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Monitoring and controlling smart home appliances using IoT devices

Bachelo's Thesis (9 ECTS)

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Monitoring and controlling smart home appliances using IoT devices

Abstract:

Usage of different smart home appliances and systems is becoming increasingly more popular in many households. There are many key points for rising number of adopters. For some it is the price as these systems and appliances are not that new to the market anymore and thus are more reasonably priced. Also, with the development in both hardware and software areas processing and memory units have become both faster and smaller which makes designing and developing different smart home devices more viable for building and selling commercially. This ensures that this smart home systems market is not dominated by few companies and gives a chance for anyone to try them out price wise. The second key point is the versatility of different smart home devices that are out in the market, ranging from lights to home automation and security. This variability lets people start out with few cheaper products like smart lighting or media devices and see if this is something for them.

Smart home appliances are devices that could be a common sight at many households like lights, speakers, TVs, air conditioners and so on but what makes them different is the built-in functionality for connecting to internet and then be monitored and controlled remotely. This ability to be remotely controlled and monitored makes it possible to develop automations that could further enhance the way these devices are used.

The aim of this thesis was to try and connect different smart home devices to one central system that could let the user of this system to control and monitor different smart home appliances and devices using their smartphones or computers. Additionally, this thesis aims to develop and showcase how to try and automate these devices from the central system. This automation will try to control the energy consumption of these smart devices by the user's location so that if user is not present then some devices could turn off or start using power saving profile. The central system will be hosted by IoT device running OpenHab OS.

Keywords:

OpenHab, system, smart home appliances, IoT, central system

CERCS:

Targa kodu seadmete seire ja juhtimine kasutades asjade interneti seadmeid

Lühikokkuvõte:

Erinevate nutikate kodumasinate ja -süsteemide kasutamine on muutumas paljudes majapidamistes üha populaarsemaks. On mitmeid faktoreid, miks nende kasutusele võtjate arv kasvab. Mõne jaoks on see hind, sest need seadmed pole enam turul uued, seega ka enamikel seadmetel on hinnad palju käepärasemaks muutunud. Samuti on nii riist- kui ka tarkvara arengu tõttu protsessorid ja mäluüksused muutunud kiiremaks kui ka väiksemaks, mis muudab erinevate nutikodu seadmete kujundamise ja arendamise elujõulisemaks äride jaoks See tagab, et vähesed suuremad ettevõtted ei domineeri nutikodu süsteemide turgu, andes võimaluse ka väiksematel ettevõtetel oma lahendusi luua ja müüa, mis annab kõigile võimaluse neid seadmeid hinnatarkalt proovida.

Teine faktor on mitmesuguste turul olevate nutikate koduseadmete mitmekülgsus, alates tuledest kuni koduautomaatika ja turvalisuseni välja. See varieeruvus võimaldab inimestel alustada mõne odavama tootega, näiteks nutivalgustuse või meediumiseadmetega, ja vaadata, kas see on midagi nende jaoks.

Nutikad kodumasinad on seadmed, mis võivad olla paljudes majapidamistes tavalised nähtused, näiteks valgustid, kõlarid, telerid, konditsioneerid ja nii edasi, kuid mis muudab need erinevaks on sisseehitatud funktsionaalsus interneti-ühenduse loomiseks ning seejärel lasta kasutajal neid kaugelt juhtida ja seirata. See kaugjuhtimise ja seiramise võimalus võimaldab välja töötada automaatika, mis võiks veelgi täiendada nende seadmete kasutamist.

Selle lõputöö eesmärk oli proovida ühendada erinevad nutikodu seadmed ühte kesksüsteemi, mis võimaldaks selle süsteemi kasutajal juhtida ja jälgida nutitelefonide või arvutite abil erinevaid nutikaid kodutehnikat ja -seadmeid. Lisaks on selle lõputöö eesmärk välja töötada ja tutvustada, kuidas neid seadmeid kesksüsteemi abil automatiseerida. See automaatika püüab nende nutiseadmete energiatarbimist kasutaja asukoha järgi kohandada, nii et kui kasutajat pole kohal, saaksid mõned seadmed välja lülituda või hakata energiasäästuprofiili kasutama. Keskne süsteem hoiustatakse IoT-seadmel, milles töötab OpenHab operatsioonisüsteem.

Märksõnad:

Kaugjuhtimine, seiramine, OpenHab, IoT, nutiseadmed, targa kodu süsteemid ja seadmed, kesksüsteem, operatsioonisüsteem

CERCS:

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1. Introduction

With the progress in various information technology fields, many aspects of human society have changed. Access to information has never been quicker and easier as devices capable of accessing information anywhere with internet coverage have become very common. Today many devices around us can receive, store, process and transfer data to us and other devices connected to them. This system is known as the internet of things (IoT). Over the years, the popularity in this field has been increasing rapidly. According to the GSM Association, it is expected that the number of IoT devices will grow to 25.1 billion by 2025 [1].

Out of many popular real-world applications for IoT is in smart home ecosystems. Through IoT, it becomes possible to monitor, control and automate smart home devices at some level, even for private consumers with no prior knowledge in this field. A large part of the popularity also stems from the fact that it is possible to create smart home systems with relatively more nominal cost than in the past. This is due to the development and the broader availability of older technologies. Adroid Market Research, a global market research firm, points out that smart home system's take-up is growing and that smart home systems' global market is expected to exceed USD 95 billion by 2025 [2].

Essentially a smart home is a home where through the internet connection, various appliances and devices can be monitored and controlled by using mobiles or other networked devices. Data generated by sensors and smart home appliances make it possible to monitor information and conditions in the home and the devices in it. This also makes it possible to gather data about users in the home and use this data in automation. For example, smart home could collect information about users location and habits in the house and, using that data, control various devices.

~~An analysis of the Internet of Things and smart home systems [2] by Adroid Market Research, a global market research firm, points out that smart home system's take-up is growing. Their analysis argues that the uptake of new technologies, the development and the broader availability of older technologies have contributed to take-up growth. The study shows that a smart home usually requires a good WIFI network throughout the house. This allows various smart home devices to be monitored and controlled using portable smart devices, so the broader availability of such conditions and devices has also increased smart home systems. It was also added that the broader introduction of smart home appliances would also favour rising electricity prices. In such conditions, it is cheaper to maintain a household with a smart home system because the user can more easily regulate the devices' electricity use. Their analysis shows that smart home systems' global market is expected to exceed USD 95 billion by 2025.~~

1.1 Aim of the thesis

The aim of this thesis is to create smart home system that could monitor and control smart home appliances through the use of IoT. To better demonstrate the IoT capabilities in the smart home system, a user tracking system will be developed. This system will collect users location data in real-time, which will be used to control devices around the user. This thesis uses an open-source home automation platform and various single-board computers to handle smart home devices and track users. As the tracking should differentiate between different users, users are located via their smartphones using either WIFI or Bluetooth. Communication between the home automation platform and user tracking devices is done by using MQTT messaging protocol.

1.2 Outline of the thesis

This thesis consist of three stategs that are:

- Setting up home automation platform. In this stage a open-source platform OpenHAB is used for monitoring, controlling and automating various smart home devices across the house. As such this stage will consist of exploring OpenHAB functionalities and possibilities, setting up the OpenHAB, connecting devices into it and implementing automation and UI for controlling and monitoring smart home devices. This stage will also describe any problems or findings found.
- Developing user tracking system. This stage will cover how house user tracking system was developed. This will cover the research into different approaches and what approach was used in the end. As such there will also be steps taken in development phase and all risen problems will also be covered.
- Connecting home automation and user tracking system. In this stage the method of connecting the home automation and user tracking system will be described. Also this stage will also contain steps for creating automations using the data that user tracking system provides.

As for thesis structure it is as following:

- Background, section for information about the technologies and tools used in this thesis.
- System specification, section describing use cases and requirements for this system developd in this thesis.
- House automation system, section about setting up home automation platform, connecting smart home devices into it and automating said devices.
- User tracking system, section about developing system for tracking users in the house.
- Final assembely and automation, section about how location data is sent between systems and used in automating smart home devices.
- Summary, section describing work and suggestions for future research.

2. Background

This sections will give information about what system will be built by the and of this thesis, as such different components and technologies will be introduced. This section will cover about different open-source house automation platforms and will also explain why OpenHAB was used in the end. Next there will be information about what tools and hardware will be used for user tracking system. Finally a overview what kind of smart house devices can be used with the system, what limitations there are and what devices are used in this thesis.

2.1 Idea

The idea of this thesis is to create a system that could automate different smart home devices in the house using information about every house user location. This means that whenever user location change is detected then devices around their current and previous vicinity should behave accordingly.

A example of possible scenario that should be possible with this system: Joe arrives at home. System detects that and will turn on lights in the vestibule and cloakroom. Next as it is warm summer day then system will turn air conditioner on. As Joe reaches his room the system will turn off lights in previous locations and will turn on lights at Joes room. As Joe likes classical music then system will start playing a piece from Mozarts collection.

After some time Joe leaves and system will turn off all the active devices and as indoor temperature is still rather high then air conditioner is set to run in eco mode for more efficient power consumption.

Later Joes wife reaches home and starts doing laundry. As she is working in laundry room and going around the house collecting old bed sheets then devie is automaticali switching on and off lights in the rooms she is visiting. In Joes room system only turns on lights and not the music as room visitor is not Joe.

According to this example the system should work wit multiple users and should be able to differentiate between them to make customized automations possible. Following subsections will introduce the components and tools used for making this system possible.

2.2 House Automation Platform

A home automation platform is a system that is responsible for monitoring and/or controlling home devices like lightning, climate, entertainment systems, appliances and even home security. These devices are typically connected to central hub that is managed by house automation platform. There are many competing vendors for these platforms and there are even number of open-source systems but it should be noted that as of now there is lack of standardized security measures and deprecation of older devices. That said home automation has high potential to lead towards energy efficient solutions that could have positive environment impact in the future [3].

2.2.1 Platforms

2.2.2 OpenHAB

2.3 User tracking system

2.3.1 Hardware

2.3.2 Software

2.4 Smart Home Devices

3. System specification

This chapter describes the use cases, functional requirements, and components for the central house automation system built and developed for this thesis.

3.1 Functional requirements

3.2 Non-functional requirements

3.3 Use Cases

4. House automation system setup

4.1 Introduction

The central hub in the context of this thesis is the primary controller. Each smart home device is connected to it, which enables it to control, monitor and automate all of them. The central hub is made up of two parts: the hardware and the software. The choice of both of these parts is discussed in this chapter of the thesis.

~~This part of the topic will focus on the creation of central system and will describe different technologies in both software and hardware that could be used to create central system or hub for different smart home devices and appliances to connect to.~~

4.2 System description

The central system in thesis will use the processing and network capabilities of Raspberry Pi 4 model B and OS that will be handling all the different smart home appliances and devices will be openHABian.

On official Raspberry website [4] the specifications of Raspberry Pi 4 model B that will be used in this thesis. They report that they have 3 different versions of this model with main difference in total amount of random-access memory preconfigured. Model used in thesis will come with 4GB of Random-access memory, WIFI and Bluetooth and with Gigabit Ethernet port. Other than that there are no other differences between three models.

On openHABs openHABian page [5] they introduce openHabian as Raspberry Pi friendly openHAB setup which will let users easily setup their openHAB based project quickly whilst also including preparations of running image on Raspberry Pi and necessary tools for getting started. On that page they also include all the features that openHABian has of which most important are Mosquitto capabilities and ability to be configure without using display, mouse or keyboard.

4.3 Assembly

Section dedicated to describing how I built the central control system or hub.

1. Setting up openHAB on Raspberry PI 4B
2. Connecting smart appliances and devices to system
3. Writing rules and logic to smart appliances/devices.
4. Visualizing smart devices on UI for monitoring and manual control.

4.4 Notes

Section dedicated for describing problems that were faced when building a central "hub"

1. Problem with probably SD card (hub not booting correctly after shutting down)
2. Connectivity issue to wifi (hub not connecting via WIFI when connection to router lost sometimes)
3. Etc

5. User tracking system

5.1 Idea

The idea of this thesis was to build a home automation system that is energy efficient. To achieve this the system is built to have presence system for users. By doing so devices can be turned off, on or to lower energy profile by monitoring user's location to them. For example if there are no users in a certain room then lights and even media devices can be turned off.

5.2 First Layer System

Section describing how users presence can be sensed if they are at home at all.

5.3 Second Layer System

Section describing how user can be sensed by room basis.

5.4 Notes

1. Issues faced with Bluetooth(setting up PI0s and Bluetooth broadcasting by devices)

6. Final assembely and automation

7. Summary

8. References

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