International Journal of Engineering & Technology, 7 (2.8) (2018) 97-102

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research Paper



Implementation of bi-directional blue-fi gateway in IoT environment

P. Gopi Krishna [1] *, K. Srinivasa Ravi [1], P. Hareesh [2], D. Ajay Kumar [2], H. Sudhakar [2]

[1] Dept. of ECE, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Guntur, A.P, India 522502
[2]Asst. Professor, Dept. of ECE, Sir C R Reddy College of Engineering, Vatluru, West Godavari, A.P, India
**Corresponding author E-mail: gopikrishna.popuri@gmail.com*

Abstract

In the world of possibilities, IoT is playing a crucial role in development and automation of things which is making life easier, comfortable and most importantly reliable. This paper implements a new IoT Gateway, BLUE-FI designed to allow interconnection between Bluetooth and Wi-Fi protocols. This gateway gives us significant advantages. It enables us to transfer data between Bluetooth and Wi-Fi devices by renovating the protocols making it more simple and reliable, which obtains information from various sensors and convert them into a uniform format. With the huge possibilities in IoT, this paper implements an application of Blue-Fi gateway through Smart health monitoring system (SHMS). Here in SHMS we use different components to help us determine the health of a patient which is updated real time. This information, i.e., Bio-metric data is transferred to concerned Doctor and is also saved in cloud for future references in diagnosis. Our proof of notion demonstrates the performance and ability of the Bi-Directional Blue-Fi through smart health monitoring system (SHMS).

Keywords: *Arduino; Bluetooth; Gateway; Interconnection; Internet of Things; Raspberry Pi; Wi-Fi.*

1. Introduction

Internet of Things (IoT) has become the trend of Technologies [1] and it is growing rapidly to integrate many communication solutions and technologies. IoT is enabled by the fundamentals of wireless sensor network which integrates a large no of autonomous sensors into a network and passes the date through wirelessly through several hundreds or thousands of nodes commonly called Ubiquitous sensor network (USN) when it is integrated to IoT. [2] Continuous medical monitoring, controlling the appliances, emergency communication of the patient can be sent to the care take and doctor through the wireless networks. IoT plays a revolutionary role in all the health care systems by monitoring the appliances, individuals, medicine etc. and managing them continuously. [3][4]. In the present era the health care is provided from hospital centered, this will have transferred to hospital-home-balanced by 2020, and by 2030 it will be home centered. [5] When the patients are confined to mobility and location in a smart home or smart hospital then the data is facilitated by the gateways which key role for transferring the data to a remote location. The gateway acts as a hub between LAN, PAN, etc. The gate is power of many different protocols for communication with several different devices and node to receive and transmit the data, it can be added with some intelligence to its functionalities. Basing on these technology small devices are connected to from a remarkable network of things. According to the survey some These Small devices are used to sense, monitor and control objects around us [6]. Object may be living thing or non-living thing, using this technology we can get information to any corner of the world. Information is passed from physical objects [7] and are communicated using modules like Bluetooth [8], Wi-Fi, ZigBee and other traditional communication protocols. These devices have their own protocols to follow. We use these devices depending upon the factors like bandwidth, distance between devices, speed of transmission, cost, power [9] etc.

While supervising patient, a doctor primarily checks the heartbeat, pulse, blood pressure and temperature [10]. Basing on these conditions, room environment is to be controlled. For example, if patient is suffering with fever, best results of recovering can happen when patient is placed in correct temperature. This is how controlling plays a role in health monitoring. It is not only handy to doctor but also to patients as well. Patients can control electrical appliances near them.

To make this easy and affordable, we have designed patient monitoring systems based on Bluetooth and Wi-Fi gateway using Raspberry Pi through MQTT protocol to avoid the interoperability of different communication protocols.

In this paper we design a g Blue-Fi gateway for smart health monitoring systems using the Bluetooth and Wi-Fi, to present the concept of health care applications with performance, reliability, interoperability. The proof of gateway implementation is demonstrated by smart health monitoring and controlling system.

The rest of the paper is organized as the section 2 discuss the related existing work, section 3 describes about the proposed architecture section 4 describes about the implementation of the hardware, results are discussed in section 5 and conclusion.

2. Literature of existing work

Many protocols are interconnected through IoT which many wired or wireless but they don't understand each other. Based upon the several applications many gateways are proposed are knocking with many efforts. A frame work for WSN -IP network interconnection is for a generic gateway is proposed in [11]. A gateway

Copyright © 2018 P. Gopi Krishna et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

with ZigBee and GPRS in proposed in [12] for wireless sensor networks to facilitate the data transmission with protocol conversion. The author in [13] has implemented a "Smart IoT Gateway: with three data communication protocols Ethernet, 3G and bus RS485, this gateway is responsible for the protocols of protocols for the received data from different sensors. In paper [14] Protocol conversions, Request, Discovery and Intelligent caching functionalities a middleware, through a gateway which enable the application code execution and conversion is done between the CoAP and TCP/HTTP by using thw EZnet Protocol stack are discussed. A sensor network system consists of several sensing servers acting as gateway to connect different sensor networks this result in high hardware implementation as well cost and scalability of making this architecture is inefficient for many IoT applications [15]. The work presented in [16] prosed a generic gateway which capable of plug and play to provide a simple and rapid employment of various sensors and the gateway offers a proper bridging between heterogenous sensor networks. Guoqiang et al proposed a gateway which provides pluggable architecture which enables the communication among the heterogenous protocols, amalgamated external interface and flexible protocol translator for the data received from the sensors [17].An intelligent gateway using android phone instead of default gateway to reduce the cost and power of a smart is proposed by Bain et al in [18]. To improve the reliability of data transmission in wireless sensor network a ZigBee and Bluetooth protocol convertor on multi sink nodes is proposed in [19]. Many other contributions are done to propose application specific gateways: "Smart e-Health" gateway is designed as an intermediate between the internet and wireless sensor network which offers local storage, central processing and data mining [20]. In [21] a gateway is proposed for smart home based on OSGI which allows the interoperability, interconnection and enables automatic discovery of device with ZigBee, X10, UPnp and Insteon protocols. For sending data to the IoT cloud from the respective local networks a gateway is proposed in [22]. Finally, in [23] to enable the communication between cloud device computing and IoT a gateway based on fog computing is proposed.

In the above literature majority of the focused on implementing the gateways to interconnect the wireless sensor networks with internet and the environments enabled with cloud computing. Some of the authors have focused on specific domain such as smart home, smart health, smart monitoring etc. some of them are limited their level to conversion of specific protocols.

3. System architecture

The present patient screen frameworks in doctor's facilities permit persistent observing of patient key signs, which require the sensors to be hardwired to adjacent, bedside screens or PCs, and basically keep the patient to his healing facility bed. Indeed, even subsequent to interfacing these frameworks to a specific patient, a paramedical collaborator need to consistently screen and note down all the imperative parameters of a given patient by monitoring the greater part of his/her records physically. Receiving such a strategy is mistake inclined and may prompt calamity on account of a human blunder. In the current proposed framework the patient wellbeing is consistently checked by the Portable multi tolerant observing framework and the obtained information is transmitted to an incorporated microcontroller utilizing Remote Sensor Systems. A Bluetooth handset is associated with each patient screen framework that devours low power and is to a great degree little in size [8]. These are particularly intended for low power utilization, with insignificant circuit segments proposed for little parcel, long separation go applications and ordinarily comprise of a low power controller with negligible assets and interface capacities. These Bluetooth is having an information exchange rate of around 10 m. So the Remote Sensor Systems appear to be a flawless fit for remote patient observing.

To enhance the exactness and to expand the productivity of the above procedures an ongoing patient checking framework in light of Remote Sensor Systems and a unified microcontroller is incorporated with a Bluetooth module is composed. This paper depicts a free framework that naturally logs fundamental parameters of patients for simple get to. The information is available to specialists through cell phone for accommodation if necessary. The proposed model is described with the help of architecture diagram and the block diagram.

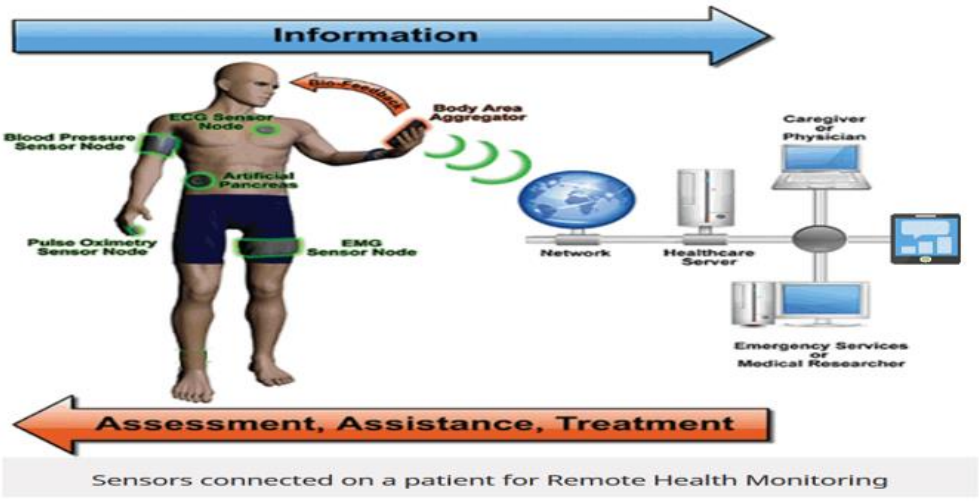


Fig. 3.1: Over All System Model Depiction Though Image.

Innovation assumes the significant part in human services for tangible gadgets as well as in correspondence, recording and show gadget. It is vital to screen different therapeutic parameters and post operational days. Subsequently the most recent pattern in Human services specialized technique utilizing IOT is adjusted. Web of things fills in as an impetus for the medicinal services and assumes noticeable part in extensive variety of social insurance applications. In this venture the Arduino Nano microcontroller is utilized as a door to impart to the different sensors, for example, temperature sensor and blood pressure sensor. The microcontroller gets the sensor information and sends it to the system through Bluetooth and thus gives continuous checking of the medicinal services parameters for specialists. The information can be gotten to at whatever time by the specialist [24]. The controller is likewise associated with bell to caution the overseer about variety in sensor yield. However, the significant issue in remote patient observing framework is that the information as to be safely transmitted to the goal end and arrangement is made to permit just approved client to get to the information. The security issue is being tended to by transmitting the information through the secret key

ensured Bluetooth module and the clients/specialist can get to the information by logging to the html page. [25] At the season of limit circumstance ready.
The interconnection between different components is explained using the architecture of system. Architecture diagram is shown in figure 4.1 The patients connect the sensors to their body and the other end of the sensors is connected to Bluetooth. The data acquired by sensors is stored in the Raspberry pi. The data values (i.e. Biometric data) are shown on mobile/PC. All the values are stored on the server and the most recent value is displayed on webpage. The doctor along with their login credentials can login and see the patient data. Doctors can see all previous records of a patient and suggest medicines and changes in prescription. Also, patients are given unique user id and password to view their records.

4. Architecture of gateway

The design of the system is briefed by giving out the working, flowcharts, hardware components and software components.
Patient monitoring gateway system is developed by raspberry pi which is fully customizable, easy to use, reliable, low cost and programmable. It is comparatively economic since it has components like Bluetooth modules and Wi-Fi modules for communication and large amount of ram and processor. The Bluetooth module in the raspberry Pi module receives the data from all the Bluetooth sensor which are paired, and convert the data into unique format and uploads the data to the cloud according their addresses. In the same Pi receives the data, signal or commands from the remote location through Wi-Fi, converts the data format and controls the appropriate appliances basing on the address.
Patient's parameters like temperature, heart beat rate, blood pressure, pulse etc. depending upon the application and availability of sensors are used and all the sensor are connected to the Arduino which is interface with Bluetooth which transmits the patients Bio-Metric data. This Bio-Metric Data is fed to raspberry pi from Bluetooth modules, which are connected to sensors. Once the data is received Later this information is transferred to server wireless using Wi-Fi module. Since this Bio-Metric data is sensitive information only authorized personnel can view this. Authorization is given only to Doctors, Nurse and family members.
This system maintains the record and data of the patient in its database and can be accessed whenever doctor wants to check the patient status and this data can also for the future aspects of the patient. In the same way the doctor or the other privileged member of the patient can monitor and control the appliance near the patient.

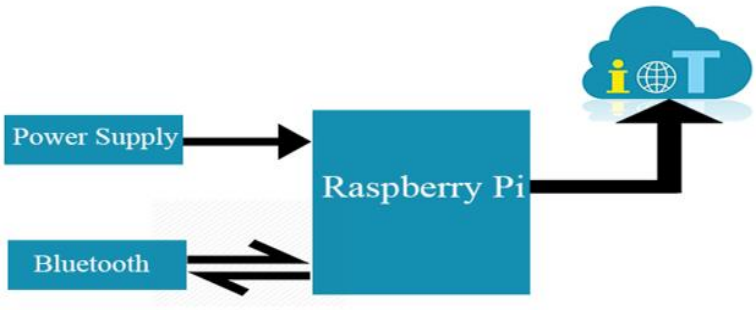


Fig. 4.1: Gateway Using Raspberry Pi.

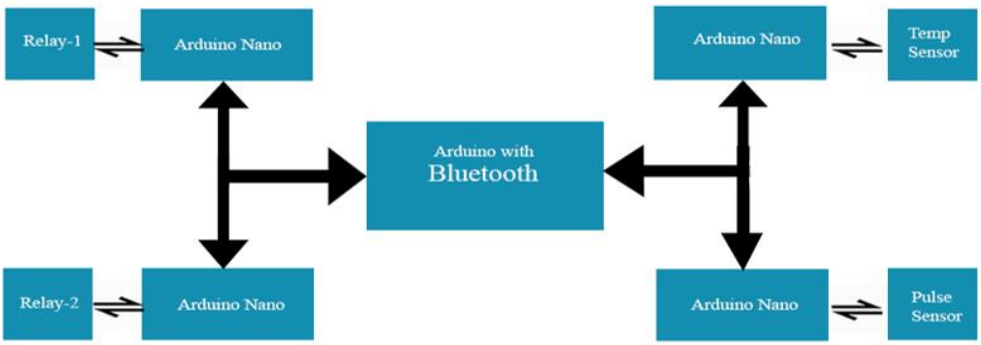


Fig. 4.2: Block Diagram of Bluetooth Interfacing with Various Sensors.

5. Hardware implementation

a) hardware implementation

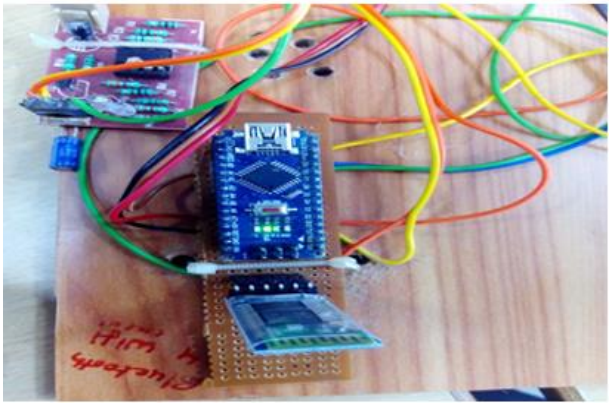


Fig. 5.1: Blue-Fi gateway.

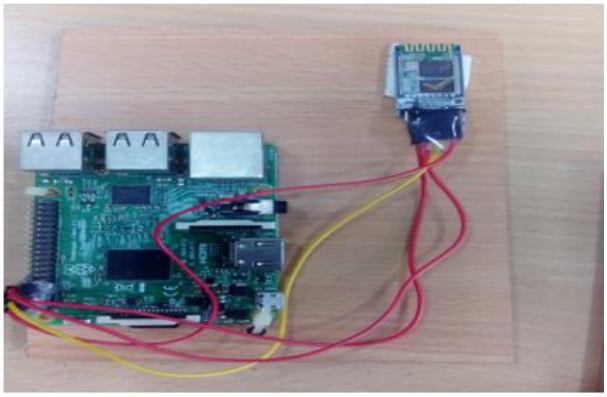


Fig. 5.2: Bluetooth Setup at Patients Module.

He above Fig 5.1 is a gateway made of Raspberry Pi. This Bluetooth module acquires data from the sensors which are connected to patient's body with Arduino Nano . The data received is transformed in and sent to cloud using Wi-Fi which is an inbuilt part of raspberry pi. We have used all things talk website for convenient sake and created a data base in the cloud which shows the different parameters of a patient. The module in figure 5.2 is used to receive and transmit data from and to sensor nodes as well as Blue-Fi gateway. The sensor node used the Arduino Nano as the controller. Data is transmitted in serial manner from the modules making it an effortless way of communication.

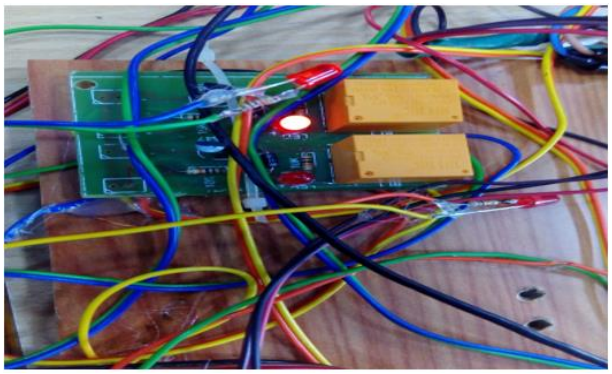


Fig. 5.3: Connection of Relays with Arduino Nano to Control the Appliance in the Patient Room.

Relay can be operated through website or Mobile app, we have connected LED's to show the output. This relay is connected to Arduino Nano which is in turn connected to Bluetooth.

b) Working

In this we will utilize Arduino Nano which consists of ATMEGA 328 microcontroller, LM35 for measuring the patient's body temperature, Pulse oximeter for recording the pulse of the patient, Raspberry pi which acts as gateway programmed with python, HC-05Bluetooth modules that are connected to Arduino Nano and sensors to obtain data from the patient to Pi is our objective. In this wehave utilizedArduinoNano for serial correspondence for which those serial TX and Rx pins will be shorted with Bluetooth Rx, Tx pins and by this we can set up correspondence amongst Bluetooth and Nano.Thus, transmitting the information got that is temperature utilizing LM35 and that information we get from its yield is in millivolts and utilizing its affectability recipe that is 10mv/c gets changed over to temperature esteem will be transmitted serially utilizing transmitter on Nano to Bluetooth.And that serial correspondence is controlled utilizing hand-off which is an electromechanical switch and has an associated and one non-associated terminals we utilize it on the grounds that to maintain a strategic distance from impact of information from Nano and other transmitting devices.And alongside temperature we additionally send the beat rates utilizing pulse oximeter. The standard of heartbeat oximetry depends on the red and infrared light retention qualities of oxygenated and deoxygenated hemoglobin. Oxygenated hemoglobin retains more infrared light and permits more red light to go through. Deoxygenated hemoglobin assimilates more red light and permits more infrared light to go through. Red light is in the 600-750 nm wavelength light band

The particular does not indicate the importance of "little code impression" or the significance of "constrained system transmission capacity". Subsequently, the convention's accessibility for utilize relies on upon the specific situation. MQTT-SN is a variety of the principle convention went for implanted gadgets on non-TCP/IP systems, for example, ZigBee. Truly, the "MQ" in "MQTT" originated from IBM's MQ Arrangement message lining product offering. Notwithstanding, lining itself is not required to be upheld as a standard element in all circumstances. [28].

c) Flowcharts

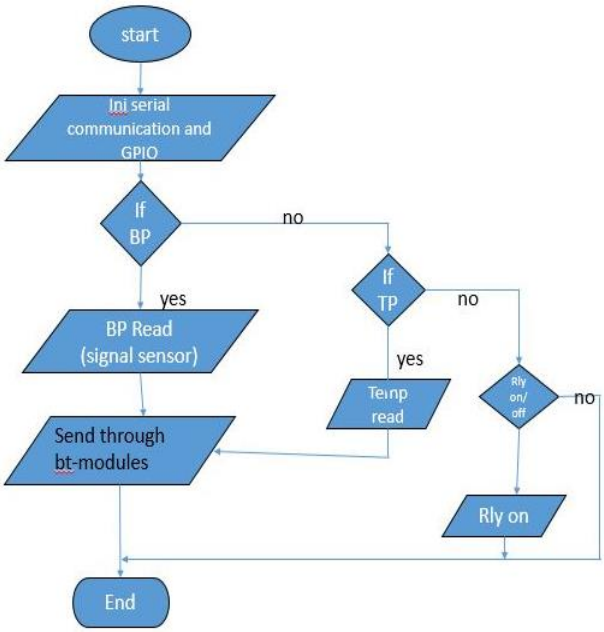


Fig. 3.4: Flowchart of Arduino Module.

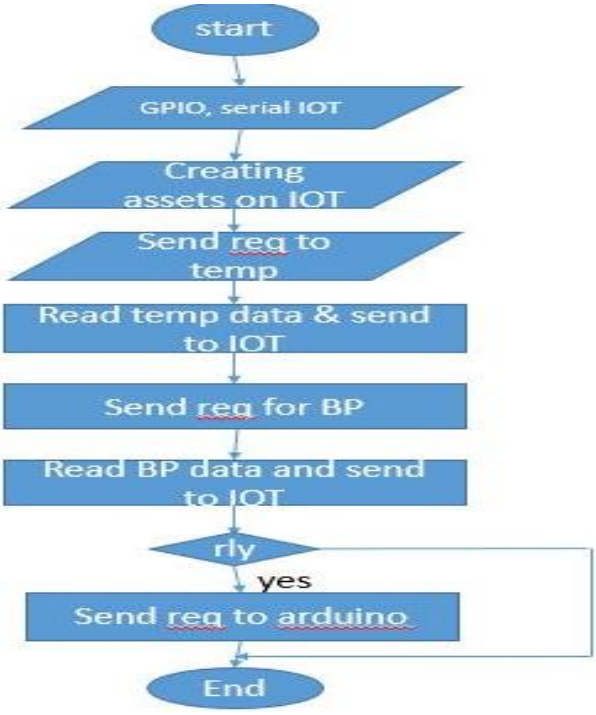


Fig. 3.5: Flowchart of Raspberry Pi Used as Gateway.

d) Data transformation

In IoT environment the sensor devices capture the data from various devices and those devices have different formats that are available in the data sheets. The gateway's primary function is to transform the data into a unique format for exchanging among the

devices. This formation is done by the address to which the data has to be transferred.

e) Data processing

IoT need to have a good latency time to close to the sensors and Actuators. The latency time decrease by processing all the sensor information to avoid this problem the gateway processes the data based on the analysis, Condition and actions which are predefined. If the data obtained from the sensor condition set by the application event, the gateway detect the event and sends a signal to actuator and give notification to the external user.

f) Protocol conversion

The gateways act as bridge connection and a translator between the Bluetooth and Wi-Fi.The gateway will be listening for the connection requests from the port interfaces and establishes a communication. When the gateway receives a data packet it compresses the source pack and maps it to a packet format according to the protocol used by the destination. These devices transmit the data in a network through MQTT message which can be implemented with less than 64kb of RAM. Publication/Subscription type of architecture is implemented by MQTT though a broker and central node. Here the gateway will be a broker

g) Data Storage

The gateway stores the data locally as well as in the cloud and can be obtained through the web application or in mobile app

6. Results

The results show the data obtained from different sensor nodes. Figure 6.1 show the app on the android mobile which contains the patient monitored data. In figure 6.2 shows the mobile app for switching the appliances ON and OFF. In figure 6.3 and figure 6.4shows the current Blood Pressure and temperature, 6.4 shows the history of blood pressure and temperature.

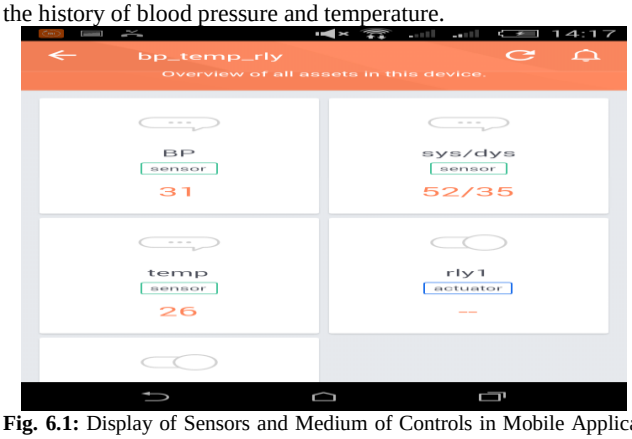


Fig. 6.1: Display of Sensors and Medium of Controls in Mobile Application.

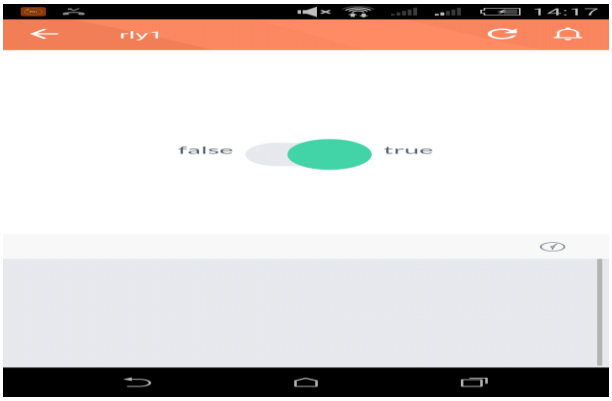


Fig. 6.2: Controlling of Relays by Mobile Application.

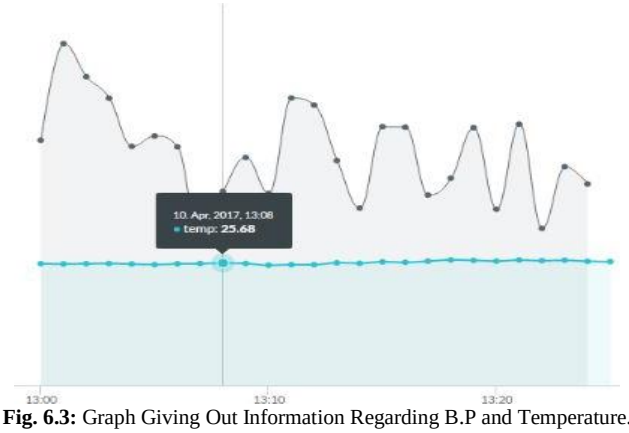


Fig. 6.3: Graph Giving Out Information Regarding B.P and Temperature.

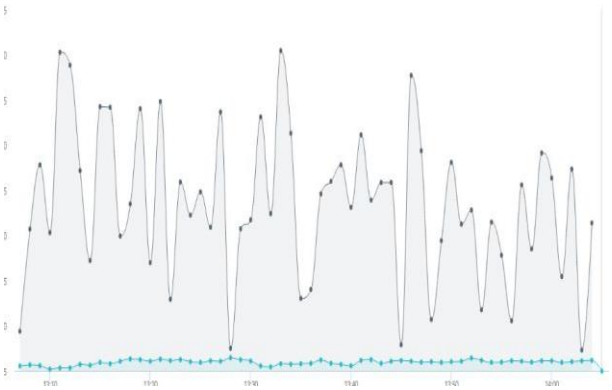


Fig. 6.4: Graph Giving Out Information Regarding the History of B.P and Temperature of Patient.

7. Conclusion

A Bi-Directional gateway is implemented and tested by taking health monitoring as a case study. This system monitors the pulse rate, temperature and the blood pressure in the PC screen by using the Raspberry Pi and it monitors and controls the fan and light in the room. This entire system requires less power which can even implemented in remote (mobile) patients too. We can add some another parameter as per our necessity. This system canbe used in many applications for wireless monitoring system. We can assimilate other wireless protocols and design a multiprotocol gateway which provisions all the wireless protocols and for multipurpose applications.

References

[1] A.H. Ngu, M. Gutierrez, V. Metsis, S. Nepal and Q. Z. Sheng, "IoT Middleware: A Survey on Issues and Enabling Technologies," in *IEEE Internet of Things Journal*, vol. 4, no. 1, pp. 1-20, Feb. 2017. https://doi.org/10.1109/JIOT.2016.2615180.

[2] Ubiquitous Sensor Networks (USN). ITU-T Technology Watch BriefingReport Series, (4), 2008.

[3] Dohr et al. The internet of things for ambient assisted living. In Proceedingsof the International Conference on Information Technology:New Generations, pages 804–809, 2010. https://doi.org/10.1109/ITNG.2010.104.

[4] M.D. Miorandi. Internet of things: Vision, applications and research challenges. Ad Hoc Networks, 10(7):1497 – 1516, 2012. https://doi.org/10.1016/j.adhoc.2012.02.016.

[5] Mari Carmen Domingo. An overview of the internet of things for people with disabilities. Journal of Network and Computer Applications, 35 (2): 584 – 596, 2012. https://doi.org/10.1016/j.jnca.2011.10.015.

[6] R. Want, B. N. Schilit, S. Jenson, "Enabling the Internet of Things", *IEEE Comput.*, vol. 48, no. 1, pp. 28-35, Jan. 2015. https://doi.org/10.1109/MC.2015.12.

[7] A.Yao, Q. Z. Sheng, S. Dustdar, "Web-based management of the Internet of Things", *IEEE Internet Comput.*, vol. 19, no. 4, pp. 60-67, Jul./Aug. 2015. https://doi.org/10.1109/MIC.2015.77.

[8] H. Jin and S. Zhao, "A New Parallel Instruction Model Based on Multi-Tasking Bluetooth Communication," *2016 12th International Conference on Computational Intelligence and Security (CIS)*, Wuxi, 2016, pp. 638-641. https://doi.org/10.1109/CIS.2016.0154.

[9] A. Jin-Shyan Lee, Yu-Wei Su, and Chung-Chou Shen. A Comparative Study of Wireless Protocols: Bluetooth, UWB, ZigBee, and Wi-Fi. The 33rd Annual Conference of the IEEE Industrial Electronics Society (IECON) Nov. 5-8, 2007, Taipei, Taiwan

[10] Ghosh, S. Aich, A. K. Ghosh, P. Das, S. Mahato and A. Dey, "Patient health monitoring system," 2016 International Conference on Intelligent Control Power and Instrumentation (ICICPI), Kolkata, 2016, pp. 114-117. https://doi.org/10.1109/ICICPI.2016.7859685.

[11] K.A. Emara et al. A gateway-based framework for transparent interconnectionbetween WSN and IP network. In Proceedings of theEUROCON, pages 1775–1780, 2009.

[12] Q. Zhu et al. IoT Gateway: BridgingWireless Sensor Networks intoInternet of Things. In Proceedings of the International Conference onEmbedded and Ubiquitous Computing, pages 347–352, 2010.

[13] S. Guoqiang, C. Yanming, Z. Chao, and Z. Yanxu, "Design andimplementation of a smart IoT gateway," in Green Computing andCommunications (GreenCom), IEEE and Internet of Things(iThings/CPSCom), IEEE International Conference on and IEEECyber, Physical and Social Computing, 2013, pp. 720–723.

[14] D. Bimschas, H. Hellbrück, and R. Mietz, "Middleware for smartgateways connecting sensornets to the internet," in Proceedings ofthe 5th International Workshop on Middleware Tools, Services andRun-Time Support for Sensor Networks. ACM. 2010, pp. 8–14.

[15] Cooking hacks. Homepage on Health Sensor Platform V2.0 for Arduino and Raspberry Pi [Biometric / Medical Applications] [Online]. Available:https://www.cookinghacks.com/documentation/tutorials/ehealth-biometric-sensor-platform-arduino-raspbery-pi-medical

[16] Ding Yi, Fan Binwen, Kong Xiaoming and Ma Qianqian, "Design and implementation of mobile health monitoring system based on MQTT protocol," 2016 IEEE Advanced Information Management, Communicates, Electronic and Automation Control Conference (IMCEC), Xi'an, 2016, pp.1679-1682. https://doi.org/10.1109/IMCEC.2016.7867503.

[17] Shaik.Razia, M.R.Narasingarao,G R Sridhar published "A Decision Support System for Prediction of Thyroid Disease- A Comparison of Multilayer Perception Neural Network and Radial Basis Function Neural Network" in JATIT (Journal of Theoretical and Applied Information Technology, 31st October 2015. Vol.80. No.3) ISSN: 1992-8645

[18] Shaik.Razia, M.R.Narasingarao published "Machine learning techniques for thyroid disease diagnosis - A review" in Scopus Indexed Journal INDJST (Indian Journal of Science and Technology, ISSN: 09746846, volume-9, Issue 28, July 2016, Article number 93705).

[19] Dr. Seetaiah Kilaru, Hari Kishore K, Sravani T, Anvesh Chowdary L, Balaji T "Review and Analysis of Promising Technologies with Respect to fifth Generation Networks", 2014 First International Conference on Networks & Soft Computing, ISSN:978-1-4799-3486-7/14,pp.270-273,August2014.

[20] Meka Bharadwaj, Hari Kishore "Enhanced Launch-Off-Capture Testing Using BIST Designs" Journal of Engineering and Applied Sciences, ISSN No: 1816-949X, Vol No.12, Issue No.3, page: 636-643, April 2017.

[21] P Bala Gopal, K Hari Kishore, B.Praveen Kittu "An FPGA Implementation of On Chip UART Testing with BIST Techniques", International Journal of Applied Engineering Research, ISSN 0973-4562, Volume 10, Number 14 , pp. 34047-34051, August 2015.

[22] A Murali, K Hari Kishore, D Venkat Reddy "Integrating FPGAs with Trigger Circuitry Core System Insertions for Observability in Debugging Process" Journal of Engineering and Applied Sciences, ISSN No: 1816-949X, Vol No.11, Issue No.12, page: 2643-2650, December 2016.

[23] A.Mahesh Mudavath, K Hari Kishore, D Venkat Reddy "Design of CMOS RF Front-End of Low Noise Amplifier for LTE System Applications Integrating FPGAs" Asian Journal of Information Technology, ISSN No: 1682-3915, Vol No.15, Issue No.20, page: 4040-4047, December 2016.

[24] N Bala Dastagiri, K Hari Kishore "Novel Design of Low Power Latch Comparator in 45nm for Cardiac Signal Monitoring", International Journal of Control Theory and Applications, ISSN No: 0974-5572, Vol No.9, Issue No.49, page: 117-123, May 2016.

[25] N Bala Gopal, Kakarla Hari Kishore "Reduction of Kickback Noise in Latched Comparators for Cardiac IMDs" Indian Journal of Science and Technology, ISSN No: 0974-6846, Vol No.9, Issue No.43, Page: 1-6, November 2016.

[26] S Nazeer Hussain, K Hari Kishore "Computational Optimization of Placement and Routing using Genetic Algorithm" Indian Journal of Science and Technology, ISSN No: 0974-6846, Vol No.9, Issue No.47, page: 1-4, December 2016.

[27] N.Prathima, K.Hari Kishore, "Design of a Low Power and High Performance Digital Multiplier Using a Novel 8T Adder", International Journal of Engineering Research and Applications, ISSN: 2248-9622, Vol. 3, Issue.1, Jan-Feb., 2013.

[28] Harikishore Kakarla, Madhavi Latha M and Habibulla Khan, "Transition Optimization in Fault Free Memory Application Using Bus-Align Mode", European Journal of Scientific Research, Vol.112, No.2, pp.237-245, ISSN: 1450-216x135/1450-202x, October 2013.

[29] T. Padmapriya and V. Saminadan, "Improving Throughput for Downlink Multi user MIMO-LTE Advanced Networks using SINR approximation and Hierarchical CSI feedback", International Journal of Mobile Design Network and Innovation- Inderscience Publisher, ISSN : 1744-2850 vol. 6, no.1, pp. 14-23, May 2015.

[30] S.V.Manikanthan and K.srividhya "An Android based secure access control using ARM and cloud computing", Published in: Electronics and Communication Systems (ICECS), 2015 2nd InternationalConferenceon 26-27Feb. 2015, Publisher: IEEE, https://doi.org/10.1109/ECS.2015.7124833.