Chapter

Dynamic HUB Selection Process in Wireless Body Area Network (WBAN)

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Abstract

Wireless body area network (WBAN), a part of WSN, plays a pivotal role in the remote health monitoring system, these days. Wireless sensor nodes placed in, on, or around the human body are used to create WBAN. This WBAN is mainly used for collecting physiological and vital signals from humans in real-time using sensor nodes. It consists of different sensor nodes and hub, which collects the data from sensor nodes and send them to the gateway. High data rates at HUB cause the damage of an organ receiving high temperature in tissue by electromagnetic signals for a long period. In this chapter, by considering parameters such as the specific absorption rate, Battery Level, Priority of sensor nodes, and signal to noise interference (SINR) a HUB is selected dynamically, which shares the work of the HUB among different sensor nodes. So that workload on HUB decreases and shares its work accordingly to other sensor nodes concerning the data collected through the software LabVIEW. This chapter also illustrates the network (testbed) created using sensors for practically making the change in HUB by using the microcontroller, power, LM 35, BP sensor, Heartrate sensors arranged in a network through Arduino programming. In both these cases, the negative effect of electro-magnetic signals in WBAN, and the tissue damage in humans reduce for remote-health monitoring while increasing the network lifetime.

Keywords: WSN, WBAN, Tissue damage, Dynamic HUB, Specific Absorption Rate, Battery level, Priority, Signal to Inference Ratio, Sensors, LabVIEW, Fuzzy system, Network Life

1. Introduction

Wireless Body Area Network is a part of Wireless sensor network (WSN). Wireless body area network contributes a wide range in health monitoring and broadened its applications considerably [1]. Many lives have been passed down through centuries, due to lack of physical evidence and analyzing the patient up to a tolerance value. WBANs are becoming the limelight in the medical field, expanding their applications in a real-time world by collecting the vitals through implanted sensor nodes. A standard for WBAN as IEEE 802.15.6 is formulated by the IEEE fraternity. This had triggered many types of research to study its uses in WBANs [2].

A tremendous increase in recent technology in the subject of sensing, processing has fueled interest in the technology-based health care system. This is an added advantage to assist an elderly patient [3]. Sensor nodes in WBANs are mounted on the surface or inside the patient skin. These nodes are tiny, light-weighted with the required power and energy. The role of these sensor nodes is to transmit the data from source to destination through the skin as a medium. A loss in the medium occurs where signals or data are absorbed by neighboring tissues, which causes a surge in the temperature of the tissue. Likely, this might cause tissue damage. This is an emerging problem throughout the world, causing the patient to endanger tissue or organ with unbearable pain.

WBAN is lauded for its function through sensor nodes and core nodes, known as HUB which acts as a switchyard between sensor nodes and the gateway. HUB is a fixed sensor node that cannot be varied according to IEEE 802.15.6. The sharing of continuous data through HUB involves higher transmission rates. In contrast, SAR, battery level, Priority of the sensor node, and Signal to Inference Ratio (SINR) are compared to other sensor nodes for better transmission [4].

In this chapter, a HUB is selected dynamically in software based on the selection process through the fuzzy decision systems as shown in **Figure 1**. The fuzzy system converts the numeric value into crisp data where the fuzzy logic is applied and calculates the output based on fuzzy rules. It compares the input data with the standard parametric values of SAR, Battery level, Priority, and SINR (Signal to Inference Ratio). The front panel in LabVIEW is used to collect the data and the processing of fuzzy comparison is done in a block diagram, where every step of data is easy to monitor. The system considers the estimated parameters for different sensor nodes by comparing and gives an estimated sensor node as a HUB.

The effect of changing the HUB dynamically is analytically carried out on a testbed using the microcontroller(ESP-32) which is a 32-bit microcontroller with 34 general purpose IO's, 10 touches sensing IO's, DAC, ADC, pulse counter, UART, I^2C interface, Wi-Fi and Bluetooth as inbuilt application functions, that are mainly used for sending the data(vitals collected) to patients or doctors or neighbors. The sensors used in this testbed are based on application-specific(i.e., in our chapter, we used LM35 for temperature, BMP180 for Blood Pressure measurement, Heartbeat sensor monitoring with finger probe).

The remainder of the work is organized as follows: a description of the relevant work carried out in a focused area is described in the second section. Section 3, gives a glance view of the proposed technique in experimental way and analysis is done. Selection 4, illustrates a detailed overview of the prototype developed,

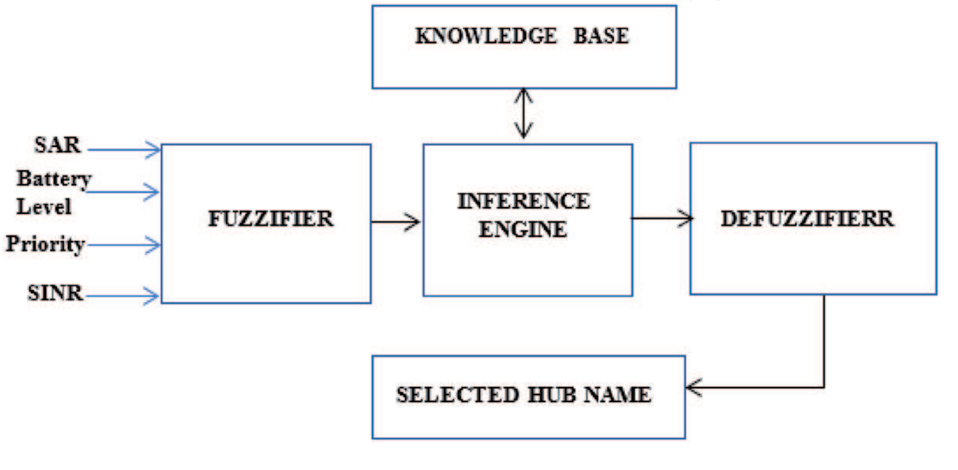

Figure 1.
Fuzzy logic for dynamic HUB selection.

presenting the obtained simulation results and discussion in Section 5. The last section,6, gives a conclusion about the chapter.

2. Related work

The benefits of selecting dynamic HUB through different metrics had a sharp fall down in the damaging of tissues or organs throughout the human body. From the outside, the deployed sensor nodes may be good but practically this causes patients an emergency condition which raises their complexity of the problem.

Not many studies have been made for the reduction of this effect on a sick person. As SAR is considered a major conflict for the rise, studies are made only on estimating and evaluating SAR [5].

By considering the location of the destination node in WBAN as a major part, Ahmed et al. proposed a technique compared to the SAR (Specific Absorption Rate) values under various conditions. It is used to estimate the SAR response on the human body.

Another proposed technique by Wu and Lin to adjust a relay node across the wrist and arm. In return, this will make sensor nodes transmit data packets to HUB with the lowest SAR values and efficient packet rate transmission. This uses an algorithm known as practical swarm optimization to maintain and identify the position of the relay node. No literature survey is added to their works. The performance of HUB is analyzed by Cicioglu and Calhan [6].

Later on, Cicioglu and Calhan made their study on implementing the techniques to maintain a HUB without any loss or damage to survivors [7]. Some other works may be added based on WBAN and SAR issues, but there is no literature study other than a specific absorption-based dynamic HUB selection, This work is extended with the fuzzy-based system in our chapter along with a new additional parameter SINR(Signal to Interference Noise Ratio). This is a major factor while transmitting the data or collecting the information from a patient. If a patient moves or any sensors placed in the network are in motion, then Interference occurs which weakens the network lifetime and manipulates the accurate data. The other major factor causing a signal to be disturbed is noise, which will be eradicated by implementing SINR in our dynamic HUB selection process. When compared to another literature survey, SINR is implemented in this chapter, to reduce the noise, interference and increasing the network lifetime. The proposed method selects a hub based on few parameters along with the signal interference or disturbance during the transmission for better and reliable communication.

2.1 HUB selection process parameters

At first sight, it looked like a typical problem for selecting a hub dynamically in WBANs. Wireless body area network has emerged their development through WSNs. Later on, by estimating the drawbacks of fixed HUB, a need for the selection of dynamic HUB has established. The wireless transmission density is neglected in the evaluating process.

A new hub is selected from the parameters like SAR, Battery Level, Priority of the sensor node, and SINR as in **Table 1**.

The parameter that we seek in the selection process plays an eminent role in the broadcast between sensor nodes and the gateway. This can be sorted for a multi-purpose decision-making system using Fuzzy-based rules. The criterions used are SAR, Battery level, Priority, and SINR.

Parameters	Low	Medium	High
SAR (W/kg)	0–1.6	1.6–2.2	2.25–3
BATTERY LEVEL (Joules)	0–1.3	1.4–2	2–5
PRIORITY OF NODES	0–2	2–5	5–8
SINR (dB)	0–12	12–20	20–50

Table 1.
HUB selection parameters table.

If the sensor node has values of SAR less than 1.6 w/kg, battery level in or around the range of 0–4 Joules, the priority of the sensor nodes which is given lowest priority is considered in selecting HUB. And SINR with a range above 20db is best for a new hub. The mentioned parameters above are according to the standard values based on LTE and IEEE fraternity. The illustration of the parameters considered in selecting HUB is depicted below.

2.2 SAR

In today's life, communication devices like mobiles, Wi-Fi have become a common part of the human lifecycle. The electromagnetic interference (EMI) radiation emitted from these devices is mean to be absorbed by a human being at a period of transmitting data. SAR expresses the amount of radiation absorbed by the body, generally represented in terms of Watt per kilogram. The SAR value is differently applicable for children [8]. Any of the communication devices near to tissue can cause damage as it continuously sends data to HUB, so a fuzzy-based rule with membership function as in **Figure 2** is implemented. The specified SAR rate according to FCC is 1.6 W/Kg [5].

This term is generated by

$$\text{Radiation} = \text{d}\left(\frac{dW}{dM}\right)dt \quad (1)$$

Here W is the power (W),
M is the mass (Kg), and.
t is the time (sec).

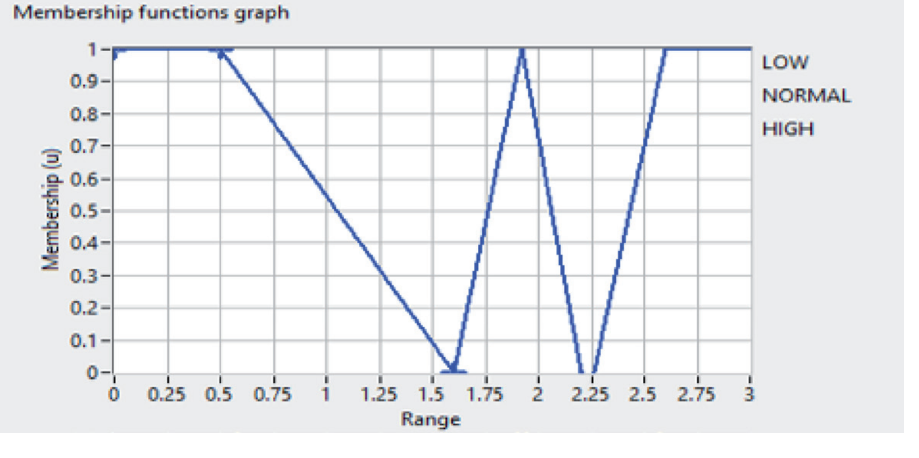

Figure 2.
SAR membership function.

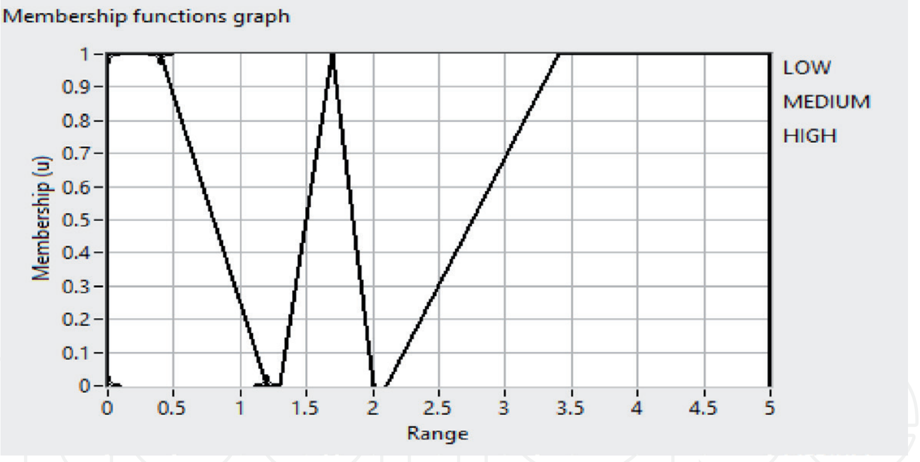

Figure 3.
Battery level range.

2.3 Battery level

The limit used is Battery level for HUB selection is as in **Figure 3**. Sensor nodes Used for WBANs have specific defined energy and power [9].

The sensor nodes can be utilized for a long time if energy is efficiently implemented. As the HUB requires more energy, a fixed hub will lose its required stamina if used for a long time at work. A sensor node is selected as a hub if it is ready to apply the maximum energy after the first sensor node failure, increasing the overall network lifetime.

2.4 Priority of sensor node

A priority of the sensor nodes in WBANs is considered as the parameter in the selection process for the new hub **Figure 4**. The highest priority is given to important vitals like EGG, EEG which transmit data quickly and a need to live for a longer period. In this selection process, the sensor node with the least priority is picked as a hub to transfer high packets.

2.5 SINR

This is the new parameter utilized in our chapter to bring down the interface or disturbances in the network. There are various data traffics in WBAN's, for

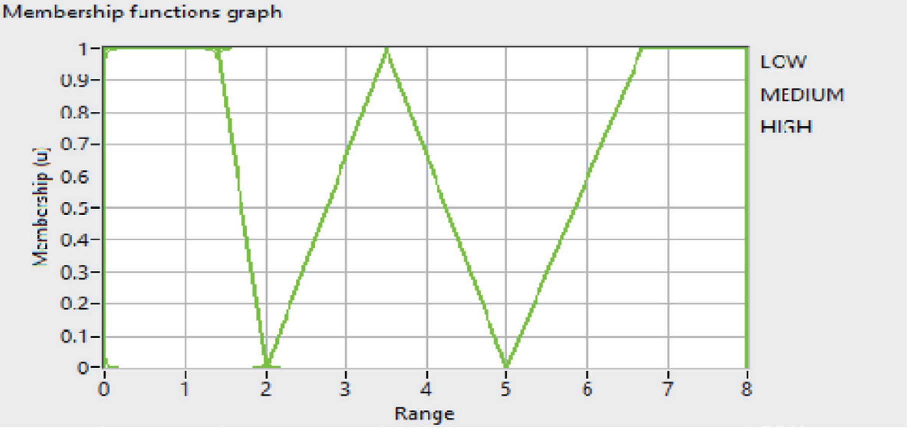

Figure 4.
Priority sensor membership function graph.

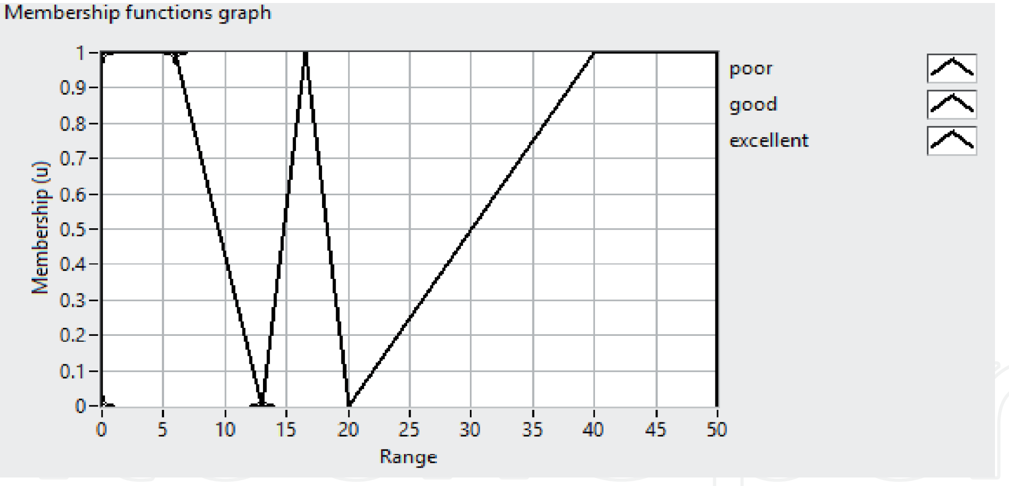

Figure 5.
SINR range in the membership function.

instance, merging of one signal with another or moment of a network from place to place. In wireless communication systems such as networks, SINR is used as the rate of information transfer representing the received signal strength. As the noise in the signal plays an efficient role in decreasing the data accuracy received at the receiver. Moreover, it is defined as the ratio of signal strength to the interference or noise of the signal. For communication link quality, SINR plays a pivotal role. SINR is used for identifying moisture and thermal noise at the sink, in wireless communication if any interference occurs at the data transmission, path loss takes space which results in great network disturbance. So, SINR is utilized to reduce this effect in data transmission.

This is also used to avoid interference in the affected sensor node. Then, a fuzzy-based membership function is used to calculate SINR ranges(0db to 12db, 12db to 20db, 20db to 50db) where the disturbance occurred due to the transmission period is sorted. In Telecommunication LTE measures the values in terms of powers of the signals that is considered as a standard value in wireless transmission of data. The SINR, greater than 20db is selected as HUB as shown in **Figure 5**. This is done by sharply bounded values in fuzzy-based logic for calculating the candidacy value, which decides the HUB using all parameters. The lowest noise signal reflects the highest valued SINR in quality of the network and interference.

3. Experimental results and analysis

LabVIEW (Lab Virtual Instrumentation Engineering Workbench) is a software platform developed by national instruments for data acquisition, controlling, and automation using Microsoft windows, various types of UNIX, Linux Mac OS. It is widely applicable for its features like graphical representation which are highly recommended for engineers and scientists, where data flow can be known and each step can be monitored if required. It also consists of different libraries with different toolkits and the major advantage of this is it is easily configurable with hardware, mainly for processing. The programs operated in LabVIEW are known as Vis. LabVIEW is a geographical programming language to create block diagrams in a block diagram panel. This is a user-friendly environment made up of a front panel and block diagram as shown in **Figure 6** for the dynamic HUB selection process along with the fuzzy-based functions.

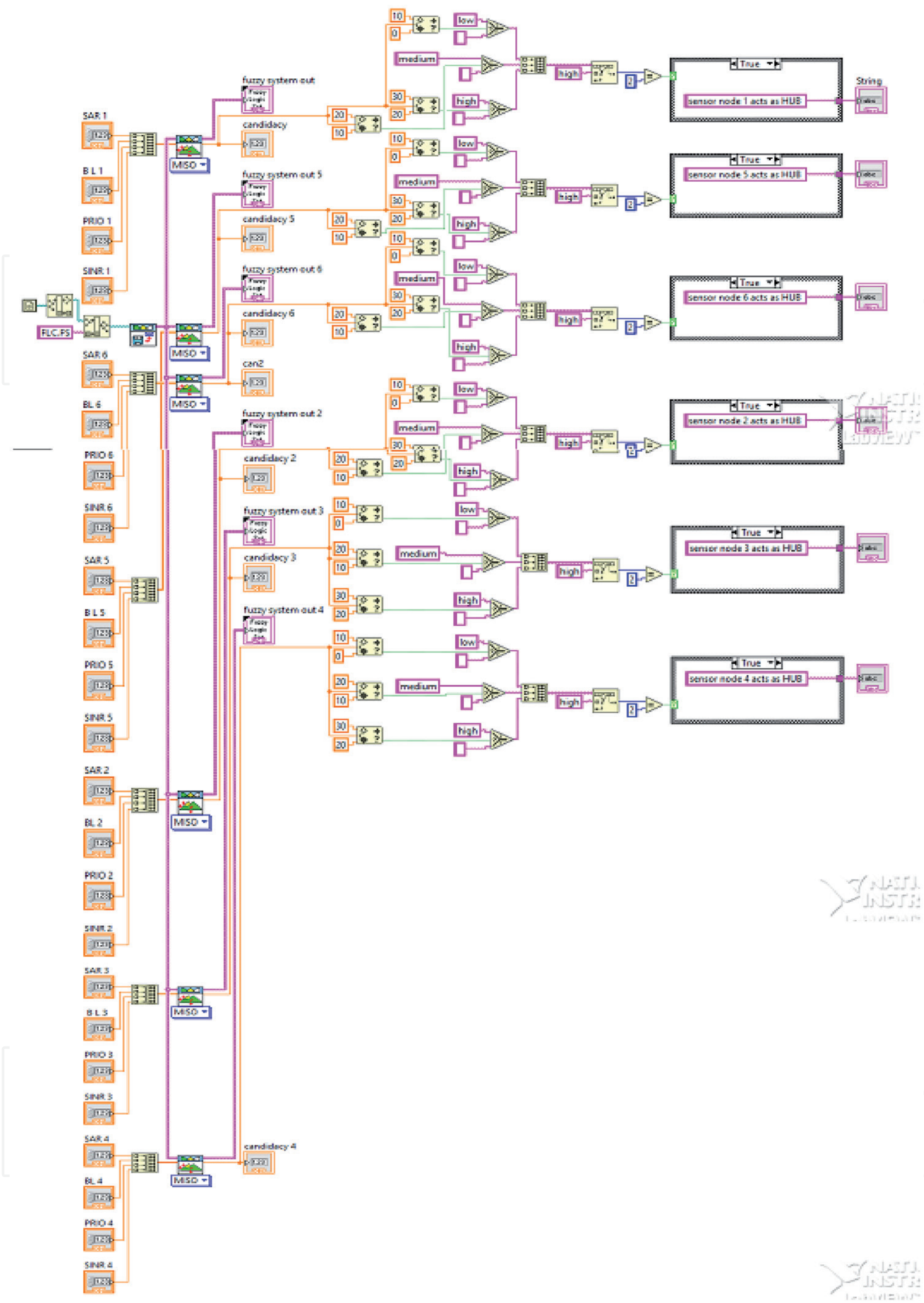

Figure 6.
Block diagram of LabVIEW for dynamic HUB selection.

The below-shown Figure represents the block diagram of the fuzzy-based system(the logic used) for selecting a HUB. Briefly, it collects the sensor data from the parametric values and processes an output by using fuzzy logic. For instance, two sensor nodes are first implemented on the front panel as shown in **Figure 7**.

In the front panel and block diagram, the input is given manually. The block diagram consists of loops and control lines where the flow of data virtually visible.

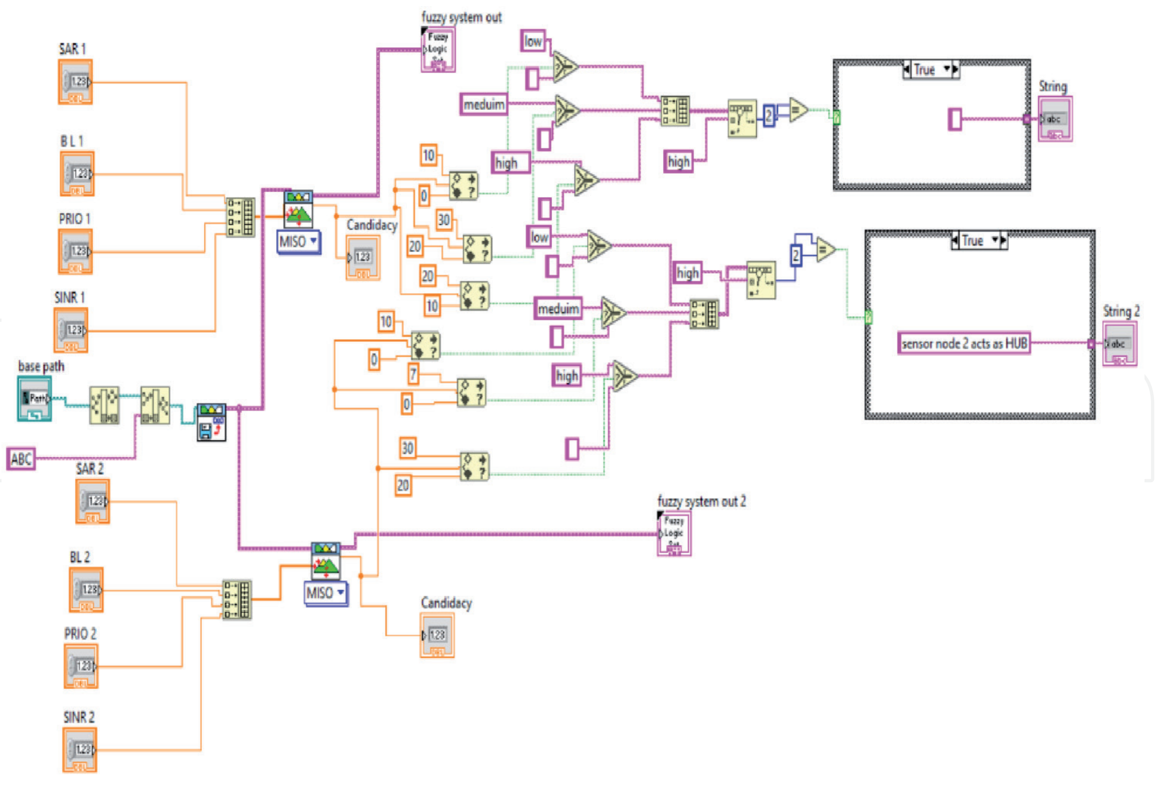

Figure 7.
Front panel code using 2 sensor nodes.

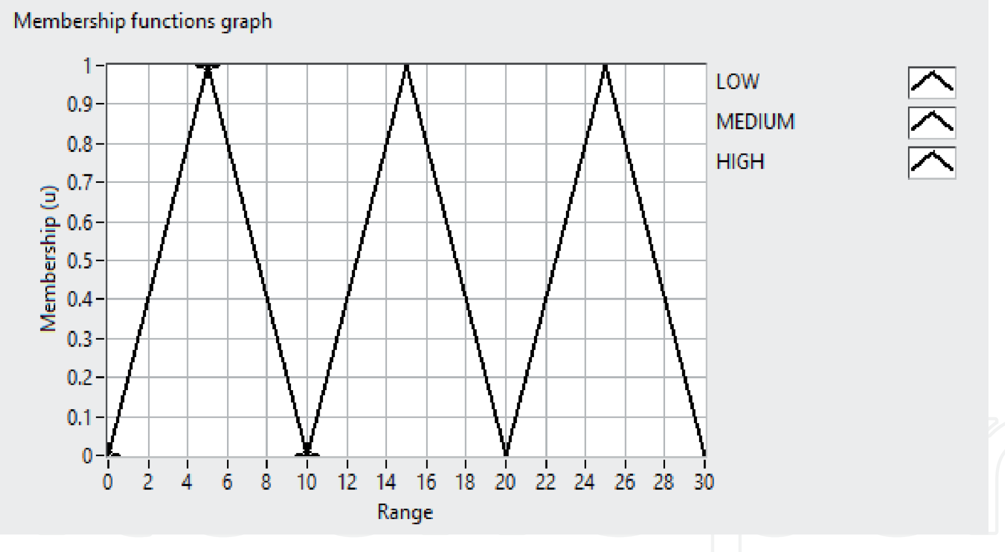

Figure 8.
Candidacy membership function.

The fuzzy system is an inbuilt library function in LabVIEW. The fuzzy system uses an engine to convert numeric data into crisp value as shown in **Figure 1** by implementing the bordered values through fuzzy rules and the output is shown in the candidacy membership function [10].

The Fuzzy output is taken and the common logic is used for a candidacy value with the highest based on the four parameters. The greatest Candidacy value will be considered as a new HUB, Which will be displayed in a string format in the LabVIEW front panel. This output is calculated as in **Figure 8** which considers the low(0–10), medium(10–20), high(20–30) range. Out of which the highest candidacy sensor node will be selected as a Dynamic HUB by using AND or OR functions.

3.1 About fuzzy and its rules

The Fuzzy-logic was initially proposed by a professor, at a university in 1965, named Lofti Zadeh [11]. It is described as a mathematical representation of executed numerical values, would rather say describing words than numbers. In this case, the fuzzy rules set understands the linguistic form of entered parameters i.e., SAR, Battery Level, Priority, SINR, and the controls convert them using an inference engine, membership function, and if-then rules presented in fuzzy rules set. This process is known as Fuzzification. Also, the conversion of if-then rules (which are expandable depending on the user application) to crisp data is known to be a defuzzification process [12]. The candidacy value is formed based on these Fuzzy based rules. There are different formations in which a HUB is selected. Out of the six sensor nodes used, we consider the rules formed are 81 which are depicted in below **Table 2**.

Sl. No.	SINR	SAR	Battery Level	priority	Candidacy level
1	Low	Low	Low	Low	Low
2	Low	Low	Low	Medium	Low
3	Low	Low	Low	High	Low
4	Low	Low	Medium	Low	Low
5	Low	Low	Medium	Medium	Low
6	Low	Low	Medium	High	Low
7	Low	Low	High	Low	Normal
8	Low	Low	High	Medium	Low
9	Low	Low	High	High	Low
10	Low	Medium	Low	Low	Low
11	Low	Medium	Low	Medium	Low
12	Low	Medium	Low	High	Low
13	Low	Medium	Medium	Low	Low
14	Low	Medium	Medium	Medium	Low
15	Low	Medium	Medium	High	Low
16	Low	Medium	High	Low	Low
17	Low	Medium	High	Medium	Low
18	Low	Medium	High	High	Low
19	Low	High	Low	Low	Low
20	Low	High	Low	Medium	Low
21	Low	High	Low	High	Low
22	Low	High	Medium	Low	Low
23	Low	High	Medium	Medium	Low
24	Low	High	Medium	High	Low
25	Low	High	High	Low	Low
26	Low	High	High	Medium	Low
27	Low	High	High	High	Low
28	Medium	Low	Low	Low	Low

Sl. No.	SINR	SAR	Battery Level	priority	Candidacy level
29	Medium	Low	Low	Medium	Low
30	Medium	Low	Low	High	Low
31	Medium	Low	Medium	Low	Low
32	Medium	Low	Medium	Medium	Low
33	Medium	Low	Medium	High	Low
34	Medium	Low	High	Low	High
35	Medium	Low	High	Medium	Low
36	Medium	Low	High	High	Low
37	Medium	Medium	Low	Low	Low
38	Medium	Medium	Low	Medium	Low
39	Medium	Medium	Low	High	Low
40	Medium	Medium	Medium	Low	Low
41	Medium	Medium	Medium	Medium	Low
42	Medium	Medium	Medium	High	Low
43	Medium	Medium	High	Low	Low
44	Medium	Medium	High	Medium	Low
45	Medium	Medium	High	High	Low
46	Medium	High	Low	Low	Low
47	Medium	High	Low	Medium	Low
48	Medium	High	Low	High	Low
49	Medium	High	Medium	Low	Low
50	Medium	High	Medium	Medium	Low
51	Medium	High	Medium	High	Low
52	Medium	High	High	Low	Low
53	Medium	High	High	Medium	Low
54	Medium	High	High	High	Low
55	High	Low	Low	Low	Normal
56	High	Low	Low	Medium	Low
57	High	Low	Low	High	Low
58	High	Low	Medium	Low	Normal
59	High	Low	Medium	Medium	Low
60	High	Low	Medium	High	Low
61	High	Low	High	Low	High
62	High	Low	High	Medium	Normal
63	High	Low	High	High	Normal
64	High	Medium	Low	Low	Low
65	High	Medium	Low	Medium	Low
66	High	Medium	Low	High	Low
67	High	Medium	Medium	Low	Low
68	High	Medium	Medium	Medium	Low
69	High	Medium	Medium	High	Low

Sl. No.	SINR	SAR	Battery Level	priority	Candidacy level
70	High	Medium	High	Low	High
71	High	Medium	High	Medium	Medium
72	High	Medium	High	High	Low
73	High	High	Low	Low	Low
74	High	High	Low	Medium	Low
75	High	High	Low	High	Low
76	High	High	Medium	Low	Low
77	High	High	Medium	Medium	Low
78	High	High	Medium	High	Low
79	High	High	High	Low	Normal
80	High	High	High	Medium	Low
81	High	High	High	High	Low

Table 2.
Fuzzy rules.

4. Prototype for dynamic HUB selection

The Dynamic Hub selection outraced the results of the traditional hub by implementing it in LabVIEW through Fuzzy based system. This is now tested by a prototype developed on the testbed to have a look at the changes in HUB selection concerning the real-time body measurements. As technology has a great impact on health and mobile phones these days become a valuable asset for a normal man. On this point, we connected an app that stores information about the vitals from the human body. Here, an embedded C is evolved to change the HUB dynamically and is provided in a mobile app where the HUB selection is shown in the app. The embedded communication devices used are for the programming of the network as they are designed for a special purpose rather than the general tasks of computers. These are inbuilt with memory storage, a processor, and some peripherals. It can assist using C, ALP, and VB, etc. It also stores the information about the vitals collected for future purposes. As discussed above, the root cause for tissue damage is the temperature rise, working for a longer period in the network. In this prototype, a traditional hub is changed according to the vitals collected from the patient. Based on the functionality and requirement, the embedded system is deployed in our mobiles and so as in this work. The different sensors used in the prototype are described below in **Figure 9**, where the network is placed on the surface of the body.

ESP-32 is a 2.4 GHz microcontroller with both Wi-Fi and Bluetooth combination chip designed for better power and good reliability with a wide range of applications, which consists of an I^2C bus interface, recovery memory, ROM, SRAM, temperature sensor, touch sensor, clock generator, a serial peripheral interface, DAC, ADC, UART (Universal Asynchronous Receiver Transmitter), PWM, Wi-Fi, and Bluetooth peripherals along with radio receiver and transmitter.10 capacitive sensing GPIOs present in the microcontroller are useful for our project as we use a touch sensor for monitoring the heart rate through the illusion of light by finger and the other three sensors are deployed.

The deployment materials used here are a Power supply, Temperature sensor, Heartbeat sensor, Blood pressure monitoring device. The power supply is used to convert high voltage to a low voltage supply, which consists of a transformer,

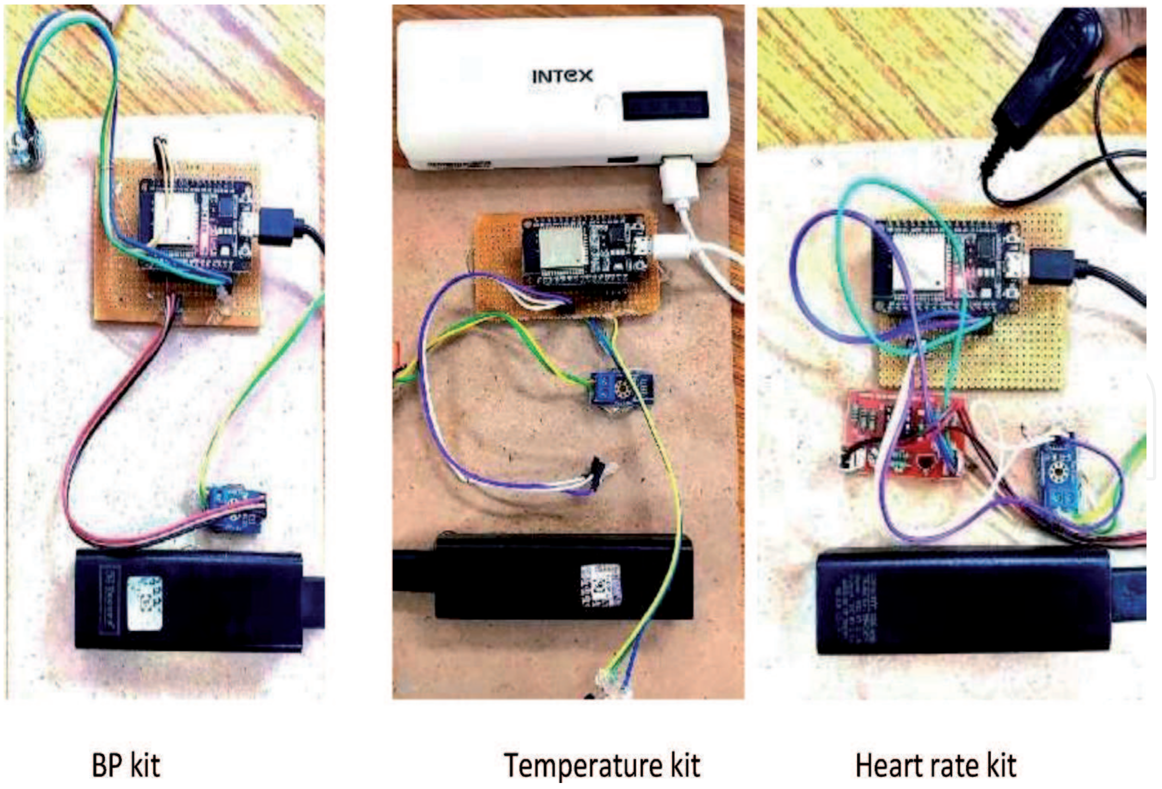

Figure 9.
Hardware kits.

regulator, filter, and rectifier. The temperature sensor, LM 35 is used here to convert the temperature into electrical signals. Yet, it does not require any calibration and best suitable for our work. Having said that, this is considered a low power supply and low self-heat not more than 0.1^0c in still air, most widely used in remote applications. The different male and female connection wires are used for creating a system.

5. Results and discussion

In this section, the results of selecting a HUB in both software and by using a Prototype for decreasing the damage of tissue when placed on the surface of the body are delineated. By using the LabVIEW-based Fuzzy rules, a dynamic HUB is selected by following the standard metric values of parameters. Here, six sensor nodes are considered and shown, which sensor node is changing as a HUB. As LabVIEW is a step-by-step procedure, we can identify the process and rectify if any mistakes happen. Whereas in the prototype developed, we considered three different sensor nodes in a testbed to run the code and examine the HUB selection process dynamically.

5.1 In LabVIEW using fuzzy

In this stage, the drawbacks of using a fixed HUB are rectified by using a dynamic HUB. We considered six sensor nodes for instance and process a dynamic HUB selection using the Fuzzy system in LabVIEW. The Fuzzy-based system consists of if-then rules in the fuzzy decision system.

The parameter values are considered from manual input through the front panel, as it is utilized to display the input and output of any program. The input given starts working in the block diagram through the Fuzzy library function as shown in **Figure 1**. The input of the Fuzzy system, consists of three sub-parts namely, entering the data, membership function, Fuzzy rules, and candidacy output. The candidacy value is sent back to the block diagram through a fuzzy out system with candidacy results and continues the process in a block diagram. As the simulation begins, the sensor node parameter value is considered and sends the information packet from all neighbors to default HUB. The aforementioned parameters are selected based on the universal standard values maintained by their respective standards. The proposed technique using Fuzzy gives an output candidacy value by comparing all sensor nodes' parametric values in the fuzzy decision system. The sensor node with the highest candidacy value I selected as a HUB. The front panel in the software implies the input to a fuzzy engine through a block diagram. Later on, by calculating the graph and candidacy value, a HUB is selected and presented in the front panel in string format.

Here the input is taken through the front panel and the process is done through fuzzy logic presented in block diagram when running the code present in it. If a sensor node has values of SAR less than 1.6 w/kg, battery level in or around the range 0–4 Joules, the SINR greater than 20db, the priority of the sensor nodes is considered and selected as a HUB. The sensor nodes are encountered with different cases such as when all the values are similar or whenever two sensor nodes exhibit the same values, then it is based on the priority of the sensor nodes, which selects the dynamic HUB. The priority of the sensor nodes plays the main role when all other parameters are in balance. In this project, the sensors like ECG, EEG, Temperature are used and temperature being the least sensor as it does not require monitoring continuously, while heartbeat and ECG are given the highest priority whose analysis is required for long hours. This helps in increasing the network lifetime by utilizing the least priority sensors.

The Figure above shown is an example of a front panel result that is selected as a dynamic HUB when placed on the surface of the human body. If any of these values change with time accordingly then the HUB is selected based on the change in parametric values. This makes the fuzzy system easy for multi-systems and increases the overall network lifetime by four times to a fixed hub.

Initially, a random node is selected as the default hub to send the information from source to sink and it is as shown in **Figure 10**. There are certain cases to examine our work. Here, When two sensor nodes of the same values are considered then the fuzzy rules are codded as it predicts the least priority sensor as Dynamic HUB as

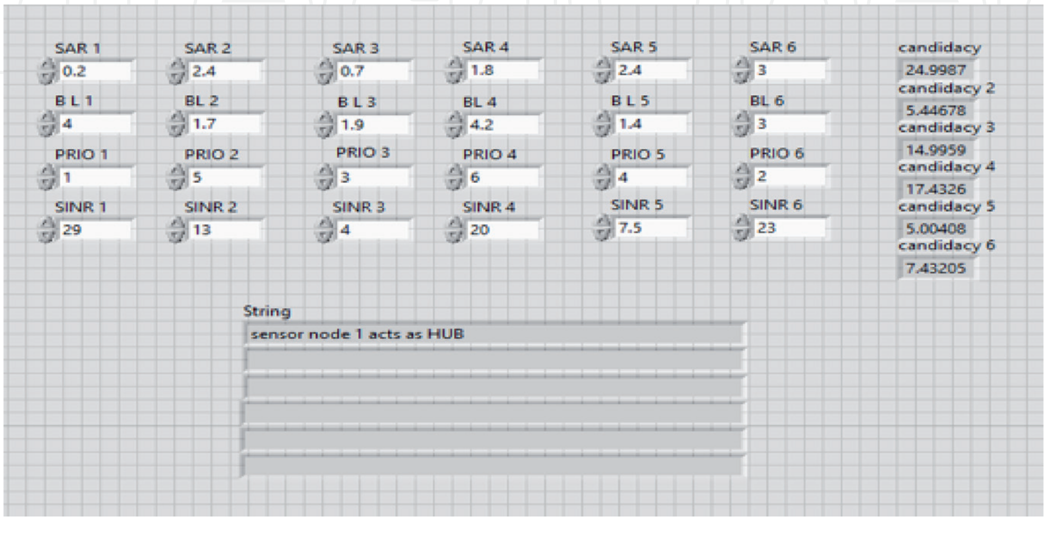

Figure 10.
Default dynamic HUB selected.

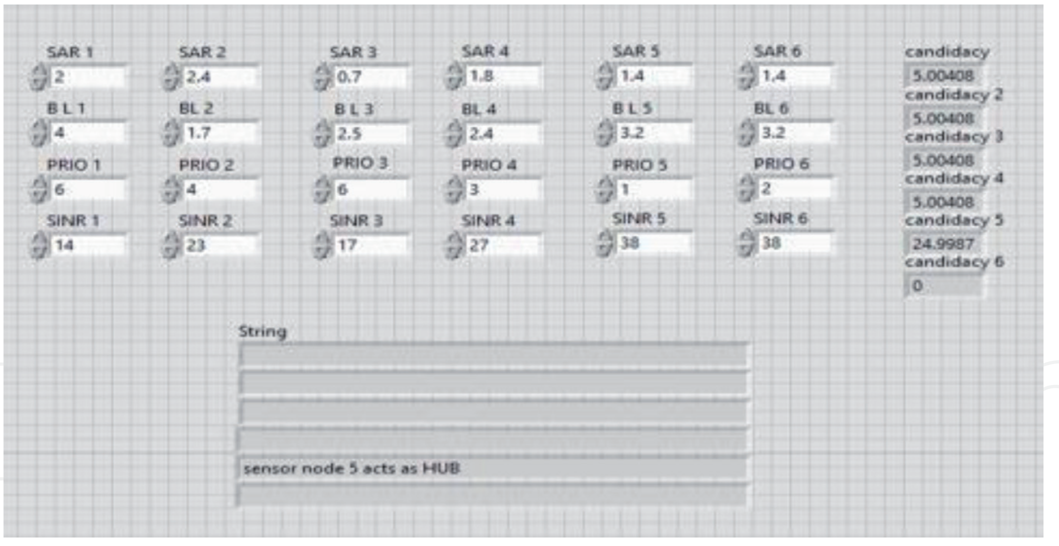

Figure 11.
Similar nodes HUB selection.

said having the least priority leads to un usage of a node for a long time which can enrich the network for the long run. This is laid out in **Figure 11**.

5.2 In prototype using sensors

The hardware kit developed here is made up of three pivotal sensors essential for the human body as of vitals. These are heart rate sensors, Blood pressure, and temperature. The heart rate sensor is a digital output that works using a microcontroller. When a finger is placed, it works on the light modulation on the illusion of blood flow, a red light which transfers from transmitter to receiver, counting the pulses through light flow. Generally used for the measuring of heart rate. Blood Pressure is measured using a mercury column. A Cuff with an oscillatory device in it is wrapped above the upper arm, where it produces vibrations in blood flow in the artery between systole and diastole pressures. The Aurdino Uno on the Arduino Desktop IDE (Arduino software) is used for code. An Arduino board is completely open-source and user-independent which uses a sketchbook, a place to store the programs. The Arduino program is developed by using a delay for our project to identify the sensor node to change as HUB. This can be negotiated for practical usage. The node change is identified by naming the sensors like A, B, and C.

The node change for values change in a mobile app is exposed as in above **Figure 12**. The last sensor used is LM 35, for measuring the temperature of a body. This also uses a microprocessor that converts the input and processed value to digital form for manual purposes. A finger grip for heart rate and a hand cliff BP equipment along with LM 35, temperature sensor are used for deployment of network and are together shown as in **Figure 11**.

The power supply is used for the input source to run the equipment. We can also find, collect or store the vital information collecting in the mobile app for further utility. The change in values for physical movement or activity or exercise results in the change of HUB, which is shown in the mobile app as below in **Figure 13**.

Here, in our chapter Arduino board is used for deploying the program in Micro Processor. A Bluetooth terminal is considered as NODES A, B, and C and performs the program as shown below. In this project, we are supposed to work offline. If we want to use Arduino UNO offline then an Arduino Desktop IDE needs to be installed. The UNO is programmed using the Arduino Software(IDE), our

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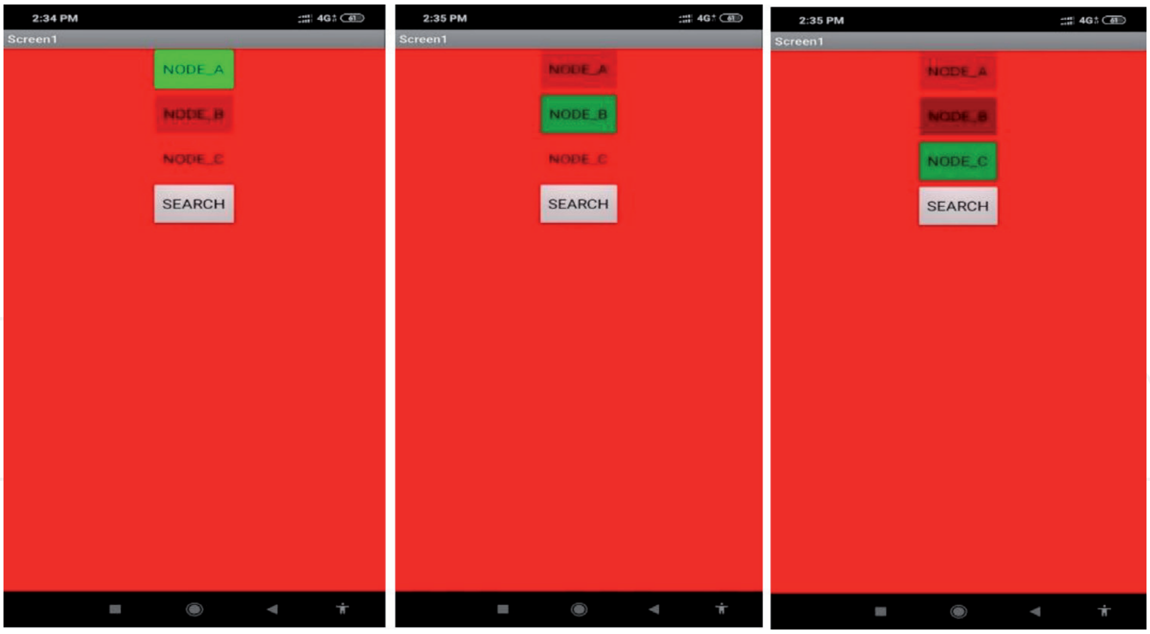

Figure 12.
Dynamic HUB identification.

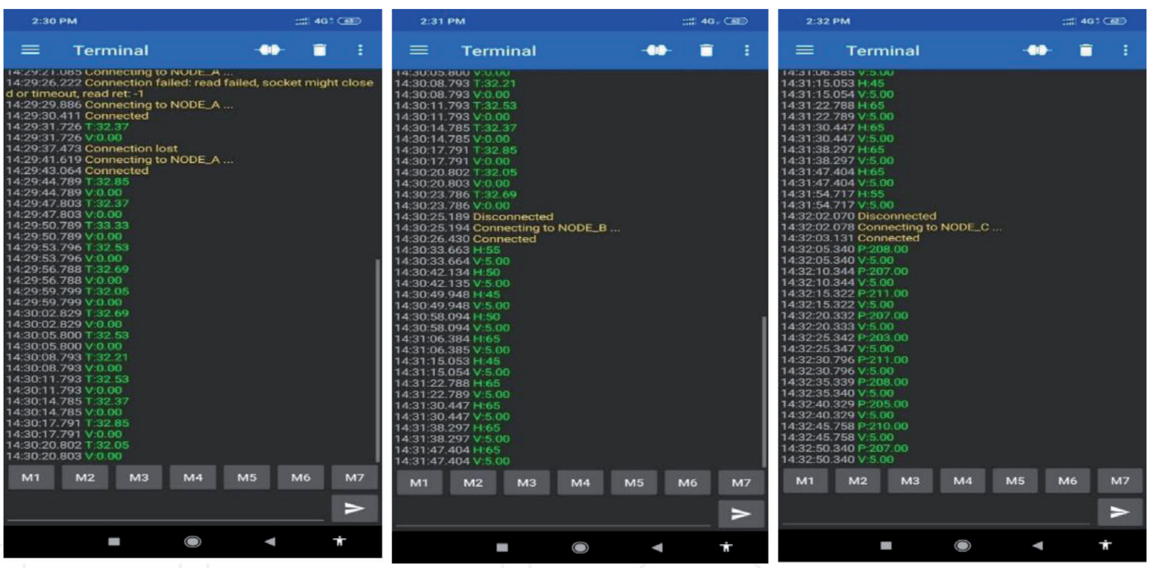

Figure 13.
Information in the node through the mobile app.

integrated Development common to all our boards. Connection is done from UNO board to system is through A B USB cable, sometimes known as a USB printer cable. Furthermore, the sensor nodes are connected with the desired pins in the micro-controller, which runs through the program shown below. The sensors give input to Arduino through a microcontroller, where the code is executed and gives the output in selecting a HUB based on the change in values of collected information. A delay function is used in our program for the identification of HUB change which is not required in real-time health monitoring.

6. Conclusion

The work carried out is to select a dynamic HUB for reducing the damage of tissue when an entire network is placed on a human body wirelessly to collect the data and send it to a receiver through a gateway. This chapter improvises the HUB features regarding fixed HUB drawbacks. With our proposed fuzzy-based framework, Hub can be changed from one sensor node to another with a change in parametric values manually. WBAN has become more reliable for patient monitoring. When compared to the one study about dynamic HUB, in this chapter, we imposed a new parameter to reduce the noise or interference of signal while the patient is in motion. This largely builds on the coherence of the system.

Practically, instead of using fixed HUB traditionally, a variable method is adopted and developed in the testbed. The sensors used in selecting the dynamic HUB are the heartbeat sensor, BP sensor(BP180), and temperature sensor(LM35), and other sensor nodes that can be utilized for other purposes of healthcare, in the real world. Different sensor nodes used in our project are real-time applications and the most useful values in analyzing a patient. The energy consumption of HUB that has a critical importance for the lifetime of WBAN is minimized, resulting in an extended network lifetime. By selecting a dynamic HUB, the load work on a traditional HUB decreases and share the burden among all other sensor nodes, which results the larger network life. To that, the selection of dynamic HUB results is reducing the damage of tissue while increasing the network lifespan. In the future, more parameters can be included either in software and hardware for efficient working of the network.

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Appendices and Nomenclature

Code for selecting a Dynamic HUB.

```
// code for Blood Pressure.
#include"Bluetooth.Serial.h".
#!defined(CONFIG_BT_ENABLED)||!defined(CONFIG_BLUEDROID_
ENABLED).
#ERROR Bluetooth is not enabled! Please run'make menuconfig' to enable it.
#endif.
BluetoothSerail SErialBT;
Void setup() {.
Serail.begin(9600);
SerailBT.begin("NODE_C);//Bluetooth device name.
Serial println("The device started, now you can pair it with Bluetooth!");
}
```

```
Void loop() {.
Float p = analogRead(34);
SerailBT.print("P:" + String(p));
Float v = analogRead(32)/200;
SerailBT.println("v:" + String(v));
Delay(5000);
}
//Code for heart Beat Sensor.
#include"Bluetooth.Serial.h".
#!defined(CONFIG_BT_ENABLED)||!defined(CONFIG_BLUEDROID_
ENABLED).
#ERROR Bluetooth is not enabled! Please run'make menuconfig' to enable it.
#endif.
BluetoothSerail SErialBT;
Int hs = 13;
Int hb = 0;
Void setup() {.
Serial begin(9600);
SerialBT.begin("NODE_B");//Bluetooth device name.
Serial.Println("The device started, now you can pair it with Bluetooth!");
}
Void loop() {.
Double x = millis();
hb = 0;
while(millis() < x + 5000).
{
If(digitalRead(hs)==0).
{
Hb = hb + 1;
Delay(300);
}
}
hb = hb*5;
SerialBT.print("H:" + String(hb));
Float v = analogRead(35)/200;
SerialBT.Println("V:" + String(v));
delay(3000);
}
//Code for Temperature Sensor.
#include"Bluetooth.Serial.h".
#!defined(CONFIG_BT_ENABLED)||!defined(CONFIG_BLUEDROID_
ENABLED).
#ERROR Bluetooth is not enabled! Please run'make menuconfig' to enable it.
#endif.
BluetoothSerail SErialBT;
Void setup() {.
Serial begin(9600);
SerialBT.begin("NODE_A");//Bluetooth device name.
Serial.Println("The device started, now you can pair it with Bluetooth!");
}
Void loop() {.
Float t = (analogRead(34)/2.7)/2.3;
```

```
SerialBT.println("T:" + String(t));
Float v = analogRead(35)/200;
SerialBT.Println("v:" + String(v));
Delay(3000);
}
```


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