temperature and humidity around the patient is set according to architectural design guidelines of medical institution so that patient can be most stable. It is designed to maintain a room around 21 to 24 degrees Celsius and 60% or less humidity, and to send push alarms in case of deviation[7][8].

## 3. Implementation and Experiment of the system

### 3.1 Implementation environment

In this chapter, design contents proposed above are implemented and simulated. Table 1 shows details of Tool, PC, Sensor, and Device systems used for implementation.

**Table 1.** Implementation Environment

| Type | Composition |
|---|---|
| Tool | Arduino IDE, App inventer, Firebase |
| PC | Window10, intel i5, 8GB RAM |
| Sensor | Pulse Sensor, DHT11 |
| Device | Arduino Wemos D1 R1(ESP8266), Bread Board, USB Connertor |

In this implementation, App inventer was used for implementing the app, while Arduino IDE for Arduino board, Google Firebase for cloud server and database design, and Arduino Wemos D1 R1 (ESP8266) as main board for Wi-Fi communication in interlocking parts. Finally, heart rate sensor and DHT11 sensor was used to measure heart rate, temperature, and humidity. Figure 3 shows Arduino device connected to sensors.

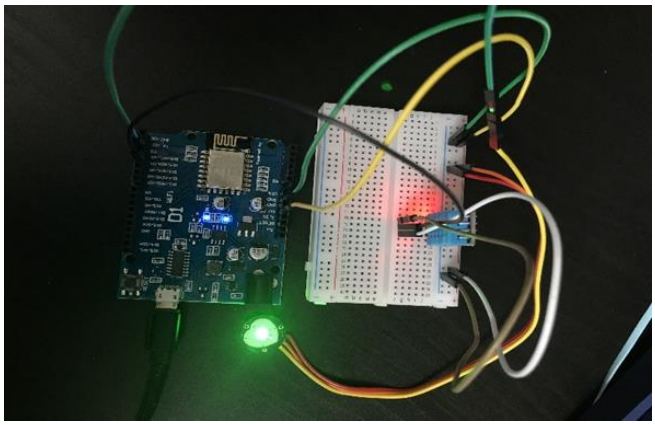

**Figure 3-** Cloud-based Patient Monitoring System Architecture

### 3.2 Simulation.

Heart rate, temperature, and humidity sensors are connected to Arduino Wemos D1 R1 to measure heart rate, temperature, and humidity per minute. ESP8266 module built into the Arduino Wemos D1 R1 supports Wi-Fi connection and transmits measurements instantly. By sending measurement results from sensors to serial monitor, it can be confirmed whether the result is accurately transmitted, as shown in Fig. 4.

Results in upper part of serial monitor (Fig.4) are measurements from heart rate sensor which records 1-minute heart rate (BPM) every second, and results in lower part are temperature and humidity data from sensor that records every second.

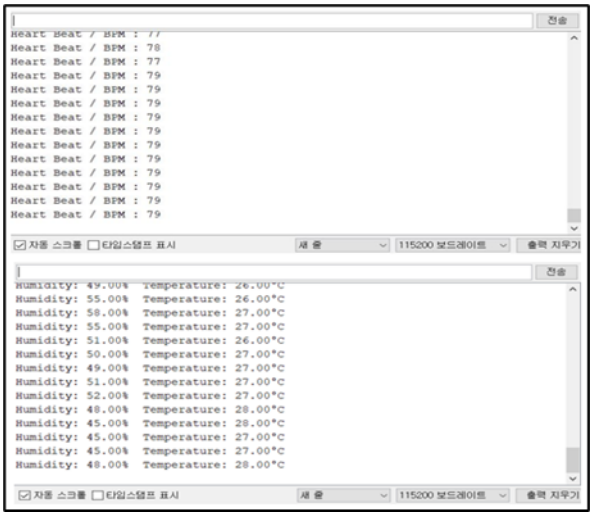


**Figure 4-** Serial Monitor with Measurement results

Figure 5 shows values measured using heart rate, temperature, and humidity sensors saved in database. Using the Humidity and Temp tags on left(Fig. 5), upper serial monitor(Fig.4) displays 1-minute heart rate (BPM) every second, and lower serial monitor(Fig.4) displays temperature and humidity of each measured by temperature and humidity sensor.

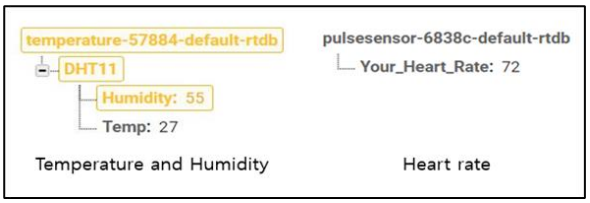


**Figure 5-** Real-time Data stored in database

Figure 6 is the overall functional screen of patient monitoring app implemented by app inventer. First screen from the left is a membership screen, where ID, password, nickname, e-mail, and password is required for registration, and those information are divided into bucket and tags to be stored in a real-time database on the firebase server. Second screen is for login, which can be done by entering ID and password that was used to register. Login is authorized by crosschecking ID and password in database but denied if there is not a match. After successfully logging in, you can navigate to desired page such as heart rate, temperature, or humidity information by check button. Heart rate screen, for instance, displays real-time BPM measured from patient. Likewise, temperature and humidity screen displays real-time temperature and humidity information around patient location. Both heart rate, and temperature and humidity information appear as a label on app screen which change whenever significant change in sensor measurements happen.

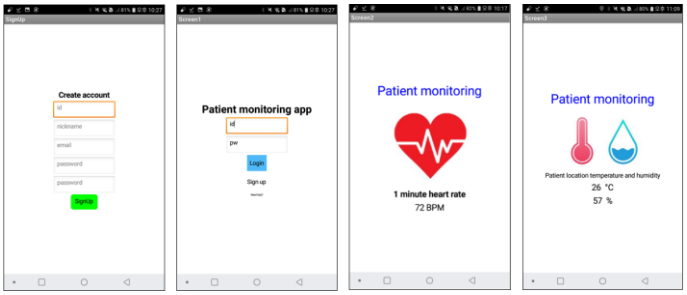


**Figure 6-** Implemented App Function Screen

Figure 7 simulates data exceeding the predetermined threshold to activate app notifications. For push alarm transmission, NotificationStyle function from app inventer was added and utilized. Measurement stored in database is uploaded to the app when started, and push alarms are sent when loaded data exceed the threshold.

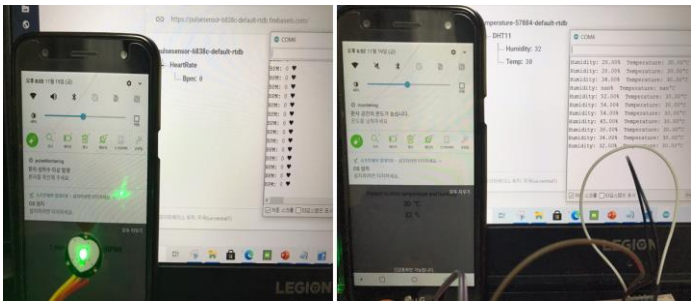

**Figure 7-** Push Alarms when Measurements Exceed Threshold

### 4. Conclusion

Growing elder population will adversely affect medical insurance's deficits, and can cause problems in medical system, such as lack of medical beds. To prepare for these problems, this paper propose a 'cloud-based patient monitoring' system for home-type medical beds. The system communicates measurements from heart rate, temperature, and humidity sensors using Wi-Fi and stores them in database. Stored data is then instantly transmitted to patient monitoring application, where user can monitor provided data. If data is beyond the predetermined threshold, it is identified as dangerous and programmed to notify the risk to application user through push alarm. Current patient monitoring systems are constructed by storing and monitoring patient information in private database own to

hospital. However, building private servers and databases is expensive. If cloud servers are used for this purpose, high-quality services can be provided at low cost. Future research about monitoring patient through various sensors, building regional cloud servers, and providing patient location information is necessary. These systems will contribute to building efficient medical system and home care.

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