Czech University of Life Sciences Prague

Faculty of Economics and Management

Department of System Engineering and Informatics

Bachelor Thesis

Implementation of the Smart Home in Specific Conditions

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Thesis title

Implementation of the Smart Home in specific conditions

Objectives of thesis

The main objective of this theses is to analyse and determine the efficiency of current and future technologies for the implementation of a smart home.
Partial goals of the thesis are such as making a literature review of the current state of technological trends in a smart home. As a secondary objective, to make an overview of the current smart home implementation in the Czech Republic and to evaluate the proposed solution for typical SH application in the selected environment and to make recommendations.

Methodology

The methodology of the thesis is based on reviewing and analysing the latest literature which includes books, reports and research papers related to the topic. The case study will be performed on the existing design and implementation. Typical environment for the smart home application will be selected based on the expert's discussion. Based on the outcomes of the literature review and the results of the case study conclusion and recommendations will be formulated.

The proposed extent of the thesis

50

Keywords

Smart home, Smart monitoring , Security, Cloud computing, sensor

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Recommended information sources

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Declaration

I declare that I have worked on my bachelor thesis titled "Implementation of the Smart Home in a Specific Conditions" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the bachelor thesis, I declare that the thesis does not break copyrights of any their person.

In Prague on March 15, 2021

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Implementation of the Smart Home in specific conditions

Abstract

In recent years, a plenty of new innovations has emerged that aim to enhance the quality of life by incorporating intelligent devices into various aspects of home life. While many of these innovations have progressed from early adopters' wish lists to the mainstream, there is still something to be said about the efficiency of the decision to upgrade from a home to a smart home. Many technologies are designed to improve comfort while ignoring concerns about energy consumption, stability, and costs; others are designed to preserve and improve comfort while lowering usage costs, such as energy and other utilities. This thesis examines the Smart Home technologies that promise to deliver the best energy, cost, and protection performance, as well as the relationship between current energy market trends and the price points needed to make those technologies applicable on a large scale. Findings show that the selected smart home devices such as smart thermostat, smart plug and others are more energy efficient than the conventional home devices.

Keywords: Smart Home, Energy efficiency, Smart monitoring, Security, Sensor, Smart device, Arduino

Implementace Inteligentního Domu V Konkrétních Podmínkách

Abstrakt

V posledních letech se objevila spousta nových inovací, jejichž cílem je zlepšit kvalitu života začleněním inteligentních zařízení do různých aspektů domácího života. I když mnoho z těchto inovací pokročilo od seznamů přání prvních uživatelů k hlavnímu proudu, stále je co říci o účinnosti rozhodnutí upgradovat z domova na inteligentní dům. Mnoho technologií je navrženo tak, aby zlepšovalo pohodlí a zároveň ignorovalo obavy o spotřebu energie, stabilitu a náklady; jiné jsou navrženy tak, aby zachovávaly a zlepšovaly pohodlí při současném snižování nákladů na používání, jako jsou energie a další služby. Tato práce zkoumá technologie Smart Home, které slibují nejlepší výkon, náklady a ochranu, stejně jako vztah mezi současnými trendy na trhu s energií a cenovými body potřebnými k tomu, aby byly tyto technologie použitelné ve velkém měřítku. Zjištění ukazují, že vybraná inteligentní domácí zařízení, jako je inteligentní termostat, inteligentní zástrčka a další, jsou energeticky efektivnější než běžná domácí zařízení

Klíčová slova: Inteligentní dům, energetická účinnost, inteligentní monitorování, zabezpečení, senzor, inteligentní zařízení, Arduino

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List of abbreviations

SH – Smart Home

PIR – Passive Infrared Sensor

GSM – Global Systems for Mobile

SMS – Short Message Services

App – Application

GPRS – General Packet Radio Services

GHAS – GSM based home automation system

Wi-Fi – Wireless Fidelity

MC – Microcontroller

TTL – Transistor-Transistor Logic

TCP/IP – Transmission Control Protocol/Internet Protocol

M2M – Machine-to-machine

LED – Light Emitting Diode

AC – Alternate current

DC – Direct current

1 Introduction

Smart Home is today's one of the growing needs in people's life. Smart Home refers to automation of home appliances which can be viewed from safety, automatic monitoring and controlling.

Information is everything in today's real life particularly when this information is prone to affect their life in close way. People are away from home for work or for other reasons and there is always insecure of what's happening in home and things related to home appliances whether they are functioning properly or they are not, and several other things associated to their house. Smart Home is required to solve these problems and provide user with the instant monitoring and controlling of home appliances. It is possible to find different devices for such monitoring and controlling.

What was once a fringe technology, Smart Home efficiency has evolved into an everyday reality. Enter the "sensors" and "reliable energy" of a modern "smart house", "smart grid" and "renewable energy" that placed our traditional lifestyles "in a new context", "in a new world". Although there are various tasks that a homeowner performs in their home, from carrying out minor repairs to repairing their appliances, many of these tasks are gradually being automated thanks to smart home controllers that can relay all of that information to the user, tasks that are often bungles that once had to be managed by the user (Smart Home Architecture for Energy Efficiency, 2018). Building automation systems, which are considered an almost mandatory requirement for the sustainable (low-energy, low-emission) home, are closely linked to achieving an energy-efficient building process.

The project is focused on Implementation of smart home on a specific condition which supports SH efficiency. Also, it will try to focus other aspects that are related to the implementation of SH. Efficiency good practices must be used in all three phases of the lifecycle of a smart device, development, integration, and usage of the IT devices into a Smart Home.

A smart home has more appliances than a traditional home and consumes more energy as a result. Furthermore, as apartment building scales grow larger, network efficiency must be considered alongside energy efficiency if the building's appliances are managed as a single system. As a result, different energy and network efficiency services for smart homes are being investigated. Besides that, in term of cost, it is not a good practice as it will make the monthly electrical bill going up, just because sometimes it’s not easy to control the electrical appliance during the holiday. If we feel something not being safe or unlocked, not easy to know the real situation and cannot going back just to lock or to check the safety. So, people will buy or install additional device which can make things easy and safe.

The Smart Home efficiency principle is presented in its entirety in the rest of the document. The system architecture, as well as system building blocks, related mechanisms, and the paper's goals, are outlined. The use cases are used to demonstrate the system's potential.

2 Objectives and Methodology

3 Objectives

The main objective of this thesis is to analyse and determine the efficiency of current and future technologies for the implementation of a smart home.

Partial goals of the thesis are such as making a literature review of the current state of technological trends in a smart home. As a secondary objective, to make an overview of the current smart home implementation in the Czech Republic and to evaluate the proposed solution for typical SH application in the selected environment and to make recommendations.

3.1 Methodology

The methodology of the thesis is based on reviewing and analysing the latest literature which includes books, reports and research papers related to the topic. The case study will be performed on the existing design and implementation. Typical environment for the smart home application will be selected based on the expert's discussion. Based on the outcomes of the literature review and the results of the case study conclusion and recommendations will be formulated.

4 Literature Review

In the literature review part, the main issues that are presented about smart home development, past, present, and future trends and about its implementation on a specific condition. As well as energy, cost, and security efficiency, on how the smart home will make peoples life safe and comfortable on these days and in the future. Ongoing basis of technological development with the specific need.

4.1 Why Smart Homes?

These days SH is one of the growing and potentially important field of research and development. Some of the broad views are a functional view, an instrumental view, including the socio-technical view. According to the functional view smart homes considered as mechanisms that's makes a better managing way of the demands of daily living through better automation and better technology (Charlie Wilson , Tom Hargreaves, Richard Hauxwell-Baldwin, 2014). It gives a good potential to manage and the way to reduce energy consumption in the house holds as part of a wider transition to a low carbon-future as instrumental view. And the socio-technical view describes that smart homes as the upcoming trend of development and growing electrification and digitalization of people's day today life (Charlie Wilson , Tom Hargreaves, Richard Hauxwell-Baldwin, 2014).

We humans interact with our environment in numerous ways that surrounds us. People observe their environmental conditions and surroundings and pursue accordingly through time.

When the surrounding environment can be made to repay this behaviour and respond to human behaviour and day to day activity, due to these changes there will be several advantages. As the changes continues such behaviour can automate different tasks that humans previously have to perform manually and gives novel services and the needed facilities (Liyanage C.De Silva, Chamin Morikawa, Iskandar M. Petra, 2012). So, when we say smart home that a home-like environment which described as with element intelligence and automatic control, these gives the ability to respond to their various behaviour of residents and it can create and provide a better ground for better various facilities (Liyanage C.De Silva, Chamin Morikawa, Iskandar M. Petra, 2012).

For building a smart home there should be a standard approach that is computerizing the devices. To get better utility consumption of the home regarding the dwellers, a set of sensors gather necessary different types of data. New computerized technologies and devices with computing power like micro-controllers analyse the received data to identify and classify activates of the dwellers and other events. This process gives them opportunity to respond for those actions and events, by controlling certain mechanisms that are built and installed for a specific purpose into the home. A simple example for such smart behaviour is turning the lights on when a person enters a room (Liyanage C.De Silva, Chamin Morikawa, Iskandar M. Petra, 2012).

Development of Smart Homes

To understand how the modern smart home came to be, it's necessary to look back in time and consider the social conditions that made integrating new technologies possible, if not desirable. It's also crucial to examine the types of technologies that have managed to make their way into the home and ask why they have been so successful. It hasn't always come down to technological advancements and entrepreneurship; as we'll see, political will and policymaking played a large role in making the home a trampoline for new technologies (Deschamps-Sonsino, 2018).

Although many of us will be vaguely familiar with the term "smart house", few of us will have a very concrete understanding of what it means (Harper, 2006). For the first time officially, it was used by the American Association of House Builders long time ago in 1984, though the first "wired homes" were built by hobbyists in the early 1960s (Harper, 2006). The wired home was a science-fiction for most of the people, but later in 1984 there was a sufficient growing interest in home automation. Most of the growing interest came from the fields of building, electronics, architecture, energy conservation, and telecommunications, and during the same decade there was increasing interest of manufacturers to consumer electronics and electrical equipment have been developing different digital systems as well as devices and components suitable for use in domestic homes (Gergely, 2018). The main important development on the field of smart homes was on two dimensions, the first one is replacement of electromechanical switching with digital switching, and the second one is changing of the traditional twisted pair and coaxial cables by optical fires (Gergely, 2018). This development paved the way to use the key to what is meant by smart homes. To say smart for home not because of how it looks like, how it was built, effective use of space or land or it's not because of environmentally friendly but is the interactive technologies that it contains makes it a smart home (Harper, 2006).

The other enabling factors for the developments are on growing new communication networks like ISDN, internet, new end devices for example, web Tv, video phones (Gergely, 2018). The concept of smart home become a popular culture in 1990s. By the end of the 20th century, many homes linked via the PC to informal on and services beyond the home. This can be seen as a proper "seedbed" for developing the smart home concept (Gergely, 2018).

Developments in the field of smart homes are not an isolated case. First, the developments take place within the society and are influenced by trends within that society. Moreover, to produce and design added value, the focus should be on the smart home environment not only that of on the used technology. The third one is creating smart environments based on the makeup of inhabitants, for example to support elderly and disabled persons. To live up fully to the expectations is however a complex process which involves various stakeholders (Charlie Wilson , Tom Hargreaves, Richard Hauxwell-Baldwin, 2014).

When mentioning about Smart home technology it's better to describe with the integration of technology with services through home automizing for a better quality of living. These days smart home technology is showing another dimension shifting from being purely focused with the integration of electrical materials or equipment's within the home and the surrounding environment to a broader perspective, which means the perspective also includes ICT functionalities (Information Centric Networking in IoT scenarios: The case of a smart home, 2015). With a very heterogeneous environment in which characterized by different types of devices, various types of connectivity technologies, system of applications and applications with numerous service patterns we call it a smart home. In the house, a high number of small end devices (EDs), like sensors or actuators, are embedded in home appliances (Information Centric Networking in IoT scenarios: The case of a smart home, 2015).

Purpose of a Smart Home

The development of Smart Home technology has exponentially increased over the course of the last few years since its inception, and that growth and development directly influenced the popularity, accessibility, and size of smart homes. Studies into this fast development in smart home popularity revealed three main pushing factors, almost all these factors are directly linked to IoT technology (A review on smart home present state and challenges: linked to context-awareness internet of things (IoT), 2018). The main purpose of a smart home is to create and develop an environment where the inhabitants can live and exercise comfortable life, with minimal effort (Fraser Hall, Leandros Maglaras,Theodoros Aivaliotis, Loukas Xagoraris and Ioanna Kantzavelou, 2020). Recent developments in smart home devices technology have provided additional functionality with alternative choices and practicality to the end user. Internet connectivity and remote management remote management provided by IOT technologies makes things better in the functionality that provides the owner with the ability to remotely control devices installed within their home including their surroundings, the popularity of smart devices implemented throughout the home would be far less than it currently is (Fraser Hall, 2020).

The other reason for the fast growth and development in smart home popularity is the issue of safety. Smart homes are the most popular use for IoT devices, and they are used to provide safety and wellbeing for the users (Fraser Hall, 2020). Also, the cost reduction of hardware for smart homes has played huge role for the popularity of smart homes (Fraser Hall, Leandros Maglaras,Theodoros Aivaliotis, Loukas Xagoraris and Ioanna Kantzavelou, 2020). During the early stages of devices for SH which is IOT devices were too expensive to acquire for the everyday user. Increase in the availability of devices and decrease in their price due to the development of IOT technologies and increase in numbers of vendors (Fraser Hall, 2020). This and other factors have resulted in the technology becoming more affordable and attainable to a mass number of users.

3.1.3 Home Automation

The Smart home in other words it is known as House automation, with the use and installing of new technology, to make the activities of inhabitants more simple, convenient, comfortable, secure (safe) and economically sound (Ameena Saad al-sumaiti, 2014) Home automation system possesses main components which makes it automated home like, User interface: as a monitor, computer, or Phone, in which to facilitate the interaction to control and give orders. There is various mode of connections. Wired connections (example Ethernet) or Wireless like, radio waves, infrared, Bluetooth, etc. Central Controller is hardware interface that have features to communicates with user interface by controlling domestic services (House, Design & Implementation of Smart, 2012).

3.1.4 Features of Home Automation System

Nowadays, wireless networking systems like Remote Control have become more popular and advisable devices in home networking. Also, in automation systems, the use of wireless technologies provides several advantages that could not be achieved with the use of a wired network only (Ameena Saad al-sumaiti, 2014).

Reduced Installation costs

As the growing development increased in the wireless technology's installation costs are significantly reduced due to no cabling is necessary.

Internet Connectivity

The availability of network and internet makes things easy to control devices from anywhere in the world with use mobile phones and other mechanisms to control smart home.

Scalable and Expandable

When it is compared the wired networking, Wireless network is especially useful when, new planning or design are going to implemented, or an extension of the network is necessary.

Security

Simple and easily to add devices to create also to implement an integrated smart home security system, which makes smart home safer and more comfortable.

3.1.5 Approaches

A Technical Approach

According to technical approach a smart home can be described as a house featured with smart objects, a home network that makes it possible to share and transport information between objects and a residential gateway to interact the smart home with owners as well as to the outside Internet world. Smart objects make it possible to connect with dwellers or to control how things are going (The Smart Home Concept : our immediate future, 2006).

It's easy to control those smart objects that can be simple to accesses it about its state, for example a refrigerator by itself which knows its state and is able to adjust the situations by itself, also other devices like telephony, security systems, videos on demand, all this and other object will be connected through the home network to give their states and able to receive instructions (The Smart Home Concept : our immediate future, 2006). Home networking gives ability to home to be fully connected, controlled externally and internally. To control the gateway and other surroundings the home networking offers access through internet networking. Based on this service it is possible to connect to the house and to get new services (The Smart Home Concept : our immediate future, 2006).

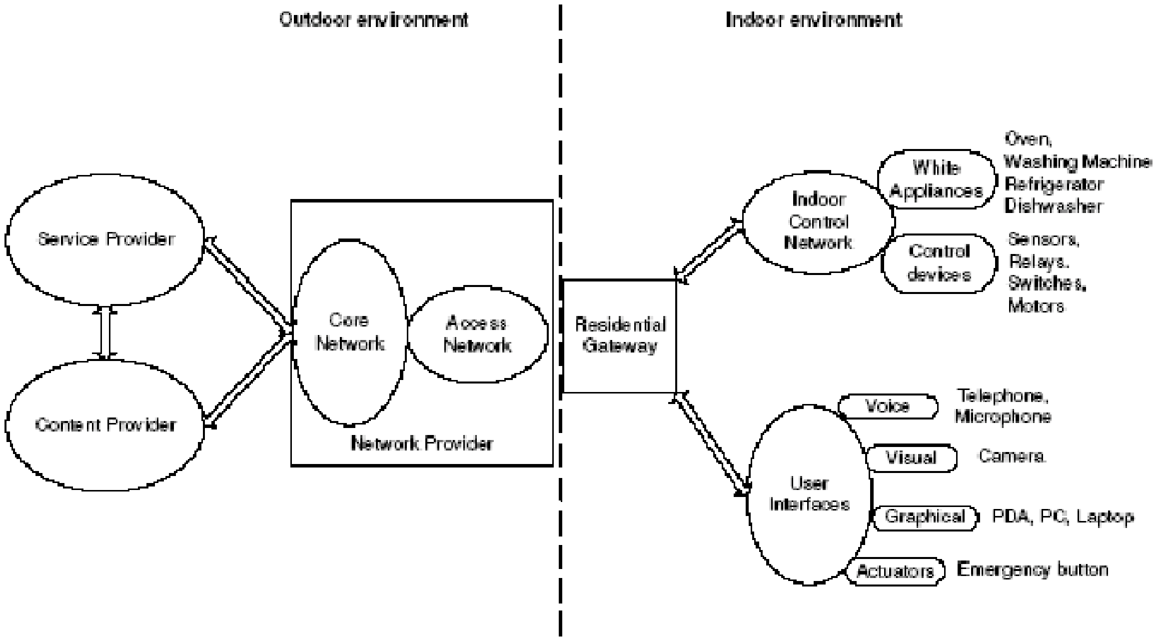


Fig 1. Smart home concepts (The Smart Home Concept : our immediate future, 2006)

Figure 1 shows how a smart home look like. Smart Home indoor environment is composed of different devices which includes white appliances like washing machine and refrigerator, also control devices like sensors, motors, and user interfaces like voice, visual or graphical. Usually most smart homes have unique residential gateways that are connected to the internet world. The outdoor environment gives accesses to communications and network between for the inhabitants and provides communications between the smart home and the provider (The Smart Home Concept : our immediate future, 2006).

Let's see different technologies to get few understandings about how it works. Some technologies like Arduino microcontrollers, ZigBee communication protocol, JSON for data exchange, and Google App Engine for Cloud computing (The Smart Home Concept : our immediate future, 2006).

3.1.6 Arduino for Programming Internet of Things

IoT is making computing and communication pervasive, mobile, and wearable, thanks to many microcontrollers and microcontroller platforms (The Smart Home Concept : our immediate future, 2006). Mentioning about Arduino it includes a programming environment and Arduino boards. The Arduino programming environment enables the developer to control, manage, compile, upload, and simulate programs. Currently, there are several Arduino boards with several performance parameters and conditions, such as the size of RAM or flash memory, the number of analogy pins or digital pins as well as with a feature clock speed. Arduino platform has better features that makes it affordable like, cheaper and cost effective, cross-platform, easy and simple programming environment, open source, and extensible software and hardware (Liyanage C.De Silva, Chamin Morikawa, Iskandar M. Petra, 2012), (Smart Home: Integrating Internet of Things with Web Services and Cloud Computing, 2013).

Using ZigBee to Network Smart Home

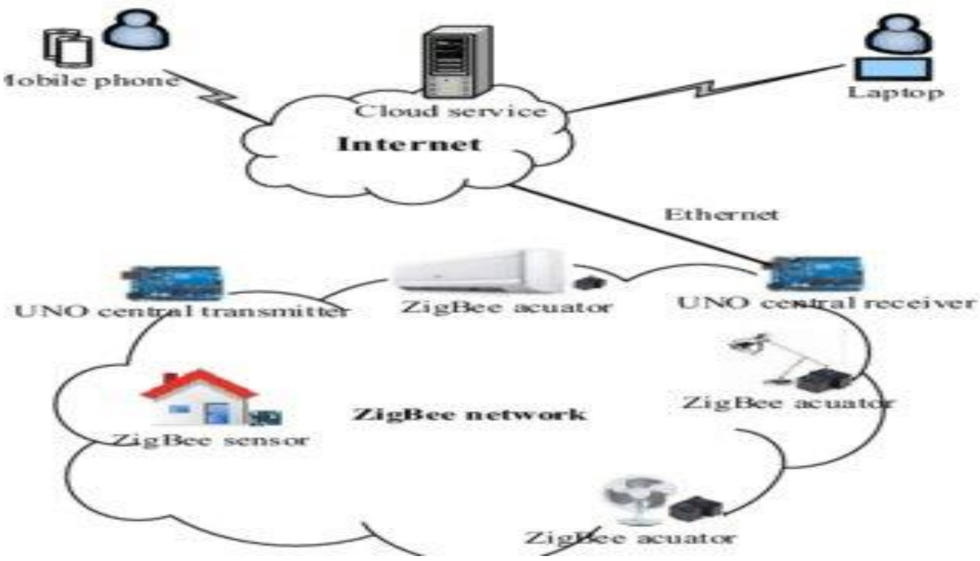


Fig.2. ZigBee home network, Source: (Smart Home: Integrating Internet of Things with Web Services and Cloud Computing, 2013)

Fig (ZigBee home network) presents ZigBee-networked smart home. There are two Arduino UNO microcontroller boards. In the first board serves when the central receiver is connected to all the actuators in the system and connected to the database server on the Internet through the Ethernet connection. The central transmitter connected to all the sensors in the system that is in the second board. ZigBee technology is usually used for as a communication device between ZigBee sensors/actuators and the central Arduino boards (Smart Home: Integrating Internet of Things with Web Services and Cloud Computing, 2013).

There would be a good environment for the deployed Arduino-embedded devices in home to communicate each other to share and exchange sensor outputs, triggers, status messages, etc., in each condition. ZigBee is one of the widely used advanced wireless technologies for establishing communication between things for home automation (Smart Home: Integrating Internet of Things with Web Services and Cloud Computing, 2013). ZigBee is a radio frequency (RF) communications standard (Smart Home: Integrating Internet of Things with Web Services and Cloud Computing, 2013). A ZigBee based network usually consists of a Zigbee coordinator and Zigbee nodes that makes the system more efficient. The Zigbee coordinator has the capability creating and maintaining the network. And the Zigbee coordinator controls each Zigbee node, such as washing machine, television, lamp, the security system etc., which are in the network (Design and Implementation of Smart Home Security System, 2014). All communications as well as interactions between Zigbee nodes propagate through the coordinator to the destination node. The maximum ZigBee data rate is about 250kbps and communication range can vary from 100m to 1km depending on the output power (Smart Home: Integrating Internet of Things with Web Services and Cloud Computing, 2013). As 40kbps is possible to reach the requirements of most control systems, and that makes it sufficient for controlling most home automation devices (Smart Home: Integrating Internet of Things with Web Services and Cloud Computing, 2013).

Some Available Technologies in Communication Domain

In the communication domain for smart home, it’s better to consider two basic and necessary needs, the first one is how to make possible the communication of the equipment in the interior part of the house. And when it comes to the second one is to connect the smart house to the outside Internet world (The Smart Home Concept : our immediate future, 2006), (The Smart Home Concept : our immediate future, 2006).

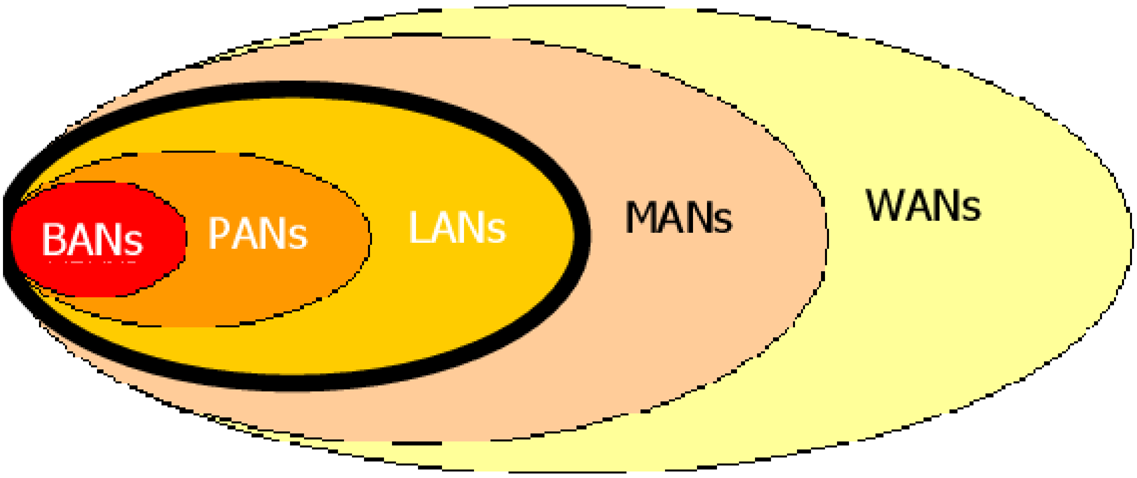


Fig.3. Different types of available area networks Source: (The Smart Home Concept : our immediate future, 2006)

Figure shows five different kind of Area networks depending on their usual placements. Wide Area Networks (WANs) generally consists of consist of satellites or antennas installed on buildings. They serve or cover great geographical areas. These wide area networks can be served by satellite or terrestrial cellular technologies or by fixed solutions without using any wire. Metropolitan Area Networks (MANs) has a potential to serve an area, for example like customers of a district (The Smart Home Concept : our immediate future, 2006). The third one, Local Area Network (LANs) serve the personal needs for an individual or private for those who are looking manage their own network. The fourth one, Personal Area Networks (PANs) serve the needs for a user with personal, small, and close objects such as a mobile telephone. The fifth one, Body Area networks (BANs) are a continuity of the personal or private network, but on a smaller scale. This type of network is well achievable when it is mainly based on the principle of smart objects localized on the body and, even in the body of the user (The Smart Home Concept : our immediate future, 2006).

So, based on their behaviours and compatibility WANs and MANs are usually used for outdoor environment. For the WANs, find the UMTS, EDGE, GPRS or satellite technologies (Charlie Wilson , Tom Hargreaves, Richard Hauxwell-Baldwin, 2014), (The Smart Home Concept : our immediate future, 2006). Those technologies are wireless (WWANs: Wireless Wide Area Networks) and they have a potential to transmit and share information at up to 30 Kilometres. For the MANs, to find WIMAX which can cover as well as transmit information at up to 20 Kilometres LANs, PANs and BANs are used in indoor environment. To apply LANs, Wi-Fi and HyperLan are mainly wireless solutions. For the wire solution Ethernet is the main one. For PANs, Bluetooth, RFID, Zigbee, UWB are also wireless solutions. It is also possible to use CEBus, Convergence, emNET, HAVi™, HomePNA™, HomePlug™, HomeRF™, Jini™ technology, LonWorks, UPnP, VESA, USB and serial link are wire solutions (The Smart Home Concept : our immediate future, 2006).

Bluetooth

Bluetooth is the well-known technology that is used in various devices in our day-to-day activity like mobile telephone and other objects. It is a set of protocols for the design of systems that makes it possible frequency control over the system. Bluetooth enables devices to be connected and facilitate sharing information within a short distance. Current technology that is available for full rise to store information in passive or active labels is RFID (The Smart Home Concept : our immediate future, 2006).

A host controller, which is implemented on a PC or an Android phone, is linked to a microcontroller-based sensor and system controller in Bluetooth-based smart homes. The researchers also developed a new protocol called Home Automation Protocol (HAP) on top of the Bluetooth software stack to enable devices to communicate with one another. The I2C Bus is used to link the system controller to electronic devices. The framework allows for the connection of several device controllers to the host controller (Arun Cyril Jose, 2015).

As a host controller, the researchers use a cell phone with Bluetooth communication and a GSM modem to link to the Internet. Bluetooth communication adapters are installed in home devices so that they can communicate with the host controller phone via Bluetooth. The paper goes into how to monitor and update home devices remotely, as well as how to diagnose and detect faults. The project also discusses using Bluetooth and the Internet to include an electronics user manual on the handset (Arun Cyril Jose, 2015). But there are some issues of using Bluetooth for home automation, some of them are,

Zigbee

ZigBee is a wireless standard of data transmission which allows communication between machines or machine to machine. It is domotics-oriented with a very low fuel electric consumption which makes its principal asset to be used in smarty objects and easily affordable (The Smart Home Concept : our immediate future, 2006). It is a radio-equipped physical object. A light switch, a thermostat, and a remote control are simple examples. Logically, separate functions can be implemented on a single device and, as such, for communication purposes, share the same radio. For example, within a single device used for industrial plant monitoring applications, a temperature sensor and an accelerometer could be combined. An application, like a home automation system, is implemented by a set of intercommunicating devices. While the PHY, MAC and network layers are used to create and maintain the interconnecting communication network of individual ZigBee devices, the sub-layer of application support is used to communicate information on the application layer between devices, such as a light switch that commands a light to be turned on or off. The following device types include ZigBee networks (The Smart Home Concept : our immediate future, 2006).

UWB

UWB: it has similar features like USB what it makes it different from USB is that UWB is wireless and allows to make communicate our current objects without wire at short distances (The Smart Home Concept : our immediate future, 2006).

3.1.7 GSM or Mobile Based SH System

Because of the widespread use of cell phones and GSM technology, researchers are interested in mobile-based home automation. SMS-based home automation, GPRS-based home automation, and Dual Tone Multi Frequency (DTMF)-based home automation are the three major communication choices in GSM (Arun Cyril Jose, 2015).

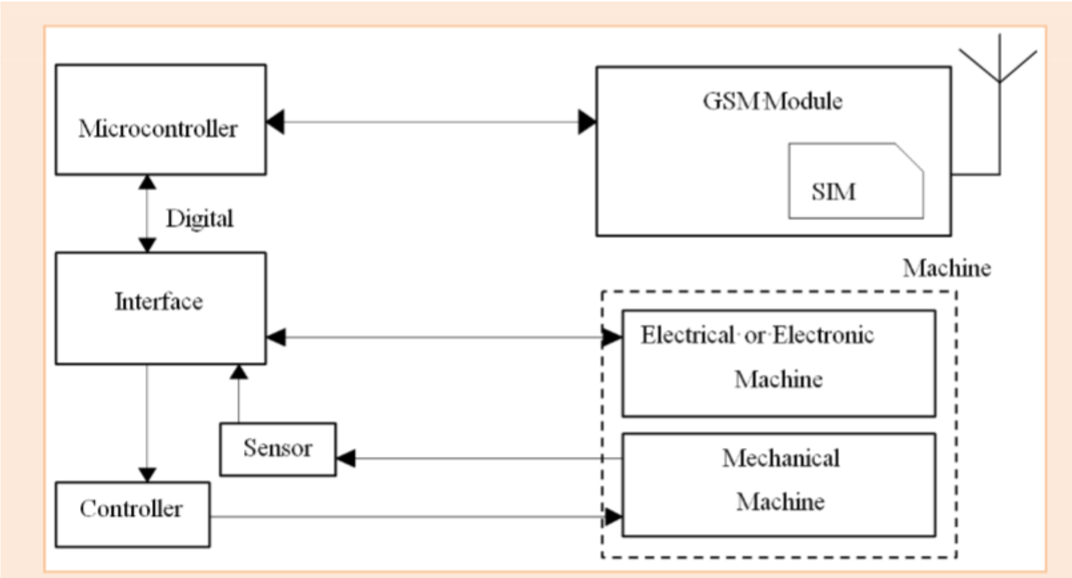


Fig.4. Mobile-based SH system, Source: (Arun Cyril Jose, 2015)

The above figure (Fig) shows the conceptual diagram of how a home's sensors, electrical, and mechanical devices connect with the home network and interacts using a Subscriber Identity Module and the GSM module (SIM). The device uses a transducer to transform machine functions into electrical signals, which are then fed into a microcontroller. A sensor performs the role of a transducer, which transforms physical quantities such as sound, temperature, and humidity into another quantity such as voltage. The readings from electronic devices are fed directly into the microcontroller. The microcontroller decodes these signals and translates them into commands that the GSM module can understand. The GSM module chooses the best communication approach based on the commands it receives (SMS, GPRS or DTMF) (Arun Cyril Jose, 2015).

3.1.7 Smart Home Security

A security system is a system which can defined as to detect intrusion, unauthorized entry into one's property which includes building or a protected area and deny such unauthorized access to protect as well as to control personnel and property from damage or harm. Security systems are already experienced in various areas like, military properties, residential, commercial, and industrial, for protection against theft or property damage, as well as personal and private protection against intruders (Charlie Wilson , Tom Hargreaves, Richard Hauxwell-Baldwin, 2014). These days prisons also use security systems for controlling and assessing of inmates. One of the most prominent is home security. Currently, possible to say home security and surveillance system is an essential necessary part of any modern automated home. Security system design starts with analyzation of needs of the inhabitants, by surveying existing suitable technology and hardware, reviewing system potential expenditure (costs), considering monitoring choices and finally planning the installation (Design and Implementation of Smart Home Security System, 2014)

The features that possessed by automated homes built in the modern days includes modern security system which helps to identify some intruders while they are accessing the home by alerting and giving information for the homeowner about the intrusion attempt, preventing the intruder from gaining access to the home, and gathering or collecting evidence for the needed security. The progress and advancement of technology brings lots of contribution to the changing concept of security in modern homes. It gives tangible changes from a traditional simple lock and key security concept to new stage of implementing sophisticated security systems by using different devices like, contact sensors, proximity sensors, cameras, microphones, alarms, etc. Connecting today's modern home to the internet is getting very popular, that makes users can access and control their homes remotely at any time without country border limit (A review on smart home present state and challenges: linked to context-awareness internet of things (IoT), 2018). There is an increase in processing power of newly designed processors installed and implemented in the modern house and the considerable reduction in different aspects which includes power consumption, the cost, and size of new electronics devices that allows the users to know and control each and every aspect of their home, like door or window security, light switches. These features make the dwellers to keep an eye on their home using live video and audio feeds from different parts of their home. They can also have full insight about various environmental factors from inside or outside of their home, like the home temperature, humidity, and other home conditions. Thanks to wireless sensor actor network, different sensors implemented in different parts of the home gather information for the habitants about the surrounding environment (A review on smart home present state and challenges: linked to context-awareness internet of things (IoT), 2018). The growing improvements in Wireless Sensor Actor Networks are certainly one of the factors that is contributing to the popularity of smart homes. Possible to mention some of the basic elements like combining ubiquitous computing, Wireless Sensor Actor Networks and with the popularity of the Internet has allowed different professions which includes designers, engineers, and researchers to come up with their new and suitable methods which allows to home inhabitants to access and control their day-to-day activity in their home and the surrounding environment (Charlie Wilson , Tom Hargreaves, Richard Hauxwell-Baldwin, 2014).

4.1.1 **Development of Smart Homes in Czech Republic**

The American Association of Home Builders recognized the term "smart home" as a technical term in 1984. Apple released a personal computer with a revolutionary graphical interface the same year, ushering in the integration of computers into smart homes. The company then expanded to other countries, including Japan, the United Kingdom, Germany, and others.

Living Tomorrow, the first major European project, was launched in Brussels in 1995 with the goal of informing the public about the latest trends in smart living. On the outskirts of Brussels, the first Vilvoorde house was established. Then there were apartments in Amsterdam and other cities. All centres are completely renovated and updated every five years to meet current technological requirements.

Microsoft opened a digital Superbyt in Prague on November 3, 2005. The historic Microsoft Windows XP operating system was now the foundation, along with the Windows Media Centre extension. Intel Pentium 4 processors provided computing power, and Moeller Electrotechnical provided intelligent Xcomfort wiring for wireless control of heating, lighting, and other components.

Insignt Home, which was established on the domestic market in 2009, developed the inHome system, which is based on the American AMX system, which is well-known for its management of the world's most advanced conference complex.

The Situation Room in the White House. The company opened its first presentation houses the same year, establishing the Innovation Centre for Modern Housing Technologies (CITIB). The centre’s mission is to inform the public about the most recent developments in the field of modern smart living. Two family houses and one garden house make up the CITIB complex, which is situated on a plot of less than 4,000 m2.
Despite the fact that smart homes are still uncommon in the Czech Republic, there are a number of companies in the Czech market that specialize in them. A list of the most important companies in the domestic market is provided below **(**Šovčíková, Radana. 2016).

Insight Home

There is a corporation owner of the company, Mr Jan Průcha, who has done more press on the subject of energy efficient houses in the media, and helped build his own, who regards it as the first home for a residential energy usage in the country. Besides operating in the Russian and Slovakian markets, the company also has partners, which has been given business by the AMX.

Loxone

The company, which is based in Austria, has been around since 2009. It focuses on the implementation of smart homes using the Loxone Mini server, which connects all of the house's individual elements for easier operation. Both a local network and an Internet connection are supported by the Loxone Mini server. However, it does not process the received customer data in either case; instead, it simply stores it on the SD card within the Mini server. In the Czech Republic, they currently have three reference projects.

Haidy

Since 2008, the company has operated on the Czech and Slovak markets as separate, but united markets. It has everything one would need for a total home automation system. In the context in which you've used it here, three options exist: Haidy Home, Haidy Plus, and Haidy Vario. Differences exist between customers depending on whether they demand easy expansion and the most or something the customer finds sufficiently challenging, onerous to increase.

Control4

It is an American corporation that was founded in 2003 and operates globally, including in the Czech Republic. It has been working with Yatun, the Control 4 system's exclusive distributor in the Czech Republic and Slovakia, since 2009. The advantage of the Control4 system is the flexibility with which it can be expanded, allowing the client to start with one smart control element and gradually add more.

iNels

This company was founded in 2013, and its home automation system is sold under the ELKO EP brand, which is a modular electronic unit manufacturer. The company iNels, for example, offers the unusual service of integrating the system into an already completed building or apartment. She also worked on the show "How to Build a Dream" with Prima TV.

SUP-TECHNIK

The company first focused on low-current installations and technologies for distributing cable television signals when it was founded in 1996. It has also focused on smart homes with its Inteliobox system since 2009. It also sells Z-Wave components, which can be inserted into almost any existing electronic device. The customer can now use remote access to control the previously "unintelligent" components.

IBSolution

In 2006, a Czech company specializing in smart homes was established. It became a certified partner of EIB / KNX, an intelligent home management system, two years after it was founded. They're also a partner of DIVUS, a touch screen manufacturer, and ABB, a provider of intelligent wiring components, among others.

4.1.2 **Smart Home Efficiency**

A smart home uses more home appliances than a normal home and, accordingly, consumes energy. In addition, network efficiency must be considered alongside energy efficiency, cost, and security as the scales of apartment buildings become larger, if there is a system that manages the appliances of the buildings as one. Thus, various energy and network efficiency services are being studied for smart homes.

3.1.2.1 Energy and Cost Efficiency

Energy efficiency carries out the same or greater quantity of activities with the same or smaller quantity of energy consumed (heat, electricity) and with less carbon dioxide emissions into the atmosphere. The inefficient use of electricity is increasing in proportion to the increase in the consumption of electricity, the increase in economic activity and the use of outdated technologies. Moreover, this increases the adverse impact on the environment and consumes resources that cannot be recovered and will not have adequate access to them for the next generations.

Energy efficiency brings great benefits to everyday life, reducing the need for imports of energy, increasing heating and cooling efficiency, saving money, improving the environment, reducing the risk of various diseases caused by harmful substances resulting from the production of energy, increasing the number of jobs, and increasing the use of renewable energy sources (Energy efficiency in smart home system, 2020). Next performance evaluation.

Domestic energy retrofit has a lot of potential for lowering carbon emissions and lowering energy demand. However, energy savings from retrofit projects often fall short of expectations. retrofit advice on calculations that included the heating of rooms using air and other system heat pumps. These audits usually concentrate on the physical characteristics of the homes using building performance models with standardized behavioural assumptions to measure home energy efficiency the Reduced Normal Assessment (RdSAP) to determine home performance as well as to estimate and suggest effective improvements. As a side note, this drone can be used as a to assess the building without the person being a part the activities. It can be used to measure the fuel consumption of a building irrespective of the person's household behaviours. Taken together with the previous outcomes assessment determination that an analysis of the later health consequences of the subsequent retrofit recommendations and impacts _increase efficacy of related interventions is decoupled from any unique occupants (Modelling Energy Retrofit Using Household Archetypes, 2020).

When considering advances in the areas of smart metering and smart grids, energy efficiency would be a big issue in future smart homes. Liberalized markets, micro energy generation, and the resulting consumer requirements would force energy providers to respond. Time-of-use and real-time pricing, for example, can assist both consumers and energy providers in reducing household energy costs and improving load management. Furthermore, if users had transparent knowledge on which energy source (wind, nuclear, etc.) is currently in use at any given moment. In the home, it all comes down to how you use this data, how you process it, and how you visualize it. We agree that an energy-aware smart home application must strike a balance between assisting users in conserving energy while still maintaining convenience.

3.2.2. Security Efficiency

The changing definition of protection in modern homes has been aided by technological advancements. It has progressed from a basic lock and key protection concept to the use of sophisticated security systems that include cameras, microphones, touch sensors, proximity sensors, alarms, silent alarms, and other features. Users can access and monitor their homes remotely at any time and from anywhere in the world by connecting modern homes to the Internet, which is very common today. People can know and monitor every aspect of their home, such as which door or window is open, which gadget or light is turned on, and which rooms are occupied, thanks to an improvement in processing power of newly designed processors and a significant reduction in power consumption, cost, and size of new electronics devices. Residents can monitor their homes using live video and audio feeds from various parts of the house. They should also be aware of various environmental variables, such as humidity, temperature, and light intensity, both inside and outside their house. Sensors collect data about the real world or atmosphere around them in a Wireless Sensor Actor Network. Actors carry out the user's or any other party's instructions about the environment. Wireless Sensor Actor Network advancements are undoubtedly a factor in the rise in popularity of smart homes. Combining Ubiquitous Computing, Wireless Sensor Actor Networks, and the widespread use of the Internet, designers, engineers, and researchers have devised effective methods for allowing residents to access and monitor all aspects of their homes, including the environment (Arun Cyril Jose, 2015).

While on the merging of homes with the Internet and ubiquitous computing, should have must offer a wider explanation or interpretation to the word "intruder" in our description, considering the number of devices used in home automation today and their vulnerabilities. In traditional homes, intruders could only steal from or invade a home if they were physically present (Arun Cyril Jose, 2015). An intruder or attacker who connects a home to the Internet can access the home from anywhere in the world at any time using an Internet connection, and they can keep an eye on the residents using cameras in the home. As a result, even without the additional security vulnerabilities of the technologies used at home, detecting, and defending against such intrusions is extremely difficult. In short, when thinking of home protection, its better think of intruders in the conventional sense, such as robbers attempting to break in by picking the lock or prying open a window, and rarely think of advanced thieves who are skilled with technology or criminals who collaborate with hackers. In order to account for system vulnerabilities, our definition of intruder must change from its conventional meaning. Alarms, infrared sensors, and touch sensors have all been used to detect and prevent such intruders, but very little effort has gone into identifying and preventing technologically qualified intruders (Arun Cyril Jose, 2015).

Residents of a modern home can access it from the outside through the Internet, the Global System for Mobile Communication (GSM), and wireless portable devices such as cell phones, tablets, and laptops, as well as stationary devices such as an office workstation (PC). In other words, the computing environment of the typical automated home user is constantly evolving. By computing environment, which means a user's network connectivity, network access at various locations, cost of accessing the home through the Internet, computer processing capacity, and other hardware available to the user. It is difficult to expect the user to be vigilant about security any time he or she enters their home from the street. This introduces new security flaws to the domestic front. Understanding the background of a user's behaviour could go a long way toward enhancing a home's protection (Arun Cyril Jose, 2015).

GSM

The interface between transistor-transistor logic (TTL) and RS-232 via the MAX-232 chip comes with the GSM SIM 900A. The RS-232 interface on the GSM/GPRS (General packet radio service) modem provides both PC and microcontroller connection features. This modem operates on 900/1800 MHz frequencies and the baud rate can be configured via the

AT command from 9600 to 115200. To enable us to connect to the internet via GPRS, the GSM/GPRS modem has an internal TCP/IP stack.

As a communication platform set-up, the GSM module is used. The message signal can be received and transmitted between the embedded system and the smart phone user. This module is connected to the main Atmega16 controller, where the Atmega16 microcontroller transmitter pin is connected to the SIM900A GSM module receiver pin, and vice versa. As an M2M interface, this module is applicable for voice and data transfer. This module has an on-board regulator that can control the variation of the stabilized voltage of the input voltage. Normally use a 12V DC power supply for this module. With the use of a simple AT command, an Internet connection can be achieved via the GPRS platform (SMART HOME: Energy Measurement and Analysis, 2020).

Arduino UNO

The Arduino UNO is a microcontroller used by digital pins to read the input values of the sensors and to write values. This module itself is a power supply that also consists of ground pins for the 3.3v and 5v sensors. Arduino UNO is capable of understanding any programming language uploaded to Arduino via IDE. The ESP826 Wi-Fi module has an integrated microcontroller where, via a serial converter, and gives ability to upload codes directly to the ESP modules. The ESP module acts as an Arduino and cloud bridge. It is powered by an external energy supply of 3.3v. It has Rx and Tx pins where the ESP266's Rx pin is connected through the Arduino UNO 3 serial output. The serial output 3 is first sent to a 1k resistor and a 2k resistor soil. The output is sent between 1k and 2k resistors to ESP8266's Rx. The Tx is connected to Arduino UNO's Serial Output 2. By obtaining the SSID and password for the routers, ESP8266 is connected to the network. The drawback of this module is that only a maximum of 3.7v can be used. The current supplied by Arduino is not sufficient to run this module and requires a separate power supply that must regulate the external supply voltage flowing out (SMART HOME: Energy Measurement and Analysis, 2020).

4.2 Selected Technologies to Increase SH Efficiency

Smart Thermostat

Smart thermostat systems (STS) may be an appealing short- to mid-term solution for improving energy quality in residential buildings. The purchase of an STS is a small investment as compared to energetic refurbishment or the replacement of an obsolete heating system (Conditions for a cost-effective application of smart thermostat systems in residential buildings, 2020). Since the Auto-Away feature detects when no one is home, the smart thermostat adapts to all adjustments in the user's schedule on a continuous basis. The thermostat then regulates the temperature to avoid overheating an empty house.

Thermostats that can adjust the temperature based on programs are referred to as programmable thermostats. It is estimated that programmable thermostats can save up to 30% on HVAC costs by adjusting the building's heating and cooling according to the occupants' daily schedule (Energy Efficiency Effectiveness of Smart Thermostat Based BEMS, 2020).

The implementation rate for energy-saving initiatives has consistently been well below what is expected in the last decade, necessitating a significant drive to meet the targets for heat consumption in buildings. In climates with extreme or wide-ranging exterior temperatures, space heating and cooling systems are needed to maintain comfortable interior conditions (Conditions for a cost-effective application of smart thermostat systems in residential buildings, 2020). More than half of the Czech Republic's current energy consumption comes from domestic primary energy sources. As a result, the Czech Republic's energy import dependence (including nuclear fuel) is under 50%, making it one of the lowest in the EU. The actual European Union average is around 60%. The Czech Republic is fully self-sufficient in terms of energy and heat generation. Electricity sources have a stable structure. Coal dominates the Czech energy market, supplying nearly 60% of electricity and a large portion of heat through district heating systems as a base-load source. Renewable energy sources other than hydropower plants are becoming more well-represented as a result of recent renewable energy promotion, but they have yet to wrest a significant share of the market from fossil fuels, despite substantial subsidies. Domestic fuels account for roughly 60% of heat output, and more than 80% in the case of heat distribution systems. The Czech Republic has a long history of heat and energy cogeneration. Cogeneration heat accounts for nearly 75% of total centrally generated heat (Department, 2016). This indictes that most households consume lots of enregy for house heating and cooling purpose.

For example, on a typical red alert day, an analysis of the effect of in-home displays and smart thermostats on peak time energy use reduction finds that STS consumes 15% less energy during peak load hours (Conditions for a cost-effective application of smart thermostat systems in residential buildings, 2020).

Smart Plug

Smart Plug is a multifunctional and simple-to-use interface that enables users to track and manage their electronic devices from any location and at any time (Integrated Smart Plug Design, 2018). Smart Plug comes in a variety of sizes to accommodate any electronic that needs to be paired. The addition of Plug numbers corrects certain flaws, such as in terms of cost. Smart Plug has a monitoring feature that allows you to see the voltage and current levels. On occasion. Knowing when the power supply voltage becomes unstable on the power source is also critical for electrical equipment protection (Integrated Smart Plug Design, 2018).

It is a plug that can be used instead of a traditional plug. Its size and plug shape are identical to theirs. However, it offers a mechanism for remote control, appliance type identification, and shutting off these devices, in addition to what traditional plugs do, which is to link electric devices to the power line.

Humans are battling energy-related issues that not only affect society and global development, but also contribute to global warming. Both industry and academia have established a number of diverse approaches to this issue. However, rather than interface metrics and benchmarks, there is a growing need for detailed, end-to-end solutions aimed at changing human behavior. As part of a larger multi-appliance energy efficiency program, which makes it visible to micro-moment-based smart plug system. The smart plug, which consists of two sub-units: the power consumption unit and the environmental monitoring unit, collects appliance energy consumption as well as contextual data such as temperature, humidity, luminosity, and room occupancy. The plug can also be used to automate your house. End-users can visualize energy consumption data as well as ambient environmental data using the accompanying mobile application. The proposed system provides cost-effective deployment while retaining adequate computation and wireless efficiency, according to current implementation results (Integrated Smart Plug Design, 2018).

Non-uniform regular energy consumption is one of the most difficult aspects of delivering household electricity and managing energy consumption. In other words, during peak hours, the cost of energy production and consumption is substantially higher than during off-peak hours. As a result, shifting energy usage to off-peak hours has no significant impact on energy consumption but can help save money on energy provision. Demand-side power monitoring approaches that are applied at the user level do not necessitate the installation of new infrastructure and therefore have a low deployment cost (Integrated Smart Plug Design, 2018).

System Wiring

The large number of wires, access or control points, and the increase in the number of new security, control, and management systems all add to the installation's complexity and potential clutter. This issue can be avoided by employing system wiring, also known as "intelligent" wiring today. This system has advantages in terms of implementation as well as user satisfaction. This can include advantages such as more comfortable and flexible household management, which can lead to a better stay in a building or energy savings. Nowadays, a system electrical installation can control all of the necessary elements of a household, from lighting to heating to the security system or heat pump control panel (Tomas Zeidler, 2015).

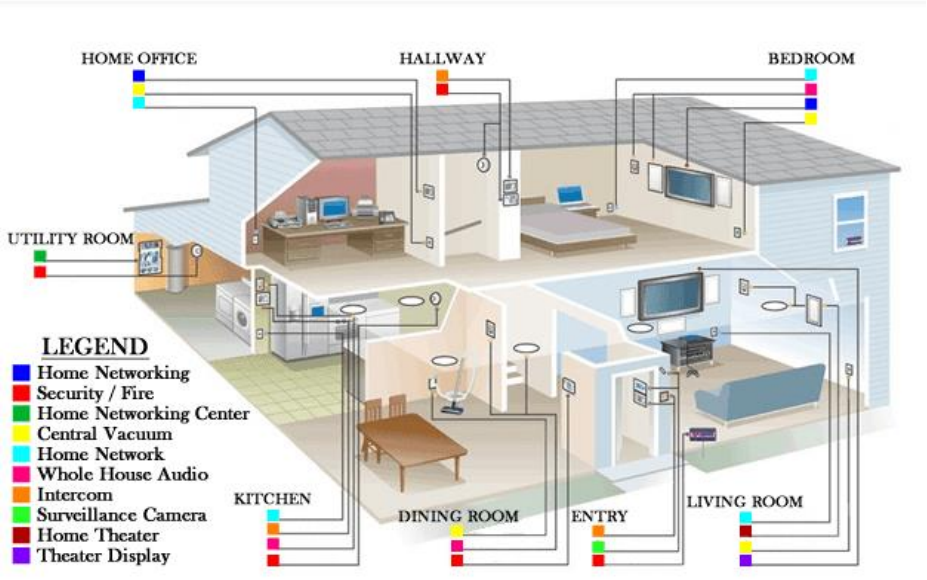


Fig.5. System/Smart wiring [source,The IT Guys, 2021]

A smart wiring Fig shows that how it looks like system wiring for better energy consumption and safe electrical instalation system.

This type of wiring, or smart homes, which are structures that use more than just system wiring, is gaining popularity these days. The reason for this is the growing demand for improved living comfort and more effective building management choices. From a comfort standpoint, the system electrical installation is known for its versatility, as the provided installation can be configured precisely to the client's specifications and redesigned from the ground up at any time. It is also possible to emphasize the system's remote control and management, as well as the system's long-term data collection, which can be used as feedback for future changes, etc. In terms of cost, this form of wiring has a lot of potential for increased energy efficiency throughout the house(Tomas Zeidler, 2015).

Comparison: system and conventional electrical Wiring

Classic wiring is the most common and unused type of wiring in the world. It's mostly used for basic electrical installations. It only consists of a power line. Individual appliance control or switching is ensured by appropriate elements in the required location. These components are connected to the appliances via a common circuit. As a result, appliances are only controlled by switching a single circuit. For conventional electrical installations, this method of control and connection has the disadvantage of limited functionality. The circuit can only be turned on or off. The most significant disadvantage of this electrical installation is the high cost and time required for any modifications, as well as the confusing and complicated connection in larger electrical installations. The low purchase price is a significant advantage over intelligent installation, which is why this type of electrical installation is widely used in small, small, and medium-sized residential buildings all over the world. Larger objects should only be installed using traditional methods if they do not require complex controls(Tomas Zeidler, 2015).

The system electrical installation, on the other hand, adheres to current trends, such as time and energy savings, ease of operation, and simple connection, which are the system installation's main advantages. The three most important elements of this system's installation are sensors, actuators, and the central unit. Sensors are installation control parts that detect system requirements. Actuators meet these requirements by switching the power circuit in question. A data bus connects all elements of the installation (central unit, actuators, sensors) and serves as the installation's backbone. The main control element is the central unit, which can be configured using a PC and a software interface to perform the required functions.It gives possibility fully automate the operation of the household with such an installation, including room temperature control, lighting, and window blinds, among other things. The simplicity of this installation's design is an advantage. However, the cost of implementation in smaller buildings is a disadvantage(Tomas Zeidler, 2015).

5 Practical Part

A smart home has more appliances and uses more electricity than a traditional home. Furthermore, as apartment building sizes grow larger, network efficiency must be considered alongside energy efficiency if the building's appliances are managed as a single device. To evaluate and determine the SH efficiency we try to analyse two mechanisms, the first one is evaluating SH devices in accordance with their energy consumption, and cost efficiency. The second one is cost effective Arduino based smart home systems.

5.1.1 Analyze and Evaluate SH Devices Efficiency

4.1.2 Methods

The purpose of the study is to find how to determine efficiency in SH devices, one of which is making sure to use the most up to date tools and technologies. The evaluation of this technology guidelines has actually been a lengthy one, and we found that the introduction of a system to keep up with which technologies have been evaluated gave us great contribution towards improving this assessment and regulations of new technologies and detection standards as well, helping us ensure this technology assessment methodologies are operational.

While most home automation systems will be placed in the smart home category, this is merely a way to differentiate them from other more lacking intelligent household networks. In order to ensure smart homes are useful and successful in the future we ca not limit ourselves to technologies based on current efficiency information. The paper focusing on energy, security, and economic efficiency within just a few pages is the shortest, and it is not meant to be just a brief overview of some emerging technologies.

The next step measures the net economic gains and energy consumption from the implementation of the new system. Under the correct governance, the benefits of these gains will likely far exceed the expenses because it needs to take into account both endogenous gains, resulting from the technology under scrutiny, and exogenous variations, depending on market factors, policy, or even other technologies that are available.Its difficult to compare the savings from a smart thermostat if while looking only at energy savings from

smart thermostatsits nescessary to look at energy savings from traditional thermostat units and energy savings from the smart thermostats. One must also consider the changes in window-pane insulation technology and panel technology. But this is not a "mutually exclusive" relationship. When companies move to a new technology, they will often integrate it into other processes that are already in place, which often means that it gets more efficient for all the existing processes (Danny Parker, 2016).
At the last, after examining all of the potential benefits and the limitations of each method, determined that the most efficient method of treating is via a pill. While it is to be expected that the processes on which others rely on can sometimes become more convoluted than the simple processes of the off-line world, this further complicates matters when begin to understand how various technologies work.

4.1.2 Available data

There are many data sources that are constantly being updated, which provide us with much needed information about various technologies that make up a smart home (Danny Parker, 2016). A lot of data focuses on heating and cooling as they account for the largest portion of energy bills in Europe (Modelling Energy Retrofit Using Household Archetypes, 2020) Smart devices have many advantages over traditional ones, perhaps for one reason or another.

Among them is the fact that many of them are capable of interactions such that they can cater for both the heating and cooling systems and other home monitoring and controling as well on their purpose. They are also working to save energy, which helps a lot. In New York, solutions rely on smart and non-smart technologies that provide clean energy (Modelling Energy Retrofit Using Household Archetypes, 2020). Examples of "smart" technologies are solar and wind power. Examples of "non-smart" technologies are natural gas and coal power. Passive systems that utilize solar power could benefit from added intelligence that would help the system more efficiently allow the sun to provide enough energy to the system. Practically speaking, this could potentially allow solar energy to provide a larger portion of the systems energy needs (Modelling Energy Retrofit Using Household Archetypes, 2020) state that during the importance of energy optimization is not possible to upgrade just a building but also the " energy efficiency is not just about upgrading housing with new smart technologies but also about proper examination of the efficiency of investments in energy optimization ". (Modelling Energy Retrofit Using Household Archetypes, 2020). The same way to analyze carbon footprints from a dual perspective, looking at operating impact and initial impact, need to apply models designed to assess the financial effectiveness of new technologies (Modelling Energy Retrofit Using Household Archetypes, 2020)in order to determine the viability of implementation.

4.1.3 **Technology selection**

Technology selection model by starting building a list of candidate technologies and rating them on their potential to directly impact utility costs in the smart home. Technologies aimed specifically at regulating the use of electricity, gas, or water, for example, will be rated higher than technologies aimed at providing improved protection, and security technologies will be rated higher than those solely aimed at sound system. In this example, the scoring is based on current data on short-term, long-term, and total other monitoring technology gains (Danny Parker, 2016), protection system efficiency data (Caputo, 2014) and data on marginal efficiency improvements in smart home energy-related systems [Ecobee, 2019]. In order to keep the model balanced, the overall energy efficiency improvement is capped at 10 percent.

In order to assess the proportion to which this score influences the final outcome of the technology selection model, the average weight of utility costs within personal expenditures is used to determine (TSM). Next, technologies are scored on their ability to minimize the time needed to conduct the tasks that the technologies are supposed to solve. Scores in this group are estimated by the implementation of the latest technology in terms of working hours (WHr) saved per month. Based on a 30-day month and 16 hours awake every day, a total of 480 possible working hours is assumed. While most field research focuses on the issue of quality-of-life (QOL) and despite the fact that accounting for quality-of-life improvements would add considerable value to this model, were unable to establish a satisfactory way to measure that quality. Indeed, accounting for and, even better, quantifying QOL presents critical research methodology challenges. Then it will assesed by using the following formula,

$$Tn = \frac{EEf}{10} \times Ut + \frac{WHr}{480} \times (1 - Ut)$$

Where:

Ut – Weight of utilities within personal expenses

EEf – Potential direct effect on energy efficiency

WHr – working hours saved through the introduction of the technology

Net Gain Evaluation

Evaluating the advantages of introducing a new technology is lay on principle one of the main problems of energy and economic efficiency. To achieve this,

$$NGm = Ef \times AMC$$

NGm - Net Gains from technology (monthly)

Ef - Gains through increased energy efficiency (%)

AMC - Average monthly cost of energy utilities

Since any change inevitably requires an initial investment expense, in order to assess the probability that a technology will become universal, need to apply the principles of Net Present Value. It needs to start by computing annual gains (NGy) based on NGm to apply the classical NPV (Net Present Value) formula. Discount rates should be chosen from available reference interest rates which, in terms of jurisdiction and time, best fit the rest of the data.

$$NGpv = \sum_{t=1}^{ULt} = \frac{NGy}{(1+r)^t} - IC$$

Where:

NGpv = Present value of Net Gains

NGy = Net Gains from technology (yearly)

ULt = Useful life of technological implementation

IC = Initial investment costs

r = discount rate

Under certain circumstances, particularly when discount rates are negligible, both for NGpv and BEP, it may be more realistic to take a simpler approach to the payback period. In this case, it will actually sum them up at their nominal value instead of estimating the current value for all possible future profits.

4.1.4 Comparative Decision Making

Once adequate data about competing technologies is available, which paves the way to the next move on to determine the potential spread rate of primary technology. The calculation takes into account, in relation to initial investment costs and sales, the amount obtained from the introduction of the technology.

$$f_{(BEP_{1\ldots n,t}, IC_{1\ldots n,t}, ULt_{1\ldots n,t}, NIm)} = \frac{2^{\frac{BEP_t - IC_t}{ULt_t}} - MAX\left(\frac{BEP_n - IC_n}{ULt_n}\right)}{NIm}$$

Where:

BEPt = Break Even Point for primary technology

BEPn = Break Even Point for competing technology

ULtt = Useful life of technological implementation for primary technology

ULtn = Useful life of technological implementation for competing technology

NIm = Net monthly income

ICt = Initial investment cost for primary technology

ICn = Initial investment cost for competing technology

Previously its already established, which is

$NGpv = BEP_t - IC_t$

By utilizing the present value of net gains directly instead of the extended BEP - IC formula, to compose the function in a somewhat simpler manner. This will help as to get to the required assessment easily.

Optionally, in order to account for the ratio of initial expenditure expenses and net monthly profits, an extra weighted parameter should be included on the top side of the function.

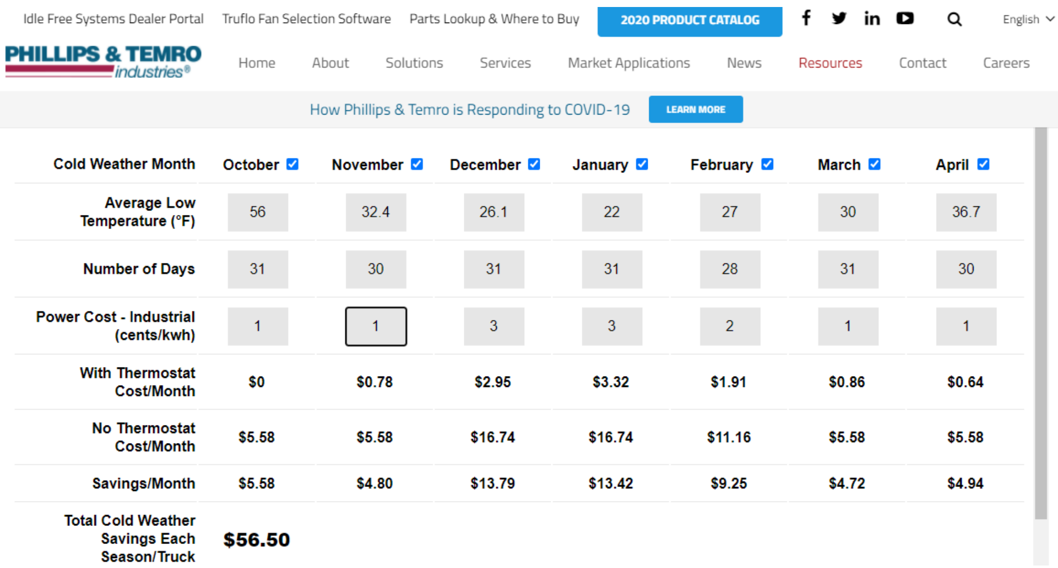
$$f_{(BEP_{1\ldots t}, IC_{1\ldots n,t}, ULt_{1\ldots n,t}, NIm)} = \frac{2^{\frac{NGpv_t}{ULt_t}} - MAX\left(\frac{NGpv_n}{ULt_n}\right)}{NIm}$$

NGpv = Present value of Net Gains

4.1.5 Appraisal of technologies (Assessment)

Its better to looked on some smart home devices which are promissed to increase the energy and economy efficency of the SH users which are Smart Thermostats, Smart plug, Video Monitoring Devices, Smart fridge, and Entire Home Audio Systems. This technology mix widely encompasses modern technical developments as well as the fundamental sub-fields of the smart home industry.

By reaching 5 smart home device producers and developers to rate innovations on the basis of their energy saving ability and to tell us how many hours they felt would be saved by adopting the technology. In total monthly expenses, the financial significance of utilities was estimated to be 23 percent, based on Eurostat (Eurostat) results.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Cold Weather Month	October	November	December	January	February	March	April
Average Low Temperature (°F)	56	32.4	26.1	22	27	30	36.7
Number of Days	31	30	31	31	28	31	30
Power Cost - Industrial (cents/kwh)	1	1	3	3	2	1	1
With Thermostat Cost/Month	$0	$0.78	$2.95	$3.32	$1.91	$0.86	$0.64
No Thermostat Cost/Month	$5.58	$5.58	$16.74	$16.74	$11.16	$5.58	$5.58
Savings/Month	$5.58	$4.80	$13.79	$13.42	$9.25	$4.72	$4.94
Total Cold Weather Savings Each Season/Truck	$56.50						

Fig.6.Thermostat energy efficiency evaluation

Data source Global pertolprice.com

Table.1. Technology selection model score for the selected technologies

Smart devices	Working Hours	Energy efficiency	Technology selection Model (TSM) score
Smart Thermostats	3.9	8.8	0.0948
Surveillance	7.2	5.1	0.0624
Audio Systems	0.5	0.9	0.0093
Smart plug	4.2	8.2	0.0908
Smart Fridge	4.5	3.4	0.0427

[Source: Own]

While one of the project original assumptions, and an important part of this model was that the attractiveness of a smart home technology would decrease if a competing technology was available, this application of the model to smart thermostats and subsequent analysis of data by Nick Wiedenmerk, John Woollen, Christopher J. Coyne and Brigham Young University confirmed that non-smart technologies also can influence adoption rates. Although there has been some delay on the part of smart thermostats in Europe as well in Czechia, the innovation has been impeded by advancements in heat transfer and insulation technologies. While were able to compute the NGm and BEP exposure for a few of the other technologies on the list, the results might have been exponentially more valuable had it been possible to include other competing technologies which can either protect them from the harm of EMF or produce in their place a more healthy environment in which to live in.

The Comparative Decision Model (CDM) required using net monthly income in order to compute the likelihood of consumers opting for the smart thermostat technology. Where data for the European Union substantially, as well for Czechia. As a result, to concur that the mean income in the European Union, about €1781 and for the Czechia €999,[EURO STAT, 2019] contains the majority of the given high income data.

Comparison: Conventional and System(Smart) Wiring system

Table.2. Description 4 + 1 (approx. 85 m2) Conventional wiring installetion price description

Description	Unit	No of material	Material		Work		Total Kč
			Price of one matereial	Total material	Price of one material	Total work	
Distribution of high current, low current							
Indoor wiring	Kpl	1	23809,9	23809,9	26096,0	26096,0	49905,9
Switchboard mounting	Kpl	1	22682,8	22682,8	11925,0	11925,0	34607,8
Drivers, sockets, boxes	Kpl	1	8790,1	8790,1	7575,0	7575,0	16365,1
STA socket (Common TV antenna)	Kpl	1	1433,9	1433,9	1668,8	1668,8	3102,7
Home phone	Kpl	1	1002,0	1002,0	385,0	385,0	13787,0
Other	Kpl	1	1131,3	1131,3	202,5	202,5	1333,8
	Kpl	1					
Total	Kpl	1	58850,0	58850,0	47852,3	47852,3	106702,3

Auxiliary work performance (PPV)		2% GRAIN	2 134
secondary budget costs (VRN) 2.7% (ZRN + PPV)			3 287
travel expenses			15 000
Total excluding VAT			126775
Price per m2	m2	83.5	1,518 most commnly

Sourse [Insight Home 2019]

Table.3. Description 4 + 1 (approx. 85 m2) System wiring installetion price description

Description	Unit	No of material	Material		Work		Total Kč
			Price of one matereial	Total material	Price of one material	Total work	
Distribution of high current, low current							
Indoor wiring	Kpl	1	26868,7	26868,7	29750	29750	56618,7
Switchboard mounting	Kpl	1	22682,8	22682,8	11925,0	11925,0	34607,8
Drivers, sockets, boxes	Kpl	1	8790,1	8790,1	7575,0	7575,0	16365,1
STA socket (Common TV antenna)	Kpl	1	1433,9	1433,9	1668,8	1668,8	3102,7
Data	Kpl	1	2700,0	2700,0	3240,0	32,40	5940,0
Home phone	Kpl	1	1002,0	1002,0	385,0	385,0	1387,0
Other	Kpl	1	1131,0	1131,0	205,5	205,5	1333,8
Total	Kpl	1	64608,8	64608,8	54746,3	54746,3	119355,0

[Source Insight Home 2019]

The distinction between modern and traditional wiring is almost non-existent. These are primarily increased internal wiring elements. In comparison, the cost of a modern installation is 10% higher than that of a traditional installation. When measured in square meters, a modern electrical installation costs about 180 CZK per square meter.

Auxiliary work performance (PPV)		2% GRAIN	2 387
Ancillary budget costs (VRN) 2.7% (ZRN + PPV)			3 287
travel expenses			15 000
Total excluding VAT			140 029
Price per m2	m2	83.5	1 677

[Source Insight Home 2019]

According to a report by the Czech Statistical Office, the average electricity consumption was 3,279 kWh per unit, in 2017, but for the year 2020 according to world data, average electricity consumption for Czech housholds is almost 5,843 kwh. At the current price of approximately CZK 4.82 / 1 kWh, the resulting annual price for electricity is CZK 15,840 per year[Eurostat].

An average value of 7% is taken into account when calculating the annual cost of failure. This cost is CZK 1,547 per year for a lifetime without warranty.

Heating, as well as the hot water heating that goes with it, is another important consideration. In the case of traditional natural gas heating, operating costs amount to approximately CZK 49,368 per year. [ePrukaz.cz 2021]

The average annual savings in the use of intelligent wiring was determined to be 30% when compared to conventional wiring after the implementation of smart wiring. The total annual operating costs are then approximately CZK 67,275 per year.[ePrukaz.cz estimation 2021].

When by lookink the savings which is Payback period (Ts),

As previously stated, the uniform initial costs are CZK 521,460. When annual operating costs are reduced by 30%, the operation of an intelligent installation costs about CZK 21,221 less than a conventional installation.

Ts = 521,460/21,182 = 24.61

The investment's return and subsequent earnings should occur in the 24th year of use.

This result helps to proced to the nex evaluation that is Net present value(NPV)

$$NPV = \sum_{i=1}^{n} \frac{Cash\ Flow_i}{(1+r)^i} - Initial\ Investment$$

In the 24th year of the life of the investment, the net present value was CZK -161,112.

5.1.2 Arduino based home automation system to determine and evaluate the efficiency

4.1.2.1 Material and Methods

Proposed System

Android operating system

The Android operating system is a type of system developed by Google for mobile phones. Furthermore, it is one of the best-selling operating systems in the world. Furthermore, Android supports a wide number of convenient and advanced applications.

The Arduino Uno is a microcontroller board based on the ATmega328p. It has approximately 20 optical output/input pins. Another point to mention is that the Arduino comes with everything required to help the microcontroller. It can also be linked to a computer via USB cable and operated by an AC-DC adapter or battery to get started. Arduino can be defined as an open source hardware platform that can sense the environment using a variety of sensors. It is a project that can be used independently or in conjunction with computer software.

The proposed system tries to solve the problem statement using mobile app to control and monitoring the house with les energy consumption and better monitoring and controling system to maximize efficiency. When inhabitants are around our home, its easy to use affordable Bluetooth communication, which means the created connection can help us to control the house appliances and see home status notifications.

The other is determining the amount of electricity used by smart home appliances. The appliances are linked to a microcontroller, which is linked to the electrical appliances' smart relay switches system (Deschamps-Sonsino, 2018).

By using these system can perform the following tasks.

- The system shall control and monitor the home appliances
- Gives the opportunity to measure the level of electrical energy used by the appliances.

On the other hand, it means it is easy to control and manage the smart home by a cost wisely and energy consumption efficiently.

Analysis

This analysis phase will gather and define all of the project requirements in a requirement specification document. This clearly indicates that the project beginning date should be by this time and the developer's understanding of the project must be understood clearly. Instead of a humanoid robot/robot, the selected one is Arduino microcontroller because it's a very easy microcontroller to program and it is cheap to obtain. The other thing is planning on learning how to program an Arduino.

This use case contains both hardware and software. Arduino is the main hardware and will be connected to the ACS712 hall sensor, relay and electrical appliance (SMART HOME: Energy Measurement and Analysis, 2020).

Hardware component

- Arduino Uno microcontroller: Arduino is open-source hardware, where the programming can be done to control the electronics devices. Generally, Arduino is used for sensing sensor/devices and controlling them.
- The Hall Sensor ACS712 is a sensor used to measure the flow of electricity to an appliance. It is powered by 5v Vcc and the sensor's output is connected to the Arduino UNO analog input. ACS712's unique characteristic is that it can measure both the DC and AC current. This sensor's drawback is its price and it must be calibrated for more accuracy.
- Thingspeak is an open source cloud platform that allows the sensor value output to be computed and analyzed (SMART HOME: Energy Measurement and Analysis, 2020).

Software components

- Arduino Uno program
- Dedicated android mobile app
- Arduino IDE
- APP inventor

Arduino and Arduino IDE

The open-source software for coding and uploading to the Arduino board is the Arduino IDE. It can be downloaded from the official Arduino website and is cost-free. Like Windows, Linux, and MAC, this software can run on O.S. This software can be written on any Arduino board and is therefore applicable to all. It is simple and easy to use the coding in this software. It's relatively simple and easy to understand the programming. The format of the Basic programming model consists of two functions:

Void setup () {} // write initialization variable or initial things before main function.

Void loop () {} // write loop able tasks or things to control in this function (Electrical appliances control prototype by using GSM module and Arduino, 2017).

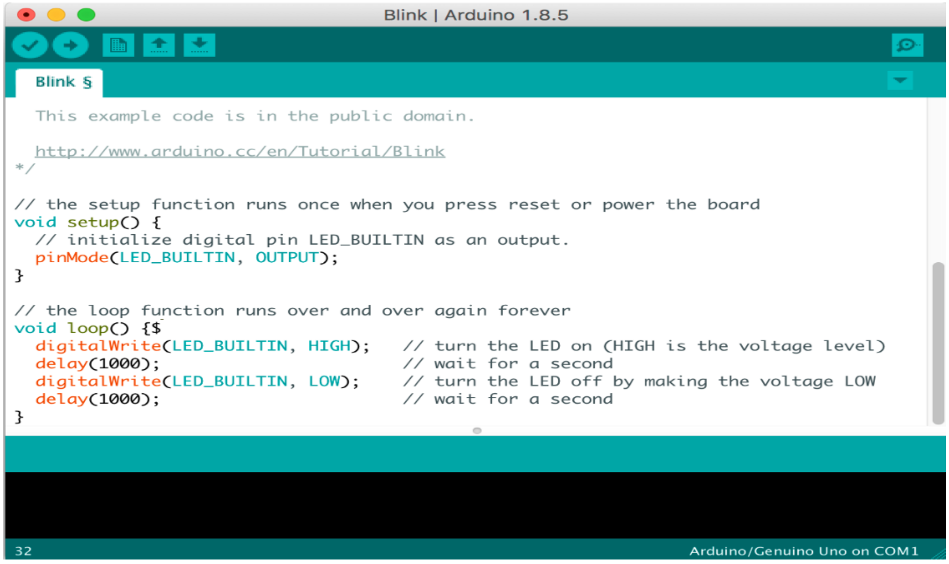


Fig.7. Arduino IDE [Source: Blink Arduino 1.8.5]

App Inventor for Android

The app inventor allows computer programming newcomers to create Android operating system software applications using a graphical interface.

- The Inventor Designer app, where you select the parts for your app.
- With the App Inventor Blocks Editor, where there is a hole insert a number of programs that will determine how the parts will behave. When programming involves the creation of a visual image of parts that are being used together and then putting the parts together in the appropriate manner.

As you add pieces to it, the developed app appears step-by-step on the phone, so its possible test the work as that is built (Electrical appliances control prototype by using GSM module and Arduino, 2017).

If it is not possible to get Android phone, there is an othe option to use the Android emulator to build the apps, software that runs on the computer and acts just like the phone does.

For Mac OS X, GNU/Linux, and Windows operating systems, and several popular Android phone models, the App Inventor development environment is supported. The app inventor gives opptions to to install applications by using App Inventor on any Android phone. First need to set up the computer and install the App Inventor Setup package on the computer before start to use the App Inventor (Electrical appliances control prototype by using GSM module and Arduino, 2017).

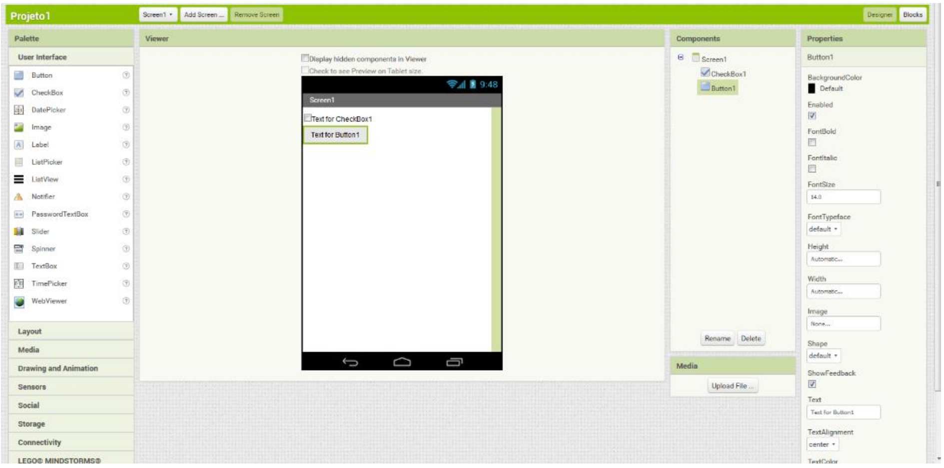


Fig.8. App inventor project page [Source: MIT App inventor]

Arduino Uno

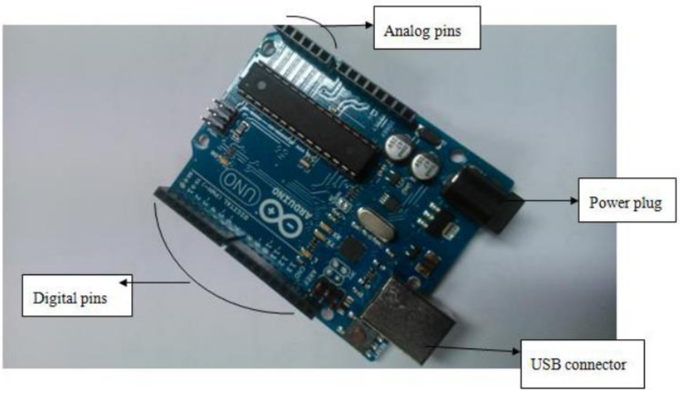


Fig.9.Front view of Arduino UNO [Source Online]

Bluetooth module HC05

To connect mobile phone and microcontroller Bluetooth module is used because the microcontroller has not the ability to function all by itself. Hc-05 module is used for this purpose, which is low power 1.8 v operation, PIO control with integrated antenna, edge connector and is easy to use with Bluetooth SPP (serial port protocol). Using Bluetooth profile and android platform architecture different type of Bluetooth applications can be developed.

HC-05 Bluetooth module consists of two things one is Bluetooth serial interface module and a Bluetooth adaptor. Bluetooth serial module used for converting the serial port to Bluetooth.

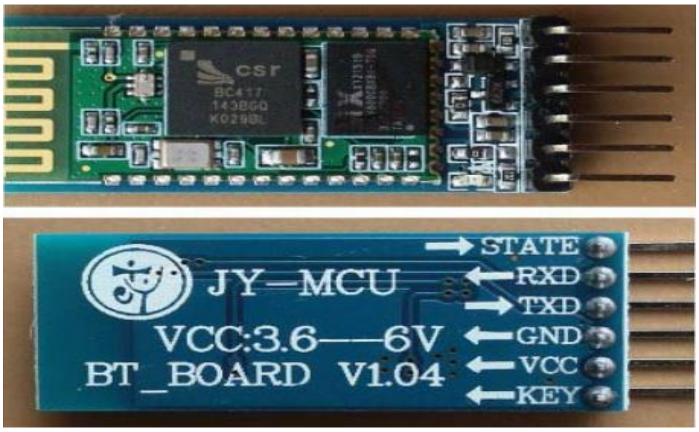


Fig.10. HC-05 Module .[Source: Circuit Digest-online 2021]

HC-05 module used for simple and easy use of Bluetooth serial port protocol module, which is designed for transparent wireless serial connection setup.

Serial port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate), With modulation 3Mbps and complete 2.4GHz radio transceiver and baseband. By using CSR Blue core 04-External single chip Bluetooth system with other familiar CMOS technology and with AFH(Adaptive Frequency Hopping Feature). This will simplify the overall design/development cycle. .[Circuit Digest-online 2021]

Relays

Look at the picture of a spark welder down below in the right side. Look for the 3 screw-type of terminals. E-cigs come in different shapes and under different brands. (eg. - they're labeled "NO", "COM", "NC" (Electrical appliances control prototype by using GSM module and Arduino, 2017) These product labels mean:

- NO: Normally Open
- COM: Common Connection
- NC: Normally Closed

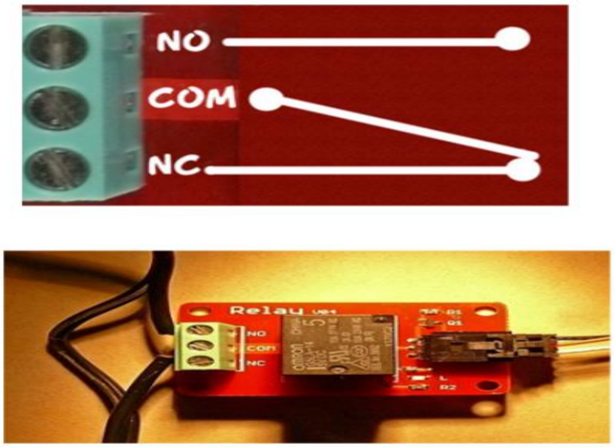


Fig.11.Relay [Source: Tigor Hamongan,. . .,2017]

This shows the switch that is inside the relay circuit board. Most effectively, this switch is thrown over the electromagnet inside. In the schematic, the Common Anode contact is connected to the Normally Closed contact. An explanation of when the relay is in the off position. When the relay is turned on the electromagnet flips the switch up and then the Normally Open voltage is created in the COM terminal. If we wish to have the lamp turned on at the same time the relay is on, then onnect the circuit from COM to NO. (Electrical appliances control prototype by using GSM module and Arduino, 2017).

LED

A typical LED is made like electronics. It is a chip of semiconducting material that is usually silicon. With LED light bulbs you will find they are more efficient and last much longer than incandescent or fluorescent bulbs. Instead of using mercury in a fluorescent bulb, LEDs do not use those toxic substances. Until recently, the other kinds of light Bulbs have not been as bright as the LED ones and are more expensive too (Electrical appliances control prototype by using GSM module and Arduino, 2017).

System design

This design phase will define the various functional and technical specifications of this project. All of the hardware, software, and all the other necessary items that must work together need to be turned on for this process to work. As for the requirement set, make sure make sure they'll always satisfy. So that it’s easy to get a sense of how to use the Arduino board and a software application resembling App Inventor, will start using both the Arduino board and the web-based application.

Users prefers to create android applications in an easy way. The Arduino software uses C and C++ to do its computing.

Three ways to control and measure energy in the home are provided by this particular project. (Electrical appliances control prototype by using GSM module and Arduino, 2017).

1. Controlling the home by using Bluetooth technology
2. Controlling the data flow by using ACS712 hall sensor

Deployment Diagram

To visualize the topology of the physical components of a system where the software components are deployed, deployment diagrams are used.

Deployment diagrams are thus used to define a system's static deployment view. Deployment diagrams consist of nodes and their relationships and the connections between hardware items in physical communication.

In this case, mobile phones, Arduino UNO microcontrollers, sensors, actuators, and communication devices are the main hardware components. The system also consists of two mobile app software components and software installed on the Arduino UNO microcontroller (Design and Implementation of Smart Home Security System, 2014). The deployment diagram indicates:

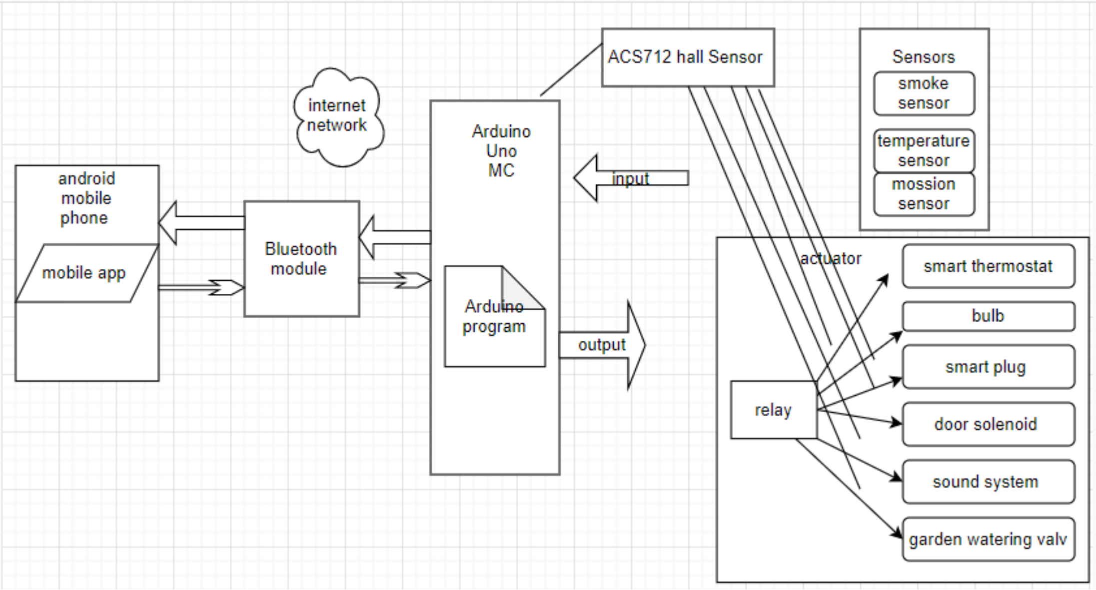


Fig.12. Deployment Diagram [Source: Own, Draw.io]

Describe the logical characteristics of each interface between the product and the users of the android software. This includes sample screen images, guides to be followed, constraints on the screen layout, standard buttons and functions that will appear on every screen, shortcuts for keyboards, standards for displaying error messages, and so on. Define the components of the software for which a user interface is needed.

User Interface

In this instance, Describe the logical characteristics of each user interface for an Android software product. Sample screen images, how-to guides, screen layout constraints, standard buttons and functions that will appear on every screen, keyboard shortcuts, error message display standards, and so on are all included. Define the software components that will require a user interface (Efficient Android Software Development Using MIT App Inventor 2 for Bluetooth-Based Smart Home, 2019).

System Architecture

For this project, applied Bluetooth system architectures, using a Bluetooth HC-05 Module and with the help of Arduino and relays, a small Bluetooth connection is established in the Bluetooth proposed home control system. The system is developed on an Android platform to monitor and control home appliances via a Bluetooth-enabled application for security and security purposes. In the system architecture where a Bluetooth-enabled Android is implemented, the master-slave structure

While the Arduino serves as a host, the phone serves as a client controller. Through the Bluetooth module, the client and host devices create a Bluetooth connection, and they can send and receive Bluetooth commands once the connection is established. The user can use the specific android app that is developed to control his/her home appliances, while the user can also check the status of their home.

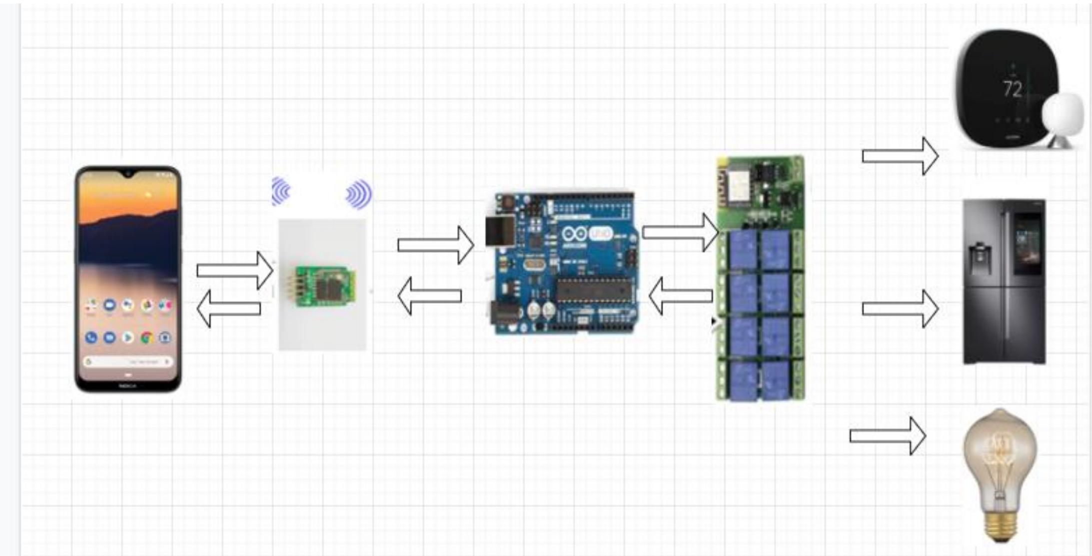


Fig.13. System arichtecture

In the course of research, the Bluetooth and Wi-Fi-based Home Automation System is developed using different mobile programming languages and cross-mobile platforms such as App Inventor.

5.2 Implementation

This system is implemented in to two ways, the first one is controlling and monitoring by using Bluetooth technology the home automation app that is installed on the user's smart phone is used to control and monitor home appliances, and the second one is measuring energy consumption of the home appliances when the user is at home and in a Bluetooth, range using this particular home automation app protects the user from spending another cost.

The third implementation step is Arduino UNO is the project's master controller, so it must first be configured. The power of 5v and the soil are taken from the Arduino. The 3.3 v power is taken from the external power supply of the breadboard power supplier for the ESP8266 module. The power of the ASP712 hall sensor is taken from the Arduino itself and the output is attached to the analogue input of the Arduino. have to remove the noise value from the sensor by measuring the electricity first. Needs to check the noise value first with just the ACS712 plug-in to Arduino and check the noise value. Then it needs the noise value to be subtracted. The current values in real time are now ready to be measured. The system is ready for the running software phase by importing the libraries for ESP8266, Serial monitor and LCD (SMART HOME: Energy Measurement and Analysis, 2020).

Smartphone, Smart Living and Bluetooth technology will be evaluated first. Secondly, the system architecture, protocol of communication and design of hardware are outlined. Then the design of a smartphone application based on Bluetooth and the prototype are presented. It is shown that a platform for implementing Bluetooth-based Smart Living application can be provided by Android Smartphone (Electrical appliances control prototype by using GSM module and Arduino, 2017).

In addition, wireless technologies benefit from the absence of cable installation costs and are very helpful in places where there is no wired network and where the use of cables would be impractical. They thus fit well, in particular, with the needs of mobile devices. They are generally subject to shorter range and lower bandwidth compared to wired counterparts, on the other hand. They also do not provide power supplies. A centralized access point that relays all traffic, or in a decentralized ad hoc manner, can work with wireless networks.

Imagine that, just using your smart phone, you can control your home's electronic devices from anywhere inside the house. Bluetooth has a range of 10-15 meters, so that any electronic appliance within the range can be switched on and off. Arduino and a Bluetooth HC-05 module used here to receive wireless data sent from the Android phone. So, the microcontroller can turn the home appliances ON and OFF accordingly (Electrical appliances control prototype by using GSM module and Arduino, 2017).

There are several different connections, such as GSM, WIFI, ZIGBEE and Bluetooth, due to the development of wireless technology. Each has its own unique specifications and applications for the connection. Bluetooth is selected with its appropriate capability from the four popular wireless connections that are often implemented in this project.
Depending on the Bluetooth device class, it can provide connectivity of up to 100 meters at speeds of up to 3Mbps with globally available frequencies of 2400Hz. And the first and the most reason to be selected that the Bluetooth based system is time wise, cost effective and it does not need lots of implementation and installation cost.

Project phase details

Wireless Bluetooth technology is used to control the Home Electronic Appliances via an Android Phone in this project phase. This phase of the project only involves the control of various home appliances via Bluetooth technology. Using Bluetooth technology over home automation helps the customer reduce the cost of their SMS while he or she is at home.

Main Components for this phase

Cables and pins, Bluetooth Module HC05, Arduino Uno, Relay, Bulb, Fun, Temperature sensor, Android phone, Bluetooth controller Android app, and Power Supply.

How to operate Bluetooth module?

The new Bluetooth module's default baud rate is 9600 bps. It needs to connect rx and tx to the controller or serial converter and provide the module with a controlled power supply of 5 volts dc.

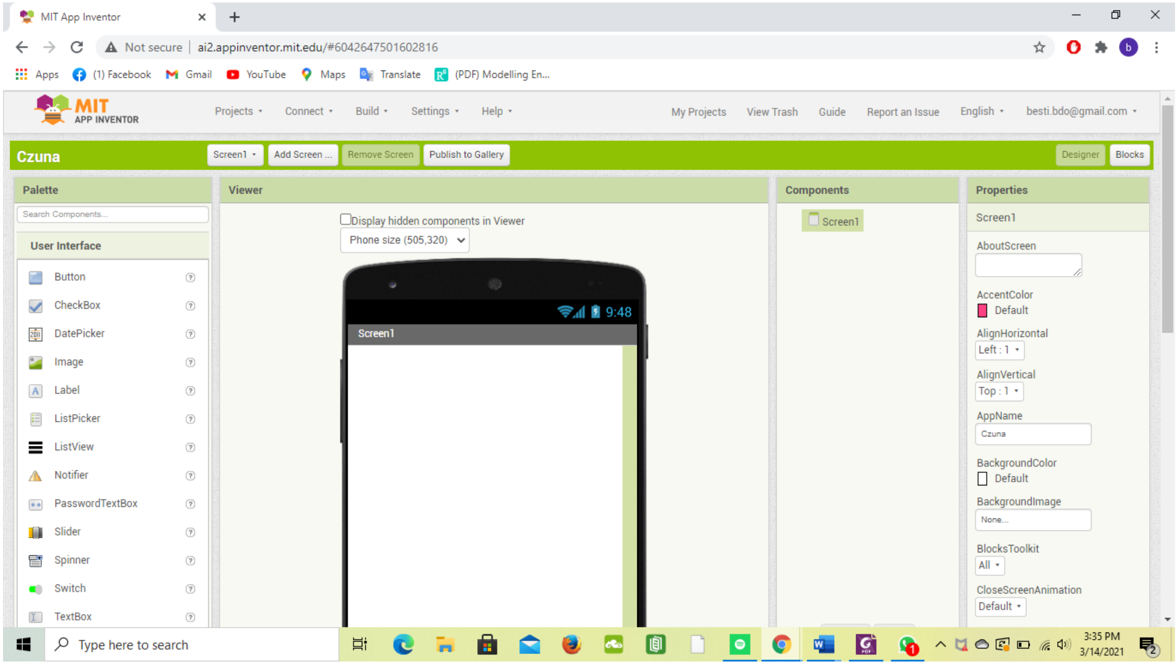


Fig.14. The Components Designer section of MIT App Inventor [Source: Own From MIT app Inentor]

Application Design and Implementation

The app was created with MIT App Inventor, which includes a Components Designer and a Blocks Editor. The Components Designed section, shown in Fig. 14, is where the user designs the application's user interface, whereas the Blocks Editor, shown in Fig. 15, is where the user defines how each component of the user interface behaves using the Scratch programming language. The appearance of the user interface, as well as how its components work, are described in each section of this section, as well as the Scratch logic blocks implementation based on the given description (Efficient Android Software Development Using MIT App Inventor 2 for Bluetooth-Based Smart Home, 2019).

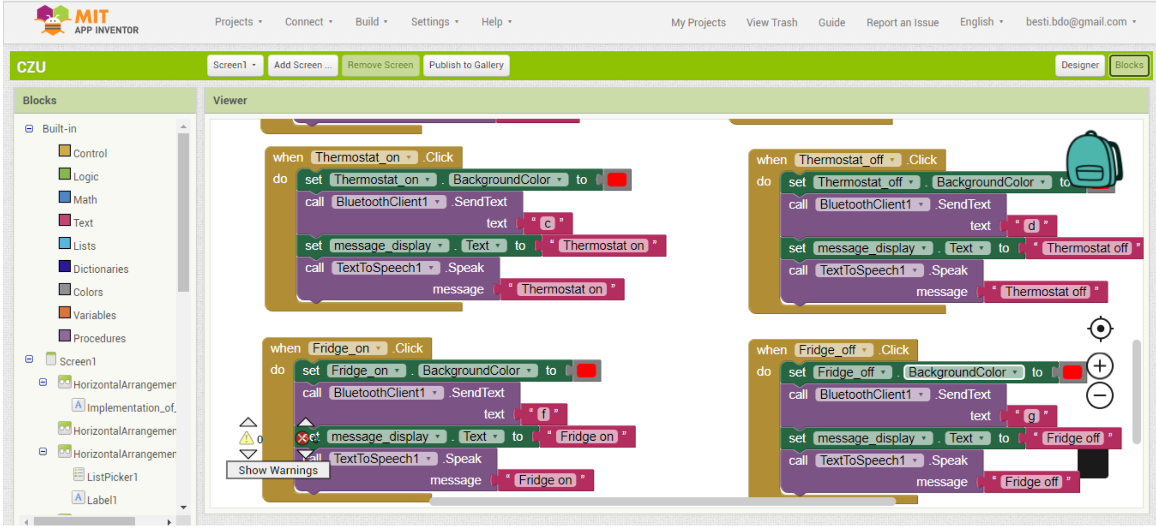


Fig.15. Logic blocks arrangement for remote Bluetooth device choice and status [Source: Own MIT App Inventor]

Bluetooth Conectivity

The application uses the Bluetooth protocol to communicate with the host, so the user must know the host's Bluetooth address and connectivity status. Figure.16. shows a flowchart of smart home connectivity using Bluetooth technology.

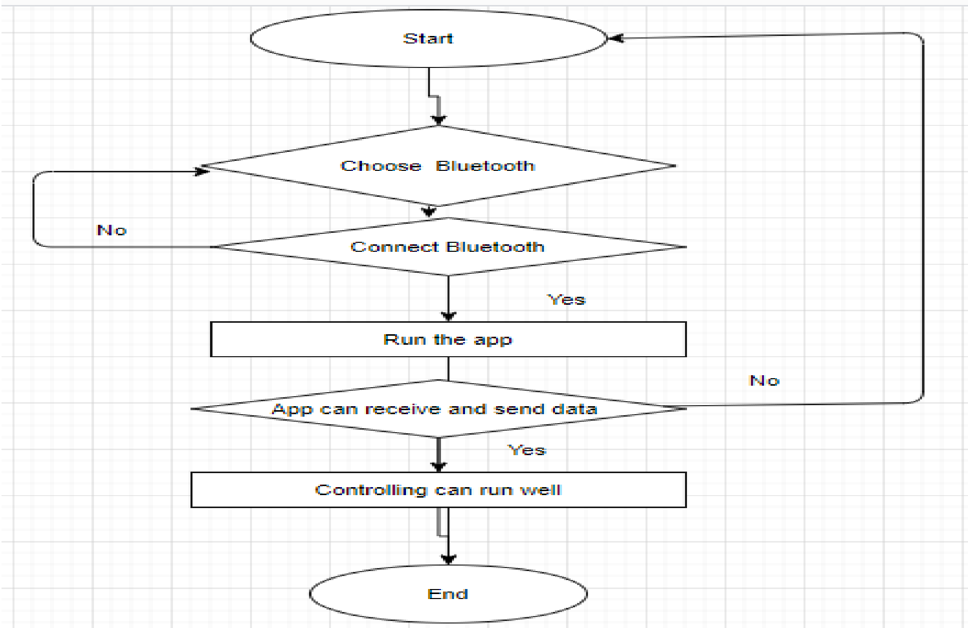


Fig.16. Bluetooth flow chart [Source: Own Draw.io]

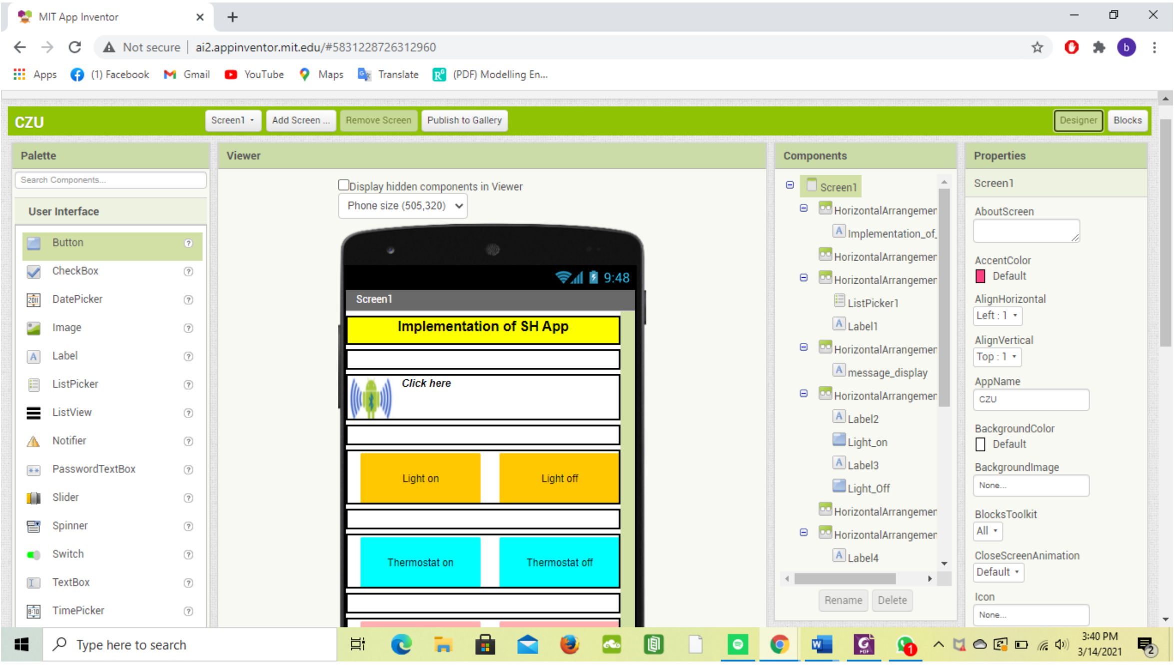


Fig.17. Appearance of the developed Android application [Source: Own MIT App Inventor]

Working Explanation

In this project, the Arduino microcontroller is used to control the project's entire process. And a Bluetooth module is used to wirelessly control your home appliances. When the user touches the button in the Bluetooth mobile app on Android mobile phone, home appliances will turn ON and OFF, deem and bright. Needs to have the Bluetooth application first in order to run this project. You need to open the app after installing it, then search for a Bluetooth device and select the HC-05 Bluetooth device (Electrical appliances control prototype by using GSM module and Arduino, 2017).

After the connection is established, an Android phone sends its command via an embedded Bluetooth module to Bluetooth-enabled client devices. The phone is used as a client controller that establishes Bluetooth module communication. The interaction between

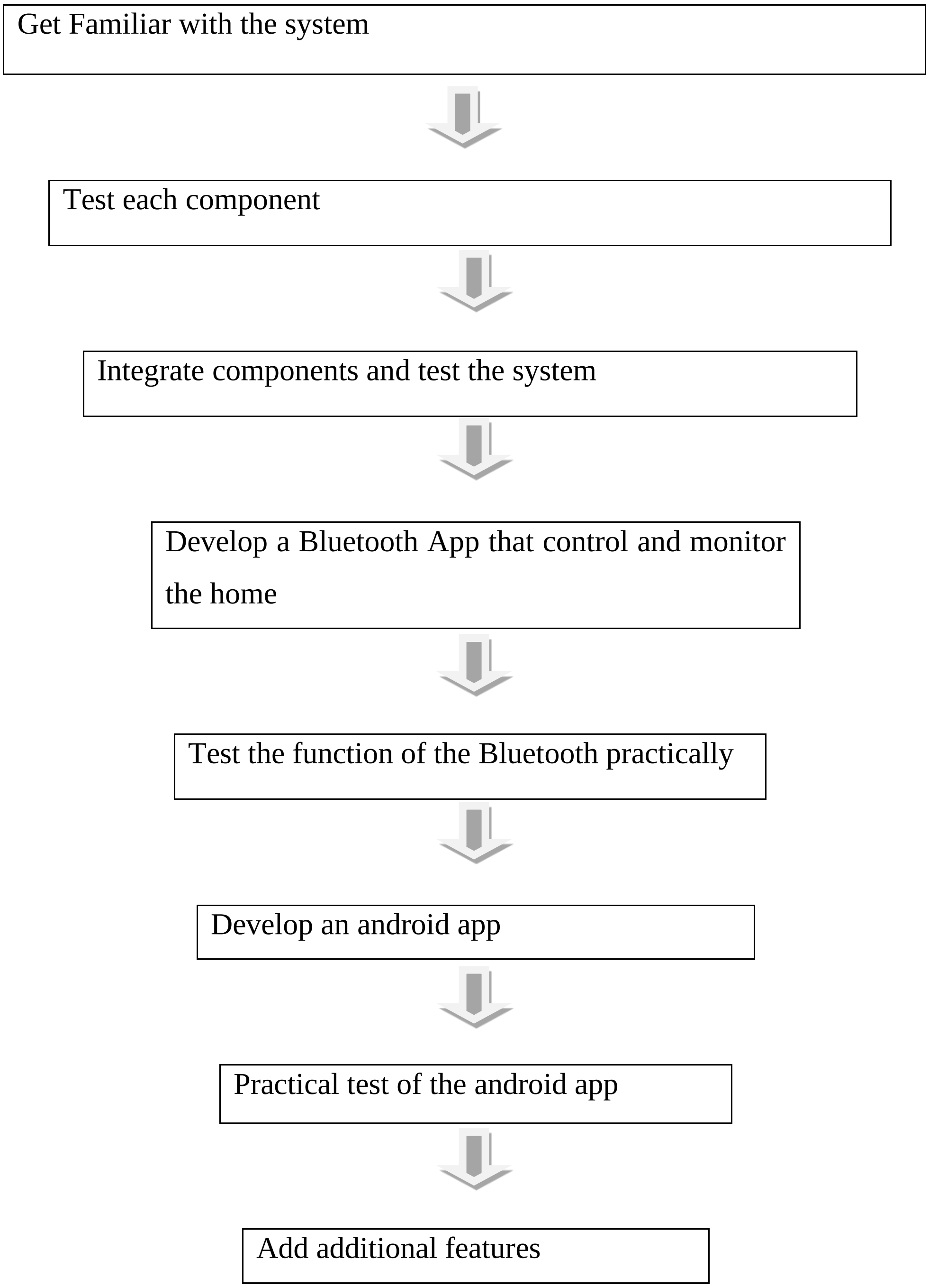
The master and slave Bluetooth devices cover the power-up and data exchange processes of the device, while the protocol is established in the Bluetooth software stack (Efficient Android Software Development Using MIT App Inventor 2 for Bluetooth-Based Smart Home, 2019). Pin Description of accelerometer:

1. STATE → Open
2. Rx → Serial receiving pin
3. Tx → Serial transmitting pin
4. GND → ground
5. Vcc → +5volt dc

6. EN → to enter in AT mode

System Process flow

The process flow has four primary components or phases for this project. By identifying the project functionalities in these four different states. More additional futures will be added to the project as the stage proceeds.



6 Results and Discussion

On the basis of the technology selection model (TSM) scores that it is possible to determine Smart Thermostats and smart plugs were the most promising piece of technology that it could study and thus proceeded to the next stage of the evaluation.

Fortunately, there is an abundance of readily accessible intelligent data for us. Technology for thermostats. With a number of technological branches reaching maturity and becoming ubiquitous on a global scale, technology can hardly be defined as 'emerging'. There are research performed by producers [Ecobee, 2019] and studies by independent sources verifying or correcting their results [Ecobee, 2019]. (Modelling Energy Retrofit Using Household Archetypes, 2020). There are even studies that examine the technology limitations and describe the scenarios under which they cease to be efficient (Danny Parker, 2016). For the evaluation purposes, after looking at the available details, author determined that the average monthly efficiency gain (21.5 percent) derived from the above-mentioned datasets was reasonable enough to be used in the calculation of economic efficiency.

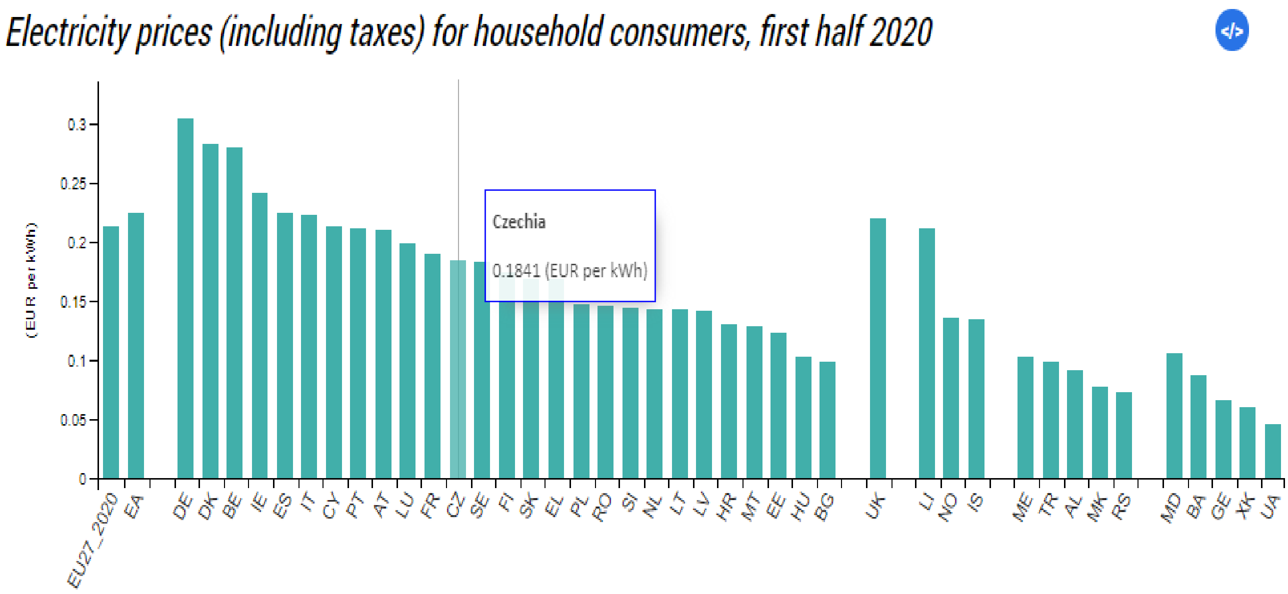


Fig.18. Electricity Prices including taxes for Czech households ,First half of 2020[Source: Eurostat]

For information on the average price per kWh for both electricity and gas, it turned the attention again to Eurostat. In the first semester of 2020, on average, a European household bought electricity for EUR 0,2126 / kWh and gas for EUR 0,098 / kWh and for Czech republic 0.1841 (EUR/kwh) or 4.82 kc/kwh. In view of the fact that Eurostat data was used in the TSM score computation, it should be noted that, while the use of data from the same source for this evaluation step makes the process consistent, the results are also Europe-related. The same price data for the US puts kWh consumed by one household at about half the price it goes for on the European market.

Of course, average energy prices for a market of the size of the European Union, which covers a large geographical area with very different weather conditions leading to very different energy consumption levels, can only reach us so far. Estimating net gains from decreased power consumption requires access to data on the average cost of the utility bills themselves. Harmonizing and processing large amounts of otherwise disparate data requires taking into account all the constraints previously mentioned. The compromise solution in this case came in the form of an average monthly value of total utility bills in the EU-28 countries for first semster of 2019 [Eurostat] at EUR 88.43, and for since the amount of data required for a single calculation of net gains based on the model far exceeded the present resources.

It is possible to estimate that passing all the data through the NGm model is, the value of the potential benefits of the technology would be € 19.01 / month. Given that the average nominal useful life of a smart thermostat is 5 years and that all the data is passed through to NGm model, which can estimate that the technology would have a value of EUR 19.01 / month for potential benefits. Given that the average nominal useful life of a smart thermostat is 5 years and that the long-term interest rate of the European Central Bank is currently at an all-time low of 0.05%, get to calculate that the BEP for smart thermostats is € 1138.90, well above the € 250 price tag (Danny Parker, 2016).

While one of the projuct original assumptions, and an important part of the model, was that competing smart home technologies influence the attractiveness of a given technology, its possible to determine that other, non-smart technologies also influence adoption rates through the application of the model to smart thermostats and subsequent analysis. Advances in heat transfer and insulation technologies appear to have slowed the adoption of smart thermostats in Europe. While able to calculate the NGm and BEP for a few of the other technologies on the original shortlist with enough precision to use the data in the final stage of the evaluation, author believe the results would have been exponentially more valuable if competing, non-smart technologies had been included in the model as well.

As previously stated when while on assesing the conventional and modern wiring system, the uniform initial costs are CZK 521,460. When annual operating costs are reduced by 30%, the operation of an intelligent installation costs about CZK 21,221 less than a conventional installation. The investment's return and subsequent earnings should occur in the 24th year of use. By evaluating net present value it shows that in the 24th year of the life of the investment, the net present value was CZK -161,112

On the second mechanism to evaluate the efficiency which is cost end energy efficient Arduino based Bluetooth system to monitor and control home appliances. The device is powered by an Arduino microcontroller and works in conjunction with an ACS712 hall sensor, which is controlled by an Android phone and has two separate futures: Bluetooth and GSM. There will be an android application to manage and track the house in both futures (SMART HOME: Energy Measurement and Analysis, 2020).

According to (SMART HOME: Energy Measurement and Analysis, 2020) and the study with the assistance of a 9v DC battery, the Arduino UNO is turned on. The ACS712 hall sensor is connected to an appliance's phase line. The ACS712 Hall sensor begins measuring the flow of electricity when an appliance is turned on. Electrical energy will be shown on the LCD as it passes through the appliances. With the aid of the ESP8266 Wi-Fi module, the calculated value will be sent to thingspeak. This module is set up to link to a Wi-Fi network with a specific SSID and password. The module will begin sending data to thingspeak once it is linked to the network. Thingspeak will begin calculating the value.

7 Conclusion

The theoretical section defines the terms and concepts associated with the topic of implementation of smart homes. It is primarily a method of identifying smart home devices based on their energy intensity and technology types.

The factors that affect smart home technology efficiency and their adoption rates are in a delicate balance. The decision isn't solely based on financial considerations, at least not in the way that commercial investment decisions are weighed. When it comes to the home user, the decision is a mix of sensible economic behaviour and extreme subjectivity. While company managers generally have no trouble recognizing net present value and behaving accordingly, the decision is a mix of sensible economic behaviour and extreme subjectivity when it comes to the home user. Yes, the long-term benefits of improved energy usage would be appealing, but only if they are also tangible in the short term.

The majority of smart home devices that are shortlisted as commercially feasible are well within energy and economic efficiency's bounds. Their current price points are already well within the range needed to expand their reach. As anticipated, the factors that seem to be slowing their adoption are more linked to their alternatives than to the technologies themselves. Other external variables have a huge impact on how the model operates. Reference interest rates are making the results of the evaluation model more homogeneous within the same broad economic zone in many places around the world right now. Also, in the press, record low oil prices are affecting the energy markets in ways that will dramatically change the outcomes of the thesis evaluation in a year.

Furthermore, the savings that can be achieved through the use of System (Smart) wiring and installation are calculated based on investment and operating costs. It's estimated to be around 30%, according to the manufacturers. As a result, the intelligent is cheaper than the classic over the course of a year. These divisions then allow for a more accurate comparison of traditional and intelligent electrical installations.

Whether or not the evaluation model succeeds in providing valuable insight into which smart home technologies are more worthy from an economic perspective, all available evidence indicates that smart home technologies are here to stay and will continue to expand their role in our daily lives.

A low-cost and modular home automation system is discussed in this paper. The smart home system is operated by an Arduino UNO microcontroller. Home appliances, lighting, and a smoke detector system are all integrated into the latter. Switches can be used to operate it manually, or a Bluetooth recognition device can control it automatically.

The HC-05 Bluetooth module that is used in the system was able to successfully connect with a variety of Android smart phones, allowing us to monitor and control the home appliance. The system is feasible because the development costs are low in comparison to other existing systems, and it also saves energy over the manual system.

The study determines how much energy is used and how much is wasted by the appliances. Appliances could be controlled using consumption data. The analysis quickly reveals the appliance's usage pattern. This pattern is able to control the device from operating unnecessarily and consumes the least amount of electrical energy. It is possible to reduce the larger amount of electrical consumption by conserving the least amount of energy from each home.

Based on the findings of the study for efficient smart home implementation, it is difficult to recommend a single solution for improved smart home efficiency, but it is possible to state that the selected SH devices, smart plugs, and system wiring provide a better advantage in terms of energy and cost efficiency.

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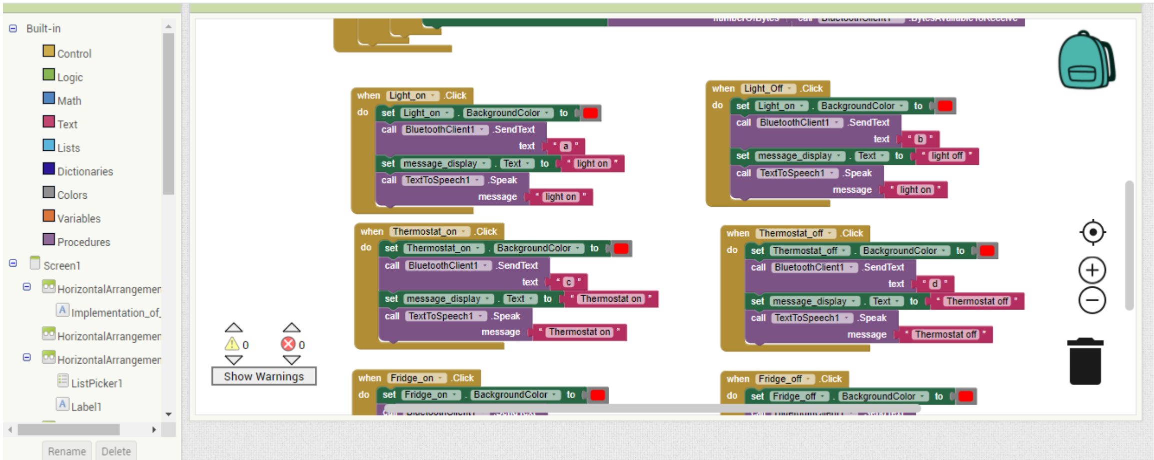
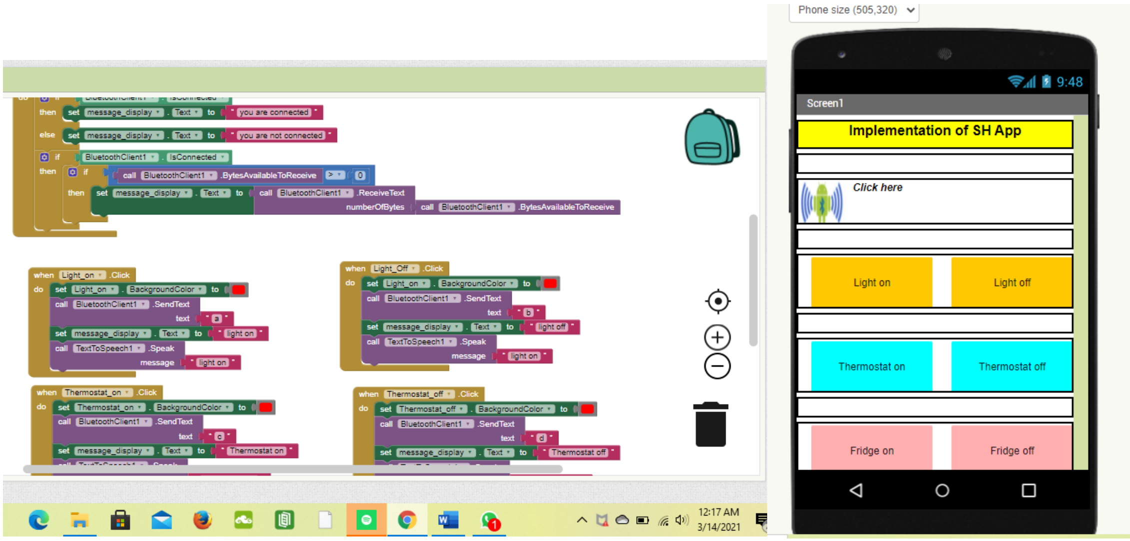
9 Appendix





Appearance of the develop app and building blocks from MIT App inventor