Designing Smart Home System with Bluetooth Low Energy

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***Abstract*—This paper presents about smart home automation systems and the communication protocols that are possible to be implemented to the system. This paper is generally divided into two main parts which are concept parts then, in the later section, the paper will dive into our project which implements one of the many communication protocols that exists in this world. Firstly, the paper discusses the many options of communication protocols, their advantages and disadvantages, then, later in the first section, presents our choice of communication protocol to be implemented for our project and our reasoning behind it. It should be noted that for each communication protocol, the detailed specification will also be included. The second section will present our full implementation of our project which will include diagrams that describe our project and present our findings on the project assigned.**

1. INTRODUCTION

Smart home denotes the use of technical systems, automated processes and connected, remote-controlled devices in apartments and houses. The main objective of the functions is to improve the quality of life and convenience in the home. Other goals are greater security and more efficient use of energy thanks to connected, remote-controllable devices. How does a smart home differ from a regular home? A smart home is equipped with technologies that make our lives more convenient and energy efficient. Today, the growing range of technologies encompasses smart home appliances, mobile devices and home automation systems, many of which are interconnected.

It’s human nature to find ways that make everyday life easier and more pleasant. The area of home automation in effect the predecessor of the smart home was brought to life through technological progress, in particular through the Internet and computer. Science fiction literature in the 1950s portrayed the first visions of homes that are monitored and controlled fully automatically by machines. The 1999 Disney film “Smart House” was about household computers and the consequences when smart machines take on a life of their own. And Disney proved to be unintentionally visionary in the part of the movie where the house’s intelligent control unit develops the feeling of jealousy. In reality, it will likely be a few years before machines can generate emotions, fortunately.

Scientists have already been working for more than 30 years on connecting home appliances and automating their use. Yet it’s only been in the past 15 years that the issue of the smart home has aroused broad public interest.

At its most basic, a smart home is one that uses so-called “smart” technology to automate and operate important tasks and devices, including lighting, heating and cooling, door locks for home security and not to forget fire alarms to increase home safety. Smart technology is technology that senses what is happening around a particular sensor or device and acts autonomously based on the information it collects. For example, a smart device might sense someone walking into a room and open the shades or turn off the lights or turn up the heat or whatever we have programmed it to do. The goal with these devices is to make your home “smart” enough that we are not bothered by manually performing mundane operations. In this thesis, we focus on prediction models in the smart home and their applications in designing various smart home services. We specifically focus on this category of prediction models and adopt a sequential prediction technique based on text compression algorithms for predicting the occupancy and mobility of the smart home residents. To evaluate the performance of the proposed solutions, a flexible small-scale smart home is constructed using motion sensors and a microcontroller. Several movement scenarios are designed, and the data has been collected by programming the microcontroller and the physical components.

For decades now, a wide range of different home appliances have helped make everyday life more pleasant, speed up processes and hence save time and work. So, what additional benefits does our smart home project deliver? Without the smart home, the impetus for a machine’s every action has to come from humans, who start processes manually and activate each device individually at the right time. The smart home relieves them of this work by enabling components to communicate with each other.

1. EASE OF USE
2. *Problem Statement*

One of the most obvious energy-wasting habits is leaving the lights on, and it’s also one of the easiest habits to fix. By simply turning off the lights when you leave a room or your home, you will save electricity and help your lightbulbs last longer. If you think you might forget, use a smart home system to remotely monitor your lighting from your smartphone.

One of the four major old age problems include physical problems. Old age is a unique life phase characterized by various health, cognitive, emotional, social, and financial changes. Most people consider old age a problem-ridden stage of life, with aging problems usually occurring after 65. Physical decline and illness are one of the biggest problems aging people experience. Deteriorating health may prevent a person from doing things you enjoy or interfere with their routine activities. Also, chronic illness in the elderly may limit or cause a loss of independence, which is distressing for most people.

1. *Smart Home Solution*

A smart home system is intended to solve a variety of issues. The main reason we created this project is that we want to make life easier and more comfortable inside our own home by making all of the systems in the house controllable with a single touch of a phone. All of the systems will be Bluetooth-connected, and we will be able to access them through specific apps. This project is also very effective in assisting elderly people and people with disabilities who have difficulty reaching certain switches in their homes. For example, a person in a wheelchair who is unable to walk would find it difficult to get up and turn on or off the light. With this project, they can easily control the lamp with their phone via Bluetooth. Furthermore, with the advent of smart heating and cooling systems, the temperature of the home can be easily adjusted. The desired temperature can be easily changed using the phone. Other than that, the smart window built into the smart home system can be easily opened and closed. Smart homes can solve a wide range of problems and daily difficulties.

Automation (such as home automation and [industrial automation](https://www.electricaltechnology.org/2015/09/what-is-industrial-automation.html) etc) has become important in today’s world as it helps to complete a task with lesser human assistance and in a smarter way. Houses are becoming smarter and developed these days with the help of automation devices. Home electrical appliances are using remote-controlled switches rather than conventional switches. In today’s world, most of the people have access to smartphones and its use have become very popular and essential in our lives. We can use smartphones to control the household appliances with just one click or one message. With the help of controllers and communication devices home appliances can be remotely controlled.

Current challenges as a result of trends like an ageing society, greater environmental awareness and the related wish for a sustainable energy supply. Increasing digitalization and new means of enhancing convenience in our own four walls were further factors that put the smart home at the centre of public interest at the turn of the millennium. Besides, it also can give a great advantage of usage and be really helpful for the paralyzed people who cannot do their work on their own and such devices can become a great help for these people.

Our smart home serves automatic lighting, better home control security and safety, and a home that is equipped with smart devices that “talk” to one another. All these things that might have qualified as fiction a decade or so ago are real and available today, with even more coming in the near future. What value might these smart devices offer us in our house or apartment? We can definitely benefit in many ways by installing various smart devices in your home. Some of the benefits are immediate, some more long-term, but all of them are very real and it is no longer a fiction story or goals anymore [8].

One of the benefits is that we can save our time and effort. These smart devices free up our valuable time for more important things. Beyond this simple type of home automation of basic tasks, smart home technology can learn about the things we and our family do and use that information to make your home more efficient. Admittedly, it does not take a lot of effort to get up and flip a light switch, but it still takes a few seconds and a little bit of expended energy. It is kind of like adding a remote control for things that previously were not remote controlled. It may seem like a little thing, but little things add up. All the individual seconds you save by not having to get up to turn off the lights or turn up the heat become minutes and then hours as time goes by. The time we save becomes time we can put to better use than flipping switches and turning dials. Our time is more valuable than that.

Next, to encounter one of the problems stated before, by having a smart home installed to our houses, we can save money and conserve the energy that is being used daily in our house. As for example, turning off the lights when no one’s in the room, running the air conditioner or furnace only when needed, or when electricity costs are at a minimum, so that we can save on your gas and electric [8]. This can save us from spending a big amount of money to pay for our monthly bills. Some of other features of our smart home is automatically locking the doors and activating home security systems when you leave the house and by inserting the feature of smart fire alarm that will be discussed more later in this paper.

 In this project, we will be using ESP 32 board for the development of Smart Home Automation project with the Bluetooth Low Energy (BLE) module which is already provided and embedded in ESP 32 board. The traditionally switches are now can be remotely controlled by a smartphone.

1. Comparing Different System Communication

We know that there are a lot of different system communication that we can implement in smart home and all of them have their own pros and cons in terms of their usability. The best thing to do before implementing our project is to compare the various communication protocols that exist out there. Therefore, we will also be discussing briefly on the advantages and disadvantages of common protocols that are widely used in the system communication of smart home nowadays, which are Wi-Fi, Zigbee, Classic Bluetooth and the brand-new Bluetooth or so-called Bluetooth Low Energy that we choose to be implemented in our project. The comparison has been made by weighing the benefits and drawbacks of these protocols in order to select the best communication protocol.

1. *Classic Bluetooth*

Bluetooth classic is essentially a two-way data transfer protocol. Bluetooth will send wireless data via radio wave, like how Wi-Fi will send data. The difference is that Bluetooth does not require any network equipment such as a modem or router. Bluetooth only requires two enable devices to function [1]. Bluetooth, on the other hand, can only communicate over short distances. For instance, in a range of 100m, which is quite short. In addition to that, Bluetooth classic will use more energy consumption that Bluetooth BLE. Figure 1 shows that main difference between Bluetooth classic and BLE [2].

1. *Zigbee*

A very popular communication protocol within the Smart Home community. Zigbee is an Open, flexible (mesh network topology), and low power communication protocol developed on the 2.4 GHz band. It is perfect for battery-based smart home applications but it is not IP-based. As such, Zigbee-based devices require a gateway to connect to the internet for IoT-based applications which increases the cost of deployment. Zigbee offers low bandwidth and sometimes experiences a great deal of interference when deployed alongside WiFi due to competition on the 2.4 GHz band.

1. *Wifi*

Arguably the most well-known of the bunch, WiFi offers the easiest and probably the most robust communication path for smart home solutions because of its ubiquitous use in other everyday applications. Most homes would already have WiFi routers which makes deployment of WiFi-based smart home devices easier and cheaper. Its high bandwidth makes it suitable for applications that require high data throughput and its IP-based architecture makes deployment for IoT-based applications relatively easier and straightforward compared to other protocols.

However, all of the goodies come at a cost that includes high power consumption, short-range, and high susceptibility to interference which makes it unsuitable for most battery-powered smart home applications. There have, however, been several improvements over the years, with the most recent version, WiFi 6, offering better power and range performance. However, there are some distinct disadvantages of using Wi-Fi as the underlying protocol for your smart home. As the number of Wi-Fi devices grows, the amount of RF interference also grows. How close you live to your neighbors, and your neighbors’ Wi-Fi networks, can impact the performance of your Wi-Fi. Most residential Wi-Fi networks use a single subnet which limits the number of devices to 255. Many Wi-Fi routers can’t even handle this number of simultaneously connected devices. Other than that, Wi-Fi devices connect in a star topology with all devices connecting to a Wi-Fi router, access point, or range extender. This limits how far Wi-Fi devices can be located from the Wi-Fi network in a home.

Other users of Wi-Fi can dramatically affect the performance of a Wi-Fi network. For example, if people in the home start streaming 4K, high definition, video over Wi-Fi, it can dramatically affect the performance of other Wi-Fi devices. WiFi requires more power than other smart home protocols. This decreases the time before battery operated smart home devices need to have their batteries recharged or replaced. Wi-Fi operates at 2.4GHz and 5 GHz. Devices connecting to a Wi-Fi network at 2.4GHz have a practical range of 150 feet. On the other hand, devices connecting to a Wi-Fi network at 5GHz only have a practical range of 50 feet.

1. *Bluetooth Low Energy (BLE)*

Number equations consecutively. To make your equations more compact, you may use the solidus ( / ), the exp function, or appropriate exponents. Italicize Roman symbols for quantities and variables, but not Greek symbols. Use a long dash rather than a hyphen for a minus sign. Punctuate equations with commas or periods when they are part of a sentence, as in:

*a* + *b* = *γ* (1)

Be sure that the symbols in your equation have been defined before or immediately following the equation. Use “(1)”, not

“Eq. (1)” or “equation (1)”, except at the beginning of a sentence: “Equation (1) is . . .”

1. *LATEX-Specific Advice*

Please use “soft” (e.g., \eqref{Eq}) cross references instead of “hard” references (e.g., (1)). That will make it possible to combine sections, add equations, or change the order of figures or citations without having to go through the file line by line.

Please don’t use the {eqnarray} equation environ- ment. Use {align} or {IEEEeqnarray} instead. The

{eqnarray} environment leaves unsightly spaces around relation symbols.

Please note that the {subequations} environment in LATEX will increment the main equation counter even when there are no equation numbers displayed. If you forget that, you might write an article in which the equation numbers skip from (17) to (20), causing the copy editors to wonder if you’ve discovered a new method of counting.

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1. *Some Common Mistakes*
   * The word “data” is plural, not singular.
   * The subscript for the permeability of vacuum *µ*0, and other common scientific constants, is zero with subscript formatting, not a lowercase letter “o”.
   * In American English, commas, semicolons, periods, ques- tion and exclamation marks are located within quotation marks only when a complete thought or name is cited, such as a title or full quotation. When quotation marks are used, instead of a bold or italic typeface, to highlight a word or phrase, punctuation should appear outside of the quotation marks. A parenthetical phrase or statement at the end of a sentence is punctuated outside of the closing parenthesis (like this). (A parenthetical sentence is punctuated within the parentheses.)
   * A graph within a graph is an “inset”, not an “insert”. The word alternatively is preferred to the word “alternately” (unless you really mean something that alternates).
   * Do not use the word “essentially” to mean “approxi- mately” or “effectively”.
   * In your paper title, if the words “that uses” can accurately replace the word “using”, capitalize the “u”; if not, keep using lower-cased.
   * Be aware of the different meanings of the homophones “affect” and “effect”, “complement” and “compliment”, “discreet” and “discrete”, “principal” and “principle”.
   * Do not confuse “imply” and “infer”.
   * The prefix “non” is not a word; it should be joined to the word it modifies, usually without a hyphen.
   * There is no period after the “et” in the Latin abbreviation “et al.”.
   * The abbreviation “i.e.” means “that is”, and the abbrevi- ation “e.g.” means “for example”.

An excellent style manual for science writers is [7].

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Headings, or heads, are organizational devices that guide the reader through your paper. There are two types: component heads and text heads.

Component heads identify the different components of your paper and are not topically subordinate to each other. Examples include Acknowledgments and References and, for these, the correct style to use is “Heading 5”. Use “figure caption” for your Figure captions, and “table head” for your table title. Run-in heads, such as “Abstract”, will require you to apply a style (in this case, italic) in addition to the style provided by the drop down menu to differentiate the head from the text.

Text heads organize the topics on a relational, hierarchical basis. For example, the paper title is the primary text head because all subsequent material relates and elaborates on this one topic. If there are two or more sub-topics, the next level head (uppercase Roman numerals) should be used and, conversely, if there are not at least two sub-topics, then no subheads should be introduced.

1. *Figures and Tables*

*a) Positioning Figures and Tables:* Place figures and tables at the top and bottom of columns. Avoid placing them in the middle of columns. Large figures and tables may span across both columns. Figure captions should be below the figures; table heads should appear above the tables. Insert figures and tables after they are cited in the text. Use the abbreviation “Fig. 1”, even at the beginning of a sentence.

TABLE I

TABLE TYPE STYLES

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aSample of a Table footnote.



Fig. 1. Example of a figure caption.

Figure Labels: Use 8 point Times New Roman for Figure labels. Use words rather than symbols or abbreviations when writing Figure axis labels to avoid confusing the reader. As an example, write the quantity “Magnetization”, or “Magnetiza- tion, M”, not just “M”. If including units in the label, present them within parentheses. Do not label axes only with units. In the example, write “Magnetization (A/m)” or “Magnetization A[m(1)] ”, not just “A/m”. Do not label axes with a ratio of quantities and units. For example, write “Temperature (K)”, not “Temperature/K”.

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The preferred spelling of the word “acknowledgment” in America is without an “e” after the “g”. Avoid the stilted expression “one of us (R. B. G.) thanks *. . .*”. Instead, try “R. B. G. thanks*. . .*”. Put sponsor acknowledgments in the unnumbered footnote on the first page.

CONCLUSION

Please number citations consecutively within brackets [1]. The sentence punctuation follows the bracket [2]. Refer simply to the reference number, as in [3]—do not use “Ref. [3]” or “reference [3]” except at the beginning of a sentence: “Reference [3] was the first *. . .*”

Number footnotes separately in superscripts. Place the ac- tual footnote at the bottom of the column in which it was cited. Do not put footnotes in the abstract or reference list. Use letters for table footnotes.

Unless there are six authors or more give all authors’ names; do not use “et al.”. Papers that have not been published, even if they have been submitted for publication, should be cited as “unpublished” [4]. Papers that have been accepted for publication should be cited as “in press” [5]. Capitalize only the first word in a paper title, except for proper nouns and element symbols.

For papers published in translation journals, please give the English citation first, followed by the original foreign-language citation [6].

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