Project report

my smart home - make your home smart by yourself

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Abstract

This report covers the Internet of Things project that comprises the development of an app for smart homes. The user of the app can view details of sensors and actuators in his home and control them. The report gives an insight on how the application has been developed, the idea behind it and a walk through its usage and future implementations.

Keywords: Smart home, Android Studio, Internet of Things, Tellstick, Raspberry Pi

Introduction

The internet of things (IoT) is a system of interconnected “things” embedded with sensors, software and other technologies that allow them to connect to the internet and exchange data with other devices. Since the number of smart devices keeps increasing and IoT is playing a more and more prominent role in our lives, it is creating an ecosystem of sensors and actuators that are able to adjust their settings based on the stimulus they get from the environment without the help of any human.

Smart homes allow you to keep track of all the devices that are present in your house and also interact with them from an application on your tablet, pc, or smartphone. Everything that can be connected to the internet can be controlled within the smart home app. Examples could be heating systems, open windows sensors, lighting, home security, and many more.

This market is in continuous growth. Nowadays most of the population possess a device like Alexa or Siri, that helps them deal with everyday tasks and can control the devices in their home. These numbers will only increase and more sophisticated applications will be needed.

Previous studies on the subject have tended to agree that automation can reduce energy consumption and carbon emissions and that a smart home can bring down CO2 emissions by 13%. For instance, a smart home application could help you remember to turn off the power to devices you have not been using like turning off the heating if the sensor tells the app that there is an open window in the room. All of those small expedients added together will make a real difference in the environmental impact.

In a smart home, devices are connected with each other and can be accessed through a central point and for this project our goal is to develop an app for smartphones that will serve that role. This is very convenient for the homeowners, because they can control every appliance from a single app and they can do it everywhere. If you forget the iron on, for example, the app could remind you with a notification, and it could be possible to switch it off remotely. Also it can increase the security of a home since the homeowner can get real time notifications on the phone if the security system detects something unusual.

Because of the great help smart homes can provide it was decided for this project to create an user friendly smart home app that allows the user to control his house in a simple way. The app was developed with Android Studio for Android devices. To connect the devices to our app we used a Raspberry Pi which was connected to the Tellstick that can retrieve and send data to the devices.

1.1 Goal

The goal of this project is to develop a smaller version of the smart home applications similar to the one already present on the market like Google home. This app would be perfect for people, who would like to bring the smart home features to their maximum potential and thereby make their life easier. It would be expected that the user is comfortable with handling devices even though we will try to be as user-friendly as possible and give all the information needed.

The goal of this application would be allowing the user to control every smart device in their house and also being able to add new devices directly to the app. It would be nice to have the possibility for the user to create groups of multiple devices based on location or functionalities in order to turn them on or off at the same time. Sensor and actuator should be able to communicate between each other, in this way if a temperature sensor detects a too hot temperature, the app can adjust the settings of the heater to get

a colder environment. These are the main points and ideas that the team will take as a starting point to develop their application.

Method

The main focus of this project was to develop the app described in the goal. The environment this app was implemented in was Android Studio. According to its promoting website Android Studio provides the fastest tools for building apps on every type of Android device. The code for the app can be implemented in different languages. The main programming languages that were decided upon was firstly java and then other languages and formats like xml for the layout. Useful features for the project of Android Studio as an environment are the visual layout editor, the fast emulator and the intelligent code editor. The editor supports among other things autofill for java code, which came in quite handy during the implementation process, since all team members had to familiarize themselves again with java. The fast emulator presents the opportunity to simulate an android phone on a computer. This was particularly useful for testing purposes without actually downloading the app to a smartphone. The visual layout editor is a tool that helps to visualize the layout of the app with an interactive preview of all the app's visual elements.

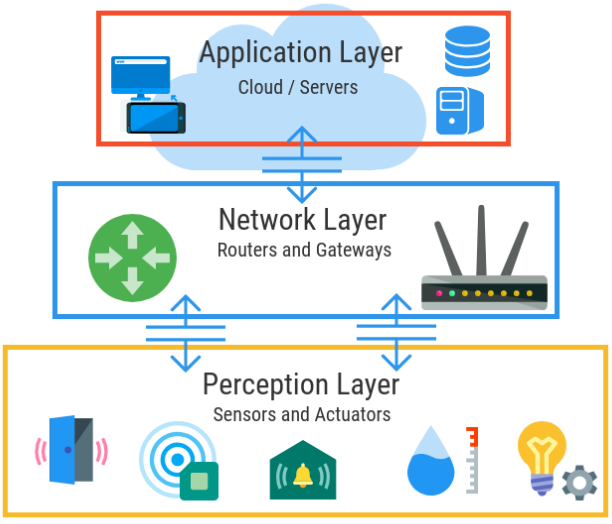

Figure 1: Typical three-layer IoT

To successfully make this project an internet of things project it does not only include the app itself but two more additional layers (see figure 1). The app with its user interaction is part of the Application layer. Through a Network Layer it is connected to the Perception Layer. The Perception Layer contains all the sensors and actuators that are associated with smart homes. So far one temperature sensor and one actuator were used for this project, though the app is built to handle more sensors and actuators.

The used sensors and actuators are connected to a Tellstick. The Tellstick (in this case the Tellstick Znet lite v2) is a wireless transmitter and receiver (transceiver) manufactured by Telldus Technologie. Telldus provides a wide support for its products. Devices connected to the Tellstick can be monitored, configured and controlled by their TelldusLive portal or through their mobile applications. This is useful when setting up all the devices and checking them individually. For this resulting project however, to retrieve data and send requests to the sensors and actuators the API Telldus Live was used.

If a user interaction in the app triggers a collection of data from the Perception Layer a Raspberry Pi is applied as a gateway. The Raspberry is connected to the Tellstick, which is again connected to the sensors and actuators. The data gets collected from the Perception Layer by the Tellstick and is passed on to the Raspberry, which in turn returns it to the app.

To set up the Raspberry it can be connected through peripheral devices such as a mouse, keyboard and a screen to the board. More importantly for this project though, the Raspberry can also be reached through SSH (Secure shell). Using SSH, it is possible to send a command to the Raspberry using Linux

commands. The third-party tool PuTTY is hereby a helpful tool for establishing this SSH connection. When everything is set up on the Raspberry, the app can also make use of the SSH connection. If the smartphone is connected to the Internet, the app can connect via SSH to the Raspberry and send Linux commands to it.

Design and Development

To understand the process of developing the goal of this project the design and architecture of the app code will be discussed in the following and challenges and their solutions will be dealt with. The whole team was working equally on the project.

1.1 Classes and Objects

Since the main language used to implement the app is java, the resulting code is object-oriented and therefore consists of classes and objects. To structure these classes the Model-View-Controller Pattern was adapted (see in blue figure 2).

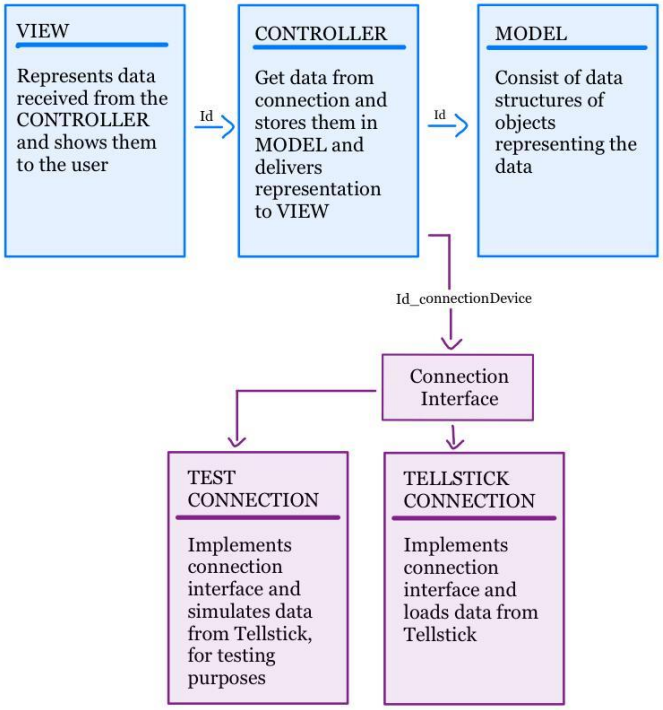

Figure 2: Typical three-layer IoT

The idea behind this pattern is to divide all classes according to their responsibilities. All classes that store the information about the smart home are part of the so-called model. The model consists of data structures of objects. Each sensor and actuator have their own object that stores all the information about it. The so-called controller is the class connecting the model with everything else. The controller communicates with the Raspberry through a Connection Interface. It receives data from this connection, stores them in the model and makes it accessible to the so-called view. The view includes all classe that are responsible for user interaction and representing data.
View, model and connection work independent of each other. Changes in one of them don't affect the other.

1.2 Challenges

After drafting the class structure the next step was to establish a connection to the Raspberry without the app. This was the first challenge encountered by the project team. The IP of the raspberry was not set correctly. Finding that out was quite time consuming. However, the development didn't stop due to the Interface Connection. The interface was implemented not only with the connection, but it was decided to also create a TestConnection that would simulate the information received through the Raspberry connection. This idea was fundamental to allow the whole team to keep improving and working on the other parts of the project, while this was being fixed. In later steps the possibility to work on the project without needing the connection to the Raspberry turned out to be an advantage, since not all team members could work on the project at the same time or place.

The main challenge with working with Android Studio was that all members of the group first had to familiarize themselves with this environment. Resulting from the inexperience importing different libraries, like json or ssh, turned out to be challenging. In addition, even though Android Studio has a visual layout editor, getting used to working on the graphical part of the project took time.

Result

Our initial goal was to create a user-friendly and very intuitive app that would allow people to be in control of the electronic devices in their homes and we think that we achieved this goal. Right now thanks to our application the users can visualize all the devices and sensors present in their home. They can also receive real time information from them even when they are not home. It is also possible to visualize new possible devices and sensors in the surrounding and with a click add them to their home application. Let's take a closer look at how a user would experience this application.

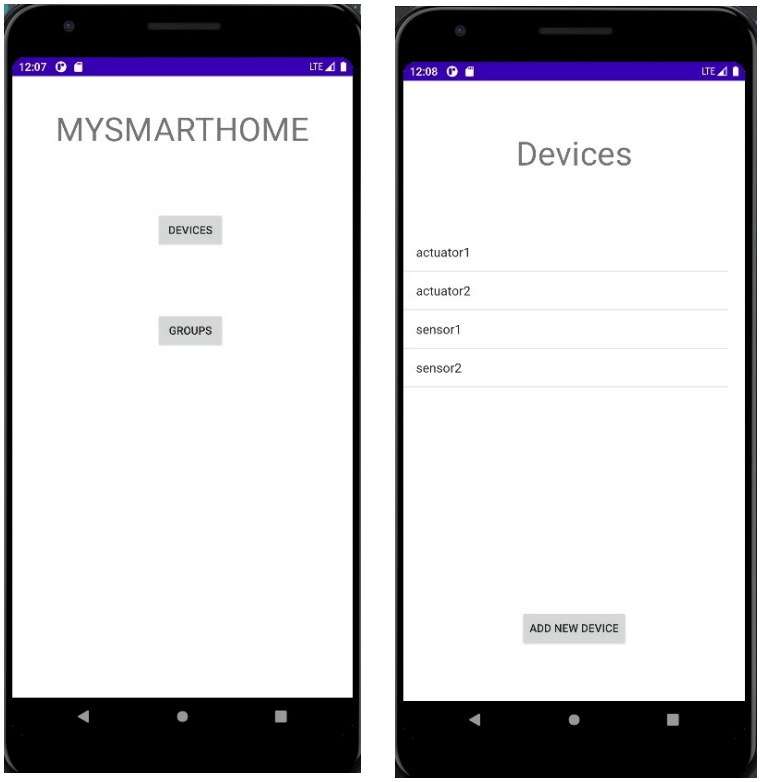

Figure 3: *(left) main page (right) list of current devices*

The left screenshot in figure 3 is the main page the user will see. Here he/she can either click on devices and get a list of all the devices available in the app at the moment (see figure 3 right-hand side) or click on groups and get a list of all the groups created in the app (the group feature is not implemented yet). From the list of devices, the user can click on one of them and an activity with all the information about it will show up.

If the device is a sensor the page shown will have all the information about the device and the stimulus it can detect (see figure 4 left screenshot). If it is an actuator the page, other than the information about the device it will also show a list of commands that can be pressed to turn on, off the device or perform other actions (the commands button are not implemented yet, but it's a goal for a future version)(see figure 4 right screenshot).

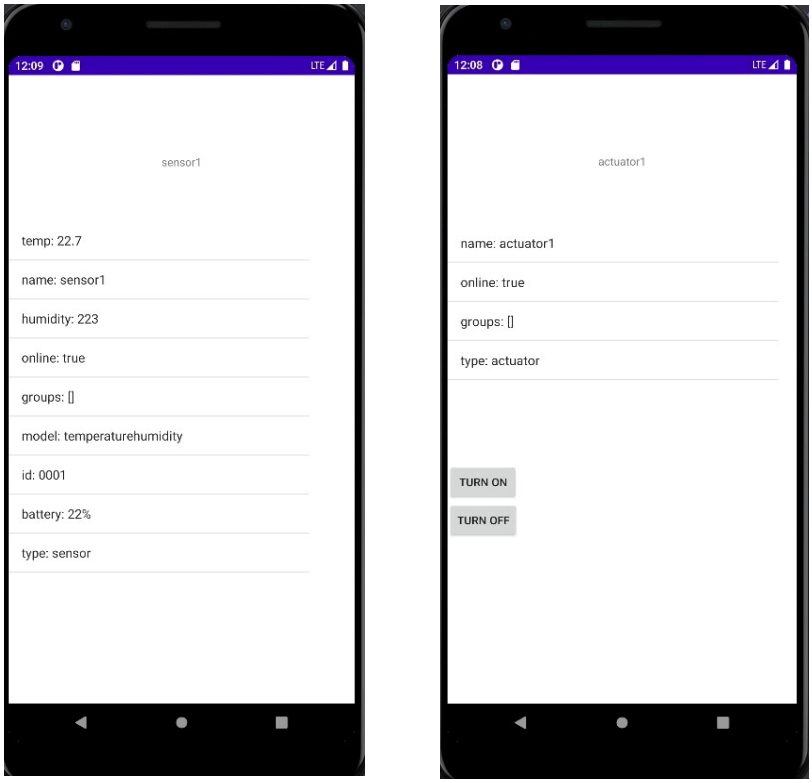

Figure 4: (left) sensor details (right) actuator details

In the list of the devices page, the user can select the "ADD NEW DEVICE" button, which will present him/her with a list of possible devices and sensors that are present in the surroundings and that can be added (see figure 5 left screenshot). By selecting one a pop app will appear, asking the user if he/her actually wants to add it (see figure 5 right screenshot). If the user press add, the device will be added to the devices list as shown in the middle screenshot of figure 5.

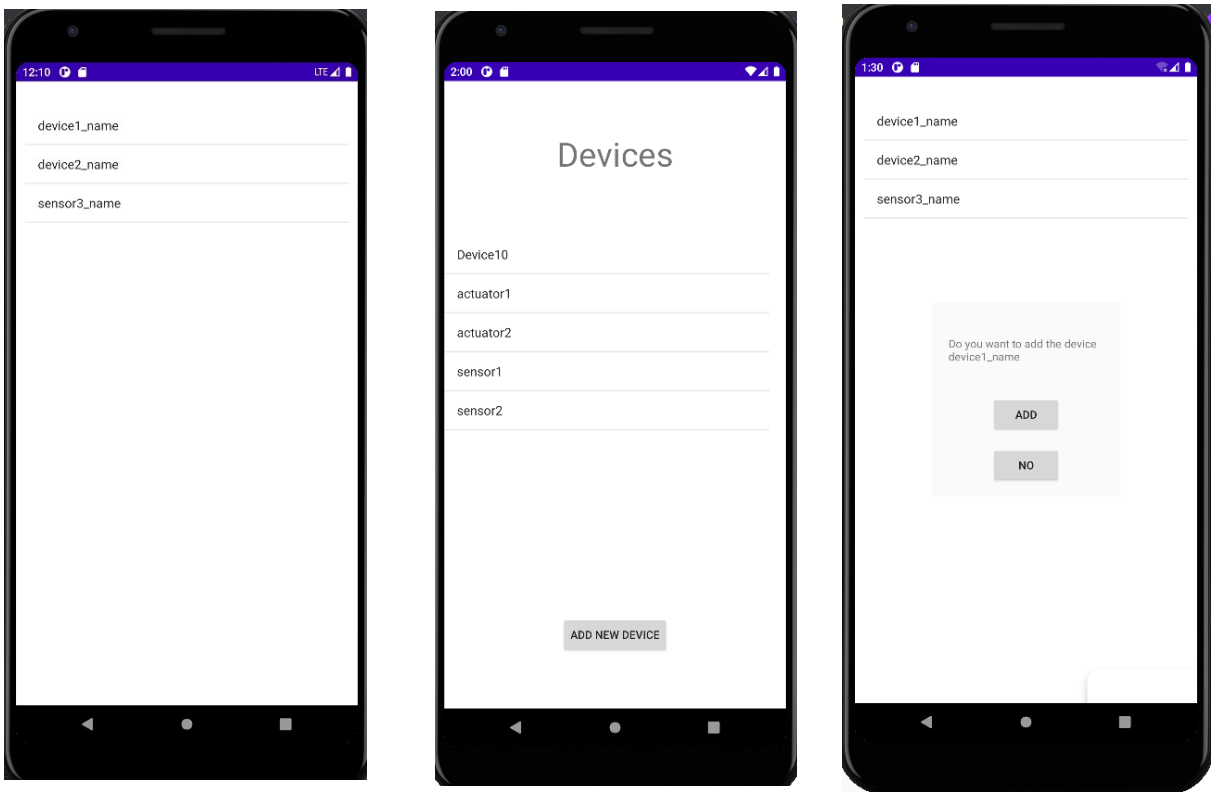

Figure 5: (left) list of possibl addable devices (middle) list of devices after adding (right) pop app

Discussion

The vision of our project was to make IoT in the form of a smart home application more accessible to everyone. The developed app is a tool for those who would like to take advantage of the conveniences smart homes have to offer in order to automate most of the appliances and let the app suggest what is best for the house also in terms of saving water, electricity and money. This application was developed taking in consideration the evolving market that right now is surrounding and supporting the growth of smart home applications.

Developing the application showed all the complexity and level of details that is necessary to make this environment work properly. Therefore a better understanding of IoT and its complexity and potential has been reached. Choosing Android Studio with its features has proven useful for the developing process. The use of an Interference to implement the connection was another helpful choice to work on the project without actually establishing a connection to the Raspberry.

The result is satisfactory. Goals like the possibility to view and control devices in a smart home and adding new devices to this smart home have been achieved. The Model-View-Controller Pattern adapted for the code structure of the application allows to add even more features, without undergoing major changes in the code structure.

Future work

This application, even though right now is only implementing a small number of features, has great potential. For the future of this product, we would like to implement the Group function, which will allow the user to bound together different elements and act on them simultaneously. For example, switching off all the electronic devices present in a room with one click.

We would also like to give the user the possibility to create different Protocols linking specific values of a sensor to one or multiple devices. Like having the irrigation stop if during the day it rains. This would have a good impact also on the environment allowing to reduce the water usage.

Also it would be useful to add a push notification feature where the app can send suggestions to the user on what to turn on and off or do in the house based on what the sensors detect.

Interesting would also be implementing Routines, such as “Leaving for vacation”, where different specific protocols would be automatically turned on, making sure that the house is properly taken care of during the absence of the owners. This could mean keeping on the necessary items like the refrigerator and the freezer, as well as, the irrigation system, while turning off all the unnecessary devices. Setting the security system and so much more.

The idea of being able to link together different devices and sensors is the future of IoT. We would be able to have a home that with only a click, or based on the time previously set, will close all the windows, blinds, turn off the lights of the room we preselected and even modify the temperature of the heating system. Right now our application is only a small prototype, but following those guidelines and goals, we could create a multifunctional app that would change the way we live in our homes.

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All references have been checked on the 07.01.2022.

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