A Rough Set Based System for Analyzing Databases

Aaron Don M. Africa, Raine Mattheus C. Manuel, Joshua Vincent G. Ligayo, Emmanuel C. Del Rosario

Abstract: Internet of Things or IOT is the future of technological automation that helps everyday living easier. An application of IOT is for building or home automation. With regards to which parts of the building, creating a smart lighting and ventilation system is one way to implement IOT. This paper aims to create a system model for smart home lights and ventilation systems where they can be monitored and controlled wirelessly with Bluetooth connection. The main controller of the lights and mechanical ventilation is the Arduino microcontroller which has a Bluetooth module that would transmit and receive signals to the end-device which is a mobile phone. The mobile phone is equipped with an application that monitors the status and allows the user to control the lights and ventilation. The group was able to create a system model for lights and ventilation control and status monitoring using a mobile device, which connects to the microcontrollers through Bluetooth connectivity in a full-duplex connection. These systems have databases, the Rough Set Theory was used to analyze them.

Index Terms: Bluetooth, Internet of Things, Automation, Lights, Mechanical Ventilation, Low-power, Rough Set Theory, Optimization

I. INTRODUCTION

In today’s world, it is the information age where multiple devices across the world are interconnected. A lot of objects are being developed to become smart objects that allow them to be connected to different devices. These smart objects can be interconnected through a network and they could work together to create an automated environment. To create this type of environment, the objects interconnected should be able to receive and transmit data using electronic devices and sensors, software applications, and a network [1]. These components are embedded in the objects part of the interconnected environment. The network between the objects and the people using it is called the Internet of Things.

In this project, only the lights and ventilation of a house will be focused on for the network at home. Both lights and ventilation are controlled by their respective microcontrollers which in this research, an Arduino Uno microcontroller. The Arduino microcontroller is equipped with a Bluetooth module for communication and an end-device, which sends instructions to the microcontroller and receives information back, will utilize its Bluetooth module. In this study, the end-device chosen was a smartphone, which is used frequently by people on a daily basis. The smartphone is equipped with a programmed software that would allow the lights and ventilation to be controlled at the same time, receive the status info on the lights and ventilation. This system also promotes understandable user interface and helps reduce power consumption [2].

II. BACKGROUND OF THE STUDY

With the emergence of smart devices, living conditions have been made easier. With a simple touch of a button, a person can turn on and off an appliance or an electronic device wirelessly. The integration of a wireless network wherein all devices are connected and controlled wirelessly has made life even easier. The network wherein all electronic devices are connected can be attributed to the Internet of Things (IOT) [6,7]. The concept of Internet of Things aims to enhance the living conditions of people by connecting everything for a person to be able to access everything with ease. The concept of smart home is closely related to the concept of IOT. A smart home is implemented using IOT. A smart home connects various facilities through a network [8]. A smart home can be implemented on even the most basic yet essential part in a person’s home like lights and ventilation. The concept of smart home and IOT can be applied to a home’s lighting and ventilation which allows them to be accessed through a controller like a smartphone.

There are a lot of researches on IOT and the implementation of a smart home but these researches use complex ideas in trying to further improve these technologies. An essential yet overlooked part of all of these concepts is its power consumption. As systems get more complex, they use more and more power. One approach to this problem is by using a low-powered bluetooth network. A bluetooth network is a popular short-range communication protocol common in almost all mobile phones. Bluetooth low energy is a popular technology in the implementation of IOT. It is a most suitable for low power consumption wireless consumption. This study aims to make a smart home with emphasis on a home’s lighting and ventilation as power efficient as possible and as user friendly as possible. The database of this system will be analyzed using the Rough Set Theory [9,10].

III. STATEMENT OF THE PROBLEM

With the fast advancement of modern technology in today’s information age, a lot of people are falling behind due to inaccessibility to new technology mainly because they are costly, and a lot are not user-friendly. Internet of Things technology is one modern technology that is very costly to implement because a lot of purchasable IOT devices are costly for the mass. With this current issue, in the future, many will fall behind, failing to be connected to the modern world. Another issue is that a lot of people consume power excessively and to counteract this, there must be an automated way to prevent the problem. These problems must be addressed as soon as possible because the world is evolving fast and to create a connected...
world through interconnected technology for every person, people should have access to affordable, user-friendly, and energy-efficient technology, starting with Internet of Things implementation at each residence.

IV. SIGNIFICANCE OF THE STUDY
The study aims to provide insight on the further development and improvement of technology that contributes to living conditions of people through the concept of IOT. This study will not only contribute in the further development of IOT systems and smart homes but also give an alternative approach to the study of these concepts in the form of power efficiency and ease of access. The study will also help provide insights in the different implementations of IOT systems and smart homes. Since the study will use a bluetooth protocol in the implementation of the project, future research can benefit from this study by further researching on how bluetooth is one of the most suitable approaches in controlling different devices in a small proximity. Other research can also benefit from this study by using bluetooth as a low-power network system in the implementation of IOT systems and smart homes. Ultimately, the main purpose of the study is to improve the living conditions of human beings. As technology rapidly advances, different technologies make things easier for humans like wirelessly controlling appliances, electronic devices and house facilities through smart homes and IOT systems make this very evident. The research will contribute to the connection and communication of all our devices for ease of access.

V. DESCRIPTION OF THE SYSTEM
The study will focus on finding a means to wirelessly control a home’s lighting and ventilation in the implementation of a smart home. The lights and ventilation of the system of the home will have a microcontroller, Arduino Uno. The Arduino Uno will be connected to a bluetooth module that will serve as its transmitter and receiver to an end-device or a smartphone. The end-device or smartphone will send instructions and receive information back from the lighting and ventilation. The end-device or smartphone will have an interface to allow ease of use for the smart home controller. Through the app interface, the smartphone would allow the lights and ventilation to be controlled at the same time and receive the status info on the lights and ventilations.

VI. METHODOLOGY
The researchers plan to have a low-cost and flexible standalone smart home system which is designed using RESTful based web services and bluetooth. It consists of an Arduino Ethernet as the controller, with the hardware modules. The smart home system has features such as human proximity sensor, temperature sensing, and temperature adjustment. The master controller has a web server running which consists of Arduino 2560 and Arduino Ethernet shield and other hardware such as ultrasonic sensor, which would be used to coordinate actions with the other sensor module. The system is designed to control more than switching, because it is designed to be low cost and energy efficient, and automatic home environment control. Furthermore, it also supports voice signals for switch functionalities. The Android based smart home app would be designed using the Massachusetts Institute of Technology App Inventor v.2. In the main menu screen it would show the controls, upon changing a devices parameters there would be a pop-up that would ask for a password. Access is only granted when the said credentials match. The usage of the proximity sensor is to switch off the lights and ventilation if no human heat is detected in the surroundings.

VII. REVIEW OF RELATED LITERATURE
A smart home system helps you by making your life easier. It could control everything you own in the house in a click. To aid humans to efficiently do task and save energy has been the goal of a smart home. As such IoT based smart home poses itself as a solution to different technological problems. Because of its independence, therefore, the system has no distance limitations. However, Bluetooth application provides a very low cost, flexible and suitable capability when applying it to a smart home system [9]. Because smartphones became a necessity in human life to help them be efficient that it has a wide range of applications such as healthcare, entertainment, and education usage of proposed smart home system using bluetooth has been successful with the features of being low cost and effective [8]. Another approach is to use Bluetooth Low Energy to improve the energy management of the system as it still is low cost this aims to address the costs of high power rating loads of energy-consuming devices [10]. Additionally, we could add features in cooperation with bluetooth such as operation status monitoring, internal data processing, and information feedback [11]. Additionally, we could also pair bluetooth with the use of PIC technology and it would still have its low cost and flexibility [12]. A variation of bluetooth smart home may also come in having a smart grid wherein, it also has capabilities to harvest energy [13]. The system may also different kinds sensor like fire, light and motion sensors to help to check appliances that uses excessive energy [14]. It could also be a sensors like ultrasonic and soil moisture sensors to help check the garden and irrigation system [15]. A specialized system could be done a specific one is for disabled people which uses assistive domestics that could be used in the future for hospitals and homes it integrates with the usage of WiFi to be able to maximize the efficiency of the system [16]. However, the most common limiting factor to the usage of bluetooth is the distance but for persons who are disabled, this helps them by having accessible technology they would not waste energy [17]. In addition, we could also add servo motors to utilize the bluetooth module by having fast switching and speed control, and light intensity control [18]. Bluetooth could also cover a specific part of the house an example of this is a smart lock system for doors that is only opened when the password is entered or the smartphone is in the perimeter for it to be controlled [19]. We could also improve the system by identifying the white space frequency to improve network throughput and performance of the bluetooth home automation system [20]. Similarly, aside from the sensors that were mentioned...
above a voice sensor to help those who are physically unable to do so [21]. In the same fashion, we could also make a security-based system which incorporates bluetooth in the door it could also check the status not only to lock and unlock the door in case a problem may arise like someone trying to open the door forcefully [22]. However, we may opt to add a lot of sensor but bluetooth protocol stack is not required for a network of sensor as bluetooth is ideal for small scale use [23]. Similar to how a thermostat reads the temperature of the air we could also have a thermometer based on bluetooth that could rapidly read the body temperature to help those who’re sick to change the temperature accordingly [24]. An application of bluetooth of railway application to detect a moving object toward it could also be used in smart homes when it detects the owner’s house the garage door would open [25]. A variant-hop scatternet may be used so that the network would also organize itself [26]. The usage of bluetooth is flexible that it could also be used to detect human physiological parameters as such we could detect blood oxygen, pulse, and blood pressure this parameters are important for those who have heart disease and could detect and send the information instantly in a smartphone that whenever grave happens the phone could call an emergency ambulance [27]. A camera may also be used as a wireless visual sensor with the usage of bluetooth we could get a status update from the sensor if there is an undetermined object that was detected [28]. An addition for the Bluetooth Low Energy devices mentioned above is it is also have good data throughput and simple software stack [29]. Similar to the door lock its aim is to secure the garage door for the car that it could only be accessed by mobile phone to have it locked or unlocked [30].

VIII. THEORETICAL CONSIDERATIONS

1. Internet of Things (IOT) - Is a network of networks that process and exchange data. The network is usually comprised of various electronic devices that exchange data with each other. The concept of IOT heavily relies on the transmission medium in order for the network to communicate reliably. Communication of IOT devices are usually wireless. Commonly, the interconnection of devices is made through the Internet, however, some other wireless means like Bluetooth and ZigBee is being used for IOT implementation.

2. Bluetooth - Bluetooth can be used as an IOT implementation because of the introduction of Internet Protocol Support Profile (IPSP). It is now capable of a link-layer connection and devices are able to detect each other.

3. Microcontroller - a microcontroller is a small computer in an integrated circuit that used in control automation of devices. Microcontrollers are essential in the implementation of IOT devices. Since some IOT devices are just normal devices a microcontroller is used in order for them to communicate with other IOT devices.

4. Rough Set Theory – It is a proper approximation of pair sets which produce the lower and upper approximation of the original set [31,32].

IX. DATA AND RESULTS

The design created by the group can be seen in figure 1. This, however, is just a system model and lacks actual testing of the practical circuitry. Figure 1 shows the system block diagram where the lights circuit and the mechanical ventilation control circuitry is connected to their respective Arduino microcontrollers. The microcontrollers are equipped with Bluetooth modules that allows the microcontrollers to communicate with the end-device (i.e. smartphone) through Bluetooth wireless communication.

The usage of Arduino microcontrollers allows for a low-power consumption system that will control the lights and mechanical ventilation. The Arduino microcontroller is also programmed to send information to the end-device of the status of the lights and ventilation if they are on or off. The Arduino can also be programmed to limit the time of operating period of either the lights or ventilation to ensure saving of energy.

The smartphone is equipped with an application that connects to the microcontrollers via Bluetooth connection and with the app, the end-user can control manually the lights or mechanical ventilation or set a time limit for operations so that the microcontrollers can automatically turn off the systems to save energy. These components were chosen for this project because they allow for a low-power consumption and smooth wireless communication with a smartphone device, which is almost present with everyone in today’s information age.
XI. CONCLUSION

The research done was implemented using Arduino. It was used as a home automation system to detect human presence and to change the room temperature and light system accordingly. Its database was analyzed via Rough Set Theory. The process of the system works by an automatic system. Then, if the user wants to override the home system he would be asked to input his password and then, he would be able to change the parameters of the system.

XII. RECOMMENDATIONS

This research paper is only limited to making a system model for the Internet of Things implementation of lights and mechanical ventilation control at home. This allows for an energy-efficient system at home that helps conserve energy by having an automated control to the lights and ventilation and having manual control wirelessly through the user’s smartphone. This research paper lacks on implementing the final physical product and is only limited to a theoretical model. For future studies, the group recommends implementing the model found in this paper and study data on its energy usage and how it impacts a household.

Lights and ventilation are not the only parts that can be connected through the system model designed in this project. A lot of things such as different household sockets can be wirelessly controlled in order to maximize power conservation. A socket extension can be used to control electricity flow wirelessly again, like the paper suggests, through the use of Bluetooth connection and with the use of smartphone which is accessible to the mass today.

Besides Bluetooth, other types of network can be used to implement the whole system. If a household has a stable internet connectivity, the wireless local area network (WLAN) can be implemented to the system model instead of Bluetooth connections. This can help make the system more user-friendly because the devices will be connected to the same network. Using an internet router for the local area network is also better than using Bluetooth modules because it can be accessible for a farther distance.

The system model found in this paper can also be used for reference on future models to make a cost-effective implementation of Internet of Things technology to the mass households. It is also recommended to test the system using cheaper microcontrollers for cheaper implementation and low power consumption.

REFERENCES

1. S. Soumya, M. Chavali, S. Gupta, and N. Rao, “Internet of Things based home automation system,” 2016 IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT), 2016.
2. M. D’Souza, N. Wilfred, R. Pereira, T. Rayen, and A. Telgote, “Home Automation using Internet of Things,” 2017 International Conference on Energy, Communication, Data Analytics and Soft Computing (ICEDCS), 2017.
3. A. Koochang, J. Nord, and J. Psalszkiecisz, “The Internet of Things: Review and theoretical framework,” Expert Systems with Applications, Vol. 133, 97-108, 2019.
4. P. Ray, “A survey on Internet of Things architectures” Journal of King Saud University - Computer and Information Sciences, Vol. 30, No. 3, 291-319, 2018.
5. M. Li, W. Gu, W. Chen, Y. He, Y. Wu, and Y. Zhang, “Smart Home: Architecture, Technologies and Systems,” Procedia Computer Science, Vol. 131, 393-400, 2018.
6. S. Raza, P. Misra, Z. He, and T. Voigt, “Building the Internet of Things with bluetooth smart,” Ad Hoc Networks, Vol. 57, 19-31, 2017.
7. Gentili, R. Sannino, and M. Petracca, “BlueVoice: Voice communications over Bluetooth Low Energy in the Internet of Things scenario,” Computer Communications, Vols. 89–90, 51-59, 2016.
8. V. D. Vaidya and P. Vishwakarma, “A Comparative Analysis on Smart Home System to Control, Monitor and Secure Home, based on technologies like GSM, IOT, Bluetooth and PIC Microcontroller with ZigBee Modulation,” 2018 International Conference on Smart City and Emerging Technology (ICSCET), Mumbai, 1-4, 2018.
9. A. Africa, “A Rough Set-Based Expert System for diagnosing information system communication networks,” International Journal of Information and Communication Technology, Vol. 11, No. 4, 496-512, 2017.
10. Z. Palwak, Rough Sets: Theoretical Aspects of Reasoning about Data. Boston, MA: Klüwer, 1991.
11. Z. Yufeng and J. Ruqiao, “Design and Realization of the Smart Home Control System Based on the Bluetooth,” 2015 International Conference on Intelligent Transportation, Big Data and Smart City, Halong Bay, 286-289, 2015.
12. V. Puri and A. Nayyar, “Real time smart home automation based on PIC microcontroller, Bluetooth and Android technology,” 2016 3rd International Conference on Computing for Sustainable Global Development (INDIACom), New Delhi, 1478-1484, 2016.
13. S. Courreges, S. Oudji, V. Meghdadi, C. Brauers and R. Kays, “Performance and interoperability evaluation of radiofrequency home automation protocols and Bluetooth Low Energy for smart grid and smart home applications,” 2016 IEEE International Conference on Consumer Electronics (ICCE), Las Vegas, NV, 391-392, 2016.
14. A. Shinde, S. Kanade, N. Jugale, A. Gurav, R. A. Vatti and M. M. Patwardhan, “Smart Home automation system using IR, bluetooth, GSM and android,” 2017 Fourth International Conference on Image Processing (ICIP), Shimla, 1-6, 2017.
15. M. Asadullah and K. Ulah, “Smart home automation system using Bluetooth technology,” 2017 International Conference on Innovations in Electrical Engineering and Computational Technologies (ICEECT), Karachi, 1-6, 2017.
16. R. A. Ramle, D. H. Z. Tang and M. M. Ismail, “Smart home system for Disabled People via Wireless Bluetooth,” 2012 International Conference on System Engineering and Technology (ICSET), Bandung, 1-4, 2012.
17. B. Debathn, R. Dey and S. Roy, “Smart Switching System Using Bluetooth Technology,” 2019 Aumni International Conference on Artificial Intelligence (AICAI), Dubai, United Arab Emirates, 760-763, 2019.
18. S. Das, S. Ganguly, S. Ghosh, R. Sarker and D. Sengupta, “A bluetooth based sophisticated home automation system using smartphone,” 2016 International Conference on Intelligent Control Power and Instrumentation (ICICPI), Kolkata, 236-240, 2016.
19. M. S. Hadis, E. Palantei, A. A. Ihann and A. Hendra, “Design of smart lock system for doors with special features using bluetooth technology,” 2018 International Conference on Information and Communications Technology (ICOICT), Yogyakarta, 396-400, 2018.
20. D. Sunehra and V. Tejaswi, “Implementation of speech based home automation system using Bluetooth and GSM,” 2016 International Conference on Signal Processing, Communication, Power and Embedded System (SCOPES), Paralakhemundi, 807-813, 2016.
21. N. B. Tshiluna et al., “Analysis of bluetooth and Wi-Fi interference in smart home,” 2016 International Conference on Advances in Computing and Communication Engineering (ICACCE), Durban, 13-18, 2016.
22. D. Sunehra and V. Tejaswi, “Implementation of speech based home automation system using Bluetooth and GSM,” 2016 International Conference on Signal Processing, Communication, Power and Embedded System (SCOPES), Paralakhemundi, 807-813, 2016.
23. J. Potts and S. Sukittano, “Exploiting Bluetooth on Android mobile devices for home security application,” 2012 Proceedings of IEEE Southeastcon, Orlando, FL, 1-4, 2012.
24. C. Dethe, W. Wakde and C. Jaybhaye, “Bluetooth Based Sensor Networks Issues and Techniques,” First Asia International Conference on Modelling & Simulation (AMS’07), Phuket, 145-147, 2007.
25. H. Li and J. Luo, “Wireless Thermometer Based on Bluetooth 4.0 Low-Energy,” 2014 Seventh International Symposium on Computational Intelligence and Design, Hangzhou, 80-83, 2014.

26. Á. Hernández, A. Valdovinos, D. Perez-Diaz-de-Cerio and J. L. Valenzuela, “Bluetooth low energy sensor networks for railway applications,” 2017 IEEE SENSORS, Glasgow, 1-3, 2017.

27. C. Yu and Y. Yu, “A Variant-Hop Algorithm in Forming Bluetooth Sensor Networks,” 2013 IEEE Eighth International Conference on Networking, Architecture and Storage, Xi’an, 302-306, 2013.

28. P. Bai, J. Li, Y. Li and X. Duan, “Application of mobile Bluetooth based on human physiological parameters wireless sensor,” 2016 IEEE International Conference on Consumer Electronics-China (ICCE-China), Guangzhou, 1-3, 2016.

29. L. Ferrigno, A. Pietrosanto and V. Paciello, “Low-cost visual sensor node for BlueTooth-based measurement networks,” in IEEE Transactions on Instrumentation and Measurement, Vol. 55, No. 2, 521-527, April 2006.

30. E. Mackensen, M. Lai and T. M. Wendt, “Bluetooth Low Energy (BLE) based wireless sensors,” SENSORS, 2012 IEEE, Taipei, 1-4, 2012.

31. Z. Palwak, K. Slowinsky, and R. Slowinsky, “Rough classification of patients after highly selective vagotomy for duodenal ulcer,” International Journal of Information of Machine Studies, Vol. 24, No. 1, 413-433, 1998.

32. A. Africa, “A rough set based data model for heart disease diagnostics,” ARPN Journal of Engineering and Applied Sciences, Vol. 11, No. 15, 9350-9357, 2016.

AUTHORS PROFILE

Dr. Aaron Don M. Africa is an Associate Professor at De La Salle University Manila.

Raine Mattheus C. Manuel is an Electronics Engineering Student at De La Salle University Manila.

Joshua Vincent G. Ligayo is an Electronics Engineering Student at De La Salle University Manila.

Emmanuel C. Del Rosario is an Electronics Engineering Student at De La Salle University Manila.