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Remote Location and Health Monitoring Device with Network Independent GPS

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Abstract : This paper will discuss the implementation of a wearable health monitoring device which can be effective in areas with little or no signal connectivity, this device was conceived specifically keeping hikers, trekkers and people in rural areas in mind, where there is limited or no network connectivity, hence monitoring them would propose a challenge.This implementation would especially be useful in tracking people participating in adventure sports where there is a high probability of getting lost or injured resulting in delayed first aid treatment and care. This implementation makes use of a data streaming network called PubNub. PubNub utilizes a cloud based infrastructure, this entire implementation is accompanied by an android application which will monitor the device in real time. So finally we have a cloud based IOT device which will further the effectiveness of telemedicine.

Keywords : Telemedicine, Atmega 328P, Arduino, Android Studio, Cloud, RF module.

1. INTRODUCTION

It is widely accepted that telemedicine is the use of advanced communication technologies and methods to exchange vital information regarding a person's health status across geographic, time and social barriers. This device is one such attempt to further the purpose of telemedicine. [1]

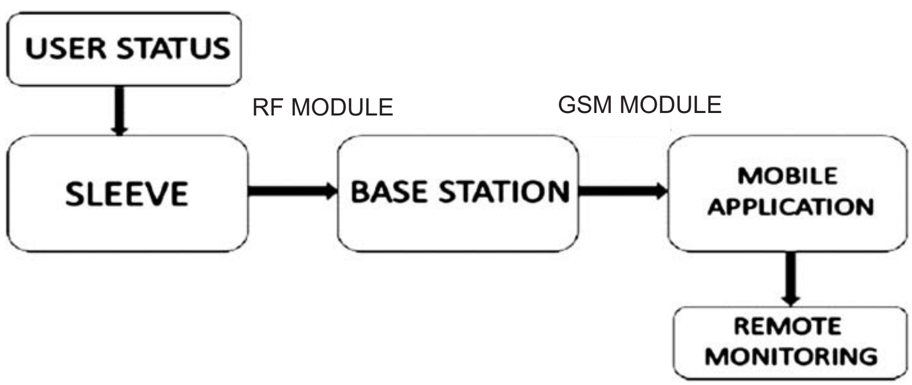

Figure 1: Device overview block diagram

The paper will discuss various technical aspects of the device such as setting up of sensors, getting accurate data, processing sensor data and transmitting the sensor data wirelessly, additionally we will discuss about the android app which is used to monitor the device in real time.

The device consists of three major parts, first the wearable portion which consist sensors to measure a person's BPM [18], location and other parameters like temperature etc. Secondly the portable base station which pickups any data coming in within a particular radius and finally the data streaming network coupled with the android app.

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Now that it is established that the purpose of the device is to function as a wearable health monitoring device, we will see what makes it different from the many existing devices such as fitness bands, activity trackers etc.

2. PROPOSED DEVICE BLOCK DIAGRAM

The device is sensor intensive with multiple functions and can be summed up by the following block diagram in Figure 1.

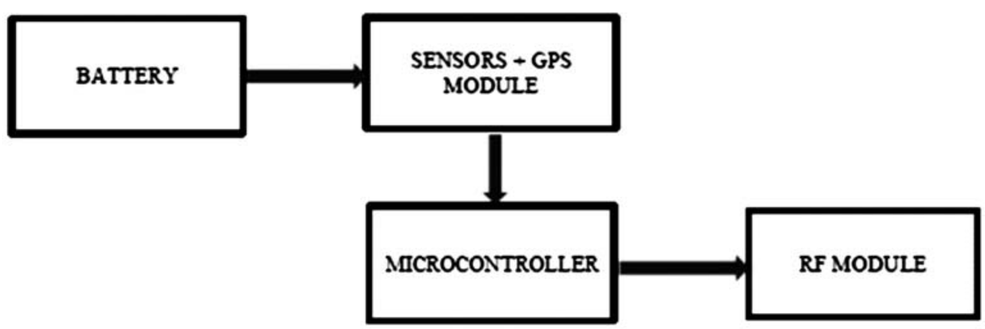
The “sleeve” is the wearable part of the device which plays host to the various sensors. These sensors collect user information and a processor on the sleeve processes this data, the processor used is an Atmega 328P [5]. After processing the data the processor transmits the data via an RF module, this transmission has a viable signal strength over a certain limited radius depending on the transmission power among other factors.

The data transmitted is coded in such a way that only the receiver which is a part of a base station can receive it. The placement of the base station in critical.The base station is placed in a region where the network signal strength is strong enough to carry the messages coming through it, hence it is placed in a region which can be considered as a conjunction for the area with network connectivity and the edge of the region without network connectivity i.e. the region in which the sleeve is being operated.

The portable base station also consists of a GSM module which establishes a connection to the cloud service provided by a 3rd part service provider known as PubNub [7]. PubNub which is a data streaming network, streams data to any smartphone which has the companion app and is connected to the internet.

3. DEVICE WORKING

To explain each of the 3 main technical parts we need to look at the various sensors used, the different methods in which communication was established and the accuracy of the obtained data along with some very important software tools used to build a platform necessary for monitoring the user’s health information.



Figire 2: Processing of sensor data

The “sleeve” part of the device makes use of a BPM sensor, temperature sensor, GPS module, battery pack and an RF module.All these are accompanied by an Atmega 328P microprocessor. The BPM [18] sensor used is SEN 11574, it takes an input power supply between 3 and 5V.

Figure 3 is the schematic of SEN 11574 the circuit essentially combines a simple optical heart rate sensor with amplification and noise cancellation circuitry making it fast and easy to get reliable pulse readings, so in order to detect the pulse we have to pass light (from an LED) from one side of a finger (preferably) and measure the intensity of light received on the other side (using an LDR). Whenever the heart pumps blood, more light is absorbed by increased blood cells and there is a decrease in the intensity of light received in the LDR, which results in the increase in resistance value of the LDR, the variation in resistance is converted into voltage and amplified by an opamp. It draws 4mA current at 5V so it is very useful to incorporate it into our device which has to share its power with many other sensors.[2]

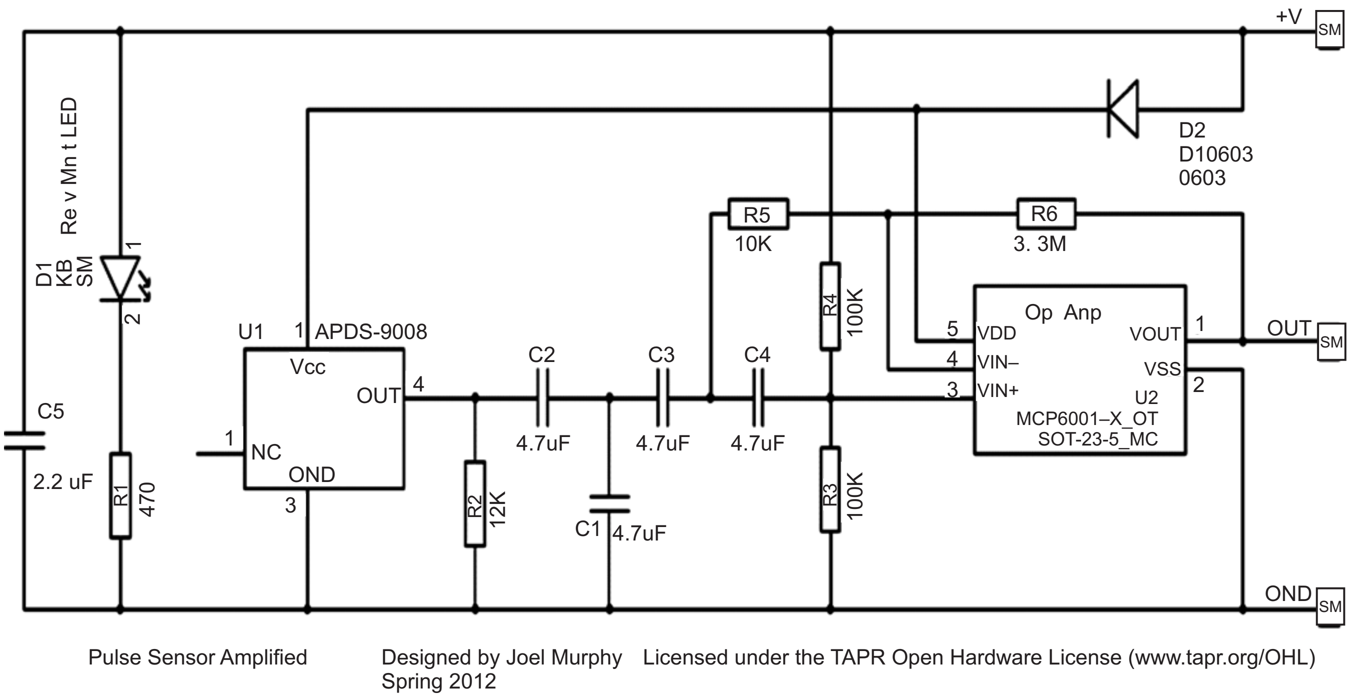


Figure 3: SEN 11574 schematic

(http://cdn.sparkfun.com/datasheets/Sensors/Biometric/PulseSensorAmpd%20-%20Schematic.pdf)

The thermal probe used to measure the temperature is M165 DS18B20,input power supply range is 3.0V to 5.5V. Its measuring range extends from -55°C to + 125°C. Its resolution is programmable from 9 to 12 bits.Its accuracy is ±0.5°C from -10°C to +85°C.[3]

The GPS module used is a U-blox NEO-6MV2,it takes somewhere between 1 second to 27 seconds to get a fix on the location under normal conditions. It has a maximum navigation update rate of 1Hz, ideally it needs a powersupply of 3.6V.[4]

In addition to all these sensors the most important part of thisdevice is the RF module. We have put to use a 433 MHZ RF module operating at 10mw, whose expected range is between 20m to 200m, since this is a prototype whose purpose is to illustrate the functionality of the concept, we are making use of it, even though the range islimited. To maximize the range a series of power amplifiers and/or an antenna can be soldered. The baud rate for communication between the modules is set at 9600.

Figure 4: Base station block diagram

The transmitted data is coded in such a way that it can be received only by the RF receiver of the “portable base station” part of the device. The incoming data is received by the receiver and then processed by the microcontroller and the data is sent to the GSM module (as shown in Figure 4) to be stored in the “cloud”.

Figure 5: Processing of sensor data

As shown in Figure 5 the GSM module establishes a connection with the cloud platform, from there the data is transmitted to the Android app.The GSM module was powered up by a DC voltage of 12V/1A specification, which was given to it via an adapter hooked onto a regular AC supply.

Now we will talk about the cloud platform used by the device.While a more straight forward approach could have been employed by designing a webpage and transmitting data onto the webpage, we decided to use the cloud infrastructure provided by a 3rd party company known as PubNub which specializes in IOT related issues, since IOT is one of the most coveted fields currently, we went ahead with it.

PubNub's most essential product is a real-time publish/subscribe messaging API built on their global data stream network which is made up of a replicated network of at least 14 data centers located in North America, South America, Europe, and Asia. Pubnub provides us with channels, each channel can be accessed by 100 devices free of cost, so the android phone which is going to have the android app for monitoring the user data of the sleeve, if it is subscribed to the channel where the messages are being published, can obtain the necessary data.

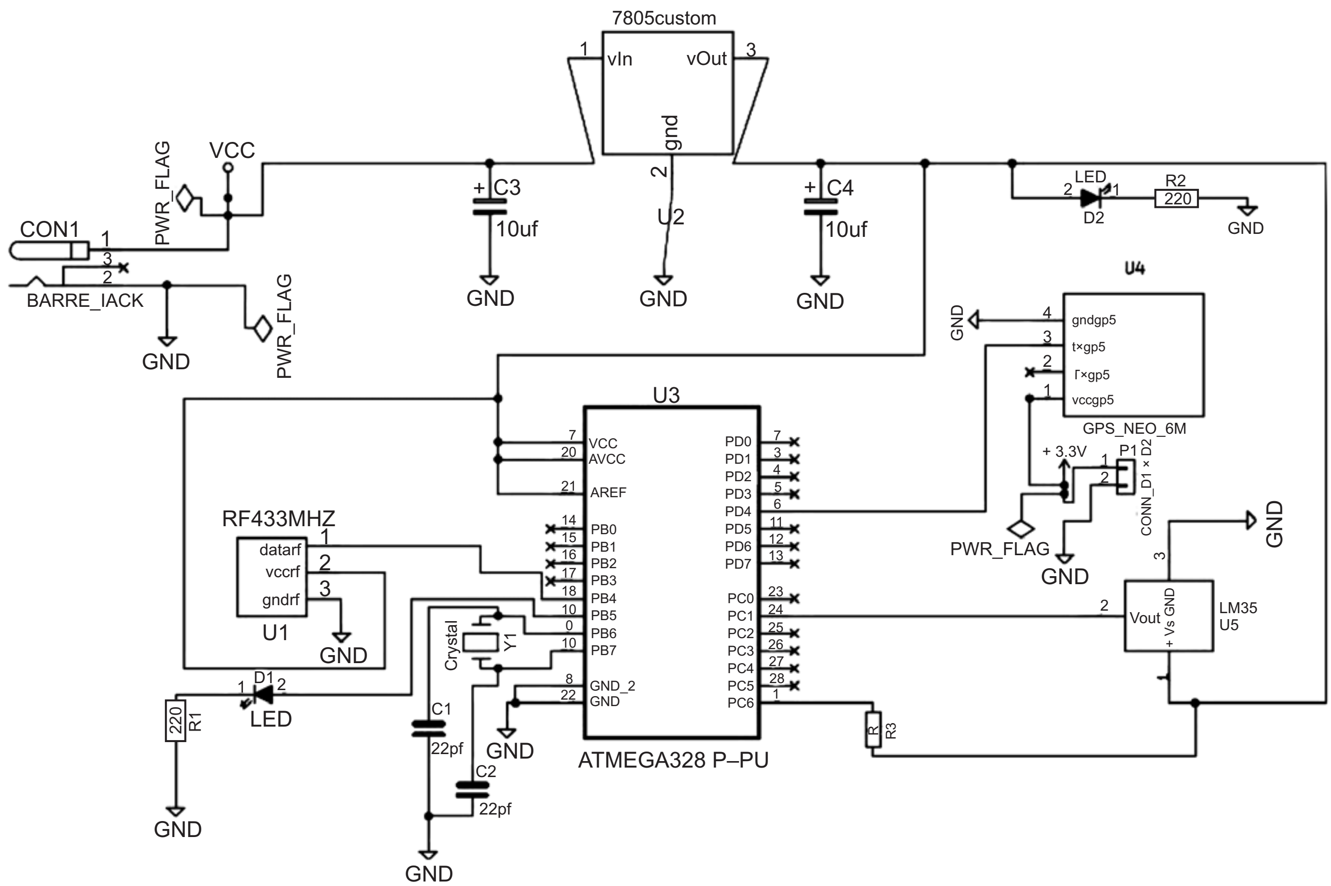


Figure 6: Sleeve schematic

To publish data onto the PubNub channel (or cloud) using our GSM module, the communication protocol for communication between the GSM module and the PubNub cloud is formatted according to a PubNub API [9].

As mentioned above the device is monitored via an Android app, its functionality can be encapsulated as follows:

The app is called the "Sleeve Monitor" and it has two screens. Each screen and its backend details are given below.

SCREEN 1: Enter login details.

SCREEN 1 BACKEND : The First Activity verifies user details and launches screen 2.

SCREEN 2: Consists of a display monitor, where incoming data will be displayed.

SCREEN 2 BACKEND : On launch of screen 2, the Second Activity calls "PubNub" service class.

PUBNUB SERVICE CLASS : Once the PubNub service class is called, it subscribes to the PubNub cloud channel via PubNub API. Then, the PubNub class gets data from the cloud and sends a "toast" message to the screen 2 activity.

BOOT RECIEVER CLASS : After initial login, always keeps listening/polling for internet activity. The IDE (software) used for this part of the project was "Android Studio". Please refer the annexures for the detailed java and XML codes of the Android app.

The "microcontroller" used everywhere in the device is an Atmega 328P whose operating voltage is 5V, recommended input supply voltage can be anywhere between 7-12V and has a flash memory of 32KB, SRAM 2KB, Eeprom 1KB, and operates at clock speed 16MHZ. [5]

4. SIMULATION AND RESULTS

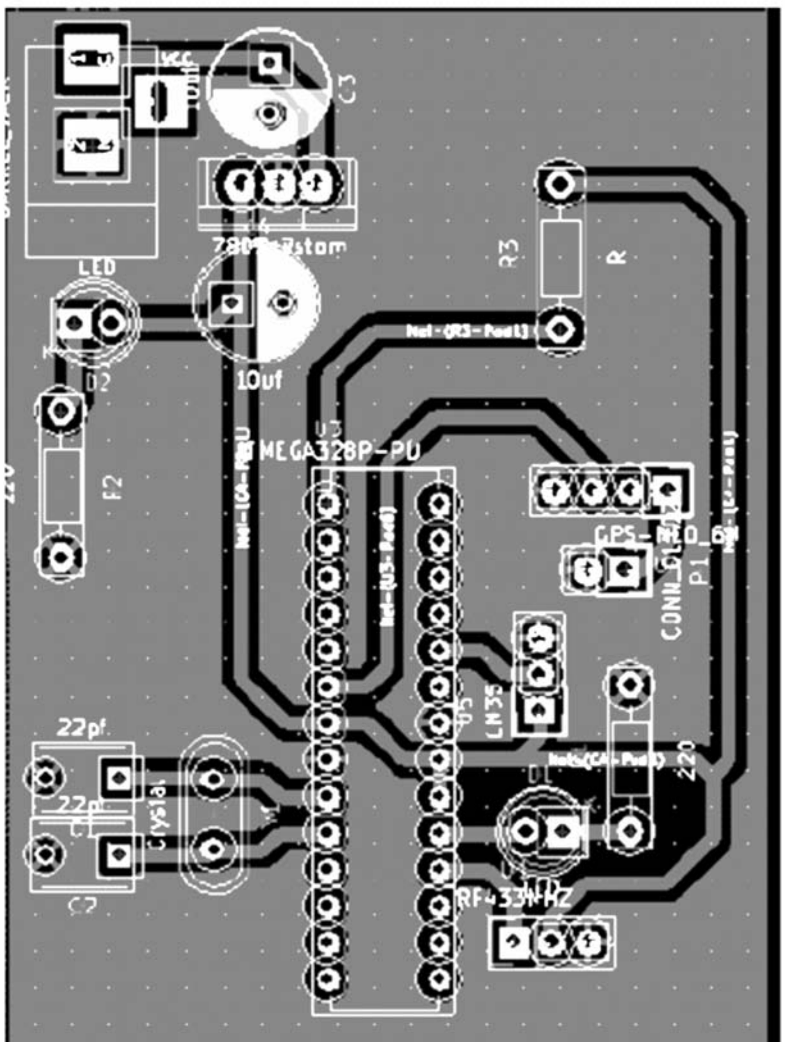


Figure 7: PCB layout of sleeve

Figure 6 is a schematic of the sleeve part of the device, Figure 7 is PCB layout of the above described circuit. The schematic is to be understood as follows, the 28 pin block is an Atmega 328p IC which is given a 5v power supply input via a 7805 (on top) regulator accompanied by two decoupling capacitors. The input power supply is a 9v battery which is represented by a DC barrel Jack. The other blocks (in anti-clockwise direction) are RF module, 16MHZ crystal, DS18B20,BPM sensor SEN 11574, Connector 1 X 02, GPS module, along with them there are other basic passive components.

RF module and DS18B20 receive their power supply from the regulator itself, but the GPS module and SEN 11574 which need a power supply of 3.3v is given power supply independently. The PCB is a 7cm X 5cm board, photoresist method was employed inthe PCB making process. The PCB is a single layer PCB with copper filling.

The entire flow of data *i.e*. sensors to microprocessor to the RF module to the base station and then to the app via the cloud was first simulated using Arduino IDE.

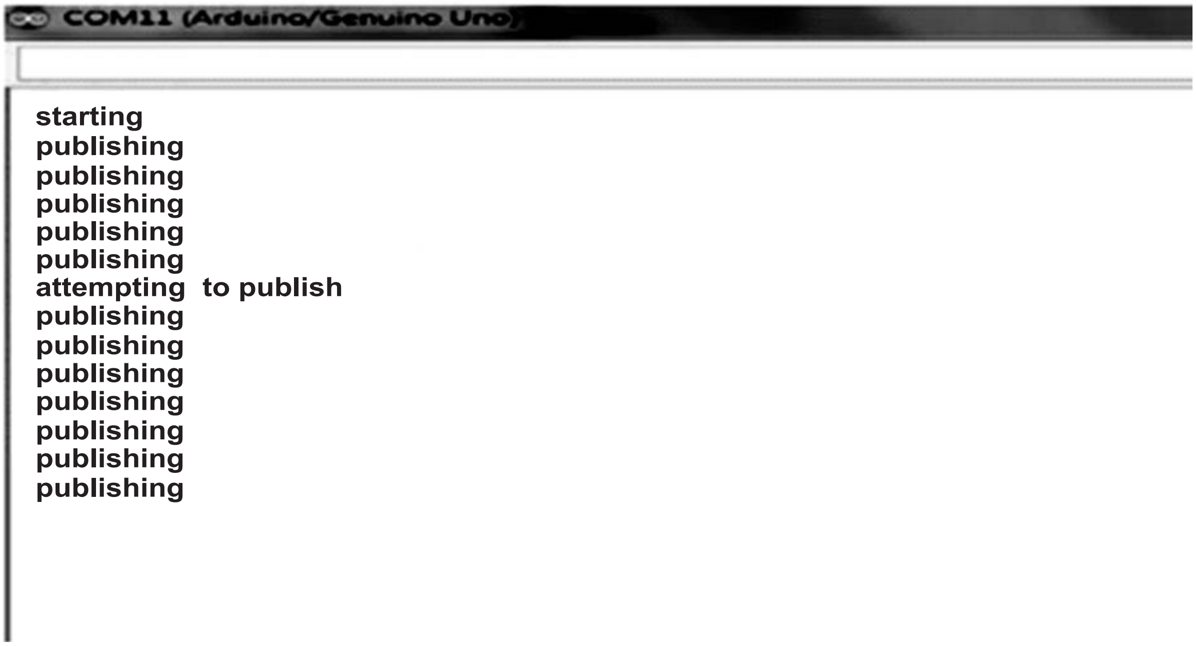
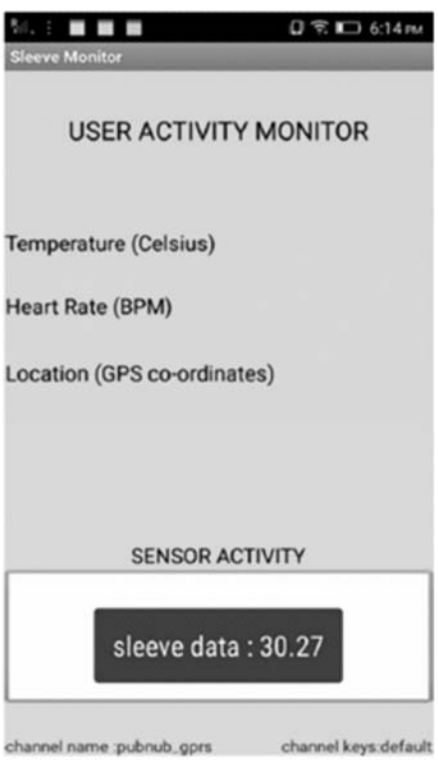


Figure 8: Arduino serial monitor

The above figure is the Arduino serial monitor, here it is displaying the status of the data which is being published onto the cloud [9].



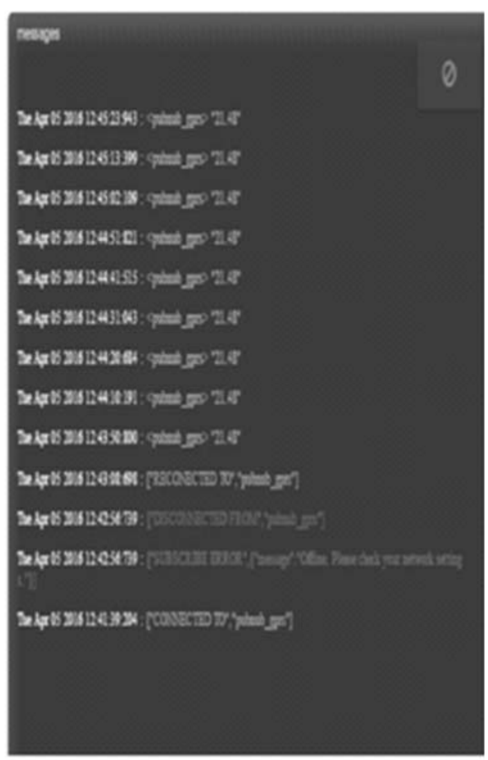


Figure 9: Screenshot of the app monitoring user data. Figure 10: Cloud debug console

Figure 9 is a screenshot of screen 2 of the Android app, its backend activity is to subscribe to the channel where data is being published. Figure 10 shows the cloud debug console, which shows the data being published in the channel.

5. CONCLUSION

When we started out our objective was to develop a wearable sleeve device that can remotely monitor and track the location of the user in secluded areas with little or no network connectivity. The most complex part of the project was establishing communication and transferring different types of data through them. There are three major communication lines in our project – the RF pair communication, GSM-cloud communication, cloud-smart phone communication. They are the most crucial part of this project and also the most constraining parts in some ways.

The future scope of work which can be done to improve the output accuracy are mainly:

RF range, since we are legally free to use 433 MHz at 10mw only, the range is limited [21]. So, a better licensed frequency at a higher power can technically provide a range spanning in kilometers, but since this project was about building a working prototype, we didn't have enough resources to venture into optimizing the output.

Microcontroller, since we have implemented and tested our device on a basic Atmega 328P, we are limited by its own specifications, though functionality wise it is acceptable, a better Microcontroller can do the same job in milliseconds, especially transmitting the data to the cloud via a GSM module, which happens once every 15 seconds.

Integration of more sensors, as stated before, any sensor depending on the need of the user can be integrated, for example accelerometer and a gyroscope combination can be used to count the number of steps, a humidity sensor can be integrated to measure the humidity in the location the sleeve is being worn.

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