

A Review Paper on Home Automation with Human Behaviour

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Abstract— Smart homes have been viewed with increasing interest by both home owners and the research community in the past few years. One reason for this development is by using modern automation technology such as Arduino in the home or building, it promises considerable savings of energy. Therefore simultaneously reducing the operational costs of the building over its whole lifecycle. At present one of major issue in Sri Lankan society is high electricity consumption. As a solution for that we are proposing a system which identifies human behaviour to make decisions mainly for lighting. The integration of these everyday systems will give the average homeowner the control they desire within their home easily. This work highlights various current systems with their pros and cons and how to prevent those weaknesses.

Keywords— smart home, automation, arduino

I. INTRODUCTION

The concept called “home automation” has been there since the late 1970s. (Cyril Jose and Malekian, 2015) But with the advancement of technology in both software and hardware fields, people’s expectations of how an automation should work or the way that the services should be provided has changed a lot during the course of time. So idea of “home automation systems” were improved day by day. This work highlights various flaws in existing home automation systems. In this paper, it has addressed what is Home automation and how it works under various technologies with advantages and disadvantages of them. After that the challenges in home automation systems from the point of view of both the homeowner and a commercial user. This work goes on to explain why home automation systems are such attractive targets for an attacker and how the various technologies handle it.

Under the first topic it has mainly considered about a brief introduction about this review paper and what is the content of the whole paper. Under the second topic “technical review” it presents a brief explanation about various home automation systems that exist and some concepts that are planning to build. It also mention about the technologies which were used to make these kind systems much more efficient and user friendly to the user. In “technological review” the main target was to address the technologies that were used while the researches

completing their projects such as neural networks, programming boards etc... The work concludes by explaining future directions home automation System Research could take in much more efficient and cost effective way.

II. SYSTEM REVIEW

Under this topic it has been described about the existing home automation systems and the systems which are still in development stage or which are still concepts. If we look at various home automation systems over the course of time, developers have always tried to provide efficient, convenient, and safe ways for home inhabitants to access their homes. Irrespective of the change in user expectations, advancement of technology, or change of time, the role of a home automation system has remained the same.(Cyril Jose and Malekian, 2015) Each and every system uses various kinds of technologies to implement there system and there are advantages and disadvantages of using those.

The paper called “Home Automation Systems - A Study” (Palaniappan et al., 2015)by S. Palaniappan, N. Hariharan, N. T. Kesh, S. Vidhyalakshimi briefly describe about some home automation systems. Based on all the systems surveyed with their pros and cons, this paper presents the features to be added to an ideal system for home automation with remote access. In this paper it shows comparison between systems such as Bluetooth, GSM, mobile based, Zigbee and Wi-Fi. The systems that have been considered by the researches have mentioned about certain common features. All of them are based under a same principle which is those kind of systems use a basic underlying communications technology. The pros and cons of the system originate according to the underlying technology. All of those systems have a controlled electrical structure which is used to connect with the electrical peripherals. They have mentioned about a common command system that will be used to issue commands to the control circuits. A major part in the system is done by the user interface. This decides how the user will interact with the system and extent of control the user applies while them using the system. This effects the usability and the user friendliness of the system. Most systems have security features as well. It has added to ensure only authorized access to avoid unauthorized accessing and unauthorized updating of current data to protect confidentiality and integrity of the system. To

prevent that most of the systems use various kinds of security mechanisms. At the same time these kind of system should be available from all over the world to a user and in real time. These are the main points that the research considered from the overall study.

There's another paper which was concerned about above technologies. That paper is "An overview of home automation systems" (Asadullah and Raza, 2016) by M. Asadullah and A. Raza. In this paper different home automation systems were surveyed with their strengths and weaknesses. As an example Bluetooth based system is a flexible and low cost medium, but that kind of system is limited to a short range of Bluetooth wireless network. System which are controlled by the voice recognition are most suitable for elderly and handicapped people, because they can control them by saying the name of appliances or by using a specific key word. Such systems are noise sensitive and the problem is accuracy can be affected by signal to noise ratio (SNR). So this kind of system is not suitable for a noisy place. Another automation mechanism used is ZigBee RF modules for the implementation of wireless network. Inside these kind of wireless networks the user has the full remote controlled access of home appliances. In this paper a GSM based module is also studied and according to this system user can control and monitor the home appliances via text message from his or her mobile phone. But these kind of systems are much more slowly compared to other systems. Internet of things based home automation system can only work in the presence of internet. The rapid growth of IOT devices brings concerns and benefits. The future of home automation system requires to make homes smarter and more convenient to make things easier to the user. As for the future work it is suggested to develop image processing based home automation system using the technologies which discussed above. In such kind of automation system, home appliances will be controlled by different gestures which will be identified through the camera. Moreover, home automation system could be developed by using technologies such as interfacing biomedical signals (Electromyography (EMG) signal) with computer, it will offer opportunity to amputee to control appliances from different arm gestures. It will be useful in area of robotics for controlling robot through gesture for different tasks. In addition, future work would be implementation of above discussed home automation systems on a much more large scale, such as factories, industries, offices etc.

So if we take those technologies individually, first we can concern about the Bluetooth technology. The paper called "Bluetooth Based Home Automation and Security System Using ARM9" (Naresh et al., 2013, p. 9) by D. Naresh, B. Chakradhar, and S. Krishnaveni, has clearly stated about how that research used Bluetooth

technology to fulfil the need of home automation. This paper put forwards the design of home automation and security system using ARM7 LPC2148 board. Home appliances are directly connected to the board and communication is established between the board and ARM9 using a Bluetooth device. According to the paper, that low cost system was designed to improve the standard living in home. Its remotely controlled by ARM9 provides help and assistance especially to disabled and elderly. In order to provide safety protection to the user, all the electrical switches were replaced by the low voltage activating switches. Moreover implementation of wireless Bluetooth connection in control board allows the system installation in more simple way. The control board was directly installed beside the electrical switches. So the switching connection was controlled by relay. Furthermore, flexible types of connections were designed as backup connections to the system in a case of emergency. The connected GUIs are fully synchronized with the ARM board. They show the real-time switches status to the user. The system is designed in a very much user-friendly way with a good interface. As for the future work, they were planning to implement the speech recognition in order to control via voice control. In that current system all the voice signal inputs to the ARM9 were transmitted to the Window GUI for signal processing. These are the key features which were mentioned on that paper. Due to the use of Bluetooth, the weakness of that system was the range of the system was concluded into a small area.

There was a paper called "Smart GSM based Home Automation System" (Teymourzadeh et al., 2013) by R. Teymourzadeh, SalahAddin Ahmed, Kok Wai Chan, and Mok Vee Hoong, mainly concerning about the GSM based system. This research work investigates the potential of "Full Home Control", which is the aim of the Home Automation Systems in near future. The study and implementation of the home automation technology using GSM used a modem to control home appliances such as light, air conditional system, and security system via SMS. The proposed system was mainly focused on the functionality of the GSM protocol, which allows the user to control the target system away from residential, using the frequency bandwidths. For the development of the smart GSM-based home automation system they have used the concept of serial communication and AT-commands. So home owners will be able to get a feedback status of each and every home appliances under control whether it is switched on or off remotely from their phones. So simply the mobile phone acts as the remote in this system. That proposed prototype was implemented and tested by the researchers with maximum of four loads and shows the accuracy of more than 98%. Finally with that kind of big accuracy this system would have been an effective system.

Another research was concerned with the use of GSM technology for their system. That was “Microcontroller Based Home Security System with GSM Technology,” (Hasan et al., 2015) by R. Hasan, M. M. Khan, A. Ashek, and I. J. Rumpa. In this paper, design and implement of a microcontroller based home security system with GSM technology have been presented and analysed. Mainly with two microcontrollers and other devices such as LED, LCD display, Buzzer and GSM Module are used for reliable operation of the proposed system. They added some ways to input to the system. First way is that the mobile phone is interfaced with microcontroller through a Bluetooth device in order to control the system. Then, a manual keypad is another way to lock or unlock the system. A Compiler Code “Vision AVR” is used to design a program that controls the system along with maintaining all functions such as controlling and security. That paper presented design and implementation of a smart home security system based on microcontroller along with GSM for user friendly application. That system was intelligent enough to monitor environment. At the same time, the user is informed about each and every security breach using GSM network that provides a special opportunity whenever the user stays at far away from home. However, Android application was the most spectacular feature in order to control the system through a Bluetooth device. The system has provided the reliable operation within reasonable cost and removes the system complexity. In this work, traditional burglar alarm mode, LED lights and LCD are the promising features used to ensure reliability. The whole system was developed on a practical home security system which requires significant effort to install it. The system is also appropriate for commercial purposes because of versatile ways of security, confidentiality and controllability. At the latter part of that paper it concluded with test results of practical circuit which show the proper functionality and also validate the reliable security compared with its reasonable cost.

Few researches concerned about using Wi-Fi technology for their system. One of them is “Design and implementation of a WIFI based home automation system,” (ElShafee and Hamed, 2012) by A. ElShafee and K. A. Hamed. That paper basically concerned about the design and prototype implementation of new home automation system by using WiFi technology as a network infrastructure connecting its main parts. That proposed system consists of two main components such as the server and the hardware interface module. That paper proposed a low cost, safe, universally accessible, auto-configurable, remotely controlled solution with many more functions. The main approach stated in the paper has accomplished the target to remotely control home appliances by using the Wi-Fi as the medium to connect system parts. Wi-Fi technology capable solution has

proved to be controlled remotely, provide home security and is cost-effective by comparing to the previous systems. In that paper the system design and the main architecture used were discussed briefly, and prototype presented the basic level of home application control then the remote monitoring was implemented according to the design. Finally, the proposed system was better from the scalability in the point of view by comparing to the previous automation systems. Unlike most of available automation system in the market, that system was scalable because by using one server can manage many hardware interface components as long as it is in the range of that WiFi network coverage.

Another research mentioned about the wireless method “Zigbee” as their technology. That paper was “Wireless home automation system using zigbee,” (Arul, 2014) by S. B. Arul. This paper contained the overall design of a wireless home automation system that was constructed and implemented. Main concept of that project on recognition of voice commands and uses low-power RF ZigBee wireless communication components which are quite cheap than other technologies. The home automation system was proposed to control all lights and electrical applications in an ordinary home or office using voice commands. The system was tested and confirmed. The main verification tests included voice recognition response test which was known as the “indoor ZigBee communication test”. That test involved sending a total of 70 basic commands and the rate of efficiency was 80.05%. Main target of that system was elderly and disabled people. This research had worked to achieve main four key features which are

- Low Power
- Interoperability
- Mesh Networking
- Robust

The system implements voice recognition unit using HM 2007. That system implemented the wireless network using ZigBee modules for their efficiency and low power usage. So the end test results were promising in that project because of those reasons.

There was a research called “Intelligent Home Automation System using BitVoicer,” (Krishna and Lavanya, 2017) by I. Krishna and K. Lavanya which is also concerned about technology in Zigbee. In most of developed countries, many households have home automation systems which notice their environment and act on the data to trigger home devices. But these systems are not very popular in developing nations with compared to developed nations due to their high pricing. Also, almost all of these kind of systems are hard coded so they just giving decisions based on the iterative conditions it recorded. The proposed Zigbee based automation system

and Wi-Fi network are combined through a mutual home gateway. That combination simply offers network interoperability, a simple and a user friendly interface, and remote access to the system. That proposed system was very useful for elderly and physically disabled persons who mainly needed the physical assistance for daily requirements. It removes the limitation of wiring difficulties and also the range of voice commands can be increased by using wireless routers and internet of things. On the off chance the practical usefulness and the cost of that automation decrease will enable compatibility with future technologies for improved user support. It mainly stated that creation capacity as well as innovation level of the system was going to enhance increasingly. In Future, by using a technology like Arduino, it can enable the control via central server through smart mobile phones.

Another related system which was created “Self-configuring home automation networks based on psychophysical principles,” (Flessner and Frenken, 2016) by is J. Flessner and M. Frenken. That paper says that the apparent comfort of building environment may be improved by the development of the interaction between users and home automation control. A higher level of interaction is possibly achievable by including the psychophysical condition of the users. A methodical way for the design of an adaptive automation system was presented. A fundamental part of this method was the comparison between current guiding principle and discoveries about the effect of environmental factors on the user’s mental and physical condition. The main application of this method was basic principle for the design of building controls. According to the researcher it could lead to the creation of healing environments. To respond dynamically on changes of the user’s condition, a rule base system had to be developed to create a self-configuring automation system. As the future works, the implementation of the idea for a selected subset such as ventilation, heating or lighting had to be done to review the feasibility of the proposed system. For that purpose, the interface between user and automation control need to be designed. One opportunity is the use of identification mechanisms to dynamically react according to different people inside the building environment. At the same time according to the identification of the users, an adaptive home automation system needs to respect different people with various requirements. Therefore the process to handle changing or oppositional requirements is required according to the opinion of the specific researcher.

According to the current systems and current technologies which are mentioned above, it can be concluded to a single table for the features of each and every system under the system review.

System	Primary Communication	Remote access	Number of Devices	Cost	Speed	Real Time
GSM	SMS messages	Access from anywhere in the world	Unlimited	High cost due to SMS charges	Slow due to delivery issues	No
Bluetooth	Bluetooth and AT commands	Restricted to Bluetooth range- 10m	Unlimited	Fast due to proximity	Fast due to proximity	Yes
Phone Based	Phone lines	Anywhere with a phone line	12 due to 12 frequencies of DTMF	Fast	Fast	No
Zigbee	Zigbee and AT commands	Around 10m	Unlimited	Fast	Fast	Yes
Wireless	Radio, infrared or other waves	Depending on range and spectrum of waves used	Unlimited	High cost due to licensing and other spectrum issues	Slow due to interferences	Yes

Table 1. Current Systems

III. TECHNOLOGY REVIEW

Under the sub section of technology review it has mainly considered about some papers which are deeply discussed about some technologies related to the proposed system. The first paper is “A tool for the analysis of energy systems in Smart Cities,”(Fabbri et al., 2016) by G. Fabbri, C. M. Medaglia, D. Sbordone, and B. Di Pietra. This paper mainly considered about the analysing energy usage and identifying the patterns within those records. Cities represent three quarters of world energy usage and 80% of CO₂ emissions globally being the most dangerous of any environmental policy challenge. To deal with this continuous urban growth there should be new methods to manage cities and make them more efficient in order to prevent those kind of problems. The union between the world of energy and the field of information technology, will pave the way for a new bionetwork of services which should enable both reduction of energy consumption and improve the better quality of life. Due to the massive development in the field of IT, it is converting all economic sectors, including energy to an optimized way than the past. In this paper the main issues related to smart grids and their integration with the cities will be analysed emphasizing the significance to set of simulation tools and models aimed at facilitating feasibility analysis for smarter energy technologies.(Fabbri et al., 2016) according to that paper a simplified tool was under development to introduce to the micro grid and distributed power systems projects. The tool takes in account both conventional and renewable technologies for energy and that was designed to simulate as a micro grids or as a distributed generation within a larger grid. According to that paper the first results from that tool had been compared with experimental results and by using these kind of data from previous tests and used to perform simulations of various systems.

There’s a paper which mainly considered about how to identify the human behaviour for such kind of a system. The paper is “(Ebeid et al., 2016),” by E. Ebeid, R. Heick, and R. H. Jacobsen. A framework for deducing user

behaviour from smart meter data has been presented in that paper. According to the researcher the framework separates the disaggregation analyses from the natural language data processing. It uses uniform interfaces to exchange data seamlessly between its items. It relies on a shared database which enables easy upgrades of the framework components. Experiments have been performed and the results have been evaluated for choosing the data reconstruction and Load Disaggregation Algorithm (LDA) algorithms. The experiments have shown the complete framework's data flow process starting from aggregating the main meter data and ending by delivering natural language reports. The experiments have validated the feasibility of the framework. Future work will include analysis of multiple users' behaviour. Different smart meter data will be utilized for improving the detection accuracy of the LDA algorithms. At the same time the researcher also concerned about the privacy of the user as well.

The paper called "Home automation system with android application," (Azni et al., 2016) by M. N. Azni et al is mainly considered about how to use android to create such a system. This work demonstrates a simple home automation system that permits the consumer to control home applications via wireless medium such as Wi-Fi using an android application. Electronic peripherals such as Lights, A/C, electronic doors and fans could be used in that proposed system. In this system, the controlling and monitoring the appliances can accomplish by using mobile based on Android application. The web interface had framework known as Restful Api and function as to control Raspberry Pi gpio using an http request. Besides that, Android apps will exploit the services provided by Restful Api for controlling gpio of Raspberry Pi. Both the methods are using Restful Api but it is included in the web interface, whereas for Android we need to add their suitable functionalities. The server software was run in a desktop PC. Raspberry Pi board was used as the main board to connect the appliances thru input ports and output ports. The communication between the smartphone and the Raspberry Pi board is based on a wireless network such as WiFi. As the conclusion, that system could be defined as useful application to everyone and especially for disabled and elderly people. This system also had been developed with a user friendly Interface to allow more users will able to implement the system in a much cheaper way. According to the researcher's point of view that project also can be developed by adding support to iPhone (iOS) and Windows Mobile user because smart phones users use other type of operating systems as well. By covering all of these main types of mobile operating system, it can increase the compatibility of the system. Therefore, more users will be able to use the system and be more beneficial to society.

IV. DISCUSSION

This paper gives a brief comparison of all the above systems described. The systems that have been studied have certain common features. All these systems use a basic underlying communications technology. The advantages and drawbacks of the system derive from this underlying technology. All the systems have a control circuitry that is used to interface with the electrical appliances. There has to be a common command system that will be used to issue commands to the control circuits. The next important feature of the system is the user interface. This determines how the user will interact with the system and extent of control the user exerts over the system. According to my knowledge the user interface should come with a web application which has a linked mobile application. So that people who are using all kinds of operating systems can access the system without having a problem. Such a system should also have the feature of being easy to install and user friendly as well. Only then can automated homes become commercially viable from user to user. There should be a lot of thought put into the design of the user interface for the project. This influences the usability of the system. Most systems also have security features to ensure only authorized access.

V. CONCLUSION

Future scope for the home automation systems involves making homes even smarter than today. Homes can be interfaced with various kinds of sensors such as motion sensors, light sensors and temperature sensors and provide automated toggling of devices based on conditions. More energy can be conserved by ensuring occupation of the house before turning on devices and checking brightness and turning off lights if not necessary. The system can be integrated closely with home security solutions to allow greater control and safety for home owners. The next stage would be to extend this system to automate a large scale environment, such as offices and factories.

Based on all the systems surveyed with their advantages and drawbacks, this paper presents the features to be possessed by an ideal system which was created for home automation. By reviewing those research papers which related to the area of home automation and related works to that area. Finally the reader can get a brief idea about what should he do and what shouldn't do during the implementation process. Plug and play capabilities might be an added bonus for the system as a further development. Ease of adding a new device to an automated house will play an important role in taking forward the systems commercially.

This paper mainly concerns about two major areas which are home automation and report generating. It has mentioned there are various options. But all these may not provide a desired accuracy therefore depending on the

problem domain choosing the best option would be of paramount importance for a successful result.

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